Ecological Risk Assessment

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By Robert T. Lackey

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In 1993, President Clinton, Vice President Gore, six cabinet secretaries, the Environmental Protection Agency (EPA) administrator, four state governors, and a cast of thousands met in Portland, Oregon, for a day to resolve an ecological issue creating gridlock in the Pacific Northwest. Owls, salmon, and trees were the dominant topics of the conference. Such ecological issues—and ecological risk assessment—have moved from the fringes of science and policy to center stage. Some observers even propose that formal risk assessment be the core organizing principle for all ecological management and protection.

Papers about risk assessment frequently appear in ecological journals, and entire books about ecological risk assessment have been published within the past few years (Suter 1993). Three EPA administrators have given major policy talks on the subject. Congressional committees have publicly endorsed the concept as the approach of choice, and the National Academy of Science has commissioned panels of experts to judge the merits of the concept and its application.

Conversely, a different, less charitable view can be found: risk assessment is no less than a form of techno-speak to justify the destruction of more and more of our nation's natural environment. Further, risk assessment is a tool used by the scientific and technical elite to impose their values and priorities on the public under the guise of scientific objectivity. Ecological risk assessment in this view is undemocratic at best, immoral at worst.

The sudden interest in ecological risk assessment is a dramatic development. My intent in this discussion is neither to advocate for, nor detract from, any of the various assessment concepts, approaches, or procedures but to summarize the issues and options.

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How Well Are We Doing?

How well are we doing in developing and implementing public policy to protect ecological resources? The fundamental measure of success in any ecological protection regulation is how well the ecological resources in question are doing.

First, and most important, many people believe the condition of ecological resources in the United States has deteriorated in spite of all our best efforts. For example, tall-grass prairie ecosystems have all but disappeared. The acreage of wetlands in the United States has declined precipitously. A number of well-known species (i.e., salmon, the northern spotted owl, and the Florida panther) are struggling to survive. Biological diversity is purportedly declining throughout much of the nation.

Others have a different view. The quality of our ecological resources is actually improving. Some species may be endangered, but we generally are doing a good job of balancing competing societal demands. Deviations from careful, thoughtful decision making often occur because scare tactics have been used to sway the process, leading to irrational and excessively costly environmental protection decisions that are counter to the best interests of the majority. With such divergent views, you might wonder if the same planet is being evaluated! Risk assessment is often cited as a formal and systematic procedure to forge consensus from these divergent opinions about the status and trends of our ecological resources.

A second stimulus for development of risk assessment is the cost of complying with environmental regulations. Since EPA's creation in 1970, the cost of complying with environmental regulations has totalled $1 trillion, according to the U.S. General Accounting Office (1992).

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Annual compliance costs now fall somewhere between $125 billion and $150 billion. We do not necessarily need fewer regulations, but those we do have, cost a lot of money.

The type of regulation being used also is changing. Command-and-control regulations were typical when pollution problems were fairly straightforward in the 1960s and 1970s. More recent environmental problems require changes in human behavior if pollution is going to be reduced. Tools such as the tax code, land use laws, and market incentives are costly and often intrusive. For example, few people appreciate a government agency telling them what they can and cannot do with their property.

Whatever the reason for the interest in risk assessment, a formal procedure that could evaluate regulatory effectiveness would be useful. Is the money being spent on regulations producing the ecological results expected? If government must intrude in our lives to protect the environment, is it actually protecting the most important ecological resources? Risk assessment offers the potential of answering these questions in less subjective ways.

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If we can quantify risks, or at least rank risks, we can allocate our efforts and regulations to protecting those ecosystems under greatest threat.

A third stimulus is the question of priorities. A committee of scientific experts, appointed by EPA Administrator William Reilly in 1989, evaluated the risks facing ecological resources in the United States and ranked them in order of risk from greatest to least (U.S. Environmental Protection Agency 1990). The top four were habitat alteration, global climate change, stratospheric ozone depletion, and decrease in biological diversity. The high priority given these four threats surprised many.

