Integrating Scientific Knowledge Into Social And Economic Decisions For Ecologically Sound Fire And Restoration Management

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Abstract

Conflicts among stakeholders and interested parties often stop or delay many projects intended to manage or improve wildland fire hazards and reach forest restoration goals. Conflicts fall into three general categories: ecological, social, and economic. In the western US, ecological issues generally center on the sustainability of ecosystems and protection of biodiversity and watersheds. Social issues include disagreements on balancing the ecological and human use values that people hold for natural resource systems and the communities existing within them, including re-evaluation of what is considered "natural". They also involve public acceptance of treatment activities such as logging and smoke production from prescribed burning, and issues of trust of federal land management agencies and logging and other industries. Economic issues include the economic viability of communities, comparative costs of wildfire suppression and damage vs. preventative fuels treatment, and the subsidies needed to mitigate wildfire hazards and achieve ecological sustainability.

While there are clear needs for mitigating wildfire hazards and for achieving some degree of economic benefit from restoring ecosystems, it often is difficult for stakeholders and interested parties to reach agreement on courses of action. Frequently, sound scientific information on ecological issues provides the "glue" that serves as a point of fundamental agreement among otherwise disagreeing partners. We have used a presentation format that describes the scientific basis for mitigating wildfire hazards and improving ecological condition of forested and other landscapes as a basis for helping natural resource managers and administrators, public interest groups, non-governmental organizations, industry representatives, and politicians find common ground. The keystone element of this format is the clear articulation of good science describing the ecological need for action (or in-action), supported by a simple ecological state and transition model used to communicate the ecological need for intervention.

We have found that Powerpoint presentations by established scientists can effectively convey the meaning and value of ecological assessments, adaptive management, integrated decision-making processes, and development of a useful landscape context for implementation that best meets ecological, social, and economic needs. While many fuel treatment projects designed to mitigate wildfire hazards and improve ecological sustainability are too new to be judged fully successful, there is clear evidence that blending good science with adaptive management of project activities is achieving initial social acceptance and helping address the economic difficulties of applying treatments at a landscape scale.

Collaboration in a contentious environment

Exploration and settlement of the western United States by Euro-Americans over a century ago began a trend of increasing human population, and with it increasing and sometimes conflicting demands on natural resources and differences in views of how they should be managed. Major fires in the western US during the last decade are convincing many people in all sectors of the population that many forests that had been shaped naturally by relatively frequent wildfires prior to European settlement, are now in a very poor ecological condition and burning at severities well outside the historical norm. This poor condition has a number of causes, including the effects of logging, grazing, fire exclusion, and tree planting on the size and number of trees surviving or established since settlement. Natural fire regimes in systems that experienced frequent low intensity fires normally would have kept tree densities lower and favored larger fire-resistant trees.

This current but sometimes reluctant agreement that many forests are in trouble is tempered by considerable disagreement over what to do about it. The reasons for disagreement are many. Some simply mistrust any agency, especially a federal one, that plans any kind of treatment on public lands, and/or they mistrust profit-driven industries, particularly logging, involved in the treatments. Others believe that any agency program to mitigate wildfire hazards subsidizes those whose have chosen to build homes in forested areas where the probability of natural fire occurrence is greater than zero. A few of these suggest letting fires burn houses, and are willing to let fire drive people out of forest settings. Some argue that forests are capable of taking care of themselves, including the natural correction of conditions that have become "out of whack." Others acknowledge that current forests are not like those that occurred historically and are likely now less ecologically sustainable (or less safe); but they like them the way they are for their aesthetic value or even the privacy they create and are willing to take the risk. Some suggest that climate change is responsible for current forest conditions. Many believe the problem is too expensive and extensive to solve, and some simply don't like change.

A broad range of people – landowners, recreationists, politicians and policy-makers, environmentalists, researchers, managers, and industrialists – are interested in the management and outcome of natural resources across all types of land ownership. Carefully conducted and well-presented science can be beneficial in finding common ground among these widely differing stakeholder groups. In this paper, we describe several communication tools we have found effective for assisting planning and decision-making processes and building community support. We present illustrations that demonstrate complex ecological conditions and processes simply and understandably. We provide diagrams that can facilitate discussions on blending ecological, social, and economic issues in decision-making processes and implementation of treatments. And we provide an illustration of the adaptive management process that helps iteratively incorporate advancing research information and lessons from management as projects proceed.

