Ecosystem Management: From Theory to Practice

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Abstract — Ecosystem management (Robertson 1992) and sustainable development (UNCED 1992) have emerged in the early 1990s as major concepts and policies for the stewardship of human and biological communities in the United States. Both have a similar goal: the sustenance of desired conditions of lands, waters, biota, human communities, and the economic enterprises that depend on healthy, productive land and natural resources. Both have a similar compelling urgency: the human population is putting increasing pressures on the health and productivity of lands, waters, air, and resources, jeopardizing the ability to reach that goal (Silver and DeFries 1990). Ecosystem management and sustainable development are proposed as a prudent path to pursue. Both are already more than dreams; to some extent they are in practice or are being seriously tested. But they are also rapidly evolving. The purpose of this paper is to describe some principles and practices that we believe are crucial to the success of an ecosystem approach to land and resource stewardship that aims to sustain desired conditions of environmental quality as well as development of human communities and economies.

DEFINING ECOSYSTEMS

The ecosystem concept is central to the new era in land stewardship and resource conservation. Ecosystems are communities of organisms working together with their environments as integrated units (after Tansley 1935). They can occur from microscopic scales to the scale of the whole biosphere. For any plant or animal, including humans, an ecosystem is its home (Sahtouris 1989, Berry 1987, Rowe 1990).

All resources for life come from an ecosystem and all waste products eventually return to an ecosystem for recycling or storage. A rotting log is the ecosystem for a fungus. A pond is the ecosystem for a sunfish. A watershed is the seasonal ecosystem for a migratory ungulate. A whole mountain range is the ecosystem for a population of wolves. And the planet is now the ecosystem for the human population. In all cases, the organisms are integral parts of a complex of other organisms working together with their physical environments as a whole. The parts could not persist without the whole and its myriad of processes.

An ecosystem perspective on land and resource management means thinking about land—its soils, waters, air, plants, animals, and all their relationships—as whole units that occur in a hierarchy of nested places. The places—or ecosystems—are open to a constant flow of materials and energy in and out. They are constantly changing over time and much of the change is not precisely predictable by science (Botkin 1991). People are integral parts of ecosystems; both dependent on their resources and factors in affecting some of their changes.

Defining Ecosystem Management

Ecosystem management is variously defined by those who are shaping its course. Beginning with a standard dictionary definition, management is the process of taking skillful actions to produce desired outcomes. Combining this with the term ecosystem, ecosystem management is the process of seeking to produce (i.e., restore, sustain, or enhance) desired conditions, uses, and values of complex communities of organisms that work together with their environments as integrated units. This

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integrated or systems concept of land and resource management is broader than traditional approaches to the preservation of nature as historically practiced in national parks, wilderness areas, and nature reserves. It is also broader than traditional approaches to multiple-use land and resource management as often practiced on public lands. Certainly it is broader than intensive agriculture. Ecosystem management emphasizes the integration of ecological, social, and economic factors at different temporal and spatial scales to maintain a diversity of life forms, ecological processes, and human cultures. Traditional approaches to land or resource preservation attempt to either freeze ecological conditions at a desired state—which is not biologically possible—or allow natural forces to run without human interference—which is appropriate in some cases but not always socially or politically acceptable. Traditional approaches to multiple-use land and resource management tend to focus on sustaining yields of desired resources and uses in compatible blends such as timber, game, wildlife, water, livestock forage, fish, and recreation opportunities (Gale and Cordray 1991). Conflict among the various resources and their human constituencies is common in multiple use (Wondolleck 1988). The primary focus of agriculture is the sustained production of desired crops of plants or animals usually achieved through the simplification of ecosystems to guide net primary productivity into the desired crops.

An ecosystem perspective enlarges the focus of land management and resource conservation to whole ecosystems rather than selected parts or processes. It does not deny the importance of producing resources needed by people. Nor does it deny the need to protect certain places from certain kinds of human activities. But it focuses on sustaining desired ecosystem conditions of diversity, long-term productivity, and resilience, with yields of desired resources and uses being commensurate with the larger goal of sustaining those conditions. This is not what many practicing biologists, foresters, fisheries managers, or range conservationists were taught about management of their featured resource.

Second, the capabilities of any ecosystem to sustain desired conditions of diversity, ecological services, and resource uses and values are a result of climate, soils, topography, biota, natural processes, human influences, and how large the ecosystem is. In general, the larger the ecosystem the more diversity, resilience, and productivity it can sustain. Existing ecosystem capabilities determine what is possible in a human time frame, say a generation to a century. Any longer than that the basic capabilities of ecosystems may change and our ability to predict outcomes is rather poor. Thus, an inventory of current conditions and trends is useful in determining what is likely in the near future. But such an inventory is not likely to indicate ecosystem conditions beyond a century or two into the future.

