ECOSYSTEM MANAGEMENT AND ECONOMICS: A REVIEW

Document prepared as part of:

THE WINE SPRINGS CREEK ECOSYSTEM MANAGEMENT PROJECT

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HISTORICAL BACKGROUND: PERCEPTIONS AND POLICY

Ecosystem management has emerged as an important paradigm for the management of forest lands. Its principles have been widely discussed over the last several years, but uncertainties remain about both the definition of ecosystem management and enumeration of its fundamental principles. While implementation of demonstration projects has proceeded rapidly, many operational details and theoretical concepts remain to be clarified. As part of a project on National Forest management in the east, this paper reviews the principles of ecosystem management and examines the potential role of economics to support management decisions by estimating values of environmental goods and by determining efficient tradeoffs when natural assets are mutually incompatible on a particular landscape.

Philosophical Context

The evolution of land management paradigms in the United States is characterized by a dynamic tension between the principles of utility and aestheticism. Pioneers in the U. S. conservation movement whose writings and actions helped shape this debate include George Perkins Marsh, George Bird Grinnell, William Hornaday, Gifford Pinchot, John Muir, Theodore Roosevelt, Aldo Leopold, and Bob Marshall (Salwasser 1991). Gifford Pinchot is often described as representing a utilitarian "resource conservation ethic", advocating the management of land to provide the greatest good for the greatest number, while John Muir is commonly associated with conservation for the sake of important spiritual values (Karr 1992a).

The current trend toward "ecosystem management" is felt by many authors to embody a significant philosophical shift. Bradley (undated) believes that the very concept of ecosystem "health" has an important moral dimension. He states that it is unlikely that any system which focuses on scientific technology and commodity markets but neglects a moral dimension can result in healthy, sustainable ecosystems.

Wallace et al. (1994) theorize that the philosophical basis for a utilitarian view of the natural world extends deeply into the fabric of our culture and they contend resource policy should be interpreted in this broader cultural context. They attribute the resource use patterns of European settlement in the U. S. to the traditions of rationality and the domination of nature inherited from European Enlightenment philosophers. They note that this world view implicitly bounds our set of management options, and go on to argue strongly for a more holistic ethical framework.

In a similar vein, Wood (1994) argues that our contemporary land policies evolved in a political and social environment concerned with facilitating settlement of the West, but are now anathema to the ethos of modern land stewardship. Cubbage et al. (1994) also identify a utilitarian emphasis associated with western settlement, however they argue these values continue to play an important and legitimate role in American culture and should be balanced with the desire for preservation in an ecosystem management strategy. Bradley (undated) states that federal agencies have grown dependent on "value" estimates which rely too heavily on market prices of commodities. He cautions that these estimates, while analytically tractable, may lead to a narrowness of perspective, and urges policy analysts to think more broadly about the nature of "values" in ways that incorporate a spiritual component.

Public Conservation Awareness

Wallace et al. (1994) go on to point out that the celebration of individual liberty, entrepreneurship, rationality, and domination over nature which underpins our private values may not create a social climate in which public needs are well represented. The American public has recognized this problem and has responded by periodically demanding protective legislation of natural resources to provide for the public good. The Society of American Foresters Task Force report (1993) chronicles four previous phases of forest land management in the U.S. They describe a period of exploitation extending from European settlement until the 1890s, a period of conservation awareness and expanded scientific management extending from the 1890s until the 1940s, a shift to timber primacy under the impetus of post-war economic expansion in the 1940s, and a broader, multiple-use perspective initiated in the late 1950s.

In a similar analysis, Dunlap and Mertig (1991) identify three waves of conservationism in U.S. public sentiment. The first, in the 1890s, was directed at curbing the exploitation of 19th century settlement. The second was undertaken in the 1930s to solve problems of the depression including soil erosion, flood control and electric power generation. The third wave, initiated in the 1950s and still underway, was initially focused on preservation of wilderness for public enjoyment, and has broadened and expanded to become the environmental movement of the 1990s.

Relevant Environmental Policy

The first national legislation to establish forest reserves at the sources of navigable streams was introduced in 1876, but failed to pass (Hodges 1985). Direct federal involvement in the management of national forests began in the United States with the passage of the Creative Act on March 31, 1891. This act authorized the creation of the federal forest reserves (Dana and Fairfax 1980). The legislation was intended to curb timbering abuses which threatened to undermine the sales value of the land to future settlers (FEMAT 1993). Twenty-one million acres were added to the reserves by 1897. This expansion in the scope of the reserves led to the adoption of the Organic Act as part of the General Appropriations Act of June 4, 1897. The language of the Act provides a utilitarian context, protecting forests for their timber values and their importance to water flows, but gives specific consideration to preferred alternate uses including mining or as agricultural lands (FEMAT 1993). Other examples of early, primarily utilitarian natural resource legislation include the Weeks Law of 1911, which allowed for the acquisition of lands in the headwaters of watersheds significant for navigation, and the Clarke-McNary Act of 1924, which offered assistance to farmers for fire protection and forest management via cooperating state forestry agencies.

Overbay (1992) chronicles the series of legislative acts that provide the context for present U.S. Department of Agriculture Forest Service policy. In addition to the Organic Act, Overbay identifies The Multiple-Use Sustained Yield Act of 1960, The Wilderness Act of 1964, The National Environmental Policy Act of 1969, The Endangered Species Act of 1973, The Forest and Rangeland Renewable Resource Planning Act of 1974, and the National Forest Management Act (NFMA) of 1976. Other authors have identified additional legislation which contributes importantly to our current natural resource policy, including The Wild and Scenic Rivers Act of 1968, The Clean Air Act of 1970 (as amended), The Clean Water Act of 1970 (as amended) and The Federal Land Policy and Management Act of 1976. Additionally, approximately 20 states have adopted laws which regulate forestry practices (Cubbage et al. 1993, SAF 1993, Wood 1994).

While the National Forest Management Act of 1976 has resulted in the largest public participation effort ever undertaken in forest planning (SAF 1993), Karr states that there is currently no comprehensive enabling legislation which addresses the issue of ecosystem management or biological integrity. Of the mosaic of current legislation, he reports that the Clean Water Act comes closest to addressing this particular issue (Karr 1992a). Although they have not been approved as of summer 1995, the new 1995 NFMA proposed regulations do explicitly incorporate language for managing the National Forests according to ecosystem management principles (Federal Register 1995).

While increased environmental concern has resulted in many new legislative initiatives on public lands, controls have not commonly been extended to private landowners. Under the Fifth Amendment to the U.S. Constitution, which prohibits private "takings" without "just compensation", private landowners have enjoyed broad protection of their property rights, and ownership of property in the U.S. has historically been associated with significant political power (Christenson 1978). Hodges (1985) points out that federal legislation has avoided direct regulation of nonindustrial private forest lands (NIPF), and during the period from 1930 to 1970 the emphasis has been placed on incentives to induce private landowners to act in ways which are responsive to public environmental concern.

Christenson (1978) observes that concern with the impacts of private land use on the rights of the public is a 20th century phenomenon. Beginning with the first zoning regulation in New York State in 1916, public constraints on the uses of private lands spread rapidly in this century and now includes all 50 states and more than 60,000 governmental agencies. He notes that as the population has grown more urban and more affluent there is increased support for restricting private rights of landowners. Cubbage et al. (1994) note that as a smaller percentage of the population relies on the forest for livelihood, there is increasing support for restrictive legislation which would serve to protect aesthetic goals.