The broad challenge – meeting human wants and needs in an ecological environment

The interrelationships between ecological, social, and economic issues may be illustrated using two Venn diagrams side by side (Fig. 1, Kaufmann et al. 1994). Wherever social and economic needs or expectations can be met while staying within the ecological capability of the land, ecosystem sustainability – and perhaps also social and economic sustainability of communities – may be achieved (black areas in Fig. 1). When decisions about land management are made with a narrow focus on only one or two of the three sets of issues, sustainability may be achieved in only a limited way (Fig. 1, left). There are numerous examples of communities and even civilizations that have failed or suffered over time because socially acceptable or economically preferred practices have not permitted ecosystems to function sufficiently close to their natural state. Often practices are not recognized as troublesome until negative ecological consequences become apparent many years later.

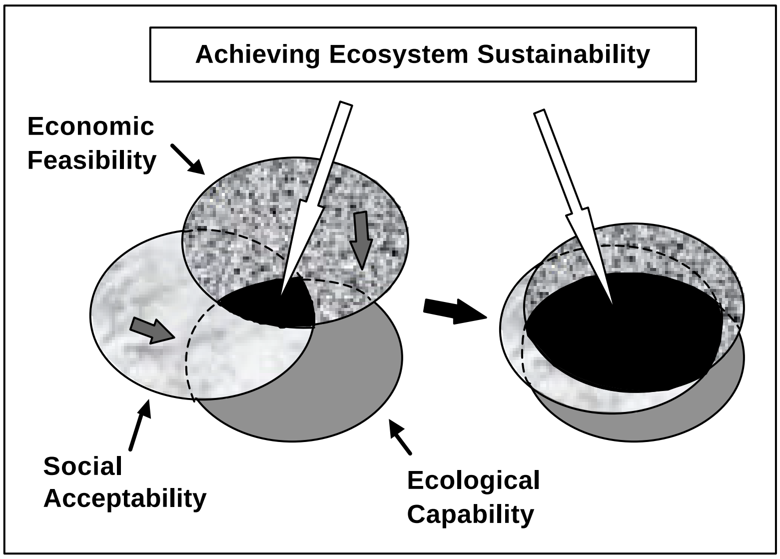

Figure 1 Venn diagrams relating ecological capability with social acceptability and economic feasibility.

An excellent fire example is the effect of fire exclusion policies enacted to protect forest resources. While fire exclusion in fire-adapted ecosystems may be socially desirable to protect peoples' lives and property, and economically desirable to protect natural resources and jobs associated with timber production and other commodities and services, the ecological consequences may be severe and, in the long run, catastrophic socially and economically as well. In ponderosa pine in the western US, for example, lack of periodic fire since the late 1800s along with the effects of logging and grazing on tree regeneration led to a forest condition that is highly vulnerable to large, severe crown fires that are well outside the historical norm. A series of fires in recent years left large areas burned with almost no surviving trees, compared with historical fires that rarely if ever killed all trees over such large areas. The ecological consequences are great, including the immediate loss of habitat for threatened species, and the loss of old-growth forests for centuries. However, social and economic losses are equally large, including loss of homes, major damage to municipal watersheds, loss of forest product resources, and loss of tourism. These consequences of fire exclusion policies were not well understood earlier (Pyne 1982).

Thus, human activities responsible for creating ecological conditions outside the historical range of variation can lead, ultimately, to loss of ecosystem sustainability (Fig. 1, left). Furthermore, it becomes clear that because rather finite limits exist on the ecological capability of land, improved ecosystem sustainability can be achieved only when human needs and expectations of ecosystems conform more closely to this capability (gray arrows in Fig. 1, left). It follows that managing natural resources to be ecologically more sustainable and safer from wildfire effects may require adjusting social and economic approaches and expectations (Fig. 1, right)(e.g., see Cissel 1998, Fried 1999, NAPA 2002, Williams 1996). Attempting the reverse -- adjusting forest processes to human needs and wants – has had serious negative consequences in ponderosa pine and many other systems around the world (Baisan and Swetnam 1997, Brown and Sieg 1996, Brown et al. 2000, Everett et al. 2000, Kaufmann et al. 2001, Touchan et al. 1996, and Veblen et al. 2000).

