STRUCTURING INFORMATION
FOR ENVIRONMENTAL MANAGEMENT

by

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One strategy for improving land management processes is to improve the available technical information tools. This thesis summarizes the concerns and designs a checklist for organizing data in structures that inform policy and decision makers about the environment.

The first part of the analysis investigates the components of land management--the political system, the actors, the problems confronted and the responses formulated. Policies and decisions are categorized to determine the major roles that technical information plays.

Currently available environmental information systems are described in the next segment. Their major characteristics are evaluated for performance in policy and decision making applications. By keying the information structures to the roles of data in land management, strategies for improving information use are outlined.

A series of short case studies demonstrates the value of matching information systems with policy or decision requirements, and illustrates approaches to improving the use of environmental data.

The thesis concludes with a summary of options and concerns for environmental information structures. The checklist can be used to design information tools that guide and improve the process of land management.

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CHAPTER ONE

LAND MANAGEMENT: POLICIES, DECISIONS AND INFORMATION

Politicians and administrators charged with responsibility for land management are influenced by, and react to, a varied environment of issues, inputs and constraints. The policies they formulate and the decisions they make are products of interest group pressure, exposure to information, political calculation and social preferences; to sort out the relative weights of these factors is virtually impossible, but they are all important variables.

This thesis investigates manipulating one of these factors --technical information--as a strategy for improving the quality of land management policy and decision making. Information about the environment and the impacts of land use alternatives is becoming increasingly available. Learning to incorporate this material into land resource allocation choices is necessary for maintaining or improving environmental quality and minimizing the ecological damage connected with development.

We have available incredible quantities of information about natural processes and environmental impacts. But land management and planning processes do not yet make effective use of these data resources. Devising methods to increase the inputs of technical information to policy and decision makers is required to capitalize on human, technological and financial investments in data collection.

We all acknowledge the plight of the environment and the needs for regulating land use to prevent deterioration of valuable resources. However, the often-repeated solutions to the 'ecological crisis' invoke restructuring social priorities and halting economic growth that damages the global ecosystem; transforming cultural man/nature attitudes to restore harmony; engineering technological assaults on ecoproblems; or recasting the economic system to internalize all externalities, thereby eliminating 'uneconomical' reductions in environmental quality.

Some or all of these metamorphoses may be ultimately essential if a well-managed environment is ever to be achieved. But such changes do not occur instantly--they take decades. In the meantime, land management-related problems must be solved by applying the information, skills and decision processes now existing.

Therefore, I intend this as a pragmatic study--to design methods for efficient use of available technical information in formulating land management policies and implementing decisions.

I must first define the groundwork for the thesis. There are, of course, assumptions behind much of the analysis that should be made explicit. Given the need for improving the quality of land management processes, two questions must be considered. What are the attributes of a 'better' policy or decision? How can management processes be improved? I think 'good' land management exhibits the following qualities:

(i) increasing citizen involvement and understanding in land management issues and processes;

(ii) increasing emphasis on interpreting information about the environment; decreasing emphasis on political viability as a key determinant of land management; that is, shifting the criteria for judging 'good' and 'bad' policies from political to technical success;

(iii) increasing concern for the environmental impacts of decisions, especially the long term consequences;

(iv) increasing the scope of concern--understanding the 'connectedness' of environmental processes and land management practices.

How can information management improve policy and decision making? If we assume that policy and decision makers want to act based on weighing environmental consequences, then they must want access to information. Their failure to consider existing data may be as much a fault of current information management and the behavior of technocrats as it is a defect in the established political system. On the other hand, if land managers place highest priority on the political viability of policies and decisions, effective information use may still upgrade the overall land management process. More effectively structured and communicated information will fall into the hands of other actors* who <u>will</u> use it. Either way, increasing

* This is part of the rationale for environmental impact statement review --the development interest (with a concern for the nature of public opinion) must identify and mitigate adverse environmental effects; the 'environmentalists' benefit from public disclosure of the information and the right to challenge the validity of the statement or the protection measures adopted.

the transfer of information to actors in land management processes encourages 'better' resource allocation choices.

The important objects of the analysis are land management policies and decisions and structures for the use of information. To clarify the nature of these components, which is difficult to discuss abstractly, and to illustrate the problem-focus of the thesis, I have composed a scenario. This brief story draws heavily on a real event, involving policy and decision makers in local government land management.

* * *

The members of the Seaside Conservation Commission wanted to be more active in their town. After all, they had a duty to protect Seaside's natural environment and there were many land parcels they thought should be guarded from development. For the past few years they had enforced the state Wetlands Protection Act*, purchased two small sites (an abandoned quarry and a wharf) using funds donated by private sources, planted elm trees, and conducted conservation walks on Sunday mornings. Spurred by the new chairman, though, all the members agreed that the Commission should be more dynamic, and make more positive efforts within its mandate.

But the annual budget from the town did not provide much money for 'dynamics'. The members thought they needed a lot more funding to be effective; and the best places for funding,

* handing out cease and desist orders to people filling marshes; recommending decisions to the Town Council and Planning Board on development proposals.

of course, were the state and federal self-help programs. A successful grant application could bring in 50% matching dollars from the state legislature, and 50% of the remainder from Congress. Therefore, the town only had to put up one quarter of the cost of any approved project. The members thought this was fantastic. But there was a catch. To be eligible for conservation-related grants, the town needed an Open Space Plan, and Seaside didn't have one; it didn't have a local planner or a regular planning consultant, either.

The Commission members were convinced that they needed professional assistance to articulate their concerns, collect the necessary information, actually write the plan and lend credentials to the document. So the Conservation Commission contracted with a consulting group to prepare the Open Space Plan in accordance with the sample outline from the state government. The state guidelines required a 'Goals and Objectives' section and a 'Five Year Action Program', in addition to demographic, physical and recreation-related information. Hoping to elicit the members' attitudes and the Commission's stance on preparing the plan, the consultants initiated discussion on the Goals and Objectives:

"We aren't sure what goals and objectives are--what's the difference?", the members first wanted to know.

"Goals describe the overall direction you want open space planning to take, the future conditions you want to aim for. Objectives are specific, short range steps toward them. For the plan, you're asked to summarize your 'goals and objectives' for conservation and recreation open space in Seaside."

"We want to protect Seaside's environment. There are lots of beautiful places here. Sort of a greenbelt through town--a buffer--to guide development, that's what we think. Like that new industrial park proposal. If that goes through, we want to have lots of land around it, to keep it clear of residential areas. Personally, I'm against the industrial park. They'll fill in Benson's pond, they'll pollute the creek. I know Seaside needs the jobs, but who'd want that thing in their back yard? Not me."

"Mostly, we want to apply for grants to buy certain parcels. There's the quarries, and the Henderson land, 110 acres we might get for free. We've got to get the money, though. We've tried conservation restrictions and easements. We made an agreement on a parcel once, but it didn't work--those easements are no good. The Commission's got to control the land to be safe."

"Let's not talk about specific parcels just yet. What's your general sense of what open space should be doing for the town; what do you want to accomplish for the town, in the long-run, with this Open Space Plan?"

This line was clearly puzzling most of the members.

"We want to preserve the best parts of Seaside's undeveloped areas--by acquiring them, and some we'll try and get donated," asserted the chairman. "And with the backing of an official plan--maps we can put in front of people--we can say 'Look here, it's in the plan, why don't you help us out' to people who might give land."

"What do you want to do with the land?"

"First we want to get it--then we'll concentrate on how to use it."

The planners thought they had better shift to a different perspective.

"The Open Space Plan is supposed to talk about more than just land acquisition. It should cover 'recreation' in a broader sense--open space like parks, playing fields, beaches; recreation facilities like tennis courts, baseball fields; and recreational programs. One of the most important considerations is that the plan relate to the community's needs. What do people in town want, for open space?"

"Baseball and tennis fields? The Recreation Committee looks after those. The Conservation Commission can't apply for grants for that; its not conservation acquisition. Besides we have more than enough in town."

"Then maybe you should work together with the Recreation Committee. We can talk to them, and include their ideas in the plan."

"Well, its <u>our</u> plan remember, but we could recommend that we work together in the future."

"What about the needs or wants of people in town. Do you think we should talk to people, hold some meetings, to get their ideas?"

"After the plan is written. Then we can show them the report and we can get ideas on what kinds of programs should be undertaken. We'd like to cut some trails, maybe bicycle paths. We want you to talk to the Department of Public Works--they're going to expand the watershed, by 300 acres, and we'd like to know what kinds of things can happen on that watershed land."

It was time to bail out.

"We'll draft some sample goal statements--we can discuss them next meeting; that should help us get an idea of where you want the plan to go."

The planners went home and pulled out some 'stock' goal statements...'Protect the special environmental features of Seaside--scenic, ecological, historic...;Provide a variety of recreational opportunities for all segments of the community...; Recognize the value of Seaside's unique character to the region and to the many tourists...'.

At the next meeting, the planners handed out their material.

"These are some goals that we think are appropriate to this Open Space Plan. In the report, we could emphasize the Conservation Commission's role in meeting these goals and point out that other committees in town also have responsibilities. Your plan can serve as a focus for the efforts of the Recreation Committee, the Parks Department and yourselves."

The members thought the goals were fine, although 'responsibility to the region' scared them a little.

"We don't like a lot of people tramping in our woods."

"Or climbing all over the rocks along the shore," added a waterfront property owner.

The discussion shifted to the Five Year Action Program.

"What we have is a list of parcels we definitely want to acquire, and a few that we'd like to but don't think we could--sort of wishes."

"How do the parcels fit with your idea of meeting open space needs? How did you decide that these are the parcels you want?"

"This piece, the Henderson property, we're sure the owner will donate it, especially if its in the plan; its fine land--cranberry bogs, blueberry patches. We could cut some great trails. And this quarry--we already own the one half, we'd like to complete that parcel. Let's see--near the cove here, there's a terrific spot with wetlands, lots of wildlife, and a small quarry. We want to spread things out in town, you know. If you give something to one part you've got to give to the others, or they get unhappy."

The staff tried to wedge in the idea of 'criteria'.

"For the plan, you should have a systematic way of choosing parcels. You choose sites to buy according to how well they meet your goals and objectives. What criteria did you use to pick these parcels?"

"Distribution around town, how likely it is to get pieces donated, variety--some of the woods, some wetlands. We don't want to ask for waterfront, though; we got money for the wharf last year. Seaside already owns 48% of its coast. That's a lot for a town."

"And we don't want to take too much land that's good for housing. There's not much land good for building in this town, because of the granite ledge. When the new soil survey comes, we'll know the best areas for development--we don't want those parcels in conservation land."

In addition to the goals and the action program, descriptions of the population, the physical environment and the recreation needs of the town had to be compiled in the document. Having collected this information, the planners presented it and suggested that it be used as a basis for establishing site selection criteria.

"Does all that have to go in the plan? We wanted it to stay short. Otherwise, no one will ever read it."

"This information is supposed to help you determine the steps you should take to meet the changing open space needs of the residents."

"Well, if its not too long we can include it."

The planners went away again; they hammered the Commission's list of parcels and justifications into a criteria list, and then showed how the parcels 'met' the criteria, and wrote it up professionally. They included several statements, on behalf of the Commission, about programs for use, about consulting with other groups in town, and about citizen input. Well aware of the document's major purpose to help draw grant money, they knew the text had little influence on anyone in town. So, the Commission had its list of sites officially justified; the planners (due to their short term involvement) accepted their inability to communicate the important issues that should have been confronted; and Seaside got its Open Space Plan.

* * *

This story illustrates a general set of concerns in land management, including: the differences between policies and decisions, and the inputs to them; the characteristics of people responsible for managing land resources; the role of professionals and technical information in policy and decision making. The story also points out a series of crucial problems in land management processes:

(i) there are 'informed' and 'uninformed' policies and decisions. Many rely entirely on personal bias or preferences, on reactions to isolated conditions or events, on political expediency, or on misinformation; few are made on the basis of available accurate facts, or as a result of thorough consideration. The Conservation Commission wanted to justify parcel acquisitions they had chosen long before gathering any data or consulting anyone else in town. The members could not detect the differences between 'good' and 'bad' information. They were unused to using information other than their personal experience, and seemed unable to treat land management problems in a general way. They made firm conclusions on the basis of isolated examples.

(ii) decisions on specific matters are best made within the context or guidelines set by policy. In the absense of articulated policies, decisions cannot be made consistently, nor can they converge on a desirable set of conditions. The Conservation Commission choose sites that appealed to them--not parcels that would necessarily add up to a coherent open space program useful to the townspeople.

(iii) existing information, that could be valuable by informing policy, is usually inaccessible and not directed at the needs of administrators or policy makers without technical expertise. Even though they knew the soil survey would indicate good sites for development, the members did not intend to use it themselves to positively guide open space planning. The demographic and environmental information supplied by the planning staff was perceived as a burden, and was not at all incorporated in the members' considerations. In the short duration of the contract, the planners were unable to significantly inject their concerns into the Conservation Commission's deliberations. The professionals certainly could not replace the members' established methods of approaching planning issues, and their technical information could not successfully challenge the pre-determined conclusions.

(iv) policies or decisions are often judged 'good' on the basis of their political success, more than on their use of accurate information and actual 'solution' of problems at hand. By distributing open space throughout the town, the Conservation Commission sought to minimize conflict. Whether or not they provided usable open land was not an issue.

This thesis investigates the use of information in land management--it analyses policy and decision making, and the characteristics of information handling, to explore these questions:

How is environmental information* used in land management? what roles does it play?

Do policies and decisions require different kinds of information in their formulation and administration?

Does better information use contribute to better land management processes?

How can information be better structured to increase its use by policy and decision makers?

To answer these questions, this thesis analyses the features of land management policies and decisions and information structures; the objective is to compare these characteristics and design guidelines for improving the management of environmental data.

Chapter Two explores the elements of policies and decisions by grouping them to describe the different roles of information in land management.

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* environmental information includes data about the biophysical, ecological, cultural (historical, aesthetic, sentimental) characteristics of the environment.

Chapter Three evaluates a series of information structuring methods--classification systems, formal models, simulation, computer systems--to assess their effectiveness in land management applications.

Chapter Four synthesizes the previous discussions, and Chapter Five presents a series of brief case studies. The description of three operating information structures guages their success relative to the specific land management problems they were designed to address.

The final chapter contains a checklist of the concerns identified for increasing the effectiveness of information use in policy and decision making. The checklist is intended as a tool to aid in designing information structures for use in land management.

CHAPTER TWO

DISAGGREGATING LAND MANAGEMENT POLICIES AND DECISIONS

2.1.1 Definitions

Policy statements provide a context or direction for guiding decisions to be made in the future. Implicit in a policy are a number of value judgements--choices to move toward a set of conditions thought desirable. Policy formulation, therefore, represents a synthesis of social forces* or preferences and environmental constraints. Policies are operationalized by a series of decisions. Decisions are specific responses to events or conditions, made with or without the guidance of a policy framework. An example will help clarify the distinction: A local government determines that wetland areas should be protected to prevent flooding and damage to wildlife habitat. This is a land management policy that may be further refined by establishing criteria for guiding land use decisions in wetland areas. Criteria might be based on recognized standards, on an exhaustive inventory of ecological characteristics, on location or on ownership. Choosing which wetlands to preserve or develop is a decision, or series of decisions.

