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EPA'S ECOLOGICAL ASSESSMENT CAPABILITY: THE NEED FOR ENHANCEMENT

Although EPA has statutory responsibilities for both human health and the environment, the Agency's approach to ecological protection is much less well-defined than for human health. This is partially due to the enormous complexity and variability of the natural environment and our lack of data on the diverse array of ecological systems. It is also due to the fact that there have been few, if any, comprehensive efforts to define what it is about the natural environment that is of interest and to guide the collection of data on ecological systems and the impact of human activities on those systems. In the absence of clear ecological goals we are ill-equipped to sort out potential ecological disasters from tolerable modifications of the environment. Consequently, we often must revert to a posture of either general resistance to any change or uninformed, yielding to the powerful pressures for economic development.

Ecological science has not been notably successful in resolving this dilemma. It provides us some principles which may be generally true but don't necessarily apply to specific situations. Also, most ecological data are either from intensive site studies which cannot be extrapolated easily to other sites, or from controlled laboratory studies which don't capture the full complexity of nature. Recently, however, there have been several successful instances of using ecological data to bridge this gap between the particular field site and the simplified laboratory. These include assessments of the aquatic resources at risk from acid deposition and the economic consequences to agriculture from the air pollutant, ozone.

To deal with ecological issues in a risk assessment mode, there are several questions we must be able to answer.

- What is it about the natural environment we are, or ought to be, concerned about?
- How can we measure these valued ecological attributes?
- What is the condition of our natural systems?
- How sensitive or robust are they?
- How are they changing?
- How are they likely to change as the result of human action or inaction?
- How can we assess the overall ecological risks of various human activities?

Some of these questions are being addressed by our present research and monitoring programs; others are being partially addressed; some not at all. Following is our evaluation of where we stand in being able to answer these questions and what might be done to improve substantially our future capability to do so. Also, we identify some ways by which EPA might be able, through research, to move beyond the somewhat negative posture associated with environmental protection to the more positive role of ecological enhancement. Finally, we propose an effort to use this new information to achieve ecological improvements by influencing the decisions of other agencies and levels of government responsible for resource and land use management.

WHAT SHOULD WE BE CONCERNED ABOUT?

One of the most fundamental limitations in our ability to assess ecological risks is lack of definition of what it is in the natural environment we want to preserve or enhance. Humans place value on their natural, living environment for many reasons, the primary ones being:

- Economic and Life Support Functions - Production of food and natural products, provision of atmospheric oxygen, flood control, waste processing, etc.

- Recreation and Aesthetics - Areas for outdoor recreation, maintenance of a pleasing landscape, preservation of symbols of our heritage (bald eagle), etc.

- Conservation - Concern that natural resources may have a future value not currently understood or appreciated (e.g., agricultural germ plasm), or that we may not be wise enough to predict all of the consequences of degradation of our environment and, therefore, should err on the side of conservation.

Because humans always will modify their environment and the environment always is changing naturally, absolute preservation is not possible. Therefore, we need to define what in the environment we value (endpoints of concern) and which components of our living environment provide those values (systems of concern).

The ecological endpoints which appear to be most closely related to social values are:

Productivity

- short-term (e.g., crop yield)

- long-term (e.g., maintenance of forests, fisheries, agricultural genetic diversity)

Species of Concern

- long-term population density (e.g., mallard ducks, grizzly bears)
- avoidance of local extinctions (e.g., game fish, songbirds)

Systems of Concern

- structure and diversity of communities, ecosystems and landscapes (e.g. shift in species composition of a forest, desertification)
- extent and distribution of ecosystems (e.g., wetlands, rain forests)

Life Support Functions

- prevention of food chain contamination
- materials cycling (e.g., O_2, CO_2, nutrients, wastes.)
- physical benefits (e.g., flood control, hydrologic cycling)
- useful by-products (e.g., pharmaceuticals)

It is possible to undertake an effort to define ecological endpoints and systems of concern and of regulatory relevance. This is not exclusively a scientific endeavor. Although it requires research on ecological functions which support human welfare, it must involve those who can articulate social values (e.g., public officials, interest groups) as well as scientists. The definitions must be expressed in terms that are scientifically meaningful and ecologically realistic, but they also must incorporate public values. This would require (1) a set of research projects to help identify systems with socially-valued attributes and aspects of those systems necessary to preserve the desired attributes (food chain linkages, biodiversity etc.), and (2) a carefully designed and managed set of interactions (workshops, etc.) among scientists and public representatives to define socially-valued endpoints.

We foresee this to be an evolving process, with completion of an initial full effort within about two to three years. At that point we should have a preliminary set of endpoints and systems of concern that could guide Agency regulatory activities. We should also have a sense of how rigorously this definition of systems and endpoints can be achieved and a realistic appraisal of how to proceed. It will not be an easy task or a task without controversy. However, it is essential to defining reasonable ecological goals for the Agency.