Informing stakeholders and partners with good science

There is a great need to provide useful, science-based information to people in all sectors of interest in natural resource issues. We have observed that good science presented well provides a basis for agreement when other issues and views tend to pull stakeholders apart (Shlisky 2002). A simple test applied to alternative courses of action – *Is it good ecology?* – often helps people focus on factual information rather than on value-laden positions. While ecology is not the only basis for decision-making and not all ecological science is in agreement, few people knowingly support decisions leading to poor ecological outcomes without compelling social or economic reasons for doing so. None of the issues are simple or straightforward. However, the development and use of simplifying models to represent complex issues is beneficial for finding common ground between stakeholders and avoiding the often paralyzing trap of excessive detail.

Ecosystems are widely understood to be complex and hard to model. Nonetheless, an ecological assessment process has proved useful for evaluating the ecological condition of ecosystem analysis areas and identifying ecological issues that need attention, even if all the intricacies of ecosystems are not well understood (Kaufmann et al. 1994; Shlisky et al. these proceedings, Maddox et al. 1999). This process is grounded in principles of conservation biology – paraphrased simply as *think long term, save all the pieces, and save all the processes* – applied at appropriate scales of space and time for the issues in question. The fundamental objective of this process is to identify those things that are within and outside the normal range of conditions for the ecosystem(s) in question (Fig. 2). Note that this process can be overwhelming if too much is attempted at once. The process is better used iteratively, focusing initially on simple, manageable issues before addressing complex situations. The iterative nature of ecological assessments is discussed again in the section below on adaptive management.

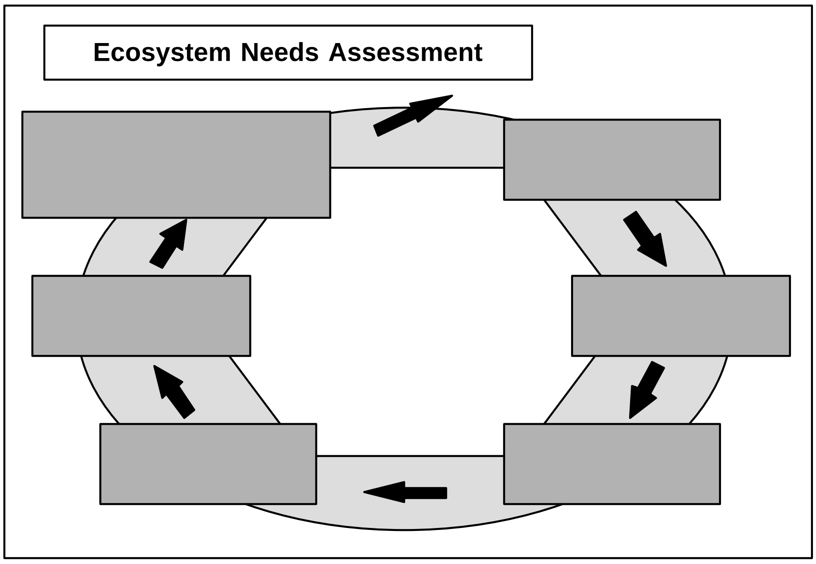

Figure 2 Ecological assessment process based upon conservation biology principles.