Clearly, policies and decisions have different information requirements. Policy, since it is an incorporation of social preferences, technical considerations and many other factors,

*expressed by pressure groups, prominent individuals, powerful economic and/or corporate interests.

represents a subjective judgement. There is no defined 'optimal' solution, only a normative evaluation of alternatives. Subsequent decisions associated with policy, however, are made within guidelines--the 'optimal' decision comes closest to actualizing the intent of the policy and requires more technical analysis. It is problem-solving in the real sense. Decisions made without a policy framework exhibit some characteristics of 'policy' as well. In the absence of guidelines, decisions include evaluations of alternative directions for land management that are highly subjective.

To complete the prelude of definitions, I inject one more assumption: a series of decisions guided by overall policy yields a more effective land management process than does an uncoordinated assortment of individual choices.

2.1.2 Approaches

There are several approaches that can be taken to disaggregate policies and decisions, and each contributes to isolating roles of technical information. The entire land management process consists of the problems requiring data for solution, the actors who use the information, and the political system within which the actors solve problems. Drawing the distinction between policy and decision making cuts across all three of these elements--policies and decisions address different kinds of problems, are made by different actors and reflect two different functions within the political framework. The rest of this chapter investigates the system, the actors and the problems (with related decisions and policies) that interact in land management.

The next section presents the dominant models of policy formulation and the political system used by political scientists. The concept of 'rational-comprehensive' information use is the focus of the discussion.

Following that, a brief description of some major characteristics of actors in land management is presented. The section summarizes factors influencing the use of technical data by various participants in land management.

The actual features of problems and associated policies and decisions are then examined. The 'nature' of land management problems confronting actors within the system is a prime determinant of information roles. The section studies in detail two key variables--the time horizon over which solutions to problems must be obtained and the geographical scale of problem conditions. Table 2.1 lists the characteristics of problems, actors, and the political system that are discussed in this chapter.

The overall analysis will describe the ways in which technical information is used in land management. If data is organized to match these roles, then information use may improve and thereby improve policy and decision making.

TABLE 2.1 FEATURES OF THE POLITICAL SYSTEM, ACTORS AND PROBLEMS IN LAND MANAGEMENT

Political System

- policy or decision making
- models of the political system
- rational-comprehensive information use

Actors

- policy or decision makers
- size or scope of jurisdiction
- values
- technical expertise
- distribution of power (centralized or diffuse)

Problems

- policy or decision problems
- time horizon
- geographical scale
- planning context (urban, rural, wilderness)
- specificity (of target sites, groups, problem conditions)
- topic (land use, resource management, pollution...)

2.2 Land Management Policy and Modeling the Political System

Policy analysis proceeds from the tenet that there is no monolithic public policy--there is only a multidimensional array of public policies, whose diversity reflects differences in the circumstances of formulation and implementation. A related proposition is that even 'the public' must give way to the existence of a multiplicity of publics in a pluralistic society.

To describe the roles and potential influence of information in land management, the complex knot of policies must somehow be untangled. Categorizing policies is essential to allow a systematic description of the varying inputs in the policy making process (especially technical information), and in the administration environment.

Researchers and analysts have provided some bases for classifying policy studies and policy formulation. The investigation of land management in this thesis follows what Jones calls the problem approach.[1] That is, the analysis tracks a particular set of issues through definition, action, evaluation and implementation. It concentrates more on the specific problem area than on the historical development of political structures (historical approach), or on the formal structure (institutional approach) and informal behavior (process approach) of institutions. But a much finer grained division is necessary, if any valuable insights into the use of environmental information are to be gained.

Political scientists have constructed a battery of models which can be used to distinguish policy formulation processes. Dye[2] has summarized and described the six archetypes. The group equilibrium model "...begins with the proposition that interaction among groups is the central fact of politics. Individuals with common interests band together formally or informally to press their demands upon government...According to group theorists, public policy at any given time is the equilibrium reached in the group struggle."[3] Advocacy planning is a product of this view of policy making. Groups in a pluralistic society seek their own information as a source of power. Public opposition to highway construction, backed by powerful interest groups with technical expertise, is an example of this theory in action.

The elite theory views policy as "...the preferences and values of a governing elite...Elite theory suggests that 'the people' are apathetic and ill-informed about public policy, that elites actually shape mass opinions on policy questions more than masses shape the elite opinion."[4] In some respects, the Conservation Commission in the story operated as an elite. The members were explicitly averse to meddling by citizens until the Commission had a document that could control open space discussions.

The institutional analysis of policy studies government structures, procedures, and relationships. "Strictly speaking, a policy does not become a public policy until it is adopted, implemented and enforced by some governmental institution."[5]

The systems theory describes policy as a "...response of a political system to forces brought to bear upon it from the environment."[6] Forces generated in the environment are inputs (such as technical information), and the political system is "...that group of interrelated structures and processes which functions authoritatively to allocate values for a society."[7] The environment is the set of all conditions external to the political system, and outputs are public policies.

Rationalism models policy as efficient goal achievement, and is perhaps the most often assumed reality of political structures and certainly of the planning process. Policy makers, in this theory, must: "(1) know all of the society's value preferences and their relative weights; (2) know all of the policy alternatives available; (3) know all of the consequences of each policy alternative; (4) calculate the ratio of achieved to sacrificed societal values for each policy alternative; (5) select the most efficient alternative."[8]

Finally, the incrementalism model holds that public policy is a "...continuation of past governmental activities with only incremental modifications."[9] This model acknowledges the constraints of time, intelligence, cost and political viability on the behavior of policy makers, and therefore describes a more expedient approach--"...attention is concentrated on increases, decreases or modifications of current program"[10], which is accepted as a legitimate and useful basis for action.

Each of these explanations is based on a set of assumptions and observations (not mutually exclusive) that attempts to describe society's methods for responding to problems through policies and decisions. The models help describe the roles of information in policy, since the character of technical information use is substantially different within the boundaries of each theory.

For example, in the group equilibrium model, information might be used in several capacities. A release of new data into the public domain may precipitate collective action and the formation of new interest groups, or stimulate conflict between existing factions. The private possession of information by any group is a source of power that can be exploited to maximum political advantage. Or, information may provide the basis for resolving inter-group conflicts by indicating a possible direction for compromise.

The rational-comprehensive model of policy formulation assumes that complete and accurate information guides the policy maker's quest for exhaustive criteria and goals, reveals alternatives to be considered, and anoints the optimal strategy for solving the problems at hand. In effect, the quality of decisions is limited only by the availability and accessibility of information, and the user's ability to metabolize it. Clearly, this model encourages the use of information more than any other, but for a group such as the Seaside Conservation Commission it is obvious that this theory sometimes breaks down.

There are two drawbacks that diminish the utility of this 'political system' approach. First, the models do not facilitate the analysis of policies <u>and</u> associated decisions. Administration is not addressed, and neither are the similarities and differences between policy and decision making. Second, and more important, each model is only a partial representation of political realities. In some cases one model is a particularly apt tool for analysis; in other instances, an entirely different model provides the most accurate explanation of events.* But, the actual choice of an explanatory theory, to apply to a given problem, is subjective. Using these models depends on an individual researcher's perceptions, assumptions and judgement. There are no guidelines, nor are there distinctive policy hallmarks, to serve as aids to this method of categorizing land management policies.

Nonetheless, there are two significant points that these models demonstrate. Studying the theories confirms an axiom of public policy formulation that is valuable in assessing the use of environmental information: in almost no circumstances does the rational-comprehensive process operate completely.** This is important--most existing information tools were not designed with this 'constraint' in mind. Rather, they were conceived as inputs to a predominantly rational process. In

*Dye's case studies illustrate very well the fact that situations can be interpreted differently by applying different models and assumptions.
**despite the common, implicit assumption that it is the only operative one.

a pluralistic system, however, policies cannot be the products of complete and objective analysis of facts and alternatives, since the criteria for evaluating 'good' policies are subjective. In his diagnosis of the constraints operating to restrict the function of the rational model, Dye lists some that are especially relevant to this investigation.

> "7. There are innumerable barriers to collecting all the information required to know all possible policy alternatives and the consequences of each alternative, including the cost of information gathering, the availability of the information and the time involved in its collection.
> 8. Neither the predictive capacities of the social and behavioral sciences, nor the predictive capacities of the physical and biological sciences, are sufficiently advanced to enable policy makers to understand the full range of consequences to each policy alternative.
> 9. Policy makers, even with the most advanced computerized analytical techniques, do not have sufficient intelligence to calculate accurately cost-benefit ratios where a large number of diverse political, social, economic and cultural values are at stake...
> 12. The segmentalized nature of policy making in large bureaucracies makes it difficult to coordinate decision making so that the input of all the various specialists is brought to bear at the point of decision."(11)

Therefore, policy inputs (including information) must always be qualified and examined in context. Since the elements are sometimes carefully selected, accidentally encountered or intuitively guessed, the characteristics of information--its availability, accuracy, the nature of presentation--are important considerations in determining its effectiveness.

The second point is that the models provide an opportunity for a normative stance. How should environmental management policies be made? What model is the most desirable for policy formulation?

My assumption is that increased 'rationality' in policy making is entirely advantageous. This does not mean that society should function strictly on the rational-comprehensive model (since it is impossible to define in a pluralistic system). Rather, it means that fostering improved use of information, in any of the political system models, is a step toward better policy making. Attempts to improve information tools contribute to better land management.

2.3 Land Management and Actors in the Process

People use information in different ways--the variations depend on a host of personal and environmental factors. To design guidelines for improving the use of technical information, some generalizations about the anticipated users are helpful. The most immediate promise for improving information use lies in keying data to the character of actors in policy and decision making--the structure of data tools is easier to manipulate directly than are the attributes of people in the process.

As indicated by the distinctions between policies and decisions, policy makers and decision makers place quite different demands on technical information. Briefly, decision makers are charged with the task of collecting and interpreting data to solve problems, within guidelines for 'good' solutions.

Policy makers must set these guidelines; hence, they weigh technical inputs against many other considerations and demands. Values clearly play a substantial part in such policy judgements. Technical information, to be influential, must penetrate these value screens.

Land management participants possess different levels of skill or expertise in understanding technical material. Information structures that are intended to influence politicians, for example, must not be so complex that they cannot be interpreted by non-technicians. How can a policy maker be expected to act on material that is beyond understanding?

The distribution of power among actors in land management processes affects the location and accessibility of data resources, and determines the leverage points for improving the design of technical information tools. In a highly diffuse land management system, information may be spread among many agencies and stored in many formats. Methods for centralizing information, and sharing it, may thus be an important concern. Where a single agency controls land management, distributing the information and the power of choice among other participants (with different interests) may be necessary.

Jurisdiction size also affects the ways that actors use technical information. This feature is discussed with geographical scale in the next section, which investigates land management problems and the kinds of decisions and policies developed to solve them.

2.4 Problems, Policies and Decisions in Land Management

The characteristics of actual land management problems--and the policies and decisions devised to solve them--include several factors that should influence data collection, interpretation and use.

'Topic' is an obvious classifier. Development choices require very different kinds of information than timber harvesting programs do; pollution control programs are formulated for different reasons than floodplain zoning ordinances are. This is a fairly rough distinction,though, since topic defines the kind of data and the analytic techniques required, but does not address the task of influencing directly policy and decisions.

'Planning context' is a similar notion which tries to describe the differences between problems in wilderness tracts and those in urban, heavily populated areas. Wilderness regions have resource capabilities to be measured, mapped, developed and managed, and myriad ecological processes to be guarded to avoid irreversible damage. The planning context implies that urban areas do not have similar considerations, and to a degree this is true.* Yet, urban regions also contain many acres of undeveloped land that must be evaluated for resource wealth and are certainly important in determining the nature of land management policies that are adopted. Coastal wetlands along the eastern seaboard of the United States are a good example--while many are surrounded by urban, intensively developed, areas,

*for example, air pollution, congestion, housing and industrial development are not 'wilderness' issues; forest management and wildlife preservation are not 'urban' concerns.

their importance to commercial fisheries remains very high. Planning context, like topic, is helpful in developing information tools for specific applications, but does not shed light on the roles that the data will actually play in decision and policy making.

The specificity of target sites, groups, resources or problems can identify information roles. For example, a decision directed at a particular site may engender more politicized opposition (perhaps less influenced by facts) from specific groups, than would a generally stated policy. This shift from general to specific, and from policy to decision, contains a major change in the use of technical information--analysing this shift requires categorizing policies and decisions. Time horizon and geographical scale, two more features of land management concerns, are useful classifiers for this purpose.

2.5 Time Horizon and Geographical Scale*as Policy and Decision Filters

The intended time horizon of a policy (the time period in which

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*'level of government' and'geographical scale' are used somewhat interchangeably here. While it is true, for example, that the federal government undertakes land management at a local scale in some circumstances, this is not typical (and the locus of management is more significant than the geographical location). So, in the context of this analysis, local governments perform land management at community scales, state/provincial governments at regional scales, and federal governments (in North America) at continental scales. In actual practice, as is noted in the concluding checklist, the specific characteristics of each land management application must be considered. But for the purpose of classifying policies, and their general characteristics, the 'general rule' is covered in this chapter.

it is to be operational and effective) determines the amount of preparatory data collection that can be done for use in program development, and indicates the urgency perceived in the nature of the land management problem.* Time horizon is one of the key variables separating policy and decision contexts. Decisions made for immediate effectiveness must rely on instantly available and accessible information and coarse grained interpretation (if no information tool exists already for such a problem); long term policies are designed to wait for exacting analysis and patient deliberation (or at least have these options available)** and to provide the preconditions for later decisions and problem-solving.

Policies and decisions formed at local, state/provincial or federal levels of government differ primarily in the kind and magnitude of problems confronted; the allocation of human, technological and financial resources to problem-solving; and the directness or immediacy of public involvement.

The geographic and jurisdictional boundary of a policy maker's concern circumscribes the nature and intensity of problems to be handled. Remember how the Seaside Conservation Commission balked at 'regional responsibility'; this attitude

*as in the essential differences between a stop-gap measure responding to public and interest group pressure, and a government sponsored research program to collect data and recommend strategy; or between a quick-reflex action to eliminate a dire threat (such as oilspill cleanup operations, begun instantly after major accidents) and an extended search for data allowed by the availability of time, or intended to dissipate group pressure and public energy by diverting or pacifying it.

**acknowledging, of course, that the long term is sometimes chosen to stall, rather than to collect information and formulate strategy.

is typical among communities who prefer to enjoy state and federal grant disbursements without sharing the benefits with a broader population segment. In Massachusetts, many towns steadfastly refuse state assistance for open space acquisition and highway construction, because they do not want to be invaded by 'outsiders'.

Local governments tend to view environmental problems and land management issues in terms of residential quality of life, demand for recreation opportunities, employment, and interest in preserving locally important environmental resources. Spillovers into surrounding communities, or actions that affect larger physiographic, economic, ecologic or social systems are not priority considerations. Such responsibilities are completely beyond the scope and capability of communities; they belong in the realms of state or federal administration. At the same time, these higher orders of government necessarily sacrifice detail in land management policies and decisions and serve a less specific, more rapidly changing set of interests.

Governmental budget constraints determine the resources that can be allocated to obtaining information and manufacturing action strategies. For example, municipalities seldom have access to the facilities and personnel required to analyse and apply remote-sensed data, despite the many potential uses for such a tool. Finances partially dictate the kind and quality of information that will be incorporated in policy formulation, and the sophistication with which the information is interpreted and applied in decisions.

Public concern for decisions and their consequences is more immediate in local affairs, and involvement is more direct.* Citizens are more aware of problems, are more knowledgeable and must live with the impacts of land management choices. These factors encourage support or opposition in environmental concerns, far more than distant or abstracted issues can. The use of information for public disclosure is therefore a major consideration: to the extent that access to data can assist citizen involvement, information management can be a powerful force.

