A CONCEPT OF NATURAL RESOURCE MANAGEMENT: AN APPLICATION TO UNICORNS

CHARLES C. KRUEGER, Department of Natural Resources, College of Agriculture and Life
Sciences, Cornell University, Ithaca, NY 14853
DANIEL J. DECKER, Department of Natural Resources, College of Agriculture and Life Sciences,
Cornell University, Ithaca, NY 14853
THOMAS A GAVIN, Department of Natural Resources, College of Agriculture and Life Sciences,
Cornell University, Ithaca, NY 14853

Abstract: Natural resource management is a dynamic, goal-oriented process that functions within a management environment and is guided by a team that represents many disciplines. The management environment is a combination of cultural, economic, political, and ecological components. The management team includes individuals who represent disciplines such as ecology, sociology, economics, administration, political science, educational communication, law enforcement, and management science. The management process is described in terms of six interactive elements that are set within the management environment. Goals (1) are broad statements of intent about the purpose of management. Objectives (2) provide a measureable definition of the goal that is expected by a specified date. Problem identification (3) determines what prevents achievement of objectives. Actions (4) are implemented to solve the problems that are identified. Evaluation (5) measures the response of the management environment to the actions in terms of the parameters stated in the objectives, and provides redirection to the management process. This later step is essential if goals and objectives are to be revised, new problems identified, and alternate actions implemented. Evaluation provides the feedback link to cause management to be an adaptive process. These five elements cycle around and interact with an information base (6) that includes published information and the collective experience of the management team.

Management of natural resources is a complex process that involves management professonals and, increasingly, the interested public. Effective decision-making can be hindered by the different concepts of the management process that occur among resource managers, and between managers and the public. In the authors' experience in Great Lakes fishery management (CCK) and management of white-tailed deer (*Odocoileus virginianus*) on Long Island, New York (DJD and TAG) and in Washington (TAG), resource managers and the public will often interact with each other about management solutions without a common agreement on goals, objectives, or problems. Without agreement on these issues, the result can be ineffective management that does not meet the needs of the public, that may be to the detriment of the resource, and that wastes available funds and human resources.

Resource managers could better guide the management process, especially when the public is directly involved, if they agreed to similar concepts about how management should be approached. Such a conceptual model must be rational and logical in sequence and yet be sufficiently robust to accomodate initial errors in decisions. The model must be self-correcting and adaptive to social and biological changes over time, and thus encourage proactive as opposed to reactive management.

In this paper, we define the environment within which management must function, discuss who the resource manager is, and propose a simplified, idealized conceptual model for resource management. Parts of the model are similar to descriptions of comprehensive and strategic planning for natural resource management (Rieck 1971, Phenicie and Lyons 1973, Matthews 1976:10, Anderson and Hurley 1980:460, Crowe 1983:7) and descriptions of business management (e.g., Kast and Rosenzweig 1970: 456, Buchele 1977:275, Odiorne 1979, Christopher 1980:23, Wren and Voich 1984:8). The purpose of this paper is to broaden the concept of resource management by discarding the common notion that management consists solely of techniques such as regulations and stocking.

MANAGEMENT ENVIRONMENT

The management environment can be described as a composite of cultural, economic, political, and ecological components within which resource agencies must function. The cultural component includes the traditions, religions, and philosophies of the general public and resource managers. This component contributes most to the establishment of values by society for natural resources. These values provide the principal motivation for resource management. Management is conducted because the end products of the process are believed to have value to part or all of society.

The economic component includes all the processes of the marketplace that can influence decisions about resource management. The economic component can influence management of the resources related to commercial fisheries and timber production for example, and has become an important consideration in management of recreational resources such as Pacific salmon (*Oncorhynchus* spp.) in the Great Lakes. The economic impact that results from management contributes to the societal perception of the value of management, and thus helps to define societal values.

