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Improving the Integration of Recreation Management with Management of Other Natural Resources by Applying Concepts of Scale from Ecology

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Abstract In this article, we examine how issues of scale affect the integration of recreation management with the management of other natural resources on public lands. We present two theories used to address scale issues in ecology and explore how they can improve the two most widely applied recreation-planning frameworks. The theory of patch dynamics and hierarchy theory are applied to the recreation opportunity spectrum (ROS) and the limits of acceptable change (LAC) recreation-planning frameworks. These frameworks have been widely adopted internationally, and improving their ability to integrate with other aspects of natural resource management has significant social and conservation implications. We propose that incorporating ecologic criteria and scale concepts into these recreation-planning frameworks will improve the foundation for integrated land management by resolving issues of incongruent boundaries, mismatched scales, and multiple-scale analysis. Specifically, we argue that whereas the spatially explicit process of the ROS facilitates integrated decision making, its lack of ecologic criteria, broad extent, and large patch size decrease its usefulness for integration at finer scales. The LAC provides explicit considerations for weighing competing values, but measurement of recreation disturbances within an LAC analysis is often done at too fine a grain and at too narrow an extent for integration with other recreation and resource concerns. We suggest that planners should perform analysis at multiple scales when making management decisions that involve trade-offs among competing values. The United States Forest Service is used as an example to discuss how resource-management agencies can improve this integration.

Keywords Hierarchical patch dynamics · Integration · Limits of acceptable change · Multiple-use management · Recreation opportunity spectrum

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Introduction

Integration of the management of recreation with the management of biophysical resources has proven problematic (McCool and others 2007). A failure to accurately understand the trade-offs of management decisions can have significant social and conservation implications. In this article, we address the issue of scale as it affects the applied integration of public-lands recreation management with the management of other natural resources. We argue that the recreational and biophysical information available for management decision making is dependent on the scale of analysis selected and that multiscale analysis is critical to understanding trade-offs in integrated management.

Two issues fundamental to natural-resource management are the choice of analytic scale and the approach used to integrate different resource uses and values. These issues increase in complexity with the integration of multiple social values and uses that may compete with each other and with conservation of natural resources. We describe two theories (the theory of patch dynamics and hierarchy theory) used to address scale issues in ecology and explore how, through spatial analysis, they can enhance the two most widely applied recreation-planning frameworks: the recreation opportunity spectrum (ROS) and the limits of acceptable change (LAC) frameworks. These recreation-planning frameworks are used in the United States by the United States Forest Service (USFS) and the Bureau of Land Management, have been widely used in other countries (Kaltenborn and Emmelin 1993; Roman and others 2007), and have been established as being central to tourism management under the 2005 International Convention on Biologic Diversity (McCool and others 2007). Therefore, improving the ability of these widely adopted frameworks to integrate with other aspects of natural-resource management has broad implications.

We believe there are three challenging issues in integrated-resource management that can be addressed by using ecologic theory to modify the applied recreation-planning frameworks: incongruent landscape boundaries (resource issue no. 1); mismatched analytic scales for different resources and uses (resource issue no. 2); and the necessity of multiscale analysis (resource issue no. 3).

We propose that incorporating ecologic scale theories into these recreation-planning frameworks will improve the foundation for integrated land management. Using the USFS as an example, we discuss how resource managers can more carefully and productively integrate recreation values with other resources in their planning efforts. However, we believe that the concepts should apply broadly to any natural resource base that is managed for multiple, competing public values.

Through the development and use of hierarchy theory and the theory of patch dynamics, conservation biology and landscape ecology have provided the science that compel us to move beyond site-by-site and species-by-species management of natural resources to spatially explicit and multiscale management of ecosystems (Noss 1990; Allen and Hoekstra 1992; Turner and others 2001; Meffe and others 2002). Although the ecologic sciences have recognized that the causes and consequences of environmental problems must be analyzed across multiple scales, social science analyses of natural resource concerns have not pursued this avenue of research as extensively or explicitly (Gibson and others 2000). However, because people interact with and value natural areas at multiple scales, e.g., an individual campsite versus an entire wilderness area, it is critical to consider these interactions across scales. Without multiscale and spatially explicit analysis of recreation to accompany that of other natural resources, important trade-offs among different social and ecologic uses and values could be neglected.

The article begins with a brief overview of the mandate for multiple-use management in the USFS. This section is followed by terminology related to scale to provide clarity and consistency. Subsequently, hierarchy theory and the theory of patch dynamics are presented to better describe how these frameworks are used in research and planning for the management of ecologic systems. The following section presents the two primary planning frameworks used in recreation by the USFS (the ROS and the LAC). A discussion of how each of these frameworks can be integrated with ecologic theories of scale follows each planning framework. The final section of the article discusses how application of the scaling frameworks to recreation can be used in spatial planning to further integrate analysis of recreation with other resources on public lands.

USFS Multiple-Use Mandate

National Forest lands in the United States are managed for multiple uses, such as commodity production, recreation, and the conservation of biodiversity and ecosystem services (Charnley 2006). Legal mandates—including the Multiple Use Sustained Yield Act (1960), the National Forest Management Act (1976), and the Endangered Species Act (1973)—require that managers address and decide among sometimes competing or conflicting uses. Increasingly, these decisions are receiving detailed public scrutiny in a contentious environment from those who demand justification and accountability for land-use planning (McCool and others 2007). As Clark and Stankey (2006, p. 1) noted, managers are expected to resolve "complex problems where understanding the interaction between biophysical and social systems is necessary to balance the complex needs of society with increasingly threatened and scarce natural resources."

