Linking Monitoring to Management and Planning: Assessment Points as a Generalized Approach

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Introduction

One of the major reasons for implementing an environmental monitoring program is to provide early warning of abnormal conditions, impending concerns, or potential shifts in resource values relative to management goals. Given the complexities of the ecosystems being monitored by land-management agencies and the myriad indicators that are used to assess these ecosystems, even the most diligent resource manager could fail to recognize the signals of impending change in the absence of an explicit process for systematically assessing sometimes subtle and cumulative evidence. In this paper, we offer the concept of assessment points as a tool for improving our ability to use monitoring data to inform the management of parks and protected areas.

Put simply, "assessment points" represent preselected points along a continuum of resource-indicator values where scientists and managers have together agreed that they want to stop and assess the status or trend of a resource relative to program goals, natural variation, or potential concerns. These points provide an opportunity to synthesize and consider a wide variety of information about the desirability, acceptability and risks imposed by the status and trend of the resource(s) in question at that point and to further consider potential management options. As such, assessment points provide a means of detecting conditions that may warrant management action with sufficient lead time to enable managers to identify and implement options that may halt or reverse an undesirable trajectory before significant damage occurs.

The idea of assessment points is not new, nor original to this paper. Rather, in this effort we have attempted to: (1) build upon good ideas that have come before us, (2) overcome perceived challenges to the widespread use of existing concepts, and (3) facilitate application of these concepts into management planning and decision-making processes for North American parks and protected areas.

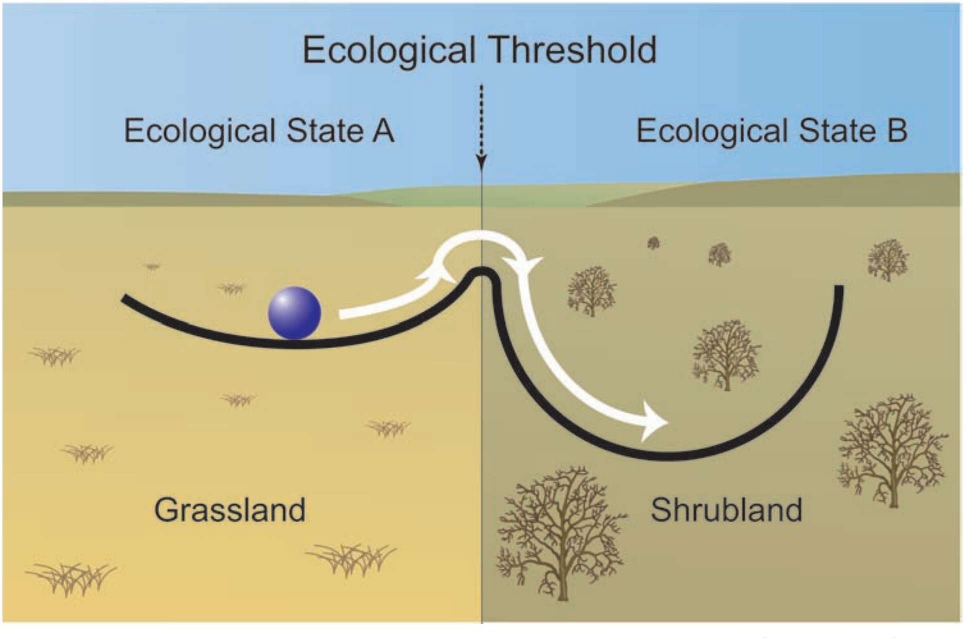
In what follows, we describe some of the existing concepts upon which the idea of assessment points is based and identify challenges to their incorporation into a management context. We explain how assessment points can be viewed as a unifying tool that enables several of these evaluative approaches to be incorporated into a single, generalized conceptual framework for using monitoring data to inform management. We outline different types and uses of assessment points and provide an example of how they could be applied in a management and planning context. Finally, we offer some advice on how to get started using assessment points.

Other concepts that identify points or zones of interest

Ecological thresholds. Among the many definitions of the term "ecological thresholds," a common thread is that they represent a point or zone in which abrupt change occurs in some ecosystem condition (e.g., a state, pattern, or process; Figure 1) (Radford and Bennett 2004; Groffman et al. 2006). Ecological thresholds are important to managers because there are consequences to crossing them. Some changes are practically irreversible, while many others can be reversed only at great expense (Groffman et al. 2006).

Despite widespread agreement among scientists that ecological thresholds are real and can be extremely important, they have not been widely used or accepted by managers. One of the biggest challenges to using ecological thresholds in a management context is the uncertainty or unpredictability involved. Because threshold responses are often complex and influenced by multiple factors (Lindenmayer and Luck 2005; Groffman et al. 2006), we can rarely predict an impending threshold-type change with any confidence. For example, of the nearly 100 examples of threshold-type changes documented in a single database (Resilience Alliance 2007), most were described only after they occurred. In addition, the act

Figure 1. Ecological thresholds are often illustrated by a ball-and-valley diagram to represent the tendency to stay or return to a given ecological state or condition or the energy required to change to an alternative condition.



of trying to determine quantitative points representing the threshold between "desirable" and "undesirable "is problematic given its subjectivity and frequent differences of opinion by stakeholders. Not surprisingly, natural resource managers have been reluctant to base decisions on poorly understood threshold values or responses.

