Is Ecological Risk Assessment Useful for Resolving Complex Ecological Problems?

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Abstract

Risk assessment has been suggested as a tool to help manage Pacific salmon (*Oncorhynchus* spp.) and solve other complex ecological problems. Ecological risk assessment is usually defined as the process that evaluates the likelihood that adverse ecological effects are occurring, or may occur, as a result of exposure to one or more stressors. The basic concept, while straightforward, is difficult to apply to all but the simplest ecological problems. Strong reactions, both positive and negative, are often evoked by proposals to use risk assessment. Ecological problems that might be addressed by risk assessment include how to accomplish the following: (1) estimate objectively the condition or health of ecological resources such as Pacific salmon; (2) reduce the cost of regulations and policies; (3) focus public and private expenditures on solving the most important priorities; (4) describe and incorporate uncertainty in decision analysis and public choice; (5) provide technical information in ways that help move beyond political gridlock; and (6) democratize the decision-making process. When applied to relatively simple ecological problems (chemical toxicity being the most common), risk assessment is popular. There are many vigorous supporters, particularly among scientists, administrators, and politicians; however, there are also critics. The intellectual history of the risk assessment paradigm does not follow a neat, linear evolution. A formidable problem in many risk assessments, and especially for complex questions such as managing salmon, is selecting the ecological component or system that is considered at risk; this selection is entirely social and political, but estimating the actual risk is technical and scientific. Defining what is at risk must be resolved within the political decision-making framework or the results of the risk assessment will be of limited utility. Use of risk assessment for the Pacific salmon problem would be difficult politically unless the boundaries of the assessment were extremely narrow. However, narrowly defining the salmon problem would make the results of the risk assessment of limited relevance in decision making. For Pacific salmon, ecological risk assessment will be of limited use except for policy problems defined by fairly narrow technical boundaries or constrained by limited geographic scope.

Introduction

Increasingly, there are calls for the use of risk assessment to help solve complex ecological policy problems. The Pacific salmon (*Oncorhynchus* spp.) situation—specifically, to reverse the decline of salmon in the Pacific Northwest—is a typical example of a complex ecological problem. The basic concept underlying risk assessment is relatively straightforward: Risk is something that can be estimated (i.e., risk assessment). In turn, that estimate can be used to manage the risk (i.e., risk management). Ecological risk assessment is usually defined as "the process that evaluates the likelihood that adverse ecological effects are occurring, or may occur, as a result of exposure to one or more stressors" (US Environmental Protection Agency [USEPA] 1992a, 1993). Extensive analyses of the options and procedures to conduct risk assessment are available for human health and ecological problems (National Research Council [NRC] 1983, 1993).

The basic concepts of risk assessment may be simple, but the jargon and details are not. Risk assessment (and similar analytical tools) is a concept that can evoke strong reactions whenever it has been used. At the extreme, some have even concluded that use of risk assessment in human health decision making is "premeditated murder" (Merrell and Van Strum 1990). A number of philosophical and moral reasons for such strong reactions are discussed in detail elsewhere (Newkirk 1992, Lackey 1994) but generally they are either concerns (1) that the analysis (risk assessment) and decisions (risk management) accept the premise that people will die to achieve the desired net benefits, or (2) that the process of risk assessment places too much power with technocrats.

Reaction to ecological risk assessment may be less harsh than reaction to risk assessment applied to human health problems, but even with ecological issues, strong positive and negative responses occur. Several legislative bills (e.g., Environmental Risk Reduction Act) have been introduced in the United States (US) Congress mandating that federal agencies use risk assessment to set priorities and budgets. Prestigious scientific panels have made similar recommendations (NRC 1993). Popular and influential publications argue for a risk assessment approach (Gore 1992). Alternatively, some conclude that risk assessment is a disastrous approach, one that is "scientifically indefensible, ethically repugnant, and practically inefficient" (M. O'Brien, Univ. Oregon, Eugene, unpubl. ms.).

Still, risk assessment has been widely used to link environmental stressors and their ecological consequences. The risks associated with chemical exposure are the typical concern. Quantifying the risk of various chemicals to human health is a logical outgrowth of risk assessment as applied in the insurance field. Over the past 20 years, a body of procedures and tools has become widely used for environmental risk assessment for human health (NRC 1983, 1993). Risk assessment applied to ecological problems is more recent but has also focused primarily on chemicals, with animals used as surrogates for "ecological health." The resulting literature is massive and is reviewed elsewhere (Cairns and Niederlehner 1992; Suter 1993; USEPA 1991, 1993). Most current and past applications of risk assessment to ecological problems deal with the toxicity of chemicals. Efforts to broaden the application of the concept to stresses beyond chemicals are summarized in several reports (USEPA 1990a, b; USEPA 1992b).

