# 1 · Introduction: What ecology can't do

SCIENTISTS have long been in the business of helping to solve practical societal problems. Leonardo da Vinci helped build machines of war; Lavoisier's talents supplied gunpowder for the American Revolution, and Pasteur's experiments showed brewers and vintners how to keep their beverages from spoiling. Indeed, scientists' skills in practical problemsolving are often a barometer for the methodological sophistication of the theories that they employ. Good methods frequently lead to successful problemsolving. Failure at practical problemsolving often indicates poor scientific methods.

What can we learn about the precision, explanatory power, and empirical adequacy of the methods of community ecology – by examining the instances in which it has been used to solve practical environmental problems? This is the main question we assess in these ten chapters. Our answer is, in part, that when we wish to apply ecology in order to promote conservation or preservation, our knowledge of particular taxa is more important than our knowledge of general theory. In other words, following Kitcher's (1985b, 1989) distinction, we believe that, for practical problemsolving, "bottom-up" approaches to ecological explanation are likely to be more fruitful than "top-down," although both are needed. Top-down approaches tend to use an account of theoretical explanation to underwrite talk about fundamental mechanisms and identification of causes in particular cases. Bottom-up approaches tend to focus on specific phenomena; they emphasize our ability to see causal relations in such phenomena and then to pull together results about individual cases or events into some sort of theoretical explanation. We shall argue that, insofar as ecology is required for solving practical environmental problems, it is more a science of case studies and statistical regularities, than a science of exceptionless, general laws. Insofar as ecology is an applied endeavor, it is more a science that moves from singular to theoretical explanation, than one that proceeds from theoretical to singular explanation.

## 1.1 Ecology as the foundation for environmental ethics and policy

Ecologists are the gurus of the environmental movement. More than a century ago, Ralph Waldo Emerson argued in his essay, "The Uses of Natural History," that ecological science provided lessons for humans. Right, said Emerson, "is conformity to the laws of nature" (Emerson 1910, p. 208). Philosophers, scientists, and policymakers have continued to argue for the privileged position of ecology and ecologists in shaping the goals of environmental decisionmaking and in providing strategies for realizing these policy goals. Some philosophers claim, for example, that the "conceptual foundation" of environmental ethics is ecological theory (Callicott 1989, p. 22). They say that ecological stability and integrity outline norms for environmental ethics (see Taylor 1986, p. 50). "Ecological theory," they maintain, provides "a social integration of human and nonhuman nature . . . interlocked in one humming community of cooperations and competitions"; this interlocking, they say, requires each of us "to extend his or her social instincts and sympathies to all the members of the biotic community" (Callicott 1989, p. 83). It also requires us to preserve the environmental balance or homeostasis allegedly revealed by the laws of ecology (Rolston 1986, p. 18). In other words, many scholars credit ecology with supplying aesthetic, ethical, moral, and even metaphysical imperatives for environmental problems (see McIntosh 1985, p. 319; Worster 1990, pp. 1–2). Perhaps no one, more than Aldo Leopold, has emphasized the allegedly normative (as opposed to descriptive) character of ecological laws and theories. "A thing is right," according to Leopold, "when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." For Leopold, ecology has revealed how to preserve the integrity, stability, and beauty of the biotic community (Leopold 1949, pp. 224–225).

Even scientists themselves have not resisted the temptation to use ecology as a metaphysics, a world view, or an 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 has directed environmental ethics and policy. The best illustration, he said, has been the role that findings about estuarine ecosystems have played in stimulating government programs for coastal zone management (Cooper 1982, p. 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 publicize the problem of acid rain (Cooper 1982, pp. 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 characterize environmental decisionmaking.

Apart from the well-publicized epistemological and meta-ethical problems with attempting to use ecology ("facts") as a normative basis for rules about action or policy ("values") (see Taylor 1986, pp. 50–52), such attempts raise an interesting scientific question. Is ecology able to perform the task assigned to it by many conservationists and policy-makers? Can it provide the basis for environmental decisionmaking?

## 1.2 Problems with using ecology to guide environmental policy

On the whole, general ecological theory has, so far, been able to provide neither the largely descriptive, scientific conclusions often necessary for conservation decisions, nor the normative basis for policy, both of which environmentalists have sought. Ecologists have not been able, for example, to determine with confidence the number of species that a habitat can support. They have examined a number of general accounts of community structure – like the broken-stick model (see Kingsland 1985, pp. 183ff.) – only to discover that, despite their heuristic power, the models typically have been unable to provide the precise predictions often needed for environmental policymaking. Similar weaknesses have dogged other candidate general theories in community and ecosystems ecology, from log-normal distribution theories to those based on information theory and chaos. Three examples – focusing, respectively, on the passage of endangered-species legislation, on a New York utility controversy, and on the failure of the International Biological Programme of the US National Science Foundation – suggest some of the reasons why ecology, despite its many successes, has provided neither a largely descriptive general theory capable of yielding precise, conservation-related predictions nor a normative foundation for specific environmental policies.