Another obstacle to more widespread use of ecological thresholds includes the ease with which gradual change, occurring before a threshold is reached, can be overlooked (Lindenmayer and Luck 2005). Issues of spatial and temporal scale, such as when resources are influenced by factors that extend beyond park boundaries (Jones et al. 1996; Groffman et al. 2006), or when park resources may be more a reflection of past land use changes than current park habitat condition (GAO 1994; Woodroffe and Ginsberg 1998), are also challenging.

Critical loads. The idea of critical loads was developed in Europe for assessing atmospheric deposition (Nilsson and Grennfelt 1988). In North America, critical loads are similarly used to protect federal land resources from negative impacts of atmospheric deposition (Porter et al. 2005). Critical loads represent the amount of exposure to one or more pollutants an environment can tolerate before suffering harmful effects. Although similar to the idea of ecological thresholds, the concept of critical loads is used in a relatively narrow context, where predictability of harmful effects is more likely. As such, it is often used as a policy or regulatory standard (see below) where the harmful effects of concern are explicitly specified.

Regulatory or policy limits and standards. A wide variety of limits and standards are used in a policy or regulatory capacity. These are usually based on health effects (e.g., Environmental Protection Agency [EPA] primary standards) or environmental effects (e.g., EPA secondary standards), and generally represent the acceptable limits of a given condition. State and federal standards of air and water quality are well-known examples. The National Park Service (NPS) uses standards in conjunction with indicators as an approach to facilitating decisions regarding the management of public use (user capacity) (NPS 2005a; Figure 2). User capacity indicators represent measurable parameters used to track changes relative to desired resource conditions and visitor experiences that are affected by public use—similar to the way in which the NPS Inventory and Monitoring Program (I&M) monitors "vital signs" in order to track changes to natural resource conditions (Davis et al. 2003). In contrast, user capacity standards represent the minimum acceptable condition for each indicator, and are used as a "management threshold" (see below) that requires action.

Management threshold. A management threshold represents a point or zone that triggers management action within a given context. The key distinction between ecological and management thresholds is whether it is an ecosystem that undergoes change (ecological thresholds), or the management of that ecosystem (management thresholds) that undergoes change when a threshold is crossed. However, management thresholds are intended to facilitate *a priori* consideration of undesirable ecosystem changes (e.g., ecological thresholds) and enable more proactive management responses.

Management thresholds also have not achieved widespread acceptance as a management tool among protected area managers. One likely reason is that park and

Figure 2. User capacity represents the types and levels of visitor and other public use that can be accommodated while sustaining desired resource conditions and visitor experiences. Photo credit: National Park Service/Jim Peaco.

reserve management decisions are not based solely on ecological science; managers need to integrate ecological, social, economic, and political values into management decisions (see also Lewis, this issue). Management thresholds are often perceived—rightly or wrongly—as being too inflexible to accommodate these alternative values, and managers can be understandably reluctant to adopt management actions without considering the full suite of values at the time a decision is made.

Desired condition/desired future condition. The concept of "desired future condition" was pioneered by the U.S. Forest Service (USFS) as part of its strategic planning process in the 1970s and 1980s (Leslie et al. 1996). Since that time, the idea has shifted and evolved within a variety of organizations and contexts, and has been used somewhat differently by different organizations (see also Bennetts and Bingham, this issue). The USFS typically used desired future conditions to define the desired state for each management unit within a national forest, often with respect to a potential vegetation condition (USFS 1993). For instance, a desired future condition could emphasize forage or timber production, leading to the desired state of a climax vegetation community. While today's USFS terminology refers simply to "desired conditions" (36 CFR 219.7), the concept remains in use. Within the NPS general management planning process, a "desired condition" is a park's natural and cultural resource conditions and corresponding visitor experiences that the NPS aspires to achieve and maintain over time (NPS 2006a).

Range of natural variation. "Range of natural variation" and associated terms (e.g., "natural variation," "historic variability") represent an idea that broadly surfaced in the 1960s as a means of guiding natural resource management (Landres et al. 1999). These ideas were largely based on a recognition that past variation in ecosystem conditions and processes could provide a context for guiding current natural resource management decisions, and that disturbances in space and time that resulted in variation were a necessary component of virtually all ecosystems. However, three common criticisms of this approach are that: (1) most ecosystems are no longer sufficiently pristine to enable such evaluations, (2) points in space and time represent a snapshot of specific conditions that are constantly changing and may not be a relevant basis for management, and (3) establishing management goals to limit the range of variation results in maintenance of a static condition for ecosystems that otherwise can be highly dynamic (Landres et al. 1999).