Defining Critical Components of Ecosystem Management

The term "ecosystem management" is fairly recent. The term has been used in a variety of contexts, and has accumulated a host of related, but by no means identical definitions. In their 1993 Report, the Forest Ecosystem Management Assessment Team (FEMAT) defines an "ecosystem" as "A unit comprising interacting organisms considered together with their environment (e.g., marsh, watershed, and lake ecosystems)" and "ecosystem management" as "A strategy or plan to manage ecosystems to provide for all associated organisms, as opposed to a strategy or plan for managing individual species." However, the report is quick to note that "ecosystem management" is an "imprecise concept" and suggests that both interpretation and implementation continue to be in "rapid flux" (FEMAT 1993).

Most broadly conceived, ecosystem management is a conceptual approach to the management of natural landscapes by owners or their agents. These ownerships may include private lands, public lands, or a mixture of both. More narrowly defined, ecosystem management may also refer to a set of specific policy initiatives implemented by the Forest Service to guide management of National Forest lands by Forest Service personnel. In this restricted context, ecosystem management (EM) applies only to management activities on public lands, and the scope of the program is constrained by legislative authority and the specific policy goals of the Forest Service. These are defined as "sustaining and, where necessary, restoring the diversity, resilience, long-term productivity, and beauty of our National Forests and Grasslands" following "the agency's Guiding Principles: Ecological Approach, Grass-roots Participation, Partnerships, and Best Science." (USDA FS 1993).

The proposed rules for the 1995 version of NFMA provide expanded direction for management of the National Forests using ecosystem management principles. The proposed language summarizes ecosystem management in ten basic principles. These include, the goal of managing for sustainability, 2) the intention of optimizing net public benefits, 3) the recognition that people are a part of ecosystems, 4) that open, ongoing public involvement is important, 5) a recognition of multiple ownerships, 6) and multiple spatial scales, 7) that NFMA procedures define the scope of analysis to be commensurate with the scope of the related decisions, 8) drawing on the best available scientific information, 9) using an adaptive management approach as new information becomes available, 10) and retaining the flexibility to efficiently adjust forest plans to meet changing conditions (Federal Register 1995).

Wood (1994) states that ecosystem management (EM) is "fundamentally a new management philosophy." Iverson (1993) believes that EM reflects a fundamental change about the nature of management which was formally "proactive for creating goods and services, but reactive for ecosystem and species needs." This shift from sustainability of outputs to sustainability of the underlying biological system is an important concept in ecosystem management. Other observers say EM is nothing new. Within the Forest Service, 65% of surveyed personnel felt that the core mission of the agency was changing or evolving, while 27% felt the agency mission was substantially the same (Shands et al. 1993).

Wood (1994) states that the primary focus of ecosystem management must be on the condition of the biological system. The goal must be the "sustainability" of the ecosystem, as measured by the system's "productivity", "integrity" and "diversity". The mechanism for achieving this state is the design and implementation of "desired future conditions" (DFCs) which are based on the site's history and ecology, as well as on economic and social goals. In this definition, social and economic goals are subordinated to the site's biological integrity.

Moote et al. (1994) review Ecosystem Management definitions and identify 5 recurring themes. Three of these address the social-agency interface, and include: (1) socially defined goals achieved by (2) collaborative decision building and implemented by (3) adaptable institutions. The remaining themes are technical and include: (4) an integrated, holistic scientific approach at (5) broadened spatial and temporal scales.

Social Issues

Socially Defined Goals: While all authors agree that socially defined goals are a critical component of EM, there is considerable disagreement over the value set which should guide the management objectives. Primary disagreements center around the moral content of world views which are characterized as biocentric or anthropocentric, and around conservation strategies which are utilitarian or more aesthetically driven. Dunlap and Mertig (1991) describe an emerging group in the environmental movement who espouse a biocentric philosophy of "deep ecology" which de-emphasizes the primacy of *homo sapiens* in resource planning. This view favors restricting human well-being when it comes in conflict with the well-being of other competing species. Alternative views are characterized as anthropocentric, putting humans and their values at the center of the planning universe.

Among anthropocentric proponents, the debate over utility or aestheticism continues. Following Muir and Leopold, Karr (1992b) calls for an "ecological integrity ethic" , while Overbay, more closely following Pinchot, states:

> "...let me reiterate, ecosystem management is not an end in itself. It is the means we will use to meet society's needs in ways that also restore and sustain healthy, diverse, and productive ecosystems." (Overbay 1992).

Ecosystem Management within the Forest Service is clearly utilitarian. It is not designed to be preservationist or to conserve natural values for their own sakes. Rather it is crafted to respond to the specifics of public demand for ecosystem integrity in so far as this reflects a broadly held public value (USDA FS 1993).

Institutions Redefined: Better interagency cooperation will be required. Wood (1994) notes that the jurisdictional boundaries of states or federal agencies are unlikely to coincide with ecosystem management units. He argues that, at the least, interagency cooperation must be significantly expanded, and suggests it might be best if Congress were to critically reexamine the existence and scope of our present land management agencies.

The Forest Ecosystem Management Assessment Team (FEMAT) criticizes the history of "incremental decision making" in federal agencies and states that a new approach will be required for success. FEMAT identifies a lack of trust between agencies and between agencies and the general public (FEMAT 1993).

Better public input is necessary. Cubbage et al. (1994) suggest that public values are not adequately reflected in the

Forest Service planning process. Iverson (1993) calls for a model where "all interested people" would share in a decision making process which is informed but not dictated by the best scientific information.

Technical Issues

Holistic Science: Ecosystem Management emphasizes the need to provide for the integrity and sustainability of ecosystems. Kessler et al. (1992) describe the need to sustain wildlands which are healthy, productive and diverse. Iverson (1993) identifies diversity, health, productivity and sustainability as the environmental values critical to ecosystem management. He believes protection of biodiversity and endangered species is a particularly important component.

Broadened Geographical Scale: Kessler et al. (1992) note that cumulative effects on air, water and habitat must be addressed at an expanded scale. While Ecosystem Management advocates an expanded scale, the size of an ecosystem management unit has yet to be defined. Wood (1994) seems to feel ecosystem boundaries are essentially arbitrary, based on agreed upon landscape characteristics. The Forest Ecosystem Management Assessment Team, proposing a management plan for the Pacific Northwest, suggests a series of reserves, embedded in a surrounding land matrix. Reserve size varies from 4.2 to 11.5 million acres. In one scenario, experimental units of from 84,000 to 400,000 acres are proposed for landscape manipulations (FEMAT 1993).

The Society of American Foresters Task Force report identifies landscape scale as a critical issue to be resolved in ecosystem management. They suggest 100,000 acres to as much as 1,000,000 acres may be appropriate for the required ecosystem perspective (SAF 1993). Grumbine (1994) suggests that management areas should be based on trophic integrity and should be large enough to meet the territorial requirements of the population of most widely ranging predators (e.g., five million acres for bears in the Greater Yellowstone ecosystem).

Acting Forest Service Chief David G. Unger introduced the Forest Service systematic approach to ecosystem scale issues on November 5, 1993, stating "The National Hierarchical Framework of Ecological Units was developed to provide a scientific basis for Ecosystem Management in the Forest Service." The intent of the system is "for stratifying the Earth into progressively smaller areas of increasingly uniform ecological potentials." This system identifies 8 levels of ecological scale for analysis. Of these, the largest 5 (Domain, Division, Province, Section, and Subsection) are characterized as global to strategic in focus. These range in size from millions of square miles down to tens of square miles. The 3 smallest classifications have some size overlap (Landscape: 1,000s to 100s of acres, Landtype: 100s to 10s of acres, Landtype Phase: less than 100 acres) and are considered tactical in scope. It is seemingly at these last 3 scales, ranging up to 1,000s of acres in size, where the Forest Service considers integrated, cohesive land management strategies may be required (ECOMAP 1993).

