# ECOLOGY & LAW

*Science's Dilemma in the Courtroom*

by Mark Sagoff

*MARINE PERSPECTIVES*, a series of papers and reports produced by the Maryland Sea Grant College, focuses on marine-related issues, including marine management, ecology, economics and ethics. Opinions expressed in the series reflect the views of the individual authors and not those of the University of Maryland or of the National Sea Grant College Program.

# ECOLOGY & LAW

## *Science's Dilemma in the Courtroom*

by Mark Sagoff

Publication Number
UM-SG-MP-87-01



The publication of this series is made possible in part by a grant from the National Oceanic and Atmospheric Administration, Department of Commerce, through the National Sea Grant College Program. Grant number 86-AA-D-SG006, projects M-3 and M-4.

# *Preface*

Science is often thought to be a neutral discipline, free from the influence of political climate or personal bias. As it has evolved in our time, science relies on empirical observation, carefully controlled or at least cleansed of circumstances that could color the outcome of essentially objective analyses.

Law and policy, however, openly reflect cultural values. Law evolves not from observation but from precedent based on consensus: we agree as a society, represented by our legal system, to hold some things permissible, others reprehensible; some things justifiable, others blameworthy.

In the last several decades, with the realization that protection of the environment and human health depends on more informed, rigorous regulation of pollutants, courts and legislatures have called upon those in the environmental sciences to testify about the intricacies of the environment, to warn us about dangers, to evaluate risks and, in effect, to help provide the information it takes to make important legal and policy decisions. That information is complex and often ambiguous — its meaning often requires interpretation.

In this way, environmental science is finding itself at the center of political and legal controversies. New philosophical and ethical challenges now face scientists, especially those working in the field of ecology, raising difficult questions about scientific impartiality and scientific rigor.

In these pages Mark Sagoff, of the University of Maryland's Center for Philosophy and Public Policy, addresses difficult questions raised by the role ecologists are being asked to play. In pursuing these issues, Sagoff challenges the philosophical assumptions that underlie our uses of science, assumptions about what kind of world we want to live in and what kind of justifications we feel we need as we pursue our vision of that world.

This paper is offered as part of the *Marine Perspectives* series produced by the University of Maryland Sea Grant College. It is hoped that this series will stimulate discussion and contribute to a continuing dialogue focused on marine science and affairs. The opinions expressed herein do not necessarily reflect those of the University of Maryland nor of the National Sea Grant College Program.

— *The Editors*

The National Environmental Policy Act of 1969 (NEPA) places ecologists in a challenging position as scientists and as citizens.[1] For at least a century, public officials have looked to ecology and the environmental sciences for help in increasing the productivity of the nation's forests, fisheries and farms. NEPA, along with the environmental legislation of the 1970s, makes an additional demand. It asks ecologists to assist policymakers not only in *managing* ecosystems for economic purposes but also in *protecting* them. The law calls upon ecology for guidance not just to make environments more productive but also to protect ecosystems for their intrinsic natural qualities as well.

It is the burden of this paper to argue that these two tasks, management on the one hand and protection on the other, make rather different demands on ecology. Ecologists may apply their science to the task of economic management by developing the insights and information society needs to manipulate, control, and convert ecosystems to provide more and more of the goods and services upon which society depends. Ecologists may then work with entomologists, agricultural scientists, biotechnologists, and environmental and civil engineers to maximize the long-run benefits nature offers man.

If ecologists apply their science to the task of environmental protection, on the other hand, they will seek to provide the insights and information society needs not only to intervene in ecosystems effectively, but also to understand how these systems function — their important evolutionary and biological characteristics — in the absence of intervention. Ecologists would then serve policymakers not only by helping them achieve given objectives, to increase the profitability of farms and fisheries, for example, but also by helping them decide what their objectives should be, i.e., what to preserve and why. The way ecology develops as a science will depend on which of these tasks ecologists emphasize and on how they strike a compromise between a research agenda which serves the purpose of management and a research agenda which aids environmental protection.

## *Two Tasks of Ecology*

NEPA, to be sure, sees ecology as a science which, like engineering, can help us harness nature for the benefit of man. It requires all federal agencies, therefore, to "initiate and utilize ecological information in the planning and development of resource-oriented projects" in order to "attain the widest range of beneficial uses of the environment."[2] Yet the Act also envisions ecology to be a science that may help society to appreciate ecosystems and to preserve them for what they are in themselves. Thus, the statute seeks to "enrich the understanding of . . . ecological systems"[3] in order to "prevent or eliminate damage to the environment" and to "preserve important . . . natural aspects of our national heritage."[4]

NEPA is typical of the many environmental statutes which followed it during the 1970s. Not one of these laws, as far as I know, calls simply for efficiency in the management of natural resources. The legislation of which I am aware not only seeks to enhance the economic utility of the environment but also seeks to identify the intrinsic natural qualities of ecosystems and asserts society's interest in protecting those qualities.

The Marine Mammal Protection Act of 1972, for example, avoids the concept of an "optimal sustained yield" by invoking the concept of an "optimal sustainable population" instead.[5] Even if this concept has no ecological meaning, its use suggests that Congress regards sea otters, seals, porpoises, and whales not just as "resources" to be "harvested" but as fellow creatures, the biological integrity of whose communities we are to appreciate and respect.