Thresholds of potential concern. Thresholds of potential concern (TPCs) were developed at South Africa's Kruger National Park (Biggs and Rogers 2003; Figure 3), where they were defined as "a set of operational goals that together define the spatiotemporal heterogeneity conditions for which the Kruger ecosystem is managed. TPCs are essentially upper and lower limits along a continuum of change in selected environmental indicators. The suite of

Figure 3. Thresholds of potential concern were developed at Kruger National Park to represent the limits of acceptable conditions, and were used for such purposes as managing elephant populations. Photo by Roy Johannesson courtesy of South African Tourism.

TPCs together represents the envelope within which ecosystem changes are considered desirable" (KNP 2007).

The TPC approach attempts to articulate predetermined responses (e.g., management triggers), as expressed by Foxcroft (2004): "An important aspect of the TPC is that they are preagreed goals, and thus, consensus has already been reached on possible sets of future actions, once the TPC is reached. This therefore implies that management is prevented from stalling or procrastinating at such point." Although we agree that having predetermined management responses is a desirable target for the future, we also believe that managers need an approach that will allow them sufficient flexibility to simultaneously consider a full suite of alternative values (e.g., ecological and social) in a given context. Thus, except where law or policy has determined, *a priori,* that some resources be given priority, having predetermined solutions may not be realistic in many situations. Having explicit assessment points along a continuum of resource conditions can provide a means of guarding against stalling from a lack of information while simultaneously allowing the flexibility needed to incorporate alternative values.

TPCs also extend the idea of ecological thresholds to include the limits of acceptable conditions; however, they are still based on a real or hypothesized ecological envelope of those limits. We extend the application of TPCs slightly to further include legal limits, subjective criteria, and other points where we feel an assessment might be warranted. Our treatment of assessment points is strongly based on Kruger National Park's development of TPCs; we have simply adapted the ideas and the terminology of TPCs to better reflect the North American park monitoring context. Readers are strongly encouraged to explore the extensive work on TPCs at Kruger National Park (KNP 2007).

Assessment points as a unifying tool

All of the concepts above define, either objectively or subjectively, a reference state, condition, or process that we wish to maintain or avoid through management actions (Table 1). In contrast, assessment points are a means of evaluating states, conditions, or processes, and linking monitoring to management actions. We do not suggest that assessment points can or should replace these other concepts. Rather, we believe that assessment points can be used as a common framework to complement these other concepts, and bring added value when used in conjunction with them. Concepts such as ecological thresholds and standards can easily be accommodated within the framework of assessment points, and will often form the basis upon which assessment points are assigned.

> ***Assessment points are a means of evaluating states, conditions, or processes, and linking monitoring to management actions.***

Assessment points bring additional information to bear along the trajectory of an indicator or vital sign, such as whether the trajectory is moving toward the ecological threshold or standard, how quickly that value is likely to be reached, and whether or not other indicators or vital signs are consistent with any undesired change (Figure

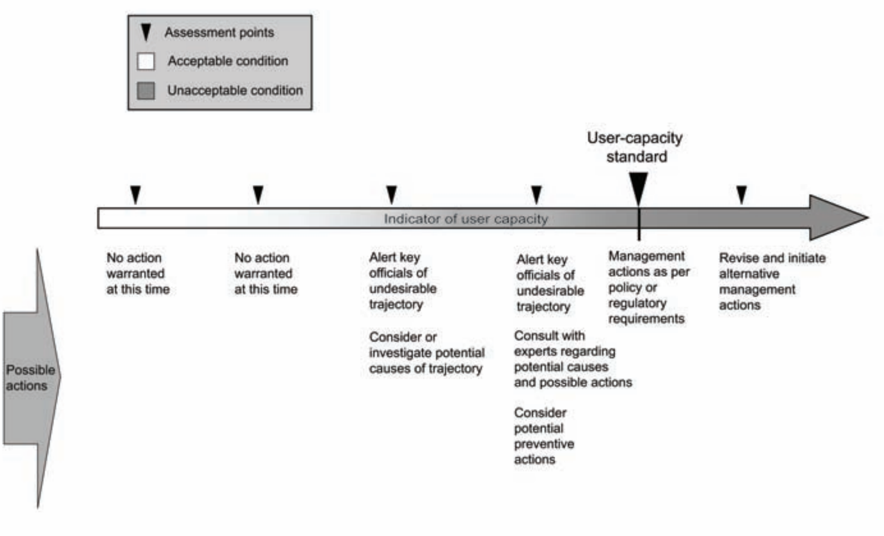
Concept	Management aim
Ecological threshold	Avoid
Critical load	Avoid
Policy or regulatory standard	Avoid
Management threshold	Avoid
Desired condition	Maintain
Range of natural variability	Maintain
Thresholds of potential concern	Avoid

Table 1. Commonly used concepts that describe, either objectively or subjectively, a state, condition, or sometimes a process that management wishes to avoid or to maintain.

