The Road to Integrating Science and Management: Planning Your Next Trip Using Hierarchical Objectives and Assessment Points

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Introduction

PROPER ENVIRONMENTAL STEWARDSHIP IS A LOT LIKE PLANNING A ROAD TRIP. We generally consider the following things before traveling: "Where do I want to go?" "How do I get there?" "How long will it take?" "How much will it cost?" The same can be true for environmental management. Managers need to plan around goals and consider the consequences of choices that they make. Sometimes they also are required to make quick decisions without the luxury of forethought and planning, just as we might race to the hospital during an unexpectedly early labor. Nonetheless, there are tools (such as objectives hierarchies) to help us plan for crises, while others (such as assessment points) help us navigate the best route along the way.

Before getting into the gritty details of objectives and assessment points, let's carry our vacation-planning analogy a bit further. We can have a very general destination in mind (e.g., somewhere out West), or a very specific destination (e.g., Grandma's house at 1916 Organic Avenue, Bozeman, Montana). Arriving at our desired destination requires different types of planning and preparation, depending on where we decide to go. If we choose the general destination, then there are many possible routes we could follow; all would get us to where we want to be. A trip to Grandma's house, however, would require more detailed planning and navigation. Needless to say, we would never give someone generalized directions to a specific destination: "To get to Grandma's house, just head west." Those instructions might get us headed in the right direction, but more details will be required along the way. An objectives hierarchy functions in much the same manner: broad, overarching goals are defined, and supported with finer levels of detail later, depending on the desired objectives.

Now imagine that we have started our road trip and, unbeknownst to us, someone has removed all of the road signs in North America. It will be much harder to reach either destination without clues along the way to tell us where we are and which way we need to go. If objectives are akin to the travel directions in this analogy, then assessment points are the road signs. Assessment points essentially capture the current condition of a resource (i.e., where you are) and provide perspective on whether that condition is good or bad (i.e., Are you traveling in the correct direction?). In this paper, we discuss three types of assessment points: those that identify desired condition, those that provide early warning ("Slow Down" or "Danger Ahead"), and those that signal imminent loss of the resource ("Stop!" or "Go Back!"). More extensive detail on the definition of and rationale for using assessment points can be found in Bennetts et al. (this issue). The goals of this paper are to introduce the concept of an objectives hierarchy, to identify different types of and uses for objectives, to show how objectives and assessment points are inherently linked, and to encourage the use of explicit, *a priori* objectives and assessment points in natural resource management and planning.

Objectives hierarchies

Key concepts. An objectives hierarchy is an exhaustive set of statements, from a general vision statement to statements of specific, technical objectives, that provides the framework for achieving and maintaining a set of goals. In fact, a complete objectives hierarchy looks like an "inverted tree of goals, branching downward from a value-laden vision statement ... to technically stated ecosystem and institutional goals" (Biggs and Rogers 2003). Each level of the framework describes, in some form or scale, a desired future state or condition of the system, starting with the primary mission, or vision statement. The subsequent levels all feed from that broad foundation and help to establish, in more specific contexts, the goals and objectives that will contribute to achieving the overall mission or vision.

Objectives hierarchies are already commonly used in National Park Service (NPS) planning processes, where tiered objectives, such as those contained within an objectives hierarchy, can connect seemingly disparate documents (Figure 1). For instance, the kinds of broad, value-laden purpose or mission statements found in foundation-planning documents (comparable to the top-tier objectives in a hierarchy) are supported by descriptions of fundamental resources and values. More-specific goals and objectives describing desired conditions for fundamental park resources (comparable to the second-tier objectives) are used in general management plans. Finally, detailed technical objectives and targets (comparable to subsequent-tier objectives) are used for achieving short-term, specific goals, and may be found in resource-implementation or annual plans.

Objectives hierarchies are less commonly used to link management, planning, and science goals. One excellent model that achieves this integration originated in the management plan for South Africa's Kruger National Park (Biggs and Rogers 2003; KNP 2006). There, objectives are expressed as a hierarchy ranging from a broad, value-laden vision of the park's mission to explicitly stated objectives needed to realize this broader vision (Keeney 1992; Biggs and Rogers 2003). The vision identifies key elements that reflect the social needs and values for Kruger, such as biodiversity, human benefits, wilderness, naturalness, and custodianship. In contrast, entries at the finest level of the hierarchy are intended to represent explicit operational targets, ultimately manifested as "thresholds of potential concern" (Biggs and Rogers 2003; see Bennetts et al., this issue), similar to what we are calling "assessment points."