Third, the collective needs and aspirations of the people who depend on ecosystems in a particular area for their well-being determine the desired current and future conditions of those ecosystems. Obviously the desired conditions cannot lie outside the bounds of what is there now or what is possible given existing ecological capabilities, financial resources, and technologies. The differences between existing and desired future conditions of ecosystems identify possible management objectives, that is, what it will take to sustain or restore ecosystem conditions to their possible and desired states and flows of resource uses and values.

**Ecosystems in a Landscape Perspective**

Landscapes are the working scale for ecosystem management. A landscape is a large area composed of many different kinds of ecosystems. It has repeatable patterns of habitats, physical features, and human influences (Forman and Godron 1986). Landscapes are large enough that it is possible to integrate the protection and management of ecosystems at site, stand, and watershed scales. Because of their large size, landscapes often involve multiple land tenures and multiple zones of different land-use classes. Thus, ecosystem management at landscape scales is invariably a cooperative endeavor.

Landscape patterns result from both enduring, slow-changing features of nature (e.g., soils, climate, and topography) and more dynamic patterns of biotic communities, ecological processes, and disturbances that shape short-term temporal and spatial change. When we look at the earth from an airplane we see a snapshot of a landscape at a point in time. If we had numerous snapshots, representing repeated fly-overs, spaced several decades apart, we would see that vegetation patterns and human influences on the landscape change from one photo to another, like a kaleidoscope.

Disturbances superimposed on long-term patterns and processes in ecosystems set the context for the temporal diversity of life and its changes over time. In some places the pattern is a patchwork of different kinds of ecosystems: in one example, stand-replacement fires create a mosaic of forests and openings at the landscape scale; in another example, the pattern might be a fairly continuous forest cover. But a view from inside a
continuous forest might still reveal a diverse ecosystem containing trees varying in age from very young to very old, multiple canopy layers, and a profuse understory wherever gaps exist in the canopy. Ecosystem dynamics in such a forest might result not from fires but from winds or the actions of age and diseases on individual trees. Landscape patterns will also change when global or regional climate change is sufficient.

**BIOLOGICAL DIVERSITY AND ECOSYSTEM MANAGEMENT**

The variety of life—plants, animals, and various microorganisms and fungi—and its many processes in ecosystems determines ecological capabilities. This variety is known by the term biological diversity (The Keystone Center 1991). It includes variation and variability in genes, species, plant and animal communities, and the many processes through which they are all interconnected through space and time.

Biological diversity is a valuable characteristic of ecosystems for ecological, economic, educational, and aesthetic reasons. It is key to the productivity and sustainability of earth's basic life support systems. It provides numerous current and future resources for human well-being. It provides opportunities for better understanding the myriad of relationships between people and their sources of existence. And it contributes greatly to the beauty and wonder of the world we live in. Biological diversity also has an ethical element: how well we conserve biological diversity demonstrates our respect for other forms of life and our commitment to the well-being of future generations (Leopold 1949).

Scientists do not know all the ecological roles or potential values of biological diversity. Nor do they understand all the processes that keep ecosystems functioning. It is not likely that they ever will. But complete knowledge is not necessary to understand that retaining the natural parts and processes of biodiversity is important for the future health and productivity of all ecosystems (Leopold 1949). How to do this in the face of a growing human population is the challenge (UNCED 1992).

Incorporating the conservation of biological diversity into ecosystem management requires actions aimed to achieve specific objectives for species, biological communities, and ecosystem conditions. A strategic framework for such actions and objectives has been developed for U.S. federal lands through a national policy dialogue (The Keystone Center 1991). Though the recommendations of the Keystone dialogue are not Federal agency policy at the current time, they have been adapted here to offer land and resource managers and scientists a framework of specific and measurable goals. To guide on-the-ground actions, the following goals should be reflected in land-use allocations, standards in land and resource management plans, and working guidelines for project activities in specific places.

**Threatened or Endangered Species**

Listed species are the most vulnerable officially recognized elements of biodiversity. A net decline in the number of listed species in the area covered by a plan or program is an ideal goal to consider in ecosystem management. To accomplish this, management must protect existing populations and habitats of listed species and restore them if necessary.

