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Young Scholars Dialogue, part of Special Feature on Science, Policy, and Advocacy Forum

Ecology, Ethics, and Advocacy

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NOWHERE TO RUN, NOWHERE TO HIDE

Anthropogenic global change is radically altering climate, mineral cycles, land cover, and biotic communities (Turner et al. 1993, Vitousek 1994). These changes ensure that everywhere on Earth is affected by human actions. In some areas, such as the center of large cities, human transformation is near absolute, whereas in other places, such as remote parks, human influence is felt chiefly through the alteration of global cycles. However, no place is free from multiple, confounded human impacts. Consequently, ecological studies, whether they attend to or not, are partially studying the impact of anthropogenic change.

Ecologists cannot ignore these changes. First, ignoring these changes will produce flawed science; if ecologists ignore anthropogenic influences, they will probably attribute change to the wrong processes. Second, and perhaps more important, if ecologists want to guide or "engineer" the human transformation of the earth to reduce unintended consequences, they need to understand how ecosystems organize and function in response to a huge variety of anthropogenic alterations.

Engineering ecological systems is dangerous. Nature is neither predictable nor inert; rather it is evolutionary and self-modifying. History, evolution, and variation are all central to ecology, but foreign to the "memory-less," repeatable, and variation-minimizing methods of traditional engineering.

Ecologists cannot hide behind "pure" science and divorce themselves from the dangerous application of ecology. Whether ecologists like it or not, managers, policy makers, and the general public use ecological theory, or at least their understanding of ecological theory, to make decisions. To promote "reflective" management and sound science, ecologists need to study, criticize, and inform the human transformation of nature.

COMMUNICATING AN ECOLOGICAL WORLDVIEW

Improving the quality of ecological decision making requires that ecologists effectively communicate not only with land managers but also with a broad community of stakeholders involved in ecological transformation. Ecologists need to communicate and work with citizens, community associations, corporations, NGOs, politicians, government officials, and professional organizations. Ecologists should not enter naively into these interactions, but should be aware of the conflicting values and goals of different stakeholders (including scientists). Because of differences in these values and interests, any policy or management action is likely to produce winners and losers. Consequently, stakeholders will attempt to use science as a tool to manipulate the decision making process to their advantage. Ecologists, therefore, need to communicate ecological understanding clearly, or the unintended consequences of their actions may return to haunt them. Along with risks, politically charged decisions also offer opportunities for ecological intervention. Although some groups may value ignorance, most groups prefer to make informed decisions. By criticizing ecological ignorance and enriching ecological understanding, ecologists can often improve the quality, and potentially the equity, of decision making processes.

Ecologists need to communicate more than ecological "facts" or management prescriptions. They need to provide a basic understanding of ecology. It is particularly important to emphasize the differences between an ecological worldview that focuses on historical contingency, population uniqueness, and irreversibility and a mechanistic worldview that emphasizes repeatability, replaceablity, and reversibility (Mayr 1991).

These differences are important, because they explain how ecological systems differ from physical systems and, therefore, how ecosystem transformations differ from mechanical transformations. Unless they provide this context, ecologists will not be able to convince managers to plan for surprises, to invest in learning, or to take a sophisticated approach to risk.

Models can provide particularly useful tools for synthesis and communication among different people. Models can be qualitative worldviews that propose one way the world may work, or models can be more testable amalgamations of assumptions and knowledge, such as mathematical formulae and computer simulations. As Walker mentions, models provide a means of "reflection" on the possible consequences and uncertainties associated with actions before they are undertaken in actuality.

The effective use of models requires a diversity of modeling approaches, the consideration of alternative models, and the continual testing and revision of models. Different types of models are appropriate for different types of communication. For example, a model that allows specialized scientists to test ecological hypotheses would probably not be useful at a public meeting for addressing the equity of a potential ecological impact . Alternative models are necessary; unless people have clearly articulated alternatives from which to choose, there is no opportunity for learning or change. Additionally, without alternatives, people may believe that they are using the "right" model, rather than one of a set of competing or provisional models. Models need to be continually revised, modified, and discarded based upon how they fare in tests against empirical data (Hilborn and Mangel 1997). Stated simply, models are useful if they are used within some sort of "adaptive management" framework that focuses on using a modeling process, rather than a specific model, to learn how a system works.