The political component may be divided into two aspects: first, the laws of government, and second the personal values of the individuals who enact, enforce, or interpret laws and policies. The first aspect can be clearly defined by the legislative statutes and administrative codes that give agencies the responsibility for management. The second aspect is poorly defined because the biases of government officials are dynamic and undocumented. Before a resource manager proposes a new program, the manager should determine if the agency has legislative authority for management, and whether the political "climate" is right for the new proposal.

The ecological component includes the ecosystem where populations of interest live, grow, reproduce, and die. Management programs that intentionally focus on a particular species will often also alter the abiotic and other biotic parts of the ecosystem. The ecological component defines the upper boundaries to what management can expect to achieve in terms of resource production rates. This component exerts control over the annual production of management products, such as number of white-tailed deer, board feet of timber, and pounds of bluefin tuna (*Thunnus thynnus*).

Natural resource managers must consider simultaneously the cultural, economic, political, and ecological components of the management environment because of the interactive nature of these elements. Historically, resource agencies have focused most attention on the ecological component; it is now apparent, however, that the other elements must be given greater attention. In some cases, resource management has been driven principally by components other than the ecology of the system being managed (e.g. Fraidenburg and Lincoln 1985).

THE RESOURCE MANAGER

Operating within the management environment described is the resource manager, who is trained traditionally in applied biology. These individuals often find themselves forced to function within cultural, economic, and political arenas as opposed to the biological focus of their education. The frequent interaction of the local manager with these other subject areas emphasizes the need for the inclusion of social sciences, communication sciences, and the humanities in the college curricula for natural resources.

Resource management at a regional or district level (e.g. Region Six) or for large geographical areas (e.g. Catskill Mountains or Lake Ontario) becomes exceedingly complex due to the extensive nature of the resource and the diversity of users. In this situation, it is unlikely that one person could conduct successful management, or that universities could purport to prepare a single person to do so. At this scale, the concept of the "manager" should instead be changed to that of a "management team" that is comprised of several individuals who represent disciplines such as ecology, sociology, economics, administration, political science, educational communication, law enforcement, and management science. This team could also be used by local managers for help in interpretation of components of the management environment in smaller areas.

DESCRIPTION OF A CONCEPTUAL MODEL FOR RESOURCE MANAGEMENT

The model that we propose has six basic elements: goals, objectives, problem identification, actions, evaluation, and an information base (Fig. 1). Goals, objectives, problem identification, management actions, and evaluation are linked to each other sequentially in a cyclic manner that provides feedback to

the management process to cause self-correction and adaptation. These five elements are linked to and cycle around an information base that helps guide the process. These six elements are connected and occur within the multidimensional management environment described above.