**Viable Populations of Native Plant and Animal Species**

Species whose demographic or habitat trends are negative but not yet to the point of endangerment may be the next most vulnerable elements of biological diversity. Some such species may even be more vulnerable than officially listed species. The ideal goal is to secure the places and functions of all native species in regional ecosystems before they reach the point where formal listing as a threatened or endangered species calls into play the extreme measures of protecting species under crisis conditions (Salwasser 1991).

To sustain viable populations of native species, habitats, human activities and artifacts, and wild populations of plants and animals must be managed to assure that populations of native species are numerous and well-distributed throughout their geographic ranges. This requires a combination of actions to protect, restore, and enhance sufficient kinds, amounts, qualities, and distributions of sub-populations and habitats. Especially important in achieving population viability is the perpetuation of multiple, interconnected, demographically resilient local populations; the characteristic genetic variation of the entire species; and the full range of the species' roles in ecological processes. Principles of conservation biology (Soule and Wilcox 1980, Soule 1986, Soule 1987) and especially the population viability analysis and management process described by Marcot et al. (in press) are useful in this task.

**Native Biological Communities and Ecosystems**

Rare, unique, or sensitive biological communities or successional stages (often highly productive sites, riparian areas, and mature or old-growth successional stages) are likely to be vulnerable elements of biological diversity in certain landscapes. Lands, human activities and artifacts, and wildlife habitats must be managed to assure that a network of representative native biological communities and developmental stages of ecosystems is maintained across the landscape. This may involve ecological restoration in some cases. Especially important are communities or assemblages of species that are rare or imperiled in the region or nation (Jenkins 1988). The matrix conditions of a landscape should provide essential resources for all species to the degree this is possible, including conditions needed for normal movement of plants and animals throughout the landscape and...
for the full range of ecological processes characteristic to the area. Where this is not possible, a specific network of sites and connections between them may be needed. The sites and connections must be sufficiently large and diverse to accomplish their intended purposes.

**Structural Diversity**

Natural elements of structural diversity such as snags, caves, fallen trees, and seeps provide habitats for many species that would not occur in an area without them. These elements can be jeopardized by intensive human uses such as fuelwood gathering, heavy livestock grazing, clearcutting, and water diversions. Elements of structural diversity should be perpetuated in qualities, amounts, and distributions within patches and across landscapes to assure their roles in sustaining desired conditions of ecosystem diversity, productivity, and resilience from site to regional geographic scales (Franklin 1988).

**Genetic Diversity**

The genetic variation of intensively managed wild plant and animal populations can decline if sufficient attention is not paid to the effects of human selection for various traits. Species and habitats, especially those of high commercial value and thus intensively harvested, should be managed to sustain natural levels of genetic variation within and among populations and the genetic integrity of representative and extreme populations (Ledig 1986, Millar 1987).

**Resources Needed for Human Well-Being**

Human well-being ultimately depends on natural resources. People will obtain those resources from somewhere. The key is to produce them in ways that do not lead to undesired environmental effects at local, regional, or global scales. If resources can be produced in ways that reduce human pressures on biological diversity in other places then resource production zones can have a positive overall effect on biodiversity conservation. High productivity sites such as flat ground with deep loamy soils, and featured species such as pines, firs, oaks, elk, and trout should be managed with state-of-the-art efficiency to sustain the production of resources needed by people, thus meeting human needs with minimal impacts on more fragile sites and sensitive species.

**Ecosystem Integrity—Soils, Waters, Biota, and Ecological Processes**

Any human activity has some effect on lands, waters, or biota. Ideally, these effects can be minimized through sensitivity to ecosystem integrity. Actions that are known to degrade site conditions or long-term ecosystem diversity, productivity, or resilience should be avoided if possible or mitigated promptly when not. The natural restorative powers of ecosystems should be employed in resource management activities. Consider the kinds, amounts, and distribution of living and dead organic matter to be left in ecosystems for long-term diversity, productivity, and resilience following resource harvest along with how much biotic production of the system is to be removed for human uses. This is essentially a principle of treating the ecosystem as "capital" and the production as "interest" (Rowe 1992).

**Degraded Ecosystems**

Biological communities, waters, and soils that have been damaged by natural events or past human actions should be placed under restoration and renewal programs, embracing the concepts and methods of restoration ecology and management (Bonnicksen 1988, Cairns 1986, Jordan et al. 1987, Jordan 1988).

There is more to the conservation of biological diversity in ecosystem management than identified in this framework but these actions are a reasonable start on a comprehensive conservation program.