WHAT IS THE CONDITION OF OUR ECOSYSTEMS?

In addition to the lack of defined endpoints of concern, ecological risk assessments are hampered by lack of appropriate data. This is not surprising given the enormous complexity of the natural world. A great diversity of ecological systems exist. Each system is unique. All systems are changing. It would be impossible to study all systems and all factors causing ecological change. Yet, to answer such fundamental questions as "Are our ecological systems being degraded by human activities?" or "Are our environmental protection programs achieving the desired ecological improvements?", we must be able to:

- measure the present state of ecological systems
- determine the nature, rate, and direction of ecological change
- estimate ecosystem vulnerability and robustness
- determine the probable causes of degradation

Traditionally, such a comprehensive undertaking has been considered too complex to be feasible, and with the historical ecological approach of intensive site studies, this is probably true. However, recent advances in comparative ecological assessment bring this objective within reach, at least for a number of ecosystems of concern.

While each individual ecosystem is unique, there are classes of systems with common physical, chemical and biological attributes. Although no two ecosystems within a class are identical, they are sufficiently similar to permit useful generalizations. This method, successfully used for streams, lakes, and agricultural systems and currently applied to wetlands and forests, provides the basis for the following approach.

1. Establish the Present Condition of Ecosystems

   a. Define classes of ecosystems based on their common attributes, e.g. types of estuaries, wetlands, or forests. Often this can be done according to regional patterns of distribution.

   b. For each class of ecosystem, select a reference system(s). Usually these would represent those members of the class least disturbed by human activities. If no such examples can be found, determine other ways to establish reference conditions.

c. Define the parameters by which ecosystems within a class can be compared. These would reflect essential structural and functional attributes of systems which relate to the ecological endpoints of concern, e.g., presence of certain species or levels of productivity.

d. Compare a sample of ecosystems within a class to the reference system(s) to determine what portion of the class is substantially different from the reference conditions. These systems have presumably been degraded by environmental stress.

2. Identify the Nature and Rate of Change

a. Use nature's historical records (a limited number of which exist, such as tree rings and lake sediments) to determine changes that have occurred in selected ecological systems.

b. Develop a rational basis for measuring future change of ecosystems through long-term monitoring.

3. Identify the Relative Vulnerability of Ecosystems

a. Define the characteristics which make ecosystems sensitive or resistant to environmentally-induced change, including recovery mechanisms.

b. Compare the distribution of ecosystems according to their ecological value and sensitivity with the present and projected distribution of anthropogenic stresses.

c. Rank ecosystems according to their vulnerability, i.e. the combination of ecological value, sensitivity to stress and likelihood of exposure to stress.

4. Determine the Probable Cause of Degradation

a. Where current ecological conditions are unacceptable, or conditions are changing in an undesirable manner, conduct ecosystem-specific studies to determine the probable cause of these conditions or changes.

b. Rank the relative importance of human activities (e.g., air pollution, habitat destruction) causing undesirable changes in various ecosystem types.

Although this approach offers great promise, it has been used only recently and under limited circumstances. We propose an initial application of the approach, involving

- compilation, analysis and evaluation of present and historic data on all major ecosystem types

- selection of several major ecosystems for a pilot data collection and analysis effort, based on the systems' representativeness, the availability of data, and the probability of a useful outcome

- design and feasibility analysis of a long-term monitoring program

- research on selected topics of importance to this approach, e.g., specific measures for ecosystem comparison

With a major effort, in about two to three years, we should be able to provide

- a preliminary evaluation of the state of our ecological systems

- priorities for concern in terms of which systems are vulnerable or damaged and which human activities are causing this damage

- pilot implementation of long-term monitoring for selected ecosystems and a plan for future monitoring of ecological systems

HOW WILL SYSTEMS CHANGE AS A RESULT OF EPA REGULATORY ACTION OR INACTION?

Once we have defined the present condition of environmental systems, determined where this condition may be unacceptable, and identified the causes of degradation, we need to be able to predict how these systems are likely to change as a result of regulatory actions or our decision not to act. This requires sophisticated understanding of ecological systems and the ability to translate this understanding into quantitative estimates of their environmental change. Although not always adequate, much of EPA's current ecological research is directed towards these questions. This includes broad-based efforts to develop comprehensive ecological risk assessment methods, such as the EcoRisk Research Program, as well as research aimed toward particular problems of concern such as acid deposition. What is needed is to use the knowledge generated by our proposed approach to evaluate validity of current ecological research priorities; to complete and validate the required EcoRisk predictive terrestrial and aquatic ecosystem models; and to focus this knowledge on specific problems of current and emerging interest to the Agency.