Developing a hierarchy of objectives can be a large undertaking, as one goal of the hierarchy is to capture all levels of detail for existing information. In most cases, not enough information is known to get us exactly where we wish to go (i.e., there are no road signs), but the purpose of the

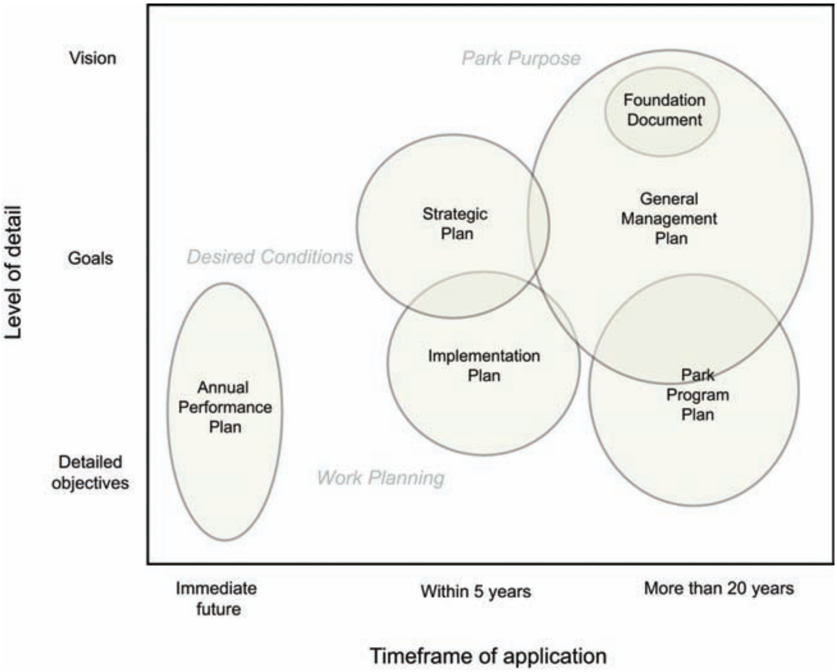


Figure 1. The relationships among NPS planning documents with respect to the level of detail found in objectives, and the intended timeframe. The intended results (shown in gray) are relative to the particular plan being considered.

framework is to help us prioritize objectives and to capture the current state of knowledge. In addition, we do not need to build the objectives hierarchy all at once; the overall strategy can be developed over time. However, because the different components are interdependent, the broader-level components usually must be developed before we can realistically and effectively develop more-specific ones.

Also, although the overall hierarchy has strategic value beyond the sum of its parts, the individual parts have inherent value in and of themselves. Therefore, even if we don't have the information needed to construct a complete and detailed hierarchy, there is considerable value in developing the parts for which we do have the necessary information. Constructing the branches for one component (e.g., biodiversity goals for zone X) may help us to see logical pathways for another (e.g., cultural values).

The National Capital Region example. Figure 2a depicts an abbreviated objectives hierarchy for the National Capital Region Inventory and Monitoring Network (NCRN), fleshed out in Figure 2b to show actual objectives for one example. The overall framework begins with the broad NPS mission to conserve resources and becomes increasingly specific depending on the resource area of interest. While the hierarchy includes several NPS programs (e.g., cultural resources, natural resources, and interpretation), our example (Figure 2b) highlights a specific aspect of natural resources (but see also Hubbard et al., this issue, for application to cultural resources). Objectives become increasingly more technical and detailed as one moves down the hierarchy. It is important to note that the hierarchy is cross-linked at many levels. For example, objectives for forest vegetation are relevant not only to objectives concerned with focal species, but also to objectives for air (e.g., in terms of pollutant impacts), ecosystem (e.g., habitats), and water (e.g., watershed protection). The level of detail is limited by the current amount of understanding.

Distinctions among objectives

Objectives related to planning. Management objectives (e.g., those related to planning) define the desired state, condition, or dynamics of an ecological system, and can be located throughout an objectives hierarchy. A myriad of terms can be used to portray some sense of what we want to achieve in the future (e.g., desired condition, target condition, acceptable condition, management target, management objective, range of natural variability, range of acceptable condition). Unfortunately, different organizations often tend to use the same terms (e.g., "desired condition") in disparate and highly specific ways in their planning efforts. The same terms also can be used differently within an organization when they are related to different scales (e.g., park- or zone-specific). As long as we operationally define our terms so that others may understand exactly how we are using them, we believe that establishing an objectives hierarchy can help us to move beyond semantic differences and toward more strategic thinking, because it helps us to explicitly visualize these terms and the scale within which they are being applied.

That stated, even the most general objectives can be hard to define. To be useful for decision-making, management objectives need to be specific, measurable, achievable, results-oriented, and time-fixed (Williams et al. 2007). Furthermore, regardless of how much time is spent defining and justifying them, management objectives are likely to change as new issues and priorities arise. It is important to recognize that objectives can differ in level of detail, intended time-frame, and primary purpose. Also, each type of objective can inform multiple types of planning (Figure 1).

Objectives related to learning. Monitoring and research objectives (i.e., those related to learning) tend to be more specific than management objectives, and often occur on lower tiers of the objectives hierarchy. Monitoring objectives define the measurements of the desired state, condition, or dynamics (as defined in management objectives). In this context, monitoring objectives directly inform management decisions because the two are linked (Yoccoz et al. 2001). We discuss an example of linked objectives later in this section.