**HUMAN DIMENSIONS AND NEW PERSPECTIVES**

The reason an ecosystem perspective is needed for land and resource management is simple. Continued growth in human populations and increases in their production, use, and disposal of resources are not matched by corresponding growth in the land base available to meet those demands under traditional resource management approaches while sustaining desired levels of environmental quality (Silver and DeFries 1990). Managers of wildlands and natural resources throughout the world, thus face a dual challenge that grows in difficulty with each passing year: to provide people with the resources needed to sustain their lives and well-being while minimizing the impacts of resource production and uses on the diversity, productivity, and resilience of the ecosystems from which those resources are taken or used (LeMaster 1992, Reid et al. 1992, United Nations 1992).
Forests as a Case

Let us take forests and woodlands as just one example of this challenge. Forests and woodlands now cover an estimated 31 percent of the planet’s terrestrial surface (4.1 billion hectares according to the World Resources Institute 1990). This is about 66 percent of the forested area that existed prior to the industrial and public health revolutions of several centuries ago. Meanwhile, the number of humans has grown by 11 times: from an estimated 500 million people to about 5.5 billion.

In per capita terms, each global citizen had an average of about 12 hectares of forest resource in 1750, while in 1990, each had only about 0.75 hectares. For the U.S., the corresponding statistics are: 45 hectares of forest per person in 1600 down to 1.2 hectares in 1990 (Salwasser et al. 1992). Meanwhile global use of wood from these forests has been increasing at an average 2 percent per year for the past 40 years (Haynes and Brooks 1991). And this does not take into account fuelwood use, which is nearly impossible to estimate on a global scale.

The U.S. is a major force in global wood use and its impacts on forests (U.S. citizen use about 33 percent of the world’s annual production of industrial roundwood). This has been reflected in several events and issues during the 1980’s that caused the USDA Forest Service to explore new perspectives for managing the complex lands and resources that comprise the National Forest System. Global issues included uncertainties associated with climate change, loss of biological diversity, and the growing human population. National issues included controversy over logging and forest regeneration methods (mostly clearcutting and even-aged forestry); declines in forest health due to pollution, drought, insects, fire suppression, and past management practices; controversy over subsidies to the development of public resources (including grazing fees and timber sales whose financial returns do not cover administration costs); loss of old-growth forests; a growing number of endangered species; poor conditions of public rangelands; rising demands of people for all natural resources; and declining domestic supplies of resources for which demand was creating increased foreign dependencies such as oil and timber. At local levels, concerns for soil productivity, aesthetics of land management practices, water quality, the vitality of communities that depend on public land resources for livelihoods and jobs, and large and largely uncontrollable wildfires, and new and conflicting uses of public lands fueled the flames of change.

New Perspectives for the National Forest System

As an example of agency leadership on ecosystem management, the Forest Service translated these issues into four reasons for a program to explore new perspectives in land and resource management during 1990-92 (Overbay 1992):

A. people need and want a wider array of uses, values, products, and services from public lands than in the past, especially, but not limited to, the amenity values and environmental services of healthy, diverse lands and waters;

B. new information and a better understanding of ecological processes highlight the role of biological diversity as a factor in sustaining the health and productivity of ecosystems and the need for integrated ecological information at various spatial and temporal scales to improve management;

C. people outside the Forest Service want more direct involvement in the process of making decisions about public resources; and

D. the complexity and uncertainty of natural resources management call for stronger teamwork between scientists and resource managers than has heretofore been practiced.

The Forest Service chartered the New Perspectives program to do five things: (1) learn how to better sustain diverse and productive ecological systems; (2) better integrate the different aspects of land and resources management; (3) improve the effectiveness of public participation in resource decision-making; (4) continue building partnerships between forest users and forest managers; and (5) strengthen teamwork between researchers and managers.

Moving Towards Ecosystem Management in the Forest Service

In Summer 1992, the Forest Service announced its intent to develop ecosystem management as a strategic approach for sustaining desired conditions of ecosystem diversity, productivity, and resilience for the multiple uses and values of national forests and grasslands. Ecosystem management is a process. It is not a goal. The goals for ecosystem management come from ecological capabilities of the land together with legal mandates and public needs and aspirations.

The Forest Service has a Congressional mandate to manage lands and resources entrusted to its care under the concepts of multiple use and sustained yield, without impairing the long-term productivity of the land (MUSY 1960). The Forest Service also has a legal mandate to conserve threatened or endangered species (ESA 1973, as amended) and to "provide diversity of plant and animal communities ... to meet overall multiple-use objectives" (NFMA 1976).

