A VALUE-BASED, MULTI-SCALAR APPROACH TO FOREST MANAGEMENT

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ABSTRACT

In this paper, a value-based, multi-scalar approach to forest management is proposed as a means through which to incorporate public concerns that are expressed for different time horizons into the management of public forest land. Under such an approach, public values—including both economic and environmental concerns—are assessed at the local level and provide the basis for managing public forests on multiple scales using the principles of hierarchy theory. This approach assesses intergenerational concerns which may be expressed on different, incommensurable scales and then develops appropriate hierarchical models of the ecological relationships which relate to those values. Using a multi-scalar approach, resource managers can select forest management practices at different scales in order to reflect these multiple public values. By managing the forest at different scales within limits derived from the values of citizens, tradeoffs between competing uses of the forest may be minimized.

INTRODUCTION: CHALLENGES FOR FOREST MANAGERS

Forest management practices have often been criticized for inadequate consideration of the public’s environmental concerns in the pursuit of economic resource use. With issues ranging from the preservation of endangered species such as the Red-Cockaded Woodpecker to the siltation and pollution of rivers and lakes, forest managers face several new and difficult challenges for managing public resources in the future. New tools and techniques will be needed in order to meet the multiple and apparently conflicting demands for the forest resource while facing these challenges. In particular, as the accumulated effects of localized management practices are manifested on increasingly larger scales, there is a need for a new approach to forest management which can account for both the multiple values and concerns of the public as well as the potentially large-scale impacts from forest management practices.

In "Thinking Like a Mountain," Aldo Leopold (1949) describes the short-sightedness of wolf eradication as a resource management practice. From the irruption of deer and devastation of the mountainside that followed the extirpation of this predator, he saw how the wolf was part of a complex interrelationship that unfolded on the mountain's time frame, not man's. Such large-scale
and longer-term impacts from resource management continue to be an issue for land managers. Increasing calls for "whole ecosystem management," such as in the Greater Yellowstone area, are clear expressions of the need to consider these large-scale dynamics in resource management in order to maintain the functioning of ecological systems which support many different features of the natural environment (Norton, 1991).

Coordination of forest management activities with other resource management efforts is becoming increasingly important. Forestry practices such as clearcutting can significantly impact aquatic systems. A system which can identify and account for these indirect effects and larger-scale considerations in local-level forest management will be needed to ensure the success of these other programs. Noss and Harris (1986) note that wildlife preservation strategies have typically been static and limited in scope. These strategies have generally focused on individual species, while the factors which affect those species and their habitat are part of larger-scale ecological dynamics. They suggest that the emphasis on endangered species and the assumption of an ecological "equilibrium" system is insufficient for the maintenance of species diversity over the long term. The problem with narrowly-focused static approaches is that they fail to recognize that individual plant or animal communities and even whole ecosystems are part of larger dynamic processes which represent the context within which they function (Leopold, 1949; Noss and Harris, 1986; Norton, 1992; see generally Costanza, Norton, and Haskell, 1992). These dynamic patterns, however, exist on many scales, each providing a slower changing context for the faster changing processes on smaller scales. In order to effectively manage for multiple and indirectly related public objectives, such as water quality and wildlife preservation, forest and other resource managers must recognize these larger-level processes and incorporate them into their planning and management efforts.

Another problem for forest managers is that many of the impacts on publicly valued resources may result from activities that take place on both public and private land. For example, erosion within a watershed and its impact on public water resources is not limited by property lines. In the South, where a significant portion of the forest land is privately held, consideration of private land management activities is particularly important. Public lands management must either be coordinated with the management of private land or public forest managers must be able to mitigate the effects of private activities on public resources. Ecological models which characterize these relationships and a management system which can incorporate these considerations are needed in order to both preserve and use public resources into the future.

Forest managers will also require a management and planning process which can address the effects on forests from exogenous factors such as acid rain, air pollutants, and global climate change. For example, managers require ecological models which can indicate how ground-level ozone affects the growth rates and composition of the forest. Alternatively, such large-scale concerns as global climate change may mean that forest managers will be called upon to proactively manage the forest as a carbon-sink in addition to managing for the demands of the timber industry and recreational use.