Even more surprising were the issues ranked lowest risk by the experts—the effects of pesticides, acid deposition, airborne toxics, oil spills, and groundwater pollution. The disconnect between ecological risk as defined by the experts and risk as defined by the focus of current regulatory efforts is striking. According to the panel, we are spending our money, time, and energy on ecological risks of lesser importance.

Formal risk assessment has the potential to carry the ranking process much further. Theoretically, we could focus our regulatory efforts on threats thought to pose the greatest risk. With a given level of either dollars or intrusion into people's lives, we could obtain the maximum ecological payoff.

A fourth stimulus is uncertainty. Scientists and policy analysts are not effectively conveying ecological options to decision makers and the public. Conveying uncertainty clearly is difficult, as is conveying the importance of the interconnectedness of ecological systems and human uses. For example, if the question arises as to the ecological consequences of moving toward alcohol-supplemented gasoline to help decrease our dependence on oil, how do we convey the ecological consequences of this to decision makers in a useful way? Burning alcohol produces byproducts that will have ecological effects. Putting more land into agricultural production to grow more corn to produce alcohol will have additional ecological effects. Runoff from these new corn fields will affect streams and rivers. Converting wetlands to corn fields to grow more corn will have additional consequences for migratory waterfowl. Very quickly everything is related to everything else, and nothing makes sense to decision makers and the public without extensive study, or people must rely on the subjective opinions of scientific or policy experts.

Formal ecological risk assessment is able to address these kinds of problems in an organized way. We all know there is no free lunch in the functioning of decision making or ecological systems. The trouble is that the cost of "lunch" is often difficult to determine and may be nearly impossible to explain to someone. Risk assessment is often touted as a tool to solve this problem.

A fifth stimulus for applying formal risk assessment is to try to break decision-making gridlock. For example, the public forests of the Northwest are nearly shut down in many places due to various lawsuits regarding endangered fish and wildlife species and other environmental issues. The use and abuse of science in courts and other forums is rampant. The public, perhaps most of us, doesn't know who to believe. Are northern spotted owls truly going the way of the dodo bird, or is concern for the spotted owl just a vehicle environmentalists are using to achieve a more fundamental political objective? Or, are industry and timber workers using the spotted owl as an excuse for problems caused by automation and harvests in excess of the rate of regeneration?

The public must form opinions, but it does so without great confidence in the available scientific and technical information. The issue tends to be couched in terms of jobs v owls. Risk assessment might allow some consensus on difficult public choice issues such as this.

A sixth reason deals with the programmatic performance measure of the benefits of regulatory choices, i.e., who should receive them? One allegation is that the affluent drive the decision-making process of managing and protecting ecological resources. In the bureaucratic jargon of the day, this is "environmental equity." Should environmental programs primarily benefit the upper middle class? Or, should environmental decision making be democratized? "Environmental justice" is the rallying cry. Can ecological risk assessment help?

What about benefits for this generation v future generations? In ecological terms, how do we compare the

alternatives through time? Risks of ecological catastrophe may be small in any one year, but in more than 50 years, things look much riskier. Throughout 200 years they may look absolutely frightening. There is no simple analog to the discount rate, which may be a blessing.

And, of course, who are the losers, and how much should they be compensated? The legal "takings issue" is important in protecting ecological resources. If government must "take" a piece of property, then a defensible reason—preferably a formal, objective one—should exist. Risk assessment might be useful in providing that justification.

enough time on paradigm selection, instead jumping right into arguing about details in the techniques of conducting assessments.

The tried-and-true paradigm is the basic political process, sometimes pejoratively referred to as "muddling through." We as scientists often do not trust this process. Decisions are rarely cost effective; efficiency is not of great importance; compromise between competing views often appears to take the worst from each. In short, the process often offends scientists' sense of order or rationality.

