Application of LAC-Type Processes and Concepts to Nonrecreation Management Issues in Protected Areas

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Abstract—When Limits of Acceptable Change concepts are applied to nonrecreational issues, two primary problems are encountered: (1) developing zoning schemes which are compatible when multiple issues are addressed, and (2) defining the desired condition and establishing measurable standards for ecosystem attributes which change in unpredictable ways. Approaches to overcome these two difficulties are described. We conclude that LAC can and should be used to address many impacts that are not related to recreational use. Where impacts are localized, nearby reference sites are often available, thus LAC standards can be developed for the amount of acceptable deviation from conditions at the reference site. However, effects-based, measurable standards may be impossible to define for landscape-scale impacts where no undisturbed reference sites exist. Substituting time as a reference, using system inputs rather than outcomes, and identifying the desired direction of desired change without specifying a standard are three approaches to overcome the problem with changeable ecosystem attributes but each approach has drawbacks.

Why Address Nonrecreational Issues?

The development of LAC-type concepts grew out of problems with defining carrying capacities for recreational use. As such, LAC was originally intended to address issues associated with recreational impacts to wildlands and visitor experience (Stankey and others 1985). However, as a result of the success of pilot-testing LAC in the Bob Marshall Wilderness Complex and the need to develop management direction for all protected areas, use of the LAC process has become more widespread. The process was immediately applied to issues other than recreational impacts. Fire management, air pollution/visibility, exotic plant invasion, domestic livestock grazing, fish stocking, and impacts to wildlife illustrate the diversity of issues included in LAC applications. Four primary reasons stand out as to why managers began to apply the LAC process to nonrecreational issues:

1. Increased emphasis on wilderness as more than recreation resource. Many wilderness managers did not feel they were fulfilling their responsibility to meet the intent of the Wilderness Act if recreation issues were the only ones addressed.
2. Citizen interest and public input. Public and agency input gathered in the first step of LAC often identified nonrecreation issues and managers wanted to be responsive. In some cases, even if managers tried to limit the scope of planning efforts, citizens were unwilling to participate unless nonrecreational issues were addressed or would charge managers with unwillingness to tackle tough issues.
3. Lack of full understanding about LAC. Publications on LAC did not explicitly state how LAC was different from other planning frameworks and did not identify the types of problems LAC could or couldn't address and why. Dissatisfaction with traditional planning frameworks or lack of knowledge about alternative approaches contributed to managers latching onto LAC without questioning whether or not it was well-suited to address nonrecreational issues.
4. Increased emphasis on an ecosystem approach to resource management. An ecosystem approach necessitates exploring how the whole system works. Due to the multitude of activities occurring in wilderness and problems created by conflicting management direction, managers felt a responsibility to develop plans that address all the issues rather than focus only on recreational impacts.

Problems with Applying LAC to Nonrecreational Issues

At least five difficulties have surfaced in attempts to apply the LAC process beyond recreation to other human activities which impact wilderness.

1. When numerous threats are considered simultaneously, zoning developed for one threat (such as recreation) may not be compatible with zoning developed for another threat (such as grazing or fire suppression).
2. Many ecosystem characteristics are so inherently changeable that it may be impossible to define the "ideal" condition and develop measurable standards for minimally acceptable conditions. How do we write standards that are "lines in the sand" when the system is inherently chaotic?

In: McCool, Stephen F.; Cole, David N., comps. 1998. Proceedings—Limits of Acceptable Change and related planning processes: progress and future directions; 1997 May 20–22; Missoula, MT. Gen. Tech. Rep. INT-GTR-371. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

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3. Inadequate knowledge about ecological systems and the nature or significance of various human activities makes it difficult to identify appropriate indicators and management strategies.

4. Where current ecological conditions are determined to be unacceptable, managers must decide between two undesirable courses of actions. They must either manipulate wilderness conditions which contradicts the intent of the Wilderness Act, or, to avoid conscious manipulation, they must allow conditions to increasingly diverge from what is thought to be "natural" (Cole 1996).