Other environmental laws speak of the "health" and "balance" of ecosystems and leave to environmental scientists the task of defining or explaining these normative concepts in ecological terms. The Marine Protection, Research and Sanctuaries Act of 1972, for example, commits the nation to preserve the "health of the oceans."[6] The Federal Water Pollution Control Act of the same year, to cite another example, requires polluters to demonstrate that their effluents meet standards that "assure the protection and propagation of a balanced indigenous population of shellfish, fish and wildlife."[7]

What I wish to emphasize is that the ecological sciences may be applied either to provide products or to protect processes. Let me explain. First, ecologists may apply their science to maximize the long-run production of goods and services which consumers demand, industry needs, and nature provides or may be made to provide if manipulated in appropriate ways. Second, ecologists may apply their science to maintain or restore the "natural" processes by which ecosystems function or which we would find in living systems if they were relatively undisturbed. I know that there are probably no completely "natural" ecosystems left in the United States or in Europe; indeed, it is probably imposible to determine counterfactually what such systems would now be like; but it is a matter of degree. The factory methods by which rainbow trout are produced in vats in Idaho are quite different from the "natural" processes by which these fish grow in wilderness streams. One may not be able to distinguish the products by look or taste; the processes, however, are hardly the same.

Insofar as we are concerned only with the products and not with the processes of nature, then we may regard the "health" and "well-being" of ecosystems not as ends or values in themselves, but only as means to ends, namely, to support or promote the health and welfare of human beings. If so, then ecologists could define the "healthy" ecosystem as one that is healthful for human beings or one that efficiently produces the goods and services upon which human beings depend. Ecologists would then not be concerned with threats to the "health" or "welfare" of ecosystems except insofar as these may be construed as indirect threats to the health and welfare of human beings. Accordingly, they may define the "health" or "well-being" of nature in terms of the health and well-being of man.

We may be concerned with protecting the processes of nature not merely for the sake of securing certain products, however, but because we regard living ecological systems with admiration, wonder and respect. We esteem these systems for their history, their beauty, their complexity, and the aesthetic and cultural significance they have for us. We take pride in preserving them, and our efforts show that we care not only about our welfare, but about the "health" and "welfare" of our natural heritage as well. Accordingly, society asks ecologists for help in understanding or defining the "health" and "welfare" of nature independently of the health and welfare of man.

Love, respect, reverence for nature — these are human values, to be sure, but they are not necessarily based on a concern with human welfare. Rather, they reflect an ethical concern with the intrinsic well-being of the environment or with the health, welfare and integrity of ecosystems considered apart from and defined independently of the needs and uses of human beings.

Ecologists may employ their science in the service of these non-commodity or non-utilitarian values by helping society to recognize the qualities of natural systems which are worthy of love and admiration and which should be preserved, as it were, because of their place in our natural and evolutionary heritage. These qualities may include the age, diversity, richness, complexity, authenticity, productivity, uniqueness or other properties of particular ecosystems. Ecologists would then help society to assess, mitigate or prevent risks to the health and welfare of ecosystems and not simply to the health and welfare of human beings.

## *An Illustration*

In order to illustrate the differences between these two tasks of ecology, let us consider a particular environmental problem, for example, the decline of rockfish (striped bass) populations in the Chesapeake Bay. We might view this as a problem of environmental management, a problem, in other words, in maintaining or improving the economic output of the Bay. We might regard the decline of rockfish, on the other hand, as an indicator of ecological "damage" to the Bay, a disruption of a "natural" balance. In that event, we may call on ecologists to determine to what extent the health of the Bay is threatened and how society should respond to that threat.

Ecologists who apply their science to the task of increasing the economic output of the Bay may look over their shoulders, as it were, at the successes of the agricultural sciences. Farmers have introduced all kinds of technologies in order to make the fields and prairies of America capable of feeding vast populations. Why not introduce similar technological innovations to manage the production of aquacultural crops in the waters of America as well? Ecologists today are working with other scientists in developing technologies to increase the production of harvestable species in estuaries like the Chesapeake. They are learning how to control and even to replace natural with artificial environments for the production of aquacultural crops.[8]

The methods of factory farming, which Frank Perdue and other poultry growers use successfully to manufacture chickens on Maryland's Eastern Shore, for example, may be applied, *mutatis mutandis*, to the manufacture of rockfish in the nearby Bay. The day may come when the Chesapeake is divided by concrete weirs into neat aquacultural plots; ecologists may then write computer programs to manage the production of crabs, oysters and other "finer" foods insofar as there is a market for them. They may even create new species by recombining genes or they may culture edible tissues *in vitro*. meanwhile the main channel of the Bay could be utilized efficiently as sewer and liquid highway.

We can view the decline of rockfish populations, on the other hand, not only in the context of economic productivity but also in the context of environmental protection. We might be concerned about rockfish, then, not as crops but as ecological indicators; we may fear that the decline in their numbers suggests a decline in the "health" of the Bay. Taking that approach, ecologists might seek ways not necessarily to maximize the production of rockfish but to abate or mitigate the anthropogenic causes of their decline. Ecologists might discover, of course, that the decline is a perfectly natural phenomenon having no anthropogenic causes. In that event, they may argue that the absence of bass may be less of a "problem" than feared, since it may not indicate a general threat to the "health" or the "integrity" of the environment.

Many writers on environmental issues would contest the sharp distinction I have drawn between the goals of environmental management and the goals of environmental protection. These writers argue that an efficient way to maintain or to increase the supply of the goods and services nature offers man is to protect ecosystems from pollution and from other anthropogenic changes and threats.[9] I do not believe this. I believe that advances in biotechnology will allow us more and more to substitute artificial for natural means of production and to become less and less economically dependent on the natural functioning of ecosystems. A general policy of environmental protection cannot be justified simply on economic and prudential grounds; it must also be justified by our sense of social pride and national self-respect. We value the "health" and "integrity" of natural ecosystems because these command our love and admiration. It is not simply to protect human health or to satisfy consumer demand.

