Ecosystem Health, Biological Diversity, and Sustainable Development: *Research that Makes A Difference*

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ECOSYSTEM HEALTH, BIOLOGICAL DIVERSITY, AND SUSTAINABLE DEVELOPMENT: RESEARCH THAT MAKES A DIFFERENCE

ROBERT T. LACKEY

Identifying critical research needs seems simple enough. But let us do a reality check for just a moment—do we really want scientists to determine research priorities? It is natural for researchers to treat the scientifically unknown and the scientifically uncertain as the core issues in public policy. It is also easy to identify a long list of research to be undertaken. Any of us could create an impressive list of absolutely essential research as quickly and convincingly as anyone bred in this Darwinian world of publicly funded research.

But a laundry list of research topics is the last thing we need. Many panels, committees, and task forces have developed comprehensive lists of research that would keep scientists busy—and funded—for many years to come (Soule and Kolm, 1989). Others have produced calls for more research on broad, general ecological topics that would justify virtually any type of research. Neither approach is very productive.

I will try to do something different—to focus on three specific research needs that will make a difference in decision making—presuming, of course, that the research was successfully accomplished. But first, we need to spend a few minutes thinking about the three themes framing this article—ecosystem health, biological diversity, and sustainable development—as a class of both policy and science issues.

Let me be clear about the context of my comments—I am speaking as a scientist who has spent half his career in government and half in academia. My views are my own and do not necessarily reflect those of my current or past employers. Further, my comments are directed to the situation in North America and especially the United States.

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CHARACTERISTICS

To a scientist looking at these three concepts, a number of common features are apparent. Probably the most obvious is that all three directly affect people What we decide to do about any of the issues will affect each and every one of us. For example, policies on sustainable development affect all individuals and organizations—both now and in the future. Public policies to encourage or discourage efficiency in farming through direct or indirect tax subsidies—or through free market policies—have an immediate impact on us all.

The three concepts also strike at the core of our values, ethics, and moral philosophy. What rights, if any, are there for the non-human world? How important is our material well-being compared to passing on a "natural" world to our children? Are our children more important than the natural world? How are the benefits of ecological resources to be distributed within society? How is an individual's creativity and labor to be rewarded versus distribution based on collective benefits to all? Is it moral to coerce people into reducing their fertility? Is it moral not to? These are not science issues, but reflect deeply held moral and religious views (Lackey, 1994). Consequently the selection of research priorities is itself a highly value-laden process.

Each concept relates to complex systems, not individual and isolated elements. For example, our concept of ecosystem health will directly define how we select and implement a sustainable development strategy. Our collective view of biological diversity will help determine what habitat we alter. In short, we cannot treat ecosystem concepts and information as marginal externalities apart from the core public and private choices we make.

Another common feature is ambiguous and divergent definitions. What do we really mean by sustainable development (Gale and Cordray, 1994)? Does it mean economic growth that is sensitive to the environmental ramifications, or is it a fundamentally different view of man's "progress?" After all, is anyone explicitly advocating unsustainable development? What is the opposite political position to favoring biological diversity? Is it economic growth? Terms such as biodiversity—as well as terms like life, liberty, and the pursuit of happiness—serve a useful role in some types of dialogue, but they mask the tough choices that society must make.

Each of the concepts also carries scientific and political baggage. Depending on one's political perspective, terms such as ecosystem health can imply a good thing, something natural...something not degraded by man. After all, no one is arguing that we ought to be managing to produce "sick" ecosystems—so the debate must be over what is meant by a "healthy" ecosystem. How many times have you challenged someone by asking exactly what is meant when the terms sustainable development or ecosystem health are used as societal goals?

Another feature of the concepts is the high degree of scientific uncertainty, especially when it comes to predicting future ecological conditions. The political science axiom is true that "if you can measure a scientific phenomenon with some accuracy, it is surely irrelevant in policy debates." When the political stakes and scientific uncertainty are high, politicians understandably want to pass responsibility to technocrats—ecologist, economists, and other "experts." Some scientists are willing to accept this responsibility. Some are not. Scientists do have an important role in defining ecosystem health, biological diversity, and sustainable development, but making policy choices is not one of them.

