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Ecological Risk Assessment Benefits Environmental Management

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Life in our modern society is full of choices. It is full of tradeoffs. New technologies and expanding human populations will continue to put stress on the natural environment and force choices to be made between preservation of "natural" areas and anthropocentric alterations of the ecosystem. These choices can be made by market forces, through litigation, or through the political process. In the U.S., we utilize a combination of all these approaches for environmental management. The value of risk assessment is its contribution to *informed* decision making in this process. The ecological risk assessment process in its ideal form is an unbiased approach for assessing the probability of harm to the environment as a consequence of a given action (EPA, 1992). This information can then be combined with other societal values and biases in the management of such risks. However, as the process currently is understood, decision makers often are accused of manipulating information in order to generate decisions or achieve buy in from the public in support of a particular political agenda. A clear understanding of the nature of the risk management process can help define areas where information should be free from social or personal bias, and areas where values and judgments are critical. We do not propose to discuss the individual's decision-making process (Morgan et al, 1992), but rather to address the social process of risk communication and environmentally-related decision-making, identifying which parts of that process require bias-free, scientifically generated information about the consequences of various actions and which parts need an understanding of the social values which underlie the informed choices among those possible actions.

Choices related to ecological risk are generally seen as involving a tradeoff between environmental quality and economic well-being. The legitimacy and value of economic, or market-driven, decisions was first put forward by Adam Smith in 1776 (Smith, 1974) and has become the philosophical basis of our economic system. Smith argued that the market, if left unregulated and free to operate according to its own laws, will yield

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socially beneficial decisions. Simply stated, if a product or its manufacturing process causes damage to the local or global ecosystem in a manner that is socially unacceptable, the product will not be purchased and so will fail in the market place. Conversely, if society believes that the benefits outweigh the detriments of the product, its members will continue to purchase the product regardless of the environmental damage. This argument presupposes an informed citizenry where consumers are aware of all the actual or potential ecological harm caused by all market activities and therefore can make appropriate decisions as consumers - in fact, Adam Smith's model was predicated on the possession of complete or perfect information by the consumer. This is clearly not the norm. It if were, we would not locate large cities on the richest agricultural lands, discharge wastes into waterways, or base energy rates solely on production costs. Additionally, our economy currently is structured as one based on income, not wealth. This is exemplified in our system of social accounts (such as gross domestic product or GDP) which only assigns value to a stock (such as a forest) once it is consumed, i.e. generates income. The system of social accounts provides no incentive for preservation of materials or environmental services for future generations. Ecological systems as reservoirs of future good or economic benefit have no value (cf. Gore, 1993). Finally, the market place has, until now, ignored the real costs of environmental pollution when determining the return on investment of production. The costs of waste disposal and clean-up have traditionally been treated as 'externalities', that is, external to the process which produced them, and assigned to society as a whole rather than assumed as a responsibility of the producer.

The free market theory has been modified to include citizen input via pressure from formal consumer and environmental advocate groups (e.g. Common Cause, Public Interest Research Group, Natural Resource Defense Fund). These groups act as informed citizens to pressure the market to respond to the demands of environmentally-knowledgeable consumers. Methods include education of the citizenry at large so all consumers can have 'more perfect information' and the idealized free market can move closer to actualization, organized boycotts of products, and pressure through the legislative and judicial processes. In a sense, the majority of consumers have turned their responsibilities for managing the market place over to a smaller group of informed advocates. This process has merit but it disenfranchises those citizens that do not

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It is worth noting that this system of social accounts was developed to help monitor recovery from the Depression. The target of fiscal and social policy was increased income flow, not the preservation or increase of wealth.

have strong advocates. The federal government is attempting to address this inequality of access through Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (Office of the President, 1994), but the effectiveness of this Order remains to be seen. Additionally, consumer advocates and environmental protection groups generally operate in a responsive mode, rather than taking a proactive stance. The market still drives the type of technology that is developed and citizens react only *a posteriori*, leaving little incentive for pollution prevention. However, this reactive, *a posteriori* approach draws heavily on the risk assessment concept as a basis for information about the probability of adverse ecological impacts and for a comparison of risks among different market options.

