
NATURAL RESOURCES JOURNAL

Volume 13
Issue 1 *Winter 1973*

Winter 1973

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AGGREGATES AND EXTERNALITIES: INFORMATION NEEDS FOR PUBLIC NATURAL RESOURCE DECISION-MAKING*

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Environmental impact statements required by the National Environmental Policy Act (NEPA)[1] and the multiple accounts embodied in the Water Resource Council's (WRC) revised evaluation procedures are but two responses to an increasingly articulated need for greater and more diverse information upon which to base public decisions about the uses of natural resources. But the difficulties involved in implementing Section 102 of NEPA and in adopting the WRC procedures attest to the uncertainty and disagreement over just what new information is needed. In this paper, we discuss the problems underlying the demands for more and/or different information before public decisions concerning natural resources are made. For the most part, we leave to others the discussion of the institutions which may be required to generate information and to use it effectively.

THE DECISION-MAKING PROCESS

Information requirements for public decision-making are defined by the political institutions and processes involved. Accordingly, the comments offered below on informational needs for improved decision-making rest upon our conception of the processes. Three aspects of this conception seem particularly significant. We view natural resource decision-making in the United States as essentially: (1) problem solving, (2) pluralistic, and (3) locally oriented.

A. *Problem-Solving Orientation*

The problem of decision-making arises because there is doubt about what should be done. Confused and unsatisfactory situations exist but it is not clear what can or should be done to improve matters. These situations must be analyzed and appropriate information must be brought forward in order for satisfactory choices to be made.

A number of authors have outlined the steps to be taken in such a problem-solving process. Most formulations include such steps as defining the problem, establishing objectives, formulating alternatives,

*The authors gratefully acknowledge support from their respective institutions and from the National Science Foundation (RANN) and the Office of Water Resources Research.

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1. 42 U.S.C. 4321 *et seq.* (1970).

evaluating alternatives, choosing among alternatives, implementation and validation. A formulation which we have found useful in previous work is set forth elsewhere.[2] Space does not permit a discussion of the process here. However, there are some implications which we would like to develop.

First, the need for a decision presupposes the existence of a problem. Defining that problem adequately sets the course of further inquiry, whether it be called decision-making, planning or some other name. Too facile or uncritical a problem definition—often caused by acceptance of a mere symptom of the problem as the problem itself or acceptance of a pre-existing statement of the problem—may be fatal to the ultimate success of the investigation. Resource planning should begin with collection and analysis of information which will help to define the problems to be attacked. It should not proceed to subsequent steps until a clear understanding of existing resource use patterns, conflicts, and interest group positions has been achieved.[3]

Second, the objectives which are chosen to guide the search for alternatives cannot be given *a priori*. They must arise out of the analysis of the problem to be solved. Their status should always be tentative and subject to revision, at least until a successful solution of the problem has validated them. To employ *a priori* objectives established outside the context of the specific problem under investigation is to run the serious risk of misconceiving the true nature of the problem and of failing to resolve it. To further regard such objectives as fixed and not open to revision during the problem-solving process is to compound the error by refusing to use what is learned as inquiry proceeds.

Third, objectives must be sufficiently specific to guide the search for alternatives (often called plan formulation in the context of water resources decision-making). Broad general objectives (perhaps better called social goals) such as economic growth, environmental quality, and equity are not useful, as experience has shown. They are so broad that there is an impossibly large number of alternatives for attaining them—far too many to permit careful examination and comparison in a finite decision-making context.

It is on these three rocks that the water resource planning objectives provided in the Water Resources Council's new proposed evaluation procedures must founder, even as the single objective of benefit-cost analysis has foundered in the past. Broad, general, fixed,

2. Airhart, A Study of Public Participation in the Upper Rock River Basin Survey (1972).

3. *Id. See also* D. Bromley, A. Schmid, W. Lord, *Public Water Resource Project Planning and Evaluation: Impacts, Incidence, and Institutions* (1971) (Center for Resource Policy Studies and Programs, Univ. of Wisconsin).

and *a priori* objectives simply cannot effectively guide the search for alternatives. At best, they can function as constraints, as the economic constraint of benefit-cost analysis has functioned in the past.