Below we define the six elements further and illustrate these definitions through an application of the model to unicorn (*Unicornus unicornensis*) management. We chose unicorn management as an example because of their considerable scientific interest (e.g., Cole 1957) and the lack of managers knowledgeable about this species. We anticipate, as a result, that readers of this paper will be able to concentrate on the concepts of the model's elements rather than on the details of the examples.
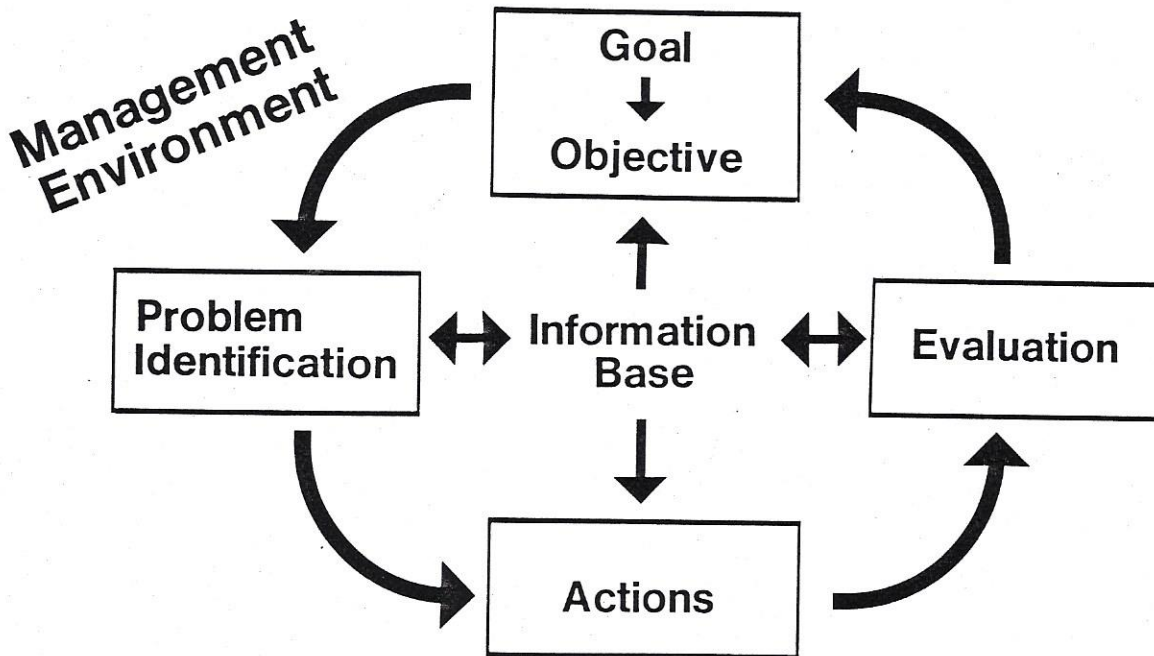

Fig. 1. Resource management displayed as a cyclic process set within an environment that has cultural, economic, political, and ecological components.

Goals

Goal definition is the first and most important step in the management process (Fig. 1). Goal statements describe the purpose of management. Goals are long-term, broad statements of intent about management. Goals explain why we manage natural resources. Goals set the entire frame of reference in which objectives are established, problems are identified, management actions are implemented, and evaluation is conducted to redirect management. The selection of goals is a difficult task. The values of various segments of society must be weighted then balanced against the well-being of the resource and a concern for resource use by future generations. We are not aware of any formal decision process that can easily accommodate these values and concerns, and therefore urge that the goal-selection process be of top priority for study by those interested in natural resource management. Senior level administrators, planners, regional or district managers/biologists, and public representatives are some of the individuals that should be involved in choice of goals. A philosopher or an individual interested in environmental ethics would also be helpful for the analysis of societal values.

Resource agencies often have several goals which are organized hierarchically. For example, state statutes often define a broad goal statement for an agency. Such goals are often termed "mission statements" by the agencies. These statements give authority and direction to an agency but are of limited assistance to the definition of goals lower in the hierarchy. Under these broad statements are program-level goals that may focus on a specific resource (such as unicorns). The model description and examples used in this paper address resource management at the program level only; however, we believe the concepts to be useful at the higher levels of agency management as well.

The unicorn management goal is based on the information that society values unicorns as oddities of the animal kingdom. Although rarely seen, great pleasure is derived by those lucky individuals who can observe a unicorn in its natural habitat (typically adjacent to watering holes). Published studies indicate that unicorns are extremely rare and in danger of extinction. Thus, agencies must manage unicorns due to the societal values reflected in the Endangered Species Act. The information described above (from the information base) provides the basis for establishment of a management goal:

To restore populations of unicorns in the northeastern United States, to ensure preservation of the species and to provide the opportunity for observation by humans.

This goal clearly states the purpose (restore populations), outcome (preservation of the species), and product of management (opportunity for observation). In addition, the goal provides a spatial definition (northeastern United States) for this new managemen program.