These features can be arranged as a framework for evaluating the roles of information in land management. Time horizon is the first filter since lead time for investigating problems and alternative solutions, and the increasing generality of issues in the future, produce large distinctions between various policies and decisions.

At the worst, policies in the short term are likely to be operating in crisis conditions or heavily politicized environments. In more favorable situations, a short term time horizon is chosen for policies that are experimental, or for decisions directed at isolated opportunities or problems. Long term policies are 'cooler' because they are usually remote. They are

*in terms of political system models, the mass-elite theory is less operative in local government, while most prevalent in federal policy and decision making.

less direct interventions into existing social patterns since administration is extended over time; the process of implementation is gradual and flexible.

Level of government is the next policy filter in this categorization. The locus of jurisdiction has a distinct effect on the information inputs, which vary according to the availability of resources, and the size and kind of problems that must be solved. There is also a significant change in the degree of public involvement at different levels of government.

Using these classifiers, land management policies and decisions can be grouped to compare the roles of technical information. Once again, 'stories' are the best way to anchor an essential discussion that should not remain theoretical. The following situations illustrate the qualitative changes in information use that occur in policies and decisions under different parameters.

2.5.1 Situation 1

Consider a small town and its responses to wetlands filling, in a series of different contexts.

A crisis situation: substantial flooding has occurred, and everyone knows the cause--loss of inland water retention due to wetlands filling. Development permits are being processed for more construction on marsh sites. The town decides to deny all building applications in wetland areas, and halt permit granting until conditions can be investigated, and longer term solution alternatives considered. One year is chosen as a moratorium period, during which the problem is to be studied.

In the second situation, widespread wetlands filling is generally known to cause flooding. Officials and townspeople realize the need to curtail such development within the near future. They elect to investigate available wetlands development control devices; begin designing a management, acquisition and protection program; and inventory wetlands to provide the technical information needed for implementing the controls.

In the third context, some officials and professionals are generally aware of increasing population and development trends. They realize the eventual need for land management strategies to handle demands on local environmental resources. They are also aware that poor land management can cause problems, but there are no bad effects observable in town at present. An 'ideal' response would be to catalog environmental features, investigate control devices, search for technical assistance in designing an overall land management program, and develop a gradual protection plan to avoid critical damage as a result of development. The likely'strategy'though, is to sit and wait. Daily routine and political obligations usually absorb available time and energy so that long range policy making is sacrificed, and no action is taken until problems are visible.

2.5.2 Situation 2

The federal government is concerned about managing forest resources* which are valuable for commercial yield, recreational potential and ecological maintenance.

In the first situation, officials learn of a unique natural phenomenon in a forested area, and seek to protect it. They recommend acquiring the site, and perhaps founding a national park or forest. During negotiations for acquisition of the land, property owners (who are reluctant to sell) attempt to eliminate the value of the proposed park by destroying the unique resource which is the object of the program. The government enacts an emergency injunction against further action on the part of the landowners until processing on the future park site is completed.

The government, in another context, is concerned about the encroachment of urbanization on the nation's total forested area. Technicians have measured reductions in commercially harvestable timber yield. The policy response is to draft guidelines for land use that favor new development in non-prime forest areas, and recommend an assessment of land resources and the demands on them.

In the third scenario, some researchers realize the value of understanding environmental features and processes for measuring environmental quality, designing management strategies,

*part of this illustration is based on a simplistic paraphrasing of the case study of the National Redwood Park documented in Public Choice and Public Policy (12) and ranking land management priority concerns. They submit a grant proposal, which is approved, for a research program in data collection, not necessarily linked to a specific problem. The series of Earth Resources Technology Satellite (ERTS) and SKYLAB photography experiments are projects of this type.

2.5.3 Analysis

The town, worried about wetlands damage, makes responses that progress from an immediate to a distant time horizon for coping with the problem of flooding. The crisis aspects of the situation diminish as the problem grows less observable and the available time for constructing solutions increases.

The set of forest management concerns illustrates changing time horizons, too, but there is an interesting anomaly. The establishment of the national park is a decision directed at a single set of conditions, that when ultimately implemented is immediate in its effects. However, the actual five-year long struggle to found the National Redwood Park in California would seem to counter this argument. From the same case study comes the example of the emergency injunction as a contrast. The time required to reach this decision and activate it was very short. The first decision (to establish the park) is, strictly speaking, in the domain of the short term. However, the extended length of time actually allowed substantial investigation of the forest features, watershed boundaries, erosion possibilities, and economic consequences of the park for surrounding communities. Therefore, the decision exhibits some of the characteristics of long time horizon. Within this decision, the injunction represents a truly short term response to crisis, directed at a specific group and site. The relationship between 'policy' and'decision' is very important here. The decision to create the park was made within the federal government's established policies of protecting special environmental features and providing recreational opportunities; it was enacted on the basis of technical information.* The decision to invoke an injunction was not guided by such a policy context. To make this decision, the actors were forced to infer conclusions, about social preferences, that were entirely subjective. They had to weigh the aesthetic value of a natural feature against the American sanctity of private property rights.

2.5.4 Classifying Decisions and Policies

The 'rules' for this classification are illustrated by the two land management stories just discussed. 'Decisions' are specific actions within policy guidelines. The time to activate decisions is mostly dependent on external variables--problem complexity, obstacles and conflicts.** Their time horizon

*foresters had discovered the world's three tallest trees and had determined the minimum 'ecological unit' around them necessary to insure their survival.
**for the Seaside Conservation Commission, once the decision to buy specific parcels was made (based on the 'analysis' the members used), implementation depended on factors such as funding constraints, bargaining with landowners, and acquiring town approval. These obstacles do not affect the time horizon of the decision, but may influence some of the parameters, such as parcel size, selling price, purchase date.

characteristics are largely arbitrary. Since decisions are the administration or implementation components of policy, their information use is automatically more oriented to technical inputs. Differentiating them by time horizon does not add to understanding the role of environmental data. (see Table 2.2)

Short term policies are literally decisions, but they are not made within policy guidelines and therefore require subjective and synthetic evaluation of a policy making nature. Intermediate and long term policies vary in the clarity of problem definition and the visibility of effects of the problem addressed. Some land management responses are listed in more than one category because they have characteristics of different types when formulated in different contexts.

2.5.5 Short Term Land Management Policies

These policies are intended to take effect immediately (which can be operationally defined as less than one month). Policy making in the short term is precipitated by crisis conditions, or is a response to 'once only' threats or opportunities that must be acted on instantly. Land management in the short term is directed at specific visible problems, groups and/or locations. (see Table 2.3)

The principal characteristics of these policies, with respect to information use, are:

(i) they rely on existing and easily obtainable data sources, and have virtually no time for specialized interpretation or

TABLE 2.2 LAND MANAGEMENT DECISIONS (EXAMPLES)

Local

- acquiring or protecting priority areas, within budget constraints.
- creating new responsibility in existing agency, or chartering new agency to administer changing concerns in land management, as expressed in policy.
- administering zoning and subdivision codes.
- injunctions against particular projects.
- rewriting zoning or subdivision laws (to include floodplain and wetlands restrictions, for example).
- creating land banking mechanisms.

State/Provincial

- acquiring or protecting priority areas, within budget constraints.
- creating new agencies or restructuring responsibilities in existing ones.
- injunctions against particular projects.
- implementing established programs, legislation.
- public appeal: seeking self-regulation among citizens or corporations to work voluntarily to solve problems.
- reviewing environmental impact statements.
- intervention in local land management.

Federal

- acquiring or protecting priority areas.
- injunctions against particular projects.
- creating new agencies, or restructuring existing ones.
- implementing established programs.
- public appeal programs.
- reviewing environmental impact statements.
- intervention in state and local land management.

TABLE 2.3 SHORT TERM LAND MANAGEMENT POLICIES (EXAMPLES)

Local

- -moratoria or injunctions against development of specific types, or in specific locations.
- -eminent domain.
- -denying development permits.

State/Provincial

- -moratoria or injunctions.
- -enacting emergency legislation.*
- -eminent domain.
- -large scale expenditures to alleviate problems.

Federal

- -injunctions or moratoria.
- -enacting emergency legislation.**
- -eminent domain.
- -large scale expenditures.

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*for example, the legislature of British Columbia passed an Agricultural Land Reserves Act, freezing all classified agricultural áreas, and precluding them from development--this was a response to large-scale development in the mountainous province's few agricultural areas.

**such as the Canadian government's declaration of sovereignty over a 100-mile territorial limit in Arctic waters, following the 1969 voyage of the S.S. Manhattan through the Northwest Passage.

new data collection programs;

(ii) they may be responses to a sudden discovery of new information that demands unhesitating action;

(iii) they may be heavily influenced by political factors; they certainly require consideration of many inputs, since they demand weighing tradeoffs (in political, economic, social or environmental concerns) between alternatives. The role of technical environmental information is less influential than in decision making guided by policy.

2.5.6 Intermediate Term Land Management Policies

These policies are generally aimed at specific problems, but not those that are thought to need immediate action. The extra time allows some data collection, and interpretation of available information for problem-specific applications. The time for the policy statement to become operational is defined as one to twenty-four months. (see Table 2.4)

The major characteristics of information use are:

(i) there is time for gathering existing information, and collecting limited new data to apply to the problem;

(ii) the policies are not characterized by crisis, so technical information has a potentially more influential role in policy formulation;

(iii) the policies tend to be problem-specific;

(iv) the policies establish guidelines for future decisions, that will place demands on technical information sources

TABLE 2.4 INTERMEDIATE TERM LAND MANAGEMENT POLICIES (EXAMPLES)

Local

- seek federal and state funding assistance for land management programs.
- establish data collection programs pertaining to specific land management problems or issues.
- official emphasis on increasing consideration of ecologic impacts and environmental quality in land management.
- maximize independence from state jurisdiction.

State/Provincial

- provide technical and financial assistance to localities.
- support information gathering programs and interpretation of data for particular land management problems.
- require consideration of environmental quality and ecological impacts in development proposals.
- seek federal funding for land management programs.
- maximize independence from federal jurisdiction.
- decentralize land management policy and decision making.

Federal

- provide technical and financial assistance to state and local governments.
- support information gathering programs for particular land management problems.
- environmental impact statement program.
- decentralize land management policy and decision making.

for implementing programs or regulations.

2.5.7 Long Term Land Management Policies

These are policies whose influence is expected to be operational more than two years in the future. They are not characterized at all by urgency or specificity of problems. Long range policy making attempts to establish guidelines for decisions before problems become chronic, or to choose directions for solving major problems that already exist. One objective of long range policy is to minimize the need for very short term policy making (which results from poor preparation and the inability to cope with critical land management conditions). Empirically, this is the kind of policy making that local governments do least well; both state and local governments tend to leave long term guidelines as a federal responsibility. (see Table 2.5)

The major characteristics of information use in long term policy making are:

(i) long term policy comes closest to representing the rational-comprehensive political system model--the absence of both urgency and specificity allows room for considering alternatives and investigating the consequences of choice;

(ii) long term policies establish the groundwork for future intermediate policies and decisions. Hence, land management in the long term is not an active regulatory force. It is actualized through subsequent interpretation in decisions;

TABLE 2.5 LONG TERM LAND MANAGEMENT POLICIES (EXAMPLES)

Local

-sit and wait.
-encourage increased public control in land management.
-establish land use guidelines for citizens, developers.
-establish criteria and priorities for evaluating land management alternatives.
-adopt state or federal recommended land use guidelines.

State/Provincial

-encourage increased public control in land management.
-establish land use guidelines for local governments, state agencies, large scale developments.
-provide technical and financial assistance to localities.
-funding research.
-training personnel, through grant disbursement.
-adopt federal recommended land use guidelines.

Federal

-encourage increased public control in land management.
-establish land use guidelines for state and local governments, federal agencies, regional scale developments.
-provide technical and financial assistance to local and state governments.
-funding research.
-training personnel, through grant disbursement.

(iii) much long term policy is aimed at providing information sources and analyses for use in subsequent applications.

2.6 Policy Outcomes

Once operational, policies and decisions affect the problems they address, the actors in the land management process, and the political system itself. The social impacts of policy have been categorized[13] as allocative, which assign benefits to some segment of society; structural, which create new administrative units or guidelines for the future allocation of resources and benefits; regulatory, which impose constraints on social behavior; and self-regulatory, which encourage social agents to voluntarily work to solve problems. These classifications wander across the distinctions between policies and decisions defined at the beginning of this chapter, but they are still useful.

To a large extent, evaluating a policy's or a decision's impact is a <u>post facto</u> exercise; only after implementation are all the effects observable (particularly those that are indirect). Yet, the desired social or environmental consequences of land management actions are consciously chosen during policy and decision making. A stern regulatory program, that is highly coercive, may signal legislative response to crisis. The creation of a new governmental agency (a structural policy) could flag an evolving change in political and administrative priorities, or could simply be an evasive bureaucratic shuffle to distract public scrutiny.*

2.7 Summary of Information Roles

To conclude the investigation of policy and decision making, here is a summary of observations:

(i) land management decisions require technical information. Using this information is an established (though not always effective or efficient) component of decision making, which tends to follow the 'rational' model.

(ii) in land management policy formulation, technical information competes with many other factors and influences; policy making is basically subjective and judgemental. To be active in shaping policy, advocates of technical information must 'wedge into' the process--by creating demand, by filling a vacuum, by becoming more adaptive to policy maker's needs and policy characteristics.

(iii) policies most concerned with technical information (those that sponsor research, encourage data collection, design alternative solutions and predict impacts) have least influence on actual land management processes. New information filters into later policies that are the products of many-sided evaluations.

The main product of this investigation is a list of roles that information plays in land management. In all cases, identification or anticipation of a problem (that may or may

*the creation of the Environmental Protection Agency, for example, except that any such governmental action may be interpreted as a 'success' or a 'shuffle' depending on the observer.

not be specifically defined) spark policy or decision responses. The significant variables in this identification are: certainty of the problem's effects, the degree of urgency perceived, the amount of data collection and interpretation applied to deriving a solution, and the thoroughness in considering the range of alternatives for approaching the problem.

The roles of technical information about the environment, in policy and decision making, gleaned from this investigation are:

1. existing information that, depending on its accessibility, availability, structuring format and understandability by policy makers, can be used as inputs to decisions that cannot wait for new sources or special interpretation.

2. sudden injections of new data that precipitate responses to crisis, or spark awareness of a specific problem or opportunity, that can best be dealt with by a single action.

3. research for new information that is commissioned by policy statements to clarify problems and their implications, to design and evaluate possible solutions, or to construct accurate descriptions of natural systems and increase the predictive capability of the environmental sciences.

4. accumulated data that is structured to meet the demands and needs of operating land management programs; as data is acquired, it is specifically tailored by users for their purposes.

The next chapter examines the characteristics of environmental information, and methods for structuring it. Structuring data to increase its effectiveness requires finding the parameters of information management that can exert the most influence. Several types of information tools are described and summarized, to key their features to the roles of information in policy and decision making.

CHAPTER THREE

ENVIRONMENTAL INFORMATION

3.1 An Information Field

A catalog of the characteristics of data sources, analysis methods, and applications is necessary for keying information use with land management requirements. With a systematic description of the features of existing data resources, strategies for improving information management for land policies and decisions can be designed. I would like to recall the perspective of this study of environmental information: data is not valuable in land management unless it is rigorously forged into applicable tools. Bemoaning the failure of policy or decision makers to use technical information is not helpful unless accompanied by strategies for increasing their capacity to understand and apply it.