A policy feature that is characteristic of each concept is the strong inter- and intra-generational element. How a society—whether it be an agrarian subsistence one or a highly industrialized one—views the costs and benefits within and between generations defines the actual decisions that are made. We can become preoccupied with preserving options for future generations at the expense of current generations, or we can preclude future options by making irrevocable choices today. Decisions to protect species on the brink of extinction fall into this category. There is no "right" answer in a democracy, no formula that will make the decisions for us.

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Finally, many decisions are irreversible. Society may think long and hard about a decision to eliminate a species. And society might be very reluctant to make decisions to eradicate a culture, whether it be indigenous inhabitants or rural communities based on harvesting biological resources. Decisions that can be easily reversed usually don't worry people too much. What research would make a difference in resolving these policy issues? Let's agree on a few criteria for selecting priorities.

CRITERIA

Research serves many purposes in society. One is to advance knowledge for its own sake. How many inventions have been made possible by basic research that had no identified purpose other than to explore the unknown? Certainly there are many, many examples. However, that is not a criterion that will be used here to set research priorities.

The first criterion I will use is that research should be policy relevant. Being relevant does not mean advocating a particular policy position, but it does mean significant interplay between scientists, policy analysts, and decision officials—with scientists not assuming the role of policy advocates. I recognize that this idealized model is much easier to accept in the abstract than in practice.

Secondly, the results of the research should help society make better decisions. "Better" is not easily defined, but two aspects of it are clear: (1) the decision reflects the will of the governed; and (2) there are few unanticipated ecological consequences of the decision. That means that not only is the research policy relevant, but it must be the specific type of information needed to improve decision making. Research on biological diversity, for example, will not, in itself, improve decision making. Studying the ecological role of endangered neotropical song birds, while a challenging and rewarding scientific endeavor, will not necessarily help make better choices.

Research should be scientifically tractable—in other words is it a problem that scientists can likely answer in a reasonable time frame? There are many technical problems that, if solved, would be very useful, but the likelihood of solution any time soon is remote. There also are issues that are not tractable because they are not research questions. Should we protect a particular species from extinction? That is a policy decision. Determining the ecological consequences of that species going extinct is a purely scientific question.

Finally, research needs should be put in priority order. Budgets are not unlimited and laundry lists of research needs solve little in allocating scarce resources. If we request more money for new research, this new research must be of lesser priority than that already being funded; otherwise we should redirect existing research dollars into the new area.

With these criteria in mind, I have identified three research priorities. Three may not seem like very many, but any credible solution would be a big accomplishment.

ECOSYSTEM HEALTH

The first research problem to solve is the policy challenge of defining ecosystem health or determining if the concept is even worth defining. We all want healthy ecosystems, but health is in the eye of the beholder. A piece of Mississippi bottomland can be equally healthy as a hardwood forest, a soybean field, or a barge canal. It depends on the desired state of the ecosystem—how close we are to achieving the desired state is how healthy, or how sick, the ecosystem is. If we cannot make substantial progress on solving this problem, the other two research priorities are not tractable.

The concept of ecosystem "health" is invoked in nearly all discussions of sustainable development and biological diversity. Prime ministers and presidents wrap their policies in the protective cover of ecosystem health. Who can possibly be against such policies? Ecosystem health must be good; ecosystem degradation and impoverishment are obviously bad. Who stands opposed to health and integrity? Is there anyone who actually champions ecological degradation and impoverishment? I contend that such terms are so value laden that they should be avoided. If you must use these terms, define their meaning precisely.

Ecosystem health is a vague concept that masks fundamentally different world views. There is a great difference between public perception of ecosystem health and use of the term by most scientists. Generally, the public tends to look at ecosystem "naturalness" as a measure of health. Scientists tend to look at any ecosystem as healthy—or sick—depending on how close it is to the desired state. An undiscovered, unaltered tundra lake and an artificial lake at Disneyland can be equally healthy, depending on what the desired state of each ecosystem is.