5. Managers often fail to implement plans, either due to insufficient resources (to accomplish monitoring, for example) or lack of political will (reluctance to risk allowing natural fire to burn, for example).

The last three difficulties appear surmountable, although clearly challenging. The LAC process or any other framework will fail unless we increase our commitment to professional wilderness stewardship. To identify appropriate indicators and management strategies we need to invest in scientific studies to more fully understand how human activities are altering wilderness ecosystems and the consequences of alternative management strategies. To address the dilemma posed by the conflict of avoiding direct manipulation of wilderness landscapes, yet also restoring natural conditions, criteria could be developed to provide guidance on when manipulation was deemed appropriate (the conditions under which the benefits of restoring natural conditions outweighed the disadvantages of actively manipulating landscapes). We could also design experimental approaches to more fully understand the consequences of active manipulation versus natural regulation strategies. To address the failure to implement plans, society needs to allocate more resources to wilderness stewardship and demand more courageous management. The LAC process, or any other process that clearly defines what is to be achieved, should facilitate this because management needs are made explicit. If insufficient resources or lack of political will results in objectives or LAC standards not being met, the shortcomings are more easily identified either by managers or public "watchdogs."

The first two difficulties—incompatible zones and defining standards for changeable systems—may not be so readily surmountable. In other words, even if we substantially increase our commitment to wilderness stewardship, these two problems may still limit the application of LAC beyond recreation use issues. However, an examination of these problems may shed light on which issues LAC (at least as it was originally conceived) can effectively deal with and which issues it cannot. Even more productively, an analysis of these problems may reveal how the LAC process could be modified to improve its effectiveness. The rest of this paper explores the difficulties and possible approaches associated with zoning and standards.

Problems with Incompatible Zones

When nonrecreation issues are considered along with recreation issues, development of opportunity classes (zoning) becomes problematic since zoning to deal with one issue may be incompatible with zoning for another issue. For example, a zoning scheme for wilderness recreation experience opportunities based on number of encounters between groups, degree of trail development and degree of campsite impact may be quite different from a zoning scheme for fire management based on vegetation type and fuel loading or a zoning scheme for domestic livestock grazing based on suitable rangeland.

Two problems are apparent. First, the lines that define zones may not coincide at all. Second, direction appropriate for one zoning scheme may create conflicts when another zoning scheme is considered. For example, a zoning scheme based on the vegetation resource may define parts of the wilderness as capable of supporting lots of cattle. However, when zoning for recreation experiences is considered, this area may best provide opportunities to encounter few other groups with little evidence of camping activities. The visitor to this area seeking outstanding opportunities for solitude may find it highly incongruous to encounter domestic livestock or heavily grazed meadows. The LAC concept was originally intended to balance conflicting goals within one topic of concern (for example, balancing the desire for natural conditions and high quality experiences with the desire for public access to be as unrestricted as possible). The situation where multiple inputs (such as both recreation use and livestock grazing) influence a single outcome (such as quality visitor experiences) was not addressed.

Three approaches have evolved to address the problem of incompatible zoning:

1. Identify one outcome (such as quality visitor experiences) as the primary "driver" and develop zoning accordingly. Integrate direction for other issues within this zoning scheme. For example, where crucial wildlife habitat exists, the zone is mapped to only provide opportunities for experiences offering high solitude and little evidence of human activity. However, integrating other resource concerns such as fire management has been analogous to forcing a square peg into a round hole. Attempts to alter fire management prescriptions to fit different recreation zones have been viewed as artificially constraining prescriptions beyond what is already imposed by policy mandates.

2. Develop multiple overlays with separate zoning schemes for each issue. Such an approach creates high complexity that makes public understanding and implementation difficult. To determine direction for one particular area, multiple layers must be consulted. There may be zones allowing both a high recreational and grazing impact, zones allowing high recreational and low grazing impact, zones allowing low recreational and high grazing impact, and so forth. This situation creates a high potential for incompatible direction.