Driven in part by this growing attention to multiple uses and values, ecosystem management was adopted by the USFS in 1992 (Grumbine 1994). The integration of ecologic, socioeconomic, and institutional elements underlies the ecosystem-management paradigm. Attention to spatial and temporal scales regarding these elements has been identified as one of the key components in the process of ecosystem management (Meffe and others 2002). Increasingly, management is also becoming more spatially explicit (Bettinger and Sessions 2003; Baskent and Keles 2005). Spatial depiction facilitates multiscale analysis and understanding of the physical arrangement of parcels of land valued for similar or different ends.

However, in practice, management still tends to be performed within each resource area independently. Subject matter experts are largely responsible for their own resource areas, and forest plans are organized with separate sections devoted to each resource (e.g., fish, vegetation, or recreation). Strides have been made to explore integration among different values at different scales, e.g., the advent of watershed analyses and adaptive-management areas mandated by the Northwest Forest Plan (Charnley 2006). As another example, the Monogahela National Forest Plan (2006) designed coarse and fine filter approaches and developed management prescription units designed around common management themes across disciplines (USFS 2006). Nevertheless, no common methodology has been adopted for integrated multiscale analysis, and it remains common to choose a single primary spatial extent (e.g., the National Forest) for analysis. Integration of recreation uses and values with biophysical resources in decision making has proven particularly elusive (McCool and others 2007).

The provision of recreation opportunities is one of the primary functions of the USFS, and recreation is the medium through which many in society experience public lands (Driver and others 1987). However, recreation uses are often viewed as conflicting with other priority values, such as timber harvesting, resource conservation, or even habitat for endangered species. Therefore, management of the recreation setting must be integrated with management of the biophysical systems. Managers need tools and processes that enable them to justify when one value (e.g., timber) should take precedence over another (e.g., recreation) or vice versa. Furthermore, these tools must account for multiple scales because analyses done only at one level may not identify important processes at other levels (O'Neill and King 1998) or may lead to management decisions that result in undesirable effects at another level.

Even with the advent of ecosystem management, multiscale analysis of the interactions of recreation with other resources remains an unanswered call in research circles (Cole and Landres 1996; Meffe and others 2002). To identify potential conflicts and trade-offs between recreation and other resource uses and ensure equal consideration of recreation, a framework that considers management (and research) of recreation across multiple scales is necessary (Stankey 1998). Although exploration of management of larger spatial extents (landscape or region) and of multiscale issues in recreation has begun, the topic is still conceptually underdeveloped (McCool and Cole 2001; Garber-Yonts 2005). Concepts and tools from the ecologic sciences may offer insights and approaches of value toward improving this end.

Terminology of Scales

The choice of scale will critically impact the patterns that will be observed, and therefore it is a fundamental determinant of our explanations of the world (Allen and Hoekstra 1992; O'Neill and King 1998). Scale choices provide us with models that permit the study of systems spatially and temporally (Peterson 2000). The process of selecting scales may unify different disciplinary perspectives, but it is important to ensure that terminology is consistent across disciplines (Gibson and others 2000).

The first important point to make is that scale is a social construction and not an inherent quality of natural systems; it is something determined by the observer by assigning values or attributes to a scale (Allen and Hoekstra 1992). In an article outlining scale issues in the ecologic and social sciences, Gibson and others (2000, p. 219) provided a concise definition of scale as referring to "the spatial, temporal, quantitative, or analytic dimensions used by scientists to measure and study objects and processes." Scale, then, involves measurement of the physical and temporal dimensions of observations (O'Neill and King 1998). Observational scales can be further broken down into "grain" and "extent" (Turner and others 2001). "Grain refers to the smallest temporal or spatial intervals in an observation set. Extent is the total area or the length of time over which observations of a particular grain are made" (O'Neill and King 1998, p. 7). Examples of appropriate metrics for scales that measure grain and/or extent include meters, kilometers, days, and years. In USFS recreation planning, the largest extent for analysis is typically defined by the total acres within a forest's boundaries because the agency's policy mandates preparation of a comprehensive management plan for each National Forest. The grain of analysis for recreation management at the forest level is currently defined by each ROS category. At the other end of the spectrum, the grain of analysis for trampling impact on a recreation site could be the square meter as assessed within a 50-m^2 campsite (the extent). Clarification and consistent use of these concepts and terms across disciplines and explicit discussion of the ways that scale is used to conduct analyses by ecologists and recreation managers should help facilitate the integration of recreation with other resources during planning efforts.

Scale Theories in Ecology

Scale issues have been extensively discussed in the ecologic literature (Allen and Hoekstra 1992; Lovett and others 2005; Noss 1990; Peterson and Parker 1998; Peterson 2000), and a full review is beyond the scope of this article. However, understanding some of the major constructs and how they are used in the study of ecosystems and in natural-resource management will help identify potential integrating frameworks for management of recreation with other resources across scales. We begin by briefly describing two key theories addressing scale issues that managers and researchers use in forest planning and the study of natural systems: hierarchy theory and the theory of patch dynamics.

