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Landscape and Urban Planning 40 (1998) 103–112

LANDSCAPE AND URBAN PLANNING

Ecosystem management: expanding the resource management 'tool kit'

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Abstract

Ecosystem management can be thought of as the minimum set of tools a land manager should have available in attempting to define sustainable alternatives for the interactions of people and the environment. It is a term that specifically refers to a process or set of activities for addressing resource management, not a prescribed outcome. As a pre-decisional process, ecosystem management amends and expands the resource management tool kit that field-level professionals rely on to understand and manage lands and resources in an ecological context. The focus of this paper is to highlight the activities in the ecosystem management 'tool kit' that are common for many agencies and organizations. Natural resources exist within certain limits and capacities. Humans are faced with difficult choices in determining how they will interact with the environment to provide for essential materials and services and maintain a healthy environment. The approach does not necessarily make hard choices any easier. The ecosystem management tool kit does support making difficult choices in the most informed and professional manner possible. Published by Elsevier Science B.V.

Keywords: Ecosystem management; Ecological approach; Resource management

1. Introduction

At the level of field application, ecosystem management can be thought of as the minimum set of tools a land manager should have available in attempting to define sustainable alternatives for the interactions of people and the environment. Ecosystem management and related ecological approaches, are being used by federal, state and private landowners and managers to address sustainable resource management. This paper attempts to provide an overview of the activities that comprise an ecosystem management 'tool kit'.

Ecosystem management reflects three distinct areas of change for resource management: (1) a shift in social values relating to the environment and with that shift a new paradigm for land and resource management, (2) the development and evolution of a framework of activities representing the new paradigm and (3) the process used for implementing the framework as a means to understand options for sustainable resource management strategies.

Ecosystem management responds to the natural evolution of social perceptions and priorities, resource management experience and scientific knowledge regarding the human–environment interaction. The approach reflects expectations for resource man-

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0169-2046/98/$19.00 Published by Elsevier Science B.V.
PII S0169-2046(97)00102-3

agement, especially on public lands, to address concerns regarding long term sustainability, desired conditions and available goods and services. Increasing world population and demands for resources has generated a widespread concern regarding the sustainability of the environment. Ecosystem management is an expanded process for developing options in this context.

2. The evolution of an ecological approach

2.1. A changing national paradigm for resource management

Ecosystem management, as a resource management tool kit, is a result of changing scientific, social, political, cultural and economic information and values. It evolved in response to the need for a better approach to managing natural resources, building from the knowledge of a wide range of scientific disciplines and the experience of resource managers. Ecosystem management consolidates a number of well established concepts and principles and combines them in a new framework for understanding and managing lands and resources. It is an approach to ecological stewardship that reflects a shift in the national paradigm of how our society views and values landscapes, public lands and the general environmental health and well being of our nation's resources.

The reasons for this paradigm shift, why it came at this point in time and why these events created the need for something like ecosystem management, have been summarized (Gordon, 1994) in the following. First, there are too many laws, or at least too many uncoordinated laws and the general realization that in trying to implement the mix of direction, there just is not enough to go around any more. Second, the accumulation of new knowledge rapidly outstripped the ability of the old paradigm to coordinate and explain it. Paradoxically, advances in knowledge highlighted the inadequacy of what we know. Third, a significant shift in public values occurred, such that there is greater interest in and desire for 'sustained ecosystems' than for 'sustained products' from the environment and especially from public lands.

2.2. An ecological approach for a continuing mission

For the USDA Forest Service, ecosystem management has been, since its early inception, an improved process or 'tool kit', for the agency to pursue its mandated multiple-use mission. In June of 1992, Forest Service Chief Dale Robertson stated that ''an ecological approach will be used to achieve the multiple-use management of the national Forests and Grasslands, ...to blend the needs of people and environmental values in such a way that the National Forests and Grasslands represent diverse, healthy, productive and sustainable ecosystems'' (Robertson, 1992).