Research has shown that biological diversity is important to the long-term productivity and resilience of ecosystems, i.e., the land. Combining this knowledge with the agency’s legal mandate, the Chief of the Forest Service, defined ecosystem management as follows: "an ecological approach will be used to achieve the multiple-use management of the national forests and grasslands by blending the needs of people and environmental values in such a way that the national forests and
Field managers and scientists are now implementing ecosystem management through changes in agency regulations, national program direction, amendments to integrated land use plans, field projects that carry out the direction in those plans, research programs, and cooperative endeavors with conservation partners in universities, other government agencies, and the private sector.

At this point, some working guidelines for ecosystem management have evolved from New Perspectives projects. These guidelines remain open for refinement and are presented here to show the state-of-the-art in the early 1990s.

1. Work Within the Scope of Natural Processes that Shape Landscape and Ecosystem Conditions. Work within the ecological capabilities and natural processes of different ecosystems, maintaining as much diversity as possible and minimizing the energy costs of management to sustain or restore desired ecosystem conditions and functions.

Natural disturbances such as fires, floods, droughts, and storms are major forces which shape ecosystems and landscape patterns. These processes are the context within which long-term management strategies to sustain desired conditions of ecosystem diversity and productivity must be developed.

Be especially careful with soils and waters, particularly in sensitive areas such as wetlands, riparian zones, fragile sites, and rare species' habitats.

Always think about scale effects, both spatial and temporal, at least one scale higher and one scale lower than what you're working on and at least several generations into the future, more and longer if possible.

Think complex, model simple, and maintain options.

2. Focus on End Results—Desired Future Ecological and Social Conditions and the land-use classes and management actions that will best attain them. Use landscapes as a basic unit for planning and managing lands to meet specific objectives for conditions that will yield both desired future ecological conditions and desired economic and social goals while reconciling conflicts between competing uses and values.

3. Coordinate Strategies for Conservation of Shared Resources. Many natural resource issues and concerns cross jurisdictional lines. Examples include migratory fish and wildlife, wide-ranging endangered species, long-term regional timber supplies, air quality, and water flows. Regional-scale ecosystems are logical units in which to coordinate land uses and management actions to achieve desired conditions regarding these resources.

Complementary roles for different land tenures, including the legitimate rights of private land holders, may be blended by using existing authorities (Salwasser et al. 1987) or concepts such as Biosphere Reserves (Gregg and McGean 1985) and landscape linkages (Harris and Gallagher 1989).

4. Get People Involved in all aspects of public resource decision-making so that managers will know their needs and views; so that people will understand their personal responsibilities, what is possible, and what the relative tradeoffs are; and to obtain informed consent on the course of action selected.

Use consensus building and negotiated problem solving (Wondolleck 1988) as primary approaches to conflict management. People who are affected by resource management and conservation strategies must feel a strong commitment to being part of the solution.

5. Integrate Information and Technology, such as ecological classifications, inventories, data management systems, and predictive models, and use them routinely in landscape-scale analyses and conservation strategies. Agencies and affected interest groups and enterprises should contribute to common inventories of the basic conditions of soils, waters, and biota and share data and other information as appropriate to their missions and property rights. Inventories of biological diversity in the U.S. should build from the foundation of state Heritage Programs (Jenkins 1988) and multi-resource inventories conducted by various state and federal agencies. They should allow prudent choices to be made based on realistic assessments of needs and priorities for investment and protection actions (e.g., Scott et al. 1987, Scott et al. 1991).

6. Integrate Management and Research to continually improve the scientific basis of ecosystem management. Agencies, universities, and affected interest groups and enterprises should cooperate in long-term, interdisciplinary ecosystem research and development. Managers need practical tools and methods for planning and evaluating the expected effects of management options. They also need expanded choices for sustainable harvest and management of resources.
7. Revitalize Conservation Education and Interpretation. Agencies, universities, and affected interest groups and enterprises should cooperate in comprehensive programs of interpretation, education, and demonstration of ecosystem management. The result should be a better understanding among the citizenry about the effects of personal actions in sustaining desired ecosystem conditions and better support for the complementary roles played by different agencies and ownerships in overall conservation strategies.

8. Develop, Monitor, and Evaluate Vital Signs of Ecosystem Health. Agencies, universities, and affected interest groups and enterprises should cooperate in identifying and monitoring carefully selected indicators of ecosystem health and diversity, including conditions and trends of valued resources. Monitoring should be guided by the use of decision analysis tools (Maguire 1988, 1991) to ensure that the most vital information is being collected in useable quality and in a timely fashion for the specific purpose of adapting management based on new information (Holling 1978, Walters 1986).