Perhaps most important from our perspective is the need to recognize that public values may themselves exist on different scales. The problem is that when compared in terms of the present, timber harvesting jobs and wildlife preservation seem to represent competing value positions (Norton, forthcoming). However, they may not necessarily imply one-or-the-other trade-offs. The point that is often overlooked is that both of these forest "uses" require the continued functioning of larger, "landscape level" ecological systems if they are to be sustained into the future. Neither economic productivity nor aesthetic and instrumentally valued natural features can be protected without protecting the complex, organized system that provides the ecological context on which all these values depend (Norton, 1991). A system which can manage public resources such as forests at these various scales is necessary in order to minimize trade-offs and maintain the ecological integrity of natural systems which support publicly valued uses and features of those resources.
THE CONCEPT: MULTI-SCALAR MANAGEMENT

In order to meet these challenges and help avoid politically-determined restrictions on economic resource use, we propose a scalar system of resource management. The idea is to develop a scientifically informed, public value-based constraint system on economic resource management. A two-stage model for such a management system has been suggested by Norton (1992), see Figure 1. Potential impacts from different management practices are located in this "risk-decision space" by the degree of reversibility of the impact (horizontal axis) and the scale of the impact (vertical axis). Activities whose impacts fall in the large lower-right area are sufficiently addressed by traditional economic approaches. The multi-scalar approach, however, supplements traditional economic methods of resource management by placing constraints on practices which have large-scale and potentially irreversible impacts. These would be management activities with impacts falling in the upper left-hand corner of Figure 1. This does not mean that restrictions are placed on activities with any large-scale or irreversible impact. In our approach, public values are used to define the type and scale of impacts which fall into the upper corner; public values define where the demarcation line falls.

Hierarchy Theory

Following arguments which suggest that evolutionary processes favor nested, hierarchical organization (Simon, 1962), Hierarchy Theory has been applied to the functioning and relationships of ecological systems (Allen and Starr, 1982; O'Neill, 1986). It represents one way of characterizing complex ecological phenomena which are interrelated but may occur at different scales. In a hierarchical structure, any given "system" operates as both a part of a larger system and at the same time as an independent "whole" in itself. As a "whole," a system exerts some constraint on its component "subsystems" which are themselves both wholes and parts. As a "part," that same system operates as an integrated component of a larger whole (Allen and Starr, 1982). Through this type of structure the stability of ecological systems is maintained.

This stability results from its constraint system. It is, however, a dynamic stability. The self-assertiveness of a constraining environmental system within its larger "environment" essentially protects the smaller-scale "subsystem" that it controls (Allen and Starr, 1982). Disturbances can be "incorporated" by a system when it exerts control over some factor that is not controlled at lower levels of organization (O'Neill et al, 1986). For example, the forest as a whole minimizes local temperature variations through evapotranspiration while individual trees cannot (O'Neill et al, 1986). Under certain conditions, however, this constraint system can be broken with effects that propagate up the hierarchy (Johnson, 1993). Leopold's (1939) examples of the effects of predator eradication and the problems of early German monoculture forestry illustrate these type of larger-scale effects which result from changes in local-level activities.

For forest management in the future, Hierarchy Theory provides a conceptual basis for incorporating economic resource management at the local level within the need to maintain regenerative systems at larger scales. In a scalar system of management local activities can be constrained by a hierarchy of longer-term, higher-level considerations. That is, in a hierarchical structure, management at the local level may vary considerably according to local desires as long as they do not interfere with objectives established for management at larger scales and over longer time frames.

In our approach, the goals for resource management at each scale are defined by ecological dynamics at those scales which are associated with the maintenance of publicly valued natural features and resource uses. Basically, management at any particular scale focuses on sustaining valued natural resources or features through time by ensuring, via scalar constraints, that management activities and exogenous impacts remain within the bounds of higher-level ecological
Fig. 1
Risk-Decision Space for Locating Management Impacts
dynamics operating in longer time frames. By recognizing ecological constraints, multi-scalar forest management can help to avoid the larger-scale impacts which result from exceeding a critical threshold at a lower level.