Hierarchy Theory

A number of issues have confounded scaling efforts in ecology, including "nonlinearity and environmental heterogeneity, dominance of different processes at different scales, cross scale connections, and emergent properties" (Peterson 2000, p. 292). Because of these factors, the decision to move across scales of analysis does not just lead to changes in size but also to changes in dominant processes or even the phenomena that are identified (O'Neill and King 1998). Ecologic systems are organized hierarchically and, in recent tradition, scale issues in ecology have been analyzed using hierarchy theory (Peterson 2000). Hierarchy theory is a scale-independent framework used to simplify the study of scale effects in complex ecologic systems (Allen and Hoekstra 1992). A central premise of the theory is that for any focus level, it is critical to look both the scale above and the scale below (Allen and Hoekstra 1992). This process of "enveloping" helps focus on the chosen level of observation while forcing the consideration of both the context (scale above) and mechanism (scale below) (O'Neill and King 1998).

Theory of Patch Dynamics

The second key ecologic theory currently used by forest managers and researchers is the theory of patch dynamics. This theory conceptualizes ecologic systems as dynamic patch mosaics and studies the structure, function, and changes within these systems (Pickett and White 1985; Pickett and others 1999). A patch is an area with discrete and homogeneous patterns *relative* to the rest of the system and independent of scale (Pickett and White 1985). Patches are formed by natural heterogeneity and disturbances, which can be either environmental or caused by human intervention. A naturally occurring meadow and a clearcut can both be considered patches within a forest matrix. A disturbance is any discrete event causing change and can be described in terms of size, shape, frequency, spatial distribution, and intensity (Turner and others 2001). Both a lightning-caused fire and human trampling within a campsite can be considered disturbances. Patches are spatially situated within the context of other patches, forming a patch mosaic. A dynamic patch mosaic "refers to the changes in a spatial mosaic of patches over time, regardless of the scale of the mosaic, or the origins of the changes" (Pickett and others 1999, p. 716).

The theory of patch dynamics has incorporated hierarchy theory by virtue of conceptualizing nested hierarchies of patch mosaics, thus extending its ability to address multiscale issues and spatial heterogeneity (Wu and Loucks 1995). At each level of observation, a patch is composed of its own smaller mosaic of patches. Thus, we can imagine a region, which contains patches of both forest and pasture, where the forest patch may be composed of a number of different patches of forest stands defined by age structure, which are each composed of even smaller patches based on fallen tree gaps within each stand. At each level, then, a patch is also a mosaic.

The theory of patch dynamics and hierarchy theory are used by forest managers, landscape ecologists, and conservation biologists in various spatial-modeling approaches to address the configuration of resources and resource uses across landscapes (Turner and others 2001; Baskent and Keles 2005). A key element of both of these theories (and their combination) is that they are scale independent. In other words, they are theories that can be applied across any scalar situation. A patch can be a clump of grass of beetle habitat, an area cleared of vegetation in a camping site, a forest stand marked for harvesting purposes, an ecosystem type analyzed with respect to ecosystem function because of climate change, or an ecoregion targeted as a hotspot for biodiversity conservation. Therefore, in ecologic scaling theory, the appropriate analytic scale is determined by the research question. The choice of scale determines the grain and extent of analysis. Once grain and extent are operationalized, the issue is spatially explicit. This is true when using either hierarchy theory or patch dynamics. The ability to frame ecologic issues at multiple scales in spatially explicit ways also provides a method for framing recreation that is useful for integrated management.

Recreation-Planning Frameworks

Currently, USFS managers use two planning frameworks for recreation: the ROS and the LAC framework (McCool and others 2007). For a number of years there have been calls to link these planning frameworks with other natural resource-planning frameworks (Mitchell and others 1993; Stankey 1998; Baskent and Keles 2005). These frameworks have the potential to integrate recreation with the management of other resources through the common element of spatial analysis (McCool and others 2007). The USFS is committed to continued use of the ROS (and its existing spectrum of categories) for forest planning nationwide (More and others 2003), whereas the LAC has been adopted by many USFS managers and continues to be the dominant framework for analyzing and managing recreation-caused changes in natural resource conditions

(Moore and Driver 2005). Therefore, it is critical to understand these frameworks and the characteristics that help or hinder the integration of recreation with other resources across multiple scales.

The ROS

The ROS was developed from converging ideas regarding the nature of the recreation experience (Driver and Brown 1978; Clark and Stankey 1979). It was originally designed as a planning guide for recreation to meet policy guidelines for integrated planning across all resources and values (Driver and Brown 1978). Earlier planning schemes were deemed insufficient because they focused simply on the provision of settings targeted at recreation activities (Driver and others 1987). Social science researchers recognized that activities themselves were only one aspect of the recreation experience. Research showed that within an activity, recreationists may seek divergent experiences; different recreationists prefer different activities within the same settings; and people have diverse preferences for managerial, social, and biophysical recreation settings (Heywood and others 1991). With this new understanding, "the objects of planning were posited as opportunities for activities in particular settings to realize desired experiences" (Driver and others 1987, p. 203). The ROS planning approach aims to provide a range of recreational opportunities across a planning unit, typically a National Forest (Driver and others 1987).