A Bigger Role for Research

Research has a significant role in ecosystem management, including the use of scientific methods in understanding the basic capabilities of different ecosystems; discerning the needs and wants of people; setting ecologically, economically, and socially sound management goals; and designing monitoring systems to allow for periodic adaptation to new knowledge (National Research Council 1990, Lubchenko et al. 1991). However, scientists are not the only source of information for solutions to difficult political and social choices. For example, there are not unique or scientifically perfect answers for how a balance of goals and practices for ecosystem management should be struck. People's values, preferences, and aspirations are crucial factors in policy making.

The role of science in ecosystem management is to help define what is possible and what is desired: to shed light on how to best attain a desired set of conditions or benefits and help people understand the estimated costs, benefits, and consequences of alternative courses. To fulfill this role effectively, social, biological, and physical sciences must be integrated to reflect the complexity of how ecosystems actually function.

LANDSCAPE SCALE ECOSYSTEM MANAGEMENT: PRACTICAL EXAMPLES

Land and Resource Management

Landscape-scale ecological planning was being attempted in some areas in the U.S. during the 1970's, stimulated by the book Design with Nature (McHarg 1969). But environmental conflicts of the 1970's led to new laws and regulations which caused many landscape level planning activities to fall by the wayside. The "gridlock" caused by current applications of narrowly focused environmental laws, regulations, and "rights" has caused natural resource professionals to seek new ways of accomplishing the vision of McHarg (1969) and others who passionately believe that we should be able to develop harmonious ways to live with each other within a healthy environment.

Scientists provide knowledge, principles, and methods. Agencies and organizations provide leadership and establish policy. But, the practical application of knowledge and technology to implement policy is clearly in the hands of the professional at the field level. The practice of ecosystem management must include the art of applying science in the intelligent, responsible planning of ecosystem futures.

Many of the recent "experiments" in landscape level analysis, evaluation and planning were stimulated through the USDA Forest Service's New Perspectives Program. Establishment of the Landscape Ecology Research Work Unit at Rhinelander, Wisconsin has provided important information in methods of evaluating "natural" and "managed" landscape ecosystems. An application phase of the program involves land management planning by an interdisciplinary, multi-ownership cooperative team effort.

One of the earliest examples of ecosystem management in the national forests was the Shasta Costa Project on the Siskyou National Forest in Oregon. This case study illustrated the basic principles of ecosystem management identified previously in this chapter. It had limited success due to divergent expectations of the participants and the political uncertainty of public land use policies in the northwest (Salwasser 1992). Stumbling blocks were more social and political than scientific, though some observers erroneously perceived how scientific information was being applied to be the major barrier to successful implementation of the new principles (Frissell et al. 1992, Lawrence and Murphy 1992).

In the Northern Region of the Forest Service, the "Trail Creek Supplemental Information Report" (USDA Forest Service 1991) provided an immediate opportunity for a regional task force to explore ecosystem management principles for conflict resolution. Two other pilot projects have recently been analyzed and compared by a team including outside participants (O'Hara et al. 1993).
A recent publication from Oregon (Diaz and Apostol 1992) offers a process for developing and implementing land management objectives for landscape patterns. A unique aspect of the process is the evaluation of flows of animals and human uses across the landscape. A major concern has been expressed that landscape-level analysis has the dangerous (inefficient) potential of adding yet another cumbersome level of planning to government projects. However, landscape analysis can be a very efficient exercise when sufficient inventory information and GIS technology are in place.

Applications of ecosystem management at the landscape level are not limited to the USDA Forest Service. During 1992, Potlatch Forest Industries in Lewiston, Idaho (Steve Smith, Lewiston, ID Personal communication) began exploring the application of landscape-scale ecosystem management in support of their Forest Stewardship Program. With operational state-of-the-art remote sensing and GIS technology in place, they are projecting the future conditions that will result from current land management activities. They can then evaluate expected future conditions against their Stewardship Goals, i.e., desired future conditions. The first pilot demonstration stimulated considerable internal professional discussion. A second pilot project is being undertaken in cooperation with adjacent public landowners who share checkerboard ownership in a 30,000 acre watershed. This represents progressive practice of ecosystem management by private and public sector parties and a great opportunity for "fishbowl visibility" by public organizations with contrasting management objectives but common ecosystem management concerns.