Adapting the risk paradigm from assessing insurance risks to assessing human health risks to assessing ecological risks has not been simple (Douglas and Wildavsky 1982, Lackey 1994). Some view ecological risk assessment merely as using new labels for old ideas. Whether ecological risk assessment will actually improve decision making and ultimately protect ecological resources is still unclear.

The Problem to Solve

Risk assessment is just beginning to be applied to the Pacific salmon problem and its utility has yet to be demonstrated. Massive scientific literature is available on Pacific salmon and the effects of fishing, hatcheries, logging, agriculture, predation, habitat alteration, etc. (see Stouder et al. 1996 and papers therein), but it is not particularly helpful in placing the "problem" in a risk assessment context. Nor is there any shortage of articles dealing with policy issues concerning salmon. In spite of this massive literature, defining risk for a complex ecological problem such as that for salmon is typically difficult. Eight general characteristics and problems must be considered. Because of very limited uses of risk assessment for Pacific salmon, experiences from elsewhere will have to be extrapolated for possible relevance.

Boundaries

First, defining the boundaries of ecological risk assessment for complex problems is never an easy task. This is the most important challenge that would face anyone using risk assessment on salmon problems. A problem can be defined along narrow, biological grounds similar to the approach taken by Nehlsen et al. (1991) or in more expansive terms such as ecosystem health (Rapport 1989). There is no consensus algorithm for deciding on the problem definition. In the successful uses of risk assessment, the problem has been defined in very narrow terms by legislation (i.e., registration of potentially toxic chemicals). If the risk problem is defined in narrow technical terms, the analysis can be accomplished relatively easily, but the result will often lack political or broader ecological relevance. For example, if the problem for salmon is limited to purely "fish" factors, such as the maintenance of all salmon stocks, then the other competing tradeoffs such as benefits from competing decisions and policy for agriculture, electricity generation, housing, forest use, and transport will not be included. If the risk problem is defined in more general, inclusive terms, the analysis may not be technically achievable. If the "entire" salmon problem is included, how do we describe the relationship between agricultural policy, for example, and salmon populations except in the most general terms? These two extremes require a tradeoff between technical tractability and political relevance (see Rubin 1989 for examples of this problem). It is important to determine precisely what problem needs to be solved and to clearly and formally reach consensus among the affected parties. Otherwise, additional technical analysis will be of limited value in resolving political choices.

Ecological Condition

Second, a basic ecological question that could theoretically be answered is to reach consensus on the condition of resources. After all, the effectiveness of policies, management decisions, and environmental protection programs must be measured against the benchmark of changes over time in resource conditions. If the measure of risk will be defined in terms of salmon, what is their condition? Often, depending on whom one believes, ecological resources are in terrible shape and becoming worse, or they are not in bad shape at all and improvements have been made. For example, look at the debate over biological diversity. Some contend that biological diversity is a measure of ecosystem health. A number of scientists contend that species are being lost at a record rate and the problem is at crisis levels (Ehrlich and Wilson 1991, Karr 1992, Angermeier and Williams 1993). Others challenge this view and point to the fairly recent (Pleistocene) major North American extinctions of the mastodon, mammoth, giant sloths, giant armadillos, giant beavers, American camel, American horse, and the big tigers and wolves, all lost to hunting, climate change, or both (Lewis 1992). Simon (1986) called into question much of what passes for rigorous analysis of species loss whereas Ehrlich and Wilson (1991) came to the opposite conclusion. The process of risk assessment, if done properly, forces the analyst and the participants to explicitly define ecological condition in terms of what is most desired.

Cost and Efficiency

A third problem that might be effectively addressed by risk assessment is the need to reduce the cost of environmental protection. Rules and regulations designed to protect the environment have cost the US$1 trillion since 1970, and cost ~$115 billion annually in the US according to the US General Accounting Office (1992). Is this money well spent? Could the same environmental benefits be achieved for less money? Some maintain that the cost of complying with environmental regulations, for example, could be reduced by a third to a half (Repetto and Dower 1992). There is no clear answer in this debate over how effectively money is being spent to protect the environment because there is no consensus on the condition of the environment.