Fourth, information which is collected and presented as a part of the decision-making process should be related to the objectives which have been tentatively established and should be gathered with a clear view towards further elaborating or revising those objectives. Far too much time and money have been expended in the past in collecting biological, hydrologic, and economic data which bore no clear relationship to the problems under investigation.

Fifth, the decision-making process is an iterative one. As the investigation proceeds through the sequence of steps previously enumerated it must always be possible to return to earlier steps and revise the problem definition, the objectives, and any alternatives which have been formulated when subsequent information sheds new light on the situation. Planning activities are all too often rigidly scheduled in such a way as to prevent or at least impede iteration.

B. A Dependence on Pluralism

Ours is a pluralistic society composed of many diverse groups possessing a wide variety of value preferences and beliefs. It is a tenet of our political system that "wise" policy results when these groups represent their interests in the political arena and arrive at an accommodation. This implies that all viewpoints are represented by groups and that the distribution of bargaining power or political influence between groups is optimal. In natural resource use policy-making, as in other areas, there is no reason to believe that either of these assumptions is fulfilled.

Yet a third assumption is that all groups are able to recognize the issues which affect them and are able to assess the extent of those effects. This assumption, also, is frequently unfulfilled in reality. However, we define the objective of providing decision-making information to be that of alleviating this deficiency. In other words, information should be generated and communicated in the decision-making process in such a way that all concerned groups may become better aware of the choices open to them and of the implications of those choices for them. Only when armed with such knowledge can they protect and improve their welfare through participating effectively in the political bargaining process.

C. A Local Orientation

Most natural resource problems in the United States have been perceived as primarily local in nature. Such things as flood control,

water supply, recreation, range management, timber production, management of non-migratory wildlife, and water quality control are usually quite location-specific. There is little reason to expect this situation to change rapidly. Most Federal natural resource projects have arisen in response to such locally perceived problems.

Of course, the ways in which the problems are addressed often carry consequences of regional or national concern. Such broader implications have helped to shape decisions in the past and will do so ever more forcefully in the future. But however clear this broader interest may be, the stimulus to planning is most often one or more problems of local scope. The planning or decision-making process cannot be considered successful until it effectively deals with those local problems, either by developing solutions for them or by showing that no solution is possible which does not create more serious problems than those which would be solved.

National environmental or natural resource use problems exist, too. Those which led to the creation of the national wilderness preservation system represent just one example of the many which could be cited. Although the discussion which follows is not oriented primarily towards such problems, we believe that it is largely applicable to them as well.

TWO LEVELS OF CONCERN

There are two different levels of concern evident in conflicts over the effects of natural resource use decisions, in addition to the concern that the original problems be resolved satisfactorily. The first is specific to a particular decision and is normally expressed by persons or groups likely to be affected quite directly by the decision to be made. For example, fishermen and canoeists often perceive themselves to be adversely affected by the proposed construction of a dam. Similarly, residents of an area contiguous to a proposed new airport clearly stand to suffer from the noise and congestion which the airport will bring. We are dealing here with side effects of problem-solving activity. These side effects are analagous to the externalities which are frequently produced by economic activities in the private sector, and we shall refer to them as externalities in subsequent discussion. It will be obvious to many readers that our suggestions for dealing with those externalities closely parallel the recommendations of many economists for "internalizing" externalities in the private sector.

The second level of concern which is widely evident in conflicts over the effects of natural resource use decisions is also rooted in the possible existence of externalities, but in a much more general sense than that just discussed. Concerns at this second level involve effects

acting over longer time intervals on all segments of society. Unlike those of the first level of concern, these externalities cannot be associated with specific groups or interests who might "bargain" for their internalization.

The bargaining process which characterizes group-pluralist decision-making is well suited to deal with the specific and well-defined externalities which are the subject of the first level of concern. The "muddling through" process is *ad hoc*, piecemeal, and experimental. It deals with particular problems, as they arise, based largely on their similarities to other problems which have been previously resolved. The second level of concern, by contrast, anticipates problems far different in degree, if not in kind, from those which society has successfully resolved in the past. It is based upon general systems thinking (ecological or economic) which stresses interrelatedness and discounts the effectiveness of piecemeal solutions.