Research objectives help to inform what is not known by promoting learning and understanding about the nature and dynamics of ecological systems. Others have classified these sorts of objectives as "scientific" (Yoccoz et al. 2001). Whatever the classification, these objectives tend to address the "why?" questions, as well as causality: "What is the response?" or "What is the consequence of doing nothing?" Research objectives have the potential to be invaluable to monitoring and management efforts because they help to quantify the significance (i.e., effect size) of important variables.

Research objectives also can be used to evaluate different management options. This is at the heart of what is often referred to as "adaptive management" (Holling

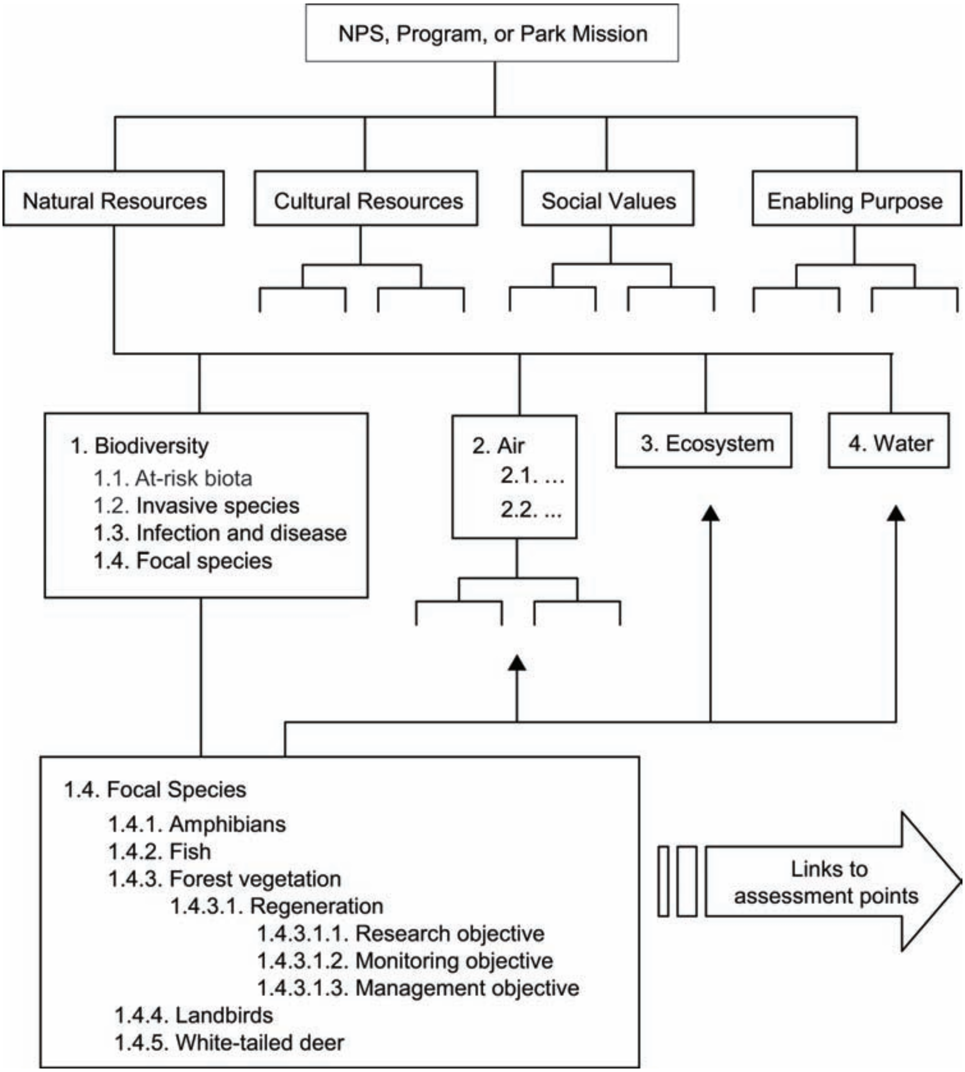


Figure 2a. An abbreviated objectives hierarchy for the National Capital Region based on the framework of Biggs and Rogers (2003). Statements for each level of the hierarchy range from value-laden and general (vision statement) to detailed and technical (objectives).

1978; Walters 1986; Lee 1993; Williams et al. 2007).[1] To do this, researchers apply alternative management actions in a study context in exactly the same way that they would otherwise apply experimental treatments. The intent is to explicitly evaluate the response of these alternative management actions in order to determine which are more effective at achieving management objectives.