Those who believe that we should preserve the natural environment for economic or prudential reasons sometimes warn that we are courting disaster — an "ecocide" of some sort — if we do not protect the natural environment.[10] Some of the arguments used to support these warnings are doubtful — for example, the view that climax ecosystems, including tropical rain forests, should be protected because they contribute to the net global supply of oxygen.[11] I do not mean to suggest that there are no limits beyond which we cannot go in destroying ecosystems with impunity. I contend only that the limits are often hard to define and defend and that some of the most popular prudential arguments for protecting the natural environment are unsound.

In the following pages I shall review two utilitarian arguments which have deeply influenced public opinion and public policy in favor of environmental protection. The first, the proposal that estuarine marshes support coastal fisheries, led to the protection of wetlands on both coasts and in the Great Lakes. The second, advocating a systematic connection between the diversity and stability of ecosystems, seems to have been largely responsible for the passage of the Endangered Species Act and is cited time and time again in the history of environmental legislation. Yet some question whether these are tenable arguments or simply wishful thinking combined with speculative rather than empirical science.

## *The "Outwelling" Hypothesis*

In his 1982 presidential address to the Ecological Society of America, Arthur Cooper states that "the most direct example of ecological influence on public policy is the role that our findings about coastal and estuarine systems played in stimulating the development of national and state programs of coastal zone management." Cooper continues:

> Ecologists, first at the University of Georgia and later at other institutions during the 1960s and early 1970s, discovered that coastal wetlands support high levels of both primary and secondary production. These discoveries formed the basis for most state legislation aimed at protection of coastal wetlands . . . .[12]

The research Cooper mentions was, indeed, influential; as he suggests, a better example of the influence of ecology on public policy may not exist. Yet these "findings," as Cooper calls them, were not put forward originally as such; rather, they were presented as guesses or as hypotheses worthy of further research.

In 1962, John Teal published a well-known paper summarizing a number of studies of various aspects of a salt marsh ecosystem at Sapelo Island, Georgia. The paper attracted attention, however, because of a conjecture or hypothesis Teal stated at the end — one unconfirmed by any studies — that "the tides remove 45 per cent of the (nutrient) production before marsh consumers have a chance to use it and in so doing permit the estuaries to support an abundance of animals."[13]

Seven years later, John and Mildred Teal published *Life and Death of the Salt Marsh*, a fine study in natural history. The book is dedicated to "conservation-minded groups for their efforts in preserving salt marshes."[14] The Teals beautifully describe and explain the life cycle of salt marshes and of the species that inhabit them; they make it clear that a self-respecting political community would go out of its way to protect such environments. The Teals, however, did not stop at a non-instrumental argument. They also proposed that marshes are "necessary to the preservation of fisheries" and thus should be protected for an important economic value as well.[15]

At about the same time, E.P. Odum introduced the term "outwelling" to describe the tidal flux of nutrients from salt marshes into estuarine systems. Odum asserted that most fertile coastal areas capable of supporting large fisheries result either from the "upwelling" of nutrients from the sea or

> from the "outwelling" of nutrients and organic detritus from shallow-water nutrient traps such as . . . salt marshes. The importance of (salt marshes) as "primary production pumps" that "feed" large areas of adjacent waters has only been recently recognized.[16]

Odum stated this idea simply as a hypothesis; he included no data showing it to be true. The thesis, indeed, at least seems contradictory on its face, since, if salt marshes are nutrient *traps* (as he and others describe them), it is hard to see how they could also be nutrient *sources.* Of course more recent research has shown that marshes may export and import different forms of nutrients at different times, but the point is that ecologists' claims were made prior to the gathering of sufficient empirical evidence on the complex behavior of nutrients in marshes — and, in a sense, the jury is still out on net impacts of nutrient cycling by marshes and other wetlands. Odum did summarize measurements that show that phytoplankton production off Sapelo Island was high. He did not demonstrate any connection, however, between this productivity, fish recruitment, and outwelling from tidal marshes.

Scott Nixon, an ecologist at the University of Rhode Island, notes that the first measurements of the flux of organic matter from salt marshes over an annual cycle did not become available until 1974, six years after Odum's paper. These measurements and others tended to disconfirm the "outwelling" hypothesis, even in respect to the Sapelo marshes in Georgia. "Yet, until very recently," Nixon writes, "the concept of 'outwelling' was taken for granted by ecologists. It was often taught as 'gospel' in basic courses, and it formed a cornerstone of many arguments in favor of salt marsh conservation."[17]

The story becomes slightly more complex because, at about this time, the public grew concerned about eutrophication caused by the abundance of nutrients, especially phosphorus, in aquatic systems. The very forms of detritus for the sake of which salt marshes were being protected seemed to overload estuarine systems by depleting oxygen and preventing the penetration of light.

Literature soon appeared in ecological journals concluding that salt marshes act as "sinks" or "filters" for these nutrients.[18] Cost-benefit analyses assigned a shadow price per acre to marshes for *both* absorbing *and* outwelling phosphates and other nutrients.[19]

Scott Nixon, after cataloguing these contradictions, points out that marshes cannot be valuable because they both absorb and outwell nutrients. He notes that George Orwell defined "doublethink" as "the power of holding two contradictory beliefs in one's mind simultaneously, and accepting both of them."[20]

In the past few years, a number of studies have been performed to determine the extent to which salt marshes are "primary production pumps" of nutrients needed to support coastal fisheries. Reviewing studies of the Georgia coast, Evelyn Haines of the University of Georgia Marine Institute concludes, "the current ruling theory, or paradigm, of material exchanges between salt marshes and coastal waters . . . is now being seriously challenged."[21]

The upshot of this research seems to be that *no* general hypothesis can yet be confirmed concerning the nutrient function of salt marshes in estuarine systems. Yet very significant efforts to protect marshes have been based in part on the presumption of such a hypothesis. Should ecologists have been more reticent or more tentative in claiming generalizable results from localized research in spite of policy-makers' demands for such generalizations? Should ecologists support a questionable hypothesis — as happened in this instance — if they believe strongly that it will justify the "right" public decision?