3. Constrain mapping of zones. For example, direction for the most "primitive" recreation experience (with few encounters with others, no developed trails, and little to no evidence of campsites) often also includes lack of encounters with domestic livestock (except pack and saddle stock). Typically, this has meant such zones must be mapped outside of existing grazing allotments. Such an approach has not been satisfactory to a variety of public interests.

When LAC concepts are applied to issues beyond recreation, zoning problems can be overcome. However, none of the approaches have proven particularly satisfactory. In practice, managers have often resorted to using zoning only for a few topics of concern and abandoning zoning for other topics so that direction for these topics applies wilderness-wide (for example, direction for livestock grazing applies wherever allotments exist; direction for fire management applies to any fire start). Zoning is still primarily used to address recreation visitor issues but has been used to address recreational packstock grazing and has been proposed for managing fish stocking (Bahls 1992; USDA Forest Service 1987). More attempts to integrate multiple issues using LAC concepts are needed to assess the severity of zoning problems. It may only mean that management complexity increases or that we need to spend more time articulating goals and establishing a clear hierarchy among multiple conflicting goals so that compromises are more explicit.

Problems with Defining Desired Conditions and Standards

The problem that may limit the application of LAC to ecological integrity issues most—regardless of scientific knowledge and commitment of resources—is the difficulty of defining desired conditions (the "ideal") and measurable standards for dynamic ecosystem attributes. Standards should be measurable, attainable and applicable into the future. When the desired condition of an attribute does not change over time, it is relatively straightforward to develop a standard that defines how much deviation we are willing to accept from the desired condition. For example, we may define a minimally acceptable state of "no more than one other campsite within sight or sound." This standard is meaningful into the future because we can define a desired condition of "no occupied campsites within sight or sound" that should be applicable over time. We may change our mind in the future about how many occupied campsites within sight or sound are acceptable but this would reflect a change in our value judgment about solitude while camping rather than a change in the desired condition.

This approach also works for some ecological attributes. For example, the needle surfaces of western conifers subjected to ozone pollution show a distinct visible discoloration known as chlorotic mottling (Stolte and others 1992). This symptom is virtually never exhibited in the absence of ozone pollution. This allows us to define a desired condition —no chlorotic mottling—and we can develop a standard for an acceptable level of chlorotic mottling that is both measurable and meaningful in the future. In these cases, we may change our mind in the future about the standard but any change would reflect a change in our value judgement about acceptable deviation from the desired (for example, if we learn that chlorotic mottling is more or less detrimental than we thought, we may change the standard, but the desired condition will always remain "no chlorotic mottling"). However, for conditions that change over time (for example, vegetation or wildlife populations), the desired condition of "protecting natural conditions or processes" cannot be well-defined because we do not know with any precision what "natural conditions" ought to be like. The shortcomings of some standards commonly used to address nonrecreational issues are displayed in table 1.

Table 1—Shortcomings of standards commonly used to address nonrecreational issues.

Topic	Desired condition	Indicator	Standard	Shortcomings
Air quality	Air quality including visibility is not impaired by human activities (affected primarily by the forces of nature with the effect of human activities substantially unnoticeable)	Acid neutralizing capacity	Alkalinity will not be reduced more than 10 percent of the baseline for waterbodies with capacity greater than 25 mg/liter	Assumes that baseline conditions represent desired condition
		Visibility	Maximum of 5 percent change in visual contrast compared to best visibility days (90th percentile)	Desired condition changes over time (90th percentile) thus represents a moving target
		Lichens	Maximum or 5 kilograms per hectare of depositional sulfate	Uses system input rather than outcome (for example, effects of pollutant on lichens)
Range condition	Forage is used in a manner that allows meadow conditions (structure, composition, and processes) to be affected primarily by the forces of nature with the effect of human activities substantially unnoticeable	Forage utilization	Maximum of 40 percent utilization on key forage species	Uses system input rather than outcome (for example, effect of given level of utilization on meadow condition)
		Range or meadow condition	At or trending towards potential natural condition (PNC)	Dependent on availability of undisturbed reference sites to define PNC

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Table 1 (Con.)