Differences of purpose, rigor, and uncertainty. While an objectives hierarchy unifies differences in detail and time-frame, individual objectives can differ with regard to purpose, uncertainty, and rigor (Table 1). Different program areas have different rea-

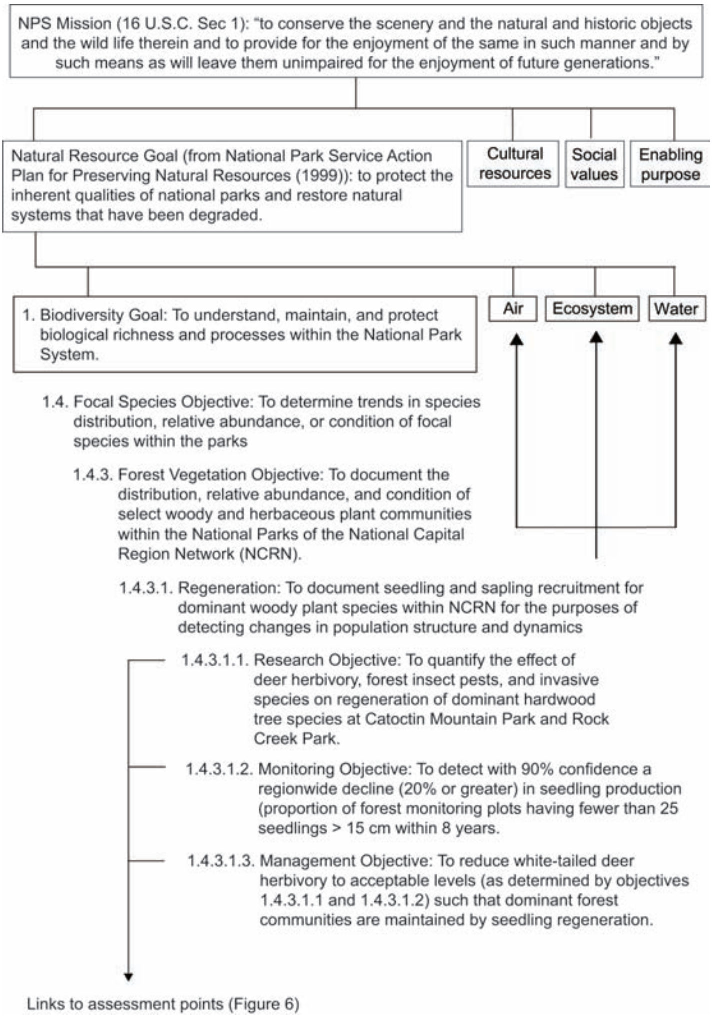


Figure 2b. A selection of hierarchical objectives for seedling regeneration, expanded from Figure 2a. Objectives become more detailed and explicit as one moves down the hierarchy. Note that Management Objective 1.4.3.1.3 is directly linked to the data provided by related monitoring and management objectives. Desired condition, early warning, and impending-loss assessment points relating to the regeneration objectives are shown in Figure 8.

sons for collecting environmental data. Each need may be equally valid and informative, yet how one controls uncertainty and defines an acceptable level of effort (rigor) can be quite different, according to his or her objectives. For example, a program charged with monitoring population abundance for forest insect pests (e.g., gypsy moths) will use objectives and a sampling design appropriate for detecting population trends or rates of change while also ensuring a desired amount of statistical precision. However, a management objective meant to control pest outbreaks, or a research objective meant to examine the implications of an outbreak, each has a different fundamental

Forest-insect Pests		Program areas		
		Monitoring	Management	Research
Considerations	Purpose	Detect trends	Prevent impairment	Quantify effects
	Uncertainty	Statistical "Is it *real*?"	Efficacy "Is it *working*?"	Causality "Is it *meaningful*?"
	Rigor	Survey design	Document actions	Experimentation

Table 1. An example of how particular program areas might consider a particular monitoring indicator. Each program can have fundamentally different, yet equally valid, objectives for collecting and using similar data.

purpose, and requires a different level of rigor, design, and analysis.

Linking management, monitoring, and research objectives. Management, monitoring, and research objectives should complement one another, but are not the same, and are not each defined at every level. The suite of these three objectives shown in Figure 2b illustrates how objectives can be used to gain complementary information. In this example, to best understand regeneration in the National Capital Region, research examines the potential causes of decline (herbivory, insect pests, and invasives). Monitoring documents the current condition and trend of indicator measures (seedlings), and management evaluates actions that use research and monitoring results.

As another example, using stratification and covariates that are meaningful to managers can help to improve monitoring inference. To derive inference for an entire park unit, for instance, all of the areas of that park must have at least some chance of being sampled. Stratification is often used to partition the areas that are more likely to respond similarly to change. If strata relate to management regimes (e.g., planning zones), then additional information can be derived about the effects of those management regimes. Similarly, we can often improve our precision for estimating trends by accounting for some of the sources of variation. For example, bird populations often respond to changes in vegetation; by accounting for changes in vegetation, we improve our estimates of trend in bird populations. When we can connect these sources of variation to management actions, we can derive additional information about the effects of those actions.

How objectives should be used

Strategically and proactively. Objectives are most effective when used within a strategic, forward-looking approach, whereupon the bulk of the work is done up front (i.e., "strategic adaptive management," *sensu* Biggs and Rogers 2003). Strategic adaptive management differs from traditional adaptive management in that objectives are not necessarily linked to specific management actions. Instead, emphasis is placed on increasing understanding about ecological phenomena before action is warranted. The formalization of what is known, or what needs to be known, as early as possible maximizes the window of time for securing funding and garnering support for potential management actions in the future.