Hierarchy Theory also provides a useful conceptual framework for modeling ecological systems in order to address scale-related resource management issues (Johnson, 1993). This is important because the descriptive scientific models traditionally used to characterize various ecological systems may not be sufficient for resource management in the future. Since there is no single or "fundamental" hierarchical description of nature (Allen and Starr, 1982; O'Neill, 1986; Johnson, 1993), there is no single model which could be used to evaluate the many ecological impacts of different forest management strategies. Because a particular system may be described in several ways, it has been suggested that an appropriate hierarchical description should be based on the phenomena that we are interested in observing (O'Neill et al, 1986). Since certain characteristic properties "emerge" depending on the scale of observation (Allen and Starr, 1982) and since ecological systems can be described in several different ways depending on what we are interested in observing, the development of models for ecological resource management is necessarily a prescriptive science (Haskell, Norton, and Costanza, 1992). This is particularly important for issues of scale in resource management. The correct scale on which to address a management problem is determined by what society wants to accomplish with that system (Norton, 1992). That is, an ecological system can and should be modeled differently depending on what we are interested in managing for.

Thus, in our approach public values are used not only to define resource management at different scales, but they are also used to define the ecological models of the systems to be managed. This is important since appropriate management objectives cannot be completely determined without relevant scientific understanding of the relationships that affect publicly valued natural features and resource uses. As a framework for organizing ecological systems, Hierarchy Theory helps scientists, forest managers and the public identify relevant ecological dynamics and variables operating at each scale. Through an iterative and ongoing process of interaction with the public and forest managers, scientific study can be guided towards developing hierarchical models that inform public understanding of ecosystem functioning in a way that helps to define resource management to achieve public goals (Norton, 1992).

The Advantages of a Multi-scalar Approach

A multi-scalar approach to forest management has many advantages. This approach can incorporate multiple public values into a multi-scaled management strategy and it also provides a framework through which ecological models can be developed to identify appropriate constraints for resource management at various scales. Importantly, our approach is designed in such a way that forests can continue to be managed for economic use at one level within constraints imposed by ecological considerations at higher levels so that trade-offs between seemingly conflicting values can be minimized.

With its focus on management at different scales, this approach also provides a system through which to account for many of the factors which complicate contemporary forest management. Because it recognizes the importance of regenerative landscape-level processes in maintaining all publicly valued natural "goods," scalar management can help to avoid large-scale or irreversible impacts and minimize trade-offs. Through its emphasis on multi-scaled public values, this approach provides guidance to forest managers in response to the impacts of exogenous factors. For example, air pollution has been documented to have several different impacts on forests leading to decline (see in general MacKenzie and El-Ashry, 1989). Forest managers could adjust their management practices in order to mitigate impacts on timber production or mitigate further impacts on aquatic systems by minimizing their contribution. Either way, ecological models which characterize the relevant variables and dynamics can help forest managers determine how their activities influence publicly-valued resources and identify appropriate strategies.

A multi-scalar approach can also help to coordinate forest management with other efforts to maintain publicly valued environmental resources. Although maintaining the viability of fish populations has not generally been the responsibility of forest managers, the management practices
on public forest lands nonetheless affect river and lake systems through soil erosion and nutrient runoff (Salverda, 1968; Morris, Bush and Clark, 1992). Given a publicly expressed concern for the health of rivers and lakes, our approach requires the formulation of a hierarchical model of ecological relationships appropriate for considering these impacts in forest management. In a similar fashion, forest management could also serve as a means to proactively address global warming by increasing net primary productivity in order to enhance the role of the forest as a CO2 sink (Morris, Bush and Clark, 1992). Models which can characterize the impact on the atmosphere and the ecological relationships associated with carbon fixation would facilitate such activities.

APPLYING MULTI-SCALAR PUBLIC VALUES TO FOREST MANAGEMENT

Once we have accepted the role of public values in defining not only the management but also the ecological science upon which it relies, the problem of developing a value-based management strategy becomes one of translating these values into management objectives at different scales. In order to do this we must associate different values with ecological systems at appropriate scales as noted above. Before this can be done, however, several questions must be answered. These include whose values are to be used, how are they to be assessed, how can they be translated into management objectives, and how are the values of different communities to be integrated?