One of the best illustrations of how, despite its heuristic power, general ecological theory has failed to provide a precise, predictive basis for sound environmental policy is that of the diversity–stability hypothesis. This hypothesis, simply put, is that more diverse communities of species are more stable, or that some "balance of nature" is maintained by promoting diverse communities of species. For many ecologists, complex *trophic systems* and diverse *communities* are more stable than less diverse, or simpler, ones. (For a discussion of stability and balance, see chapter 2). On the basis of the diversity–stability hypothesis (MacArthur 1955, pp. 533–536; Elton 1958, pp. 143–153; Hutchinson 1959, pp. 145–159; Lewontin 1969; Wilson and Bossert 1971, pp. 139–144; Futuyma 1973, pp. 443–446; Innis 1974, pp. 131–139; Wu 1974, pp. 155–165; De Angelis 1975, pp. 238–243; Goodman 1975, pp. 237–266; Worster 1977, ch. 15; McIntosh 1985, pp. 187, 252–256), preservationists have argued that we must exercise caution in altering ecosystems, so as to protect biological diversity and thus maintain the dynamic stability or balance of naturally functioning ecosystems (see Norton 1987, chs. 2–4). Merely on the grounds of its repetition over several decades, by the late 1960s the diversity–stability hypothesis achieved the status of a proposed truth, an ecological theory or paradigm. In the last ten years, however, at least in its original form, the thesis has been virtually refuted (Sagoff 1985a, pp. 107–110; Taylor 1986, p. 8).

The reasons for the disfavor attributed to the diversity–stability theory are both empirical and mathematical. Salt marshes and the rocky intertidal provide only two of many classical counterexamples to the diversity–stability view. Salt marshes are simple in species composition, but they are stable in the sense that species composition rarely changes over time. On the other hand, the rocky intertidal is a relatively diverse natural system, yet it is highly unstable, since it may be perturbed by a single change in its species composition (see, for example, Paine and Levin 1981; Sagoff 1985a, p. 109). Empirically based counterexamples of this sort have multiplied over the last 15 years, and May, Levins, Connell, and others have seriously challenged the diversity–stability thesis on both mathematical and field-based grounds (see May 1973; Levins 1974, pp. 123–138; Connell 1978, pp. 1302–1310; McIntosh 1985, pp. 142, 187–188; Sagoff 1985a, pp. 107–109; see also Paine 1969, pp. 91ff.; Goodman 1975, pp. 237–266; Lewin 1984, pp. 36–37; see also Soulé 1986a, pp. 6–7). Despite such repudiations, however, the diversity–stability theory has been, by far, the most basic and the most persuasive of the utilitarian arguments for environmental protection, perhaps because it is something that people like and want to believe (Goodman 1975). Policymakers and scientists repeatedly have trotted it out as a rationale for environmental policies designed to save species in a given area. Numerous decisionmakers, for example, have cited the diversity–stability thesis as grounds for supporting the Endangered Species Act (Commoner 1971, p. 38; US Congress 1973a, c; Myers 1983).

Admittedly, the demise of the diversity–stability hypothesis has not caused the repeal of the Endangered Species Act. This suggests that environmental legislation might not need to rely primarily on ecological findings, but could be supported instead by purely human (aesthetic, cultural, utilitarian, for example) preferences for preservation and conservation. Nevertheless, as a central tenet of general ecological theory, the diversity–stability thesis (in its original form) has been falsified. Its demise raises a question: Can general ecological theory bear the primary burden of justifying particular environmental decisions? This is one of the main questions we shall address in successive chapters.

In addition to the diversity-stability hypothesis, another interaction between general ecological theory (in this case, in the area of population ecology) and environmental policymaking occurred in the 1960s in the US, an interaction that also raised questions about the role of theorizing in ecology. In America's longest legal conflict over environmental policy, the US Environmental Protection Agency (EPA) challenged five New York utility companies to prove that their water withdrawals would not adversely affect the environment. Specifically, the disputants disagreed over the effects of withdrawals on the Hudson River striped-bass population. After spending tens of millions of dollars researching this problem, scientists still could not estimate, precisely, the ecological effects of the water withdrawals. Their failure illustrates the fact that general ecological theory was and is not precise enough to help adjudicate courtroom conflicts over environmental welfare. Unable to resolve their dispute on the basis of general ecological theory, the parties negotiated an outage schedule based on purely practical constraints (see Barnthouse *et al.* 1984, pp. 17–18; Shrader-Frechette 1989c, p. 81).