A priori objectives can be extremely powerful, do not require a wealth of scientific data, and help us to gain the data we need. When linked to early warning assessment points (see below), *a priori* objectives ensure that relevant data are collected *before* management action is required. The time spent synthesizing information up-front pays dividends later in terms of identifying research needs and collecting monitoring data. Allowing for the maximum window of opportunity in which to collect data improves the quality of the options available when action is required.

To express a hypothetical desired state or condition. How objectives are stated is very important. To return to our trip-planning analogy, people often disagree not about where they want to go (i.e., the desired condition of the resource), but how they want to get there, or whether they can get there feasibly within their logistical or financial constraints. Therefore, objectives that strive to bring about or explain a desired condition should be adaptable and accommodate different paths toward the same end result. Whatever its goals, each objective should be considered as a hypothesis that is open to debate. Treating objectives as hypotheses is essential for refining certain assessment points (see below). Assessment points meant to indicate reaching a desired condition may shift in time and space, which may lead to uncertainty about whether we have achieved our objectives. As we navigate to our intended destination, the negotiation of objectives, desired condition, and assessment points requires a similar negotiation in determining that "Yes, we have arrived."

Historically, the objectives (especially management objectives) developed by agencies within the Department of the Interior have been constructed based on actions, rather than a desired state, outcome, or condition. For example, an objective for fire management might be stated as, "to burn the grassland habitat of a given park every seven years." This objective is fine, if the intent is to account for the activity of park personnel. If, however, the intent of burning is to reduce the encroachment of shrubs, then this objective does little to ensure that result. An alternative objective, expressed as a desired state, might be, "using fire as the primary tool, maintain a maximum of 20% shrub cover on the grassland habitat." An objective expressed as a desired condition provides a much stronger basis for evaluating how well the intent of the action was achieved. Using our trip analogy, adopting an action-based objective would be similar to stating that our objective was to drive, but failing to express where it was we wanted to go.

Cross-linked and iterative. Effective environmental stewardship will incorporate monitoring, management, and research objectives such that they complement and reinforce one another. Monitoring objectives in the absence of management objectives will be of limited value, and building an effective research strategy that will inform management decisions requires having some sense of management goals. If you don't know where you are, then you won't know where you are going.

Assessment points

If an objectives hierarchy expresses where we want go, then assessment points help us to navigate the way. Assessment points are predefined and often negotiated values that signal important changes to the resource being monitored. They can be defined even in the absence of empirical data, and crossing a point does not imply that immediate action is warranted. Assessment points are forward-looking tools that advise us, as in the road sign analogy, when we should pay attention and begin making adjustments (Caution; Slow Down; Stop!). By linking our objectives hierarchy with a series of assessment points, we directly link desired-condition objectives (i.e., those related to management) to learning objectives (i.e., those related to monitoring and research), thereby linking the management, planning, and monitoring functions of the National Park Service.

Assessment points can tell us where we are, which routes makes the most sense given where we want to go, and how long it might take us to arrive. Let's imagine that we can construct a set of objectives that define resource condition along a spectrum, from complete degradation to no impairment. This can be a straightforward exercise if we know what the destination (desired state or condition; say, "no impairment") looks like (i.e., we have been there), which is seldom the case. In the absence of that knowledge, however, we can define points of interest along the spectrum indicating important transitions (e.g., changing from a desired state to a less-desirable one). In this section, we describe three types of assessment points that are useful for natural resource stewardship and planning: (1) points that describe desired condition, (2) points that serve as an early warning, and (3) points indicating imminent loss of the resource (Figure 3). We must make two assumptions when constructing these types of assessment points. First, we assume that we can meaningfully define the continuum from undesired to desired condition (i.e., we have an idea of where we want to go). Second, we assume that we can accurately observe when the transitions occur (i.e., that road signs exist and we can read them).

Data, especially those collected from rigorous monitoring protocols, are critical to the use of assessment points. We can imagine monitoring data as repeated snapshots of ecological condition over time; each monitoring event tells us where we lie along the full spectrum of possible condition. In this context, our status bar provides an upper and lower limit to condition, and monitoring data indicate where we are, where we are headed, and (ideally) how fast we will get there.

Desired-condition assessment points. The first type of assessment points we consider are those that represent the upper bound of what is considered acceptable (i.e., "desired") condition. If these points were road signs, they would read, "Welcome to your destination!" or, conversely, "You are now leaving D.C." Desired condition does not necessarily imply a pristine ecological state. In some instances, it may be impractical or unreasonable to use an ecological standard that may not be reached in the foreseeable future. For example, national parks within urban settings face an onslaught of stressors that are generated outside park boundaries (e.g., polluted air or water entering the park). That is not to say that desired-condition assessment