Priorities

A fourth problem that might be solved by risk assessment is determining priorities for protecting the environment. Are public and private resources being used to solve the right ecological problems? What is the relative risk of various threats to the environment? For example, how are decisions made to save Redfish Lake sockeye salmon (*O. nerka*) by allowing the bull trout (*Salvelinus confluentus*) to disappear? Some argue that risk assessment should be used to totally set the regulatory and research priorities (Shifrin 1992). Others argue that scientists and the media have vastly overstated the risks of many chemicals to the environment (Whelan 1993). Whether your political rallying cry is "Back to the Pleistocene" or "Save people, not owls," there is little consensus on even the most critical risks to ecosystems.

Scientific Uncertainty

Fifth, uncertainty is difficult to address in all types of ecological analysis as well as to present to decision makers in an understandable way. As an illustration of analytical uncertainty, Hall (1988) evaluated several important and commonly used ecological models and the data that were offered to support their validity. While the models evaluated made intuitive sense, the data to support the models were weak. Others have looked at uncertainty and its effect on natural resource management problems (Ludwig et al. 1993) and concluded that classical deterministic models do not work in practice because uncertainty, incomplete information, and the dynamics of bureaucracies undermine management effectiveness. Use of classical population models to manage natural resources does not work well in practice because chaos, natural variation in ecosystems, and the unorderliness of natural processes and events make predictions unreliable for all but the most simplistic questions (Botkin 1990). For example, fish stock-recruitment models do not work well for management purposes in most situations.

Winners and Losers

Sixth, aside from the difficulties of uncertainty and the use of models, there is the issue of winners and losers in society. The policy questions surrounding the salmon issue immediately evolve to winners and losers. The question of who receives the benefits and who pays the costs is a major debate in all natural resource and environmental policies and regulations. As with the salmon problem, the benefits (and costs) of potential management and regulatory decisions are not soundly quantified. Risk assessment is often advocated as a tool that will force a clear statement of the benefits and costs. The decision of which option to adopt may not be easy, but at least (theoretically) the ecological consequences are clear within the bounds of uncertainty previously discussed.

Analytical Tools

Seventh, analytical tools are needed to help move beyond political gridlock. The salmon controversy is an excellent example. How much of that problem is analytical and how much is due to fundamental differences of opinion on what is most important to society? Major environmental change will almost certainly result in "violent conflict" within and between societies, and will likely become more severe as competition for natural resources intensifies (Homer-Dixon et al. 1993). Causes of gridlock are often exemplified by NIMBY (not in my backyard) or in the extreme case, BANANA (build absolutely nothing anywhere near anyone). Risk assessment, if executed properly, might at least create a framework for the debate.

Who Decides

Eighth, are environmental decisions driven by the will of the majority or by an elite (politicians and technocrats) that is out of touch with that majority? Control of the decision-making process may be exerted by controlling jargon (P. Loge, US Congressional staff, Tempe, Arizona, unpubl. ms.). Those who do not speak or understand the jargon are usually excluded. A formal, open analytical framework such as risk assessment might democratize the process, which, the argument goes, is now run by professionals with "after the fact" input from the public. There is a virtual cottage industry supported by attempts to "solve" the salmon problem. Each interest group, organization, and agency is represented by professionals who speak the same technocratic language.

Risk Assessment in Practice

In spite of the difficulties of defining problems in complex ecological policy questions, the use of risk assessment to help solve ecological problems is widely supported. The closest application to the salmon problem is the 1993 "Forest Summit" held in the Pacific Northwest to help resolve the timber versus spotted owl impasse; it was, in part, based on an implicit but highly simplified risk assessment framework. The approach to analyzing the spotted owl versus late successional forest issue is sometimes proposed as the model to follow for risk assessment with the salmon issue. Legislation being debated in the US Congress would mandate use of risk assessment by federal agencies for many problems. Clearly, many people think that risk assessment is a valuable tool and should be used extensively in solving ecological problems.

However, there is a vocal group of critics debating the use of risk assessment for ecological problems. They argue that risk assessment and risk management are essentially a triage approach: deciding which ecological components will be "saved" and which will be "destroyed." The theme of "biospheric egalitarianism" is a mindset that makes risk assessment a real anathema. Many risk assessment critics have a strong sense of technophobia and often view mainstream environmental organizations as co-opted by industrial or technocratic interests (Lewis 1992).