Information is 'encountered' in a variety of formats. There is a unique information field that exists for each individual consisting of three major components:

(i) 'personal', internal information, that individuals carry in their minds and use both 'rationally' and intuitively.

(ii) 'accidental' information--chance collisions with fragments of data, to which individuals react.

(iii) 'external', organized information (such as technical environmental data), in libraries, agencies, reports, with varying degrees of understandability and accessibility to individuals.

It is not unreasonable to assume that personal information and chance discoveries are the most influential components in the information field--but they are also the most difficult to manipulate. This study of environmental information concentrates on the organized data collections employed (sometimes poorly, sometimes effectively) by land management policy and decision makers. Improvements in the use of technical information can be made in two realms: organized information can be injected into the less formal, unsystematic channels; and data resources can be tailored to the needs of land managers.

3.2 Data Transformations

Sources of technical environmental information can be described as a hierarchy of aggregations and transformations of basic data. These transformations occur in two types--those solely for purposes of storage, retrieval and display; and those that manipulate data for specific applications. There are different considerations involved in each.

The first order information source is direct collection: observation, survey, measurement, photography (ground or remote-sensed). These are governed by the first kind of transformation: to what degree is the data aggregated in storage, and can the original material be retrieved? how selective or comprehensive is collection? what resources (financial, human, technological) are available?

Second order sources* are data sets collected by other users, and probably for different applications than the current user's intention. Constructing a second order information source requires decisions on the transformation parameters just listed --choices must be made concerning storage and retrieval format, selectivity and resource constraints. Most environmental information is of this kind. United States Geological Survey maps, soil surveys, and aerial photograph interpretations are among the most common examples.

Third order information sources include models, simulations, resource inventories and environmental classifications. These are characterized by their design for specific applications in research or land management. Transformations in second and third order sources are oriented toward these considerations: what is the nature of the problem being investigated? what are the constraints of resources (financial, technological, human)? how can the information be most usefully organized to help solve the problem? Whether or not the information can be used for other purposes, once aggregated, is not usually an important concern.

From here on, manufacturing second and third order data sources is called 'designing information structures'. As the above descriptions indicate, a structure transforms data--by

* second and third order sources of information are more fully described in the next section, where they are defined as structuring methods.

categorizing, calculating, aggregating--to forge it into an information tool. The structure is dependent on the actual data content and the designer's 'fix' on a particular purpose for the information. Because environmental information structures are the organized component of the information field for land management, the next section describes them in detail.

3.3 Information Structures

3.3.1 Resource Inventories and Environmental Classification Systems

These structures are used for classifying and inventorying land use, ground cover, resource bases, or visual quality; recording biophysical, ecological, aesthetic or cultural features of the environment; assessing the capability, feasibility, and/or suitability* of sites or regions for various uses. Figure 3.1 illustrates the elements in building and applying classifications and inventories.**

The essential characteristics of these structures can be summarized as follows:

Applications: they are designed for specific problem-types, and often for specific locations. Although some evaluators rank 'flexibility' of applications and geographic scales as a virtue in these structures, there are sacrifices attached to designing

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* a distinction, used very early by Angus Hills, to describe alternative land uses in terms of physical, economic and social constraints.
** each method described in this section is illustrated with a figure of the structure. As nearly as possible, the 'building blocks' in the diagrams are standardized, to allow comparison between methods.

FIGURE 3.1 ENVIRONMENTAL CLASSIFICATION

RESOURCE INVENTORIES

PURPOSE

.land capability
.resource management
.landscape quality
.
.

DATA COLLECTION

.physical
.biological
.empirical
.institutional
.
.

TRANSFORMATIONS

.classification, descriptive modeling
.geographical, topical reference
.aggregation, interpretation
.(ranking, weighing)
.
.

OUTPUT

.descriptive
.maps, documentation
.
.

for adaptability. Systems constructed for particular problems, sites and/or users are likely to be more efficient problem-solving aids than general techniques would be.

Inputs: data collection and analysis programs can be matched closely to budget or facility constraints (with variations in accuracy, complexity and thoroughness, of course). The systems can be designed for manual or computer operation. Data that is used in these structures is carefully selected for application to the problem involved.

Outputs: these systems are usually displayed in maps (drafted or computer-generated) and accompanied by documentation (descriptions of categories, symbols, conceptual framework). The format contains enough material to communicate the information, but provides no specific guidelines for incorporating it in decisions or policies.

Analysis methods: classifications and inventories are primarily descriptive and empirical. Some systems include numerical algorithms* for ranking the capability of land for alternative uses. The recreational potential of landscapes, for instance can be valued using pre-defined, weighted criteria, such as topographic variation, nearness to water, presence of spectacular features, or difficulty of access. Judgement plays a large role in these rankings, and in the design of classification systems in general.

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* for a notable example of a complex ranking system, see Angus Hills' evaluation techniques for land capability in <u>The Ecological Basis for Land Use Planning</u>. (14)

Land use classifications, inventories of harvestable forest yield and agricultural capability analyses were the first experiments in descriptive information schemes. Since the earliest attempts, the design of related methodologies has improved and their application has expanded. Landscape architects and resource planners have constructed descriptive techniques to provide "...valuable information on the environment as one important set of considerations within a comprehensive planning and design process."[15]

Resource classifications and analyses generally obey the rules of sound taxonomy[16], and are based on either logical hierarchical divisions of environmental types and features, (see Figure 3.2) or similarities extracted from a data set, which determine the classes used in the system. Specific applications for which methods are now in use include forest resource inventories, recreation potential analyses, land use capability studies, landscape features and visual quality assessments, and water resources planning.

Informative comparisons and evaluations of these descriptive techniques have been made by several researchers. Table 3.1 is a list of criteria, developed by Carl Steinitz, for assessing the characteristics and performance of classification schemes and resource inventories.

Here it is important to identify two main threads in studying information structures. One evaluation concentrates on the structure's technical merits: the suitability to problem-type,

FIGURE 3.2 A HIERARCHY OF ENVIRONMENTAL FEATURES

(from the Rockport Land and Water Inventory)

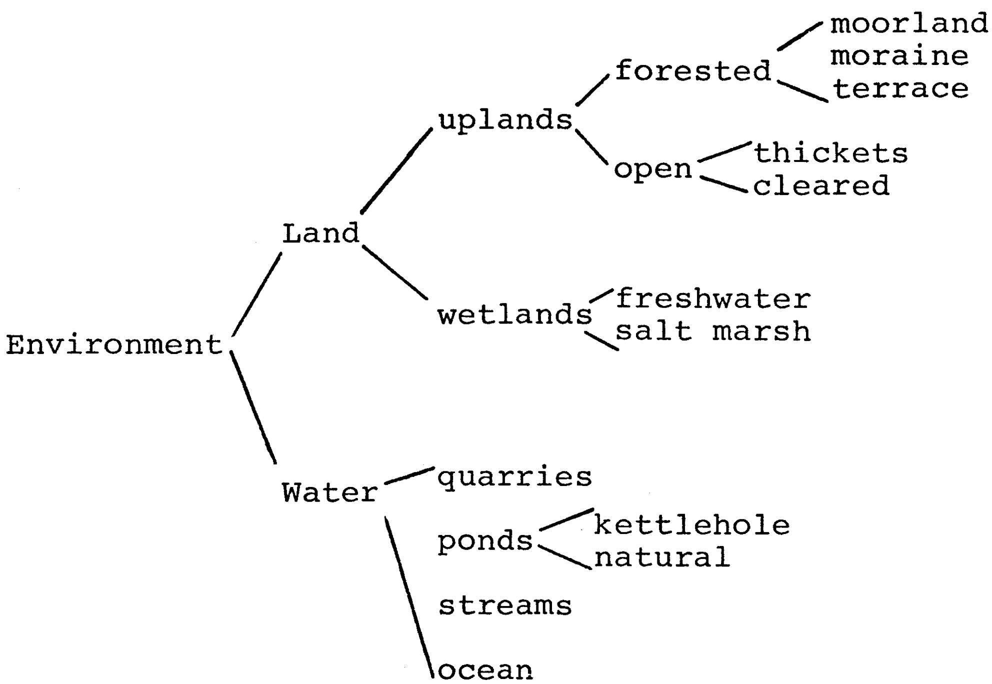

TABLE 3.1 CRITERIA FOR EVALUATING ENVIRONMENTAL RESOURCE ANALYSIS SYSTEMS (Carl Steinitz)[17]

a. clearly defined, unambiguous, mutually exclusive categories.

b. include all relevant variables.

c. applicability throughout area of interest.

d. applicability for all necessary analysis techniques.

e. applicability at larger and smaller scales.

f. ability to generalize value scales.

g. capacity for being updated.

h. accomodation of interests of broad range of users.

i. addition capability in area and variables.

j. orderly and compact economical format.

the quality and logic of the categories chosen, the efficiency of storage and retrieval, and the comprehensiveness of data coverage within the study area. Steinitz's criteria are mostly of this type, and approach evaluation from a professional's or technician's* perspective. A second approach evaluates structures from a policy maker's viewpoint. Criteria developed for this track would address an information structure's ability to influence and improve land management policy. Both of these are vital to building good information structures, but so far the first has received nearly all the emphasis in actual design and evaluation.

Belknap and Furtado made a brief attempt at assessing techniques for their policy and planning applications. They criticized the methods of Hills, Lewis and McHarg for being "...difficult to integrate into the total (planning) process"[18] and "...treating too briefly the problems of economic and social evaluation. They leave to the larger process many of the problems of value identification and social and economic analysis that are often considered to be central to the problem of resource planning."[19] This evaluation with respect to the 'larger process' and 'value identification' is a reference to policy making. Chapters Four, Five and Six will return to this consideration. First, the catalog of information structures must be completed.

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* that is, toward evaluating the system's success in decision making.

3.3.2 Models and Simulations--Ecological Applications

In 1967 Belknap and Furtado concluded their evaluation of resource analysis methods by observing that "...simulation of the total environment seems beyond the current capability of computers and analytic methods. Thus it is necessary to continue to search out indicators of particular environmental complexes and conditions..."[20] This skepticism was well-founded, and the authors expected improvements, in information structures for land management, to come from descriptive, empirical techniques. The qualms about simulating the entire environment with computer technology are still valid, but successful research has been conducted in modeling particular ecosystems. The experiments are aimed at increasing understanding of the structure and function of ecological units, and learning to predict the impacts of intervention. Mathematical modeling and computer simulation have come to the frontier of the environmental sciences in general. The application of these techniques to land and resource management is a popular research topic, but as yet there are few operating successes.

Modeling ecosystems draws on knowledge from information theory, mathematics, systems theory and, of course, ecology. In order to understand the structure and function of a community, all the identifiable and measurable parameters must be monitored. Interactions between species and the inorganic environment are described and quantified where possible, in order to predict future states of the ecosystem. Such models have been designed for scientific applications. They are costly to produce and are as yet only in the early stages of development.* One ecosystem frequently modeled is the rocky intertidal seashore.[21] This environment is the meeting-place for inhabitants of the land, sea and air, and the system is governed by tidal and solar cycles. The community is divided into zones of habitation fixed by exposure to the sea, spray and air. In a standard model, these components are combined with species population counts, measurements of abiotic factors**, and rough observations of ecological relationships.***

The parallel development of computer simulation techniques could make modeling a powerful predictive tool. "Through simulation one can study the effects of certain informational, organizational, and environmental changes on the operation of a system by making alterations in the model of the system and observing the effects of these alterations..."[22] (see Figure 3.3)

The Oak Ridge National Laboratory is developing a regional ecological simulation model as part of the Regional Environmental Systems Analysis. The goal of the project is to produce a series of compatible simulations of socioeconomic, land use,

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* The controversy surrounding environmental impact prediction illustrates the immaturity of our ecological science. What to measure? How to measure it? What do the measurements mean? These are hard questions that are not yet answered.

** temperature, salinity, pH, incident light energy, dissolved oxygen, nutrient supply.

*** predator/prey ratios, diversity, competition for food and space, limiting factors, dominance, response to tidal and solar cycles, colonization, matter and energy transfers and food webs.

FIGURE 3.3 ECOLOGICAL MODELS/SIMULATIONS

PURPOSE

.system description
.predictability
.
.

DATA COLLECTION

.measurements
.ecologic
.biophysical
.
.

TRANSFORMATIONS

.mathematical descriptions
.ecological relationships
.model building--analytic or descriptive
.simulation
.testing, calibration
.
.

OUTPUT

.predictions
.quantitative or qualitative
.computer formats
.
.

sociopolitical and ecological activities and processes. When complete the system is expected to 'answer' a series of questions such as this*:

> "(1) Given predicted increases in employment and urbanization, what will be the landscape pattern over the next 15 years?
> (2) Given the landscape pattern change, what would be the effect on privately owned woodlots of increased forest harvesting by TVA?
> (3) If TVA harvests a large number of woodlots and if private land owners harvest their own land due to economic pressure, could this affect water quality of the streams in the area?
> (4) If water quality of streams in the area is affected, would biota of the reservoirs of the area be affected?" (23)

The Natural Systems Analysis model is concerned with the third and fourth of these questions. It contains: (i) a land-cover submodel that simulates the successive changes of vegetation communities and adds the human intervention of agriculture and urbanization; (ii) a regional water system submodel**; and (iii) a submodel correlating water quality indicators with the lifecycle characteristics of selected aquatic species. The designers and operators of the model described their major tasks and difficulties to be: collecting, storing, manipulating and displaying data; describing natural systems with sufficient accuracy; discovering reliable, meaningful indicators of environmental quality; and learning to predict the system's behavior using these components.

Some of the major characteristics of these mathematical

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* for the East Tennessee Development District in the Tennessee Valley Authority (TVA).

** including parameters such as run-off volumes and peaks, sediment transport characteristics and water quality indicators.

models and simulations are:

Applications: these techniques are developed for specific locations. Applying a model to a new site is only possible if the same ecosystem is being studied, and even then extensive recalibration is necessary. Ecological simulations are designed primarily for scientific research, and have only recently been used in land management experiments for predicting environmental impacts.

Inputs: large investments of time, money and technology are required to produce and test a single model. Simulation is only wieldy with the use of computers. The quality of the model depends directly on the accuracy of the information inputs, and the level of understanding of ecological principles that informs the design. A major 'input' to model construction is selectivity: which variables to measure and test; which to weigh most heavily; which relationships to include in the analysis.

Output: is generally in the form of equations for the state of the variables tested by the programmed simulation. Since the models are mathematical formulations, so are the 'answers', which must be interpreted by technicians.

Analysis method: by definition simulations are analytic; some models are only descriptive but simulation requires quantitative measurements.

Modeling and simulation have generally been applied to three kinds of problems[24]: testing hypotheses about the system under study; estimating the effects of changes or stresses on the system; and solving problems for which the user defines criteria for choosing 'optimal' answers.