The political arena offers several avenues for consumers to shape the market place, either *a posteriori* or *a priori*. Laws are promulgated through legislation that provides the broad outlines within which the society wants to function. Statements such as "protection of human health and the environment" are in most of our environmental legislation, with the exact definition of what is to be protected left deliberately vague, because it is in the gray areas that debates about values and social priorities take place. This provides room for experts in the executive branch to utilize the science and process of risk assessment to determine possible actions by the market such that the probability of harm to the environment is minimized. Regulations such as discharge criteria and new chemical registrations serve as *a priori* risk management decisions which guide the functioning of the market. Clean up of hazardous waste sites and management of currently produced hazardous waste products provide *a posteriori* management controls. Development and implementation of environmental controls mandated by the political process has resulted in a $150 billion a year industry, representing a shift in the market that occurred only after legislation was introduced. As a result of this legislation which ties pollution prevention and mitigation costs to specific processes, costs of environmental management now can be incorporated into market prices for products rather than paid out of general social funds. Finally, the legislative and regulatory process can require preservation of ecological resources for future generations, even in the absence of economic forces. These actions require the general acquiescence of the public through the admittedly slow and cumbersome political and judicial processes. Special interest groups influence the process by forcing legislation that more specifically defines "environmental harm" in terms that are

compatible with their desires or by seeking adjudication in the courts for differences in interpretation of this terminology.

These legislative and judicial processes highlight a major area of controversy in the process of ecological risk assessment, that is, the definition of what is at risk. The functioning of the global ecosystem can be assessed from a myriad of viewpoints. An evolutionary view may look at a temporal span of millennia and integrate large geographic regions. A shorter time frame would be used when taking an anthropocentric view of the effects of human interactions on the world's ecology. Immediate, short-term and localized needs may require a view from the perspective of a very specific area and time-frame. In any of these cases, the components of a particular system and their integrated functioning may not be known in their entirety so defining the system at risk may become increasingly problematic. Additionally, there is a social range of values about the importance of natural systems, ranging from those which treat them as a resource to be exploited to those who believe that any impact upon an ecosystem is a negative one. Finally, the definition of "adverse environmental change" is not clear, either from a scientific perspective or a social, anthropocentric viewpoint. Therefore, prior to conducting an ecological risk assessment, it is essential that the questions of what is at risk and what constitutes an adverse effect be clearly defined, and it must be recognized that these definitions are socially determined.

The value placed on environmental goods and services (or, phrased another way, on the structure and function of an ecosystem) is a cultural norm and may be driven by needs such as survival. Therefore, it is not sufficient for regulators, scientists, and industry experts to define the assessment endpoints of an ecological risk assessment without the inclusion of all stakeholders. Eastern Europe and the former Soviet Union apparently valued production over ecosystem protection as evidenced by the extreme cases of pollution now visible in those areas. The deforestation of large parts of Africa and India by individuals seeking wood and other biomass to burn for energy for cooking and heating is a byproduct of actions directed toward satisfying survival needs. Agricultural and hunting-gathering societies tend to be more protective of their environment than societies dependent upon other means of subsistence for their individual and group survival is more directly and clearly tied to its effective functioning over time.

Nor is it possible to change the perception of risk held by lay people merely by providing them documented evidence of actual risk (Slovic et al., 1979). The most thorough risk assessment is not a guarantee of public or regulatory agency acceptance of the characterization of risk. The public cares greatly about its level of trust in those conducting or sponsoring the risk assessment. This means a detailed technical presentation of the assessment approach or results will often not meet the audience's needs if there is no trust in the speaker (Covello et al., 1990). In addition, the perception of risk is a complex interaction of actual risk (e.g., mortality rate), catastrophic potential, fear of the unknown, control over the risk, and immediacy of the effect (Slovic et al., 1979). Ideology also affects our perception of risk (Dake and Wildavsky, 1991). Egalitarians perceive greater risk from new technologies and less risk from social deviance or economic troubles than do individualists or hierarchists. Finally, there is a sexual bias in risk perception, with women more likely to perceive risk than men (Hoefer and Raju, 1991).