Cawrse et al. (1994) describe the scale changes which resulted from review of a remanded timber sale under new Ecosystem Management guidelines. They describe a prior stand-based focus which was 10-100 acres in scope within a compartment context of 500-1500 acres. Under new ecosystem guideline they report the scale of the analysis was expanded to consider the Big Creek Drainage (10,000 acres) within the context of the 100,000 acre Highlands Plateau. Cissel et al. (1994) describe a project size of 19,000 acres.

Broadened Temporal Frame: The Forest Ecosystem Management Assessment Team addresses the time dimension of Ecosystem Management in terms of the set of tasks appropriate to each of three identified time frames. The shortest time-frame is defined by actions required to protect biodiversity and threatened ecological processes. An intermediate time-frame is defined by extended activities to restore "spatially appropriate" landscapes consistent with an overall strategy of multigoal landscape allocation. The longest of the three time-frames is characterized by "adaptive management", and is therefore temporally open-ended (FEMAT 1993).

Summary and Conclusions

People have debated the goals and methods for natural resource use and/or preservation for over 100 years. In that sense, ecosystem management is not new. It represents another chapter in a continuing national debate. The imprecision of "ecosystem" boundaries has led some to question the usefulness of ecosystem management as a concept. A more positive perspective argues that "ecosystem" is not so much an imprecise concept as a *multi-scaler* concept. To attempt to rigidly define boundaries is to miss the critical point that management decisions affecting ecosystems must be concurrently examined at multiple scales and over multiple time-frames before accepting a particular decision. This reality will require a public reassessment of both our social goals for natural resource management and our position as a society on public welfare when it conflicts with private property rights. The economics of private markets and the ethics of private property are certain to impose bounds on the scale at which ecosystem management can be implemented. These are challenging issues to be addressed in the context of a national consciousness which has always regarded land as abundant and where the rights of private landowners have been highly regarded.

ECOSYSTEM MANAGEMENT WITHIN THE USDA FOREST SERVICE

The Forest Service and the U.S. Department of the Interior Bureau of Land Management (BLM) together manage 461 million acres or about 20% of the U.S. land base (Wood 1994). The Forest Service is responsible for the management of 191 million acres within the national forest system (Robertson 1992). These lands are important sources of timber, clean water, and other forest resources, as well as providing important wildlife habitat, recreational opportunities and a reservoir of biodiversity for future generations.

Forest ecosystems and "timberlands" (lands capable of producing annual volume greater than 20 cubic feet per year and not otherwise removed by law from timber production) comprise a significant portion of the U. S. land base (490 million acres). Timberlands represent the primary land type under management by the Forest Service. At present, approximately 32% (730 million acres) of the United States land base is forest land (SAF 1993). The National Forest System includes 140 million acres (73%) classed as forest land. Of these, 85 million acres are classed as timberlands (Powell et al. 1993). The Forest Service report on Forest Resources of the United States, 1992, reports that National Forests represented 17% of U.S. timberlands and accounted for 12% of timber harvested in 1991. In 1991 National Forests contributed 16% of U.S. softwood growing stock removals and 6% of U.S. hardwood growing stock removals (Powell et al. 1993).

Forest Service Policy Prior to Ecosystem Management

The nucleus of our present-day National Forests were transferred from the Department of the Interior to the Department of Agriculture in 1905, at the urging of Gifford Pinchot. The transfer decision was based on Pinchot's utilitarian philosophies. Despite this utilitarian origin, the eventual forest management policy of the Forest Service became the protection of the forest in natural conditions. Only after the perceived depletion of our private timber reserves during WWII did the focus of Forest Service management turn primarily toward timber output (FEMAT 1993). By the time the "third wave" of environmentalism began to sweep the U.S. in the 1950s and early 1960s (Dunlap and Mertig 1991) timber production had come to dominate Forest Service management of National Forests. Some areas of important recreational or aesthetic importance were transferred to the National Park system.

Eventually, the Forest Service supported the Multiple Use Sustained Yield Act of 1960 (MUSY), which formally articulated multiple goals for National Forests (FEMAT 1993). Under MUSY, Forest Service research increasingly focused on the complex interrelationships between benefits (primarily wood, water, wildlife and recreation), but the agency emphasized commodity production in its management decisions (Hewlett and Douglas 1968).

The first Forest Service program specifically designed to achieve "more natural" forest management was the "New Perspectives" management program. It was a departure from clearcut and plant silviculture and sought to achieve harvest results which more closely mimicked natural disturbances (Cubbage 1995). Shands et al. (1993) describe 4 goals for the program: sustaining ecological systems for a wide variety of benefits, an integrated approach to resource conservation, public involvement in the decision-making process, and scientific and management partnerships to facilitate adaptive management. Clark and Stankey (1991) performed a Delphi survey which identified several broad needs for New Perspectives: review of agency motives and decision making processes, integration of changing public values into planning, improved knowledge and management tools, and a more integrated approach to both forest uses and forest processes.

New Perspectives was conceived as a two year transitional program of demonstration projects (USDA FS 1993). The program was launched in June of 1990, and by March of 1992 it included more than 260 individual projects (Shands et al. 1993). Salwasser (1991) identified four primary principles for the program: (1) ecosystem health (including: soil, water, air, biological diversity and ecological processes), (2) human needs for commodities, recreation and religion, (3) continued economic development, and (4) maintenance of options for the future.

Guiding Principles of Ecosystem Management

Ecosystem Management replaced New Perspectives in 1992. It is a combination of technical prescriptions including an ecological approach and best science, and social components including grassroots participation, and expanded partnerships. It is to be phased in over a 3 to 5 year period (USDA FS 1993). The approach seeks to sustain and restore the long-term productivity, resilience, diversity and beauty of areas under management (USDA FS 1993).

The Forest Service has been criticized for its perceived lack of responsiveness to changes in public values. Segments of the public have expressed distrust of the Forest Service and this has been reflected in increasing levels of litigation (FEMAT 1993). A major goal of ecosystem management is to change the public's perceptions of how Forest Service decisions are made by seeking direct, grassroots, public involvement in the decision process (Mrowka 1993, USDA FS 1993). The social context in which ecosystem management occurs is considered to be equally important to the biological-physical context (USDA FS 1993).

Chief F. Dale Robertson of the USDA Forest Service formally launched the policy of ecosystem management in 1992. Writing in a June 4, 1992 memo he said, "By ecosystem management, we mean that an ecological approach will be used to achieve the multiple-use management of the National Forests and Grasslands. It means that we must 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).

Robertson goes on to call for 3 organizational initiatives in the pursuit of 4 broadly defined goals. First, he calls for increased public involvement and a "higher level of dialogue". Second, he urges an expanded role for conservation partnerships, and third, he encourages continued and increased collaboration between scientists and land managers. These initiatives support the 4 broad goals of land stewardship (protecting and restoring integrity, biological diversity, and ecological processes), community sensitivity (providing commodities, recreation and spiritual renewal to human communities), economic and biological efficiency, and finally, a balance between land and people, current and future generations.

