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Scientific Responsibility and Responsible Ecology

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Ecology has been called the relevant science. If this relevance is to be anything other than a catchy phrase, two things are necessary. First, ecology must generate reliable information and insights about environmental systems. This means that the information must be gathered in a rigorous and unbiased way and interpreted objectively: the science must be sound. Second, ecological information must be incorporated into management practices and policy decisions, the arenas where this information can make a difference. This means that the information must be gathered in a way that will provide useful insights to management and policy, and it must be communicated in a way that is understandable to people who have not been raised on a diet of ecological jargon.

Baskerville's essay ("Advocacy, science, policy, and life in the real world," *Conservation Ecology*) addresses primarily the second point. Here, I will comment on the issue of scale as it relates to Baskerville's thesis and then offer some thoughts on the first point, which I believe is the more important of the two.

Baskerville notes that the scale on which ecological research is conducted rarely matches the scale of management. In his view, this leads to a preoccupation with describing fine−scale patterns rather than discovering how systems actually function. The latter concern is simply a misreading of current trends and activities in ecology, which are increasingly focused on ecological mechanisms and processes. The concern with mismatched scales, however, is very real, and it permeates all of ecology, whether basic or applied. We know that ecological processes, and the patterns they produce, change as the scale in space or time changes. We also know that these changes are often nonlinear (Wiens 1989, Levin 1992). What we do not know is the nature of the "scaling functions" that describe these relationships for particular phenomena. Thus, although logistical necessity and ecological tradition (e.g., a preoccupation with experiments) usually dictate that ecological investigations be conducted at relatively fine scales of space and time, it is not clear how these findings should be extrapolated to the broader scales on which management is usually practiced. Simple linear extrapolations usually will not work. The issue of extrapolation is one of the most vexing in ecology, but if ecologists wish to contribute to effective resource management and scientifically based policy, it must become a central focus of ecological research. Some progress might be made by implementing carefully designed multiscale investigations (e.g., Koch et al. 1995), by integrating some of the approaches of macroecology (Brown 1995) with fine−scale, mechanistic studies, or by using theories of self−organizing processes in ecosystems (e.g., Holling et al. 1996) as a framework for evaluating scale dependency and scaling functions.

Baskerville argues that, if ecological information is to be relevant to management and policy, ecologists must scale their studies to match the scales used in management. In my view, this is an unrealistic demand, not because ecologists are unlikely to do this, but because it is not likely to advance ecologically based resource management. Management scales have been determined by a variety of factors: some economical, some political, some simply traditional, but all essentially anthropocentric. These scales of management do not necessarily coincide with the scales on which organisms respond to their environments, on which the processes affecting biodiversity or disturbance regimes operate, or on which ecosystems function. Ultimately, the health and profitability of the resources that are being managed depend on these organismal, population, and ecosystem scaling relationships, and to regard the scales of management as fixed and inviolate is a mistake. Rather than imposing a management scale on nature, efforts should be made to adjust the scales of management to those of natural processes, insofar as economic, social, and political constraints permit. This is, in fact, the approach being developed in the "new forestry" practiced in parts of Sweden and elsewhere (Haila 1994, Pastor et al. 1996).

Thus, problems with incorporating ecology into management and conservation stem, at least in part, from problems in translating patterns and mechanisms across scales. Detecting such scale−dependent effects depends, of course, on the scientific rigor of the studies conducted. More importantly, how (or whether) ecological science is applied to broader issues of public concern depends critically on the integrity of the scientific process. Let me turn now to the issue of sound science.

Ecologists are increasingly being drawn into environmental debates, whether about the effects of land uses or management practices (such as grazing of rangelands or clearcutting of forests), conservation issues (such as the design of natural reserves or the management of endangered species), or environmental perturbations (such as oil spills or global change). These are often emotionally charged issues. They attract media attention and, not infrequently, foster litigation. Because they are socially relevant, they are often associated with opportunities for research funding. Collectively, these pressures create an atmosphere in which advocacy for a particular position in a debate may affect the scientific process. At its worst, advocacy may masquerade as science (Wiens 1996) or science may be perceived as advocacy (Westoby 1997). Both erode the credibility of honest science.

Advocacy can influence the scientific process in several ways, beginning with the questions we ask. Most questions in ecology are influenced by our preconceptions about nature or current fashions in the discipline. Questions that relate to environmental or management issues often carry with them values (e.g., oil spills are bad) that can affect the way the questions are framed and the range of answers that can be obtained. Thus, instead of asking, "Did an oil spill have environmental effects, and if so, what?", the question may become "How bad were the effects?" The distinction is important, for the first question leads to an unbiased examination of environmental effects, whereas the second restricts attention only to environmental damages. We often initiate a study because of some environmental debate and the need to bring scientific evidence to bear on the issues, so some element of advocacy in the questions we ask is probably unavoidable. Biased questions, however, do not lead to good science.

Advocacy can also affect the way a study is designed. It can lead to conscious or unconscious bias in the selection of study areas, the way sampling stations are distributed, or the degree to which pseudoreplication is tolerated. Control areas may differ systematically from treatment areas, for example, but these differences may be ignored in analyzing results; as a consequence, all differences are mistakenly attributed to treatment effects (Wiens and Parker 1995). By specifying that certain variables will be measured while others will not, the results of a study may be constrained, enhancing the likelihood that one will find what one expects (or wants) to find. Whether or not values are implicit in the questions we ask, the study design and analysis must be rigorous and unbiased. Weak or biased study designs lead to weak or biased "scientific evidence," which is worse than worthless in environmental debates.

Perhaps the most pernicious and subtle effect of advocacy is on the interpretation of results. Even if a study is objectively framed and conscientiously designed and analyzed, the findings still must be placed in a context. Rousseau (1992) drew attention to what he called "pathological science," in which researchers unknowingly lose their objectivity in interpreting data that are near detection limits when much is riding on the results. Advocacy can reinforce this tendency, particularly because environmental debates are often emotionally charged. We care about the environment; that is why many of us became ecologists in the first place. Faced with the uncertainty that characterizes most findings in ecological research, it is all too easy for these feelings to influence how we view data, which results we choose to emphasize or to disregard, or whether what begins as speculation becomes transformed into "fact" because it is consistent with an advocacy position.

The responsibility of the ecologist, then, is to do science, and to do it as rigorously and objectively as possible. We must accept what our results tell us, not what our emotions might say. This is not to say that ecologists must retreat into the ivory tower and refrain from taking positions in environmental debates. There is an urgent need to bring scientific evidence to bear on environmental and management issues. These issues are so pressing that ecologists have a responsibility not to remain quiet when their findings can contribute to the debate. We should communicate the results of our science clearly and vigorously, in understandable terms, to the public and policy arenas. In so doing, however, there is also the paramount responsibility to recognize our own advocacy and to distinguish clearly between statements that are based on science and those that are based on personal values or viewpoints (Pitelka and Raynal 1989, Murphy and Noon 1991). We might take our lesson from the atomic scientists who, following the development of atomic energy at the end of the Second World War, spoke out frequently and vigorously about the potential abuses of this power, without compromising or distorting the science itself.

Ultimately, of course, ecological science is only one of many inputs to the development of management protocols or environmental policy. Some of these inputs reflect advocacy positions based on economics, religious beliefs, or political agendas. As ecologists, our agenda should be science, and our responsibility is to ensure that scientific findings carry the greatest possible weight in societal decisions about the environment.

RESPONSES TO THIS ARTICLE

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