Risk assessment is also challenged from a different, more utilitarian perspective. The assertion is that, while the concept of risk assessment is sound, the process of risk assessment is often controlled by scientists and others who have political agendas different from the majority of people. Critics contend that "risk assessors" use science to support their position under the guise of formal, value-free risk analysis. Risk assessment thus has the trappings of impartiality, but is really nothing more than thinly disguised environmentalism (or utilitarianism). The apparent lack of credibility and impartiality of the science (and risk assessment) underlying the policy debates over acid rain, stratospheric ozone depletion, global climate change, and loss of biological diversity is often offered as an example of how science has allegedly been misused by scientists and others to advocate political positions (see Limbaugh 1992 for a sense of the concern).

Risk assessment has historically been separated from management (Ruckelshaus 1985). Such separation requires that scientists play clearly defined roles as technical experts, not policy advocates; these distinctions are blurred when scientists advocate political positions (Lewis 1992, Ray 1992). Further, some critics charge that scientists who use their position to advocate personal views are abusing their public trust. The counterargument is that scientists, and all individuals for that matter, have a right to argue for their views and, as technical experts, should not be excluded simply because of their expertise. Others conclude that the execution of the scientific enterprise is value-laden and therefore partially a political activity. Rather than attempting to be solely scientifically objective, a scientist should also be an advocate (O'Brien 1993). Either way, the role of the analyst must be clear to everyone using the results.

History of the Paradigm

Neither risk assessment nor any other commonly used management tool is completely new, but draws on earlier tools and shares some of the core principles. For example, both assessment and management are based on the fundamental premise that all benefits are accruable to man. This is a utilitarian approach and a necessary assumption in all the models or paradigms that follow. "All benefits are accruable to man" encompasses the fact that society might choose to protect wilderness areas that few visit, preserve species that have no known value to man, or preserve natural resources for their scenic beauty (Lackey 1979, Johns 1990, Foster 1992). Benefits may be either tangible (fish yield, tree harvest, camping days, etc.) or intangible (pristine ecosystems, species preservation, visual beauty, etc.). It is easy to jump past the fundamental premise of a utilitarian assumption, but much of the political debate revolves around the issue of whether a person operates with a utilitarian world view or an ecocentric (or other, usually religiously based) world view. It is not a trivial difference. However, in practice the split between those with utilitarian and ecocentric (or other) world views is not complete; most of us manifest features of both (Herzog 1993).

The multiple-use model of managing natural resources has been the basic paradigm in North America during this century. Popularized early in this century by Gifford Pinchot and others, it has been used extensively and widely in fisheries, forestry, and wildlife (Pinchot 1947). The idea is simple: there are many benefits that come from ecological resources (commodity yields, recreational fishing and hunting experiences, outdoor recreational activities, ecosystem services such as water purification, etc.) and the mix of outputs needs to be managed to produce the greatest good for the greatest number of people over a sustained period of time (Callicott 1990, 1991; Smith and Steel 1996). The concept is straightforward and works well if there is a high degree of shared values among the public.

A number of variations in the multiple-use model arose over the middle years of this century: maximum sustainable yield, maximum equilibrium yield, and optimum sustained yield. Widely used in teaching and management, these concepts have dominated mainstream professional thought and practice through current times (Baranov 1918, Graham 1935, Ricker 1954, Beverton and Holt 1957, Roedel 1975, Larkin 1977). As with all natural resource management paradigms and goals, none of these evolved in a linear manner (Walters 1986, Barber and Taylor 1990). The basic idea is that commodity yields (fish, trees, wildlife) could be produced annually from "surplus" production and could be continued in perpetuity with sound management. All these models suffered from the problem of a heterogeneous public with conflicting demands and an inability, in fisheries management at least, to control harvest pressure. Even today, there is still a struggle to control fishing pressure in politically acceptable and managerially efficient ways (e.g., individual transferable quotas).

Scientific management is a related management paradigm that includes operations research, management by objectives, optimization, linear programming, artificial intelligence, and other mathematical procedures (Lackey 1979, Sokoloski 1980). There are many outputs from ecosystems, both commodity and non-commodity, and these can (must) be measured and the integrated output optimized. The outputs are selected by experts, who then use mathematical tools to quantify and evaluate various combinations of outputs. Input from the public was not particularly important because there was a "correct" optimal set of decisions to maximize output. The natural resource professional is dominant in the process. The view that "if politicians and the public would just stay out of the process, we professionals would manage natural resources just fine" is characteristic of scientific management. There are many examples of the collapse of fisheries based on following this general management approach.