It is therefore imperative that all stakeholders are involved in defining the system at risk, which changes to the system are considered adverse, and the level of change which constitutes an effect. Thus, all the humanistic biases that were just discussed can be incorporated into the risk management process at the beginning, assuring buy in by all stakeholders in the outcome of the assessment. However, a method is needed that will direct the discussions of ecological values and risk determination in a constructive manner. There are several tools available for directing discussion and achieving consensus, even on qualitative values (Linstone & Turoff, 1975, Saaty, 1990, Glicken and Engi, 1992). The Delphi method uses iterative solicitations of inputs from an anonymous group of 'experts' to move toward consensus. The Vital Issues process uses a pairwise comparison mechanism for capturing the individual choices of a group of known stakeholders. The key to the success of the pairwise decision-making technique is that decisions are reduced to a series of orderly comparisons between pairs of alternatives where the alternatives - and, in some methods, the problem itself - are defined by the participants. These alternatives may be arranged in a manageable tiered structure or hierarchy. Additionally, the technique accommodates uncertainty and allows for revision if additional groups or viewpoints are added. Biases among participants are clearly identified and the results can easily be tested for sensitivity to changes in assumptions and judgments. Thus, if polarity exists among participants on a low-priority item, it may be prudent to "agree to disagree" and move forward. However, if polarity occurs on a high priority item, extra effort should be devoted to

understanding the differences and working towards a common understanding. These methods also provide an explicit audit trail on how consensus was reached and, therefore, why certain decisions were made. This is a powerful feature of this type of decision management process as it allows others to quickly understand the reasoning that leads to each decision.

Stakeholder involvement in land-use and policy decision processes is not new in the environmental arena. The US Forest Service has begun a formal process for public participation as a consequence of the listing of the spotted owl as an endangered species and the changing policies of the executive branch on land use practices. This process includes highly visible public forums such as the President's Forestry Summit held in Portland, Oregon in 1993 as well as small, community-focused workshops. These workshops were developed to bring together all stakeholders (loggers, timber-dependent businesses, environmentalists, etc.) to examine their fundamental values and resultant attitudes towards the issue at hand. Sessions were based on mutual learning, sharing, defining fear, expectations, hidden agendas, and values exercises. They dealt with change and paradigms and most importantly, with the concept of dignity in consensus groups. The outcome was several new Forest Plans that embodied the land management ethics of the participants and so were acceptable to a broad spectrum of opinion. These same concepts and approach can, and should, be applied to other types of ecological risk assessments where a common (and legal) desire exists to mitigate or prevent adverse ecological effects. After all, risk management is, in the end, a human judgment decision.

An ecological risk assessment has numerous decision points based on objectives, criteria, and the overall goal of protecting human health and ecological integrity. Decision making in this ecological risk management process is difficult because tradeoffs must be made among competing objectives, usually with differing amounts of information on each objective. In order to make informed decisions, one must be able to evaluate and measure both quantitative and qualitative aspects of the decision. Uncertainties and competing interest groups also add to the complexity of decision making. The ability to make effective decisions in the face of this complexity can be a significant impediment to conducting the ecological risk assessment (Kapustka and Williams, 1991). This is especially important in situations that pose marginal risk to resources. Does intrusive remediation impose greater injury than the residual contamination? Is remediation technically feasible or cost effective? Answering such

questions which are simultaneously value-laden and technically driven seems to require Solomonic wisdom. No individual or small unit working in isolation on narrowly defined segments of the problem can be expected to have consistently satisfactory results. Technical information must be communicated to risk managers and stakeholders in an effective and comprehensive manner. Stakeholder concerns must also be communicated and effectively incorporated into technical approaches and management options. Risk communication, therefore, becomes central to effective risk management.

Some guiding principles that should be used in the risk management process are:

- there are no right answers, but there are many wrong answers. Balancing human needs in the context of long-term ecological consequences can yield better environmental management decisions;

- "The essence of effective communication is remembering what it is like not to know." (Wurman, 1989). Stakeholders usually consist of members of the public or Trustee agencies that are less informed than the scientists and technical experts. An effective communicator has to be aware of what the audience needs to know and how to best address the different levels of understanding among members of the public and stakeholder groups;

- "The core goal of effective risk communication should be to produce an involved, informed, interested, and fair-minded public so that public concerns become, or remain, reasonable, solution-oriented, and collaborative." (Covello and Allen, 1988);

- Poor risk communication often has more disastrous results than no communication at all; and

- A perception by stakeholders that their input is given serious consideration as part of the risk assessment and management processes and subsequent remedial action decisions will ensure that trust is accorded to the decision makers.