The ecosystem management concept is defined in detail by the context in which it is applied. That is the social, cultural, economic, political, administrative and environmental circumstances of a specific place suggest what elements of the tool kit might be appropriate. Ecosystem management amends and expands the resource management tool kit that field-level professionals rely on to understand and manage lands and resources in an ecological context.

2.3. A concept for an approach, not a specific outcome

Ecosystem management is a term that specifically refers to a process or set of activities for addressing resource management, not a prescribed outcome. Attempting to improve the approach used to understand lands and resources in a manner that can benefit many different values and desired conditions is a significant change from historical shifts that emphasized a change in priority for a particular outcome.

Each era of American natural resource management history has been characterized by a general societal image or paradigm of acceptable land management and resource priorities. (USDA Forest Service, 1976; West, 1992) These can be summarized by the following: 1700s to early 1800s—conquest of the vast wilderness for human progress; Mid to late 1800s—acceptance of economic exploitation of resources to fuel expansion; Early 1900s—establishing the public domain, conservation practices for public lands; Mid 1900s—efficient utilization and accommodation for as many views and values as possible;

Late 1900s—ecological management, sustainability of the environment and economy.

During each of these eras the views and values of society, with regard to the perception of acceptable approaches for managing resources, were often described or defined by the general goal or vision the acceptable paradigm of the time sought to provide. While rarely definable in a succinct, literal and routinely practical manner, certain terms gained widespread acceptance as both identifying concepts and describing results related to resource management. Terms such as conservation, preservation, multiple-use, single-use, dominant use and others became 'sign posts' for stereotyping views, values, philosophies and to a large degree outcomes of resource management strategies applied under those headings.

The focus of ecosystem management on expanding the available tool kit, as opposed to articulating a new and different vision about correct outcomes for resource management, has caused some misunderstandings regarding its goals and process. For example, it has been erroneously suggested that ecosystem management is intended to replace multiple-use (Sedjo, 1995) and that the process requires unthinking acceptance of particular approaches for delineating ecosystems on the ground (Fitzsimmons, 1996). As with any tool kit, the individual tools can be hypothetically envisioned in application in both helpful and impractical ways. Until the approach is more widely understood as a highly flexible process for understanding conditions, trends and options and not a set of predetermined products and priorities, some misconceptions may continue to occur.

2.4. Seeking sustainable resource management options

Ecosystem management includes an explicit focus on understanding and developing options for sustainably managing resources in particular situations. The context for 'sustainability' is the interaction of the environmental, social and economic features associated with resource management considerations of a particular place. This is not to suggest in any way that sustainability was thoughtlessly absent from all previous concepts. Sustainability has however taken on a different focus in recent times, evolving from a concentration on sustained products and conditions in the short term, to an emphasis on sustainable processes, functions, ecosystems and outcomes over long time spans.

The application of an ecosystem management approach does not result in a predestined 'best' solution or condition. It is intended to improve and expand the information collection and analytical process that leads to the identification and understanding of possible sustainable options and the likely futures from implementing those options. In every resource management situation, there is a large number of sustainable futures. The process of choosing a desired state, the management strategy to get there and maintain it and the associated values, products and outcomes likely from those decisions, is outside of the ecosystem management framework. Decisions about which future to choose remain in the complex arena of legal, social, political, economic and administrative processes.

Ecosystem management evolved with a land ethic that challenges humans to examine their role as a part of the larger environment and to recognize a moral responsibility to each other, to future generations and to other species with which we share the planet. This land ethic implies a code of conduct for the human interaction with the natural world that ensures current and future generations of all species healthy, functioning ecosystems. In the past, land ethics attributed to a particular resource paradigm by competing philosophies and interests, have typically been portrayed as representing a narrow, self-serving priority rather than a broad based public good. Supporters of the paradigm have countered with their own version of why the land ethic underlying their particular vision was in fact clearly in the nation's best interests. The land ethic associated with ecosystem management simply encourages that we as humans attempt to live sustainably in a finite environment.