We shall consider these ethical questions after discussion of another attempt to justify environmental protection on utilitarian grounds.

## *The Stability/Diversity Hypothesis*

Of all the utilitarian arguments put forward for environmental protection, the stability-diversity argument has remained among the most general and the most influential. Senator Tunney, for example, arguing for the Endangered Species Act, told Congress in 1973:

> (t)o allow the extinction of an animal is ecologically, economically, and ethically unsound. Each species provides a service to the environment; each species is a part of an immensely complicated ecological organization, the stability of which rests on the health of its components.[22]

This passage reflects a view popularized by Barry Commoner a year earlier, which stated that:

> the more complex an ecosystem, the more successfully it can resist a stress . . . . Like a net, in which each knot is connected to others by several strands, such a fabric can resist collapse better than a simple, unbranched circle of threads — which if cut anywhere breaks down as a whole.[23]

R.H. MacArthur proposed in 1955 the possibility that an index of trophic diversity might be correlated with and provide a measure of community stability.[24] This conjectural relationship was taken up by G.E. Hutchinson, in 1959, in a fascinating and beautifully written paper, in which he argues that the relationship between trophic diversity and stability has an evolutionary dimension, since stable communities will outlast unstable ones, and thus diversity will increase over evolutionary time.[25] These suggestions were further elaborated by a number of theoretical ecologists with the result, according to Daniel Goodman, that "there came to exist a coherent and aesthetically pleasing body of theory which predicts that complex trophic systems will be more stable than simple ones, or, in general, that more diverse communities will be more stable than less diverse ones."[26]

The intuitive and ideological appeal of the stability-diversity hypothesis led to a major Brookhaven Symposium in its honor in 1969; however, the hypothesis was already beginning to succumb to a variety of observational and theoretical objections. Salt marshes, which we have mentioned, are comparatively simple in species composition; they are very stable but not very diverse ecosystems. The rocky intertidal, as Paine pointed out, is one of the most species-rich and diverse natural systems, yet is easily perturbed by a single change in its species composition.[27]

Empirical refutations of this sort quickly multiplied; devastating mathematical and theoretical objections followed. May and Levins, for example, adduced a number of mathematical models to show that increasing the complexity of model systems (i.e., the number of connecting links) increases the probability of instability, exactly the reverse of Commoner's intuitive claim.[28] More recently, Connell has argued that greatest stability is often found at an intermediate level of diversity, and this remains a tenable position.[29]

Daniel Goodman, reviewing the literature in 1975, concludes that no good case can be made for stability-diversity models in ecology. They may best be understood as hold-overs from the Renaissance faith in the Great Chain of Being coupled with the more general conviction that nature does nothing in vain.[30] Thomas Zaret, reviewing the literature in 1984, is somewhat more charitable. He says, "scientists are still very much interested in the relationship, or more appropriately, in the presumed or hoped-for or wished-for relationship, between diversity and stability of biological communities."[31]

Should ecologists downplay or reject utilitarian arguments for preservation which few, if any, trust? Scott Nixon, for one, has cautioned the scientific community not to risk its objectivity even to win the "battle" to preserve natural environments. Nixon acknowledges that scientific support for the "outwelling" hypothesis was useful in gaining time for wetland preservation. But he admonishes that science "is a social enterprise we communicate through the scientific literature, and and we must do nothing to undermine the integrity of that communication."[32] Nixon urges ecologists to get their science right even at the risk of losing a political battle. "It is a bad bargain to trade our credibility for political advantage."[33]

Goodman suggests a different course. In an "Environmental Postscript" to his review of the stability-diversity theory, he notes:

> The diversity-stability hypothesis has been trotted out time and time again as an argument for various preservationist and environmentalist policies. It has seemed to offer an easy way to refute the charge that these policies represent nothing more than the subjective preferences of some minority constituencies. The burden of evidence subsumed in this review indicates that this particular defense will not be possible much longer, since continued scientific support for an untenable theory would become an embarrassment to that spirit of detached empirical sobriety which so often is held up as an ideal of scientific comportment.[34]

Yet, instead of insisting that ecologists publicly retract the hypothesis, Goodman observes that it "is the sort of thing people like, and want, to believe."[35] So why not let them believe it? Goodman looks forward to the time, now approaching, that "the essential imagery of this once-scientific hypothesis will recede to a revered position in the popular environmental ethic, where it will doubtless do much good."[36]

## *A Dilemma in Ecology*

So far, I have described two prudential or utilitarian arguments for protecting natural ecosystems from pollution and other forms of anthropogenic damage. The scientific bases for these arguments are as yet unconfirmed. There are other examples of the same sort of thing. Many environmentalists have argued, for example, that persistent pollutants, such as DDT and PCBs, concentrate and accumulate along food chains. According to this speculation, which provided a widely accepted argument for prohibiting persistent organochlorine insecticides in the environment, the mass of these pollutants is conserved as it passes along the food chain, so that concentrations increase. This idea, like the outwelling hypothesis, was first put forward tentatively as a hypothesis and then became widely accepted without experimental confirmation.[37] Indeed, on the basis of experiments which have now been done, it is fair to say the idea is questionable at best.[38]

Tropical rain forests may not contribute net oxygen to the atmosphere, marshes have not been shown convincingly to be strong factors in estuarine production, "it is time to drop the diversity-stability hypothesis from the ecologist's repertoire,"[39] and organochlorine pesticides do not generally biomagnify along the food chain: what, then, is a conscientious environmentalist to do? Ecologists, insofar as they are sympathetic to the national goal of environmental protection, find themselves in a dilemma. On the one hand, they may decry influential arguments that remain unproved, as Scott Nixon recommends, even though they lose many of the most effective prudential reasons for preserving ecosystems. On the other hand, they can quietly go about perfecting their technical models while allowing bogus arguments such as these to biomagnify along the chain of popular ecology and public policy, where they "will doubtless do much good."