Scientists do have a role in defining ecosystem health, biological diversity, and sustainable development, but making policy choices is not one of them.

What, then, is the operational definition of ecosystem health? There is none without an implied value statement. Therefore, we ought to focus on the "desired" state of the ecosystem and how close we are to achieving that desired state. This view doesn't have the zing of a Pepsi jingle, nor the emotion of a rain forest fund raising poster, but it is reality.

In a democracy it is the values and priorities of society that are important, not the values and priorities of scientists. But, information also influences values and priorities, so the technical views of scientists are relevant and essential. The interplay between what is possible and what is desired is a fundamental concept in defining ecosystem health. Democracies will deal with defining ecosystem health by making decisions, or deciding not to make decisions, with whatever information is available. For good or bad, that is democracy in action. Scientific information can play a role in shaping at least priorities, if not values. Values and priorities are not fixed over time. They change in response to many external forces. Increasing knowledge can change a person's priorities and possibly values.

Determining relative priorities often involves weighing costs and benefits, both of which can be tangible or intangible. For example, some of the costs and benefits of ecological decisions are easily measurable in monetary terms, but other costs and benefits are losses of personal freedom or property rights. The decrease in value of a person's property is relatively easily measured, but not the loss of the intangible rights to personal choice. How are these costs (or benefits) to be treated? Who benefits from decisions and who pays the costs? It is politically appealing to say that there are win-win decisions, but that rarely reflects reality.

Finally, who decides values and priorities? At least in the United States, in some simple sense it is elected officials or bureaucrats who serve at the public's pleasure. Whoever decides which values and priorities will be implemented, it needs to be clear that it is values being decided, not scientific judgments.

There are certain elements of ecosystems that we suspect the public values highly. What are these? What ecological states have these values? It is a truism that the public wants "healthy" ecosystems, but what are these? Do we want natural, unaltered ecosystems? Do we want ecosystems that only appear to be natural? Do we want natural ecosystems, but without natural events such as wildfire, disease, and starvation? Do we want introduced species as part of the ecosystems? The major ecological effects in North America were caused by the introduction of species like wheat, cows, pigs, and humans. Are these kinds of introductions okay?

The methods and procedures for determining public values and priorities are poorly developed for ecosystem health. Scientists and analysts can only provide the most useful information and options for policy alternatives if public values and priorities are reasonably well understood. Currently nearly everyone can claim support for a particular political position.

Therefore, the first priority for research that will make a difference is to develop or adapt procedures to determine public values and priorities for ecosystems. Such a research challenge should not be taken lightly. We don't need more rhetoric on the importance of healthy ecosystems or healthy economies; what we need is research to help clarify society's expectations. Scientists need to say to the public and to politicians: we can help you with information to achieve the desired state of ecosystems, and we can provide you with the ecological consequences of various decisions, but we cannot—and should not—decide what is desired.

Social science research is not traditionally seen as an ecosystem health topic. It should be. I call for no inventories of species at risk; for no modeling of nutrient cycling; for no long-term studies on wilderness ecosystems; for no toxicological testing on panthers or pandas. Some ask if this is even science at all. It is a scientific problem, but is not the traditional research that most of us have done. It is a very different approach.

BIOLOGICAL DIVERSITY

The second research priority is to help solve the biological diversity policy impasse. Simply stated: the public values something about biological diversity, but we do not know what it is or how to compare it to alternative options (Perrings, et al. 1992). Few policy debates seem more intractable than the debate over biological diversity and what, if anything, to do about it (Shrader-Frechette and McCoy, 1993).

There are two very different elements to biological diversity and it is important to keep them separate.