The ecological assessment process focuses on an initial analysis area, which may be as small as a private lot in a forest (10s to 100s of hectares) or as large as an ecoregion or more (millions of hectares). Frequently a multi-scale approach, concurrently assessing larger or smaller areas, is also considered as the analysis proceeds. The process recognizes the importance of reference ecological conditions, based largely on historical ecosystem characteristics where available and including structure, composition, and processes governing ecosystem function (Fulé et al. 1997, Hessburg et al. 1999, Kaufmann et al. 1998, Quigley and Arbelbide 1997, White and Walker 1997). Reference conditions serve as a basis for evaluating existing conditions. This is done using what often are called coarse and fine filter analyses (Fig. 2). A coarse filter analysis determines if the major components of an existing analysis area, a landscape for instance, are similar or dissimilar to those found under reference conditions. This analysis might detect, for example, that a historical landscape of old and young trees in a mosaic of small patches has been replaced with uniform large patches of younger, denser trees. The coarse filter analysis focuses on the major components of the analysis area. Smaller unique or special habitats, threatened or locally rare species, or the early detection of invasive species are assessed with the fine filter analysis.

The ecological assessment process is a powerful approach for helping evaluate and select courses of action in the decision-making process. It draws together relevant ecological insights from research and information in natural resource databases to develop an understanding of the current condition of ecosystems and what might be needed to correct significant difficulties. While this process sometimes only makes the obvious explicit, it also may uncover unexpected but significant information. For example, research demonstrating that not all ponderosa pine forests had a history of frequent, low-severity surface fires led to different recommendations for fire management and forest restoration where historical fires were mixed in severity (Brown et al. 1999, Kaufmann et al. 2001, Kaufmann et al. 2003).

Simplifying the ecology

The complexities of ecosystems are often overwhelming and not fully understood. Yet responsible management of natural resources requires that activities be consistent wherever possible with the natural ecology of systems in question. Thus a wide array of people – managers and policy-makers, special interest groups, the public, the press, etc. – would benefit from simple ecological messages based upon sound ecological science. In the last decade, significant progress has been made in assessing ecological conditions (Quigley and Arbelbide 1997, Smith 2000). Recent efforts have expanded to describe complex ecosystems using simple ecological models (Beukema et al. 2003, Shlisky 2002). These state and transition models, also called frame or box models, are proving very effective for communicating considerable information about the ecological condition of natural resource landscapes.

An example of a simple state and transition model is shown in Fig. 3 (Kaufmann et al. 2001). Ponderosa pine is a widely distributed fire-dependent forest type in the western US. In many places it forms associations with Douglas-fir, a fire-sensitive species when young that often becomes dominant as a result of fire exclusion. Ponderosa pine/Douglas-fir forests have a wide range of stand structural characteristics, and an equally wide range of natural disturbances and other processes that govern change. Nonetheless, all of the structural conditions of many of these landscapes can be collapsed into the four broad categories shown in Fig. 3. Furthermore, the primary natural processes that govern change are fire and

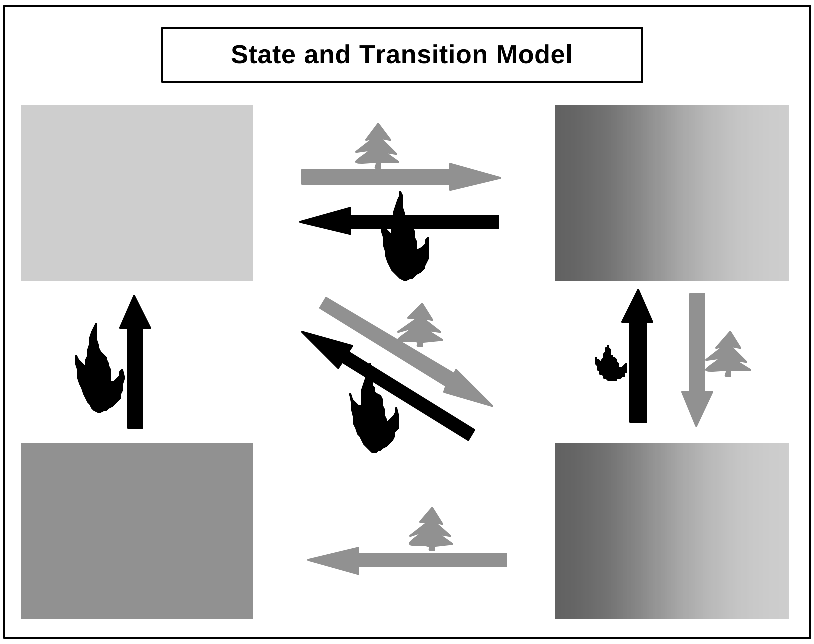

Figure 3 Simple state and transition model for ponderosa pine/Douglas-fir forests in the Colorado Front Range. Arrows represent tree establishment and the effects of fire.

tree regeneration and growth, with other processes generally being less consistent or occurring at smaller spatial scales.