There is an easy and obvious way out of this dilemma. It is for environmentalists, including those scientists who favor environmental protection, to recognize that society, as it expresses itself in legislation, protects the natural environment for more than economic and prudential reasons. The reasons are also ethical, cultural and aesthetic. An estuary like the Chesapeake is a way of life for those who depend on and care about it; it has a history which is part and parcel of our national history; we wish to protect it as we would protect any aspect of our character, personality and heritage of which we are proud. It does not really matter whether salt marshes in general do or do not function as sources or as sinks for nutrients essential to coastal fisheries. What matters is that salt marshes — as John and Mildred Teal have brilliantly shown — have a life and death that reflect aesthetically and ethically on our own.

Environmental scientists who favor the protection of ecosystems, however, may be reluctant to appeal to ethical and aesthetic arguments. First, they may fear that policymakers will respond only to economic and prudential considerations. This fear too often becomes a self-fulfilling prophecy and would not be justified otherwise. The reauthorization of the Endangered Species Act, an ethical law which makes little economic sense, encountered no serious difficulty even during the Reagan years. The law remains popular because people believe we owe more to nature than to drive species into extinction. People hardly believe that society will someday find a use for endangered species like the Colorado squawfish or the Indiana bat.

When I discuss the Endangered Species Act with environmentalists, however, they rarely cite the ethical reasons which, in fact, justify it. Instead, they often contend that we should save each and every species in its habitat because diversity maintains stability and, besides, you never know when you will need those genes.[40] They then cite some "lowly" organism which has done humanity much good. My Aunt Tillie used the same argument for saving everything in her "you never know" drawer against the day when she might need it. She eventually had no room for herself. The argument that prudence requires us to save every species, no matter how improbable its economic value and how costly it is to maintain, substitutes an incredible utilitarian justification for sound and substantial moral arguments. It is a counsel of despair.

Second, ecologists may believe that as scientists they cannot deliberate over ends but only means to ends. They recognize that they act as scientists when they provide the information society needs to achieve the goals and purposes of environmental policy. They may worry, however, that they do not act as scientists but only as citizens when they help society to define those goals and purposes. The ecologist is cautioned, then, that in his role as scientist, he should be "as objective as possible . . . in supplying predictions of the potential impact of a project on an ecosystem . . . ."[41] In his political role, "the role of recommending as to the acceptability of the predicted impact, the ecologist should recognize that he is speaking as a citizen-professional and that his recommendations inevitably reflect his own value system."[42]

This advice assumes correctly that the choice of overall goals for environmental policy requires political not simply scientific judgment. Once the political decision has been made, however, the scientist has a role in interpreting as well as in implementing that judgment. If the goal of environmental policy were to maximize the long-run utility of the resource base, for example, then resource economists would analyze or interpret this goal — they would fill out its meaning for policymakers — as well as provide suggestions as to how to achieve it. Since the political decision went a different way, since it calls for the protection of the "health" and "integrity" of the environment, it gives ecologists and other environmental scientists the task of helping society to interpret as well as to achieve these objectives. In this sense, the ecologist is responsible not only to assess risks to the "healthy" functioning of ecosystems, but also to advise society on the acceptability of those risks.

## An Analogy

The thesis I have presented may be clarified by an analogy between ecology and medicine. Occasionally a doctor will prescribe a drug not for a health-related purpose but to help a person exceed his or her "natural" capacities, for example, to stay up several nights to study for an exam or to run a marathon without feeling pain. We do not believe that the primary purpose of medical science, however, is to change the normal healthy functioning of a person's body in order to allow that person to do abnormal or extraordinary things. We think that the primary purpose of medicine is to maintain or restore normal health by preventing illness or curing disease.

Likewise, ecological science can show us how to manipulate biological systems in order to make them do extraordinary things. We might suppose, however, that the role of ecological science is not only to intervene into healthy ecosystems to make them economically more valuable or efficient. It is also to maintain and restore the normal health or normal functional capacity of these systems by preventing illness and curing disease.

It is the logical characteristic of the concept of "health" and of related concepts of medical goodness (such as "normal" or "natural") that they are *privative* concepts, which is to say, are defined in terms of their opposites.[43] The medically bad, in the sense of illness, malfunction and disease, is logically primary to the medically good. Accordingly, ecologists should not seek to define the "health" and the "integrity" of biological systems as if these were positive, measurable qualities. Rather, what is to be measured, quantified or defined is various kinds of environmental injury, insult and distress.

We are now in a position to see that ecology can be legitimately applied to achieve both an instrumental and a non-instrumental good. An instrumental good is always good for a purpose: for example, a forest might be "good" in an instrumental sense if it is a good producer of timber. That conception of good is positive; the contrary, a "poor" forest, would be privative, in that it has less of or lacks the desirable property. The positive is logically prior to the privative with respect to the instrumental good.

With respect to a good like biological "health" or "integrity," however, the basis of definition is different. In restoring an estuary or a forest to good health, the ecologist does not necessarily make it good for any purpose; he or she does not necessarily make it more valuable from an economic or utilitarian point of view. Rather, he cures the environmental system of some undesirable change or removes some impediment to its normal functioning; for example, he may try to mitigate the impact of some project on an ecosystem. The "bad" thing — illness or disease — is identified as bad; the good in question, environmental health, is defined as the absence of the "bad." The privative is logically primary to the positive with respect to this noninstrumental conception of the good.