Topic	Desired condition	Indicator	Standard	Shortcomings
Aquatic condition	Aquatic conditions are not impaired by human activities (affected primarily by the forces of nature...)	Streambank stability	At least 80 percent of the natural streambank stability is maintained	Dependent on availability of undisturbed reference sites to define PNC
		Riparian species composition	Streambank vegetation is maintained at minimum of 85 percent of potential natural condition	Dependent on availability of undisturbed reference sites to define PNC
Fire	Permit lightning caused fires to play, as nearly as possible, their natural ecological role. Reduce, to an acceptable level, the risks and consequences of fire within wilderness and escaping from wilderness	Appearance of suppression activities	Evidence of suppression activities will not be noticeable within 1 year	What is considered “noticeable” may vary among observers
		Number of percent of natural ignitions suppressed, risk of escapement	No more than 5 percent of natural ignitions are suppressed over a 10 year period. Natural ignitions are allowed to burn unless the risk of escapement (burning adjacent property or resource values) is greater than 10 percent	Uses system input (fire suppression) rather than outcome. Unknown if desired outcome (natural processes operating freely) is really being achieved
Exotic plant invasion	Native plant communities are maintained in their natural condition without the occurrence of exotic plant species	Number of acres or percent of area occupied	Regionally designated exotic weeds occupy no more than 2 percent of the wilderness acres. Aggressive invaders are not present	Uses system input (presence of weeds) rather than effect of weeds on native plant communities
Wildlife	Provide an environment where the forces of natural selection and survival rather than human actions determine which and what numbers of wildlife species exist. Protect threatened or endangered species and their habitat and aid in their recovery	Population objective	Meet State population objective for moose (or other game species)	Promotes static condition rather than allowing natural processes to determine population numbers
		Compliance with species recovery plan	At least 90 percent compliance with food storage regulations in grizzly bear habitat	Uses system input (for example, visitor behavior) rather than outcome (for example, bear response). Difficult to determine the relative significance of multiple factors impacting wildlife

The problems associated with changeable natural systems can be overcome in a satisfactory manner if the impact is *localized* or the concern is limited to the *presence* of a change agent (such as an invader species) rather than the *effect* of the change agent on the ecosystem. For example, with exotic invasions, the desired condition can be defined as "no invaders" (thus, is not changeable) and a standard can be written to define an acceptable deviation from the desired in terms of acres or numbers of invaders. When an impact is localized, undisturbed reference sites are often available nearby, thus standards can be written to specify the amount of acceptable deviation compared with off-site reference sites. In the example above, even if the concern is the *effect* of the invader on the ecosystem, we could write a standard defining the acceptable deviation in species composition of communities that have been invaded compared with reference sites, *if* the invasion is localized.

Similarly, writing a standard for the acceptable amount of vegetation cover on campsites is problematic because the "natural" amount of vegetation varies from site to site and changes from year to year with such climatic factors as amount of precipitation. However, the standard can be written as "no more than 50 percent less vegetation cover on campsites compared with reference sites." Vegetation cover, both on the campsite and reference site, can fluctuate with the vagaries of environmental change, but the 50 percent deviation remains constant into the future.

Defining standards as the amount of acceptable deviation from a reference site should be applicable to most recreation impacts, localized grazing impacts, mining impacts, many exotic invasions (those in which invaded places can still be compared with noninvaded places), and many stream diversions. However, this approach appears unlikely to work for managing impacts at the landscape scale, such as air pollution, fire suppression and management, widespread grazing, landscape fragmentation, and impacts to large mobile animals. For these influences there are no relatively undisturbed reference sites in the landscape.