While the model shown in Fig. 3 is greatly simplified, it has proven very effective in conveying key ecological information about presettlement ponderosa pine forests and about human-caused changes in these forests. Following the steps of the ecological assessment process shown in Fig. 2, reference condition studies clarified the expected characteristics and amounts of each of the four components of these forests in the Front Range mountains of Colorado, USA (Kaufmann et al. 2001). The proportion of a historical landscape in each of these components is shown in Fig. 4 (Historical to Settlement). An examination of current forests ("Existing Conditions" in Fig. 2) revealed major changes in the proportions of these components (Settlement to Current in Fig. 4).

Many more details about landscape ecology and natural disturbance history are known than shown in these two figures, but with a small amount of narrative, these simple diagrams convey important ecological insights to interested listeners and readers. For instance, since settlement, changes in forest structure have led to dense, young forests with large amounts of Douglas-fir. In recent decades, conditions have reached threshold levels at which stand-replacing crown fires are much more likely than the less severe fires that had occurred historically. If it is presumed that historical forests were ecologically sustainable and that current climate change is insufficient to displace these ecosystems or significantly alter their fire regimes, then guidelines for restoring these forests would favor changing the proportions of these components to better match those prior to settlement. Managers and more informed stakeholders can be provided with more details about age, size, and density of landscape components as desired. The scientific message in Figs. 3 and 4 is strengthened with knowledge of fire behavior patterns under different conditions. Treatments that restore forests to an ecologically sustainable condition are the same as those needed to mitigate wildfire hazards and reduce the threat of large, stand-replacing fires.

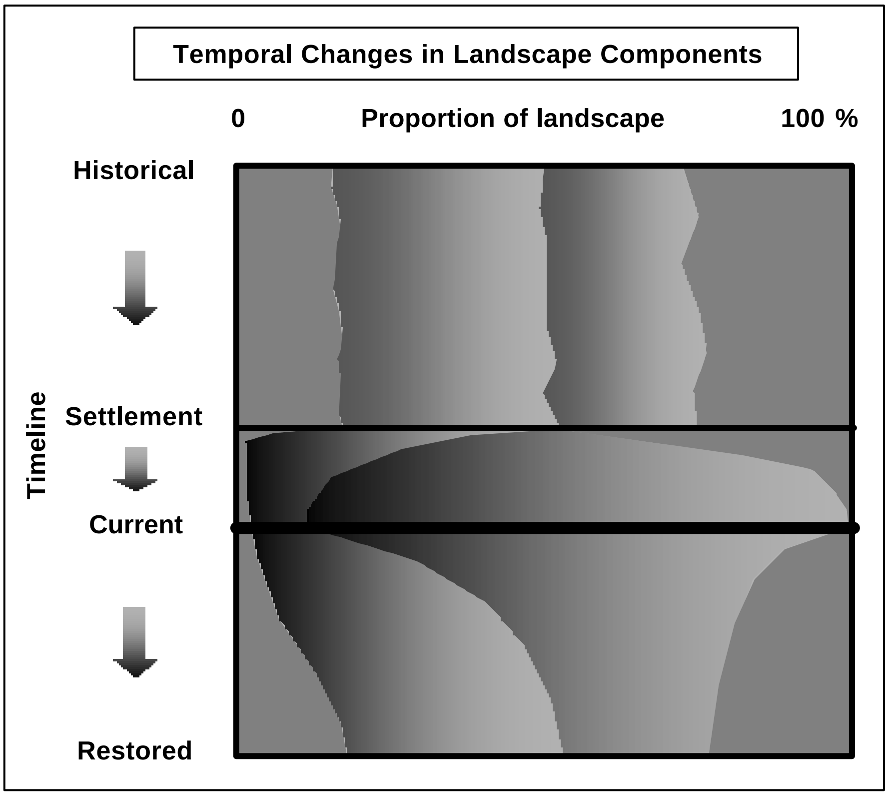

Figure 4 Changes in landscape components before and after Euro-American settlement and recommended during restoration.

