How the Tail Wags the Dog: How Value Judgments Determine Ecological Science

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ABSTRACT: Philosophers, policymakers, and scientists have long asserted that ecological science – and especially notions of homeostasis, balance, or stability – help to determine environmental values and to supply imperatives for environmental ethics and policy. We argue that this assertion is questionable. There are no well developed general ecological theories having predictive power, and fundamental ecological concepts, such as 'community' and 'stability', are used in inconsistent and ambiguous ways. As a consequence, the contribution of ecology to environmental ethics and values lies more in the realm of natural history and case studies than in the realm of general theory. Moreover, although general ecological theory is unable to contribute to environmental values in the way many philosophers and policymakers have hoped, environmental values can and do contribute to ecological hypotheses and methods. Using examples related to preservation versus development, hunting versus animal rights, and controversies over pest control, we show that, because ecology is conceptually and theoretically underdetermined, environmental values often influence the practice of ecological science.

KEYWORDS: animal rights, balance of nature, community, ecology, ecosystem, pest control, science, stability, values

Philosophers and policymakers often argue for the privileged position of ecology and ecologists in defining the goals of environmental ethics and decision-making. Some philosophers claim, for example, that ecological theory is the "conceptual foundation" of environmental ethics (Callicott, 1989, 22). They say that ecological stability and integrity outline norms for human behavior toward the environment (Taylor, 1986, 50). Ecological laws and principles, they

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maintain, reveal the details of the environmental balance or homeostasis we must preserve (Rolston, 1986, 18). In short, many philosophers and policymakers credit the science of ecology with supplying aesthetic, ethical, and even metaphysical imperatives for environmental problems (McIntosh, 1985, 319; Worster, 1990, 1-2).

1. THE CASE FOR ECOLOGICAL SCIENCE DETERMINING ENVIRONMENTAL VALUES

Perhaps no one has emphasised the allegedly normative consequences of ecological laws and theories more than Aldo Leopold. “A thing is right,” said Leopold, “when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.” For Leopold, ecological principles reveal how to preserve the integrity, stability, and beauty of the biotic community (Leopold, 1949, 224-225).

Even scientists themselves have not resisted the temptation to use ecology as metaphysics or ethics – the foundation for environmental policy. When he was President of the Ecological Society of America, Arthur Cooper argued that there were numerous examples of the way that ecology directed environmental ethics and policy. The best illustration, he said, was the role that findings about estuarine ecosystems played in stimulating government programs for coastal zone management (Cooper, 1982, 348). Cooper also noted that ecological findings were directly responsible for environmental decisions to limit the use of DDT; to promote multispecies forests; and to publicise the problem of acid rain (Cooper, 1982, 348-349). In other words, Cooper appears to have said that ecological ‘facts’ provide at least part of the basis for inferring what ethical, political, and practical ‘values’ ought to characterise environmental decisionmaking.

Apart from the well publicised epistemological and meta-ethical problems with attempting to use ecology (‘facts’) as a normative basis for rules about action or policy (‘values’) (Taylor, 1986, 50-52), such attempts raise at least two related questions. (1) Can ecological theories help determine environmental ethics and values? (2) Can environmental ethics and policy help determine ecological theories? We shall argue that, contrary to popular opinion among philosophers, general ecological theories have little to contribute to environmental ethics and values, despite the fact that natural history and well developed case studies do have important roles to play. Moreover, environmental ethics and values can help determine ecological decision-making.

2. THE CASE AGAINST ECOLOGICAL SCIENCE DETERMINING ENVIRONMENTAL VALUES

Conservationists often need largely descriptive, scientific conclusions as a basis for decision-making, but general ecological theory has, so far, been unable to provide them. They often need a normative basis for policy, much of which general ecological theory has been unable to supply. Ecologists have not been able, for example, to determine with confidence the number of species that a habitat can support. Although they have offered a number of general accounts of community structure – like the broken-stick model (Kingsland, 1985, 183 ff.) – having heuristic power, their models have typically been unable to provide the precise predictions often needed for environmental policymaking. Similar weaknesses beset other candidate general theories in community and ecosystems ecology, from log-normal distribution theories to those based on information theory and chaos.