When ecologists apply their science to understand the health and integrity of ecosystems, they seek to prevent, mitigate or cure the illnesses and diseases which may affect the normal functioning of these systems. Ecologists must identify these illnesses and assaults and find ways to counteract or prevent them, just as doctors have this responsibility for human beings. Practical problems may prevent ecologists from pursuing this task, but there are no credible logical or philosophical impediments. Healing is a perfectly legitimate task for ecology as a science.

## *Two Roles of Ecology*

Richard Rorty has proposed that there are two criteria we might apply to the vocabulary used within a science:

1. It should contain descriptions of situations which facilitate prediction and control;

2. It should contain descriptions which help one decide what to do.[44]

These criteria are not mutually exclusive, but they describe tasks which a given conceptual approach or terminology might not perform equally well. Rorty offers psychology as an example of a science divided between a terminology intended to facilitate the prediction and control of human behavior and a terminology intended to promote mental health and help people decide what to do. Analogous divisions may be seen in sociology, anthropology and other sciences.[45]

Consider psychology. According to B.F. Skinner, a leading psychologist of the behaviorist school, the "scientific analysis of behavior must . . . assume that a person's behavior is controlled by his genetic and environmental histories rather than by the person himself as an initiating, creative agent . . . ."[46] In order to explain behavior, as Skinner argues, one must identify the variables that control and cause it and then describe a general rule or "dynamic law" that relates these variables to the behavior they are then said to determine. The law can be confirmed or disconfirmed by experiments which test predictions based upon it. These "dynamic" or "covering" laws, by allowing the scientist to predict behavior under certain conditions, also allow the scientist to manipulate and control that behavior. Knowledge is power.

Skinner understands that human behavior in ordinary life will have such complex causes that it will be harder to predict than behavior elicited under laboratory conditions. He argues (ecologists could make the same point about the systems they study) that "we cannot predict or control human behavior in daily life with the same precision obtained in the laboratory, but we can nevertheless use results from the laboratory to interpret behavior elsewhere."[47]

Skinnerian psychology has been challenged in part because most of us do not believe in manipulating, controlling and managing human behavior (except in extreme instances) to serve ends determined by the government or by some other authority. We prefer a psychology intended to give people not power over each other so much as power over themselves. This is a medical or therapeutic conception of psychological sciences; it strives not to manipulate and control the human mind but to cure it of illness and dis ease. This therapeutic approach would succeed precisely by achieving what the behaviorist approach rules out, namely, self-control and moral responsibility.

Both the behaviorist and the therapeutic approaches in psychology may be "objective" or "scientific"; they differ not in their status as sciences, but in the goals they seek to achieve. Given our ethical view of how people are to be treated, we are attracted to a science that can help us respect one another as persons and act within, not beyond, the concepts of freedom and dignity, good and evil, right and wrong. Accordingly, we may prefer the conceptual approach because we prefer the goal of therapeutic rather than behavioral psychology.

The analogy with ecology should be clear. If we assume that the goal of ecology is to permit society to manipulate and control ecosystems to serve utilitarian ends, then we shall prefer one conceptual framework to another and we might even signal this preference by saying it is "objective" and "value-free." Such a framework, for example, might help us to convert estuaries to the purposes of aquaculture just as a behaviorist technology (with surgery, perhaps) can change an autonomous person into a "cooperative" citizen.

At the present time, however, we respect natural estuaries more than well-ordered aqaucultural reserves and autonomy more than obedience. Accordingly, we may not be satisfied with a terminology which helps us to manipulate and control events, even if we could get one, in the social, or for that matter, in the ecological sciences. We may seek to maintain the good of the person (or of the environment) rather than to manipulate the person (or the environment) to serve some other, e.g., economic, conception of the good. Given our respect for natural ecosystems, a vocabulary that offers us an evaluative understanding of nature may be more useful than a vocabulary that gives us a manipulative understanding, just as a humanistic psychology is more useful than a behavioristic psychology, except in extreme instances, given our conception of human beings as self-willed persons.

What we have most use for is a psychological terminology that makes moral reflection possible, a terminology, for example, that will help us to identify illness and disease and provide the conditions under which healing takes place. Likewise, we may look for a terminology in the environmental sciences that will help us to appreciate estuaries, for example, and to understand how to protect or to restore them. In short, we may seek a vocabulary or conceptual framework in these sciences that helps us to *evaluate* not simply to *control*, to *appreciate* not simply to *manipulate*, to *protect* not just to *manage*.

Ecology strives to offer society two kinds of knowledge and, therefore, two kinds of power. The first provides a scientific framework in which we may manage ecosystems to maximize the goods and services we may derive from them. The second provides a scientific framework in which society can appreciate the qualities of those systems and evaluate policies concerning them. The first kind of knowledge advances environmental management by enhancing our power over nature. The second promotes environmental protection by enhancing our respect for nature and therefore our power over ourselves.

# *Notes*

1. 42 U.S.C. Sections 4321, 4330-4335, 4341-4347 (1976).

2. Sections 4332 and 4331.

3. Section 4321.

4. Section 4331.

5. 16 U.S.C. Sections 1361-1362, 1371-1384, and 1401-1407 (Supp. V 1981), as amended by the Commercial Fisheries Research Development Act, Pub. L. No. 97-389, Sections 201-202, 96 Stat, 1949 (1982). The Act (as Section 1362) defines "optimal sustainable population" with respect to any stock as "the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constitutive element." For an excellent discussion of the Act and the tension between the goals of management and preservation, see Michael J. Bean, *The Evolution of National Wildlife Law* (New York: Praeger, 1983), esp. chap. 11.