WRESTLING WITH REAL-WORLD QUESTIONS

Traditional engineering uses physical rules to manipulate the world and, consequently, it has benefited from advances in physics. Physicists have had great success in developing scaling rules that explain the behavior of physical systems over a wide range of scales. As we discussed, many people have a similarly mechanistic view of nature, leading them to hope that ecological scaling laws can be derived that would inform management the way physics informs engineering (Bak 1996). However, ecological research has demonstrated that different processes dominate at different spatial and temporal scales (Levin 1992). Although interesting in its own right, this scale variance makes it difficult to predict how processes will interact across scales, or how ecological understanding at one scale can be transformed to be applied at another scale.

These scaling differences mean that ecological engineering has more diffuse and less tractable negative externalities (e.g., irrigation leading to the spread of river blindness) than does traditional engineering (e.g., a bridge collapsing due to an unexpected load). In traditional engineering systems, failure is often local, abrupt, and catastrophic, whereas "failure" in ecological systems often occurs gradually over larger areas. The chronic and diffuse nature of ecological degradation makes dealing intelligently and equitably with the unpredictable, the unknown, and surprising aspects of ecosystems difficult, but this does not obviate the need to actually make decisions and manage these systems.

Ecologists must use redundancy, diversity, and the production of novelty to hedge against surprise. Engineers traditionally have attempted to avoid disaster by "fail-safe" design (e.g., over-building a bridge by a safety factor), but we know that there is no "fail-safe" strategy for ecological management. Ecological management plans need to be "safe-fail," and this goal requires diverse, rather than efficient, management.

Ecological management needs to combine a diversity of approaches within an experimental setting. Diversity reduces the cost of any individual failure, and an "experimental" setting allows scientists to analyze the consequences of management. Experimental management requires replicated management treatments that can be compared against controls to test competing hypotheses (Walters and Holling 1990). In the short term, management that follows "best practices" is cheaper than experimental management techniques, but a monolithic approach reduces the ability of management to improve, leaving it vulnerable to change. The capacity of experimental management to adapt and learn provides it with a better chance of avoiding the disasters that often beset monolithic management. Over longer periods of time, the adaptability of experimental management makes it both cheaper and safer than monolithic management.

Ecologists can also learn from previous interventions in other systems. Although each situation is unique, there are also similarities among situations that can inform intervention. To utilize existing information effectively, ecologists must develop the statistical and modeling sophistication to integrate known, or prior, information into their analyses (Dixon and Ellison 1996).

A DIVERSITY OF APPROACHES

Baskerville advocates that scientists pay more attention to the scales of managers, while Wiens argues that managers should pay more attention to ecological scales. We propose that ecologists and managers should view management interventions as opportunities to learn how ecosystems function at different scales. Management interventions provide ecologists with opportunities to integrate small-scale understanding or experience with the larger scales that increasingly influence many resource management problems, but exceed the time frames and budgets of the average researcher. Such integration offers opportunities for theoretical advance, as well as for solutions to directly applied questions. We are not suggesting that applied ecology should be the only ecology practiced. Ecosystems are not defined by the bounds of a management plan. The scales of human impacts do not always coincide with the scales of key ecological processes, nor do management questions fully define ecological issues (e.g., studying the impacts of new logging strategies on the forest may not consider impacts to salmon populations). To advance, ecology must encourage a diversity of approaches.

Ecology needs to expand to include the large without abandoning the small. Ecological research must range from the natural history and behavior of a single species to regional experiments. Small-scale experiments and species-specific research remain crucial to our understanding of biological processes at management scales. As Walker noted, it would be dangerous to solely address management questions: "If all scientists do is work on today's problems with managers, we run the risk of not developing new ideas and understanding about ecosystem ecology." A diverse ecology requires a diversity of researchers. All questions cannot be efficiently addressed by the same set of skills. Ecology requires, therefore, a diversity of ecologists and ecological practitioners. Ecologists should fear limited "cultural diversity" in science and resource management, just as we fear a simplification of biodiversity in nature.