One of the most fundamental reasons that ecology has not been able to provide precise and predictive information to undergird environmental policies and values is that ecologists have defined and used two of the concepts most basic to community ecology – 'community' and 'stability' – in ambiguous and often inconsistent ways. Not only have they used different terms to represent the same community and stability concepts, but ecologists have employed the same terms to stand for different concepts. In the case of stability or balance, for example, Pimm (1984; see Westman, 1978) lists five different ways in which ecologists think about the stability concept – in terms of (1) variables returning to initial equilibrium; (2) how fast they return following a perturbation; (3) the time a variable has a particular value; (4) the degree to which a variable is changed following a perturbation; and (5) the variance of population densities. Not only are these five variations on the concept not compatible, but some of them do not even refer to the same state variables or parameters. Some ecologists use the term 'stability' without presupposing, for example, that variables have some value for a specified length of time, whereas other ecologists accept this presupposition. As a consequence it is difficult for community ecologists even to make logical contact with each other because there is no consensus on what stability means and on how it ought to be measured (Shrader-Frechette and McCoy, 1993, ch. 2; McCoy and Shrader-Frechette, 1992).

At present a number of ecologists appear to think of stability in terms of 'connections' (via food webs, competition, predation, and so on). The larger the number of connections among the component species of a community, no matter how those connections (or increases in complexity) come about, the greater the alleged stability of the community (Hengeveld, 1988; 1989). Despite numerous attempts to link some measure of complexity or connectance to stability, the matter remains poorly resolved at present. There are at least three current problems with attempting to define stability in precise, lawlike ways. One difficulty is that we do not understand how stability at the population level relates to that at the community level. The relevant causal relationships are simply not understood (Pimm, 1984). A second problem is measuring stability, given that there are at least five different definitions of stability, not all of which even purport to measure the same parameters.

A third difficulty with stability concepts is determining the temporal and spatial scale over which some type of stability might be assessed. In general, the difficulty is that, the greater the temporal scale, the greater the probability that some values have not remained stable, owing to extinctions and disturbances. Likewise, the greater the spatial scale, the greater the probability that some values have remained stable, owing to the fact that extinctions and disturbances are less likely to affect an entire area, as the area becomes larger. In short, determinations of whether some value is stable may be, in large part, a function of the temporal and spatial scale chosen for the study, as Connell and Sousa (1983) detail. They conclude, from their review of previous studies of stability, that virtually no evidence exists for conceiving ecological stability as some variable remaining at equilibrium or returning to equilibrium following perturbation, once difficulties like inadequacies of scale are resolved. They conclude (p. 808):

> Previously published claims for their existence [stable states] either have used inappropriate scales in time or space, or have compared populations or communities living in very different physical environments or have simply misconstrued the evidence.

Indeed, virtually every modern author, writing about stability at any level of organisation, includes some mention of the problem of scale (Berryman, 1987; Blondel, 1987; Davis, 1986; Graham, 1986; Morris, 1988; Pimm, 1984; Ricklefs, 1987; Shrader-Frechette and McCoy, 1992, 84-99; Shrader-Frechette and McCoy, 1993, ch. 2; Shugart and West, 1981; Williamson, 1987).

Because of these problems with the causal relationships allegedly accounting for stability, the various terms and meanings attributed to stability concepts, the different ways of measuring stability, and the problem of scale in determining stability, it appears that the modern concept of stability is, at best, imprecise and, at worst, vacuous. Certainly, because of these problems of scale, causality, and so on, the ecological concept of stability is of limited help to environmental policymakers who wish to focus their environmental ethics on preserving stability. It would be impossible to determine, uncontroversially, whether particular actions helped to preserve stability if the stability concept itself were controversial because of problems such as scale or causal relationships.

Equally serious difficulties beset the concept of ecosystem or community that is foundational to ecology. There is no ‘thing’ – no ecosystem or community – that is the uncontroversial subject for what is allegedly balanced or stable. Ecologists have used ‘ecosystem’ and ‘community’ terms in ambiguous and often inconsistent ways. Not only have they used different terms to represent the same community and stability concepts, but ecologists have employed the same terms to stand for different community concepts. As a result, there is no clearly defined and circumscribed conception of 'community' (Shrader-Frechette and McCoy, 1993, ch. 2; Thorpe, 1986; Williamson, 1987).

Moreover, despite the fact that we are able to trace some of the ways in which the community concept appears to have changed over time, historical and philosophical analyses reveal that ambiguities continue to beset the term, 'community'. Clements (1905; 1928), for example, distinguished several different ways of conceptualising communities, in terms of a simple juxtaposition of species in space and time, for example, and in terms of a pattern of various distributions of species. Yet Clements provided no clear criteria for confirming the presence of communities in nature, and his use of the community concept functioned largely as an idealised metaphysical 'type'. The inability of ecologists to document the existence of certain community 'types', however, meant that the classification schemes of Clements and others failed to provide much insight into the ecological organisation of alleged natural systems such as communities.