Ecosystem management, including permutations such as watershed management (Likens 1992, Naiman, 1992) and "new forestry" (Swanson and Franklin 1992, Slocombe 1993), has become popular in the past decade. Both ecosystem management and watershed management have ambiguous definitions such as the popular wall poster for ecosystem management: "Considering All Things." Usually other concepts, such as biological diversity, are embedded in ecosystem management, although biological diversity is an ill-defined concept in its own right (Cairns and Lackey 1992). For example, in our quest to restore salmon stocks, should we eradicate predators such as squawfish (*Ptycocheilus oregonensis*) and competitors such as walleye (*Stizostedion vitreum*) or do we restore ecosystems (habitat) to some desired state and let nature take its course? Does ecosystem management mean we optimize this mix of species? These and myriad others are policy questions and must be explicitly answered regardless of which management approach is used. They must be answered as policy questions, not scientific ones. Advocates of ecosystem management often see it as a fundamental shift in management and assessment thinking; skeptics see it as a "warmed-over" version of multiple-use management or, more pejoratively, as "policy by slogan."

A different approach is embodied in chaos theory and adaptive assessment and management, and is fundamentally a response to the high degree of uncertainty in ecosystems discussed previously. The basic idea is that ecosystems are unfathomably complex and that they react to unpredicted (chaotic) events; thus, it is pointless to develop sophisticated ecosystem models for decision making based on equilibrium conditions (Holling 1978; Walters 1986, 1990). There is also constant feedback between man's decisions and adjustments of the ecosystem to those decisions. Uncertainty is so great that it is not feasible to create useful predictive models. Also, for alternatives that preclude future options, adaptive environmental assessment and management will not work well (e.g., construction of dams on the mainstem of the Columbia River has had major ecological consequences and each major project was an irrevocable decision [Volkman and McConnaha 1992]). In general, the manager or analyst will make a series of small decisions, evaluate the results, and then make revised decisions. To make a big decision requires strong public support and acceptable ways to compensate the losers; there is little in the history of salmon management to show that this condition will be realized.

The concept of total quality management (TQM) is a concept that became popular in business and government in the 1980s and 1990s (Osborne and Gaebler 1992). The widespread efforts to "reinvent government" have their basis in TQM. The core idea is that the customer comes first and, in turn, management should be measured by what customers want. In natural resource management and environmental protection, the "customer" is often defined as the public. Hence, TQM presupposes that an agency can find out what the public wants in terms of ecosystem management and protection, and then deliver that product. There are difficulties in defining the public, but TQM has been successful in some business applications. However, its usefulness in managing and protecting public natural resources is open to question (Bormann et al. 1994). In a pluralistic society, a common public goal for salmon that will allow the principles of TQM to be used effectively is unlikely.

Risk assessment and management, the final management paradigm reviewed here, has been used as a tool in some of the previous paradigms, or as a stand-alone approach. Strongly advocated by some (USEPA 1990a), the approach has generally been used for assessing chemicals and their role in altering ecosystems or components of ecosystems. The basic idea is that there are a number of risks to the environment and ecosystems, and these risks ought to be identified, quantified, and managed. The application of risk assessment to ecological questions such as Pacific salmon management is a formidable challenge because there are no examples of it being used successfully for ecological problems of this complexity. For example, risk assessment has been used for addressing technical questions concerning hatchery and power plant operation but not for complex salmon policy problems.

Tools Used in Ecological Risk Assessment

There is a fairly standard set of tools and techniques used to generate the data for risk assessment. However, who assumes the "burden of proof" is another challenging element of conducting risk assessments (Brown 1987, Volkman and McConnaha 1992, Bella 1996). Do risk assessors assume that current ecological conditions are the norm and any proposed deviation from the status quo must be justified? Or do they assume some pristine ecological state as the norm? Or do they assume that the person or organization proposing the action must justify it? One of the reasons that the Endangered Species Act and Section 404 of the Clean Water Act are so potentially powerful is that they effectively shift the burden of proof to those who would change a defined condition (e.g., species must not go extinct, or wetlands must not be altered unless there is explicit government approval). The practitioners of ecological risk assessment often overlook values, ethics, and burden of proof in defining the problem, and operate instead on the purely technical level (Brown 1987). For example, why do we assume that the physical alterations of salmon rivers, such as the Columbia, are a given? Is it not an option to demand that the organizations responsible for dams either demonstrate that the dams are not adversely affecting salmon populations, or alter their operations (including removal) so as not to adversely affect salmon? Why should the burden of proof rest with those trying to protect or restore salmon?