6. 33 U.S.C. Sections 1401-1444 (1976 & Supp. V 1981) and 16 U.S.C. Sections 1431-1434 (1976), esp. Section 1432. Compare the Coastal Zone Management Act (16 U.S.C. Sections 1451-1464 (1976 & Supp. V 1981)) which calls for management programs that would give "full consideration to ecological, cultural, historic, and esthetic values as well as to needs for economic development" (at Section 1452[2]).

7. Usually called the Clean Water Act, 33 U.S.C. Sections 1251-1376 (1976 & Supp. V 1981), at Section 1312.

8. *The Washington Post*, Wednesday, Sept. 26, 1984, pp. C1, C6 describes as follows the view of George Krantz, "director of tidal fisheries for Maryland."

> In the view of Krantz, who as chief regulator of the bay played a key role in the moratorium of rockfish recently announced by Gov. Harry Hughes, the bay in 1994 should be run more like a farm than a wilderness . . . .
>
> He said watermen must earn the right to fish the bay. "You don't think Frank Perdue lets just anyone grow his chickens, do you?"

Also in the article:

> "Well, Potsy, it looks like this is the end of Rock Hall," one waterman said to another over coffee one afternoon in that small striped-bass fishing village.
>
> "It looks that way," said the second waterman. "It's communism, is what it is."

9. See, for example, Walter Westman, "How Much Are Nature's Services Worth?" *Science* 197 (1977): 961.

10. See, for example, Barry Commoner, *The Closing Circle: Nature, Man, and Technology* (New York: Knopf, 1972).

11. Climax ecosystems produce no more oxygen than they consume through the long, slow burning of decay. Thus, T.C. Whitmore writes: "The suggestion, sometimes made, that atmospheric oxygen levels would be lowered by removal of tropical rain forests rests on a mistaken view of climax ecosystems." "The Conservation of Tropical Rain Forest," *Conservation Biology: An Evolutionary-Ecological Perspective*, edited by M. Soule and B.A. Wilcox (Sunderland, Mass.: Sinauer, 1980), p. 313.

12. A.W. Cooper, "Why Doesn't Anyone Listen to Ecologists — And What Can ESA Do About It?" *Bulletin of the Ecological Society of America* 63, no. 4 (December 1982): 348, 350.

13. J.M. Teal, "Energy Flow in the Salt Marsh Ecosystem of Georgia," *Ecology* 43 (1962): 614-24.

14. John Teal and Mildred Teal, *Life and Death of the Salt Marsh* (Boston: Little, Brown, 1969), p. v.

15. Ibid. p. 201. Teal (p. 210) notes that aquaculture could presumably yield much greater harvests of fish, crabs, shirmp, etc., than preservation even with predator control.

16. E.P. Odum, "A Research Challenge: Evaluating the Productivity of Coastal and Estuarine Waters," in *Proceedings of the Second Sea Grant Conference*, University of Rhode Island, October 1968, pp. 63-64. In a paper critical of his earlier work E.P. Odum has retracted the outwelling hypothesis. "The Status of Three Ecosystem-Level Hypotheses Regarding Salt Marsh Estuaries: Tidal Subsidy, Outwelling, and Detritus-Based Food Chains," in *Estuarine Perspectives*, edited by Victor Kennedy (New York: Academic Press, 1980), pp. 1185-95. Odum writes that outwelling is periodic and seasonal in many or most

localities and that its importance "will likely vary from locality to locality"; quotation at p. 492.

17. Scott W. Nixon, "Between Coastal Marshes and Coastal Waters: A Review of Twenty Years of Speculation and Research on the Role of Salt Marshes in Estuarine Productivity and Water Chemistry," in *Estuarine and Wetland Processes*, edited by Peter Hamilton and Keith MacDonald (New York: Plenum Press, 1980), pp. 437-525; quotation at p. 440.

18. The authors of one such paper, published in 1973, fail to cite a single marsh-estuarine nutrient uptake study, yet assert:

> When nutrient-rich effluents enter a marsh the nutrients are effectively trapped by the tidal circulation pattern, and assimilated in the productive biological system.

James G. Gosselink, E.P. Odum and R.M. Pope, *The Value of the Tidal Marsh*, Center for Wetland Resources, Louisiana State University, Baton Rouge (1974). Quoted by Scott Nixon, "Twenty Years of Research," p. 443.

19. R.M. Pope and James G. Gosselink, "A Toll for Use in Making Land Use Decisions Involving Tidal Marshland," *Coastal Zone Management Journal* 1, no. 1 (1973): 65-74. For another amusing instance, see L.A. Shabman and S.S. Batie, "Estimating the Economic Value of Coastal Wetlands: Conceptual Issues and Research Needs," in *Estuarine Perspectives*, edited by Victor Kennedy (New York: Academic Press, 1980), pp. 3-15, esp. pp. 7-8. The authors review economic techniques to set "shadow" prices of these two functions of the salt marsh without questioning whether these "values" are consistent.

20. Nixon, "Twenty Years of Research," p. 442.

21. Evelyn B. Haines, "Interactions Between Georgia Salt Marshes and Coastal Waters, A Changing Paradigm," in *Ecological Processes in Coastal and Marine Systems*, edited by Robert J. Livingston (New York: Plenum Press, 1979), pp. 35-46. Ecologists during the early 1970s who criticized the "outwelling" principle were largely ignored. For example, Richard Walker, "Wetlands Preservation and Management on the Chesapeake Bay: The Role of Science in Natural Resource Policy," *Coastal Zone Management Journal* 1, no. 1 (1973): 75-101. Walker (p. 80) mentions the statement by William Niering (in *The Life of the Marsh* (New York: McGraw-Hill, 1966), p. 170) that "(b)ecause of the high nutrient content of a tidal marsh, plants and animals are abundant, and some are of great value to man. At the mouth of the Niantic River in Connecticut, about 15,000 bushels of scallops are harvested each year." Ironically, the scallops appeared after the disappearance of the thick marsh grasses, since scallops require a fairly open environment in order to graze plankton in tidal currents. See Nelson Marshall, "Studies of the Niantic River, Connecticut,

with Special Reference to the Bay Scallop," in *Limnology and Oceanography* 5, no. 1: 86-106 (February 1960). From examples such as these, Walker concludes (p. 90) that "little can be said about the dependence of important species on marshes, nor the response of the estuarine ecosystem to marsh destruction."