4). In short, assessment points can serve as "road signs" (see Carter and Bennetts, this issue) whose purpose is to inform management about the status and trend of an indicator or vital sign, as well as provide additional available information.

In addition, the process by which we propose to use assessment points can be a useful tool for informing management in anticipation of any trajectories of concern. Assessment points provide an opportunity, but not an obligation, for managers to take

Figure 4. Concepts such as regulatory or policy standards, or ecological thresholds, can and should be used as assessment points. Additional points can be used to account for uncertainty, evaluate the trajectory toward a point of particular interest, or to consider alternative management options that might halt or reverse and undesirable trajectory before it reaches the threshold or standard.



action prior to reaching a value where a stronger response may be warranted. Such actions could include informing key collaborators of an impending value of importance (e.g., ecological threshold or standard) or compiling information about potential consequences of alternative responses.

Assessment points as part of an adaptive process

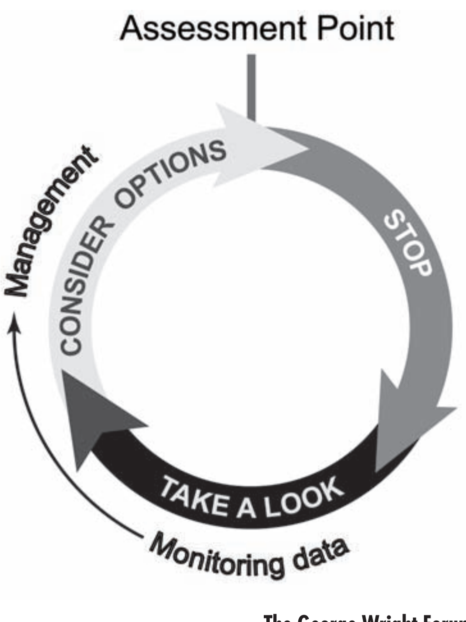
Assessment points are points along the distribution of values (i.e., spectrum of condition) of vital signs or indicators (including stressors and drivers) where managers and scientists agree to stop and take a closer look at existing data to determine the level of risk to a resource. An assessment would typically consider such questions as:

- Are we at risk of crossing a threshold or standard?
- Is the trajectory headed toward a threshold or standard?
- How much time do we anticipate it might take to reach a point of concern?
- What actions might we take that to slow, halt, or reverse the undesirable trajectory?

This "closer look" may or may not lead to a decision to act beyond the assessment itself. The key point is to articulate a process that leads to early detection or anticipation of a potential problem, and to identify and encourage actions that reduce costs and consequences by addressing problems while they are smaller and easier to treat. Below, we outline our general view of a process that is formal, in the sense of being laid out in advance, but also highly flexible and adaptable to the institutions and context in which it is applied (Figure 5).

Stop. The first job of an assessment point is to ensure that there are pre-established circumstances when we stop to engage in an assessment. Having these pre-established circumstances in place is a particularly effective way to decrease the likelihood that subtle changes will evade detection in the course of day-to-day operations. How frequently we assign assessment points will depend on our level of uncertainty about system responses, as well as how conservative we want to be in our detection of changes. The frequency of assessment should be tailored to the needs of a given agency or organization, and it should be adaptable. After one or two assessments, a decision may be made to increase or decrease the frequency or intensity (discussed below) of assessments. At Kruger National Park (Biggs and Rogers

Figure 5. Assessment points can be viewed as part of an adaptive process in which managers and scientists agree to stop and take a closer look at existing data to consider the level of risk to a resource as well as possible actions that might be taken.



2003), managers found that early in their program, their thresholds of potential concern were being reached too frequently, resulting in excessive time and effort. In such cases, the solution is simply to adjust the assessment points until the "right" frequency and intensity of evaluations are achieved.

Take a look. This is the stage at which monitoring data play the strongest role, because it requires checking the status of a suite of appropriate indicators. Status can be evaluated by metrics such as the number of indicators that suggest concern is warranted, or how close the values of indicators are to reaching an undesirable condition.

However, as we have emphasized, adaptability to the particular institutional framework will be a key to success. An assessment need not be an extensive, costly effort if the assessment point was conservative and there is little evidence that indicators are pointing to a problem. In contrast, indications of an imminent, important change would trigger a more intense assessment that could include alerting additional staff of the problem, engaging additional experts, or commissioning a separate study. If management actions resulted from previous assessments, then the management response should be included as part of the current assessment.

Consider what, if any, management options should be exercised. The intention of this step is to consider whether action can, or should, be initiated when the condition of a resource has reached, or is approaching, an undesirable state. The intent is not to dictate an *a priori* decision to initiate a specific management action, except where other mandated standards or thresholds already exist, or when agreement on the appropriate action has previously been made. At this step, the total suite of values could be considered in the context of the strength of the evidence that an undesirable condition has occurred or is forthcoming, and of the seriousness of that condition (e.g., Is it reversible? What other ecosystem components are likely to be affected?).