The ROS was designed to be a systematic, practical, and spatially explicit approach for recreation management (Stankey 1998). The intent was to develop an inventory of relatively unique settings at a relatively broad extent (McCool and others 2007). Recreational opportunity settings are operationalized based on five inventory mapping criteria defining their biophysical, social, and managerial conditions (Stankey 1998). Although primarily anthropocentric, the criteria can be spatially identified in a simple global information system (GIS) analysis. Specifically, the mapping criteria are (1) remoteness (i.e., distance from roads, trains, or facilities), (2) size of area, (3) evidence of humans (i.e., degree of modification), (4) social setting (i.e., solitude/crowding), and (5) managerial setting (i.e., managerial controls/interactions) (More and others 2003). Only five criteria were used to maintain simplicity and to ensure that the system was easy to implement and not too costly or time consuming for agencies with limited resources (Moore and Driver 2005). The USFS has operationalized the ROS framework by developing a set of six classes based on combinations of the mapping criteria: primitive, semiprimitive nonmotorized, semiprimitive motorized, roaded natural, rural, and urban (Driver and others 1987). These standardized rules permit comparison of opportunities across national forests or changes in opportunities during time.

Although the ROS has primarily been used to identify the existing supply inventory of recreation opportunities, it can be used as a tool to measure demand preferences for planning, as a marketing tool, and as a framework for impact assessment (Moore and Driver 2005). To be more effectively used as a planning tool for future recreation allocation decisions, it is important to understand public demand for different opportunity types within the ROS. This would help in identifying the extent and location of the lands that should be allocated to different ROS categories (the manager's decision) as well as help to understand how the management of other resources may impact these desired future conditions. A number of studies have been done evaluating different indicators of the social, managerial, and biophysical setting preferences of the ROS (Heywood and others 1991; Shafer and Inglis 2000; Lawson and Manning 2002; Pierskalla and others 2004). However, these have not been systematically incorporated into planning for future demand for specific recreation-opportunity settings. This type of demand data for future preferences for specific ROS categories, and specific biophysical settings, may need to be further developed before it will be commonly included in the planning process. The ROS can also be used as a marketing tool to inform recreationists about different recreation opportunities that currently exist (Moore and Driver 2005). Furthermore, the ROS has the potential to be used as a tool for impact assessment, or more broadly for measuring potential resource management trade-offs, by identifying the impact on recreation from proposed natural-resource management decisions and vice versa. However, the usefulness of the ROS to identify trade-offs has been identified as one of the most underutilized potentials of the ROS system (McCool and others 2007). We believe that all of these uses of the ROS can be enhanced by integrating lessons from ecologic scale theory into the ROS framework.

Incorporating Ecologic Scaling Theory Into the ROS

The ROS defines specific inventory-mapping criteria for identifying categories, which makes it possible to spatially identify the opportunity settings across a National Forest or any other landscape. To recast the ROS supply inventory in the language of the theory of patch dynamics, the mapped the ROS categories become "patches" within a "patch mosaic" of the ROS categories across an entire forest. The patch represents the grain of the analysis and the patch mosaic is defined as the overall extent. However, through the use of hierarchy theory we can additionally conceptualize a hierarchy of nested patch mosaics of recreation opportunity settings.

We have identified two adjustments that could improve the ROS framework to allow for the use of nested patch mosaics, improve integrated resource management, and address the three integrated resource-management issues. These adjustments also address the ROS Users Guide (1982) recommendations that recreation classes should be of a scale suitable for both recreation and natural resource-management planning. The first adjustment is to include vegetative associations as part of the ROS mapping criteria, and the second is to use those vegetative associations to identify nested patch mosaics within each ROS category. Under this revised framework, the nested patch mosaics include (1) a National Forest patch, which is a mosaic of recreation-opportunity category patches (current ROS system; Fig. 1 [Panel A]) and (2) each ROS category patch, which is also a mosaic of vegetative patches (new criteria; Fig. 1 [Panel B]). In addition to the ability to identify a specific vegetative association within an ROS category (e.g., SPM-riparian; Fig. 1 [Panel C]), this adjustment permits analysis of vegetative associations that may contain a variety of recreation opportunity classes (e.g., campsites in riparian areas across primitive (PRIM), semiprimitive/nonmotorized (SPNM), and semiprimitive motorized (SPM); Fig. 1 [Panel B]).