A major component of the risk assessment process is the effective communication of the methods and results of the various risk assessment tasks as the process is proceeding, rather than solely at the end of the process. With any major project that

may affect the public or public resources, effective communication of the outcome of the project is essential. In the science of risk assessment, the public has difficulty understanding both the process and the results, the risk assessors have difficulty understanding each other and public needs, and the risk managers frequently have difficulty communicating on a multiplicity of levels. Effective risk communication is about narrowing the gap between our understanding of the actual risks involved and the perception of that risk. Chief among the variables contributing to the perception of high risk is the ability to control the risk. Slovic (1987) reports that people are 1,000 times more likely to accept the risk they control over the one they cannot.

A formal risk assessment process has several other advantages as applied to environmental decision making and management of ecological hazards (Suter, 1993):

- it provides the quantitative bases for comparing and prioritizing risks;

- by expressing results as probabilities, it acknowledges the inherent uncertainty in predicting future environmental states, thereby making the assessment more credible;

- it provides a scientific basis for cost-benefit analyses; and

- it clearly separates the scientific process of estimating the magnitude and probability of effects from the process of choosing among alternatives and determining the acceptability of risks.

The last point is clearly the most important argument in favor of the risk assessment process. Values, biases, and societal influences define the question and influence the management decision. However, the processes for determining the hazard of a proposed action and magnitude of the exposure of ecosystem components to that hazard are scientifically based. The characterization of the probability that an adverse outcome will occur as a result of the exposure of the environment to the hazard in question also is based on expert judgment and interpretation of the body of scientific fact. The results of a risk characterization must be stated as a probability of an event occurring as future effects cannot be predicted with certainty. This is not merely a limitation of science. Rather it is an acknowledgment of the stochastic and chaotic

patterns of natural processes. A risk assessment can also provide a series of probabilities of the occurrence of an adverse effect under different scenarios.

It is at this point that the scientific and technical aspects of the risk assessment end and the incorporation of value into the risk management process begins. Societal values and biases come into play as we choose among the available options. A great deal of confusion and debate over the value of the risk assessment process could be avoided if there is a clear understanding about which part of the process requires the input of societal values (problem definition, management decisions) and which parts should be a purely technical analysis based on the best available data (hazard and exposure evaluation; risk characterization). It is equally important to refrain from injecting biases into the scientific parts of the risk assessments. Ecotheology and wise-use advocacy must be relegated to the problem formulation and decision-making phases of the risk management process. The calculation of risk probabilities must be made without *a priori* pressure to generate the "right" answer. Conversely, the risk assessors must realize that risk management decisions will not necessarily take the path which minimizes risk. There will be many instances where social values will dictate that environmental harm should be allowed to occur due to a preference for the perceived beneficial anthropocentric tradeoffs. This distinction between the parts of the risk management process that are based on objectively generated information and the parts that are driven by social values must be maintained.

In summary, the value of the risk assessment process is its contribution to *informed* decision making. Problem formulation is driven by social values. (Protection of the spotted owl habitat became a "problem" because it was perceived to impact the economic survival of logging-based communities in the Pacific Northwest.) The assessment and characterization of the impact of anthropocentric activities on the environment (the risk assessment) should be a purely technical analysis driven by scientifically acquired data and free from social bias. (The assessment of the impact of the destruction of old-growth forests on the continued existence of the spotted owl was such an activity.) Finally, the process leading to a decision about action to be taken relative to the (dis)continuance of the environmentally-impacting action in question is one heavily laden with social values and dependent upon effective communication between the technical individuals or groups handling the risk assessment and the stakeholders who helped define the initial problem and who will be impacted by its resolution. This constitutes the risk management process--the definition of the

problem, the risk assessment, and the resolution of the problem which incorporates information from the risk assessment into the resolution process. This process takes place within the larger political arena that reflects society's priorities in regards to both short-term gains and long-term sustainability of the global ecosystem and human societies.

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