The June 4 Robertson memo provided additional operational guidance. It called for the determination of desired future conditions (DFCs) of the ecosystem as a management focus. These are to be consistent with the ecological potential of the site and pursued by means of adaptive management. Multiple landscape scales are to be considered over a span of at least several decades.

Additional guidance from James Overbay followed on June 25, 1992. Overbay (1992) called for specific Plans outlining a "joint Region-Station strategy for implementing ecosystem management", and a transitional implementation time-frame of 5 years to allow for smooth implementation through the existing NFMA planning process. The Overbay memo adds some new detail. The Regions are instructed to:

* "Implement a hierarchical ecosystem classification and integrated inventories to support ecosystem management."

* "Continue to develop and extend field demonstration projects initiated under New Perspectives, including their use in interpretation, professional training, and conservation education on ecosystem management."

In Salt Lake City a workgroup of Forest Service personnel defined ecosystem management as the "integrated use of ecological knowledge at various scales to produce desired resource values, products, services, and conditions in ways that also sustain the diversity and productivity of ecosystems." Further, "Ecosystem management is a means to an end. It is not an end in itself. We do not manage ecosystems to preserve some intrinsic values or solely to imitate conditions that occurred at some time in the past." (USDA FS 1992).

Subsequently, the following 6 guiding technical principles (USDA FS 1992) have emerged:

<u>Sustainability</u> of the ecosystem; key criteria are: viable biological processes, biodiversity, and soil productivity (USDA FS 1992, USDA FS 1993).

Dynamics which recognize that management goals must harmonize with system capabilities that vary from site to site, and recognizes that a variety of diverse communities will increase options under uncertain future conditions.

Desired Future Conditions are used to characterize management goals for both the system and its intended outputs.

Coordination at the landscape or watershed level.

Integration of scientific information and management tools consistent with ecosystem management of the "big picture" rather than analysis of the separate pieces.

Adaptive Management to changes in biological systems over time and to expanded scientific understanding.

Desired Future Conditions figure prominently in Ecosystem Management planning within the Forest Service. The term was introduced by Kessler et al. (1992, p. 222) who wrote, "We need instead objectives that relate to ecological and aesthetic conditions of the land - a desired future condition if you will - *and* that sustain land uses and resource yields compatible with these conditions... The new paradigm must not diminish the importance of products and services, but instead treat them in a broader ecological and social context." Determination of DFCs includes six steps: assessment of site history, capability, and current inventory, an economic analysis to determine a feasible set of alternatives, integrated planning to determine DFCs, and development of an action plan (USDA FS undated). Morland et al. (1994) note that because of the inherent complexity of biological processes, managers should seek to establish DFCs which are within the "historical range of variability" for a specific site.

There are at least two views of the forces driving the Forest Service's transition to Ecosystem Management. One view is that the policy is evolutionary, the next logical step in meeting the agency's dual mandates of public service and management based on best scientific knowledge (Robertson 1992). An alternate view would suggest that the scientific basis for ecosystem management is still tentative, and that its rapid adoption was an expedient (and possibly unfortunate) response to growing public dissatisfaction with the Forest Service (Hoover and Mills 1994).

The Public-Private Land Mosaic

In the Eastern United States particularly, the land ownership pattern is highly fragmented, with even the largest government holdings characterized by substantial private inholdings. There is a need to think carefully and critically about whether ecosystem goals apply equally to both public and private lands (Cubbage 1995). Iverson feels that a fragmented management strategy is counter-productive and that intensive private forestry will result in public demands for large counterbalancing "reserves" on public lands. He calls instead for a shared public-private commitment to foster biodiversity (Iverson 1993). The FEMAT report also concludes that the goals of private forestry may not meet all legitimate social needs, but it raises the question of whether (and to what degree) public lands should be used to "take up the slack" in order to meet public needs and allow free use of private lands (FEMAT 1993).

Wood (1994) believes that the rights of private landowners must predominate, but that likely private actions and the overall landscape mosaic must be considered by federal agencies as they plan for ecosystem sustainability on federal lands. The SAF Task Force report stresses that a broad array of different landscape conditions are needed for the success of ecosystem management. Therefore ecosystem management can accommodate different owner objectives including intensive forestry, so long as these are integrated in a landscape context (SAF 1993). The Forest Service explicitly states that its Ecosystem Management guidelines apply only to federal lands, though success requires an awareness of decisions made by private landowners within the landscape mosaic (USDA FS 1993).

Differences from Past Practice

Integrated Approach to Biological Systems

By the 1990s, many people believed that forest health was deteriorating and that components of ecosystems valued by the public were being damaged or lost. This was attributed to instances where focus on selected forest components resulted in damage to other components insufficiently considered. In the southern United States the shift to even-aged, short-rotation pine silviculture, combined with fire control, was regarded as the primary component in the precipitous decline of the red-cockaded woodpecker (SAF 1993). The USFWS attributes decline of the spotted-owl to habitat fragmentation and declines in old-growth acreage (SAF 1993). Salo and Cundy report that timber management practices which resulted in degraded riparian habitat contribute to decline in anadromous fish stocks in parts of the Pacific Northwest (SAF 1993). The FEMAT report states that past logging practice in the Pacific Northwest contributed significantly to declines of anadromous fish stocks and to the decline of the Northern Spotted Owl (FEMAT 1993).

In response to such fears, Ecosystem Management was proposed to improve forest health. Ecosystem Management represents a shift in management focus from agricultural production of outputs to an emphasis on ecosystem capabilities, and system health and sustainability (Mrowka 1993). Wood (1994) states that historical practice has partitioned the resource to accommodate multiple desired uses in ways that often made little sense when the landscape was considered as a whole. He advocates moving away from allocation by desired use and moving toward allocation based on sustainable service levels.

The Forest Service Salt Lake City workgroup identified an integrated approach to the whole ecosystem over an broadened spatial and temporal scale as the primary feature which distinguished ecosystem management from former management practice (USDA FS 1992). This larger scale invites consideration of factors including biodiversity, edge effects, forest fragmentation, and pollution transport which were impossible to fully consider at smaller scales (USDA FS 1993). Cawrse et al.

(1994), reporting on an Ecosystem Management demonstration timber sale, describe the explicit definition of DFCs and an expanded spatial scale as the two largest departures from prior practice.

Changes in Timber Management

Timber harvest practices are in transition under ecosystem management. The National Forest Management Act of 1976 set a limit of 40 acres or less for clearcuts except for harvests of Douglas-fir, southern yellow pine, and Alaskan hemlock-sitka spruce, which were allowed to be larger. In 1992 Chief Robertson called for the elimination of clearcutting in National Forests except in instances where it is "essential to meet specific forest plan objectives". While not stated as a goal, it was anticipated that this change might lead to a 70% reduction in the 310,000 acres clearcut in the base year of 1988 (of 728,424 acres total harvest). It was further anticipated this might lead to a short-run reduction of about 10% in timber yields from federal lands. No long-term supply effect was anticipated (Robertson 1992). By 1990 clearcut sales had already declined 37% over base year (1988) sales of 323,548 acres. By 1992 clearcut harvest had declined 50% from base year sales (USDA FS 1993). By 1993 total clearcut acreage had declined to 132,674 acres, and in 1994 the clearcut volume had fallen to a low of 100,796 acres (USDA 1995).

Clearcutting is being increasingly replaced by other silvicultural treatments including group selection, shelterwood, and seed-tree management plans (Cambell and Sherar 1989). Increased efforts will be made to ensure biodiversity in areas scheduled for regeneration (USDA FS 1993).