In addition to direct resource management action, other potential actions include:

- Informing certain individuals of the current condition or trajectory;
- Synthesizing information on management options in advance of a future assessment point;
- Considering or commissioning supplementary research;
- Evaluating the risk and costs of not taking action at this time; and
- Consulting other experts.

Types of assessment points

Assessment points, as we envision them, may be assigned for a variety of reasons (see below) and expressed in a variety of forms. To be meaningful, assessment points must represent a quantitative value and avoid ambiguity about whether a given point has been reached. The actual point may represent the measure or value of a given indicator at a given point in time; the value of a derived or aggregated measure or index; or the value of a rate, whether it be the rate or frequency of a given ecological process or the rate of change for the values of a given indicator.

An assessment point's form depends on its purpose. One simple form may be based on time, where annual or other reporting cycles are used as a routine check of indicator values to determine if they meet or exceed values of concern (another type of assessment point). As we indicated, the idea of assessment points does not replace alternative concepts. As such, there may be more than one type of assessment point for a given indicator. For example, a water quality standard may represent one type of assessment point (a legal standard), but others may be used for the same indicator to provide early warning of the impending standard. Similarly, a desired condition may form the basis for an assessment point but be poorly defined or subject to disagreement about the actual value. In this case, assessment points may be used along the trajectory to help refine the definition. Carter and Bennetts (this issue) explore these and other potential purposes in greater detail.

How assessment points are determined

The planning processes used by agencies responsible for managing parks and protected areas generally employ a hierarchical structure that includes a broad mission or vision at a high level, and focuses at lower levels on very specific, quantifiable management objectives or targets in space and time (see also Carter and Bennetts, this issue). How assessment points are determined, and by whom, depends very much on where within this hierarchy they are applied, and for what purpose they are assigned.

It is important to note that assessment points are identified by scientists and managers working together to determine assessments that best fit their particular needs. Except for regulation-driven assessment points, neither policy nor management mandate dictates the frequency or values of assessment points, nor the content of an assessment or potential action. The collaboration between scientists and managers to determine assessment points is, by itself, an important step toward the integration of science and management. Some of the considerations that might go into such a negotiation include:

- Is the assessment point associated with a policy or regulatory standard that requires specific action?
- If the assessment point is based on a desired condition, is that desired condition well defined, or in need of refinement?
- What is the level of uncertainty regarding the resource condition, and how conservative would we want to be in detecting a point of concern?
- If the point is based on a concern about the resource, what are the consequences of overshooting it?
- What frequency, type, and amount of information best fits the needs of scientific validity and the information needs of management?

How assessment points could be used: An example

In 2005, Yosemite National Park completed the *Merced Wild and Scenic River Revised Comprehensive Management Plan and Supplemental Environmental Impact Statement,* which includes indicators and standards for user capacity that could be used in conjunction with assessment points. Ten indicators reflecting the ecological and social values of the river, including water quality (with *Escherichia coli* bacteria as a metric), were chosen. In the Merced River Plan, the standards associated with *E. coli* are "anti-degradation" for each segment and, at an absolute minimum, meet the state and EPA standard for recreational contact (NPS 2005b).

On-going monitoring of eight front-country sites will establish more protective, Yosemite-specific standards (NPS 2006b). Instead of just waiting to see if the standards are reached at some point, managers and scientists could assign a series of assessment points to each standard, along with a list of potential actions that might occur if an assessment indicates that a given condition has been reached. To account for a modest level of variability in *E. coli* laboratory testing, a screening value of 1.3–1.5 times the EPA standard could be used as an assessment point. Because initial monitoring results suggest excellent water quality along the Merced River (NPS 2005c), an assessment point that identifies an increasing trend in colony-forming units (CFU) of *E. coli* would be important. During such an assessment, potential management actions would be considered that would prevent a gradual transition to an undesired state (Table 2).

Why assessment points are relevant to management

For any management option—including assessment points—to be meaningful, we must have some idea of what we want to achieve through management. Whether this is expressed in terms of management objectives, desired conditions, or another form, the important point is that if we don't know our ultimate goal, then it will be virtually impossible to recognize: (1) when we accomplish it, (2) if we are on a right or wrong path, or (3) whether or not our management is effective (see also Carter and

Table 2. Hypothetical assessment points for use with the Merced River Plan.