The first is the role biological diversity plays in ecosystem and, in particular, its relationship, if any, to ecosystem stability. You often hear advocates say that biological diversity should not be reduced because ecosystems need high diversity to be sustainable. I will talk about that purported linkage later, but now I want to focus on research needs associated with the other element of biological diversity—its intangible value—the value that people place on species or ecosystems beyond any practical or measurable utility.

> *An undiscovered tundra lake and an artificial lake at Disneyland can be equally healthy.*

Society places value on specific aspects of biological diversity. For example, people value cougars, koalas, and condors. There is also value for medicinal plants, ecosystem services, and commodity yields. The level of the value is open to debate, but not the fact that there is *some* value. We have the Endangered Species Act, and international treaties and conventions that attempt to codify such societal values, however ephemeral the values might be (Eisgruber, 1993).

The scientific basis of the Endangered Species Act is essentially species-by-species protection, or even protection at the level of the "evolutionarily significant unit." But does this approach work? People who value all species' right to exist are disappointed in the law, as are those who feel that preservation of obscure species, much less evolutionarily significant units, is too costly. Nearly everyone supports seals and salmon, but how many support preservation of the small pox virus? Do these life forms have a right to exist? We do not have a good handle on what the public feels is important about biological diversity. Worse still, political rhetoric obscures our scientific ignorance. The Endangered Species Act is a scientifically simplistic response to complex policy goals. Does it reflect the values and priorities of the public?

The research that will make a difference would be to formulate a better scientific paradigm upon which to base legislation to resolve biological diversity choices. To do this, analysts would have to determine in a credible way public values and priorities relative to biological diversity, and develop scientific options for formulating laws and policies to implement those values and priorities. It is certainly true that the public most highly values charismatic megafauna—the warm fuzzies of the animal world—the cats, canines, and kangaroos—and wants those protected. But, how about the competing demands to protect less appreciated fauna and flora, the viruses, bacteria, and insects? What is their relative priority for scarce resources? Or, is it true that the public values all species and they all ought to be protected at any cost? Or, is it really ecosystems that the public values and these ought to be protected? And, of the various kinds of ecosystems, which are the most valuable to the public?

Research of this type is very difficult to conduct. It requires an effective blending of social and biological science in ways that neither feels comfortable nor is easily accomplished. We have to go far beyond traditional public opinion polls and willingness-to-pay surveys. However, to successfully develop a scientific paradigm that will allow politicians to implement effective laws, it is essential that both biological and social scientists be focused on this research question.

SUSTAINABLE DEVELOPMENT

The third and final research priority is to resolve a key scientific issue that underpins sustainable development.

The basis for sustainable development is mushy. What exactly is meant when the term is invoked? Sustainability of what? Sustainability over what time frame? Sustainability over what geographic region? Are societal values and priorities assumed to be fixed or is some change anticipated? "Sustainable development" appears to have a built-in logical inconsistency. Are we dealing with developments which are sustainable? Or, is development sustainable? These are not trivial nuances in the use of terms, but differences lead to very different policy positions (Brown, et al.; Dovers and Handmer, 1993; Goodland, et al., 1993).

But there is an idea, an aspiration, and a concern struggling to be understood. It is easy to dismiss the idea by attacking the fuzzy logic and apparent oxymorons imbedded within the concept, but we should not. There is a desperate need for rigorous policy analysis of sustainable development and a public dialog without the political rhetoric.

The use—and misuse—has so confused the policy debate that it is not clear whether an intelligent dialog is now possible with the use of the terms "sustainability," "sustainable development," and similar concepts. That will have to be addressed in another article. I will focus on needed research which will help crystallize some of the key points of debate.

The basis for sustainability is the apparent relationship between ecosystem stability and biological diversity. In short, do you need high biological diversity to maintain stable ecosystems, and thus permit sustainability to be achieved (Peters, 1991)? One of the main purported reasons for maintaining high biological diversity is to maintain stable ecosystems. Is this relationship true? It certainly has some apparent logic.