Later ecologists attempted to explain natural communities as interacting groups of species (Caswell, 1976; Fretwell, 1975; Hutchinson, 1948; Taylor, 1988), but the precise nature of this interaction was never a matter of consensus among ecologists. By the middle of the century, Macfadyen (1963, 177-179) showed that ecologists had at least seven different ways of thinking about communities, most of which were not compatible. Within these seven community concepts, he pointed out that ecologists disagreed as to which characteristics were actually properties of communities; some of these characteristics included co-occurrence of populations, constancy of species composition, and emergent and organismal properties.

Throughout most of the 1960's and 1970's many ecologists viewed the community as a self-regulating feedback mechanism (Odum, 1977). Critics charged that, although interdependencies exist among species, ecologists have not shown that communities have precise, uniform, or recognisable interactive structure and they have not established that ecological interactions such as competition are responsible for whatever structure may be thought to exist. As a result, many ecologists turned to a probabilistic account of the community concept (Simberloff, 1980), one based on mere co-occurrence of species. Because mere co-occurrence of species may produce no self-regulating feedback, some ecologists have argued that no community concept may exist at all (Hengeveld, 1989). Apart from whether or not there is a community concept, however, it is clear that, at best, there is no agreement on whether and what the processes might be that allegedly structure communities and how those communities must be defined. And if not, then there is no unambiguous concept of 'community' or ecosystem (Peters, 1991, 80-91; Shrader-Frechette and McCoy, 1993, ch. 2). Building a general ecological theory on notions of 'community' or 'ecosystem' that are ambiguous, inconsistent, and unclear is like building a skyscraper on sand. Or, as one *Science* author put it several decades ago: "it is highly improbable that a group of individuals who cannot agree on what constitutes a community can agree to get together for international cooperative research on communities" (McIntosh, 1985, 216). If ecologists are agreed neither on what communities are, nor on what processes (if any) structure them, then it is not clear that they have much to contribute to policymakers and environmental ethicists who need a precise, predictive prescription for building healthy communities and for preserving some alleged balance or stability in nature.

In addition to their conceptual disagreements, ecologists are likewise divided on what structures communities or holds them together. Because they do not know what, if anything, organises communities (e.g., predation, competition) in precise ways, ecologists have not developed an uncontroversial, general theory of community ecology that is capable of providing the specific predictions often needed for environmental problem-solving. As one ecologist put it, "the search for general theories languishes" (Murray, 1986, 146). This search is in trouble, in part, for the reason that Schoener (1972) recognised two decades ago; ecology has a "constipating accumulation of untested models", most of which are untestable. Models have other virtues besides testability, of course, but the fact that so few models in ecology are testable suggests that Woodwell (1978) may have been right when he spoke of ecology's being in a state of "paradigms lost".

If one cannot tell what a community or stability is, then it is likely not possible to determine – in any precise way – what a natural community or ecosystem is and when it is in some equilibrium or homeostatic state. As a result, ecologists are forced to define 'natural' communities and systems in a highly stipulative and question-begging way, in a way that presupposes a number of subjective judgments about what is natural, what is a community, what is desirable, and what ought to be preserved. Such subjective judgments, however, are more in the realm of environmental values than in the domain of ecological science. But if so, then ecological science has little that is precise and firm to contribute to disputes over environmental ethics and values.

3. ENVIRONMENTAL VALUES MAY INFLUENCE ECOLOGICAL SCIENCE

If our earlier remarks about the empirical and conceptual underdetermination of ecological science are correct, then it is reasonable to expect that, because of this underdetermination, subjective judgments often provide the foundation for much of what passes as ‘ecological science’. Such a foundation suggests, furthermore, that values also may help structure the resolution of alleged scientific disputes in ecology. Let us examine three typical cases in which it appears that values related to preservation versus development, hunting versus animal rights, and conflicts over pest control actually may determine the ecological hypotheses and theories alleged to resolve such controversies.

4. VALUES AND ECOLOGICAL DISPUTES OVER DEVELOPMENT

Some scientists are involved in environmental policy arguments between developers and preservationists. Hutchinson’s account of the feedback processes structuring communities (1959; 1975), for example, affirms the importance of maintaining the existence of a hypothetical balance of nature. If one accepts this account, then Hutchinson’s ecological conclusions (along with his associated methodological value judgments) can easily be used to support the position of preservationists rather than developers.