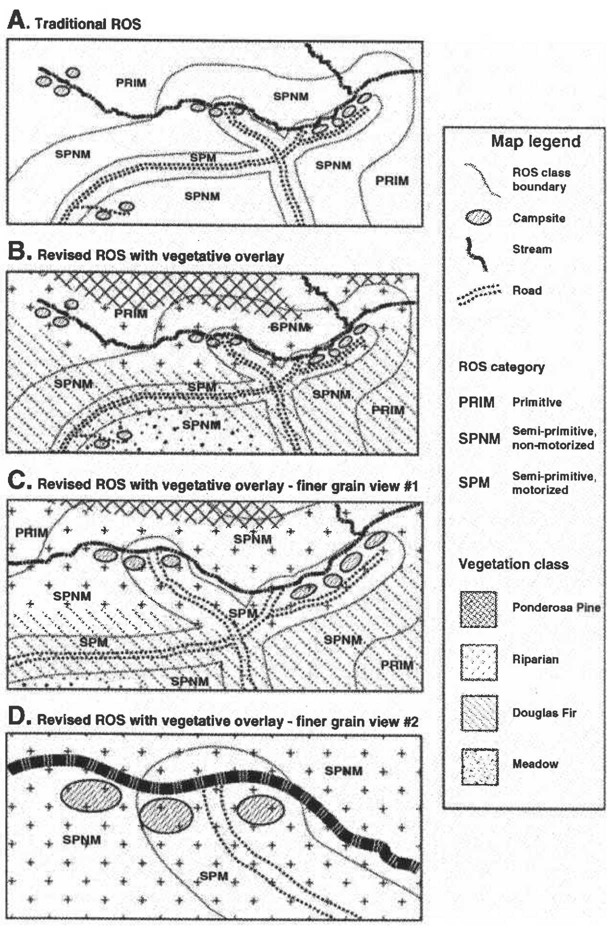

Fig. 1 A revised ROS mapping scheme

The first effect of the revised ROS framework is that the integrated resource management issue of congruent boundaries can be addressed (resource issue no. 1). A significant drawback to the ROS as currently implemented is the narrow way in which it defines the biophysical setting. The mapping criteria are based on many of the variables important to recreational visitors (remoteness, size, and degree of modification) but not ecologic criteria. Indeed, because the ROS is based on criteria largely related to human development and social interaction, there is not a high likelihood that the boundaries of an ROS patch will match those of ecologic vegetative patch.

For example, a 5,000-ha wilderness would be considered one "primitive" recreation patch, but there are likely to be ecologically distinct vegetative patches within it. A smaller "roaded-natural" recreation patch may be of one vegetation type, but that vegetation patch might continue across several ROS patch boundaries. Identification of management trade-offs between recreation and management for these other resource values are difficult with the boundaries of current ROS categories. For example, if there are vegetative associations being considered for harvest, in need of management for forest health, or of critical importance as habitat for an endangered species, inclusion of vegetative boundaries in recreation planning is critical for integration. Overlaying recreation patch boundaries with a mosaic based on vegetative patches provides a mechanism for reconciling otherwise incongruent boundaries. This would allow for an analysis of trade-offs at scales lower than the current recreation opportunity patch ("primitive" example) and across recreation patch boundaries by identifying the different types of recreation opportunities associated with specific vegetation types ("roaded natural" example). These types of aggregation and clipping overlay exercises in GIS are basic *if* the vegetative data are included as part of the analysis.

Having congruent boundaries also improves the usefulness of the ROS framework for addressing marketing and demand issues. Although not perfectly matched to recreation landscape preferences, vegetative associations may do an equal or better job of capturing patterns of recreation use than do ROS patches. It has been shown that water and vegetative associations are part of the biophysical setting that recreationists consider important (Brunson and Shelby 1990; Heywood and others 1991; Pierskalla and others 2004). Vegetative associations are indicators of many of the other features that are commonly used in recreation-site planning, such as water, geology, topography, and animal habitat (Moore and Driver 2005). Recreational visitors also move directionally through pathways and across the ROS categories (Pierskalla and others 2007). Because of these factors, recreation is often concentrated within various vegetative associations and is not evenly distributed across an ROS patch. Therefore, a description of the recreation opportunities that a forest provides (inventory) that includes vegetative associations will improve marketing these opportunities. Demand studies that include preferences for vegetative associations along with the other traditional ROS criteria will help forest managers to weigh decisions on the future allocation of recreation opportunities at much finer scales and with additional detail that is important to recreationists. With the explicit inclusion of a level of recreation mosaics to be described primarily by vegetative cover, a direct link to the management of natural resources becomes an integral part of recreation management.

In a different but related problem, a revised ROS framework would address the integrated resource issue of mismatched scales (resource issue no. 2). For example, forest health treatments might be restricted to certain vegetation types and impact recreation only within limited portions of a given ROS recreation patch. An ROS category would be too broad an extent in this case. In addition, a planned harvest or prescribed burn of a particular forest type (vegetative patch) may cross multiple recreation patches, thus making the ROS too fine a grain in that case. If the extent of these natural resource actions is different from a recreation decision extent, the trade-offs with or impacts on recreation may not be considered in the most optimal way. The addition of vegetative associations to the revised framework provides two new opportunities for minimizing scale mismatches: (1) It provides a finer grain of analysis with the new vegetative mosaic within the ROS patch level, and (2) it enables analysis of multiple recreation opportunities across a single vegetative patch. Therefore, in addition to providing matching boundaries for recreation and vegetative associations, the revised ROS provides for additional levels of analysis at scales likely to be relevant to many natural resource decisions and consequently more useful for trade-off analysis.

The revised framework also facilitates multiscale integrated management. At different scales of analysis, different processes and phenomena may be identified that are critical to the measurement of trade-offs (resource issue no. 3). Conceptualizing the landscape as levels of nested patch mosaics and applying the concept of enveloping from hierarchy theory allows for the identification and analysis of recreation opportunities and trade-offs at multiple scales. For example, one could inspect the likely repercussions of disallowing camping along a given road spur within one opportunity patch (e.g., SPM-riparian; Fig. 1 [Panel D]). Examination of the context (level above Fig. 1 [Panel C]) could indicate whether displaced users could be easily absorbed by other opportunities in similar settings or, conversely, whether the decision would eliminate a specific opportunity altogether from a forest. At each of these levels, trade-off analysis could be conducted with regard to the management of other resources. The implications of a forest harvest, or the need to protect spawning grounds within a particular streambed, could be analyzed as to its impact on recreation at various levels. The revised framework enables trade-off analysis to be conducted within multiple levels of recreation and/or levels of vegetative association. Analysis of this sort would allow insights into how decisions made at one scale may influence recreation and other resource values at a variety of scales.