A second basic, but different, approach would be to follow the chemical. The problem is that bobwhite quail do not respond to a chemical in the same way as an entire agroecosystem—and chemicals are just one of many stressors. In most cases, chemicals are not the primary cause of ecological changes. Remember the ranking of risks to ecological resources (habitat alteration, global climate change, stratospheric ozone depletion, and loss of biological diversity). To use this analog, we must simplify, often to the point where the relevance of the results may be in question.

Another critical problem is that, contrary to individual humans who die, ecosystems change dramatically throughout time, have no optimal condition, and are only healthy when compared to some desired state specified by humans. Ecosystem "health" is strictly an anthropocentric term.

The disconnect between ecological risk as defined by the experts and risk as defined by the focus of current regulatory effort is striking.

. . . the affluent drive the decision-making process of managing and protecting ecological resources.

Why Risk Assessment?

Why conduct risk assessment for ecological problems? Assessing risks has an intuitive appeal to most people. If we can quantify risks, or at least rank risks, we can allocate our efforts and regulations to protecting those ecosystems under greatest threat. After all, this approach for human health risk assessment has been generally accepted; why not use it for ecological resources? Some in the environmental community regard decisions based on risk assessment the "moral equivalent of murder." The same thought process leads to the conclusion that risk assessment applied to ecosystems is equally unacceptable. I will not spend additional time discussing this philosophical position, but its importance and influence in current ecological debates, such as the Northwest forest and salmon debates, should not be underestimated.

Which Paradigm To Follow?

Once a basic risk assessment paradigm is defined and accepted, many of the scientific and technical issues will fall into place. We ecologists usually don't spend

insurance analog. After all, if uncertainty is the problem, then the insurance industry has a good record of success. The average person can relate to this. A large body of procedures exists for measuring risk for all kinds of activities.

The problem is that few ecological risks can be measured with any accuracy. I am always struck by the despondent look that comes across the face of a policy analyst when the person realizes the wide confidence intervals on all the ecological predictions we ecologists are even willing to provide. In most cases our predictions are little more than first-order guesses.

The third approach is the human health analog. In this approach we generally define the human individual or subpopulation and the ecosystem as the analogous items potentially at risk. Using this analog it is easy for most of us to understand risk as applied to ecosystems. The approach works fairly well when applied to simple ecosystems exposed to single stresses, where one species can be used as a surrogate, e.g., bobwhite quail used as a surrogate for agroecosystems potentially affected by a particular

Fundamental Assumptions

Two core views of the world compete for the basic assumption of ecological risk assessment. The first, the most comfortable to most of us and the most amenable to scientific information, is the assumption that all benefits of decisions affecting ecological systems are accruable to humans, the anthropocentric view of the earth and its resources.

To be sure, we may preserve wilderness that few visit, protect from extinction obscure species that have no demonstrated utility, and spend vast sums to restore habitats for species of limited economic value. All these efforts provide benefits to people; the benefits may be non-economic and non-monetary, and may be only to buy some indeterminant form of future insurance, but they all benefit humans. Nature may benefit but only as a byproduct of the primary

decision. The entire regulatory framework to protect ecosystems is set up under this assumption. We protect biodiversity because some people believe bad things may happen to future generations if we don't. We preserve wilderness areas because just knowing that unaltered ecosystems exist has value to people.

The alternate world view is ecocentered, often called earth-centered. This is the realm of deep ecology and certain religious or philosophical creeds. The basic tenet is that benefits accrue to all species; humans are only one species and are no more important than others. It follows then that all species must be treated equally. We protect ecosystems because all animals and plants have a right to exist. The importance of biodiversity is because it is morally right, not because biodiversity might be important to humans.

Risk assessment is an anathema to those holding this view. The mere discussion of ranking risks to ecosystems would be similar to deciding which humans should live or die. The intensity of the debate about the morality of abortion is similar. The debate is morally based; rational argument plays little or no role. From this philosophy comes uncomfortable questions such as "Should we be subjecting thousands of animals to suffering so the fragrances of our shampoos do not sting our eyes?" It is easy to dismiss this view in a room full of rationalists, but the ecocentric view is increasingly important in the political process. For those individuals who hold an ecocentric worldview, or those who lean in this direction, risk assessment will not be useful. In fact, it will likely be perceived as a form of ecological triage.