Bioassays are the most commonly used tools in producing the basic data for ecological risk assessment dealing with exposure to chemicals. There are many permutations of the basic bioassay and the literature is massive (Jenkins et al. 1989, Cairns and Niederlehner 1992). Bioassays work well for certain types of ecological problems and especially for the "command and control" regulatory approach. Severe limitations occur in assessing multiple, concurrent stresses, assessing effects on ecosystems or regions, or assessing effects that are not chemically driven (e.g., land-use alterations). It is easy to lose sight of the fact that bioassays are simplifications of the ecosystems and regions with which risk assessors are concerned and are merely surrogates for the realistic tests or experiments that cannot be performed. On an administrative level, the use of bioassays has become institutionalized, and the public may now view such tests as more relevant to protecting the environment than is warranted.

Environmental impact analysis and monitoring are additional tools that are often used in risk assessment. Such analyses are relevant to real-world problems and are often targeted directly at the public choice issues. Because problems are relevant, they are often complex scientifically, and the resulting predictions lack the scientific rigor typically seen in peer-reviewed journals. As a result, users often lack confidence in the reliability of the predictions. Moreover, the process of developing an environmental impact statement may be more important than the actual document produced.

Modeling and computer simulation are tools that have proved to be very popular in ecological risk assessment. These tools have many desirable features, such as the ability to deal with complex problems, the ability to evaluate alternative hypotheses quickly, and the ability to organize data and relationships into a defined whole. However, modelers often fall into the trap of substituting analytical rigor for intellectual rigor. Very simplistic (and incorrect) ideas can be masked by mathematical complexity. Even some of the most widely accepted and applied models in ecology illustrate the problem with developing and applying models to actual management issues (Hall 1988). Further, the ease and beauty of tools such as computer-assisted geographic analysis can also cause the analyst to lose sight of intellectual rigor and common sense.

Because most ecological risk assessment problems are complex and do not lend themselves entirely to laboratory experiments, field experiments, or modeling, the use of expert judgment and opinion is desirable and necessary. Expert opinion is useful but is not without problems. For example, when experts have dramatically different opinions, how does a risk assessor handle this analytically? Experts can be wrong and history is filled with examples of experts being completely in error. Alternatively, risk assessors trust that experts are less wrong on topics of their expertise than are non-experts, and the use of experts and formal expert systems will continue to increase. When relying on the opinions of technical experts, there is the particularly insidious problem of separating clearly their personal and organizational values from their technical opinion (Philpot 1992).

Risk assessment, at least in the problem-formulation stage, must include an explicit determination of what the customer wants. The customer is usually the public or a subset of the public (or an institutional surrogate such as a law or a court determination). This is not as easy as it sounds. The typical type of information from the public is that people want to "protect the environment," "protect endangered species," or "maintain a sustainable environment." The same people may also say that they want to "protect family wage jobs," "maintain economic opportunities for our children," and "protect the sanctity of personal property." It is very difficult to move beyond such platitudes and obtain information that is really useful in risk assessment. On the other hand, individuals or elements of society with a direct and vested interest will have very specific preferences. Those less directly affected tend to have more general preferences. For example, Gale and Cordray (1994) found various elements of the public possessing at least nine different concepts of sustainability for forests, many of which are mutually exclusive. Some people may talk about democratization of the decision-making process (Bormann et al. 1994). This radical concept would fundamentally alter how business is done, but some argue that a radical change is needed.

Application to the Salmon Issue

The first step in conducting any analysis of ecological risk is to clearly define the problem. Unfortunately, this step is often overlooked or resolved simplistically (Stout and Streeter 1992). In many cases, agreeing on the problem is impossible because that is in itself the political impasse. There is also tension between analysts who want to simplify the problem so that it is technically tractable, and politicians who want to keep problem definition as realistic (i.e., technically complicated) as possible. Defining the problem is a political process, requiring technical input, but it is based on values and priorities.