Potential Solutions to the Lack of Reference Sites

Three possible approaches can be suggested as ways to develop explicit management direction for landscape-scale impacts when no relatively undisturbed references sites exist. These approaches are (1) substituting time as a reference, (2) defining standards based on inputs rather than outcomes, and (3) identifying monitoring indicators and the direction of desired change but not setting standards.

Substituting Time as a Reference

One approach to the problems associated with dynamic natural systems is to substitute a reference time for a reference site (Kaufmann and others 1994). The idea is to describe conditions (either in structure or process terms) during a past time when undesirable human influence was absent. Then a standard is written as an acceptable deviation between existing conditions and this past reference state. Two substantial difficulties with this approach are (1) the challenge of describing past conditions and (2) the arbitrariness of deciding on the reference time to use. This forces managers to address issues such as whether or not the influence of Native Americans should be considered desirable. Although challenging, these difficulties are often surmountable, particularly for landscapes that change slowly. Some characteristics of past ecosystems can be described with considerable precision (see, for example, Swetnam 1993) and consensus can frequently be reached on an appropriate reference time.

However, even when past conditions can be described and consensus exists on an appropriate reference time, this approach has the drawback of promoting static rather than dynamic systems. In 1963, a Commission chaired by Starker Leopold issued the recommendation that National Parks be managed to present a "vignette" of primitive America (Leopold and others 1963). This recommendation has been criticized as being out of touch with modern ecology, which reveals that natural ecosystems are characterized by constant change (Botkin 1990).

Some have argued that the problem of static management can be circumvented by developing desired conditions that incorporate a historical range of variability (Morgan and others 1994). This approach allows for more variation and, therefore, is an improvement; however, it limits variability to that measured during a given window of time. Moreover, this approach does not allow for a trajectory of change over time. Ironically, what we have learned about ecosystem behavior from historic ecological data—that ecosystems constantly change in novel and unpredictable ways—is the precise reason we must be careful about using historic data to develop standards for future wilderness ecosystems. Establishing future desired conditions on the basis of past conditions—even if they incorporate some degree of historic variation—may be better than developing no targets at all, but it is far from the ideal of permitting the free play of natural processes. Furthermore, such an approach may force managers into manipulating conditions to restore a particular vegetative condition diminishing the ability to learn how relatively undisturbed systems work.

Defining Standards Using System Inputs

When the LAC process was developed, it advocated developing standards for outcomes (wilderness conditions) rather than inputs (human activities). For example, a standard for number of encounters between groups is preferable to a standard for amount of recreational use because it more directly relates to the goal (ensuring opportunities for solitude). A recent report by the Ecological Society of America about ecosystem management noted that objectives should be stated in terms of "future processes and outcomes" rather than management activities and other inputs (Christensen and others 1996). Outcome standards are preferred because it is the outcome we really care about and because outcomes may be influenced by several inputs. Nevertheless, if we cannot define acceptable outcomes, perhaps the best remaining option is to define acceptable inputs.

For example, it has been shown that air pollution can reduce tree growth rates (Adams and Eagar 1992). We may be unable to define a standard for future tree growth rates because (1) future growth rates will differ from current rates due to natural climate change and (2) all trees in the future may be adversely affected by air pollution. However, this problem may be circumvented by using the knowledge derived from studies of pollutant effects on tree growth rates to set maximum acceptable levels of air pollutants. By keeping human activity inputs (air pollutants in this case) to acceptable levels, we should keep resultant outcomes within acceptable levels. A key to making this approach work is developing the knowledge of cause-and-effect relationships necessary to model the outcomes likely to result from different levels of input.