Other ecological conclusions, however, provide a foundation for the claims of developers. These conclusions presuppose no causal regularities. Their proponents argue that it is necessary to show departure from random assemblages (which advocates of the ‘balance’ allegedly have not done) before positing biological mechanisms to explain presumed departures (Chase, 1986; Simberloff, 1983; Strong, *et al.*, 1979; Strong, 1982; Strong, *et al.*, 1984). If one subscribes to this second account, then (although Strong, Simberloff, and others probably would not want their ecological conclusions used in this way) their skeptical response, to those postulating a ‘balance of nature’, could be used to support policies of commercial development of wilderness areas. Developers could point out that, if there were no conclusive ecological evidence for a ‘balance of nature’ preserved in pristine wilderness, then postulating such a balance would require opponents of development to make contextual and methodological value judgments. Because positing some ‘balance’ is dependent on making such value judgments, then it would be more difficult for environmentalists to argue against development on the grounds that it might destroy some inherent ‘balance’. Such disputes over development versus preservation illustrate that because of the magnitude of the empirical underdetermination of ecological theory (regarding balance or stability), scientists have been forced to make methodological value judgments about which, if any, account of balance or stability to pursue. Alternative value judgments about stability, in turn, have different consequences for environmental values and policy (Shrader-Frechette and McCoy, 1992).

5. VALUES AND ECOLOGICAL DISPUTES OVER HUNTING

Similar values conflicts face ecologists confronting the disputes between hunters or ranchers (interested in human control of predators) and preservationists. Many ecologists have claimed, for example, that predators control their prey populations; they have based this claim on a famous account of an eruption of the deer population on the Kaibab Plateau (a wilderness area near the Grand Canyon) after predators were removed (Chase, 1986, 24-26, 69; Leopold, 1933). A number of ecologists also subscribe to the "world is green" thesis and posit that herbivores in general are regulated by predation, and that herbivores could never be regulated from below (Hairston, *et al.*, 1970, 382-386; Hutchinson, 1970, 338-351).

Ecologists who accept the methodological value judgment, for example, that the Kaibab case is paradigmatic for explaining structure in all biotic communities also likely accept an account which claims that predators structure herbivore communities of species and keep them 'in balance'. As a consequence, they are likely to accept the ethical and policy position of some persons in the US Department of the Interior and the US Department of Agriculture. Proponents of this position maintain that, because predators control deer populations, for example, and because predators are often killed by hunters and by ranchers protecting their livestock, therefore prey populations need to be kept in check artificially, through hunting. Thus, the ecological findings and methodological value judgments supporting a predation account of community can be used by those who favour hunting as a wildlife-management policy. Of course, other ecological findings and methodological value judgments, also supporting a predation account of community structure, can be used by those who are opposed to hunting as a wildlife-management policy. Groups like Defenders of Wildlife and the National Audubon Society, for example, might claim that predators regulate their prey in a more natural or efficient manner than hunters do. They support the view that human hunting – focused on trophy animals – and natural predation are very different types of selective pressure. Therefore, even though members of such groups believe that predation structures communities, they remain opposed to hunting.

Ecologists who reject the predation account or the "world is green hypothesis" (Murdoch, 1966, 219-226), however, come to different value conclusions. If they claim, for example, that species populations are not kept in check in any regular way, or that they are kept in check, not by predation, but by competition or by some other factor accounting for the 'balance,' then they might argue that prey should not be controlled. Indeed, to support their position, preservationists have argued both that there was no Kaibab deer eruption, and that a reduction in predators does not necessarily cause an increase in the prey populations (Caughley, 1970). The point here is not whether such arguments are right or wrong, but that the preservationists who might use such arguments employ methodological value judgments quite different from those of the hunters, who also claim to be interpreting the same observational data.

The further point is that it appears possible that ethical commitments (e.g., to hunting or to predator control) might influence methodological value judgments used to interpret data about species eruptions and the role of predators. Such methodological value judgments, in turn, might influence whether one subscribes to a belief in some thesis about ecological stability. These beliefs about whether or not some balance or stability exists, in turn, support particular environmental values and policies designed either to maintain or to disregard the alleged balance. While there is no necessary connection between adhering to a particular account of stability or ecological balance and subscribing, as a consequence, to certain environmental values or policies, belief in the balance does appear to increase the probability of environmental action designed to safeguard that balance. Hence, this controversy – over hunting versus preservation – shows both that policy conflicts often cannot be adjudicated by appeal to the scientific facts of the matter (whenever the ecology is underdetermined) and that methodological and ethical value judgments might guide interpretation of the data.