As we have shown, by adding a single overlay of vegetative associations to the ROS framework and applying scale theories from ecology, planners can identify trade-offs among recreation opportunities with the management of other resources at various scales. However, as currently employed, the ROS does not specifically address how the recreation activities themselves may change or impact other resources. The next section explores the recreation-planning framework best designed to address that issue.

The LAC Framework

The LAC framework was developed to address the issue of recreation-carrying capacity and to manage recreation impacts (Stankey and McCool 1984; Cole and Stankey 1998). It is a tool used to help define the types and levels of recreation impacts that would be accepted before restrictive management actions would be taken (Stankey 1998). Typical changes to the environment that are reported with the LAC framework include vegetation disturbance and loss, soil compaction and erosion, damage to shrubs and trees, water pollution, harvesting of animals and plants, and disturbance to wildlife (Cole and Landres 1996; Marion and Farrell 2002).

The LAC is based on the premise that natural systems are dynamic and change over time and that recreation will cause change within these systems. The framework also recognizes that management actions can modify or control recreation impacts and that the determination of what is an "unacceptable" amount of resource change is a value judgment (Stankey 1998). The major steps involved in the LAC process are as follows (Stankey and McCool 1984, p. 467):

Identify area issues and concerns.
Define and describe opportunity classes.
Select indicators of resource and social conditions.
Inventory existing resource and social conditions.
Specify standards for resource and social indicators for each opportunity class.

Identify alternative opportunity class allocations reflecting issues and concerns and existing resource and social conditions.
Identify management actions for each alternative.
Evaluate and select a preferred alternative.
Implement actions and monitor conditions.

Standards for the LAC on what is deemed acceptable change and potential management prescriptions will depend in part on the opportunity class or zone where the analysis is taking place (Stankey and McCool 1984). Similar to the ROS, opportunity classes refer to the resource, social, and managerial settings (Cole and Stankey 1998).

Through application of the LAC, much has been learned about the nature of how recreation activities (e.g., camping) change the biophysical setting and the factors that influence the magnitude of the changes (Leung and Marion 1999; Cole and Monz 2004). However, these are generally measured at the site level, i.e., with a fine grain and narrow extent. Few studies have examined these changes at multiple scales or with attention to spatial patterns (Cole and Monz 2004). An example of the critical importance of multiple scale analysis is given in Joao (2002), who found that the accuracy of an environmental impact analysis of a proposed road was both quantitatively and qualitatively (expert opinion) different based on the scale of analysis selected. A second empiric example illustrates how single-scale analysis might negatively impact management decisions. In a study of campsites in the Popo Agie Wilderness, Cole and Monz (2004) examined resource change with a grain of 1 m but considered the spatial arrangement of resource changes across multiple extents. They found that specific campsites were heavily changed in terms of vegetation loss and soil compaction. However, at the scale of a forest stand the resource change became a point within an undisturbed matrix, and when considered at the level of the wilderness, the impacts were negligible (Cole and Monz 2004). In this case, if managers focused narrowly at the extent of individual campsites, they might determine that the impacts on the natural resource were unacceptable and take action to restrict use. Recognizing the importance of scale selection and multiscale analysis, Cole and Monz (2004, p. 84) affirmed that:

> Since conclusions about the significance of recreation impact will vary with the scale of analysis, it is important to carefully match the scale of analysis to the objectives of any study of recreation impact, including monitoring efforts. Studies that evaluate impact at multiple scales are likely to be particularly insightful.

Just as the ROS is often too large grained, analyses in the LAC planning efforts are often too fine grained to be easily integrated with other resource concerns across the landscape. This is not necessarily a limitation of the framework; it simply reflects how the LAC has been used to date (Cole and Monz 2004). We believe that by using insights from ecologic scaling theory that the framework can be improved to better integrate recreation with the management of other resources.

Incorporating Ecologic Scaling Theory Into the LAC

The LAC has the flexibility to address specific biophysical (e.g., vegetation, water quality, wildlife, rare species) issues at the scale and spatial location appropriate to the resource concern or issue. However, the LAC framework does not explicitly account for multiscale analysis, reflect scale issues in recreation, or compare the impacts from recreation with those from other sources. Application of the ecologic-scaling theories to this framework will allow each of the three integrated resource management issues to be addressed. The concepts of nested hierarchies and enveloping are particularly useful for identification of multiscale issues for recreation management and multiscale trade-offs with management for other resources. Furthermore, the additional level of nested hierarchies of vegetation classes within the ROS provides a more direct link between the two planning frameworks.

The direct link to analytic scales of recreation management in the LAC is the opportunity class settings. Outside of designated wilderness, the opportunity class generally corresponds with the ROS category. In this case, the opportunity class faces the same limitations as the ROS category in terms of lack of ecologic grounding. Paralleling the discussion on incongruent boundaries of the ROS category patches and vegetative associations, the "area issues and concerns" of the LAC may have an extent that is much smaller than an ROS category patch or cross the ROS patch boundaries (resource issue no. 1). Because many of the recreation impacts of concern are related to impacts on vegetation, we suggest that the mosaic of vegetation within an ROS category patch may be a more useful extent by which to identify opportunity classes because it provides opportunities to match the resource issue being addressed in the LAC at a finer grain. Three potential matching extents can be analyzed: (1) the traditional ROS patch (Fig. 1 [Panel A]), (2) the vegetative patch within an ROS category patch (i.e., riparian within the SPNM; Fig. 1 [Panel B]), or (3) the vegetative association across the ROS category patches (i.e., riparian with PRIM, SPNM, and SPM; Fig. 1 [Panel C]).