It is worthwhile, at this point, to step back to see how these three applications pertain to land management policy and decision making. As described in section 2.1, decisions made within a policy context are provided with guidelines for 'optimal' solutions, and can theoretically take advantage of simulation/modeling techniques. However, modeling and simulation are not directly useful in policy formulation. One of the major characteristics of land management policy making is the absence of criteria for choosing 'optimal' solutions--the 'problem-solving' use of models is therefore not appropriate. And even if policy alternatives were tested by using predictive models, the actual policy choice would still rely entirely on weighing subjectively the simulated impacts against all the other inputs external to the model.*

There are two main drawbacks to using simulations and formal models in decision making or for testing policy alternatives. First, overwhelming commitments of money and machinery are required to produce and operate a single tool--the Oak Ridge experiment has cost nearly two million dollars to date. Second, simulation models are in the realm of 'high' technology. The complexity of the tools precludes understanding, access and use by anyone save the designers and other 'experts'. If land

* acknowledging that there are not now any models capable of describing everything in the policy making environment, and that there probably will not be any for a long time.

management is a responsibility that we are unwilling to assign to small groups of technicians, then the usefulness of simulation experiments must be questioned.

3.3.3 Land Use and Ecologic-Economic Tradeoff Models

These techniques measure the tradeoffs involved in land use decision and policy alternatives. (see Figure 3.4) Isard, who devised an extensive ecologic-economic interaction model, asserts that the first objective of such information is to "... make regional planners aware and other social and environmental analysts at or close to the decision making level aware of the intricate interrelationships between the economy and the ecosystem and between economic development and environmental management."[25] He and his co-researchers present an input/output model of the food web consumption and production processes of an estuarine ecosystem, as a case study. This is combined with a regional economic interrelationship table that includes natural resource inputs and pollution/emission outputs. This overall matrix, combining ecologic and economic information, is "...useful for systematic description, for comprehensive planning and programming, and for thorough study of the direct and indirect impacts of major developments."[26]

A similar model was described by Davis et al, who designed the "Economic-Environmental Tradeoff Model for Industrial Land Use Planning",[27] that evaluates the social, economic, and environmental impacts of alternative industrial land use plans. "The

FIGURE 3.4 ECOLOGIC-ECONOMIC TRADEOFF MODELS

PURPOSE

.identify conflicts between economic development--environmental quality
.
.

DATA COLLECTION

.ecologic--matter transfers
.input/output analysis
.interrelation tables
.
.

TRANSFORMATIONS

.economic valuations of ecologic changes
.ranking, weighting effects
.
.

OUTPUT

.matrices, tables
.conflicts identified
.'solutions'
.
.

methodology consists of a Regional Analysis Submodel and a Site Analysis Submodel. The first component is based on an extended input/output analysis incorporating land use, resource inputs and waste emission outputs. The second component is an empirical analysis based on the specific suitability and compatibility of proposed land use development packages."[28] This regional analysis submodel is essentially the same as Isard's input/output interrelations approach, but makes the significant addition of calculating the employment effects of new development. The tradeoffs are between these social/economic benefits and the adverse environmental impacts that result from industrial pollution. Isard's ecological analysis, however, is considerably more extensive in the variables it tracks. The Tradeoff Model's second component, the site analysis feature, is a direct use of McHarg's resource inventory and ecological description techniques. This attempt to combine two different environmental structures is an interesting approach.

The major features of these structures are:

Applications: these models differ from the ecosystem simulations in that they are designed specifically for application to land management and include environmental, economic and social factors. They are attempts to inform decision making by translating technical data into environmental quality and economic development considerations, and by identifying conflicts or advantages that result from land use alternatives. The structures are excellent bookkeeping devices since they contain a highly accurate tabulation of matter transfers between all economic and ecologic* 'agents'. As with ecosystem models, these structures are location-specific, and not easily transferred to other contexts.

Inputs: to be useful in decisions, policy inputs are required to establish the importance of variables in the model. These structures require large investments for research, measurement and testing.

Output: the matrices and interrelations tables are massive and difficult to use. The tabular information is hard to communicate or grasp.

Analysis method: mainly analytic and quantitative; the attempts to combine analytic and descriptive structures are intended to extract advantages from both techniques to address land management decisions at regional and local scales. This acknowledges a current limitation in input/output analysis. The necessary data is so hard to assemble that it is not available for localities. The combination also reflects the difficulty in applying analytical techniques to the problem of site selection, unless guided by rigid criteria.

3.3.4 Structure by Geographical or Topical Reference

These tools involve the minimum transformation of data.

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* except that 'all' is defined before applying the model, and is usually limited to biota with readily measurable commercial value. The difference between an aid to decisions and an aid to policies is once again illustrated. It is a policy problem to determine the non-commercial value of environmental features. The models only help after this choice is made.

There is no loss of detail, because all data is stored and referenced without being aggregated. As a result, any applications of the information require the user to define a framework for the intended purpose. Included in this category of information structures are surveys, maps (all the second order data sources listed earlier), libraries, computerized data banks. (see Figure 3.5)

3.3.5 Information Systems

All information structures require some degree of internal information management: procedures for sorting, retrieving, manipulating and displaying data. To facilitate this handling of information, and sometimes to help make information more available to various user groups, special systems have been developed. (see Figure 3.6)

The Oak Ridge Regional Modeling Information System[29] was constructed to manipulate and analyze the data required for the regional systems modeling program described earlier. The system includes geographically referenced data storage, manipulation subroutines and display capabilities to control the vast quantities of information necessary for operating the models.

The Lake Tahoe Basin Information System[30] represents a long term experiment in creating an accessible information bank for the public and decision makers. It followed the assumption that better informed citizens and administrators make better quality decisions.

FIGURE 3.5 'LIBRARY' TECHNIQUES

DATA COLLECTION

.
.
.

TRANSFORMATIONS

.geographical reference
.topical reference
.
.

OUTPUT

.user-defined data base

FIGURE 3.6 INFORMATION SYSTEMS

PURPOSE

.information handling

.

.

.

DATA COLLECTION

TRANSFORMATIONS

OUTPUT

.governed by structuring method
.classification, inventories
.models, simulations
.'libraries'

In Pepper's case study of the Tahoe Basin Information System, which includes banks of geographically and topically* referenced data, he documents the successes and failures of the venture**. Pepper also lists criteria for evaluating information systems. (see Table 3.2) These are partially based on Steinitz's evaluations of empirical methods, but are more concerned with performance in decision making.

The characteristics of these information systems are:

Applications: they are designed to manage information for use in a particular structuring service to the public and decision or policy makers.

The specific input, output and analysis method characteristics of an information system must be described in terms of the structuring method it serves. Angus Hills[31], for example, used a complex system to code large quantities of information about a site using maps and alphanumeric symbols. Computerized information systems are in more common usage now; routines for storing and retrieving data, and computer graphics techniques are being developed to ease input and output.

3.4 Applications

In the analysis of land management policy (Chapter Two), four major roles of information in policy and decision making

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* geology, hydrology, topography, vegetation, sensitive areas, land use.
** One key problem was the obstacle imposed by having the 'system' several hundred miles from the users. Only telephone contact was feasible, and this was found to inhibit use.

TABLE 3.2 CRITERIA FOR INFORMATION SYSTEMS

(after Pepper)[32]

a. system designed as a component within a decision making process.

b. system issue-oriented, relating to environmental quality issues and criteria, related to spatial size and characteristics of the decision making process (high speed, accuracy at low cost).

c. accessible and comprehensible to inputs and outputs by broad range of participants.

d. maximum incorporation of known interrelationships--high degree of predictive ability.

e. data inputs determined by users/participants, not by suppliers.

f. spatial graphic display consistent with context of issues.

g. all information used should become public domain.

were extracted. Information is available in the series of structures just described. The information roles and the design of information structures connect in a set of specific applications--the uses that people have in mind when they collect data, organize it, use it, and try to communicate it. These uses include:

(i) assessing and predicting environmental impacts;

(ii) monitoring pollution; tracking environmental changes over time;

(iii) defining and measuring indicators of environmental quality;

(iv) educating citizens, policy or decision makers;

(v) increasing scientific knowledge;

(vi) storing data for later use;

(vii) influencing social attitudes, shifting preferences through 'propaganda' or polemic.

All of these applications are intended to influence decision or policy making in land management. Success at this has been limited, though, because information structures have been designed primarily for technical considerations. They have not been constructed with the differences between policy and decision making in mind, or with specific concern for the roles that technical information actually plays in land management.

Now there are two questions left to answer. Which structures are most effective for policy use, and which for decision use? And, how can those structures be made even more effective?

The established land management process itself answers part of the first question. A quick tabulation of the information structures now in use by government agencies shows a predominance of empirical, descriptive techniques. The Massachusetts Mapdown land cover inventory[33], the New York State LUNR system[34], classification schemes in Scotland[35], Germany and Holland[36], the Canada Land Inventory[37], the USGS system for classifying remote-sensed information[38]--are all descriptive techniques informing land management processes.

These choices of descriptive structures are obviously intentional. But are they chosen because of: a lack of applicable substitutes? the powerful influence of people like Ian McHarg[39], who advocate these techniques? or the unique applicability of these methods to decision and/or policy making?

The next chapter keys the roles of information in policy and decisions to the characteristics of information structures, to provide some answers to all these questions.

CHAPTER FOUR

KEYING INFORMATION TO DECISION AND POLICY MAKING

As mentioned in Chapter Two, designers can follow two tactics to increase the effectiveness of information use in policy and decision making. They can link information structures with the needs and character of policy and decision processes, and they can seize opportunities to increase the capacity of actors to use technical information.

The idea of building information structures that conform to policy and decision making is not new, but it is not helpful as it stands, either. Werner Hirsh notes that "...indiscriminate collection and storage of information does not immediately advance knowledge and policy."[40] And Pepper makes the similar observation that "...an information system designed to improve decision making should be based on an understanding of the decision system it must serve."[41] Responding to policy making and decision making, though, are two different problems.

This chapter investigates specific tracks for keying information to land management. The following sections analyze the implications (for organizing data) of varying 'rationality', time horizon and level of government in policy and decision making.

4.1 Information and the Rational-Comprehensive Approach

4.1.1 Conforming to the Process

When working within the context of policy, decision makers have a mandate to use available technical information and guidelines* for defining an 'optimal' solution. So, their selection of technical inputs depends on: (i) the availability and understandability** of information; (ii) their judgement of the quality, accuracy and reliability of information; (iii) their skill at using data resources; (iv) how well they can evaluate decision alternatives and their impacts; (v) how well they understand the intent of the policy they are implementing; and (vi) the constraints of available time, funding and personnel. As well as they are able, decision makers follow a 'rational' model of planning and implementation.

Policy makers have a much more synthetic and subjective task to perform. Their formulations are governed by constraints

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*the guidelines given in policy are, of course, often ambiguous and must be operationally interpreted by decision makers before they can act on them. These interpretations can be far removed from the original intent of the policy makers. This is an incentive for increasing the capacity of policy makers to understand and use technical information, so that they will learn to explicitly state the guidelines they intend to include in policy statements.

**the United States Legislative Reference Service is an interesting example of a program to make information available to policy and decision makers. The Environmental Policy Division provides data references, analysis and evaluation services to members of the Congress. The Service attempts to "...keep objective, technological questions separated from the political context..."(42) It draws information from "...the literature, individuals and institutions. The information is recast for clarity, evaluated for validity, analyzed for gaps and conflicts, and submitted without advocacy to the legislator."(43) The Service sees its role as being "...a common centralized data-gathering and information dissemination center to serve all parties in debate."(44) Certainly such a service is valuable, but the disadvantages must also be considered. It is partially because information exists in forms not understandable or accessible to policy and decision makers that they must rely on the Service's translation. And despite the agency's claim to objectivity, there is always selective communication and interpretation of data when it is filtered by intermediaries.

such as: (i) how well they can predict the effects of policy alternatives; (ii) the political viability of alternative actions; (iii) their perceptions of social preference*; and (iv) the same characteristics of technical information considered by decision makers.

In order to be effective in decision making, information must be structured to overcome the 'manipulatable' constraints on its use. In policy making, the information must be structured to meet these same barriers, and also to communicate its significance to actors, with little technical expertise, who are synthesizing many inputs. Policy making demands less specifically tailored information than decision making, and more emphasis on the general implications of data.

For decision making, both descriptive structures and predictive simulation modeling techniques are valuable tools.** The more accessible and understandable they are to managers and administrators, the more influential they will be.

For policy making, information structures must clearly emphasize the land management implications of data in terms of human health, environmental quality, and ecological stability. These are metrics that are more readily accepted, weighed and synthesized in the political system than are opaquely technical inputs. Well-communicated information could become an alterna-

*such as choosing present or future benefits/disbenefits; emphasizing economic, social, environmental or ecological considerations in policy choice; determining the relative priority of land management issues in the entire policy context.

**with the limitations discussed in Chapter Three.

tive to the hotly polemic 'environmentalist' arguments prevalent in current debates. At present, descriptive, empirical techniques* come closest to meeting these criteria, since they are the least complex, the most simply displayed and interpreted, and allow maximum freedom for individuals to weight the information for policy syntheses. Improving these techniques is the best strategy for improving land management policy making.

Models and simulations that predict the impacts of policy alternatives are useful--but they cannot replace the policy maker's subjective assessment.** Such models will not be used if they try to circumvent the political process. Experiments like the Oak Ridge battery of regional models are of questionable value, from the policy maker's perspective, because their design includes many of the 'rankings' and 'weightings' that the policy maker prefers to make individually.

Besides conforming to the land management process, an information structure must insure that users are capable of getting data out and interpreting it correctly. As Hirsh warns, decision makers (and policy makers, I would add) may ignore "...not only information that is useless but also that which is useful if they have no guidelines for using the information provided."[46]

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*resource inventories and classifications, described in Chapter Three.
**"...the legislator and public administrator must make their own synthesis, but they can do their jobs more effectively if the data relevant to these decisions have been organized and reduced to understandable terms." (45)

4.1.2 Changing the Process Over Time

The tactic of designing information structures to conform to land management processes was chosen as a direction of likely immediate success. In longer run considerations, though, actually changing or promoting the evolution of policy and decision processes* can be effective in improving land management. Information structures can be designed to encourage capacity-building in the processes they serve.

By introducing new information management techniques to policy and decision makers, it is possible to incrementally increase their ability to use technical inputs. Information tools can initiate a process that, to a point, improves land management. For example, demonstrating to citizens the methods of environmental classification can communicate the value of systematically considering land use problems.**

There are certainly limitations to the 'evolution' that can be influenced by designing information structures. The ceiling on increasing actors' capacity to use technical resources is imposed by constraints of time, expertise and problem complexity.***

4.2 Information Structures and Policy Time Horizons

An effective information management system must be respon-

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*for example, by increasing the capacity of policy makers to understand technical material; increasing citizens' involvement in land management by increasing their capacity to act in town affairs.

**the Rockport classification, described in Chapter Five, tried to do this.

***there is a barrier beyond which only highly technical data and expensive technology are capable of solving certain problems.

sive to the demands of the time horizon in which it is operating. Policies activated in the short run rely on data that is instantly available and as accurate as possible. Intermediate term policy making is based on accumulated information that is already structured for applications similar to the problem confronted, or on limited programs for new data collection. Long time horizons allow extensive programs for gathering and interpreting new information, independent of specific applications.

When information use depends entirely on immediacy, structures that allow recovery of original data are valuable. Short term policies are often focused on 'new' problems, for which there is no established reference material and perhaps no precedent for action. To be influential in these situations, information must be structured to promote flexibility in problem application and to facilitate analysis of unanticipated conditions.

Information tools for intermediate policies must be able to be updated, to take advantage of new data resources that are useful in administering programs. Another valuable feature is the ability to identify gaps in information content; this helps direct long term research efforts while the system is prepared for incorporating new data.