Changes in Agency Culture

Mrowka (1993) notes that ecosystem management represents a move from an agency culture based on scientific management toward a culture which seeks to be more interactive with an interested public. The role of science is seen as providing information to facilitate a dialogue rather than rigidly determining management outcomes. People are seen as part of ecosystems. Therefore, exploring the public's needs and wants and integrating them into both planning and management is described as part of the ecosystem management process (USDA FS 1993).

Under Ecosystem Management, the primary implementation method is collaborative determination of Desired Future Conditions. In this context, timber production can be seen to be a beneficial result of achieving agreed upon DFCs (USDA FS 1993). Overall, Ecosystem Management can be viewed as a paradigm intended to move the ethos of the agency from production of goods under environmental constraint to one of sustenance of forest health with production of commodities included whenever it is consistent with sustained health.

Summary and Conclusions

Chief of the Forest Service Jack Ward Thomas has stated, "Ecosystem management is a concept in search of a context... Never forget that ecosystem management is as much about *people on the landscape* as it is about the landscape itself (Thomas 1995)". An adaptive management approach seeking the dynamic involvement of citizens in land management decisions is a departure from the relatively static legislative and administrative responses of the past. This initiative for greater public interaction seems to stem from a desire for consensus and from the recognition that the management units appropriate for ecosystem management will span both agency boundaries and public-private ownership boundaries.

Another significant departure from past practice is the emphasis which the Forest Service places on a variety of spatial and temporal scales. This multiplicity of spatial and temporal perspectives is a fundamental shift from the preceding multiple use paradigm which emphasized a single perspective to insure multiple outputs. An unresolved question for managers is how to appropriately frame the various scales which will be used to analyze the success of implementation. How spatial boundaries are designed will have significant effects on program decisions.

Shifts in management emphasis from commodity production to forest health sustenance would also substantially alter National Forest policy and practice. The sustained pursuit of ecosystem management may lead to a sea change in National Forest management. While it is unclear how ecosystem management will effect the absolute area committed to timber harvest, the intensity of overall harvests and the volumes removed will surely be reduced, hopefully in exchange for improvements in metrics thought to be associated with forest health. The Forest Service also hopes that ecosystem management will increase public input and satisfaction, improve scientific management, and enhance agency esteem. The new paradigm will surely focus agency attention on a lofty and important set of goals. Whether ecosystem management can provide the scientific rigor and the political resilience to achieve these goals will be extremely interesting to assess.

ECONOMIC CONTEXT FOR ECOSYSTEM MANAGEMENT

Historical Economic Background

Early economic theorists expressed concern in various ways with the possibility of environmental limits to economic growth. Victor (1991) identifies Smith, Ricardo, Malthus, and J.S. Mill as early contributors. Research in land economics in the 1950s and 1960s acknowledged the importance of nonmarket aspects of land but regarded these components as "extraeconomic" (Krutilla and Fisher 1975). Mansfield (1982, p. 9) provides a clear example of the prevailing view when he writes,

> "Economic resources are scarce, while free resources, such as air, are so abundant that they can be obtained without charge. The test of whether a resource is an economic or a

free resource is price: Economic resources command a nonzero price but free resources do not."

In response to the environmentalism of the 1960s, economists began to expand the scope of their analysis to include *in situ* values of environmental systems. The body of work which has resulted from applying the principles of neoclassical welfare economics to the valuation of environmental systems is commonly referred to as environmental economics.

Contemporary literature on ecosystem management reflects a debate over the appropriate role of economics. Some authors equate economic analysis only with the study of priced commodities and marginal benefits. Expressing a broader view, Milton Friedman has stated that "an economic problem exists whenever *scarce* means are used to satisfy *alternative* ends." Friedman further states that economic analysis may be undertaken whether or not the good is traded in priced markets, and whether the underlying nature of the good is material or intangible (Friedman 1962, p.1). Boulding posits the notion of an "econosphere" as the conceptual universe within which something has an economic reality (Boulding 1966). He makes the point that in the "cowboy economy" of the past (e.g., neoclassical analysis) things became economically significant only when they entered production functions as an input.

Land (1994) believes that environmental economists will be unsuccessful in attempts at benefit estimation due to the formidable problems of quantifying benefits and biological uncertainties which may prevent sufficiently complete characterization of the choice set facing the consumer. He believes that levels of resource utilization should be set exogenously in a policy context and that economists should restrict their focus to cost-efficient implementation methods. Shaw (1984) expresses a similar position, feeling that even if the precision and validity of economic valuation were beyond dispute, these valuations could only represent a minimum value, due to the complexity and uncertainty of fully enumerating environmental benefits.

Environmental vs. Ecological Economics

Costanza et al. (1991) describe a "'conventional' economics" which they characterize as generally insensitive to spatial scale and resource limitations, focused on profit and utility maximization, with insufficient attention paid to nonhuman components of the environmental system. They call instead for an "ecological economics" with a more transdisciplinary approach. The International Society for Ecological Economics (ISEE) in its mission statement

> "is concerned with extending and integrating the study and management of 'nature's household' (ecology) and 'humankind's household' (economics). Ecological Economics studies the ecology of humans and the economy of nature, the web of interconnections uniting the economic subsystem to the global ecosystem of which it is a part. It is this larger system that must be the object of study if we are to adequately address the critical issues that now face humanity." (Costanza 1991a, p. *v*).

The world view of ecological economics owes much to Georgescu-Roegen's exploration of economics and thermodynamics. He characterizes neoclassical economics as a circular flow whereby individuals combine capital endowments with labor to produce income with which to purchase goods and invest in capital... ad infinitum. Georgescu-Roegen states that within this framework neoclassical economists have done a good job of addressing conservation of mass, but the analysis neglects the second law of thermodynamic entropy (Georgescu-Roegen 1971).

Adding entropy to the analysis changes the theoretic world in several important ways. First, it shifts the frame of reference from an "econosphere" to a biophysical, planetary frame of reference. Daly draws the distinction clearly when he says that in environmental economics "the economy contains the ecosystem", whereas in ecological economics, "the ecosystem contains the economy." (Daly 1992). The human economy may be modeled as a process which transforms low entropy inputs irrevocably into higher entropy outputs which consumption transforms into still higher entropy waste. This process is not a circular flow, but a unidirectional process. Second, land becomes a unique asset. Georgescu-Roegen likens it to a "net" which can capture low entropy solar inputs. If it were possible to increase the entropy inflow by technological means, these gains would be limited by the ability of biophysical systems to assimilate the associated heat waste. This places limits on the theoretical gains achievable by technological innovation. The ability of the system to absorb waste is seen as a function of area, "integrity", and perhaps other variables.

Positivism vs. Subjectivism

A final distinction can be made between the positivist analysis of environmental economics and the more normative approach of ecological economics. Sahu and Nayak (1994) make a distinction between an environmental economics which is "positivist", "value-free", "unidisciplinary", and an ecological economics which is "subjective", "ideological", and "multidisciplinary". Costanza refers to a hierarchy of goals with sustainability being the most important (Costanza 1991b). Klassen and Opschoor (1991) describe a value hierarchy in ecological economics, with continued human existence and environmental compatibility as the two highest values. These are values which are societal. On a lower tier of importance are those values which characterize individual "wants". These "wants" may be optimized subject to conditions for the overriding societal values having been met. But in the paradigm of ecological economics, environmental sustainability is to explicitly direct economic development.