Perhaps the most spectacular interface between general ecological theory and environmental policymaking is systems ecology. In the middle 1960s, many ecologists urged a dramatic new approach to ecology, namely, the study of functional ecosystems using the methods of systems analysis and those of an international program of biological research called the "International Biological Programme" (IBP). Initially presented by a committee of the International Council of Scientific Unions (ICSU), the IBP research was funded, in the US, by the National Science Foundation and by the Atomic Energy Commission. As one scientist put it, very likely the most important event for US ecology in the last 30 years was participation in the IBP (see McIntosh 1985, p. 214). The focus of this international cooperative research in the

IBP, "big biology," was quantifying trophic effects in ecosystems and using nutrient cycles, flows of energy and matter, and systems analysis as the way to understand ecosystems. The difficulty, however, was that after a decade of millions of dollars of funding for large-scale, long-term ecosystems studies, the IBP, despite its successes (see Worthington 1975), could provide no precise theories having predictive power. Hence, the IBP provided little assistance to scientists who wished to use general ecological theories and their predictions to help justify specific environmental policies and actions. In 1974, the IBP was formally terminated (see McIntosh 1985, pp. 213ff.).

Despite the fact that ecologists had gleaned information from their ecosystems models in the decade of IBP funding, the general theory behind ecosystems ecology was unable to provide precise predictions that could be confirmed and used in the environmental courtroom. Indeed, many scientists claimed that the ecosystems approach was "unrealistic in view of the lack of valid theory" (McIntosh 1985, p. 234). Regardless of whether the predictive failures of ecosystems theory were a result of the infancy of ecology or a consequence of the inherently problematic character of the ecosystem concept, the fact remains that the ecosystems research of the IBP did not unequivocally vindicate general ecological theory. One of the concerns of this volume is to analyze the reasons for methodological failures such as the IBP. We shall also investigate alternative, practical contributions that ecological knowledge might make to applied science and to environmental problemsolving.

## 1.3 The argument of the chapters

In the next three chapters, we investigate some of the reasons why community ecology – so far – has been unable to arrive at a general theory having adequate explanatory power. These three chapters spell out what ecology can't do. In chapter 2, we show 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. Moreover, despite the fact that we are able to trace some of the ways in which the community and stability concepts appear to have changed over time, our historical and philosophical analysis reveals that there is still no clear and unambiguous meaning for these two central terms. Building a general theory of community ecology on such ambiguous, inconsistent, or unclear terms 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" (quoted in McIntosh 1985, p. 216). Much foundational work remains to be done.

Of course, complete agreement on the meaning of key terms and concepts is not essential for all communication in science. As Hull (1988, pp. 6–7, 513) points out, "weasel words" are important to scientists because they "buy time" while researchers develop their theories and positions. Nevertheless, although conceptual vagueness and disagreement have not brought ecology to a halt, and although they have not destroyed its heuristic power, conceptual difficulties have often prevented the formulation and evaluation of powerful, precise, general theories (in ecology) that are useful for solving specific environmental problems.

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, organizes 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 problemsolving. Chapter 3 discusses the most prominent of those ecological theories claiming to give such a general account, island biogeography. The chapter explains why island biogeography is still beset with controversy and, therefore, why it fails to provide a fully explanatory, complete, general theory of community ecology that is able to help resolve practical controversies over conservation decisions.

Inadequate understanding of the concepts and community structures unique to ecology are not the only reasons why community ecology, despite its heuristic power, has no general theory able to provide policy-related predictions. This area of biology has many of the same problems that make theory-building in any science difficult. One of the biggest obstacles is the fact that all empirical results, including those of ecology, are value laden. Chapter 4 examines some of the ways that science is laden with values – especially epistemic or cognitive values, but occasionally ethical values – and why it is impossible to avoid at least some of these values. It also illustrates some of the ways that cognitive or epistemic values arise in ecology. Chapter 4 further reveals that, unlike more descriptive sciences, much of ecology

Cambridge University Press
0521418615 - Method in Ecology: Strategies for Conservation
K. S. Shrader-Frechette and E. D. McCoy
Excerpt
More information



(especially conservation biology) is faced with developing theories that are often implicitly ethical or prescriptive. The theories are implicitly prescriptive because certain normative goals are built into specifying what is "natural" or "healthy" for the environment. In other words, because ecology is goal-directed in the way that medicine is, for example, it faces more complex epistemological and ethical problems – than other sciences do – in attempting to develop a predictive general theory. It must not only explain and predict a factual state of affairs but also help policymakers describe and defend that state as somehow healthy or normative.