3. Better questions, better answers and the need for a new approach

3.1. A need shared from many perspectives

Ecosystem management evolved as a widespread understanding from many disciplines, that a different

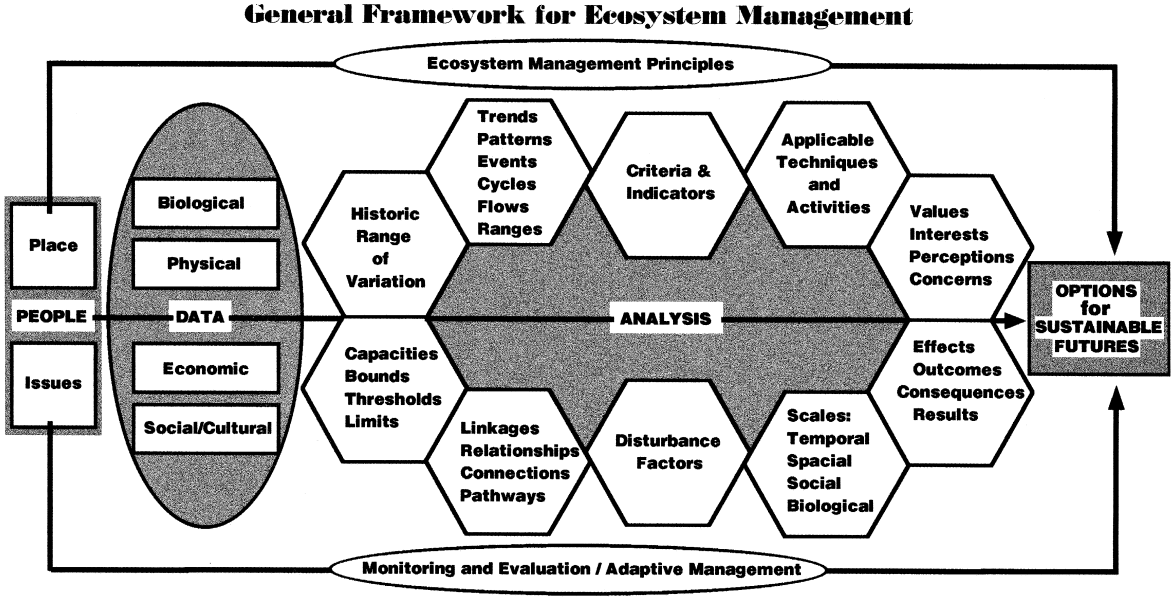

Fig. 1. General framework for ecosystem management.

approach to resource management was necessary to understand and deal with the current range and complexity of issues. Within the last decade, scientists, managers, technical specialists and a wide range of environmental interests began to examine, discuss and test elements of an improved framework for addressing the interaction between people and natural resources.

Based on court decisions, concern and dissatisfaction with the divisiveness of past processes and perhaps most importantly the experience of scientists and resource stewards, the framework for what is now referred to as ecosystem management emerged (Fig. 1). It was driven by dilemmas and issues that rendered previous approaches inadequate to deal with current problems and demands.

The expanded framework was based on a modified set of questions regarding public lands and resources and relied on an expanded information base for an improved understanding of sustainable management options. As Maser (1993) notes, ''We also must understand that conflicts over values, either ecological or human, are not battles over numbers, but rather battles over different visions of the world order and their respective desirability and long-term, ecological sustainability. We cannot, after all, legislate feelings or values, only behavior. In the end however, it is the sum of the consciousness of our daily choices of behavior, which ultimately is based on the questions we ask, that will make the difference. Keep in mind, therefore, that while a good question may be valid for a century or more, we may get a different answer every decade, an answer that brings us a greater understanding of the question. And in the final analysis, it is the quality of the questions we ask that guide the conscious evolution of humanity, not the answers we derive.''

3.2. Standing on a common foundation

The individual principles and concepts that help describe an ecological approach have been in the scientific literature for some time. An exhaustive listing of ecological concepts will not be addressed here. Adequate treatments of the range of basic principles and related theory are provided by Decker et al. (1991), Grumbine (1994), Kay (1994), Kaufmann et al. (1994), Lackey (1998), Levin (1992), Maser (1993) and Jensen and Bourgeron (1993) and others.