Blending ecological, economic, and social issues

Improving current natural resource conditions to make forests ecologically more sustainable and safer from wildfires clearly involves more than simply understanding the ecology and treating land based upon ecological recommendations. It also involves addressing social issues that arise from people's values, objectives, attitudes, and beliefs, and evaluating economic issues that affect the feasibility and practicality of treating land areas that often are near where people live, work, and recreate. We recognize the political element, but here we treat political and administrative aspects as part of the social and economic issues.

In recent decades, resource management in the US has shifted from a greater focus on economic aspects of resource utilization and sustainable production of goods and services, toward a more balanced approach in which ecological and social issues are added to the decision space along with economic issues (Fig. 5)(FEMAT 1993, Grumbine 1994, Kaufmann et al. 1994, Landres et al. 1999, Overbay 1992, Rauscher 1999, Rauscher et al. 2000, Rickenbach and Reed 2002, Shlisky 1993, Swanson et al. 1992). The development of ecological assessment processes and simple ecological models discussed earlier addresses the needs of this new approach. This change is significant because it more firmly roots management activities in good ecology; but with it comes a clear need for decision-makers and interested parties to be informed with an understanding of ecological issues as well as social and economic ones.

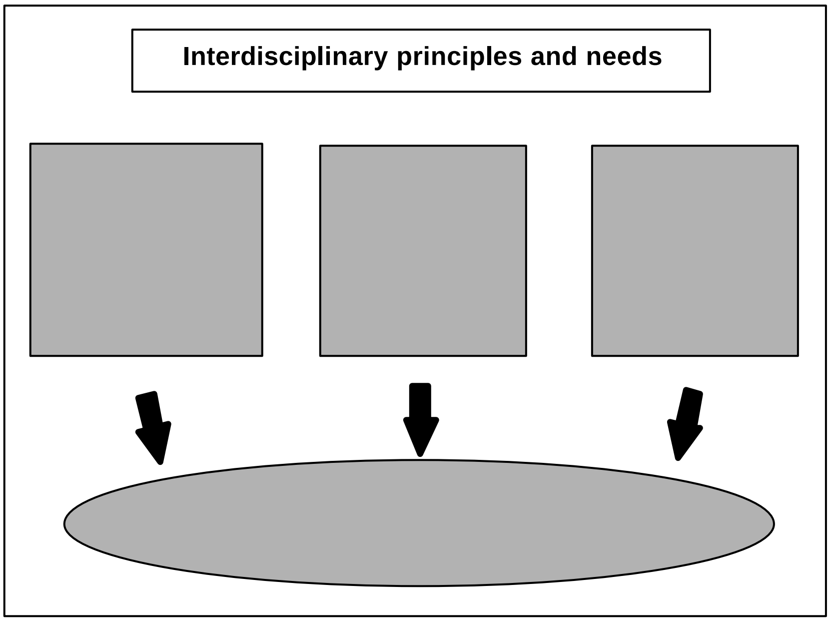

Figure 5 Blending ecological, economic, and social principles and needs in the decision space.

Just as there are ecological principles and ecosystem needs, so also are there social and economic principles and needs. Social and economic issues reflect wide variation stemming from ethnic backgrounds and personal experiences to contrasts in land ownership and resource management expectations and to dependence on natural resources for jobs, materials, recreation, or privacy. In general, however, simplified models of complex social and economic issues are not readily available, and their development could benefit decision-making, planning, and communication efforts. Often members of various sectors of interest in natural resource issues inadvertently mix issues. A concern that thinning may destroy habitat for deer or elk, for example, may really reflect an unrecognized or unarticulated concern about loss of privacy if trees are less dense. Thus a clear articulation of the nature of each type of issue can be helpful, because it facilitates evaluating issues using specific and relevant information. Furthermore, clear information on the benefits and costs of alternative management actions specific to ecological, social, and economic elements helps weigh alternatives appropriately in the decision space.