Most new information is collected from long term research programs. This data filters into the domains of interest groups, governmental agencies and administrators, and elected representatives. Ultimately it is incorporated into the standing collections geared to intermediate policy and associated decisions. The data is, therefore, not structured for the unique demands of short term policy making. To meet these demands, two devices are useful: (i)libraries of unaggregated data that can be applied as necessary; and (ii) selective data assembly (in a descriptive classification system) of the environmental characteristics most significant in defining land management limitations and opportunities. The Southeast New England River Basin Commission classification scheme,[47] one of the cases in Chapter Five, is a good example of this second type.

4.3 Information and the Level of Land Management Jurisdiction

With respect to level of government, the financial, technological and human resources available, and the nature and magnitude of the land management problems,are the first concerns in designing an information structure. These criteria have already been summarized by Steinitz.[48]

Another important aspect is successful and efficient meshing between information systems at different jurisdictions. At present, information structures make little attempt at compatibility with other systems cataloging the same region at different scales. When systems overlap geographically and bring together the detail of local knowledge and the powerful resources of federal interest, for example, maximum cooperation should be stressed. Such systems could be designed as 'families' within a controlled pattern.

'Environmentally critical areas', land features that have received considerable attention in all state and federal land use legislation, can illustrate the potential of a family of information structures. The "Virginia Critical Areas Study"* lists comprehensive criteria for defining such areas of critical concern:

> "A critical environmental area is: (1) an area which has unusual or man-made features which are worthy of protection by state or local governments;...(2) a natural area which is crucial to an ecological system and should be protected from inappropriate development;... (3) includes certain natural, scenic, or historic areas which are presently endangered, or in obvious danger of destruction, alteration or loss because of the activities of man;...(4) an area which can be considered to contain a primary state resource;...(such as for) wildlife, mineral or agricultural production."(49)

Clearly, there will be connections between the critical areas perceived by nations, regions and communities. The overlap is not necessarily geographically exact, but is a coincidence of interest in the management of valuable resources. Structuring the relevant information for inventorying critical areas could be accomplished in stages such as the following: (i) localities identify and describe areas of concern, based on their own criteria; (ii) state level interests are added when they have been neglected by localities and when conflicts between local priorities must be arbitrated; (iii) the federal level injects its considerations and referees interstate con-

*as described and quoted in "The Reference Guide to Definitions and Classifications of Areas of Critical Planning/Environmental Concern and Development of Regional Impact/Benefit". (see bibliography) cerns.

Such a design takes advantage of the detail and close scale at which local resource management operates, and the scope provided by the larger scale and superior resources of higher orders of government. It also locates decisions within the jurisdiction of closest contact between land management issues and the people who experience the effects of choices.

Public involvement is another concern that varies across government levels. Citizen involvement is generally direct at the local level, but it is also likely to be more politicized or emotional than responsive to technical information and its interpretation. At the federal level, citizen involvement tends to be limited to the activities of powerful interest group lobbies or prominent individuals.

Relating information to public involvement is a matter of access and understanding--similar concerns to those of increasing the use of information by administrators and representatives. Devices such as environmental impact review and public hearings are intended to make information available to citizens. The public disclosure of data can assist people in determining their individual priorities and preferences in land managment.

The role of information structure in assisting citizen involvement is not major, however. The real concern is the lack of channels for ongoing citizen input to policy and decision making. Information structures should be designed to permit maximum accessibility and understandability to the public.

But without a corresponding program that cultivates citizens' capacity to identify problems, voice opinions, and formulate policy*, access to information can dissipate participation energy as much as it can focus it.

4.4 The Role of Case Studies

In the next chapter, three systems are described and evaluated to help translate the rough guidelines, developed in this chapter, into a checklist for designing information tools. This checklist is presented in Chapter Six, and can be used to improve existing structures or to build new ones.

The case studies fulfill three functions. They ground the information/policy/decision discussion on real examples; they demonstrate the value of the approach to information management advocated in the checklist; and they provide the opportunity to experiment with suggestions for improvement.

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*the Rockport classification system (see Chapter Five) was part of a project intended to create a citizen involvement process that would increase the capacity of individuals to influence town planning and policy making. In part the goal was to establish channels for recommending policy to officials, whose routine duties and concern for political survival precluded long range policy making. (50)

CHAPTER FIVE

CASE STUDY INFORMATION MANAGEMENT STRUCTURES

The brief case studies in this chapter are intended to demonstrate the importance of evaluating information structures for their performance in decision and policy making. I have only chosen three cases, but each system has interesting characteristics as an environmental information tool.

I have evaluated the land and water inventory for the town of Rockport, Massachusetts[51] mainly because I helped design and complete it--therefore I know the objectives of the system well, and am familiar with its successes and failures. The system was part of a full-scale experiment to increase citizens' capacity to be involved in community planning, and to improve the policy making process in the town.

The Southeast New England River Basin Commission's (SENE) Development Capability Analysis[52] is the second case. I have chosen it for its emphasis on inventorying and displaying "...not only the location of the region's water and related land resources, but also how the characteristics of those resources presented opportunities or limitations to growth."[53] In several respects this information structure represents an environmental information tool appropriate to short term land management policy making.

The final case study is the "Information System for Environmental Planning" developed by Lyle and von Wodtke.[54] This system is interesting because it is a hybrid of empirical and analytic evaluations of environmental features and their implications for land management. It claims to be designed to operate in a land management planning capacity and to be helpful in decision making by offering an 'objectively' determined evaluation of environmental planning alternatives. This system, the authors explain, lays the groundwork for a future quantitative modeling effort, which will provide more exact analysis of land development proposals.

The evaluation of each case study follows this outline:

1. Description of main features of the system.
   (a) structure
   (b) objectives
   (c) input/output
2. Evaluation of the system's performance.
3. Improvement suggestions, using the considerations developed in previous chapters.

5.1 The Land and Water Inventory for Rockport, Massachusetts[55] (see Figure 5.1)

5.1.1 Description

Structure:

(i) the physical environment is classified in ten categories based on characteristics of soil, geology, hydrology, topography, vegetation and landscape:

rocky coast	surface water
pocket beaches	forested moraine
salt marsh	wooded terrace
coastal thickets	moorland
inland wetlands	developed

FIGURE 5.1 LAND AND WATER INVENTORY FOR ROCKPORT, MASS.

ENVIRONMENTAL DATA

.geology
.soil
.hydrology
.topography
.vegetation
.landscape

CLASSIFICATION

.ten environmental types

LAND USE IMPLICATIONS FOR EACH TYPE

.feasibility (physical constraints)
.suitability (aesthetic, historical value)

SPECIAL SITES

.feasibility
.suitability

(ii) each type is mapped and accompanied by a description of the natural features and the land use implications, discussed from the perspectives of suitability. based on physical environmental constraints,and desirability, based on cultural values ascribed to particular sites--historic, scenic or sentimental.

(iii) the general description is given for an entire environmental type in terms of capability for conservation, light recreation, major recreation facilities, light-, medium-, and intensive-development. Within each general type, sites with special constraints or opportunities are flagged--these include hilltops, steep slopes, fragile ecological units and particularly scenic landscapes. (see Figures 5.2 and 5.3)

Objectives: This inventory is unusual in that it was never intended to be an operational input to land management decisions in the town. As part of an experiment in increasing citizen involvement, it was intended to show how classifying the physical environment could be applied to policy and decision making. The information system illustrated how the town's data resources could be structured, how the environment's characteristics indicate constraints on land use, and how an information tool could aid conservation and development choices.

The citizens in the project used the classification system as technical support for policy recommendations to town officials.*

*Policy recommendations included: "15...that Rockport draw up and adopt new subdivision and zoning by-laws that take account of ecological and aesthetic considerations...A. new conservancy or wetlands districts be created to protect sensitive wetlands and water pockets...C. Appropriate local environmental review procedures be adopted providing for a careful analysis of the short-term and long-term effects of new development...F. A detailed map be drawn up and adopted which officially identifies all sensitive ecological areas

FIGURE 5.2[56]

Coastal Thickets

Area involved: 335 acres

Percentage of overall acreage: 7.5%

Characteristics
Soil: Firm; underlaid by sand and gravel in some locations; very thin as it approaches the coast.

Surface Geology: Some outcrops, but less than most areas; underlied by bedrock close to the surface.

Vegetation: Covered in low plants, vines, bushes, grasses and some low trees.

Topography: Level or gently sloping; 0-70 feet above sea level.

Drainage: Internal; in most areas directly into the ocean.

Relationship to the Surrounding Environment
Coastal thickets begin inland with a gradual transition from the forest and woodland types. As thick vegetation nears the coast, thin soil and drying winds prevent growth of tall plant cover, which is replaced by luxuriant bushes and herbaceous plants. Very near the coast these plants grow thinner until at the rocky coast there is no vegetation.

Uses

Appropriate:

1. Light outdoor recreation, such as hiking, nature observation
2. Major recreation facilities, such as tennis courts
3. Conservation
4. Light development, if serviced with sewers and water
5. Medium development, if serviced with sewers and water

Inappropriate:

1. Intensive development

Special Sites
1. Halibut Point — site undesirable for development due to its unique natural beauty and nearness to existing preserved areas.

2. Straightsmouth Island — site already chosen as a conservation area; a wildlife reservation site owned by the Massachusetts Audubon Society.

3. Loblolly Cove — site undesirable for development due to the natural beauty of its combination of pocket beach, rocky coast, thickets, and wetland.

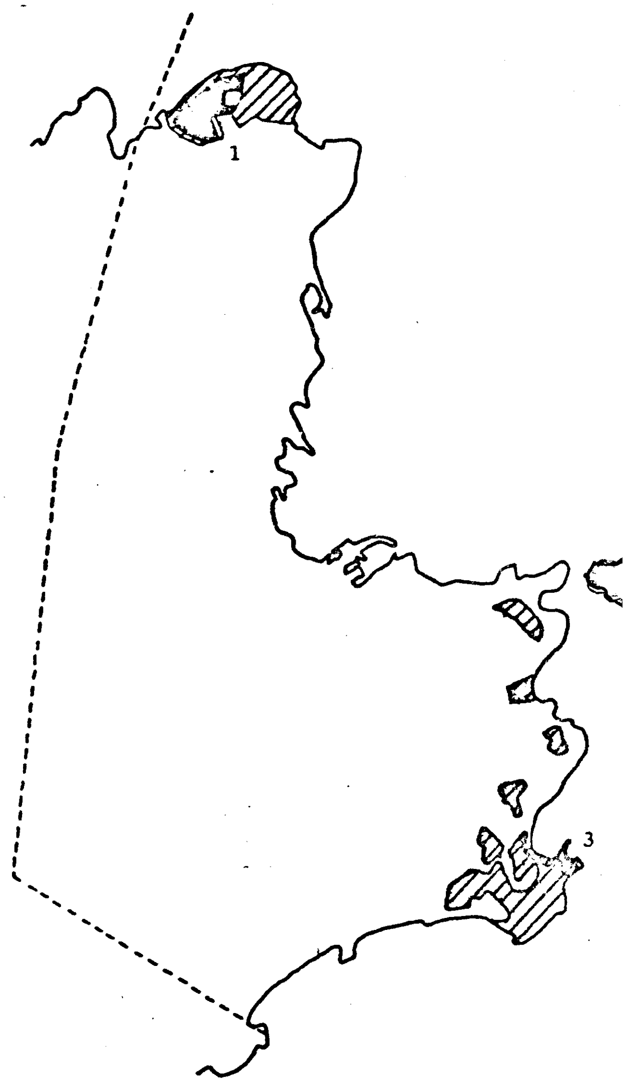


FIGURE 5.3[57]

Wooded Moorlands

Area involved: 227 acres

Percentage of overall acreage: 5.0%

Characteristics
Soil: Very thin glacial till susceptible to rapid erosion in sloping areas.

Surface Geology: Many bedrock outcrops.

Vegetation: Some areas have low tree cover, such as pines and small deciduous trees; other areas are covered with brush and low herbaceous plants.

Topography: Fairly regular; generally 100-150 feet above sea level and highest in Rockport.

Drainage: Rapid; through surface channels under heavy precipitation, otherwise internal.

Relationship to the Surrounding Environment
Generally on the highest ground in Rockport, wooded moorlands merge into denser woodland and forest as soils grow thicker and less susceptible to erosion at lower elevations. Changes in vegetation and boulder/bedrock cover are steady but gradual so that boundaries are approximate. The shores of surface waters (e.g. quarries) are particularly sensitive and are valuable for public recreational purposes.

Uses

Appropriate:

1. Light outdoor recreation, such as swimming, hiking, nature observation

2. Conservation

3. Light development, if sewered

Inappropriate:

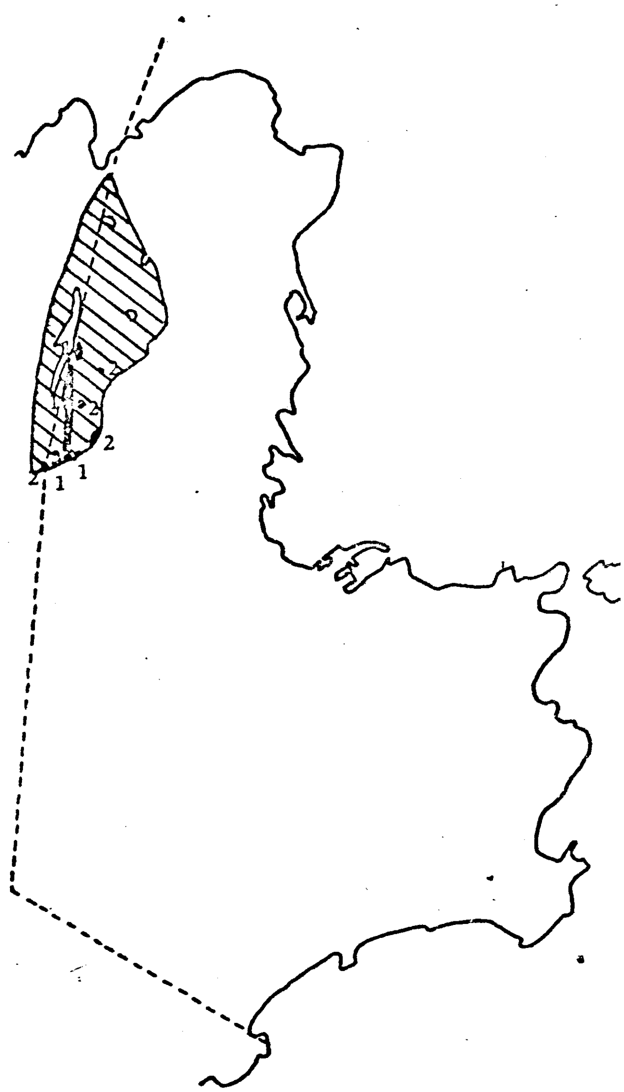
1. Major recreational facilities

2. Medium development

3. Intensive development

Special Sites
1. Steep slopes — sites inappropriate for any type of development due to susceptibility to soil erosion.

2. Hill tops — sites inappropriate for any type of development, since loss of vegetation could result in soil erosion and excessive near-surface drainage problems; prominant development on hilltops is also undesirable as it would detract from the visual quality of the environment.



Since the town had no land management policy base, and no scheme for structuring its data resources,* the citizens advocated the land and water inventory as a model information tool for Rockport.

The categories in the system were chosen by the staff to illustrate clearly the differences between environmental types and to correspond with the landscape patterns that people in the town distinguished in their own references.**

During the design of the inventory, a secondary experiment was conducted. All the information was translated into the USGS classification system scheme for remote-sensed data. Nothing operational ever came of this attempt, though, since there was no existing program to 'accept' this information.