Approaches to Assessing Ecological Risk

What do we mean by "ecological risk?" Risk implies there is a "more desired" condition and a "less desired" condition. Human values define both. Terms such as "degraded," "destroyed," and "sick" imply an undesired ecosystem state. Perhaps a more accurate term for this paper would be ecological "consequence" analysis rather than ecological "risk" analysis.

I have always envied scientists working in health risk assessment because a generally accepted view exists that healthy humans are clearly better than sick ones and that living humans are generally better than dead ones. In ecological risk assessment, a corn field, a short-grass prairie, a mountain lake, a river flowing through southern Louisiana are only healthy when compared to the desired condition of those ecosystems. They all may be healthy or degraded.

A half-dozen or so basic tools are used to conduct risk assessments. Each has numerous variations, and many risk assessments use a combination of these approaches. First, the most commonly used approach is the bioassay and its many permutations. The idea is simple and straightforward. There is a stressor of concern, usually a chemical. A surrogate for an ecosystem is selected, often a species of fish, a representative bird, or a combination of plants. The chemical is tested for toxicity, usually under laboratory and highly controlled field conditions. The approach is similar to animal tests conducted in health risk assessment. The assumptions are that the chemical exposure applied under laboratory or controlled field conditions can be related to those found in nature, that the surrogate animals or plants represent the ecosystem or ecosystems of concern, and that a factor can be added to allow for a margin of safety—whatever the concept of "safety" means in ecology.

This approach has some advantages. It is simple to use and easy to understand; a large database exists for many chemicals and species; many laboratories and qualified people can perform these kinds of tests; and the tests and approaches are similar to those used in health risk assessment.

The problems with the approach are also apparent. The approach works best for chemicals, but many, perhaps most, of the major risks to ecosystems are from stressors other than chemical. The approach assumes that a simple surrogate (one or a few species) will respond in the same way as an ecosystem. It does not work well in complex ecosystems, across large regions, or with chemicals that cause low-level, but persistent, ecological effects. In short, it works well for a narrow, though important, set of concerns.

A second approach is the environmental impact analysis and its derivatives. This approach has been used to assess the ecological risk of proposed projects such as dams, highways, and logging. The approach involves identifying the ecological consequences of various options without value judgment. It may be quantitative or simply a best guess. The hey-day of this approach was during the 1970s. Many variants were developed, particularly to add a sense of quantification and standardization. In practice, the process of developing the environmental impact statement often became more important than the actual document and its conclusions. Environmental impact statements are frequently described now in terms of the number of feet of shelf space occupied. Volume of information usually is inversely related to the confidence that ecologists have in the accuracy of the predictions. The more confident we are in what will happen, the shorter the document.

The real advantage of environmental impact analysis is that the full range of ecological effects can be addressed. All types of data can be included. Lack of good predictions is the major disadvantage.

A third approach is the use of models, which tends to be heavily quantitative with use of computers, mathematical analysis, and, more recently, geographic information analysis, visualization, and animation. This approach rapidly caught on in the late 1960s and early 1970s. Some of the luster has dulled because several famous models turned out to make terribly inaccurate predictions; one prominent example is the 1972 Club of Rome model, which predicted worldwide famine and environmental disaster within a decade, at least according to its critics. The degree of justification of the criticism is open to debate, but the usefulness of model-generated predictions is debatable. Others examples abound. Proponents are often as strident as critics.

A modeling approach to ecological risk assessment has some advantages. Complex ecological systems can be evaluated. The most sensitive data and relationships can be identified through sensitivity analysis and then data collection efforts focused on acquiring the most critical missing data.

A fourth approach is the use of expert judgement, which can be used alone or in combination with others. In a sense this is the original approach to risk assessment.