**Education**

Land and resource management is only one venue for the emergence of ecosystem management in practice. Undergraduate, graduate, and professional education are also adopting the concepts. The University of Montana, as one example among many, has been offering an annual continuing education program, "Ecology and Management of Forest Landscapes", for the past five years. Part of the training includes a landscape planning exercise for a 3,200 acre landscape within Lubrecht Experimental Forest. (This same area is used for a senior-level, conventional, integrated resource management planning exercise.) For the landscape shortcourse, students go through six basic steps:

1. Familiarity with the area through displays of information available in the GIS (topography, stand types, soils, vegetation habitat types, roads, wildlife distribution, etc.)
2. Establishment of five alternative management directions:
   - A. No Treatment and Fire Control
   - B. No Treatment and Natural Fire Allowance
   - C. Optimize Biological Diversity (Using Silviculture & Fire)
   - D. Mimic Natural Stand Conditions (Using Silviculture & Fire)
   - E. Optimize Intensive Timber Production within Old-growth and silvicultural constraints.
3. Student teams develop written landscape prescriptions to implement a specific management direction (specification of what treatments, when to implement, and where to implement).
4. Utilize simple succession/treatment algorithms to move the stands through time and display future landscape maps at 30 year intervals for 120 years into the future. General summaries of multi-resource production and values can be generated to accompany the map displays.
5. Group evaluation of each of the alternative directions and prescriptions against a standard set of criteria that relate specific concerns addressed in current definitions of ecosystem management.
6. Students play the role of the public in advising Lubrecht Experimental Forest relative to our general management directions for that part of the Forest. Rather than rank the five alternatives, we ask them to identify one preferred alternative and rate the others as "unacceptable" or "acceptable".

The strength of this exercise for practical consideration is that it is simple, rapid, efficient, and easy to communicate to a general public audience. Simplified algorithms for predicting succession are adequate for the major questions being addressed. A long-term perspective on the future and demonstration of natural stand dynamics become self evident. Major issues of forest health, biodiversity, old-growth preservation, role of fire, silvicultural systems, sustainability of various items and human activities can be addressed. Major tradeoffs involved with single-purpose objectives become transparently obvious. Individuals have the opportunity to express and defend their personal priorities in a comfortable group setting. Since it is a classroom exercise, consensus is less threatening.

During the evaluation, we find it very difficult to address many stated "ecosystem principles" because they are difficult to quantify or measure. For other attributes, we recognize that certain inventory information would be crucial before making final decisions. However, the process is valuable in sending students out, inspired with ecosystem management thinking and awareness of new technology to tackle the difficult, almost impossible task of being a leader in the practice of ecosystem management. ("The impossible just takes a little longer." -Author unknown)

As theory concepts, principles and methodologies are debated at symposiums and workshops, we must have faith in the army of professionals waiting to practice ecosystem management, if we can continue to provide knowledge, methods and support for their job at hand. We can only hope that doors will remain open in the U.S.A. for dedicated professionals to continue to practice their honorable, selfless, profession for the "greatest good for
the greatest number in the long run". "Those who say it can’t be done need to get out of the way for those who are already doing it!" (Lee Iacocca?)

CLOSING THOUGHTS

The need for new perspectives in land and resource management gave people inside and outside the Forest Service a chance to try some new and some old thinking. Five themes have emerged:

A. Sustain diverse and productive ecological systems;
B. Integrate the different aspects of land and resource management, research, and conservation;
C. Improve the effectiveness of public participation in resource decision-making;
D. Build partnerships between resource users and resource managers; and
E. Strengthen teamwork between researchers and resource managers.

Sustaining desired ecological, economic, and social conditions in ecosystems that are managed for multiple purposes, such as the National Forest System and other public lands in the U.S., is a big challenge. But it is not an impossible task if people realize that no single objective can dominate ecosystem management at all geographic scales or even at the same site for all times. Success in sustaining desired ecosystem conditions will depend on having scientifically sound, economically feasible, and socially acceptable strategies for achieving combinations of ecological and social goals. For example, it will depend on meeting specific objectives for viability of native species and biological communities such as spotted owls, grizzly bears, elk, and tall-grass prairies. It will depend on meeting specific objectives for the characteristics of landscapes such as habitat conditions that are aesthetically pleasing and allow for free movement of plants and animals over time. It will depend on coordination among people responsible for species or resources that transcend administrative boundaries such as the spotted owl, large predators, eagles, migratory birds and mammals, and timber and mineral resources. It will depend on practical management standards for the desired characteristics of distinct patches in a landscape, such as diversity of species, structures, and functions provided by snags, fallen trees, riparian areas, and prairie barrens. It will also depend on better integration of research with management, especially in monitoring conditions pertinent to objectives.

These and other actions to sustain desired ecosystem conditions in multiple-use lands are changing traditional approaches to both multiple-use management and nature preservation. Some of these changes may result in higher management costs or in resource management being carried out in areas previously considered to be "off-limits" to human use of resources. Only site-specific assessments can show what the nature of the changes might be. In any case, changes in public land uses are often difficult to establish and implement both politically and logistically. But they are tractable if people decide they are willing to make them. This will require dedicated professional leadership and commitment, an eagerness to share in the excitement and potential of ecosystem management with the publics, and a stable social setting that supports long-term common good.