One apparent need not adequately addressed by current research is development of a practical understanding of the direction, time course, and mechanisms of ecological recovery from natural and anthropogenic stress. Another need is for an improved understanding of ecosystem roles in the maintaining of productivity and biological integrity in landscape units. This understanding must be comprehensive enough to permit prediction of the long-term consequences of ecosystem stress, and broad enough to encompass the regional setting and values that control ecological and human health. To achieve this, we must conduct research in applied and landscape ecology that can identify and quantify the roles, functions, and vulnerabilities of community/ecosystem level processes that protect life-support systems, biodiversity, food chains, and general resource values. Such predictive landscape ecology will help the Agency to develop regional regulatory goals that preserve both ecological and economic values.

This enhanced understanding of ecological values and vulnerabilities would enable us to address specific problems and ecological systems of priority concern to the Agency:

- Atmospheric Change - Considerable effort has been devoted to acid deposition. A small on-going effort deals with stratospheric ozone depletion. An effort is planned to begin this year on climate change. Other potential problems such as transport of toxic organics and metals are not being addressed. Except for acid rain, a substantial expansion of all these efforts is needed.

- Hazardous Waste Disposal - The Agency's ability to factor ecological considerations into its prioritization of Superfund sites is inadequate. Assessment of both site-specific and cumulative impacts is required. Better understanding of ecological impacts, lateral transport of contaminants from hazardous waste sites, soil ecology, and effects of soil microorganisms on contaminant behavior will allow design of more effective site monitoring methods, including the use of bioindicators. Research on these problems is limited and needs substantial strengthening.

- Accidental Chemical Spills or Releases - The Agency is developing an information base on health effects of chemicals for the Chemical Emergency Preparedness Program. Comparable information is needed for ecological impacts and ecosystem recovery, such as those related to fishery contamination.

- Biotechnology - The Science Advisory Board recommended an expanded research effort to assess possible impacts on natural communities from genetically engineered microorganisms, including organisms developed to degrade environmental pollutants. EPA's research on this topic remains very limited, given the implications of this exploding new industry. A more concerted effort should be pursued.

- Nonpoint Sources - Nonpoint source activities are probably the largest remaining cause of degradation of our aquatic resources. Because of the nature and complexity of these sources, they are not easily assessed by traditional approaches and are especially amenable to the broader ecological approach proposed by this initiative. A number of nonpoint source management techniques (BMPs) have been identified, but their potential effectiveness has not been tested against ecological endpoints of concern. The diversity of agencies and levels of government involved in managing nonpoint sources makes this problem especially appropriate for a research-and information-sharing, rather than regulatory, approach.

- Estuarine and Coastal Waters - An expanded research effort should be pursued for estuaries and coastal waters, which are the ultimate recipients of many toxic contaminants. The impacts of eutrophication, changes in salinity patterns, and nonpoint source runoff, as well as physical habitat destruction from dredging and wetlands loss are not well characterized nor understood.

- Wetlands - A significant start was made last year on wetlands research. As the program has moved ahead, the demand for scientific information has expanded and additional research needs have emerged. Increased resources would provide substantial gain for the Agency in dealing with problems of wetlands mitigation and water quality benefits.

HOW COULD WE CHANNEL ECONOMIC GROWTH TO ACHIEVE ECOLOGICAL BENEFITS?

The previous sections of this document deal with ecological risk assessment. Ecological science offers an additional role of providing ways to balance economic growth and ecological protection. Our economic and population growth, especially as they impact land use, are large factors influencing ecological values. In some instances, information gained from answers to questions we pose could have an unintentionally negative influence on economic growth. These questions as stated in this initiative tend to focus on potential ecological harm rather than identifying new ways to balance society's seemingly conflicting goals of economic growth and preservation of ecological values. For example, the multibillion dollar Westway Project for New York City was indefinitely postponed largely because the loss of a critical striped bass nursery area was considered an unacceptable ecological cost. While there was general agreement that such a loss would be unacceptable, there was little agreement whether an alternative nursery area could be developed because of the minimal, inclusive research. Even though there may be no reasonable alternative nursery sites for Westway, the lack of information on potential alternatives

precluded consideration of this possibility. Similar examples can be found for endangered species, wetlands protection and mineral exploration. If we knew more about possible mitigative measures for various types of development, we could avoid some of these "all or none" decisions and, by influencing planning at an earlier stage, reduce the number and intensity of confrontations over development vs. environment.

While the Westway Project provides an example where the ecological consequences of an economic project are clear, most development is implemented without adequate consideration of potential unacceptable ecological consequences. This is due more to a lack of understanding of ecological values as they pertain to the particular project than to a lack of concern for such consequences. For example, for many years we filled and drained large areas of wetlands before we comprehended the ecological losses. We are now modifying our policy to reduce the loss of wetlands but we still do not know if we will be able to maintain their quality and ecological diversity.