Objectives

Objective statements explicityly define measureable characteristics of the resource, users, and/or resource utilization that will occur during the process of goal achievement (Fig. 1). Objectives provide the criteria by which we measure our progress towards goals. Objectives are measureable and should contain parameters related to the products of management. Objectives also must contain an explicit time frame that specifies when the objectives will be accomplished. Current measurements of a parameter must exist (from the information base) in order for future levels of a parameter to be specified in an objective. In addition, as parameters are chosen for objectives, this selection must be considered as a commitment by the agency to their future measurement. The levels of parameters specified in objectives need not always increase over the time of the management program but could be chosen to be stable or decrease from current levels. Often multiple objectives will be required to quantify the achievement of a single goal. Choice of objectives requires participation from several types of professionals, such as: program administrators, local managers/biologists, planners and budget analysts, and, in some cases, individuals external to the agency who can provide specialized sociological, economic, political, and ecological information.

The choice of objectives for unicorn management is governed by the information available about unicorn population ecology and the public demand to observe unicorns. For example, unicorn populations elsewhere in the world are stable and reproductively self-sustaining where they occur at densities of 20 breeding pairs per square mile. However, minimum herd size under such conditions is approximately 80 breeding pairs, which means that a minimum of four contiguous square miles is required to achieve population restoration where ideal habitat occurs (much of the Northeast). A recent preliminary habitat survey suggests that six populations could easily be supported. There now exist three extant but rapidly declining populations of unicorns. Due to the large human population in the Northeast, demand for unicorn observation is estimated to be approximately 44,000 day trips annually. With this information, the unicorn management objectives were established as follows:

1. To secure permanent protection for unicorn habitat at six sites in the northeastern United States, each with a minimum of four square miles, by 1988.
   A. Three areas are to be within or adjacent to the habitat used by the extant populations.
   B. Three areas are to contain suitable habitat where unicorns may be reintroduced.

2. To maintain population densities at an average of 20 breeding pairs per square mile in each of the three extant populations by 1994.

3. To establish three new populations of unicorns in secured habitat areas by 1994 and to maintain these populations at 20 breeding pairs per square mile by the year 2000.

4. To provide facilities for public access at the six habitat sites, which can accommodate an average of 20 visitors per day per site by the year 2000, and with full use expected by the year 2005.

The objectives above provide quantifiable endpoints for management of unicorns. These objectives quantifiably and temporally describe successful progress toward the unicorn management goals.

Problem Identification

The next step in the management process is to determine what problems prevent achievement of the objectives (Fig. 1). This step is essential if the appropriate management actions are to be chosen. Often management personnel and the public skip this step and assume agreemeent on problems, which is rarely true. If this happens. selection of actions becomes a chaotic process that can result in contradictory actions being implemented. As with the other elements of the management model, the process of problem identification is dependent on the information base. The local manager/biologist who has experience with the resource, and scientists who study the resource are examples of individuals who can help in the transfer of information and with the identification of problems. In some cases, the major problem identified may be a lack of information, and thus studies may be initiated to aid the definition of problems. In other cases, the management team may conclude that the problems related to achievement of objectives are insurmountable, and therefore return to redefine the goals and objectives.

As would be expected, the problems associated with unicorn management are related to land ownership (objective 1), control of mortality (objective 2), stocking techniques (objective 3), and facility development and public information (objective 4). The unicorn management objectives and goal cannot be achieved unless these problems are solved. The specific problems identified are as follows:

1. All available unicorn habitat is currently in private ownership and threatened by urban development.
2. Mortality among adult males is excessive, largely due to illegal harvest by market hunters selling horns for medicinal purposes.
3. Techniques for capturing and transporting unicorns efficiently have not been developed.
4. Architectural designs of public facilities have not been developed to allow observation of unicorns without serious disturbance to populations.
5. The public will be unaware of new opportunities to observe unicorns which will be available in the year 2000.

Actions

The fourth step in the management process is the selection and execution of actions to solve the problems that prevent achievement of the objectives and goals (Fig. 1). Actions or tactics represent what is traditionally thought of as "natural resource management" and have comprised the focus of college courses and texts in resource management. Actions include regulation, stocking, popuiation control, habitat management, and public education. More broadly, actions may be classified as sociological, economic, political or legislative, and ecological, which follows the components of the management environment. Implementation of tactics requires the allocation of money and human resources from agency budgets. As a result, the control of the implementation of actions is usually linked to agency budget planning and is often termed tactical or operational planning.