<table>
<tr><th>Assessment point</th><th>Criteria</th><th>Potential actions
(NPS 2005b)</th></tr>
<tr><td>Increasing CFU before reaching other assessment point (trend)</td><td>Trend moving toward "degradation" (plan standard)</td><td rowspan="7">• Determine if high value is an isolated event or due to sampling error.
• Increase monitoring frequency to determine when E. coli has decreased to a desired level.
• Educate users regarding impacts of activities on water quality.
• Post signs restricting access and providing water quality information.
• Close sections of river temporarily or permanently.
• Restrict or redistribute specific uses (rafting, swimming, etc).
• Expand infrastructure (restrooms, etc.).
• Limit overall number of users through entrance station quotas.
• Reduce/limit stock use in certain areas</td></tr>
<tr><td>50 CFU/100 mL</td><td>Guesstimate of upper range of current condition</td></tr>
<tr><td>150 CFU/100 mL</td><td>Approaching regulatory standard</td></tr>
<tr><td>235 CFU/100 mL</td><td>California and EPA single-sample limit for full-body contact (regulatory and plan standard)</td></tr>
<tr><td>300–350 CFU/100 mL</td><td>Screening value to account for uncertainty</td></tr>
<tr><td>500 CFU/100 mL</td><td>Approaching regulatory standard</td></tr>
<tr><td>576 CFU/100 mL</td><td>EPA single-sample limit for partial body contact (regulatory and plan standard)</td></tr>
</table>

Assessment points could be assigned before degradation occurs, at regulatory standards, to account for uncertainty of the actual value, or to assess the risk of the current trajectory.

Bennetts, this issue). Thus, a key first step is identifying the desirable and undesirable conditions within a management area.

Further, if we realistically expect assessment points to be incorporated into management, then the approach must overcome obstacles that have hindered the use of related concepts by including:

- The capability to cope with the uncertainty;
- The capability to accommodate abrupt or gradual undesirable change;
- The capability to incorporate multiple stressors and/or spatial and/or temporal scales; and
- The flexibility to incorporate a broad suite of values into the management decision process.

Below, we discuss how assessment points are able to meet these and other challenges to linking monitoring to management.

Assessment points cope with uncertainty. Uncertainty in ecological systems is ubiquitous and should not be used as an excuse for failure to take action or to consider a suite of possible actions. However, uncertainty about the precise response to an ecological driver should not be confused with uncertainty about whether there is an expected response to that driver. To use an analogy from human health, most would agree that smoking is unhealthy and can result in cancer, even though we are uncertain about the exact time that cancer is likely to occur. Similarly, the risks of ecological consequences need to be considered even if we cannot accurately predict the exact point at which they might occur. In many cases, there may be early warning signs of a trajectory leading to an undesirable condition. We need to regularly look for these warning signs and evaluate the potential severity and magnitude of the consequences of change.

An important benefit of assessment points is that they provide a means of embracing uncertainty. They also enable us to anticipate undesirable changes with sufficient lead time to enact a management strategy that may reverse or ameliorate an undesirable trajectory early in the process. For example, Figure 6 illustrates a hypothetical threshold that is poorly defined (i.e., with considerable uncertainty about its location). To address this uncertainty, assessment points can be assigned to indicator values preceding the hypothesized threshold, thereby stimulating an examination of all evidence relevant to evaluating whether or not the ecological threshold is impending. Assessment points can be assigned in increasing frequency as the hypothesized threshold is approached (i.e., as its probability of occurrence increases). An adaptive framework promotes the articulation of alternative hypotheses about important ecological processes. A set of assessment points can be implemented to reflect each of the alternative hypotheses as a means to accommodate realistic levels of uncertainty.

Perhaps the most basic form of uncertainty about ecological thresholds in a given system is whether or not they even occur. In a recent synthesis, Lindenmayer and Luck (2005) reported that some studies detected ecological thresholds that were predicted, while others did not. They attributed the diversity of outcomes to both methodological differences among studies and real differences in ecological responses. Similarly, Groffman et al. (2006) suggested that although there is abundant evidence that threshold behaviors occur in many ecosystems, this does not imply that they exist in all systems. The routine use of defined

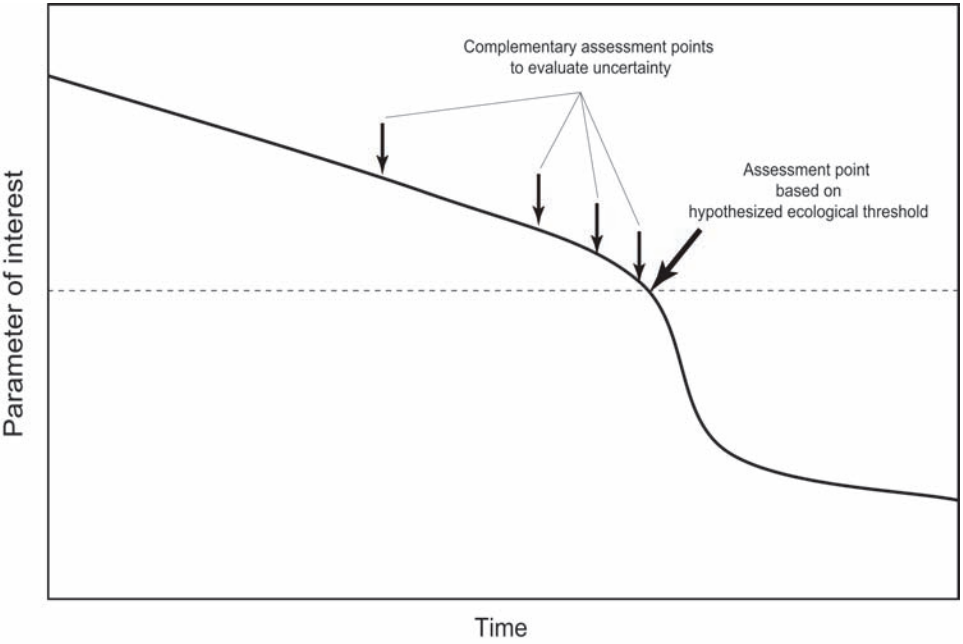


Figure 6. Assessment points can be assigned before a hypothesized ecological threshold is reached in order to account for the uncertainty of the actual value of that threshold or to assess the risk of the current trajectory.