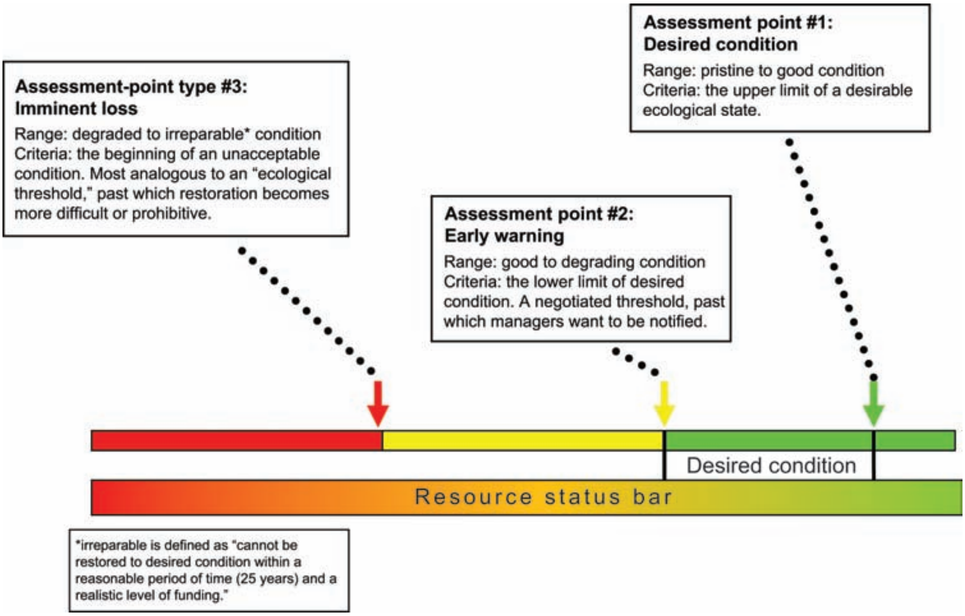


Figure 3. Generalized status bar spanning wholly degraded to pristine resource condition (condition improves moving left to right). Three types of assessment points related to relative condition are shown: (1) desired condition, (2) early warning, and (3) imminent loss.

points do not have an ecological basis in such places; they do. However, a desired condition may be one that minimizes external threats, instead of eliminating them.

The benefit of identifying a less-than-pristine desired condition is prioritization; doing so sets a more reasonable benchmark for restoration and management activities (Figure 4). Setting a reasonable standard for restoration allows managers to shift resources more easily than if they were continually trying to achieve pristine conditions that are unrealistic. It also allows some flexibility in defining the upper limit of pristine when natural and cultural mandates conflict. For example, a historic battlefield park may be required to maintain a cultural setting (e.g., pasture land, fields, small woodlots) that is at odds with an unmanaged community (e.g., an oak–hickory forest; Figure 5). Setting a desired-condition assessment point that is slightly less than ideal allows for such conflicts to exist.

An alternative approach is to use the desired-condition assessment point as a conservative upper limit that may be revised upward as new information is acquired. When scientific evidence is scant or equivocal, it may be more practical to set the upper bound where definitive information exists that is locally relevant—so-called "regional benchmarks." In this context, the desired condition does not refer to the ideal condition of a particular indicator, but to the best condition that exists within a more regionally defined area.

Early warning assessment points. The second group of assessment points is used to signal potentially harmful trends in resource condition. These points are proactive in nature, and are critical because they (1) synthesize current knowledge, (2) gen-

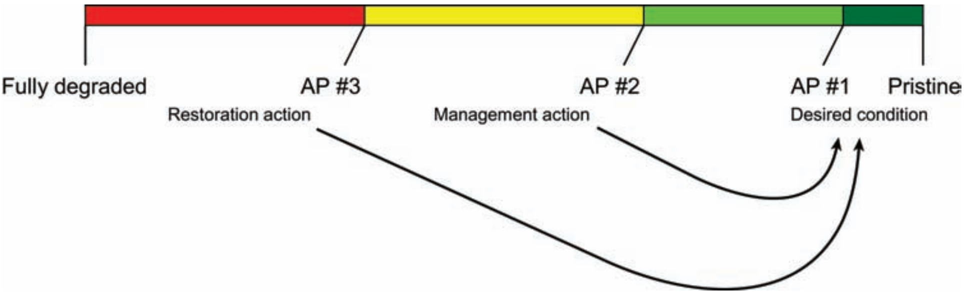


Figure 4. Status bar showing assessment points (APs) as related to management actions. Research that refines understanding of desired ecological condition is prioritized when status is good (above AP #1). Identifying funding options and defining management strategies that mitigate impairment or restore condition are prioritized when condition is declining (moving from AP # 2 to AP #3). Restoration action is required when condition is poor (below AP #3). Assessment point #1 (desired condition) does not necessarily define a pristine state, but rather serves as target for management and restoration actions.

erate a research agenda to refine points, and (3) are the most cost-effective because they are the road signs that say "Slow Down," "Caution," or "Trouble Ahead," allowing managers to take action while restoration is still feasible.

Detection of an early warning does not necessarily trigger management action. What it does trigger is a meeting in which those collecting the data (via a monitoring program, for example) brief those using the data to make decisions (resource managers). "How confident are we with these data?", "How fast are conditions degrading?", "What are the management options?", and "How much could restoration cost?" are all questions that could be addressed during this briefing. We cannot stress enough the importance of using early warning assessment points to get the attention of resource managers; given the wide variety of crises faced by land managers on any given day, early warning points give scientists and managers alike the opportunity to stand back, take a breath, and evaluate the current situation (Figure 6).