Contemporary economic analysis of ecosystems is based on the concurrent evolution of environmental economics which is striving to extend the realm of neoclassical analysis, and ecological economics which is seeking a transdisciplinary synthesis between ecology, economics, and other of the social sciences. The two approaches can lead to different results, and it will be useful to compare notions of "value", "sustainability" and measurement tools, before proceeding to a more detailed level of analysis.

Concepts of Value

Utility theory forms the basis for value in environmental economics. The preferences of individual consumers are accepted as sovereign, and individuals are assumed to maximize the utility (pleasure) they derive from consumption, constrained by the limits imposed by their incomes and any pre-existing wealth (taking initial endowments as exogenously given). Pareto efficiency, a measure which seeks to improve the lot of at least one individual without making any other worse off, is used as a welfare yardstick by which to compare the optimality of alternative states (Binger and Hoffman 1988, Varian 1992). Utility and Pareto efficiency can be aggregated to form money metric social welfare measures by asking consumers what they would be willing to pay (WTP) for an environmental improvement, or willing to accept (WTA) for a decrease in some dimension of environmental quality (Randall 1988). Pearse and Holmes (1993) note that a value system based on preferences revealed by individuals is not the only method by which social values might be assigned, but that the choice between individual preference and some other more socially centralized value system is a judgement which will significantly affect benefit estimates and which should be carefully considered.

It should be noted that this conception of economic value based on the consumption preferences of individuals is not necessarily compatible with all views of ecosystem management, or with the views of ecological economists. Daly clearly expresses the position of ecological economics. He describes an "ethicosocial limit" to economic growth. The limit comes from recognizing the costs to other species and future human generations of continued material expansion. Failure to acknowledge and be governed by this limit will result in deterioration of the social order which makes commerce feasible and life desirable. The recognition of the "rights" of nonhuman species is explicit and distinguishes ecological economics from environmental economics. Daly continues,

> "many would consider ... the value God places on His creation and His purposes for it, which may be more subtle

> and inscrutable than simply maximizing present value for the current generation of entrepreneurs...Moral claims for the intrinsic worth of sub-human species should exert some limit on takeover, although it is extremely difficult to say how much." (Daly 1987, p. 330).

This more biocentric vision leads to a definition of "efficiency" which is significantly different from Pareto efficiency. Taking the distributional outcome as exogenously given, biocentric efficiency may be defined as the allocative path which results in the greatest conservation of low-entropy energy.

Sustainability

The concept of sustainability figures importantly in definitions of ecosystem management. Sustainability has also been a critical concept in economics, though not all utilitarian concepts of sustainability derived by economists can be applied successfully to ecosystem management.

A discussion of sustainability must begin by reviewing at least three types of underlying assumptions. First, it is of critical importance whether natural and man-made resources are considered to be somehow equatable in value, and intrinsically exchangeable. A second and related point is to identify the beneficiary; the present generation, or is it future generations of consumers only, or do benefits extend to other species or perhaps even the systems themselves? Brown (1990) notes that due to uncertainty and a positive rate of time preference there is the tendency to value benefits available in the near future more highly than those available only in the distant future. This introduces a bias against values to future generations. The final set of issues relate to uncertainty and irreversibility. To what extent is the possibility for success conditioned on our having correctly understood the nature of the underlying system, and correctly anticipated its response? Is it possible to reverse an action if its consequences prove to be suboptimal? What about the people who are uncertain about their choice or preference? Should they not be willing to pay to preserve the option of using that resource in the future? These questions were raised by Weisbrod (1964) and Krutilla (1967), in papers that introduced the concept of option value into the conservation literature.

Option value takes traditional welfare measurement a step further by incorporating risk and uncertainty into an individual's choice. Weisbrod stated that decisions ought to include an option value of preserving the natural area in its original state. The actual option value can be viewed as a risk premium or the difference between what a risk-averse consumer is willing to pay at a predetermined non-discounted price and what the expected consumer surplus is without risk aversion (Fisher and Krutilla 1985).

An extension of option value known as quasi-option value allows the incorporation of future information and combines it with the issue of irreversibility. In these quasi-option models, the option valuation incorporates the marginal value derived from postponing a decision in order to gain more knowledge in the future. The quasi-option value is conditional on the value of this better information (Fisher and Krutilla 1985, Hanemann 1988).

Neoclassical View

A strongly neoclassical view of sustainability, expressed by Solow and others, takes as its goal the potential for constant per capita consumption from generation to generation (Solow 1974, Solow 1993). Substitutability between natural resources and human technology is assumed possible where these are used as factors in production. At some level of marginal substitution natural amenities and consumer goods are also considered fungible by individuals in their consumption decisions. If other inputs (man-made or natural) can be used to substitute for a natural input in short supply, then scarcity will lead to higher prices which will spur technological innovation and the introduction of a backstop technology which relies on a different input mix. It may be efficient to deplete natural stocks. This will not have a negative impact on intergenerational equity as long as productive capacity of the depleted stocks is offset by technological innovation and alternate sources of man-made capital.

If we consider only the utility decisions of the current generation a more extreme view is possible. Decisions of the current generation may be considered to include their bequest provisions for future generations. This may lead to the result that even the most broadly substitutable measures of consumption are not sustained, either because of self-interested choice on the part of the current generation or a positive discount rate for future consumption.

Ecological Economics View

By way of contrast, the extreme position in ecological economics requires the sustainability of ecosystems of which man is but a part. This extends the umbrella of sustainability beyond the consideration of service flows to humans. It also includes qualitative descriptors of the natural systems. While it is admittedly subjective, Costanza proposes a "health index" to estimate three environmental attributes: vigor, organization and resilience (Costanza 1992). The relevant time frame is that of evolutionary time. When the goal is defined as sustenance of ecological systems, substitutability between natural capital and technology as factor inputs in production becomes largely irrelevant. This result derives from the fact that the requirement of preserving the integrity of natural systems imposes severe constraints on their exploitation, and precludes the option of replacing overexploited systems with technology based alternative inputs.

Toman summarizes these three positions as "neoclassical egalitarianism", "neoclassical presentism" and "ecological organicism" respectively (Toman 1994). Although ecosystem management need not require a position of "ecological organicism", an approach explicitly concerned with the integrity and sustainability of environmental states is incompatible with Toman's "neoclassical presentism" and must put strong restrictions on the utilitarian notions of "neoclassical egalitarianism" to restrict conditions of substitutability between natural and technological assets.

The fact that natural capital exists in fixed supply and provides direct utility through amenity values and existence values are strong reasons for suggesting that it be considered as separate from other forms of capital. This is essentially the position taken by Pearce and Turner (1990). They define a sustainability predicated on the perfect substitutability of manufactured and natural capital as "weak sustainability". They argue for a distinction between natural and man-made capital and suggest a sustainability criterion ("strong sustainability") which would require nondeclining stocks of both forms of capital (Pearce and Turner 1990, Turner et al. 1993). Daly has suggested it is acceptable to substitute within natural capital, so that non-renewable assets may be drawn down so long as they are offset by compensating balances of renewable assets (Daly 1991). These views of sustainability can be integrated with the more utilitarian visions of ecosystem management, but may still be too open-ended to satisfy the more biocentric definitions of ecosystem management.

Foy and Daly suggest an interesting analytical structure. They describe three economic-environmental interfaces: allocative efficiency, distributional equity, and scale. Allocative efficiency corresponds to a Pareto efficient criterion in which no individual can be made better off without a decrease in the welfare of a second party. Distributional equity addresses the normative issues of "fairness" in access to resources between populations and across generations. It also influences efficiency in the sense that populations with insufficient access to either labor or capital are unlikely to be able to optimize the use of natural resources as an input and thus are unlikely to be on the efficient frontier of sustainable resource use. Scale considers the continuity of efficient solutions across various levels of aggregation. This is important to preclude solutions that are optimal only as a result of artificial bounds placed on the problem statement. For a system to be sustainable, it must function successfully along all three interfaces (Foy and Daly 1989).