Input/Output: The data sources used were USGS topographical maps, soil and geology surveys, low-level aerial photographs, NASA high-altitude visible light and infrared photographs, and direct site visits. The soil and geology information was far out of date, but this was not a problem since the system was not

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and the development capabilities of each parcel of land in Rockport." (58)

*of special interest at that time was the new soil survey that was soon to be completed, and for which all town officials (Conservation Commission, Department of Public Works, Planning Board) had great hopes.

**Professor Kevin Lynch suggested the value of keying local residents' 'environmental classifications' to the land and water inventory. He advised that people maintained personal classifications of their surroundings, and could perhaps identify more readily with a system keyed to their own categories than with a system with unfamiliar divisions. Professor Lynch's study for the Vineyard Open Land Foundation (59) was a helpful reference for the system designed for Rockport.

to be'implemented'. The inventory was not computerized--the information was assembled manually and published in report form.

5.1.2 Evaluation

The strongest features of this classification system are:

(i) the system was a learning device for citizens--showing them how to use technical information as a basis for developing policy recommendations.

(ii) the inventory provided a model for structuring environmental information as a useful tool in policy and decision making.

(iii) the data provided technical support for a series of recommendations to town officials--all the suggestions called for increasing the consideration of ecological and environmental factors in land management.

(iv) most importantly, the information (and the citizens' use of it) became an aid to intermediate and long term policy making. Officials in town had neither the time nor the expertise to approach land management problems in a systematic fashion. Most decisions were made on an _ad hoc_ basis. The staff helped the citizens, with tools like the inventory, to fill this void.

There are aspects of this system that did not work well, and some problems that were not adequately considered:

(i) the system was designed to aid policy making by the citizens, and was a model for future information use. Such systems are also valuable for use in decision making, as has been discussed in the previous chapters. The inventory should have stated explicitly its potential role in policy and decision making, and the differences between them.

(ii) the citizens were the system's audience; the inventory helped a segment of the population engage in policy making using technical information. Officials in the town could also have benefited from such a learning experience, but there were insufficient time and staff to work with both groups. The system should have included a message to officials concerning the information's usefulness to town land management.

(iii) although the inventory was intended to provide a model, no specific guidelines for update or revision were provided. The citizens participated in the design and construction of the inventory, but probably could have gained from specific suggestions for later work.

(iv) the attempt to mesh with the USGS system was ill-founded. Such a correspondence would be valuable in the context of a program for collecting local environmental information in a standardized format, but no such program existed. The effort was an interesting experiment, but had little practical value at the time.

(v) most importantly, the system did not address the needs of short term policy making at all. The town was in a policy vacuum for land management--officials had recently enacted a moratorium on certain developments, and did not know how to proceed to make more comprehensive policy or long term solutions. The inventory proved to be a useful long term policy making tool, but supplied no guidance for immediate action, except to begin implementing the recommendations.

5.1.3 Improvements

(i) A specific explanation of the inventory's potential application to decision and policy making should have been available to the citizens and to officials in town. Also needed were specific suggestions for future inventories that could structure new information as it became available. Detailed explanations of the connections between environmental features and land use limitations or opportunities, and instructions for determining the capability of land parcels, should have been provided. A set of descriptive models of environmental processes would have made a significant contribution to the value of this inventory.

(ii) to accommodate the town's needs for immediate land management guidance, the inventory should have emphasized the major constraints and problems already existing in the town. A special list of sites with critical conditions would have aided Rockport's officials. Rather than waiting in uncertainty for new information and policy guidelines, they could have taken interim actions based on limited, but accurate, technical information.

5.2 The SENE River Basin Commission Resource Development Capability Analysis[60] (see Figure 5.4)

This system is described in Chapter 3: Guiding Growth in SENE's 1974 resource study.* The study describes the implications of environmental characteristics for land management. Beginning with a concrete rationale for guiding growth and development, the study outlines a method for classifying land on the basis of its capabilities and limitations for use--not in terms of specific uses, but in terms of general constraints and opportunities.

5.2.1 Description

Structure: Using an explicit list of criteria (see Figure 5.5), the SENE Resource Development Capability Analysis inventories the major water and related land resources of the region, and the special considerations for managing each of them. Resources are grouped into three main categories--Critical Environmental Areas, Developable Areas Requiring Management, Preempted Use Areas--which are subdivided into eleven development capability subcategories (see Figure 5.6) The text of the information system describes each resource and its importance. Based on the classification scheme, the report documents a series of land management policy alternatives and clearly demonstrates the value of technical information in guiding land management in Southeastern New England.

*this description is based on a draft version of the SENE report, since the final text was not complete at this writing.

FIGURE 5.4 SENE RESOURCE DEVELOPMENT CAPABILITY ANALYSIS

DEFINE RESOURCES

- .water related land resources
- .beaches, dunes, aquifers, wildlife habitat, etc.

CRITERIA FOR CLASSIFYING RESOURCES

- .sensitivity and retrievability
- .threat to public health and safety
- .scarcity or uniqueness
- .institutional criteria
- .intrinsic values

CLASSIFICATION SYSTEM

- .environmental areas requiring protection
- .developable areas requiring management
- .preempted use areas

FIGURE 5.5 CRITERIA FOR CLASSIFYING RESOURCES[61]

a. Intrinsic Resource Values: Resources which provide services to man, as wetlands provide natural valley flood storage; renewable resources which are needed for production such as wildlife habitat, and non-renewable resources such as sand and gravel needed in construction; and resources which have amenity value such as scenic, recreational or educational areas.

b. Resource Sensitivity and Retrievability: Resources which are particularly vulnerable to development, such as barrier beaches or shoreward dunes, or not easily retrieved once developed such as filled-in wetlands.

c. Threat to Public Health and Safety: Resources which would present a threat to public health and safety if developed, such as the threat of flooding presented by flood plains or beach development.

d. Resource Scarcity or Uniqueness: Resources which are particularly scarce, unique and therefore valuable, such as high yield aquifers in ground water dependent areas, scenic promontories in generally flat landscapes, or regionally or nationally significant historical sites.

e. Institutional Criteria: Resources which are similarly regulated or which have already been classified by such acts or guidelines as the:

- Water Resources Planning Act of 1965
- National Environmental Policy Act of 1969
- Federal Water Pollution Control Act Amendments of 1972
- Coastal Zone Management Act of 1972 and related Committee Reports
- Rural Development Act of 1972
- U.S. Water Resources Council, Principles and Standards
- Proposed federal land use bills
- Massachusetts Wetlands Act
- Massachusetts Environmental Policy Act (MEPA)
- Martha's Vineyard Land Use Act
- Proposed Nantucket Sound Islands Trust
- Rhode Island Statewide Land Use Plan

FIGURE 5.6 THE SENE RESOURCE DEVELOPMENT CAPABILITY SYSTEM[62]

Physical Environmental Areas Requiring Protection

Water Bodies--includes estuaries, shellfish flats and spawning areas.

Priority Protection Areas--wetlands, well sites, beaches and critical coastal erosion areas.

Other Protection Areas--flood plains, specified agricultural soils, unique natural and cultural sites, proposed reservoir sites and related watersheds, and upland erosion areas.

Developable Areas Requiring Management

Water Resource Limitations

Aquifers and/or Recharge Areas--highest yield aquifers in each basin.

Wildlife and Scenic Resource Limitations

Wildlife Habitat--best upland wildlife habitat other than publicly owned land or wetlands, and commercial fishing grounds.

Landscape Quality Areas--land characterized by high landscape quality.

Soils Resource Limitations

Ledge and/or Steep Slope--land with slope greater than 15 percent and/or with rock near the surface.

Severe Septic System Limitations--land with severe septic system limitations.

Moderate to No Septic System Limitations--land with moderate or no septic system limitations.

Preempted Use Areas

Urban Areas--residential areas on less than one-acre lots, institutional, commercial and industrial development.

Publicly Owned Lands--major parks, forests, watersheds and military lands.

Objectives: The study was intended to "...suggest strategies for protecting the critical water and related land resources of Southeast New England while accommodating future economic activities; and to suggest ways that growth might be guided to preserve the amenities of the region and the quality of its resources."[63]

The capability analysis identifies the resources and the problems with which it is most concerned-- water related land features* with special limitations on development and use (because of physical constraints, special planning significance, or major social disbenefits that would result from poor management).

The study, and the information structure it uses, details a set of explicit recommendations for actions within the SENE region to achieve effective resource management. Tracing out a series of policy alternatives**, the report demonstrates how the capability analysis is valuable under any choice. Finally, it lists the positive implications for the region that would result from implementing the land management recommendations.

These benefits include:

-positive effects on the national economy, by reducing the resource and public investment costs of growth.

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*wetlands; beaches; dunes; bluffs; waterbodies; well sites; estuaries; flood plains; prime agricultural lands; unique natural and cultural areas; aquifer and recharge areas; upland wildlife habitat and high landscape quality areas; soils with development limitations; developments of regional impact; key facilities; large scale or growth inducing development.

** continuing existing programs; increasing the protection of critical areas; improving the management of developable areas.

-savings in construction and infrastructure costs, energy and water consumption.
-overall improvements in regional environmental quality.
-mitigating the traditionally negative effects of development such as erosion, water pollution, flooding, loss of wildlife habitat.
-benefits for the regional economy--by encouraging economic activities most appropriate to New England.
-insuring and improving the quality of amenity resources.

Input/Output: The Commission drew on local and state agencies to help prepare the capability analysis. The entire structure was costly to produce, and had many data sources and a large staff available. The quality of the analysis and the thoroughness of the investigation reflect these advantages.

The material is summarized in a report available only in draft form at this writing. The structure does not depend on computers--maps and documentation are the display media. The distribution of the output is an interesting concern--who will have access to the data and who will use it? The structure is very good, and the information extensive. It should reach many actors in land management policy and decision making.

5.2.2 Evaluation

There are several strong features of this scheme that make it an effective tool both for policy and decision purposes.

(i) the land management implications of environmental characteristics are expressed clearly in terms of limitations, impacts or losses due to poor management, and the effects on environmental quality*. Technical information is presented in a

*The capability of lands important for the use, management, or development of water resources is limited "...for a number of reasons. Some are vital to the preservation of drinking water supplies. Others form part of the marine context directly applicable to policy formulation. The economic and social benefits of land use and development control are described, as are the dangers of mismanagement. Therefore, the information tool is directly applicable to short term policy.

(iv) an explanation is provided of the rationale for the information system's design, as are instructions for using the information (and a convincing discussion of why to use it). The recommendations for policy formulation follow unambiguously from the analysis of land capability and the evaluation of policy options.

5.2.3 Improvements

(i) the information is provided at a large scale (1:125,000), which is appropriate for regional and/or state policy and decision making. The system could be keyed to local level detail, to provide the site specific data necessary for actual regulation. This would be a good opportunity to develop a cooperative, patterned set of information systems at different scales of concern.

(ii) the information is in an excellent format for use in policy making, but is not applicable to decision making for specific problems (other than the protection of water related land resources) such as environmental impact prediction,

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(continued from previous page)
food chain or serve as wildlife habitats. Still others would be a threat to public health and safety if developed. The decision as to whether such lands are to be developed or preserved invokes weighing the benefits of development against the benefits of preservation (or the costs of development)." (64)

guidelines for development near fragile areas, and guidelines for facilities siting. This is not a problem with the system, but is another opportunity for matching with other information sources.

(iii) the system description does not refer to disseminating the information to agencies, local governments or citizens. Nor does it discuss the specific actors that the recommendations are intended to influence. Since the documentation goes as far as tracing out policy options and suggesting state and local actions for growth management, SENE should have considered the implementation prospects completely.

(iv) an inventory of existing problem sites or resource damage areas would have been a valuable addition. Such an inventory could complete an accurate description of the regional resource base, and indicate starting points for growth and development regulation efforts.

5.3 The "Information System For Environmental Planning"[65]

(see Figure 5.7)

> "This information system is based on interactions of location, environmental effects, and developmental actions. The system is designed to identify optimum locations for development on the basis of natural processes, to make qualitative predictions of environmental effects of proposed developments in order to evaluate environmental impacts, and to determine what human activities will bring about the least change in natural processes on given land."(66)

FIGURE 5.7 "INFORMATION SYSTEM FOR ENVIRONMENTAL PLANNING"

ENVIRONMENTAL EFFECTS

.qualitative models of environmental processes
.matter and energy flows

PHYSICAL CHARACTERISTICS

.soil
.geology
.hydrology
.vegetation
.wildlife

DEVELOPMENTAL ACTIONS

.capital investments
.operating facilities

INTERRELATIONS TABLES

.cross-reference environmental effects, physical characteristics, and developmental actions

5.3.1 Description

Structure: This system is an information tool for guiding development decisions on an ecological basis. The authors claim that it is a way to assemble the best available information in a format useful for comprehensive planning; it can be updated and is flexible in terms of application; it can "...incorporate changing goals and priorities as perceptions and attitudes change."[67]

The information structure is relatively complex, and covers three main factors: environmental effects, location, and development actions. Environmental effects are predicted by using a series of descriptive models of natural systems. These are presented as flow diagrams that describe energy and matter transfers. The transformations are categorized as: inputs and outputs, storages, workgates, plants, animals, and human enterprise. (see Figures 5.8 and 5.9)

The models allow analysis of a development as a new factor introduced to the flow; the effects of this stress can be traced through subsequent processes and a prediction of impacts can be made. The authors expect that, as data becomes more available, the flow diagrams can be reconstructed as mathematical models.

In practice, the flow diagrams are interpreted according to the physical characteristics of particular land parcels. Information on the physical characteristics of the study area*

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*precipitation, plant climates, plant communities, slope, elevation, drainage patterns, flood plains, water features and other special features, soil, geology, land use, traffic volumes.

FIGURE 5.8[68]

TRANSFORMATION SYMBOLS and KEYS DEFINITIONS:

INPUT OR OUTPUT
Importation or exportation of material or energy to or from a given system.

STORAGE
Temporary retention of material or energy in a certain level of a given system; such as the storage of water in a reservoir.

WORKGATE
A material flow acted upon by the energy of some outside force; such as evaporation of water.

PLANTS
Reception and processing of materials and energy through the process of photosynthesis; such as in green plants.

ANIMALS
Reception and processing of materials and energy through the process of respiration; such as herbivores and carnivores in a grazing food chain.

HUMAN ENTERPRISE
A systematic or purposeful human activity, transforming material and energy; such as agriculture or manufacturing.