A. The First Level of Concern

One of the authors has argued elsewhere[4] for a more disaggregated information display than that traditionally employed in public natural resource decision-making (benefit-cost analysis is the most formalized of these traditional approaches). We will briefly summarize that argument here.

Our points of departure are the iterative decision process and the group pluralist institutional structure, as previously explained. The nature of the planning process requires that the information which is assembled to facilitate the evaluation of alternatives serves at least three purposes. First, such information should provide the basis for a judgment as to how successfully the alternative in question will achieve the plan formulation objectives previously established. Second, since those objectives were posited tentatively as ways of resolving the problems which gave rise to the inquiry in the first place, the information should shed light on the suitability of the objectives themselves. Third, the information assembled should reveal any new problems which adoption of that particular alternative might create. If it does so, then additional or alternative plan formulation objectives can be established to address those problems and new alternatives can be formulated in a subsequent iteration of the planning process.

The group pluralist institutional structure requires that the infor-

4. Lord, *Information Requirements for Environmental Decision-Making*, in Economics and Decision-Making for Environmental Quality (J. R. Connor and E. Loehman eds., forthcoming). *See also* D. Bromley, A. Schmid & W. Lord, Public Water Resource Project Planning and Evaluation: Impacts, Incidence, and Institutions (1971) (Center for Resource Policy Studies and Programs, Univ. of Wisconsin).

mation display reveal the probable impacts or consequences of each alternative upon the major interest groups likely to be affected. The information should be in such a form and of such a kind as to be meaningful to those groups. If this is accomplished, each group can then assess its stake in each alternative and can participate in the intergroup bargaining process leading to eventual agreement on a particular alternative.

Considerations such as these suggest a two-dimensional information display for evaluation purposes. The first of these dimensions is the type of effect produced by the alternative being evaluated. All of these effects can be described in physical terms, and most of them can be quantified. All of them should be expressed ultimately in terms which enter into at least someone's preference function—in terms which relate directly to the original problems or to new ones which might be expected to arise. Thus, although it may be useful to show the degree of improvement in dissolved oxygen conditions in a certain water body (particularly if one of the plan formulation objectives is to raise D.O. to a specified level), it is also necessary to show the effect of this improvement on the various uses made or to be made of that water.

Types of effects may be differentiated broadly into monetary and non-monetary categories. The monetary category includes those effects which can be brought to a single basis of comparison (monetary units), usually because they are exchanged through market transactions and are priced. This presumes that the exchange ratios (prices) assigned by the market are broadly accepted estimates of the (marginal) importance of these effects. The monetary category should be further differentiated into market and non-market sub-categories, in recognition of the fact that monetary values are customarily assigned to some non-marketed effects on the basis of a variety of analytical techniques of varying levels of acceptability.

Many effects of public resource allocation decisions are not the subjects of market transactions and cannot be assigned reasonable monetary values with available analytical techniques. Such affects must be listed in non-monetary or physical units which are normally non-commensurable, although we subsequently refer to a few recent approaches for attaining at least some degree of commensurability (through the development of environmental quality indices, for example).

The second dimension of the information display is the incidence of the effects produced by a course of action. For political decision-making purposes, as we have said, it is important to show who receives the various kinds of benefits or bears the various kinds of costs of an

alternative. Appropriate categories here may include geographic regions, units of government, industrial sectors, and other kinds of interest groups. Traditional evaluation approaches, notably benefit-cost analysis, have led to poor decisions in part because they have over-aggregated information on the incidence of effects, thus encouraging uninformed reaction and irrational positions in favor of or in opposition to many alternatives.

The foregoing is a very brief description of the major elements of an information display which should facilitate better evaluation of public choices from the point of view of the first level of concern. An illustration of its application is available.[5]

B. The Second Level of Concern

We have described an information system which seems to us well suited to improving the efficiency of natural resource decision-making. But the type of improvement it would produce is defined in terms of the first level of concern, that which reveals the direct or immediate externalities that might be produced by undertaking a specific public project.

A notable deficiency of our proposed information system is that it does not come to grips with problems subsumed under the second level of concern. These are problems which are more aggregate in nature. They are likely to be matters of national or at least regional concern. Furthermore, they are more appropriately matters for program level analysis rather than project level analysis.