Adapting to new information

Earlier it was mentioned that the ecological assessment process could be considered iteratively, beginning with relatively simple situations before progressing toward complex ones. Rarely are all, or even most, of the answers to important questions available when projects are implemented. Adaptive management provides for initial management activities based upon available information, and continuing management after a monitoring and evaluation assessment of the outcome of activities relative to initial plans and expectations.

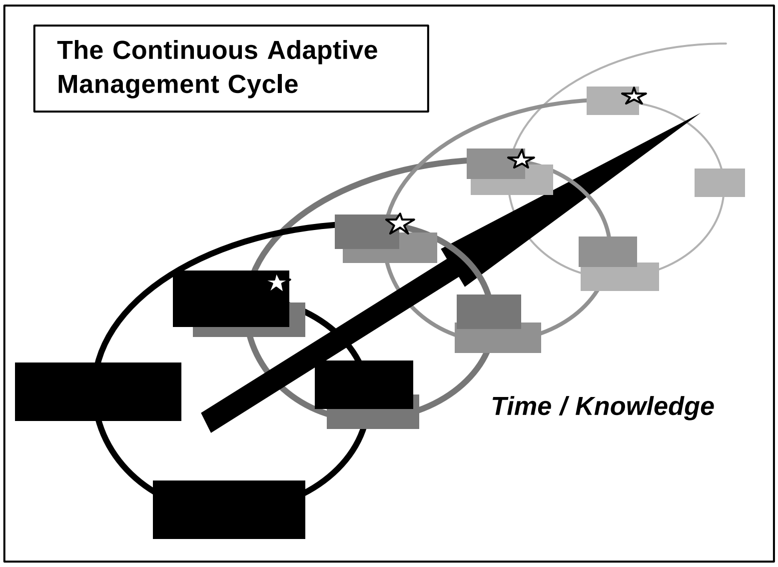

Figure 6 Incorporation of new knowledge into management cycles over time.

Integrating findings from research and monitoring as plans are implemented has tremendous potential for improving management activities. New input may also come from more sophisticated iterations of the ecological assessment process, or from analyses of social acceptability or economic feasibility of activities. The spiral time/knowledge process shown in Fig. 6 illustrates that in adaptive management no plan is repeated cyclically, but rather is improved through experience and addition of new information. The star in the planning box in each cycle in Fig. 6 symbolizes these new inputs.

Measures of success

The illustrations and approaches outlined in this paper have been used in many presentations and projects. Two representative examples are drawn from training and planning settings. First, these diagrams are used in the introductory lecture for an advanced training course in fire management, taught at a national level for fire and planning experts (Rx-510, Applied Fire Effects, National Advanced Resource Technology Center, Arizona, USA). Since the addition of these materials to the course curriculum, the ecological assessment process and adaptive management cycle have become important, unifying themes carried throughout the week-long course, referenced in a majority of subsequent lectures.

Second, these materials were introduced at the beginning of a multiple-year, multiple-site Fire Learning Network program (see Shlisky et al., these proceedings, and Shlisky 2002). The Fire Learning Network is a collaborative project between The Nature Conservancy, US Department of Agriculture Forest Service, and US Department of the Interior that focuses on developing and implementing community based resource management programs designed in part to restore the use of fire in ecologically appropriate ways. The materials presented here continue to guide network participants as they establish a science basis for developing and communicating plans to other stakeholders. The success of Network projects requires an integrated consideration of ecological, social, and economic issues, and efforts are largely modeled after the approaches described here.

Presentation formats

The illustrations presented here have been published and referenced frequently. They are most effective, however, when used in Powerpoint presentations. Animations for each diagram allow narration in which a series of points about specific situations can be made. Furthermore, illustrations can be accompanied by photographs, text, tables, and charts, which also can be animated. Carefully prepared presentations convey large amounts of information in a straightforward manner and in a brief period of time. When accompanied by handouts of the presentation material, the animated presentations become even more effective for informing people about complex issues.

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