A variety of applications can be supported by an ecosystem management approach including land

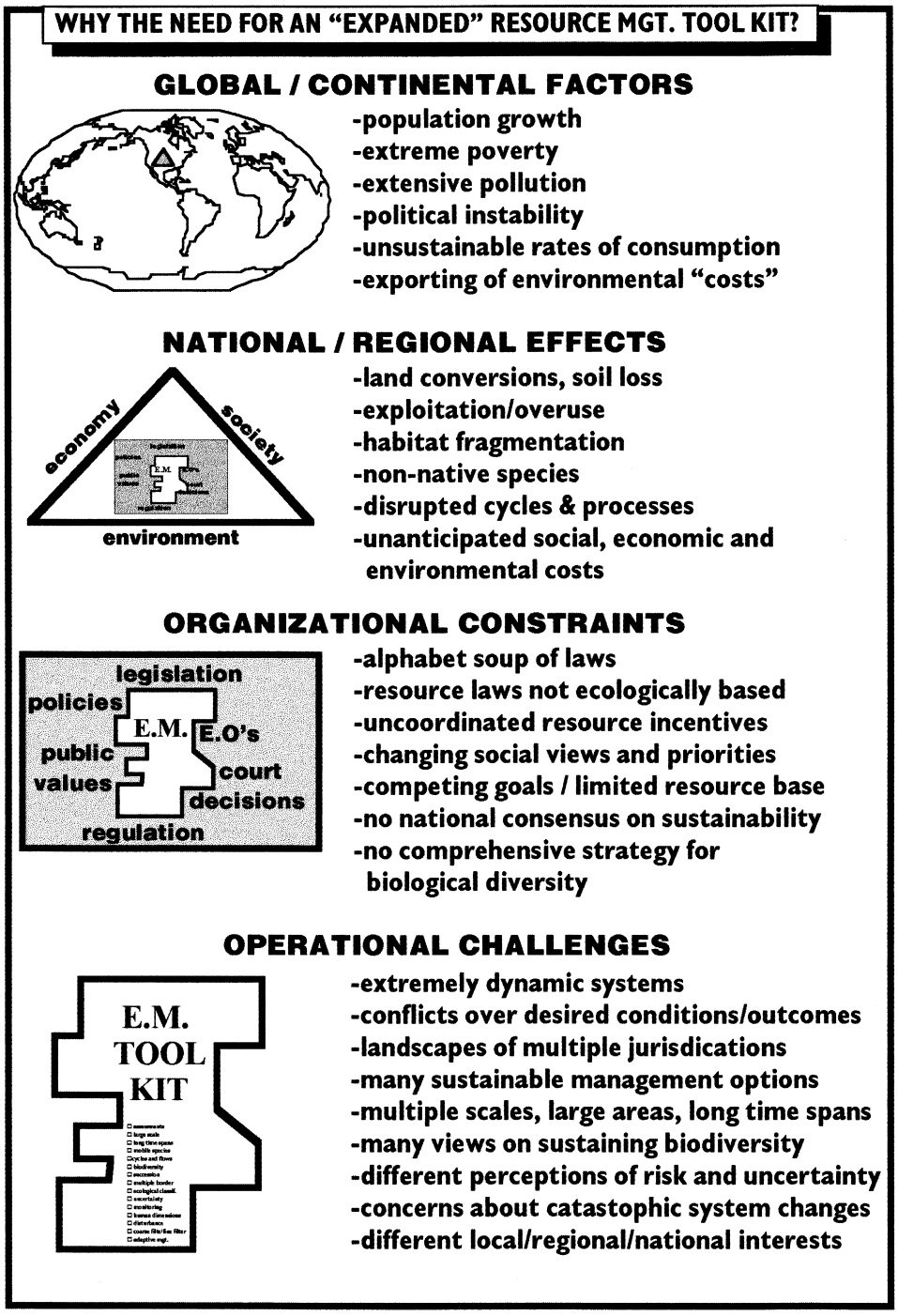

Fig. 2. Factors, effects, constraints and challenges illustrating the need for an expanded 'tool kit' for resource management.

management, assistance, advice, research, regulation and monitoring. The philosophy, framework of activities and general process have utility to many goals, including those in the private sector, as a means to help understand and support decisions for a wide array of values and interests. The development and implementation of ecological approaches by federal, state and private interests was motivated by a generally common experience with complex resource concerns and highly interrelated decision space.