A “Bottom-Up” Valuation

Wilkinson and Anderson (1987) note that in the past, public forest management and planning was a decentralized activity where local managers used their knowledge of the specific characteristics of the local forests that they managed in order to both protect and use the resource. In the 1920s timber management plans determined the amount of timber that could be harvested from "working circles" which were areas large enough to support local forest-based industries. Such efforts also included explicit concern for protection of the local watershed and recreation was increasingly considered in the plans. However, as private timber lands were cleared in the post-war building boom of the 1950s, this relatively uncontroversial planning framework began to break down as increasing demands were placed on the national forests for all its resources. The result of the controversy over multiple-use forest management was several pieces of legislation which established national planning along with a range of legal standards for local forest planning and management. The need for federal action arose from both lumber industry demands as well as increasing demands for the preservation of existing wilderness areas.

The change that occurred was the imposition of national-level values on local-level forest management. Wilkinson and Anderson note that the unit planning framework that replaced multiple-use plans in the early 1970s were intended to ensure greater consistency between national and local land use priorities. In this new framework, "Area Guides” advised forest planners of an area's relative ability to achieve national objectives for various resources (Wilkinson and Anderson, 1987). In essence, local resources were no longer being managed to meet locally defined needs as expressed by local values.

In order to see how this may affect ecological systems it is important to look at how cultural institutions define the relationship between man and his environment. In his ecological history of New England, William Cronon (1983) illustrates how different social institutions led to different interactions between humans and the environment which shape the landscape in different ways. The role of values, including cultural beliefs, plays an important part in this. Most importantly, the
notion of resources as commodities and monetary wealth as an indicator of status weigh into Cronon's description. The latter concept in particular has a significant impact on resource use: European markets...at least in theory "erected a shrine to the Unattainable: Infinite Needs." Those needs were determined not only by the local communities which became established in colonial New England but by all distant places to which those communities sold their goods. The landscape of New England thus increasingly met not only the needs of its inhabitants for food and shelter but the demands of far away places' markets for cattle, corn, fur, timber and other goods whose "values" became expressions of the colonists' socially determined needs. (Cronon, 1983: p.166)

A similar phenomenon occurred in the Southern forests as the region sought to finance industrial development, and thus increase their wealth, through the exploitation of its forests (Williams, 1989).

While both the Native Americans and the colonists shaped the land to meet their own purposes, they did so in fundamentally different ways. The colonists, with their experiences of timber as a scarce resource in England, saw the forests as an abundant resource to be exploited. With no prior experiences within the landscape of the New World, they did not see the forest as an integral part of their lives. In contrast to the colonists however, the Native Americans had a much closer understanding of the land, through a longer historical association with it, such that they were able to maintain its functioning and coexist within it.

The point is that local forest land must be managed based on the values expressed by local citizens who are familiar with their surrounding landscape and its unique features. Centralized planning, as mandated by federal laws, runs the risk of failing to adequately reflect the relationship of local residents to their landscape even as it tries to balance between preservation and harvesting interests in the aggregate. This is again a problem of scale, but one of the scale of management. Thus, we believe that local values must form the basis for managing local forests and from which the larger scales of management must be derived.

**Assessing Scalar Public Values**

With local values as a starting point, the task assessing these values requires attention. Using Sagoff's (1988) hypothesis that citizens may make different choices depending on the context of a question, we can formulate a procedure for assessing public values in different time frames. Assuming three levels of values--individual, intergenerational, and evolutionary--three time horizons can be considered. These do not represent absolute time periods but ranges reflecting the different contexts for consideration of values.

In order to assess "individual" values for local forest management in the short-term, members of a local community can be asked to state their preferences in terms of the present. In this context, it is likely that they will assume the current rules of economics and express values based on present worth, discounting benefits which accrue in the future. In this case, citizens might express a preference for timber harvesting jobs or recreation-related jobs over increased protection of natural resources. The values expressed in this context should be consistent with those assessed using traditional economic methods.

Next, in the context of a "constitutional convention," community members could be asked what values should guide forest management over the long term, including what, if any, environmental "goods" should be maintained for future generations. That is, ignoring your current situation, how would you rewrite the rules for your children? In the context of suggesting resources or natural features that they wish their great great grandchildren will be able to utilize and/or experience, citizens may modify their usual discounting across time because they are not constrained by their current economic situation (Norton, forthcoming). In this context, citizens may express a desire to preserve a certain vista or ensure that future generations will be able to fish in a particular river, lake or stream. These are the values which may not be captured by traditional methods since they represent values which operate on a different scale than short-term economic concerns. They are values that are not necessarily exclusive of present-oriented concerns for employment.