In defining risk assessment for Pacific Northwest salmonids, an analyst explicitly resolves whether the focus is on preserving some or all stocks (or any other evolutionarily significant unit) from going extinct, or maintaining some or all stocks at fishable levels. These are largely mutually exclusive alternatives. They are also not scientific decisions. Further, defining which species, communities, or ecosystems are to be evaluated in risk assessment is a value-based, not a scientific, determination (Costanza 1992a, b). Does the analyst consider the baseline condition to be 10,000 years ago, 200 years ago, or for the Columbia Basin, pre-impoundment construction (basically before World War II)? Analysts should not decide these questions; society should. Depending on the baseline selected, the results of a risk assessment will differ.

Most practitioners argue that, to be more useful, risk assessment (estimating risk) must be separated from risk management (making choices) both in practice and in appearance (Ruckelshaus 1985, Lave 1990). There are counterarguments against separating assessment from management (Jasanoff 1993). Usually the arguments recognize that it is impossible to separate a person's values from his technical (risk assessment) activities, and therefore the separation is illusionary. Separating the two activities (management and assessment) is not as easy as it might appear. Many scientists have strong personal opinions on public choice issues that concern ecological resources. It is difficult for anyone to separate purely technical opinions from personal value judgments. Even more difficult is convincing all elements of the public (all stakeholders) that the assessment is being conducted without a bias on the part of scientists.

The best scientists and most credible scientific information must be used in risk assessment. Besides being independent, the assessors must not advocate their organization's political position or their personal agenda. If the risk assessment is not perceived to be independent, the results will be tainted (Botkin 1990). Further, the research and assessment function within an organization should be separated from the management and regulatory function (Risser and Lubchenco 1992). Credibility and impartiality are difficult to maintain, especially in the public eye (Smith and Steel 1996).

Risk analysis will result in a number of options to manage the risk. These may range from drastic, expensive options to those that maintain the status quo, which may also be expensive. Options must be presented as clear alternatives with statements of ecological benefits and costs, and measures of uncertainty, for each. There is not a lot of rationality in most decision making, but there should be in decision analysis (Douglas and Wildavsky 1982). For example, risk analysts (and scientists) deal with estimates of ecological change, and risk managers (and politicians) deal with ecological degradation and improvement. As one scientist concluded after listening to a discussion of the pro's and con's of salmon streams being filled with downed timber from trees in buffer strips blowing over, "Your ecological mess is my ecological nirvana." Such statements move the scientist out of the scientific realm and into the political, value-driven realm. It may well be true that such ecological conditions are better from the policy perspective of enhancing salmon, but they are not better from a scientific perspective.

For the salmon problem, my recommendation is to not conduct a risk assessment unless there is a high likelihood that it will be used in decision making. If expectations are raised, and if no decision is made, the public has a sense of government institutions not working. Further, risk analysis of any significant ecological problem will result in options that create both big winners and big losers. It serves no productive purpose to try to convince losers that they are really winners. If someone's property will be effectively expropriated for some larger societal good, that action should be clearly stated in the assessment. Conversely, if an owner is permitted to alter his property for short-term gain, but at huge expense to society at large or to future generations, that also should be clearly stated.

Future Research Needs

It is easy to create a long list of research needs for the salmon problem. An implied premise of creating such a list is that insufficient research is the limitation to better management. It is not. The salmon problem is complex. The evolutionary biology and zoogeography are complicated and not well understood. The genetics of the species remains unclear. Oceanic influences are ambiguous. Considerable information on salmon and their habitat exists, but much of it is not directly usable for risk assessment and management. The baseline condition for salmon populations is open to considerable debate. Genetics, habitat relationships, ocean productivity, interactions with other organisms, human harvest, water quality issues, the effects of stocking, and the general problem of uncertainty and random events are all areas of concern and interest to researchers. However, I propose that what we need most is to better link research to the way society makes decisions.

First, ecological risk assessment needs to be modified to create a paradigm of ecological consequence analysis. The concept of risk applied to natural resources (including salmon) will only work for a narrow set of problems where there is a clear public (and legal) consensus, and on issues where there is an agreed-upon timeframe of interest (e.g., are benefits and risks defined over 10 years or 10 centuries?). With all ecological risks, a probability (of cause and effect, or ecological change) is neither good nor bad, it is only a probability. The resolution of many ecological problems is not limited by lack of scientific information, or technical tools, but by conflict created by fundamentally different values and social priorities as to what is most important (e.g., cheap food via irrigation water use versus fishing, cheap power versus free-flowing rivers, personal freedom versus land-use zoning). If we are dealing with an ecological problem that is at an impasse because some of the stakeholders do not accept the utilitarian model, we should not be surprised when risk assessment and management will not resolve the issue. We need to do ecological consequence analysis and let the political process select the desired option.