Nearly all of the ecological research sponsored by EPA and proposed in this paper is concerned with preventing undesirable ecological changes resulting from human activities. We have been conditioned to accept that any and all human activities will adversely impact our environment, which is not necessarily true. What we have not considered are the actions possible not just to protect, but to enhance ecological values. If ecological improvements could be incorporated into economic development projects at small additional cost, through their advocacy, EPA might be able to assume the role of an enhancer as well as a protector of the environment. For example, it may be possible to go beyond present regulatory programs to encourage the creation of new wetlands, as well as prevent the loss of existing ones.

Specifically, three research approaches are possible:

- Assess ecological systems that are subject to damage from particular types of economic or land-use development and develop technical guidelines to steer development activities away from the more sensitive and valuable systems to those of less vulnerability and ecological value.

- Assess and develop mitigative measures for selected types of development activities which could help offset or remediate the ecological impacts of these activities.

- Explore ways to build enhanced ecological values into our current landscape and into new development projects.

An initial modest investment and cautious, small scale testing and evaluation are recommended. Within about three years we should attain a sense of the technical feasibility and value of this approach.

HOW CAN WE USE OUR RESEARCH PROGRAM TO INFLUENCE OTHER AGENCIES AND LEVELS OF GOVERNMENT?

The condition of the natural environment is affected by many human activities other than those which cause pollution, such as habitat destruction or modification (e.g., filling of wetlands), resource misuse (e.g., overharvesting, overgrazing), species introductions (e.g., Dutch elm disease), atmospheric change (e.g., fossil fuel combustion), as well as

the combined effects of these activities plus pollution. This means that many activities which affect the natural environment are under the jurisdiction of agencies and government bodies other than EPA. Currently there is no coordinated means by which these diverse authorities can assess the cumulative ecological implications of their actions. No one is effectively relating the parts to the ecological whole.

We propose three components to this effort.

- Assess the overall ecological impacts of selected resource and land-use activities. Such an effort would have substantial implications for the scope of EPA's research programs, which have so far concentrated on pollution-related problems. Within two to three years, we could provide an assessment of several major land-use activities and an overall evaluation of government-wide monitoring for ecological effects from land-use and resource management activities, including recommendations based on several tested prototype monitoring systems. We also could provide guidelines for a standardized collection of environmental data. The level of effort could vary widely depending on Agency emphasis.

- Couple with this assessment of the ecological consequences of various land and resource use activities an organized effort to disseminate the conclusions of these assessments to all appropriate levels of government. This calls for new staff capability, either within or outside the Agency. It is assumed that this staff would attempt to operate in an impartial risk-assessment mode, and a major management challenge would be how to maintain an objective rather than advocative posture among this staff. The Agency could then choose whether, and how, to use this information to persuade or influence other public bodies to take actions for ecological protection. NEPA offers one mechanism available for doing this.

- Mount a focused effort to communicate information on ecological endpoints and systems of concern to academia and other research bodies so the national research community will become more directed towards important ecological goals and therefore more involved in public decision-making.

CONCLUSION

Traditionally EPA has used ecological science to respond to specific problems rather than to anticipate problems. This has resulted in piecemeal information and decisions which don't account for the full complexity of nature. Even while we appear to solve specific problems, we lack confidence that our actions will result in actual ecological improvements. Each new problem forces us to gather new data, since there is no comprehensive ecological baseline.

We propose to develop the information necessary to give greater focus to our ecological assessments. Ecological science has evolved to the point where, at least for certain ecological systems, it is possible to

- define ecological endpoints of concern and of regulatory relevance
- assess the overall condition of the environment relative to these endpoints
- define the major causes of degradation of these ecosystems
- develop plans for establishing ecological baselines for the future

We propose a major effort to apply this approach to selected ecosystems. At the end of two to three years, we should be able to recommend an overall ecological assessment/monitoring program for the Agency. The ecological endpoints and priorities from this effort would provide considerable "leverage" for ecological decisions made by the EPA and other public bodies.

We believe that now is the appropriate time to apply ecological science more vigorously to specific Agency concerns by

- assessing particular environmental problems of concern, e.g., atmospheric change
- undertaking specific research activities of high need, e.g., mechanisms of ecosystem recovery
- developing technical guidelines to mitigate the effects of economic and land-use development, and to enhance rather than just protect ecological systems

These activities involve interests and expertise found in other Federal agencies. Throughout, these proposed steps would involve close cooperation with the appropriate agencies.

We believe that EPA has an unusual opportunity to develop the scientific basis for setting national ecological goals. No other public body appears to be as appropriately positioned as EPA to assume this leadership role. The need is apparent and it would appear to be best accomplished through research and information sharing at all levels of government.