On a third level, community members may be asked what values they associate with the
very long term. Values at this scale could be a desire to ensure the survival of the human species or alternatively a more inclusive value that reflects concern for the evolutionary potential of other species and natural systems. Minimizing the impact or reducing the possibility of global climate change might be a value expressed in this context. These values as well as those above can be transformed into management goals at various scales which provide constraints on local-level management activities through a multi-scalar management system.

However, the process of assessing these values may not be as simple as gathering citizens together and asking them questions about their economic and environmental values. The problem is that non-economic values associated with particular places and environmental features may not be explicitly recognized by individuals. Edward Relph suggests that the landscapes within which we live are "inconspicuous backgrounds" to our everyday experiences: "for much of the time, landscapes stay as unobtrusive backgrounds to other more important concerns, but occasionally they are brought forward into our awareness...in certain affective states...we may be predisposed to notice the world around us" (1985: p.24). On the local level, the value assessment process can serve to draw out this background and its scalar dimensions. Furthermore, the local view of the surrounding landscape may not be captured by descriptions in "scientific" language (Mugerauer, 1985).

Mugerauer (1985) suggests that "environmental hermeneutics" can be employed to discover the subtle relationship between a community and its local environment. This involves an understanding of the local language and the meaning of the environment within that language, including its historical dimensions. This does not mean that anthropologists or linguists must be dispatched in order to assess the value of the environment and its specific features for a local community. It merely implies that a more interactive approach should be employed in order to draw out these values. An ongoing discussion between local residents, forest managers and scientists which educates the citizens about ecological relationships can draw out these values and the ecological importance of the landscape in the "background" of the features they value.

An interactive approach to assessing local values has an additional advantage. In a highly mobile society such as ours, there is little time to develop experiences with a particular place as we move from one location to another without the time it takes to recognize and experience the features of one's surrounding landscape. An interactive valuation process can educate residents about their local place and bring about a recognition of the landscape and values associated with maintaining larger-level processes. This allows them to make more educated decisions about the values and goals they choose for the management of public forest lands.

Through this interactive value assessment process local values provide two pieces of information for multi-scalar management: (1) values to emphasize in the management of the local area and (2) values that need to be maintained by larger-level systems. These values can then be used to determine both economic and environmental resource management goals that are supported by the local residents.

Translating Values into Scalar Management Objectives

An interactive approach is not only necessary from a value assessment perspective but it also provides the means through which to determine appropriate hierarchical models and management goals for forest managers. As was noted earlier, because specific management goals cannot be understood prior to scientific understanding, developing goals and hierarchical models which characterize the dynamics that affect valued natural features should be an experimental and interactive process. Biologists and ecologists must be part of this process in order to help the public and forest managers to define the appropriate spatiotemporal scale on which to define the system to be managed (Norton, 1992). Through an interactive and experimental process, the boundaries of the system and the ecological dynamics relevant to those objectives can be identified and appropriate goals for management can then be defined (Norton and Ulanowicz, 1992).

On the local level, individual values can be used to define the boundaries of the system to be managed and linked to appropriate dynamics at that scale. For example, in order to maximize job opportunities for a timber community, silvicultural techniques for economically sustainable timber management have been well developed. The forest can be maintained in several different
ways including the use of even-aged stands with clearcutting or old growth uneven-aged stands with selective cuts, as well as other types of practices. At this level, the boundaries of the system to be managed are usually defined at the stand level which is about 100 hectares or less (Morris, Bush and Clark, 1992). At this scale, site factors play an important role and represent the relatively stable context within which the trees of a stand grow. These include soil conditions (especially nutrient flows), topography, aspect on a slope, and climate (Spurr and Barnes, 1980).

Conversely, the value of maximizing recreational attractions could translate into the management goal of establishing and maintaining a "wilderness" area. Since wilderness areas are not confined to a single forest stand but represent a collection of various forest habitats, the scale of management for these systems must necessarily be larger. The boundaries of the area to be managed might be set at the range of the largest ranging species (Noss and Harris, 1986). In this case, diversity within the management unit is an important feature to manage for. This might involve minimum technical interference in natural forest development so that plant and animal associations develop and natural forest succession proceeds uninterrupted by man (Morris, Bush, and Clark, 1992). Management may also involve some protection from impacts such as recreational use and, in more interventionist practices, fire suppression.