For example, measuring the trampled vegetation on a 50-m^2 campsite may be the relevant extent when assessing visitor preferences for a campsite and tolerance of impact within a certain opportunity class. However, if we are concerned about the impact on the viability of a specific plant association, it might be more useful to measure the recreation impact relative to the extent (and resilience) of that particular association. If the vegetative cover has a large extent, multiple 50-m^2 clearings are likely not a threat to the resource. However, for endangered and/or endemic vegetative species that occur within small spatial extents, a 50-m^2 area of vegetative trampling could be catastrophic. The decision regarding which focal level to use would depend on the resource issue and the level of detail necessary for measuring and monitoring resource impact and recreation planning.

The need for matching analytic scales and multiscale analysis can also be addressed by applying ecologic theories to the LAC (resource issues no. 2 and 3). A key component in the LAC planning process is defining the degree of resource change (e.g., to wildlife habitat, soil compaction, water quality, vegetation cover, crowding) that is deemed acceptable. Determining the degree of acceptable change requires explicit attention to the extent of analysis as well as the grain. Furthermore, this must be done at multiple scales because determination about important drivers of impacts at one scale might change when adopting a different scale. Framing the LAC in terms of enveloping and nested patch mosaics improves its usefulness for planning beyond a site-by-site basis and facilitates multiscale analysis.

Although in practice data are often collected at the recreation setting (e.g., campsite), enveloping this scale by considering the scale below, such as square meters within the campsite (the grain), and the context or scale above, such as a vegetative association of interest within an ROS patch (the extent), would provide useful information about the impact of recreation on the resource at several scales. For example, impacts that appear large at a fine scale such as a campsite (Fig. 1 [Panel D]) may appear negligible at broader scales (Fig. 1 [Panel B]). If the broader extent is considered, it might be determined that relative to the overall abundance and arrangement of other valued resources, the disturbances to the resource caused by recreation were insufficient to warrant restrictions on visitor freedom and access. Conversely, the cumulative impact of recreation might be missed if not considered at larger scales. For example, multiple campsites and stream crossings can combine to have significant impacts at the larger scale (Fig. 1 [Panel B]). Therefore, the choice of scale clearly matters in deciding whether or not recreation is a relatively significant impact on ecologic conditions.

Because the LAC data are spatially located, the cumulative resource disturbances (i.e., vegetation loss) can be calculated at multiple spatial extents, which facilitates comparison with the disturbances created by other resource uses (Cole and Landres 1996). For instance, we could compare the impacts caused by recreation with those of other processes, e.g., road construction, harvesting, grazing, fire management, management of adjacent lands, insect or disease control, or other resource disturbances, that may overshadow and/or add to those caused by recreation. Some of these are within managers' ability to control, and others are not. A thorough understanding of recreation impacts across scales is necessary if we are to understand how adjusting recreation use (by limiting and/or redirecting) may impact resources in the context of these other issues. It may turn out that the most effective measure for addressing resource impacts, e.g., habitat loss within an entire forest, water quality within a particular stream, or compaction of soil within a vegetative association, have less to do with local recreation management and more to do with other resource management practices. Conversely, it may be determined that disturbances from recreation are the critical threat to those resources.

The LAC was designed as a tool to explicitly integrate recreation with other resources, but it was primarily designed to ascertain a point at which recreation can no longer be permitted to cause additional changes in ecologic systems (Cole and Stankey 1998). Framing the LAC within a nested patch mosaic allows consideration of how recreation can disturb other resources across scales as well as how those disturbances compare with others occurring across the same scales (resource issues no. 2 and 3). Analysis at multiple scales enables managers to deliberately articulate the trade-offs rather than assuming that recreation impacts are harmful enough alone to justify restricting use. Through the application of scaling theories to the two recreation-planning frameworks, we have addressed one way to overcome the three integrated resource-management issues. Spatial tools provide the medium to merge the ROS and the LAC and to more thoroughly integrate these planning frameworks with the management of other resources.

Linking Recreation with Other Natural Resources Through Spatial Planning and Management

Spatial information has become a critical element of ecosystem management within all natural resource–management agencies, including the USFS. This is because every resource has a spatial and temporal component, and because ecologic processes and management actions apply to a particular spatial extent (Dale and Noon 2004; Kruger 2004). Furthermore, because of increasing and competing uses of National Forests and an increasingly spatially savvy populace, there is an increasing demand from the public for forest management to become more spatially explicit (Murray and Snyder 2000). Managing systems spatially requires scale considerations and spatial juxtaposition of alternative management uses, facilitating analysis of trends and patterns and the evaluation of future forest plans (Brunckhorst and Rollings 1999; Murray and Snyder 2000; Shindler 2000; Bettinger and Sessions 2003). However, the incorporation of recreation-planning frameworks into these types of "what if?"–scenario planning is one of the least used advantages of the ROS planning system (McCool and others 2007).