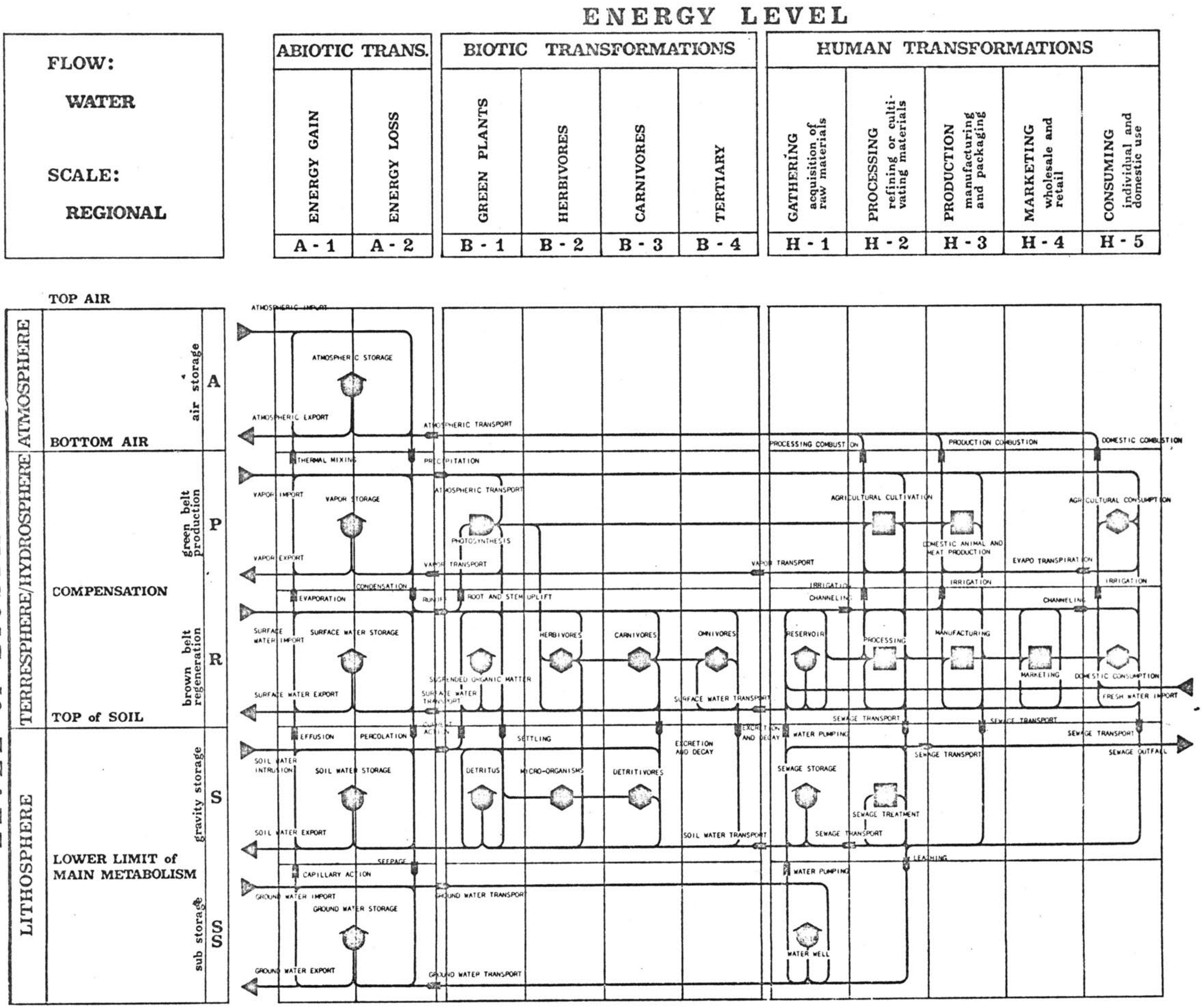


FIGURE 5.9[69]
LEVEL of BIOSPHERE

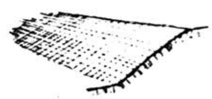
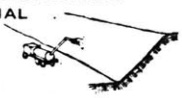
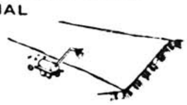
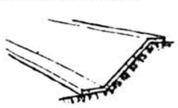
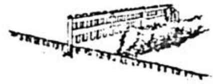
Transformations and Circuits for Regional Water Flows is stored in a grid system that operates at three scales: regional--22.9 acre cells; planning unit--2.6 acre cells; local--.28 acre cells.

The third information component is 'developmental actions'. These are human activities* which cause changes in ecological processes. Actions that are intended to reduce environmental effects are subdivided into techniques for accomplishing them. (see Figure 5.10)

These three components are brought together in charts that detail the interactions between ecological processes, locations and development. For example, a process such as water erosion is linked to developmental actions and the effects on soil or vegetation can be traced, for a specific location. Since all information is cross-referenced, a 'search' could start with a physical characteristic and find all the natural processes that shape it, or all the developments that could have adverse effects on it.

Objectives: This information system is an attempt to "...relate environmental impact analysis to established planning procedure,"[71] and incorporate the intent of recent environmental legislation into "...the comprehensive planning process."[72] The designers sought to supply planners with a technical information system

*subdivided into: capital (investments in physical alterations to the land); and operational (actual use of the environment). The authors give an example--highway construction is a capital action that alters landform; highway use is an operational action that changes air and water quality, causes noise,etc.

DEVELOPMENTAL ACTIONS	COMPONENTS	METHODS	DESCRIPTIONS	TRANSFORMATIONS AFFECTED	COMMENTARY
LANDFORM STABILIZATION	SOIL RETENTION	CULTIVATION 	Prevention of erosive forces of water moving downhill by contour plowing (lateral furrows).	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Temporary measure requiring constant monitoring and maintenance does not prevent wind erosion. Encourages percolation.
		PLANTING 	Use of plant material as soil binder. Method of planting varies: 1. Planting from containers 2. Aerial seeding (large scale) 3. Hydro-seeding (broadcast in liquid mixture by machine).	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Effectiveness dependent on species of plants, time of planting. Consideration should be given to use of natives vs. Exotics and the need for irrigation.
LANDFORM STABILIZATION	SOIL RETENTION	JUTE MESH 	Heavy woven jute layer used as surface soil binder, often used in conjunction with planting. Rolled onto slope in strips.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Interim measure while plants become established. Will decompose in a short period of time.
		STRAW COVER 	Straw, broadcast over slope, then rolled into surface with sheepsfoot roller forming a compacted, bound surface.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Interim measure while plants become established. Requires monitoring and maintenance.
		ROCK BLANKET 	Layer of rock applied to surface.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Requires much manual labor for placement. Machinery required may cause incidental compaction.
		SPRAYED SYNTHETIC MATERIAL 	Chemically derived materials applied in liquid or filament form. Applied by machine.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Temporary measure, leaving residue of materials for indefinite periods. Generally hampers plant germination, and can stop percolation when applied heavily.
LANDFORM STABILIZATION	SOIL RETENTION	DEGRADABLE SPRAYED MATERIAL 	Organically-derived materials applied by machine.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Temporary measure, with residue breaking down in relatively short period of time. Usually encourages germination and growth of plants.
		IMPERVIOUS MEMBRANE 	Waterproof surface coating, such as concrete or asphalt.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Permanent measure, severely affecting many natural processes. Displaces animal habitats.
		WINDBREAKS 	Plant material or structural elements to prevent wind erosion by slowing and settling airborne particles.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Incidentally alters air flow. Serves as method of landform alteration in that soil builds up around barriers in many cases.
		NO SOIL RETENTION	Erosion control rendered unnecessary by use of stable, natural landforms and avoidance of alteration.	Sedimentation Soil Storage Water Erosion Wind Erosion Runoff Resource	Allows natural processes to continue uninterrupted.

Control by Design Chart

that would be adaptable to changing policy guidelines.

> "The system does not include social or economic variables. These must be dealt with by other planning techniques and combined with information concerning natural processes to eventually formulate plans. Thus, the Information System is but one component of a comprehensive planning process. Later on, an effort may be made to incorporate social and economic data into this system."(73)

The system was designed to fill what the designers saw as an information vacuum for planners faced with the relatively recent demands of considering the ecological effects of development and land use.

Input/Output: Preparing the 'library' of ecological process flow charts (such as the one in Figure 5.8) requires detailed knowledge of the natural environment in the region where the system will be used. Then the physical characteristics of the study area must be carefully inventoried and stored. The lists of development actions to be tested (actions likely to occur in the area) must be compiled, and the related effects traced through the flow diagrams. To operate the system for a test site requires substantial investment.

All the information is stored and cross-referenced by computer, to facilitate handling. The material in the system is complex, especially the flow diagrams and the interrelations tables for ecological processes, development actions and location. Actually using the system, though, does not require dealing with all the 'background'--the system gives direct answers to specific questions about environmental impacts.

5.3.2 Evaluation

(i) the main achievement of this information system is that it provides a thorough analysis of the factors involved in predicting environmental impact (limited by the accuracy and validity of existing ecological theory). By following the conceptual framework, a complete checklist of the sources and kinds of impacts, and the design methods for minimizing adverse effects, can be obtained.

(ii) the system is explicitly directed at decision making applications, and is designed for use by professional planners.* As such, it is quite technical and complex. The flow diagrams are a good example of this complexity--they are difficult to read and understand quickly. In fact, the authors recognize this problem and define one direction for continued work as follows:

> "Finally, much improvement must be made in the means of interaction between planner and system. More efficient programs are needed. Ideally these can use plain English and feature almost immediate response, so the planner can carry out several reiterations of a model in a short time without programming assistance. Such convenience and simplicity in application would make widespread use almost certain." (74)

(iii) the system is not at all oriented toward informing

*The system's emphasis provokes a discussion of the role of planners in land management. One view would contend that planners are technicians responsible for assembling data and evaluating decision alternatives within the context of externally defined policy; that they provide 'objective' analyses of information; that they are effective when they provide thorough technical analysis and professional recommendations. This may be contrasted with a model in which planners are active in influencing land management policy (for example, by working to improve policy processes and increasing citizens' involvement); they realize the subjective nature of all information use in policy; and they are effective when they work to insure implementation of recommendations. This particular information system could be used in either model--<u>how</u> it is used would change.

land management policy making. Policy is treated as an external variable; the information tool can adapt to shifting priorities. For this reason, the desire to add economic and social information is useful only if the designers wish to make an advanced predictive model for policy alternative testing. This improvement, of course, would be very costly.

5.3.3 Improvements

(i) as a decision making tool, the information tool is comprehensive and well designed. The biggest problem (at least in terms of the documentation) is clarity of communication. Much of the presentation format is to complex. Flow diagrams are an accurate accounting of ecological processes, but are not good communicators. Pictorial models of ecologic models would be clearer. The models themselves are excellent---a series of diagrams based on these materials would have been a valuable addition to the Rockport classification system. Conversely, if this system is used to produce land capability studies, presentation of the data in a series of maps would be a valuable public information source.

(ii) the system's role as a decision making tool raises an important point. The designer of an information system must make a firm choice--it is very difficult to serve policy and decision making and communicate information to the public. Emphasizing one track demands sacrifices in others--the choice revolves around the designer's notion of effective use of information. This environmental information system tries to serve professional planners, but at these 'costs': the system responds to, rather than influences, policy making; the information is not useful to nonprofessionals (such as citizens or policy makers); there is no implied attempt to improve the land management policy process, only an attempt to adapt to priorities or preferences.

CHAPTER SIX

SUMMARY OF GUIDELINES

Throughout this study--the investigation of decisions and policies, the analysis of information structures, the brief glimpses at operating systems--my objective has been to derive guidelines for designing environmental information tools. A number of concerns, questions and recommendations has surfaced at each stage of the thesis. This final chapter collects them, in a checklist format, as an aid to information managers. The 'technical' concerns developed by the various researchers mentioned in the text are included, and all the considerations are treated as options in design. These are not criteria in the strict sense; the following questions are choices available in constructing information systems.

6.1 Paralleling the Land Management Process

6.1.1 Context

(i) is the information structure intended to aid decision making or inform policy making? (pg.18-20,22;Section 2.7; Ch.4) If the structure is a decision making tool, the technical demands are stringent--accurate problem definition, incorporating the best available theory and information, devising or locating analytic and problem-solving techniques. For use in policy making, communicating information to non-technicians is most important.

(ii) are the implications of the environmental data made clear? In what terms--human health? public safety? economic, social, ecological impacts? environmental quality? (pg 84,107) The metric used to interpret information partially determines its impact on users.

(iii) what specific applications (problems, issues) are intended? should the system be flexible in terms of applications (such as land use, agriculture, forestry, wildlife, pollution problems) or should it be tailored to highly specific use? what planning context (urban, rural, wilderness) is the system designed for?

The analytic techniques and the theoretical groundwork used in the system should be chosen for the application. Flexibility allows wider application of the information management tool, but may demand sacrifices in efficiency for specific uses.

(iv) is the system for local, regional or continental scales of problems? what are the constraints of finances, technology and personnel? does the system make best use of available resources?

It is important to consider the relationship of the information tool to the size of the area in which it will operate. Level of government is a surrogate variable for many significant factors--kind and magnitude of problems, amount of data required, resources available, scope of concern. In considering resource investment in information structures, expenditure <u>over</u> <u>time</u> must be calculated. The long term costs must be weighed against the anticipated value of the product.

(v) is the system to be used in short, intermediate or long term policy making? for testing policy alternatives? for predicting policy effects? (Ch. 4)

Short term policy making requires immediate information; there is little time for data collection or interpretation. Intermediate and long term policies are implemented by series of decisions, with technical information requirements.

(vi) what value scales or judgements (policy statements) are necessary inputs to the system? should the system be able to adapt to changing priorities or values? (Section 5.3.2)

Any information structure used in policy making should not attempt to make internal policy syntheses or evaluations. For testing policy alternatives or predicting impacts, complete user control over adjusting value inputs is essential.

6.1.2 Users (Section 2.3; Chapter 4)

(i) who will use the information tool? is the system understandable to professionals, administrators, representatives, citizens?

(ii) who will have access to the information? what will be the constraints on access?

(iii) does the system contain guidelines for use?

(iv) who will decide the uses of the information? who will determine the data inputs, and who will collect them?

(v)what are the capabilities of the people who will use the information? is the information tool geared to their needs?

(vi) is power centralized or diffuse among actors? will the system attempt to counteract or reinforce existing conditions?

The information tool must be designed according to the characteristics of the anticipated users. Many of these choices are value judgements--if citizen involvement is taken as a goal in land management, then all information structures must emphasize access to people. To adequately answer all these 'user' questions, the designer must understand the client, and define measures of effectiveness for information use.

6.1.3 Features

(i) does the information system define gaps or inadequacies in the data base, or in the accuracy of interpretation skills? does it offer direction for data collection or research efforts?

(ii) can original information be recovered, so that it can be applied to new or different problems?

(iii) at what scale or range of scales should the system operate? what other information tools are operating in the same geographical region (at the same scale, smaller or larger)? is there value (to either system) in making information compatible by relating the systems?

(iv) can the information system be updated (can new information or new concepts be added)?

(v) is the information base comprehensive or selective?

(vi) does the system have predictive capabilities, in terms of environmental impacts?

(vii) what analysis techniques are included?

(viii) what are the data sources, the methods of storage, retrieval and display? is the system manual or computer-aided?

(ix) is the system efficient (fast, economical, near users)?

6.2 Influencing the Land Management Process

To improve land management processes through the design of information structures, communication and teaching aids must be built into data tools. Professionals in the environmental sciences who view themselves as actors in improving decision and policy making will concentrate on achieving accessibility and understandability in technical material.

(i) will the system try to influence policy or decision making?

(ii) will the system teach users? is it designed to help users (citizens, representatives, administrators or professionals) learn about ecological processes; environmental quality; the constraints, opportunities or impacts related to land use and development? does it help users learn to use technical information to set priorities, to observe and define problems, make decisions, formulate policies? (Chapter 4; Section 5.1)

(iii) is the system supposed to convince anyone to consider ecological/environmental factors in land management?

(iv) to an extent, information gives power--to whom should the information tool give power?

(v) what is the role model for planners/professionals implied in the design of the information system? (Section 5.3.2)

Building information systems involves two processes: defining 'effective' information use in policy and decision making and manipulating environmental data. By identifying many of the choices required to judge 'effectiveness' and organize information, this list of questions can aid the design of information tools that guide and improve the process of land management.

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