Find a technical expert whom you trust and ask for an estimate of risk caused by the stressors of concern. More recent modifications have focused on organizing expert opinion in a way that provides consensus results or even quantitative results. An appropriate example is the "panel of technical experts" assembled by EPA to rank ecological risks. This example also illustrates a potential problem: the "experts" ranked risks differently from the public. The experts ranked hazardous waste and chemical pollution at the bottom. The public gave top ranking to the same risks.

Political choice, the fifth approach, is fundamentally different from the first four, is the tried-and-true decision-making method in a democracy, and is strongly value-laden. Scientific information and scientific "truth" may or may not have a significant role. Political choice is able to resolve almost any type of issue; those few where it fails turn out to be civil wars. Many scientists are offended by this approach because answers are almost never "right." The 20-year acid rain controversy is a good example of the use and misuse of science in the political process. The policy decisions were difficult, complex, and very expensive; scientific information was often distorted by all sides attempting to bolster their policy positions.

Finally, the approach to ecological risk assessment most difficult to describe and appreciate is the ecocentric stance, which is a fundamentally different philosophy. "Ecocentric" is not really a great descriptor; neither is "deep ecology," a term sometimes used. In this view, benefits do not all accrue to man. All species receive benefits. Decisions tend to be made on what is "right," not what analyses tell us is optimal, most probable, or most efficient.

One example of the concerns that people who hold these views may have is that language (jargon, if you will is power, and that language keeps the public out of the decision-making process. Generally, you cannot participate in ecological decision-making unless you know the jargon. Simple, moral questions get lost in the language of the technocrats. The process of risk assessment and risk management can and does control the language of the discussion and thus disenfranchises those who do not speak this language.

Another example of ecocentric concern is the charge of "speciesism." As a pet "owner," this concern hits close to home. There are 50 million pet dogs in the United States; what is more American than having a pet dog? An ecocentric view is that pet ownership is slavery. One species has enslaved another. Worse, pets do not help us meet our survival needs but are merely kept for personal gratification.

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Making fun of these views and showing how illogical they are is easy for rationalists, but we spend millions of dollars to save three whales stranded in shelf ice in Alaska, as happened several years ago, when any rational analysis would have shown this to be taxpayer money that was wasted. Yet at the same time we cause thousands of rabbits to suffer corneal lesions, infections, and pain so that eye shadow doesn't make our eyes red. Few of us spend the extra money to buy "cruelty-free" products. All of us are a mixture of both human-centered and ecocentered world views—only the ratios vary.

The Major Challenges Ahead

What does the future hold for ecological risk assessment? Two safe predictions are foremost:

First, ecological risk assessment will continue to stimulate controversy and debate, sometimes strident and divisive, as we see in the Pacific Northwest. Tension will be particularly severe with issues where the desire of some to achieve environmental benefits comes at the cost of individual rights. After all, the critical habitat of the endangered silver-bellied, rough-legged, lesser nocturnal snail is also someone's backyard.

Second, the paradigm of choice for assessing ecological risk, a modified version of that used in assessing health risk, will continue to be widely used. The paradigm will work reasonably well for simple ecological and political problems, particularly those dealing with chemicals and simple ecosystems. It will not work well for more complex ecological and political problems; unfortunately, these are the most important. Conversion of natural ecosystems to agricultural use, to places for human habitation, and for human transport dwarf the changes caused by most other environmental stresses.

Conclusion

Ecological journals will continue to publish more and more ecological risk papers; more books will be written on the subject; more talks will be given on the best paradigm to use; Congress and the Executive Branch will continue to look for ways to prioritize ecological risk; and more panels will be commissioned to pass judgement on approaches and methodologies. But the real challenge for applied ecologists will continue to be: how best to put the right information on the table, in the right form, and at the right time to best incorporate ecological consequences in the decision-making process. Those of us who are scientists must avoid the comfort and serenity that comes from distancing ourselves from the rough and tumble world of the decision-making process; we must be equally vigilant to guard against a natural tendency for personal values to color our scientific work or conclusions.

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