The choice of actions should involve the local managers/biologists responsible for implementation. Law enforcement personnel should be included whenever regulations are considered as an action. Simulation modelers can be helpful by developing models to assess the probable responses of the management environment to different sets of actions. Agency personnel responsible for budget planning should also be included since actions cost money.

Implementation of actions most often will include the local managers/biologists, technicians, and other agency personnel. In some cases, volunteer help from the public may also be used.

In the unicorn example, actions must be chosen to solve the problem of the development of privately-owned habitat (problem 1). One tactic to solve this problem is as follows:

1. To purchase habitat in contiguous parcels until four square miles are secure at six location.
   A. To inventory areas of suitable habitat.
   B. To select the most suitable locations for purchase that are consistent with the population rehabilitation and human observation objectives.
   C. To promulgate legislation to obtain the budget appropriation required to purchase habitat.
   D. To assess properties, contact landowners, and buy land.

This action includes steps that are ecological (inventory of unicorn habitat), legislative (legislation for budget appropriation), and sociological (contact landowners). The contact of landowners would require that attention be given to education of the public in order that landowners would understand their role in the management program. This educational aspect may require the development of an array of educational materials and use of a variety of media that explain the program.

Evaluation

Evaluation determines the response of the management environment to the actions implemented and compares these measurements to the parameters stated in the objectives (Fig. 1). Evaluation is the last step in the management process and includes four parts: parameter measurement, comparison to objectives, assessment of the comparison, and management revision. First, the parameters stated in the objectives are measured as response variables to the management envirnoment. Next, the comparison process determines whether the objectives have been achieved. Third, assessment follows to determine the probable causes for (or the lack of) achievement of objectives. Fourth, the management program is revised based on the results of assessment. Measurement of parameters may involve statisticians, agency research personnel, private consulting firms, and university scientists. The comparison and assessment parts of evaluation would include the above individuals plus the agency's program administrators. The individuals who would be involved in management revision would depend on the management step being revised.

The evaluation step allows the management process to cycle to the next appropriate step to revise goals, modify objectives, identify new problems, and select new management actions. Evaluation is essential if management is to be self-correcting to earlier errors and adaptive to a changing management environment. Unfortunately, in many agencies this step has been neglected entirely.

Evaluation of the unicorn management program would be designed around the parameters specified in the objectives. For example, the number of habitat areas, their size, and their location would be determined administratively (objective 1). Ecological studies would be conducted on both the extant and introduced populations (objectives 2 and 3). The existence of public access facilities would be determined administratively, and a study of public use of those facilities would ascertain whether full use had occurred (objective 4). Minimally, these determinations must occur in the years specified by the objectives. Preferably, the measurement of parameters would be ongoing prior to these dates so that interim evaluation would permit quicker program revision, if necessary. Parameter measurement and program assessment contribute directly to the information base (Fig. 1).

The results of parameter measurement about unicorn management would then be compared to the parameter levels specified in the objectives. For example, the size of the habitat areas would be compared to the four square miles specified in objective 1. Assessment would then follow this comparison. If the size of some habitat areas purchased was smaller than specified by the objectives then the reasons for this deficiency should be determined. Were landowners uncooperative in selling land because they did not understand its future use? Were land prices higher than anticipated and the budget allotment was spent quickly? Did the habitat inventories fail to identify six habitat areas of the size specified? Redirection of the management program might include more intensive public education about the benefits of unicorn management, to increase budget allotments for land acquisition, and to revise objective 1 to specify fewer than six habitat areas. If an objective is not met, then the time frames of that objective, and usually other objectives, must be revised to later dates. If habitat is not acquired (objective 1), then it will be difficult to increase extant populations and to establish new populations (objectives 2 and 3).