Similarly, the maximum allowable number of animals has often been used to define the acceptable level of grazing impact rather than defining acceptable compositional or soil change in meadows. For fire management, we could define a standard for the number of natural ignitions that are suppressed, rather than for the forest structure and composition we really care about. In practice, this approach has been used to write a standard that says, "lightning fires are suppressed only when one or more of the following criteria are met: likely to escape wilderness boundaries resulting in loss of valuable resources outside wilderness, creates unacceptable smoke in communities, protection of life is not assured, there are inadequate fire personnel to manage the fire." Such a standard might be improved by incorporating an acceptable degree of risk within each of the criteria. However, with both of these examples, it is critical to develop more precise models of the relationships between inputs and outcomes. How does the number of grazing animals affect meadow composition? How does the number of suppressed natural ignitions affect forest composition?

Using system inputs to define standards will not work well in situations where it is the removal of an input that is causing the impact we care about. Examples include the loss of predators, disruption of animal movements outside the wilderness, and fire management in systems where most fires burned into the area, instead of igniting within the area.

Identifying Direction of Desired Change Without Setting Standards

There may be issues for which we simply cannot specify desired conditions with any precision because conditions are constantly changing, there are no reference sites in the landscape, we do not want to promote static conditions, and we consider input standards to be ineffective (for example, where there is little information on cause-and-effect relationships). In these situations, if there is consensus that current conditions are unacceptable and consensus about the desired direction of change, we can begin to improve conditions. We can implement management actions, monitor conditions to evaluate progress away from currently unacceptable conditions and conduct research to adjust future management.

Fire management provides a good example. In many wildernesses, it is clear that forest structure has changed markedly as a result of fire suppression. In many places we know that a forest structure with fewer saplings, fewer total trees, fewer vertical layers, and more discrete spatial aggregations of trees would be closer to "natural" than the existing structure (Kilgore 1987). We also know that fire characteristics have changed. Before the recent era of fire suppression, fires in some vegetative types were more frequent and typically smaller and less intense than they are today (see for example Swetnam 1993). From analysis of historic ecological data (Stephenson and others 1991) we can develop past forest structure and fire process descriptors that might make reasonable short-term targets. Even though desired long-term forest structure or process objectives are uncertain, there is often agreement that more fire in the landscape is desirable. Therefore, we can develop management prescriptions that will provide for more fire in the landscape and can be easily adjusted as more is learned.

Additional research will be needed to aid understanding of ecosystem change, although it is unclear whether new research could eventually provide precise standards or would simply show the need for adjustments to management prescriptions. To aid understanding of ecosystem change, simulation models could be developed that estimate the trajectory of natural climate change. This would require differentiating between human-caused and natural change and removing the human component from observed climate change. Estimates of natural change, coupled with understanding of effects of climate change on fire processes and vegetation structure, could provide the basis for more precise targets that incorporate the inherent changeability of natural ecosystems.

Conclusions

We conclude that the LAC process can be used to manage threats to wilderness ecosystem integrity other than recreation. Effective preservation of wilderness ecosystems will require greater commitment of resources to threats-based research, monitoring, and wilderness management. This is simply the cost of professional management. However, LAC applications are more problematic for some threats to ecological integrity than for others. We believe the fundamental application problem is the difficulty of writing standards in situations where (1) desired conditions cannot be well-defined due to "chaotic" variability in the system, and (2) impacts are not localized.

LAC standards may be impossible to define for landscape-scale impacts with no undisturbed reference site. Two approaches to overcome this problem involve relatively little departure from traditional LAC concepts. Standards could be written as deviations from historic predisturbance conditions. This approach suffers from a tendency to promote stasis. Theoretically, this deficiency could be mitigated by developing simulation models capable of identifying natural trajectories of ecosystem change and calibrating standards accordingly. Alternatively, standards could be written for inputs rather than outcomes—defining maximum levels of human input, as opposed to minimally acceptable wilderness conditions. This approach will not work for all threats and requires substantial understanding of the linkages between human-related activities and wilderness conditions.

The final alternative represents a substantial departure from the LAC concept, in that standards would not be developed. The direction of desired change would be identified, but no minimally acceptable condition would be specified. Management would be incrementally refined as more is learned but what constitutes "success" would not be known with any precision. Further elaboration of exactly how this process might work seems worthwhile.

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