6. VALUES AND ECOLOGICAL DISPUTES OVER PEST CONTROL

Similarly, in conflicts over chemical, versus biological, forms of pest control, scientists often appeal to methodological value judgments when they are faced with scientific or factual underdetermination. According to Strong, Simberloff, Abele, and others (Strong, *et al.*, 1984), no deterministic community structures ought to be posited until one has shown departure from random assemblages. They maintain that, if one cannot provide strong evidence for deterministic community structures, then one ought not posit an interactive notion of balance or stability. And if not, goes the argument, then one ought not argue that chemical pest control destroys some balance of nature. Indeed, according to this position, one cannot destroy something whose existence is in question and which cannot be defined operationally. The judgment that no interactive balance or stability exists, however, is dependent upon a number of methodological value judgments, for example, regarding the nature of random behavior, and the evidence that is sufficient to reveal the presence of community structures.

Some ecologists, however, obviously reject the conclusions of Strong, Simberloff, Abele, and others (Gilpin and Diamond, 1984), and therefore accept an interactive view of the balance of nature. For example, if one adopts an account of the balance of nature that presupposes causal regularities, an account based on the importance of predators, then one would have grounds for supporting biological pest management. One might claim that biological control was less likely to disturb some sort of stability or balance in nature. In either case, the fact that the ecology itself admits of alternative, plausible interpretations of the alleged 'balance' data means that (in this case) general ecological theory cannot provide us with clear guidelines for actions that are in accord with environmental welfare. And if not, then general ecological theory provides little help in adjudicating conflicts over environmental well being (Hughson and Popper, 1983; Popper and Hughson, 1983). In the pest-control case, as in the previous two examples, the reason for the lack of ecological conclusiveness is similar to that in many other areas of science: ecologists interpreting observational data are always forced to make methodological value judgments because general ecological theory is weak. The problem with such value judgments may be more acute in ecology than in other sciences, however, simply because the empirical underdetermination is so great.

7. WHERE WE GO FROM HERE

Not all methodological values are created equal, however. Some are more problematic than others. That is, they may be more ad hoc, or they may be based more on gratuitous assumptions, or they may be less internally consistent, or they may contribute less to heuristic or explanatory power than other judgments. Hence, the ecological conclusions founded on more questionable value judgments are likewise more problematic. For this reason, it is important for scientists to distinguish different types of methodological value judgments, to assess their respective reliability, and to understand the relationships among methodological value judgments, various ecological conclusions, and their environmental applications. If the three ecological and environmental controversies surveyed in this essay are illustrative, and we think they are, then ecological conclusions, even those grounded in hypothesis-deduction (H-D), are not adequate to support environmental values and environmental policies in an uncontroversial way. Perhaps ecologists and environmentalists have placed too much faith in algorithms, general ecological theories, or H-D methods that would preclude the necessity for tough-minded, situation-specific, methodological analysis in ecology and for sophisticated natural-history knowledge of individual taxa (see Shrader-Frechette and McCoy, 1993, 11-105).

If the examples discussed in this essay are representative, then what environmental policymakers need from ecologists is not general ecological theory, because such general theory is highly controversial and value laden. There is no 'easy ecology'. Instead, what policymakers need are specific conclusions, based on individual case studies, that allow for decisions in those cases. Although there is no space to defend the point here (but see Shrader-Frechette and McCoy, 1993, 106-148; Shrader-Frechette and McCoy, 1994), in order to ground environmental policy, ecology needs a new account of rationality and objectivity, one grounded in natural history and case studies. Just as a recent US National

Research Council/National Academy of Sciences (NAS) report emphasised (see Orians, *et al.*, 1986, 1, 5), ecologists need to illustrate how case-specific ecological knowledge, rather than general ecological theory, can be useful to environmental problem solving. Ecologists have shown, for example, how successful policies of environmental management for the red-cockaded woodpecker relied not on general ecological theory but on specific, carefully gathered, natural-history information about desirable habitat and breeding characteristics of the woodpecker (Walters, 1991, 506-518). Other case studies directed at obtaining specific natural-history information, for example, about the vampire bat, enabled ecologists to make recommendations about successful environmental policies of pest management for the bat (Orians, *et al.*, 1986, 28, 151-164). Such examples suggest that ecologists might provide a firm foundation for environmental policies by means of case studies and natural history rather than by employing outmoded versions of general scientific theories (see Shrader-Frechette and McCoy, 1993, 1994).

Moreover, as this essay illustrates, the hypothetical-deductive foundation of general scientific theories is undercut by the presence of methodological value judgments. For this reason it is important for ecologists to determine the degree to which controversies in ecology – and in science generally – turn on specific methodological value judgments. Indeed, this is one of the points illustrated by the previous three examples (preservation, hunting, and pest control): conceptual and methodological analysis – philosophical analysis – may contribute to the assessment of environmental value judgments that influence ecological science. Hence, contrary to what is commonly believed, it may be less the case that ecological science influences environmental values, than that environmental values also influence ecological science.

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