The conceptual, theoretical, and evaluative problems associated with developing a precise, quantitative, and explanatory ecological science have suggested to some experts that ecology can play virtually no role in grounding environmental policy. In the last six chapters of the volume, we show why this pessimistic conclusion is unwarranted, despite the difficulties we outlined in the previous three chapters. Chapter 5 describes several things that ecology can do. It can often give precise answers to precise questions based, for example, on detailed natural-history knowledge or autecology. Ecology can also give us specific answers to practical environmental questions posed in individual case studies. As chapter 5 argues, ecology is, in part, a science of case studies, with both the assets and liabilities that the method of case studies entails.

Moreover, as a science that often emphasizes case studies, ecology is frequently able to establish where the burden of proof lies in an environmental controversy. Chapter 6 argues that, contrary to accepted scientific practice, in cases of scientific uncertainty, there are sound ethical and epistemological reasons for the ecologist to minimize type-II statistical errors. Minimizing type-II errors often is able to prevent the worst sort of environmental damage. Because chapter 6 argues for a new way to look at scientific error and for a reversal of the accepted opinion on whether to minimize type-I or type-II errors, when both cannot be avoided, the chapter is likely to raise a host of scientific, conservationist, and ethical objections. In chapter 7, we answer many of these objections and, in the process, clarify the notion of rationality underlying the application of much ecological science to environmental policy. We argue that, although ecologists in the past have frequently employed a notion of "scientific rationality," current applications of ecology to environmental problemsolving require them also to use "ethical rationality." Likewise, we explain the precise conditions under which ecological methods ought to be epistemologically conservative and ought to avoid rejecting the null hypothesis.

In order to illustrate what is perhaps our main claim about what ecology can do – namely, it can give practical advice in particular cases – in chapter 8 we present a case study. The study concerns the Florida panther, a subspecies now on the edge of extinction and reduced to about 40 individuals statewide. One question the panther poses for community ecologists is whether their discipline can provide scientific evidence relevant to the possibility of saving the subspecies in the wild. Providing a detailed analysis of specific ecological information, we show how and why ecologists can contribute to answering this question about panther preservation. Giving practical, scientific advice about particular cases, like the Florida panther, however, does not resolve all controversy about ecological methods and about how they might inform conservation policy. There are a whole host of normative, ethical, and economic questions that arise whenever one attempts to apply scientific conclusions to real-world conservation problems. In chapter 9, we discuss many of these normative questions as they arise in the panther case. Even if we could not argue effectively that ecological methods and ethical analysis have much to contribute to the future of science and conservation policy, it would be in our interest to believe so. Ecology will progress as a science only if those with the talents to make it do so also have the conviction that they will succeed. Lacking this conviction, ecologists are likely to fail. Optimism is our only scientific option.

In chapter 10, we summarize our arguments for what ecology can do, and we explain why precise concepts, theories with great explanatory power, and practical knowledge in particular cases will not resolve all the scientific difficulties facing community ecology whenever it is used to undergird environmental decisions. Perhaps more than other disciplines, ecology is beset with the difficulty of developing laws and theories about different cases, no two of which are similar in all relevant respects. Hence, compared to other scientists, ecologists face a particularly problematic task when they attempt either to move from singular to theoretical explanation (bottom-up) or to apply a general law to a specific case (top-down). They must clarify how and why the case is relevantly similar to others allegedly covered by the same law, and they must know the precise constraints on idealization in science. Of course, all scientific laws are idealized, and all particular applications of them raise questions about the required closeness of empirical fit in a given situation. Because of the difficulty of finding situations/cases in community ecology that are precisely and relevantly similar, the ecologist faces the problem of scientific idealization in an acute way. In the final chapter, we give some very preliminary suggestions for ameliorating the difficulties associated with idealizations in community ecology. Further, in the context of summarizing what ecology can and can't do, we close the volume by making several suggestions about the precise role of methodological value judgments in ecology and about the apparent inability of ecologists to follow a hypothetical-deductive model of scientific explanation. We conclude by pointing to several facts that suggest a bright future for the important, but relatively undeveloped, task of applying ecology to practical, environmental problem solving.