The "Safe Minimum Standard"

The views of environmental and ecological economics are synthesized to some extent in the concept of the "safe minimum standard" (SMS). This concept is based on the fact that actual benefits are hard to measure, and since it is assumed that ecological integrity conveys benefits then, at a minimum, it is important to provide a level of preservation that ensures the persistence of critical habitats and the survival of minimum viable populations of species (Ciriacy-Wantrup 1952). The complexities of cost-benefit analysis are avoided by establishing a decision rule to maintain a SMS unless the opportunity costs of doing so are socially excessive. Ciriacy-Wantrup argued that the costs of preservation will be relatively small if there are close substitutes available for the goods and services of the endangered habitat or species. Bishop (1978) further refined the concept in a game theoretic context by calling for minimizing the maximum possible loss. However, he cautioned against too much concern for extreme situations and emphasized that the primary focus should be on a rational approach to finding a middle ground.

The SMS approach does not have to deal with discounting by its acceptance that future generations will gain from the conservation measure the current generation assumes. Also, a risk premium is not measured since the risk is equivalent to the gross uncertainty in the decision itself. However, Bishop (1993) notes that problems remain when the current generation must make the cost decisions, and that too strict a policy of conservation might backfire and make all generations worse off. SMS does provide a practical if less than ideal way of making decisions. It must be kept in mind that this method does not provide explicit values or policy recommendations. Its primary benefit is in increasing clarity by redefining the decision options.

Measuring Economic Benefits

Monetary Measures

Mitsch and Gosselink characterize what they call "conventional economics" as an attempt to reduce all components of environmental benefit to a single monetary index for evaluation, and suggest that because of the variety and complexity of ecological outputs, the tools of economic analysis may be of only limited usefulness (Mitsch and Gosselink 1993, p. 527-530). Pearse and Holmes note that evaluating aggregate changes in social welfare requires a consistent measure, and that it is expedient to use benefit cost analysis and monetary evaluation in this context. They go on to note that this does not imply that all relevant benefits are best expressed in terms of money (Pearse and Holmes 1993). Svedin (1985) makes the simple observation that a variety of metrics are usually available and that the appropriate metric is the one which is most pertinent to the question at hand. While this is a powerful notion, it is still by no means transparent which metric or metrics best capture the multiple aspects of *in situ* ecosystems.

While it may be useful to augment a particular analysis with additional perspectives, environmental economists are in general agreement that a use of a monetary metric is a valid and indispensable component of any environmental valuation. This view results from the basic assumption that value derives from what people find useful, and from a decomposition of the basic components of value in an ecosystem. These components may be broadly characterized as market-priced commodities, unpriced goods which are enjoyed or consumed without charge, and goods which provide value by virtue of their existence. These distinctions will be pursued in greater detail in a later section. The important metric issue is that given the assumptions of individual preference and Pareto efficiency, monetary prices well describe the market component of ecosystem value. Since any other metric would be required to preserve these qualities, it seems intuitive to seek to integrate the unpriced components of value into the existing functional metric.

Some authors have objected to the attempt to reduce natural systems to a monetary measure. Norton (1988) distinguishes a class of "true values" which are what people really care about, and notes that these are often not adequately reflected in either market prices or monetary valuations. Funtowicz and Ravetz argue that money is only one aspect of value; the aspect which is appropriate to commercial markets. They feel that it may not be possible or appropriate to attempt a "numeraire" for many environmental goods and they suggest that as ecological economics continues to develop as a "post-normal science" a "plurality of perspectives" may be required (Funtowicz and Ravetz 1994).

Energy Metrics

Odum argues that the choice of money as a metric is inappropriately limiting. He emphasizes energy content and thermodynamic conservation as primary measures of value. This approach has been well received among some ecologists. Odum writes, "Ultimately, it is not just human beings and their money that determine what is important; it is all the world's energy. It is, therefore, a mistake to measure everything by money. Instead we should use energy as a measure, since only in that way can we account for the contribution of nature." (Odum and Odum 1976, p. 50).

Although Odum's "emergy" (embodied energy) concept has been linked with entropy measures, Georgescu-Roegen, one of the early proponents of a thermodynamic concept of value, notes that while an energy component is necessary to a sustainable measure of value, it will not generally be sufficient. A useful measure must also include a component of instrumentality (Georgescu-Roegen 1971). The energy standard of value does not consider consumer tastes, therefore Daly (1987) also concludes that it is "erroneous". Hyman and Stiftel (1988) review energy analysis in some detail and identify several additional problems with its application as a measure of value.

Multiple Criteria

Another alternative to monetary valuation which is favored by Munda et al. (1994) is to employ multiple criteria. The authors state that any proposed policy measure requires an "evaluation method" defined as a "set of rules...required to transform the facets of a certain planning proposal into statements about society's wellbeing." According to this view, the society may approach this evaluation task with a variety of instruments. These include "monetary evaluation", but also include a class of nonmonetary methods including "multicriteria decision analysis" (MCDA). Because it considers multiple objectives, this approach is one of negotiated compromise rather than optimization.

The MCDA process which Munda et al. describe is in essence a political conflict resolution strategy. The system of decision rules outlined are sensitive both to decision maker's preferences and to weighting factors if an aggregation model is employed. The authors concede that this process is "invariably subjective" and dependent on the "ethics and ability of the modeler". They make the case that this has the benefit of introducing a needed element of flexibility into the policy process. It is not clear how the MCDA framework leads to an explicit consideration of the trade-offs which must be evaluated in the context of the negotiation. The last word on this issue is perhaps stated best by Hof (1993, p. 175):

> "in the area of 'ecological economics'... there appears to be growing sentiment that an economic objective function (maximizing net benefits measured with a pecuniary numeraire) is not appropriate for forest management, especially in the public sector... I would like to point out that even if we abandon an economic numeraire - a monetary measure of good and bads - it does not necessarily mean that we should abandon the economic logic of efficiently allocating scarce resources. To abandon the fundamental efficiency logic would be to conclude that more of whatever is good is not good and less of whatever is bad is bad."

The problem remains, if not money, what else? This is an area where ecological economics has yet to offer a useful alternative. As Hardin (1968) was early to point out, trade-offs routinely occur between environmental goods which many prefer to consider noncommensurable. Discomfort with the process does not eliminate the need for assigning meaningful valuations.

Components of Ecosystem Value

Components of ecosystem value may be placed in three broad classes: commodity goods with market prices, depletable goods without market prices (fish and game as examples), and nondepletable, unpriced goods. In this last classification, the goods may be further subdivided into those which enter the utility function of the individual through some form of experience (e.g, recreation), and those which need not be experienced but have value for their existence value alone.