Second, the concept of ecological health needs to be better defined and understood by politicians and the public. The fundamental problem is not lack of technical information but what is meant by health. Is a wilderness condition defined as the base, or preferred level, of ecological health? Is the degree of perturbation by human activity the measure of ecological health? The concept of ecological degradation is human value-driven; the concept of ecological alteration is scientific. If the consequences of chaotic events in ecosystems are considered, what is natural (Botkin 1990)? There are scientific answers for some of these questions, but political (social) answers to many others.

Third, risk assessors need better ways to use expert opinion. Most of the policy-relevant problems in ecology are too complex for easy scientific experimentation or analysis. An old rule in policy analysis is that if something can be measured, it is probably irrelevant to public choice. If problems are simplified to the point of making them scientifically tractable, then the result may lack policy relevance. Expert opinion must be used. Computer-generated maps and computer-assisted models may be elegant, but for really important decisions, the political process demands expert opinion.

Fourth, better ways to evaluate and measure public preference and priorities in framing ecological issues need to be developed. Public opinion polls always show that the public is very supportive of the "environment," as it is with "peace," "freedom," and "economic opportunity." The public is similarly supportive of preserving biological diversity, ecosystem management, and sustainable natural resource management (Smith and Steel 1996). Unfortunately, this type of information is of limited use in helping frame or make difficult environmental decisions. The public is not a monolith; it encompasses many divergent views, and individuals vary greatly in the intensity of their opinions. Individuals may argue forcefully for the industrial economic paradigm or for the natural economic paradigm, but practical political options are not framed in this context.

The fifth critical need is to develop better ways to present options and consequences to the public, to policy analysts, and to decision makers. Society is not well served by statements such as "it is a complicated problem and you need to have an advanced degree in ecology to understand it," or "you can select this option without significant cost to society" when there will be costs to some people. The main message in risk assessment must be that environmental protection is difficult and that decisions must be clearly framed as decision alternatives.

The Challenge to Biologists

Biological and social science must be linked if public decision making is to be improved. Too often fisheries, forestry, and wildlife problems are viewed as biological challenges. It is society that should define problems and set priorities, but the public speaks with not one, but many voices. As Gale and Cordray (1994) pointed out for forest management, many of the stated public demands are mutually exclusive. Ecological health, for example, is a social value defined in ecological terms (Costanza 1992a). But incorporating public input into risk assessment and management may be carried to the extreme (i.e., democratization). Such a radical concept is anathema to most scientists and politicians.

Scientists must maintain a real and perceived position of providing credible ecological information, information that is not slanted by personal value judgments. Those of us involved in risk assessment cannot become advocates for any political position or choice lest our credibility suffer (Lave 1990, Philpot 1992). Such a position may be painful at times because who among us can completely separate personal views from professional opinions?

Biologists must educate the public (and political officials) about what scientific and technical information can and cannot do in resolving public choice issues such as the salmon decline problem. We should never hear the question "When will the scientists be in a position to answer this policy question?"

Public choice for issues like the salmon problem is too important to be left completely in the hands of technocrats; we should seriously consider democratizing the decision-making process. Most current public decision making involves professionals controlling the process with public input requested as desired (Merrell and Van Strum 1990, P. Loge, US Congressional staff, Tempe, Arizona, unpubl. ms.). Values and priorities originate with what the public wants, but are we really ready for democratization? Do any professionals want to trust the public with defining goals? After all, biology, ecology, fisheries, wildlife, and forestry professions tend to be filled with people with a strong natural resource protection streak. Perhaps the public will not support such professional positions.

We should not become complacent that complex ecological problems, such as as illustrated by Pacific salmon, have only technological and rational solutions. Tools such as risk assessment might help at the margins of the political process but are not going to resolve the key policy questions. Non-rational ideas are extremely important in all crucial public choice issues. We must guard against technical hubris, the false sense of confidence in technology, technological solutions, and rational analysis . . . including risk assessment.

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