The learning process on ecosystem management is far from complete. In fact, ecosystem management as a process for sustaining diverse, healthy, and productive land has just begun. To date, we have some principles, guidelines, tools, research and development programs, and several hundred practical demonstrations to draw from. These will expand in our continuing pursuit of new knowledge and technologies.

An ecosystem perspective on sustaining desired conditions of diversity and productivity in multiple-use lands is the right way to go. But it is insufficient by itself to sustain a harmonious relationship between people, land, and resources. Regardless of how well ecosystem management works, other actions will be needed to bring people and land into a better harmony.

Needed: A Globally Responsible Conservation Ethic

Foremost among these actions, Americans must become more conservative in how they (we) produce, use, and dispose of natural resource products. American behaviors regarding consumption and waste of resources are major forces of change in the global ecosystem (Silver and DeFries 1990). Americans need to renew their conservation ethic to bring balance to the complementary roles of managing ecosystems, producing resources, and conserving resources (Postel and Ryan 1991). A recent public opinion survey found that, despite an economic recession, the American public is prepared to make the commitments such an ethic entails (The Roper Organization 1992).

Sustaining diverse, productive, and resilient ecosystems in the U.S. is important. But it must be balanced by a commensurate change in how and where Americans get and dispose of their resources. The potential off-site effects of protecting ecosystems in one place, such as old-growth forests or wildlife refuges in certain regions of the U.S., while continuing profligate use of resources that are produced in other places, such as oil from the middle east or timber from Canada, are not well understood by many people.

All of this planet’s ecosystems are ultimately interconnected. The potential for interregional and international transfers of the economic, ecological, or social effects of where resources are produced and where they are used highlight the veracity of Garrett Hardin’s (1985) comment that “it is not possible to do
only one thing in an ecosystem." U.S. resource policy needs to start paying as much attention to the off-site effects of actions or inactions we take to protect nature or produce resources as we do to the on-site effects. And we need to think more about long-term dynamics in ecosystems. Things do not stay fixed or in the same place over time. Again we turn to Garrett Hardin (1985). His key ecological question, "and then what?" is a clue to how citizens and ecosystem managers must think when they think they are closing in on a simple solution to a complex problem.

Needed: A New Model for Conservation Science

Finally, to shape ecosystem perspectives on land and resource management, especially on the linkages between ecological, economic, and social factors that an ecosystem view implies, social, biological, and physical sciences must become better integrated (National Research Council 1990, Lubchenko et al. 1991). We will not learn how to sustain diverse, healthy, and productive ecosystems if we continue to pursue only traditional disciplinary sciences and education whether they be oriented to biological, physical, or social goals.

Ecosystem perspectives on sustainable resources management have the capability to bring forth a new model for developing the scientific basis of conservation: interdisciplinary teams of researchers working hand-in-hand with managers, educators, and citizens to address both short and long-term dynamics in the many dimensions of relationships between people and the land. The working principles for such a model, known as adaptive management, have been evolving for nearly 20 years now (Holling 1978, Walters 1986). It is time to make the adaptive management model standard procedure for sustaining diverse, healthy, and productive ecosystems.

ECOSYSTEM MANAGEMENT: A PROCESS FOR SUSTAINING DESIRED CONDITIONS OF ENVIRONMENTS, COMMUNITIES, AND ECONOMIES

Ecosystem management employs a full spectrum of land-use classes and resource management practices—ranging from preservation to sustainable production to restore and sustain diverse, healthy, productive ecosystems. Four principles guide the practical development of ecosystem management (adapted from Robertson 1992):

1. Protect the land by restoring and sustaining the integrity of its soils, air, waters, biological diversity, and ecological processes, thereby sustaining what Aldo Leopold (1949) called the land community and what we now call ecosystems.
2. Meet the needs of people who depend on resources of the land for food, fuel, shelter, livelihood, and inspirational experiences.
3. Improve the well-being of communities, regions, and nations through efficient and environmentally sensitive production and conservation of natural resources such as wood, water, minerals, energy, forage for domestic animals, and recreation opportunities.
4. Seek balance and harmony between people and land with equity between interests, across regions, and through generations, meeting this generation's resource needs while maintaining options for future generations to also meet their needs.

LITERATURE CITED


MUSY. 1960. The Multiple Use and Sustained Yield Act of 1960