Scientists and managers must negotiate early warning assessment points in advance; that is, they must agree about where the points should be located. Regardless of whether a given point will be based on an ecological threshold, a user capacity standard, a desired condition, or some other parameter, scientists and managers need to decide, together, how cautious they want to be, and what degree of assessment will be warranted at a given point. Do managers want to be notified only when a point of con-

Figure 5. National parks meant to preserve historic events may also contain significant natural resources, which often requires managers to balance competing objectives to preserve both natural and cultural resources. Photo courtesy of Tom Paradis.

Figure 6. Invasive species are more difficult to eradicate after they are established, making early detection of outbreaks highly important for managers. Photo courtesy of Tom Paradis.

cern is imminent, or well in advance of any concern? When should a synthesis of the expected consequences be conducted, and conducted by whom? Is there a need to synthesize the evidence for expected responses to alternative management actions? These decisions should all be negotiated and agreed upon between scientists and managers. As a matter of course, early warning assessment points are likely to differ among parks to reflect different resource situations and different judgments of individual scientists or managers.

It should be recognized, from the outset, that a primary purpose of assessment points is to enable more informed decisions. This is most likely to come about when it is done in such a way as to be mutually beneficial. The process of scientists and managers working together to determine what would work best in their situations has the additional value of beginning a dialogue that should help scientists to better understand the information needs of managers, and help managers to play a stronger role in understanding the strengths and limits of the scientific process as well as making the science more relevant to their needs.

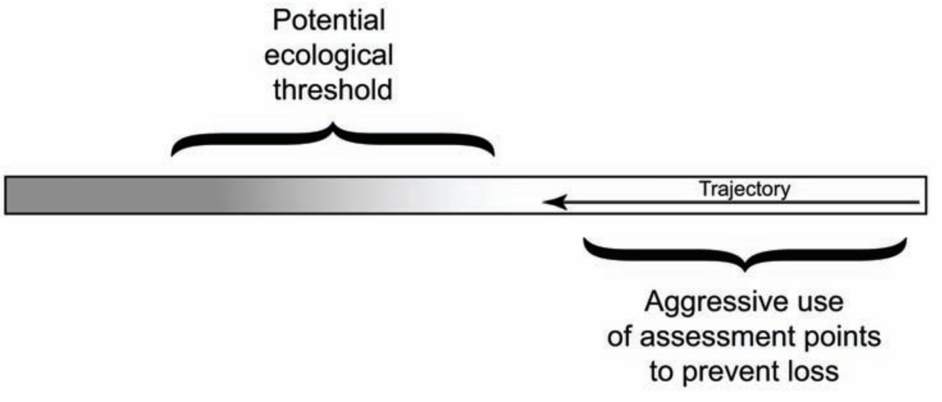
Assessment points used to prevent loss. To many ecologists, assessment points generally evoke the idea of "ecological thresholds" (Bennetts et al., this issue). Of the three types of assessment points described here, those used to prevent loss are most closely related to that concept, because they indicate a fundamental change in the functioning or sustainability of the ecological system. In contrast to other kinds of assessment points, which may represent the bounds of a desired condition or other subjectively defined state, these mark the point of potentially irreversible loss of the resource and, therefore, should be considered as a special class wherein management intervention to prevent the loss or reverse the trajectory is unequivocally warranted.

Unfortunately, these types of points are often the result of complex, non-linear interactions of ecosystem components that are difficult to predict. Consequently, they tend to be retrospective in nature, and are used for crisis management. They signify the breaking point of irreparable loss or impractical restoration (Figure 4). Management options are generally very limited, costly, and tend to be less effective at these points. As such, if the expectation of such an ecological threshold is the basis for these assessment points, then a more conservative and aggressive approach to assessments prior to these points' being reached is warranted (Figure 7), likely requiring more frequent and/or more in-depth assessments when a trajectory is approaching a predicted ecological threshold (i.e., when the early warning assessment points indicate a problem).

Linking objectives and assessment points. In the case of the NCRN, forest management strategies are enhanced by linking different types of objectives to one another using assessment points (Figures 2b, 8). The definition of a desirable state is based upon acceptable ranges of ecological condition, which is defined by the zone between assessment points #1 (desired condition) and #2 (early warning). Monitoring objectives provide status information that informs management objectives. Predefined assessment points are used to inform management decisions about seedling regeneration and the presence of invasive species and insect pests.

If information is not known about a desired range for an indicator, then research objectives (in conjunction with covariates and stratification) explicitly identify assessment points that are needed. In the NCRN example, not enough information is known to define the point at which the occurrence of insect pests causes irreversible harm to the forest community (Figure 8). Research elucidates assessment points, monitoring uses them to provide context for ecological condition, and management uses them to define appropriate management strategies.

Figure 7. A generic resource status bar showing a potential ecological threshold (analogous to assessment point #3). As resource condition for a particular indicator declines, assessment points should be used more frequently and conservatively to ensure that loss does not occur.