In our approach, intergenerational values represent social constraints on shorter-term preferences. These values are associated with longer time horizons and will generally correspond to management objectives at larger spatiotemporal scales. These higher-level objectives then provide the basis for constraints on management practices at lower levels. This is because in order to maintain a natural "good" expressed by these values over this longer time frame, the ecological processes of the relevant system at this scale must be maintained. This means that once an intergenerational value is translated into a relevant hierarchical system and management goal, the lower level components which contribute to that system should be constrained by appropriate limits.

Thus, a larger-scale management program can be established, as defined by intergenerational value choices, in order to monitor and coordinate the activities of lower level forest management. For example, the major outputs from catchment basins include water and its associated load of dissolved nutrients and particulate matter (Nelson, 1970). The transport of soluble nutrients is of the most concern for the health of aquatic systems because of the impact of increased concentrations of phosphorous and nitrogen in terms of stream and lake eutrophication (Morris, Bush and Clark, 1992). However, sedimentation from soil erosion and rates of water yield can also have a significant impact (Morris, Bush and Clark, 1992). These factors represent the principal issues of concern in terms of managing the forested watershed to minimize aquatic impacts.

When combined with assessments of the current health of the aquatic systems of concern, these variables can be converted into appropriate management goals which would then have to be incorporated into local management plans. This does not mean that uniform restrictions on, say fertilizer use or clearcutting, would be placed on all lands within the watershed. Instead a watershed-level hydrologic model can be used to identify where higher levels of fertilizer are unlikely to impact the aquatic system and where they are more likely. This means that economic forest management, in accordance with the local values in specific areas, could continue as long as the practices did not violate the watershed-scale requirements for maintenance of the aquatic systems.

Importantly, studying natural dynamics and experimenting with conservation practices provides both scientific progress and increasing public knowledge of the role of ecosystem dynamics in maintaining publicly valued resources and natural features. Through such an approach, hierarchical models and management objectives can be sorted out according to their usefulness in clarifying, explaining, and achieving public goals (Norton, 1992).

**Integrating Values at Higher Levels**

Before a multi-scalar management strategy can be fully defined, the longer-term intergenerational values of local citizens must be integrated with the values of citizens in other local areas. On the local level, the basic principles of economics may be used for determining
management activities because they are compatible with the values at this scale. However, local practices defined by these values operate with higher-level constraints in our approach. Since intergenerational values are associated with the longer term, the corresponding ecological systems and dynamic processes which maintain a resource or natural feature in that time horizon generally occur on larger scales which may require the management of practices outside of the boundaries of the local community.

In such a case, citizens from all communities with intergenerational values that require landscape-level management must be brought together so that they can achieve a consensus on what the management goals for higher levels should be. In this manner, the higher-level constraints which are imposed upon local management activities through landscape-level management will not be forced from the "top-down" but will be based on local values with knowledge of the particulars of local ecosystems. Using the process described above, it might be determined that maintaining viable fish populations in rivers and lakes is important to the residents of several communities. For example, by agreement residents within an area might conclude that they wish to maintain one particular fork of a river or, on the other hand, they might wish to maintain all the rivers in their area. If they chose to maintain all the rivers in the area, then the watershed that they must focus management on would be much larger than that for just one fork. In each case, landscape-level management would apply certain constraints on forest management practices within the corresponding watershed. A similar integration could theoretically be performed for global-level concerns, although the difficulties of doing so are quite large.

CONCLUSION

In conclusion, what we have proposed is an alternative to traditional approaches to forest management. It is intended to provide constraints on economic forest management when those practices may interfere with the maintenance of resources and natural features that are valued by the public for the longer-term. It is a multi-scalar management system based on locally assessed values which attempts to inform those value choices through an interactive and ongoing process involving forest managers and ecological scientists as well as the public. Through this system of ecologically informed scalar management, we believe that our approach provides a framework for addressing multiple public values which can meet many of the challenges facing forest managers today. Perhaps most importantly, our approach seeks to facilitate a system of forest management which can maximize public preferences by developing ecological models which characterize the variables and dynamics relevant to publicly valued resources and natural features at various scales.

LITERATURE CITED


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