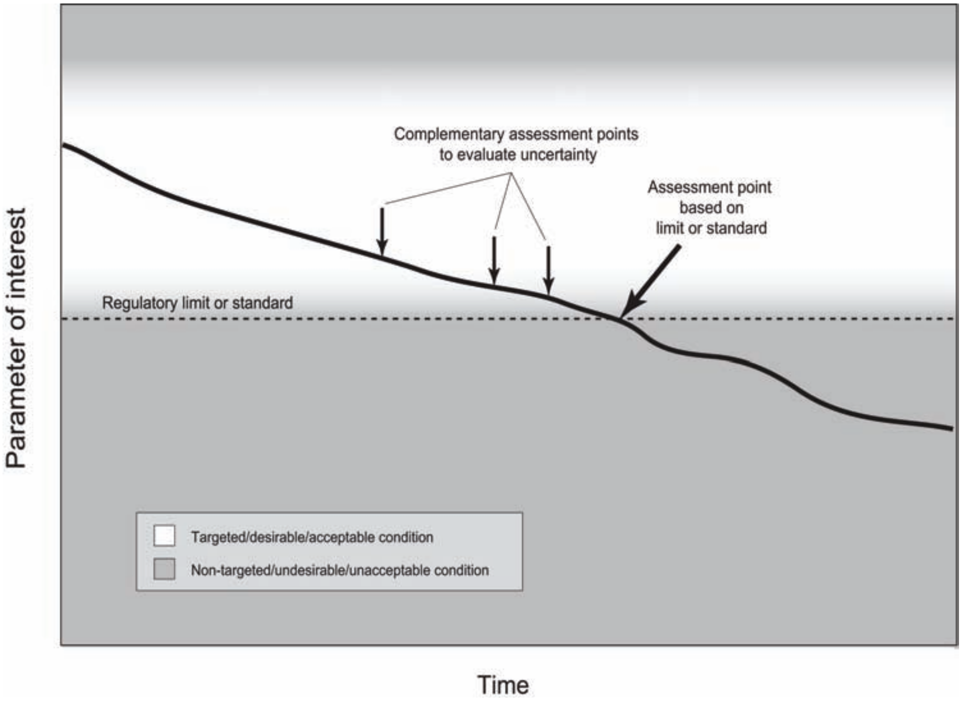
assessment points greatly increases the likelihood that pertinent measurements will be obtained before a system crosses an important ecological threshold. Thus, a key contribution of a formal assessment-point framework can be to help identify, describe, and define the existence of thresholds in a variety of ecosystems.

Assessment points can accommodate gradual and abrupt change. Although most management efforts that have used threshold concepts have emphasized event-driven or abrupt change (Watson et al. 1996; Lindenmayer and Luck 2005), ecosystem responses to stressors can also be slow and gradual (Watson et al. 1996; Rapport and Whitford 1999). Because incremental changes are usually less obvious to observers, an approach that focuses only on abrupt or event-driven change is likely to overlook substantial but slowly occurring degradation (Watson et al. 1996; Lindemayer and Luck 2005). In contrast, assessment points can easily accommodate virtually any type of ecosystem response, provided they have a clear reference to what is considered a desirable condition of the resource or ecosystem. Similarly, there may be consensus that a point exists at which the condition of a resource is no longer acceptable, but disagreement about the precise point where degradation has occurred (see also Carter and Bennetts, this issue). This case is addressed by explicitly defining multiple assessment points along the system trajectory, stimulating the evaluation of criteria to determine acceptability, and determining whether or not those criteria have been met (Figure 7).

Assessment points incorporate multiple stressor effects and multiple spatial and/or temporal scales. Especially when used in conjunction with conceptual models, assessment points can help us to tease out the complex, multiple factors (e.g., stressors, spatial and temporal scales) that may be contributing to change. Conceptual models help to organize our understanding of ecosystem dynamics (Stringham et al. 2003) by identifying known or hypothesized ecosystem stressors (Kurtz et al. 2001; Ogden et al. 2005). They can also help guide our use of assessment points. Say, for example, that an assessment point is based on an ecological threshold related to an abrupt shift in water quality. A conceptual model may identify several indicators of the threshold in question. In this case, evaluation of a cumulative set of indicators may be an explicit part of a given assessment to determine the evidence for an impending threshold. Similarly, an assessment may explicitly call for an evaluation of one or more indicators at one or more spatial and/or temporal scales.