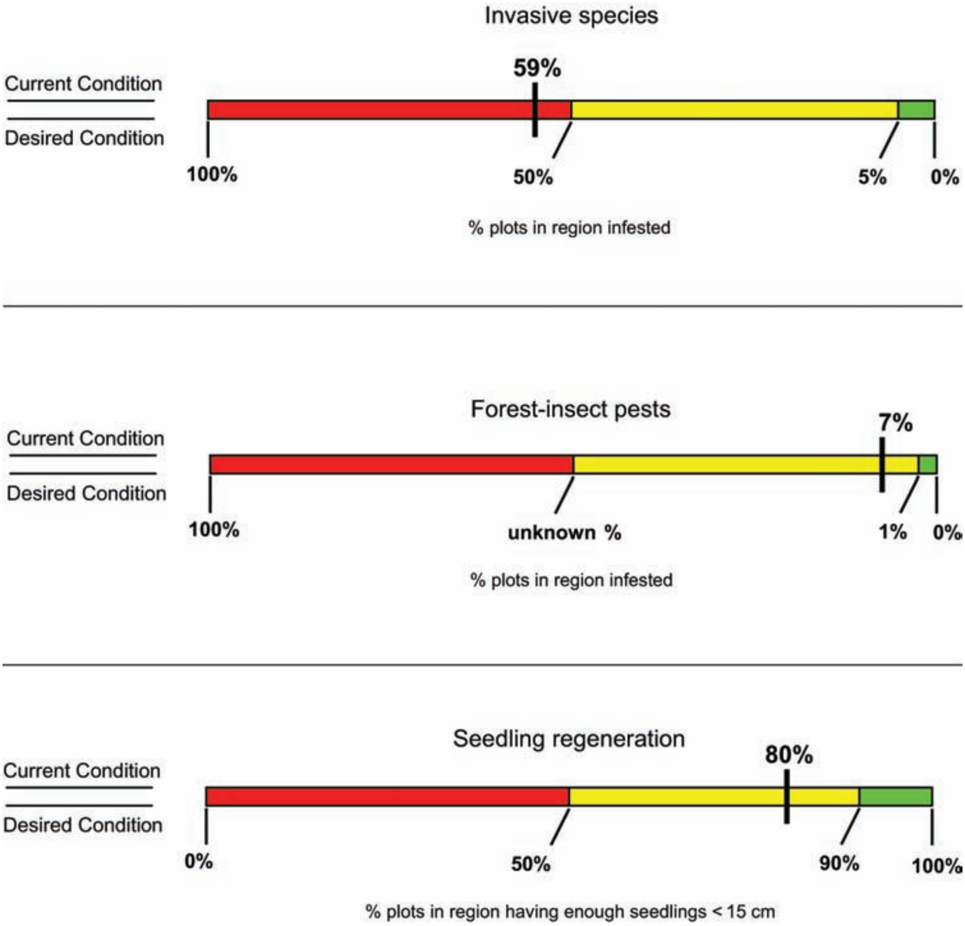


Figure 8. Three status bars used for monitoring indicators related to forest vegetation for the National Capital Region Network, measured in 2007. Current status is indicated above the resource status bar; assessment points related to desired condition are below. A large percentage of plots contain at least one exotic species. Low seedling regeneration (<90%) and high occurrence of forest insect pests (>1%) are of concern when current status is compared to early warning assessment points.

Conclusion

An objectives hierarchy and associated set of assessment points are not unrelated ideas; each improves the other. You can reach your destination with only a road map (i.e., a set of objectives) or by only reading road signs (i.e., assessment points). However, the trip is much easier, and probably quicker, when you have a clear travel plan and navigational aids to guide you.

The ideas we present here are not new; the NPS has established a planning framework that uses tiered goals and objectives (Figure 1), Kruger National Park has shown how thresholds of potential concern (what we call "assessment points") can be used within an objectives hierarchy (Biggs and Rogers 2003; KNP 2006), and the value of using interrelated objectives is a cornerstone of the adaptive management process

(Williams et al. 2007). Yet, the explicit use of predefined points that define acceptable resource condition, and the process of linking them to planning processes, has not become institutionalized in the NPS. Two new initiatives are taking on this challenge: resource stewardship strategies and watershed condition assessments (please see www.nps.gov/policy/DOrders/draftDO2-1.html; and www.nature.nps.gov/water/watershedconds.cfm [an internet site], and www1.nrintra.nps.gov/wrd/Watershed/index.cfm [an intranet site], respectively]. Our purpose for this paper is to encourage the use of predefined assessment points in all levels of natural resource stewardship planning. Assessment points, when linked to explicit, predefined objectives, offer a consistent framework for characterizing and understanding resource condition. Perhaps a good metaphor for life may also have relevance to the integration of science and management: the journey is as important as the destination.

Acknowledgments

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Endnote

1. The Department of the Interior's definition of "adaptive management," which was adopted from that of the National Research Council (2004), is as follows: "Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural varability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders" (Williams et al. 2007:4).

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