The context for ecosystem management and related ecological approaches, also share a common foundation in issues at the global, continental and regional scales; (See Fig. 2) (Salwasser, 1991; Jensen and Bourgeron, 1993; Szaro and Johnston, 1996). In the broadest context, a number of common factors drive environmental concerns at the global level. While individual countries may be more or less impacted by each factor, all nations are effected at least indirectly by the situation of the global community. Each country in turn manifests the effects of global factors in their particular social, economic and environmental conditions and trends. These conditions are dealt with and addressed by institutions and interests within the administrative and legal constraints and cultural operating environment of that country and situation. The available approach, or the 'tool kit', which any agency has available to address the existing operational challenges of resource management is represented by processes like ecosystem management.

The evolution of ecological approaches came about largely as a result of applying increased scientific understanding and management experience to resource problems that simply could not be well understood or reasonably resolved using traditional approaches. The common foundation of complex human–resource interactions existing at several scales simultaneously has led many organizations to develop ecological approaches for understanding sustainable options for resource management that have many similar components.

3.3. Evolving terminology

It should be noted that certain terminology and definitions are not common between agencies, even though the scientific base is very similar. The lack of consistent terms and usage is not surprising given the youthful state of ecosystem management as 'an approach'. Where some terms may have a widely used definition, e.g., 'Biological Diversity: the variety of life and its processes' (Council on Environmental Quality, 1993), the definition may have limited practical application for managers. Even when a term or concept has been in use for many decades, e.g., 'natural' (Shrader-Frechette and McCoy, 1995), or 'balance of nature' (Reice, 1994), the ecosystem management paradigm has caused a critical review of how these terms are understood in regard to land management. There is no intent to dismiss certain problems that arise from lack of consistent definitions. It is simply understood that as the package evolves and matures, the science of ecosystem management will develop a more standardized, well defined set of terms.

4. The ecosystem management 'tool kit'

4.1. What kinds of tools are included

Supporting the general framework for ecosystem management is a set of activities, seen by many agencies and groups, as fundamental to implementation of the approach (National Science and Technology Council, 1995; Szaro and Sexton, 1994).

The focus of this paper is to highlight the activities in the ecosystem management 'tool kit' that are common for many agencies and organizations. It is not intended to suggest the understanding of how those activities are applied in a particular situation, is totally refined. It is intended to highlight that many of the tools that make up the approach can be identified and agreed upon by individuals in a number of agencies and organizations.

This listing that follows represents the set of activities that are commonly recognized by ecosystem management practitioners in many agencies and organizations. The many site specific details related to implementing each activity are not universal and in most cases continue to develop and be adapted to particular situations. There are numerous excellent examples in field situations of individual activities. Many organizations continue to develop, refine and apply ecosystem management activities to address resource management issues.

The list of 'tools' is in itself representative of the multi-faceted nature and complicated operational challenges associated with implementing an ecosystem management approach. The activities are complex and highly related. Most are related to, or based on scales. All are part of an ecological approach. All rely on using the best available science. All are improved by collaboration with others. Activities are listed under a series of headings as a means to simplify explaining the type of ecosystem management tools being implemented in field situations. There are many different and useful ways to categorize the ecosystem management tool kit. The headings used here are only to make it easier for the reader. It is clearly recognized that most tools do not fit neatly into any one category and that there are many equally practical ways to define categories.