It is tempting to suggest that broad, comprehensive program planning be employed at the Federal level to deal with the second level of concern. Nonetheless, it seems to us that our analytical tools and our knowledge of the workings of broad social and environmental systems are far too primitive at this time to support the kind of centralized and comprehensive planning which would be required to devise optimal national programs.

C. Environmental Quality Indices

The National Environmental Policy Act has stimulated the development of several schemes for quantifying environmental quality. It is not always clear how the resulting environmental quality indices are intended to be used in decision-making, but presumably all are attempts to deal more adequately with second-level environmental

5. S. Born & W. Lord, Chippewa Flowage Investigations (1972) (Univ. of Wisconsin Environmental Resources Unit).

concerns. That developed by Leopold[6] rates a variety of environmental impacts on the basis of magnitude and importance. The Battelle environmental quality index[7] recognizes 78 separate environmental parameters and uses a system of weights, representing the aggregate judgment of a panel of experts, to indicate their relative importance. Stover's scheme[8] has similarities to those of both Leopold and Battelle, but also incorporates a time dimension and provides a specific method for comparison of design alternatives.

Although they vary in approach and in possible mode of application in decision-making, the several environmental quality indices share certain common features. All provide quantitative measures of the magnitudes of selected environmental attributes and most additionally achieve some measure of comparison between different environmental attributes by including a system of value weightings. But those value weightings, although necessary to achieve comparison, are basically arbitrary in origin.

We do not wish to discourage attempts to develop quantitative measures of environmental impacts or to discourage inquiry into the ways in which social value judgments are and can be made. Indeed, quantitative measures have several important features of real value. In a purely pragmatic sense, they may allow the consideration, albeit imperfect, of environmental concerns otherwise ignored. More fundamentally, by incorporating specific value weightings they may provide the necessary arena for full public discussion on what appropriate weightings might be. Nonetheless, we are forced to conclude that the indices of environmental quality which we have examined carry more danger than promise if adopted in their present forms. It is too easy for a busy decision-maker to accept uncritically a numerical value, whether embodied in a benefit-cost ratio or an environmental quality index. It is also too easy for such an index to become a substitute for full public information and the resolution of conflicts by creative plan formulation and political bargaining.

D. Plan Formulation Constraints

To avoid the pitfalls of over-reliance on quantitative indices and yet improve upon our present methods of addressing the complex large-scale problems which characterize the second level of concern,

6. L. Leopold, A Procedure for Evaluating Environmental Impact (Geological Survey Circular No. 645, 1971).

7. Dee, Final Report on Environmental Evaluation Systems for Water Resource Planning to Bureau of Reclamation (Jan. 31, 1972, Columbus, Ohio: Battelle Memorial Institute).

8. Stover, Environmental Impact Assessment: A Procedure (1972).

we propose a revitalization of the notion of constraints. Although primitive in concept, the use of constraints or limits is likely to be a more practical and successful approach than more sophisticated optimizing techniques which require more and better information than we are likely to have available for some time to come.

Environmental and social systems analyses should be undertaken to explore the implications of major public programs, in the broadest terms. These analyses will suggest appropriate constraints to be imposed upon Federal project decisions, which would otherwise reflect largely local concerns. The familiar efficiency criterion of benefit-cost analysis as it has been applied, albeit imperfectly, is in practice a good example of such a constraint. The time is now ripe for the incorporation of other constraints in a similar fashion in public decision-making. The confusion which surrounds the attempts to make the Environmental Policy Act[9] workable and useful would be much reduced if some other constraints could be established and employed.

If we wait for perfect information upon which to base the establishment of additional constraints or limits we will never have them. It is our contention that enough is known now to establish several constraints, in addition to economic efficiency, which will greatly improve public decision-making and which will stimulate investigation and discussion, thus leading to still further improvement in the future. Because constraints are established within a context of uncertainty and considerable ignorance they should be viewed as tentative, subject to revision or even replacement, and subject to some flexibility in application. As the results of systems analyses become available, the criteria should be modified in keeping with the better understanding of systems effects which will then obtain.

It is much easier to propose and to defend the use of national constraints or limits in natural resource decision-making than it is to suggest what those contraints should be. This is a consequence of our ignorance of the workings of environmental and social systems and of our uncertainty about what optimal value weightings might be. Nonetheless, we shall discuss briefly several plausible constraints in order to illustrate the application of the concept and encourage further discussion of specific constraints or limits.