In an amusing footnote that bears repeating, Walker comments (p. 77): "It is ironic that wetlands have traditionally been drained for many of the same reasons they are now being preserved: public health, flood control, aesthetics, and productivity (agricultural), for instance. Is this so much a product of changing knowledge as it is of changing values?"

22. 119 Cong. Rec. 25,668 (1973) (remarks of Sen. Tunney).

23. Barry Commoner, *The Closing Circle* (New York: Knopf, 1971), p. 38.

24. Rc.H. MacArthur, "Fluctuations of Animal Populations and a Measure of Community Stability," *Ecology* 36 (1955): 533-36.

25. G.E. Hutchinson, "Homage to Santa Rosalia or Why Are There So Many Kinds of Animals?" *American Naturalist* 93 (1959): 145-59.

26. Daniel Goodman, "The Theory of Diversity-Stability Relationships," in *Quarterly Review of Biology* 50 (1975): 237-66; quotation at p. 239.

27. R.T. Paine, "A Note on Trophic Complexity and Community Stability," *American Naturalist* 103 (1969): 91-93. Rain forests in South America are often cited as examples of the relation between diversity and stability, yet historical evidence based on pollen data indicate that tropical forests are "dynamic and ephemeral rather than stable and ancient." Roger Lewin writes:

> The tremendous diversity of both plant and animal species of tropical forests has long dazzled inquiring naturalists. Pondering on the origin of this diversity, ecologists have doubtless been impressed by the apparent agelessness of the forests, and so diversity came to be associated with environmental stability. The emerging realization that tropical forests are mere biological youths, constantly suffering dynamic turnover, is helping to overthrow this intuitively appealing equation. High diversity through instability, not stability, is how the question now reads, which brings the forests in line with other avenues of biological inference.

R. Lewin, "Fragile Forest Implied by Pleistocene Data," *Science* 226 (October 5, 1984): 36-37.

28. R.M. May, *Stability and Complexity in Model Ecosystems* (Princeton:

Princeton University Press, 1973). R. Levins, "The Qualitative Analysis of Partially Specified Systems," *Annals of the New York Academy of Sciences* 231 (1974): 123-38.

29. J.H. Connell, "Diversity in Tropical Rain Forests and Coral Reefs," *Science* 199 (1978): 1302-10.

30. A.O. Lovejoy, *The Great Chain of Being* (New York: Harper, 1936).

31. Thomas Zaret, "Ecology and Epistemology," *Bulletin of the Ecological Society of America* 65, no. 1 (March 1984): 4.

32. Nixon, "Twenty Years of Research," p. 510.

33. Ibid.

34. Goodman, "The Theory of Diversity-Stability," p. 261.

35. Ibid.

36. Ibid.

37. The hypothesis was stated tentatively by E.G. Hunt and A.I. Bischoff, "Inimical Effects of Wildlife of Periodic DDT Applications to Clear Lake," *California Fish and Game* 46 (1960): 91-106.

38. For a careful review of the literature leading to this conclusion, see F. Moriarty, *Ecotoxicology: The Study of Pollutants in Ecosystems* (New York: Academic Press, 1983), esp. pp. 135-54.

39. William J. Kimmerer, "Diversity/Stability: A Criticism," *Ecology* 65, no. 6 (1984): 1936-38; quotation at p. 1938.

40. For an example of this argument, see Norman Myers, *A Wealth of Wild Species: Storehouse for Human Welfare* (Boulder: Westview Press, 1983).

41. W.Van Winkle, S.W. Christensen and J.S. Mattice, "Two Roles of Ecologists in Defining and Determining the Acceptability of Environmental Impacts," *International Journal of environmental Studies* 9 (1979): 247-54; quotation at p. 252.

42. Ibid.

43. For an analysis of health as privative, see Georg Henrik von Wright, *The Varieties of Goodness* (London: Routledge & Kegan Paul, 1963), chap. 3.

44. Richard Rorty, "Method, Social Science, and Social Hope," in *Consequences of Pragmatism* (Minneapolis: University of Minnesota Press, 1982), p. 197.

45. For a good example of explanation in sociology that does not require deduction from predictive laws, see Erving Goffman, *The Presentation of Self* in Everyday Life (New York: Doubleday, 1959). For an argument concerning cultural anthropology similar to that given here, see A.O. Hirshmann, "The Search for Paradigms and a Hindrance to Understanding," in *Interpretive Social Science*, edited by Paul Rabinow and William Sullivan (Berkeley: University of California Press, 1979), pp. 163-79.

46. B.F. Skinner, *About Behaviorism* (New York: Knopf, 1974), p. 189.

47. Ibid., p. 228.

# *Acknowledgement*

Mark Sagoff's research in ecology and public policy has been supported by the National Science Foundation, the National Endowment for the Humanities and the Maryland Sea Grant College. In writing this paper, Sagoff received support from the Environmental Protection Agency. The views expressed in this paper are those of the author only and not necessarily those of any governmental department or agency. An earlier version of this essay appeared in *Environmental Ethics*; permission to use this material is gratefully acknowledged. The author wishes to acknowledge helpful critical suggestions from many readers and colleagues, especially Dr. Grace Wyngaard and Dr. Henry Shue.