4.2. Institutional 'tools'

4.2.1. Organizational norms and behaviors

- Seeking solutions that are a foundation for sustainable environments, economies and social and cultural values,
- using highly participatory processes for public involvement throughout the approach,
- seeking and forming as many partnerships as possible,
- developing, seeking out, utilizing and transferring the very best scientific information available,
- using a holistic view, addressing the sum of the parts, not just individual pieces,
- maintaining, enhancing, protecting, or restoring biodiversity,
- maintaining viable populations,
- cooperatively developing desired conditions for landscapes,
- structuring research efforts to support ecosystem management needs at multiple scales,
- providing training programs for ecosystem management.

4.3. Operational 'tools'

4.3.1. Analyses and assessments

- Conducting information assessments and analyses across administrative and political borders to develop necessary information at multiple scales, especially the 'broader' scales where many organizations have common information needs,
- developing information about species and their habitat needs,
- developing information about vegetation, associated communities and their structure, composition and function,
- developing information about ecological processes: carbon cycle, nutrient cycle, hydrologic cycle, biological diversity, succession, population dynamics,
- assessing patterns and trends of shifting human uses,
- addressing expectations for resource use,
- analyzing relationships of type and amount of resource use over time,
- addressing information about connected resource uses at landscape, regional, national and international scales as a context for understanding the role of local situations.

4.3.2. Multiple scales and levels

- Selecting scales and boundaries appropriate for highly mobile species,
- evaluating information at multiple scales, at a minimum at least one scale above and one scale below the project or issue being reviewed,
- developing and using multi-scale means for identifying and analyzing patterns, mosaics and connections,
- developing and using multi-scaled means for evaluating hierarchical relationships between broad regions and landscapes, between landscapes and patterns and between patterns and associated mechanisms,
- examining relationships across trophic levels,
- examining relationships across biological levels of organization,
- evaluating systems and information from the general view of common elements through a 'coarse filter' and hierarchically related uncommon elements through a 'fine filter',
- using nested and hierarchical relationships to evaluate processes, functions, landscapes, patterns and related mechanisms from both a 'top down' and 'bottom up' strategy,

- evaluating structures, functions, patterns and spatial relationships over long time spans.

4.3.3. Multiple borders and boundaries

- Using ecological boundaries or landscape features representative of ecological units for organizing information,
- using a wide range of assessment and analytical boundaries to organize and collect information necessary to address problems and issues related to sustainable solutions,
- developing common boundaries and approaches when appropriate, to facilitate the collaborative accumulation of information and its subsequent sharing and use.

4.3.4. Inventory, ecological classification and information

- Integrating functional inventories and data collection approaches to better support multidisciplinary, holistic information management,
- integrating inventories and information within scales,
- integrating inventories and information between scales,
- developing common ecological classification systems,
- cooperating with partners on developing common data standards and collection protocols,
- sharing data bases, data and models whenever practical.

4.3.5. Risk, uncertainty and complexity

- Embracing complexity, in the environment, in human values, in the information needed to conduct ecosystem management,
- recognizing uncertainty as a normal part of natural systems and building it into models and options,
- building continuous change and recognition of a highly dynamic system into analyses and subsequent decisions,
- explicitly documenting what is both known and unknown about key features, attributes and processes,
- reconciling views between different perspectives and backgrounds to achieve a consensus on risk and uncertainty.

4.3.6. Monitoring and evaluation / adaptive management

- Documenting key assumptions about past, present and future conditions and the expected results of management decisions as a basis for monitoring change and evaluating management actions,
- evaluating monitoring data to develop information and knowledge necessary for answering resource management questions,
- defining key features and their related threshold levels of change,
- adopting strategies that protect systems from reaching threshold levels of change (e.g., species extinction, soil degradation),
- defining and monitoring practical criteria and parameters to address sustainability,
- developing and using practical indices and measurements for biological diversity,
- developing, monitoring and evaluating criteria representing ecosystem process and function,
- using an adaptive management approach for resource management activities.