A little background....It is important to acknowledge policy bias. Most of us tend toward a bias that views undisturbed ecosystems as essentially good—in short, desirable. Altered (usually by man) ecosystems are necessary, perhaps, for sustenance, but are not ideal—they are undesirable. In fact, the very concept of "natural" is somehow wholesome and pure and, almost by definition, does not involve man. How many people are there in the photographs used in Sierra Club calendars?

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There are also some strong biases in science. There are changing schools of scientific thought that are no less powerful than the changes in dress fashion. Who would feel comfortable in a loin cloth, a Nehru jacket, or a poodle skirt? In this century alone, scientist have embraced theories of the balance of nature, ecosystem succession, dynamic equilibrium, and chaos. The concept of the "ecosystem" had its fashion heyday in the 50s and 60s, and it is becoming increasingly popular to challenge the existence of "ecosystems." Even the myth of a pristine continent of 1492 has rapidly fallen from favor in scientific circles (Denevan, 1992). To be caught in an out-of-fashion scientific viewpoint is no less a crime than to be caught with a costume from the past.

If we look at the specific scientific problems we face with sustainable development, they most often revolve around: how much can we use an ecosystem and keep the ecosystem stable? The technical question is: how much can we stress an ecosystem and still maintain it in its desired condition? History is replete with examples of overharvest (Ludwig, Hilborn, and Walters, 1993; Hilborn and Ludwig, 1993). Is there a clear linkage between stress—and use—and ecosystem stability? If there is, then we can safely add in safety factors that have been described as a precautionary principle. How much biological diversity is necessary to maintain a desired degree of stability?

Research that will make a difference would determine, in a credible way, the linkages between external stress or use, internal biological diversity, and ecosystem stability. It seems obvious that greater diversity within an ecosystem should result in greater stability, but the available data do not support this relationship. The very core of any strategy for sustainable development is predicated on the assumption that we understand the linkage of biological diversity, ecosystem stability, and the relationship to external stress. If scientists cannot work out this linkage, we will continue our wandering in the proverbial policy desert for a long time.

CONCLUSION

To conclude, how do I answer the charge to identify the key research priorities—let me briefly summarize:

First, figure out how to get a credible handle on what the public, or more accurately, "the publics," consider to be the "desired" condition of ecosystem—the "health" of ecosystems. The operative word here is credible. Credible information doesn't exist now and therefore anyone can claim the mantle of public support.

Second, develop a different scientific paradigm upon which to base biological diversity legislation. Policy makers need a replacement for the one used in the Endangered Species Act. This is a tough scientific challenge, but one that is sorely needed. It also will be difficult to conduct such scientific analysis free of the political debate over the importance of biological diversity compared to other societal benefits. As it stands now, few are pleased with the results of the Endangered Species Act, but virtually everyone supports the preservation of our biotic heritage.

Third, determine the relationships between external stress, biological diversity, and ecosystem stability. The ecological basis for sustainable development, sustainability, and environmental sustainability is stable ecosystems. This does not mean "static" or even "equilibrium" ecosystems, but "stable" ecosystems. How much diversity is required to maintain ecosystems in that desired state?

Finally, none of these research tasks will be easy to accomplish. Each will take a serious, sustained effort, a vigorous and ongoing dialog between scientists and policy analysts, and a high degree of scientific creativity if the results are to be useful in resolving important public policy questions. But, success in any of these three research priorities would make a difference.«

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Dr. Bob Lackey is professor of fisheries science at Oregon State University. In 2008 he retired from 27 years with the Environmental Protection Agency's national research laboratory in Corvallis where he served as Deputy Director among other senior science and management jobs. Since his very first fisheries job mucking out raceways in a California trout hatchery, he has worked on an assortment of natural resource issues from various positions in government and academia. His professional assignments involved diverse aspects of natural resource management, but mostly he has operated at the interface between science and policy. He has published over 100 articles in scientific journals. Dr. Lackey has long been an educator, having taught at five North American universities and continues to teach a graduate course in ecological policy. Canadian by birth, he is now a U.S.-Canadian dual-citizen living in Corvallis, Oregon.

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