The ability to overlay multiple perspectives (topography, vegetation, wildlife habitat, timber, recreation, etc.) of the same geographic extent provides managers with the ability to integrate multiple concerns within the same decision environment. Spatial explicitness introduces a common foundation that multiple disciplines can use to communicate and make more informed multiattribute decisions (Mitchell and others 1993). In addition, spatial-planning frameworks for biophysical resources often incorporate hierarchy theory and the theory of patch dynamics into their models (Baskent and Keles 2005). Planners and modelers have a specific interest in including recreation more thoroughly in spatial planning (Murray and Snyder 2000; Bettinger and Sessions 2003; Baskent and Keles 2005). We have described how applying ecologic theories to the recreation-planning frameworks (the ROS and the LAC) allows for improved spatial integration of recreation and natural resource planning by addressing the three scale issues of integrated resource management.

We have noted the utility of the ROS framework for spatially identifying the spectrum of opportunities at a relatively broad extent. However, the grain of analysis of the ROS system is the ROS category patch, which does not automatically correspond to ecologic boundaries and often encompasses a patch mosaic of vegetative associations. However, these vegetative associations are often used in management for harvesting decisions, for identifying habitat for wildlife management, and for identifying rare or unique ecosystems. Therefore, to better facilitate the integration of resource management with recreation for spatial analysis, we suggest directly linking the recreation-planning frameworks with patches based on vegetative associations. In the early days of the ROS, such data were not available in spatial form, but today most forests have vegetative-association GIS layers.

The addition of the new level of recreation analysis based on vegetative associations and application of the concepts of "nested patch mosaics" and "enveloping" from theories in ecology provides additional detail on recreation opportunities and impacts and facilitates spatial integration in a way that improves analysis of trade-offs with the management of other resources at multiple scales. This is true for both recreation inventory (the ROS)—and recreation impact (the LAC)—planning frameworks. This would make use of data that the USFS already has mapped, so integration would not be costly. Furthermore, the GIS applications involved are basic, and no technical hurdles or excessively time-consuming operations are required for analysis. The adjusted frameworks would lead to the ability to identify an ROS patch by both its ROS category and vegetative association, such as roaded/riparian or semi-primitive nonroaded/ tundra. These smaller units can correspond to the opportunity classes of the LAC, thus directly linking the two systems. This would allow for greater understanding of trade-offs with the management of other resources at finer scales where specific recreation and natural resource interactions take place. It would also allow greater sensitivity to the relative importance of recreation disturbance in different habitats, facilitating management decisions that better balance recreational values with other resource values.

Conclusion

The two recreation frameworks discussed in this article were designed to be integrated with planning for other resources. However, despite years of planning, direct integration with natural resource planning is seldom in evidence (McCool and others 2007). In part this may arise from incongruent boundaries, mismatched scales for the management of different resources and uses, and the need to work at multiple scales. We have proposed that applying scaling theories from ecology to recreation frameworks will enhance the ability for direct integration. Specifically, the concepts of nested patch mosaics developed from hierarchy theory and the theory of patch dynamics (Allen and Hoekstra 1992; Wu and Loucks 1995) provide a useful framework for analyzing recreation impacts and trade-offs with the management of other resources at multiple scales. The increased use of spatial planning tools by the USFS (and other agencies worldwide) provides fertile ground for integration when ecologic scaling theories are applied to the recreation frameworks.

Considerations for Application of a Revised Framework

Primary arguments against modifying the ROS include cost-effectiveness, technical difficulty, and complexity (Moore and Driver 2005). The first two of these have been addressed in the article, and the third warrants further discussion. There are two elements of complexity that deserve discussion: (1) complexity for the USFS (or others who apply the modified ROS or the LAC systems) and (2) complexity for the general public or recreationists. Both of the complexity issues must be considered in the context of the potential for improved integration with the management of other resources that have been outlined in this article.

The increased technical complexity in analysis for the USFS regarding GIS overlay procedures for the ROS is negligible because of advancements in this technology and fact that the data layers are already available. However, there is likely to be an increase in the detail of assessment required (i.e., recreation at the vegetative association), which would take additional time and consideration as the system was instituted. For example, recreation planning would need to consider issues at the level of ROS category and vegetative association, such as semiprimitive motorized/riparian and semiprimitive nonmotorized/ponderosa pine. The complexity of the modified frameworks is also dependant on the grain of the vegetative layers. Several different vegetation mapping schemes are used by the USFS and others (Brohman and Bryant 2005; Comer and others 2003; Eyre 1980; Homer and others 2002). Most classification systems are organized hierarchically. The goal would be to aggregate and disaggregate vegetation classes to a degree that would be useful for natural-resource considerations but not too complex for the proposed revised recreation-planning frameworks. Application of a revised LAC is also likely to require more time and consideration because multiple scales of analysis must be considered, evaluated, and monitored. However, we believe that ecologic research on scale issues in landscape ecology and conservation biology compels this action (Allen and Hoekstra 1992; Lovett and others 2005; Turner and others 2001). The second audience for which complexity might be an issue is the general public. We agree with others that the general public has become increasingly spatially savvy (Murray and Snyder 2000) and that recreationists are interested in vegetative attributes for their recreation planning (Brunson and Shelby 1990; Heywood and others 1991; Pierskalla and others 2004).

Because planning and management of other resources is becoming increasingly detailed and spatially explicit (Bettinger and Sessions 2003), recreation frameworks should follow this trend to ensure that optimal decisions are made regarding trade-offs at all scales. We suggest that both of these modified frameworks should be applied to test for efficiencies and improvements in our suggested modifications. With improved GIS tools, existing vegetation maps, increased spatial understanding by the public, and need for improved integration of recreation with the management of other resources, now is the time to move to a more complex, yet more insightful recreation analysis.

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