1. Economic Efficiency

This traditional constraint requires that an honestly computed benefit/cost ratio be greater than unity. It reflects a concern that the nation's output of marketed goods and services is at least not reduced

9. 42 U.S.C. 4321 *et seq.* (1970).

by adoption of the action under study. It is a less comprehensive index than the theoretical social welfare function of the welfare economists, for it comprehends only marketed goods or services, and those which can be assigned reliable monetary values.

2. Income Distribution

This constraint would require that a proposed action not result in a less equal distribution of money incomes than would prevail in its absence. The Gini coefficient, familiar to economists, provides a standardized index of the degree of equality of income distribution. It can be applied to the population to be affected by the proposed action under study.

3. Equity

This constraint would require that the costs of pursuing a particular action be borne by those who would benefit from it. An equity constraint competes with and may be inconsistent with the income distribution constraint. It also supplements the efficiency constraint by realigning incentives in such a way as to discourage enthusiasm for inefficient alternatives. Its inclusion would lead to more specific identification of beneficiaries and cost-bearers, perhaps the single most important step to be taken to improve public decision-making.

4. Diversity

The importance of diversity, in both natural and social systems, has been highlighted by many writers. The maintenance of diversity represents a hedge against uncertainty by preserving a wide variety of options and potentials. In addition, diversity, at least for natural systems, generally implies a more stable system, maintaining a capacity for incremental adjustment but less vulnerable to catastrophic disturbance.

Existing indices of diversity[10] in plant and animal communities are difficult to measure and do not take into account non-living aspects such as visual diversity, soil and bedrock types, etc. When we consider social systems, which may be even more complex and less clearly understood, and in which human preferences become an important factor upon which to construct a classification of those elements to be included in any measure of diversity, the task of quantification becomes formidable indeed. Despite these imposing problems, we believe that a diversity constraint, even though beset by definitional and measurement problems, would be useful at this point in time.

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10. The commonly used Shannon-Weaver diversity function is discussed by Ramond Margalef in the 1969 Brookhaven Symposium, *Diversity and Stability in Ecological Systems*, at 25.

5. Closure

This constraint would require that some provision be made for amelioration of all potentially harmful physical by-products of the action under study. The range of possible provisions could be very broad, including such measures as recovery and chemical conversion of toxic wastes, treatment of organic wastes, utilizing the assimilative capacity of natural systems, and by-product recovery and utilization. Two standards of application might be appropriate; one somewhat permissive standard for naturally occurring or readily degradable substances and a much less permissive standard for synthetic substances which are not readily degradable. This distinction would recognize the greater danger potential of synthetic substances for which natural assimilative processes have not evolved, and the consequently greater uncertainty about their long run consequences for some or all forms of life.

It is apparent that it would be impossible to employ inflexible constraints of the type which we have suggested. Some degree of mutual inconsistency exists between them, so that to adhere to one may mean to violate another. None is absolutely desirable. And each is imperfectly understood, so that it should be regarded as only a rough guideline. But such considerations do not detract from the argument that each stands for an important consideration, however imperfectly understood. To employ such constraints, even quite flexibly, is to require planners to assemble and present pertinent information, and thus to permit and encourage political debate and consideration. We believe that this would be a helpful step forward.

Planners would be required to present an analysis, for each specific constraint, showing whether a particular course of action violates that constraint. If a violation were proposed, a showing of justification for the violation would be required. This would likely hinge upon an analysis of the trade-offs between the various constraints, or between the constraints violated and the plan formulation objectives adopted for the project under study. Such an analysis would have to be the result of an examination of alternatives for meeting the objectives of the plan formulation.

SUMMARY

We have discussed the information required for better natural resource decision-making from the point of view of three essential functions. These functions are: (1) definition of the problems to be attacked and the propounding of effective solutions, (2) exposure of the immediate additional conflicts which such solutions may generate, so that they may be addressed in the planning process and, (3)

avoidance of some of the broader adverse consequences of natural resource decisions in the aggregate, national level. Our suggestions are based upon a view of the decision process which is problem-solving in nature, usually local in initial focus, and conducted within the context of a group pluralist political system.