Values from ecosystems seem to have been most fully enumerated in the case of wetlands. Provision for "no net loss" under section 404 of the Clean Water Act has resulted in studies to delineate wetland ecosystem boundaries and in research into ways to evaluate or value *in situ* ecosystems. Rapid assessment models are commonly used to identify potential ecological values which might exist on a site. A review of rapid assessment models from the Army Corps of Engineers (WET) and those from 5 states (Connecticut, North Carolina, New Hampshire, Oregon, and Virginia) identify 8 types of ecological assets including 1) water table alterations (quantity or quality), 2) bioremediation of pollution, 3) soil stabilization, 4) fish and wildlife values including habitat, primary and subsequent production, and landscape connectivity corridors, 5) recreational values, 6) commercial products, 7) aesthetic values, and 8) ecosystem integrity (Ammann et al. 1986, Adamus et al. 1987, Ammann and Stone 1991, Bradshaw 1991, NC DEHNR DEM 1993, Roth 1993). It is useful to note that while wetlands provide priced market goods and non-market consumable products, many of these values are essentially nonconsumable and relate to the existence and sustainability of certain site attributes. This last class of existence values are extremely difficult and perhaps impossible to quantify and to value. Many authors have noted this difficulty and identified a need for comparing the relative values of highly dissimilar attributes, but to date very little progress has been made.

Nonmarket Valuation of Ecosystem Benefits

Since prices are not available for non-market goods and services, economists have developed more complex indirect or implicit pricing and contingent valuation methods (Freeman, 1993). Pearse and Holmes (1993) identify two approaches to the valuation of unpriced benefits. The first approach, which includes techniques of hedonic cost models and travel cost models, is based on the observed behavior of individuals. In the travel cost methodology, the monetary costs of reaching a site where free or nominally priced benefits may be enjoyed is taken as a measure of value. Since consumers incur different costs as a function of their distance from the site, differential costs and frequency of use can be combined to form an estimate of demand. In the hedonic method, priced goods which are identical except in certain qualitative aspects are compared, and the difference in market prices is inferred to be the value of the qualitative attribute (e.g., structurally identical homes with different market prices resulting from differences in their environmental amenities). The second method, based on survey information elicited from individuals, is the basis of the contingent valuation (CV) method. Using CV, consumers are asked what they would be willing to pay (WTP) to preserve an existing unpriced benefit, or what they would be willing to accept (WTA) to forego the benefit in exchange for compensation. This hypothetical payment schedule is used to estimate demand. Critics of the non-market valuation techniques cite at least three reasons: 1) the economic methods for valuing non-market goods are unrefined and imprecise, 2) that we have yet to clearly categorize or clearly define the types of goods or products from wildland management, and 3) that we have yet to clearly identify the users of the ecosystem products (Shaw 1984).

While travel cost models and hedonic models have been used successfully in a variety of environmental contexts (Palmquist 1991), they have not yet been adapted to estimates of existence values (Pearse and Holmes 1993, Whitehead 1990). Several authors suggest that existence values are a significant and perhaps predominate component of overall ecosystem values (Pearse and Holmes 1993, Whitehead 1990). Pearse and Holmes (1993) identify 3 types of nonconsumptive values: option value, bequest value, and existence value. Writing in the context of option values for species preservation, Krutilla (1967) identified three types of option values: existence, bequest, and scientific. Existence value refers to the value a person may derive from merely knowing the species exists. A bequest value is where an individual wishes the option to preserve a species so that future generations may benefit from it. A scientific value is the public knowledge that a species may provide utilitarian benefits in the future under a different set of technological specifications. These are the value components which predominate the discussion of ecosystem management, particularly as concerns "integrity" (e.g., existence value for biodiversity) and "sustainability" (e.g., bequest value and option value). It therefore seems likely that the greatest advances to benefit estimation in an ecosystem context will result from applications of contingent value methodologies which can capture estimates of existence values, though there will undoubtedly continue to be specific applications for which hedonics or travel costs will be both adequate and more efficient.

Estimating Tradeoffs and Values

Under ecosystem management, tradeoffs can exist in two forms. First, the manager must select levels of incompatible services from a particular ecosystem. Second, it is also generally true that there will be a tradeoff between the level of financial expenditures and the quality or quantity of environmental services. That is, for any given mix of ecosystem services, it would generally be possible to improve some aspect of the service by spending more money. In this second instance, an economic analysis would equate the change in cost to the increase in social benefits as measured by willingness-to-pay. Ecosystem benefits are not independent from one another, and the natural processes which form *ecosystem production functions* are still incompletely understood. These problems, in addition to the lack of market prices, raise formidable challenges to the estimation of benefits.

Several authors have attempted to use contingent valuation or other survey methods to estimate a dollar value for *in situ* environmental services. These techniques have been most widely applied in the estimation of wetland values, with results ranging from $27 to $8000 per acre. This broad range is the result of both wide variability in the localized site values as well as uncertainty in techniques for value estimation (Stavins 1990).

Using contingent valuation, Whitehead (1990) estimates that willingness to pay for preservation of a wetland in Western Kentucky may approach $4000 per acre. He concludes that a significant component of that overall benefit is from nonuse values. Other valuation results include $27 per acre for inland recreational fishing in Massachusetts (US ACOE 1976), $490 per acre for waterfowl benefits and recreational fishing in Michigan (Jaworski and Raphael 1978), and $6800 per acre for ecological waste assimilation services in Virginia (Gosselink et al. 1974). The variability in these estimates has caused their usefulness to be questioned. Much work remains to be done interpreting these results and "indexing" these numbers so that they may be integrated with consumer's budgets and revealed consumption decisions.

Less rigorously, it is still possible to broadly characterize benefits. Pearse and Holmes (1993) identify wildlife and fishing as the most important component of benefit from Southern National Forests in Region 8 based on estimates of both consumer surplus and market clearing prices. They further note that in two mountainous Forests (the Nantahala and the Pisgah) timber outputs provided 9.4% of the benefits and generated 33.8% of the costs while recreation, wildlife and wilderness jointly comprise 80.9% of the benefits but only 25.3% of the costs.

The lack of independence between ecosystem benefits creates problems not only for valuation but also for appropriate allocations of costs. Hof and Field (1987) make the point that, within limits, the allocation of costs among multiple outputs from a forest system is arbitrary, and that it is extremely unlikely that any joint cost allocation scheme will lead to optimal output level decisions.

Summary and Conclusions

The application of economic tools to the challenge of ecosystem management is a process which is still in its early phases. The assumption of nonsubstitutability of goods which is implicit in a goal to sustain specific ecosystems imposes constraints on consumption and utility which are more restrictive than those which would occur in standard neoclassical analysis. Also, understanding the nature of ecosystem "goods" is complicated by the fact that the ecosystem is sometimes an input in the production of a desired good, while at other times the ecosystem itself is the good. Further, when the ecosystem is an input in some ecological production function which provides a desired product (e.g., streams as a means of producing trout), it is generally the case that the production function is not well understood and/or is believed to have a large stochastic component. When this is true, the production effects of changes in the input are highly uncertain (e.g., efforts to increase trout stocks by manipulating the quantity of large woody debris in a stream reach may or may not have the predicted effect).

A final complexity is introduced by the strong likelihood that much of the value of ecosystems resides in "existence values" such as option value for future use or bequest value to future generations. This suggests that the values are not only unpriced, but also not directly observable in the behavior of the current generation of consumers.

While these are formidable difficulties, they do not diminish the importance of a role for economics. Ecosystem management exists in large measure because classes of environmental assets are perceived as currently or potentially scarce. Economics provides an analytic structure for evaluating the efficient allocation of scarce resources. It is also critically important to find a quantifiable and explicit method of addressing the resource tradeoffs which will necessarily occur under ecosystem management. In these areas optimization techniques, contingent valuation, and other survey techniques may prove to be of considerable use. While a definitive measure of "value" for environmental resources may prove intractable, economic tools may still yield significant insights into service levels desired by the public and into tradeoff preferences between mutually exclusive goals.

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