Information Base

At described above, each management step interacts with the information base (Fig. 1). The information base is used to guide the decision processes within each step. The information base includes published results of sociological, economic, political, and ecological studies as well as the collective experience of the management personnel involved. A conscious effort must be made to use both types of information. Use of this management model will cause the information base to grow, primarily due to the evaluation step. Thus if the management environment does not substantially change, management should improve over time since the probability of correct decisions will increase.

Several types of information were used in the unicorn management program. The goal was set based on the knowledge that society values unicorns. Objectives were set based on ecological information about the reproductive requirements of unicorns in terms of habitat requirements and population densities. Sociological information about the lack of public awareness of the unicorn management program was useful in the problem identification step. Information about the habitat requirements of unicorns was needed to guide the purchase of proper habitat as an action. The results of the evaluation step contributed to the information base.

DISCUSSION

The management process as described cycles within and responds to the management environment (Fig. 1). Cultural, economic, political, and ecological components may change individually or in synchrony and thus require that management programs adapt if they are to remain effective. The effects of natural resource management must be recognized as one source of change in this environment. For example, management that influences resource utilization may alter what users expect to receive from a resource. Thus, values related to user satisfaction may change and affect the future demands placed on a resource and on management agencies. A better understanding of societal values and the forces that change values is required if natural resource management is to serve the public effectively.

The responsibility to ensure that management follows a rational, directed approach rests with the personnel involved in natural resource management. As described earlier, contributions from many types of people are required to conduct effective resource management, from philosophers to ecologists and from agency administrators to technicians. A key to management success is for each individual to understand their role in the management process and how they can contribute cooperatively to the efforts of the management team. Bureau and regional chiefs or directors should focus most closely on the selection of program goals and the process of management, and not get "bogged down" in the fine details of actions. Local managers/biologists must help set goals and objectives so they can later choose and implement effective actions. University personnel should contribute research results to the information base, help evaluate actions, and provide agencies with unbiased advice. The should conduct research that provides the information anticipated by the agency to be important for future management decisions. If the management team understands the dynamic process of management and works cooperatively, natural resource management will successfully meet the challenges of the future.

LITERATURE CITED

Anderson, K. H., and F. B. Hurley, Jr. 1980. Wildlife program planning. Pages 455-471 in S. D. Schemnitz ed. Wildlife management techniques manual. The Wildl. Soc. Washington, D. C.

Buchele, R. B. 1977. The management of business and public organizations. McGraw-Hill Book Co., New York. 348pp.

Christopher, W. F. 1980. Management for the 1980s. AMACON, New York. 295pp.

Cole, L. C. 1957. Biological clock in the unicorn. Science 125: 874-876.

Crowe, D. M. 1983. Comprehensive planning for wildlife resources. Wyoming Game and Fish Department. 143pp.

Fraidenburg, M. E., and R. H. Lincoln. 1985. Wild chinook salmon management: an international conservation challenge. North Am. J. Fish. Mgmt. 5: 311-329.

Kast, F. E., and J. E. Rosenzweig. 1970. Organization and management a systems approach. McGraw-Hill Book Co., New York. 654pp.

Matthews, W. H. 1976. Resource materials for environmental management and education. Massachusetts Inst. of Tech. Press, Cambridge. 259 pp.

Odiorne, G. S. 1979. MBO II a system of managerial leadership for the 80s. Fearon Pitman Publishers, Inc., Belmont. 360pp.

Phenicie, C. K., and J. R. Lyons. 1973. Tactical planning in fish and wildlife management and research. U.S. Fish and Wildl. Serv., Resour. Pub. 123. 19pp.

Rieck, C. A. 1971. Program planning: a managerial attitude. Pages 14-17 in R. D. Teague ed. A manual of wildlife conservation. The Wildl. Soc., Washington, D.C.

Wren, D. A., and D. Voich, Jr. 1984. Management process, structure, and behavior. J. Wiley and Sons, New York. 653pp.