Assessment points can incorporate a broad suite of values. In and of themselves, assessment points do not provide a means for weighting ecological risks against other societal values. However, the process of conducting an assessment at a given point—in contrast to conforming to a predetermined management threshold—offers a simple means of maintaining vigilance over undesirable change, while also permitting the incorporation of alternative values into

Figure 7. Assessment points can be used as a means of evaluating that acceptability along a continuum of change, whether it be gradual or abrupt.



the array of response options at any given point. In fact, consideration of alternative values can easily be included in any assessment.

Assessment points can aid in the planning process. Carter and Bennetts (this issue) describe how assessment points, in combination with an objectives hierarchy, can complement the planning process by helping to link planning, management, and monitoring. They can also help define goals and objectives at various levels of the planning process when such goals or objectives have been otherwise difficult to articulate. Similarly, when the planning process is stalled due to uncertainty, assessment points can play a pivotal role in evaluating alternative options in an adaptive management context, thereby providing a feedback mechanism between monitoring and planning.

Assessment points are financially feasible and responsible. In this age of limited resources, the economic costs of any program—including the implementation of assessment points—must be taken into account, particularly in light of the uncertainty associated with both the risks and the benefits. Here too, assessment points offer a means of balancing costs and risks. If there is little evidence of a detrimental change at a given assessment point, then an assessment may consist of little more than a decision to move on to the next point. This flexibility allows the complexity and cost of an assessment to be scaled to the perceived importance or risk of the particular situation. Addressing potential problems is likely to be less costly if those problems are identified at an earlier stage in their development.

Getting started

Any implementation of assessment points needs to be tailored to the specific needs of a given situation and organization; however, the place to start will typically entail consideration of a series of questions intended to determine three things: (1) what type of assessment points are needed for a given vital sign or indicator, (2) at what indicator values or times assessment points should be assigned, and (3) what should be included in a given assessment. Each of these should be discussed and negotiated initially by an appropriate group of scientists and managers. Appropriate documentation of this process will help facilitate learning from the process as well as to ensure institutional memory of the decisions.

What types of assessment points are needed? Probably the first criterion for determining what types of assessment points are needed is the purpose for which they are being assigned. There will likely be more than one type of assessment conducted for a given situation. If it has not already been determined, a good starting point is to consider what information the indicator or vital sign is intended to convey, and to determine what parameters for the resource would best serve its intended purpose. If assessment points are being used in conjunction with one of the previously described concepts of a point or zone of interest (e.g., standard, desired condition), then that point or the limits of the zone of interest will be one type of assessment point. Additional points could be assigned to provide early warning for that point or zone of concern. If that point or zone is not clearly defined, as may be the case for some desired conditions, then assessment points may be assigned along the trajectory of indicator values to assess the conditions and to refine what is desirable or undesirable. At this point, we might also ask ourselves if there is disagreement about the value of a desired condition. In such cases, rather than the disagreement being a reason to stall efforts, assessment points might be used to help resolve differences of opinion by evaluating resource conditions at intermittent points over time. Again, see Carter and Bennetts, this issue, for more information on types of assessment points.

At what indicator values or times should assessment points be assigned? In most cases, assessment points will be assigned according to both time and indicator values. If a monitoring program has annual or other periodic reporting cycles, then these may serve as a temporal basis for assigning assessment points in combination with actual values of indicators. For cases where the value of a resource indicator has not exceeded a value of interest or concern, then an assessment above and beyond the normal reporting may not be necessary, although this should be negotiated *a priori* (see below). If a point is intended to provide early warning, then it should be assigned based on how conservative that early warning should be. Some managers may want to be aware of an undesirable trajectory long before any concern is warranted; others may prefer to be alerted and consider options only after it is determined that an undesirable condition is imminent.

What should be included in an assessment? The content of every assessment is negotiated from the outset and potentially refined as things progress. As previously discussed and partially articulated in Table 2, assessment may include informing key individuals, evaluating risks of inaction, synthesizing information about potential actions, evaluating complementary indicators, considering supplementary research, consulting with experts, or taking legal or policy-mandated actions.

The simplest case may be an assessment that consists simply of a routine (e.g., annual) report. If the value of an indicator at a routine reporting time is far from a value of concern (as negotiated *a priori*) and the rate of change is not of concern, then the assessment requires no additional action. However, the distinction between an assessment and traditional report is that within the assessment-point framework, the range of values that define "no concern" and the authority to determine that range will have been negotiated from the outset. Assessments that extend routine reporting should also be negotiated, and reflect the information needs and management styles specific to the situation. If assessments are unilateral and forced, they will quickly lose value and interest. Assessments should be adaptive. If they initially take too much time for too little gain, then consider cutting back. In our opinion, assessment points should be viewed as customizing the ways that scientists and managers exchange information for their mutual benefit and the benefit of the resources.

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