4.3.7. Human dimensions

- Examining factors and relationships representing the Human Dimensions and incorporating that information in analyses addressing resource management options,
- looking at human–environmental interactions within the context of large landscapes,
- attempting to understand relationships and linkages across local/regional/national/international scales,
- seeking and developing data quantifying aspects of human dimensions,
- applying social/cultural classifications that support understanding the human landscape,
- defining key elements and relationships within social system functions and processes,
- cooperating with states and other federal agencies in developing and sharing data on values, views, priorities and perceptions people have in regard to natural resources,
- utilizing analyses that incorporate and develop information about the connections of the social, economic and environmental elements of landscapes.

4.3.8. Disturbance factors, landscape patterns, historic range of variation

- attempting to work within and mimic natural processes and patterns,
- defining and characterizing major disturbance factors and their frequency, distribution, pattern, proportion, distribution across and within landscapes,
- describing the types of communities, patterns, structures and composition of landscape elements resulting from various types of disturbance,
- determining the historic role, resource uses and related disturbance activities of humans in the landscape,
- characterizing the likelihood of species types, numbers and distribution related to disturbance,
- characterizing the likelihood and nature of cycles, processes and functions related to disturbance,
- evaluating the historic range of variation to characterize variability associated with sites, species, systems, landscapes, functions, patterns, processes and cycles,
- characterizing linkages, connections, interrelationships and thresholds to the degree practical,
- recognizing the unusual, rare, or unique elements.

4.3.9. Desired conditions / landscape and system goals

- Describing the conditions, trends, patterns, structures, components, events and processes, features and functions desired to be maintained, or reached at some point in the future, for specific areas,
- describing the key features associated with measuring and assessing sustainability, with specific attention to how much, for how long, in what condition, over what area, exhibiting what pattern and associated with what degree of variability over what time and space.

4.3.10. Decision support systems, geographic information systems

- Using geographic information systems and related decision support systems to evaluate information over time and space,
- developing models and predictions that support resource management information needs.

5. Conclusion

Ecosystem management is based on an evolving historical framework that responds to a shift in the national paradigm of environmental interests, values and goals. The title ecosystem management is representative of a number of similar processes that seek ecological approaches for the sustainable management of the environment, social and cultural values and economic interests.

Ecosystem management is not a linear, highly regimented, one-way trip to a new and substantially improved ‘right answer’. As individuals and organizations test, re-examine and re-adjust specific activities and general processes, the vision for ecosystem management will grow, change and improve. The science of ecosystem management will be a dynamic stage for framing and addressing questions about the environment. It should be understood and approached as a heuristic exercise that incorporates human needs and values with our best understanding of the capability of the environment. It is an effort to ask new and better questions about this relationship with a focus on determining sustainable solutions to resource problems that have developed over several decades. As noted by Perry (1995), ‘‘It is necessary to recognize that we are unique animals with no top predator to control our consumption and with enormous power to alter the patterns of nature, sometimes in ways we wish we hadn’t. The question is not what this generation can do, but what we cannot or should not do if our goals include passing to the future a better world than we found. Clearly articulating ecological potentials, constraints, uncertainties, tradeoffs and risks is the role of scientists and managers. Once the ecological side-boards are clearly stated, the democratic process and the enormous ingenuity of humans can turn to the task of what can be done within those sideboards.’’

Science alone has not, does not and will not produce the ‘right’ answer. Decisions will continue to be a complex blending of social, economic, political and scientific information. The evolution of a common ecosystem management ‘tool kit’ offers federal agencies and other interested organizations a platform for collaborative development and application of this approach as a means to provide the best possible information for decision making processes.

The more successful efforts are to address sustainable solutions, the more likely current and future generations are to have expanded options for their needs and problems.

An ecosystem management approach is not a panacea for current natural resource management issues. The fact remains that natural resource systems have certain limits and capacities. There is a wide range of competing values and uses. There are more people with more demands than resources can sustainably provide for. Difficult choices have to be made. The approach does not necessarily make hard choices any easier. The ecosystem management tool kit does provide an improved means to understand sustainable management options and supports making difficult choices in the most informed and professional manner possible.

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