ADVOCACY AND SCIENCE

Ecologists are frequently confronted with situations that they feel are wrong. However, it is difficult to decide when advocacy is an appropriate role for a scientist. As informed individuals, ecologists abandon the duties of citizenship if we hide our values behind a veil of scientific objectivity. However, if ecologists use scientific standing to advance appealing, but scientifically unsound, arguments, we abandon professionalism and scientific ethics.

Science in the service of decision making requires different outputs than science done without such a goal (Walters 1986). Ecologists need to be especially aware of the possibilities of type I (accepting a false hypothesis) and type II error (rejecting a true hypothesis) when the consequences of these different types of error may be unequal. For example, if rejecting a true hypothesis would result in an action with a much higher cost than accepting a false hypothesis, it is sensible to design an experiment and analyses to take those considerations into account. Ultimately, ecologists should be driven by professional standards so that an ecologist would feel comfortable with her methods even if they were used by someone else to advance an opposing hypothesis (e.g., her work for Greenpeace should be held to the same standards that she would expect from ecologists working for Exxon). Our advocacy may direct us to particular questions, but it should not instruct our answers.

Ecologists are not the only ones who need to be held to higher standards. Often, in the face of deadlines or political pressures to act, management policy is developed by picking the politically expedient aspects of ecological theory (e.g., "disturbance is natural"). Ecologists need to hold managers, policy makers, and the public accountable to the full scope of an ecological theory, with all its alternative hypotheses, confidence intervals, and context specificity.

Managers cannot simply claim to be "practitioners" who carry out the plans recommended to them by the scientists and policy makers. Managers need to be both practitioners and scientists; they need to join ecologists in understanding how humanity is altering ecological systems. They need to learn to operate with alternative testable hypotheses and to work for change, rather than to build barriers against it.

BARRIERS AND BRIDGES

Scientists who want to improve the management of ecological systems need to better understand the decision making process and to combine ecological knowledge with concepts from non-ecological fields such as economics, finance, ethics, planning, and anthropology. An increased demand for cross-disciplinary and collaborative work to address complex, real-world problems carries with it an increased demand to be able to communicate and learn from people from other backgrounds and with other worldviews.

Ecologists need to become better at communication if non-ecologists and ecologists are going to work together to advance ecological theory and practice. Journal publication is an efficient way to communicate among scientists, but a poor route for communicating new findings in ecological science to policy makers, managers, or the public. Journal articles are difficult to obtain, understand, or apply. These barriers slow the spread of ecological knowledge from the active research community. Journals also afford no reasonable mechanism for dialogue with the policy and applied realms.

Collaboration and communication are risky for ecologists, because they take energy away from studying ecology. If too much emphasis is placed on understanding all fields and issues that impinge upon ecology, ecologists risk becoming jacks-of-all-trades who are masters-of-none. To maintain the integrity of ecology as a discipline, ecology needs to maintain a strong scientific focus and champion science that is repeatable and methodologically objective.

Applied research opportunities for young scientists should be increasing, with the ecological transformation of the Earth and the attendant problems that this transformation brings. However, reversing ecological degradation often is considered a luxury, in part due to the difficulty in creating effective market mechanisms to efficiently and equitably distribute the benefits and costs of ecological transformation.

REFLECT BEFORE ACTING, BUT ACT

Baskerville condemns ecological management as "inadequate reflection before action." This statement may become the epitaph of human civilization, but ecologists should not let future generations say that the world was destroyed by "a lack of action after a lot of reflection." If ecologists wish to alter the way in which the world is being transformed by human activities, then we must begin by identifying problems and offering to help work toward solutions.

Ecology is still a young science. Little is known about how ecosystems function, and even less about the consequences of anthropogenic global change. Applied ecology offers great opportunities to acquire ecological understanding, but non-applied ecology also offers many rewards. It is vital that ecologists be aware of their role in supplying the theoretical underpinnings for a more reasoned transformation of the Earth's ecological systems, even if they do not work directly on that transformation themselves. No one person can do it all, but ecologists working together, with other scientists, managers, companies, governments, and the public, have the potential to achieve a great deal.

RESPONSES TO THIS ARTICLE

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