APPENDIX E.
WORKING TOWARDS DESIRED, BUT UNCERTAIN FUTURES

For the most part, the process of defining desired conditions will bring the manager to a characterization of the resource appropriate for the near future, possibly up to 25 years. This is a reasonable time frame to think through long-term strategies and avoid reactionary decision making. But what about a process to identify what is desired in 50 years? This would be much more difficult, given our concessions to resource complexity and uncertainty of future societal value or environmental condition shifts. Yet, this is still a worthwhile and critical exercise. Without a long-term articulation of goals, managers will struggle with challenges presented by novel stressors (in type or intensity) or ecological surprises, both of which are anticipated in the context of global change (climate, human population and standard of living pressures, biological invasions, pervasive contaminants, and landscape fragmentation). Historically, desired conditions were driven by static historic conditions, but since have been improved by incorporation of historic range of variation (HRV) of resource or process variables. While biological invasions and land fragmentation have altered process and composition of resources, global climate change has inserted such uncertainty into the question of historic condition persistence that some scientists now see the HRV as less useful to predicting the sustainability of forest systems [1]. Researchers now use terms such as "anthropocene" [2], suggesting that for the first time in history, human influences have been documented as the driving force in global processes. Other concepts introduced recently are novel ecosystems [3] and "no-analog futures" [4], in which biological communities will not shift en masse in response to changing conditions, but that individual species will shift ranges in response to novel climates and a re-shuffling of species compositions will lead to emergent communities and ecosystems. Whether communities shift piecemeal or not, significant water and biological resource reorganization is expected. Manager will still need to justify actions. In this section, a set of approaches to addressing uncertainty are presented. The role of a clear desired condition is included, but the role of the DC varies with each approach. At a minimum, a DC helps managers understand the degree of departure from the DC that global change agents cause. These approaches, listed roughly in order of how much a DC is applied are:

A. Adaptive Management
B. Shift level of organization - maintains specific aspects of DC
C. Resiliency - maintains specific aspects of DC
D. Models – project likelihood of persistence of DC or shift to alternative states
E. Intermediate Outcome – manage for alternative state; persistence of DC pending
F. Scenarios -identifies possible alternative states, including DC
G. Mitigate Stressors – apply cause-and-effect relationships; loose relationship to DC
H. Trends - Focuses on manipulations reflecting baseline condition - no clear DC

Managers are reminded that "one size does not fit all," and are encouraged to use multiple, or combinations of approaches. The approaches here also represent a gradient of decision-making options based on firm evidence.

A. ADAPTIVE MANAGEMENT

Adaptive management (AM) of natural resources is one of the most commonly evoked and cited methods for the stewardship of public lands, however interpretations of adaptive management vary greatly. The concept of adaptive management (AM) has evolved in theory and application since its early development in the late 1970's [5]. Originally, AM was designed as an approach to manage the harvest of fishery and forest resources, focusing on the use of systems models to guide management decision making. Recently, applications have expanded to grasslands [6], waterfowl [7, 8], invasive pest and weed species [9, 10], and as a management framework for regional ecosystems [11, 12]. As the concept of adaptive management has continued to evolve and is more broadly applied, distinctions between AM and other forms of environmental management have become less apparent. In addition, the distinction between an adaptive style of management and the application of AM as a specific approach to the management of natural resources has become unclear. Despite these ambiguities, there is a growing sense that AM might be a useful tool for the management of Park resources. As part of a broader ecosystem management (EM) paradigm, components of an AM framework may be a valuable in achieving desired future conditions and management outcomes.

Broad, general interpretations of adaptive management lead to confusion and frustration; to be implemented effectively, adaptive management must be defined clearly and consistently [13]. Unfortunately, this is not a simple task. Adaptive management is an approach to management, not a single cookbook of steps that can be applied by rote to every management issue. Cookbook approaches tend to stifle the creativity that is crucial for dealing effectively with uncertainty and change. Thus, it is difficult to define adaptive management clearly, concisely, and consistently without constraining its application.

Elements of Adaptive Management

Adaptive management involves:

- Explicitly recognizing that there is uncertainty about the outcome of management activities;
- Deliberately designing management policies or plans to increase understanding about the system, and reveal the best way of meeting objectives;
- Carefully implementing the policy or plan;
- Monitoring key response indicators;
- Analyzing the outcomes, considering the objectives and predictions; and
- Incorporating results into future decisions.

Adaptive management requires participants who are willing to "learn by doing," and who acknowledge that making mistakes is part of learning. Adaptive management can be applied to any management situation where incomplete understanding of how the system functions creates uncertainty about the outcomes of management decisions, or about which is the best management option. All such situations can benefit from a thoughtful, deliberate approach to learning, although they may vary in the rigor with which different elements of adaptive management are applied.

The key elements of adaptive management can be described using the operational steps for AM as found in the Dept. of Interior AM Technical Guide[1]:

- Stakeholder involvement Ensure stakeholder commitment to adaptively manage the enterprise for its duration;
- Objectives Identify clear, measurable, and agreed upon management objectives to guide decision making and evaluate management effectiveness over time. A clear desired condition is necessary to identify these objectives;
- Management Actions Identify a set of potential management actions for decision making;
- Models Identify models that characterize different ideas (hypotheses) about how the system works. Again, a well-articulated desired condition is necessary to develop these hypotheses;
- Monitoring Plans Design and implement a monitoring plan to track resource status and other key resource attributes;
- Decision making Select management actions based on management objectives, resource conditions, and understanding;
- Follow-up monitoring Use monitoring to track system responses to management actions;
- Assessment Improve understanding of resource dynamics by comparing predicted and observed changes in resource status; and
- Iteration Cycle back to Step 6

What are the benefits of Adaptive Management?

Adaptive management is a strategy for dealing with the uncertainties and gaps in understanding that complicate management decisions and give rise to controversy. Proponents argue that we can learn to manage more effectively by designing and implementing management activities so that they: (i) can be evaluated reliably, and (ii) can improve understanding of the relationships that underlie measured responses. Key benefits of adaptive management are summarized below.

Well-designed experiments allow managers to evaluate reliably the effectiveness of alternative management actions

Adaptive management allows managers to more quickly determine which activities are inadequate to achieve management objectives, which are detrimental, and which are unnecessary. Inadequate and detrimental activities are expensive in both ecological and economic terms. Unnecessary activities are economically expensive. Given the level of uncertainty that characterizes our understanding of park ecosystems and the outcomes of resource management, most management activities should be viewed as experiments; predictions about their impacts are untested hypotheses. Designing these experiments well, using principles of experimental design, allows clearer interpretation of results. Management activities that are not designed as experiments at best provide ambiguous information, and at worst provide misleading or conflicting information [14]. Because the

[1] More information on the background and operational steps to Adaptive Management is found in the DOI Technical Guide on Adaptive Management http://www.doi.gov/initiatives/AdaptiveManagement/documents/html.

effects of management are difficult to separate from confounding environmental effects, managers are left wondering whether management actions actually caused an observed outcome or not.

Adaptive management increases understanding of how ecosystems function

Management experiments can be designed to increase understanding of how ecosystems function. Several alternative ecological mechanisms may underlie a particular observation or response. These different mechanisms may suggest different management remedies. Discriminating between alternative mechanisms of system function can lead to more effective management, can suggest previously unthought-of management options, and is useful even if specific objectives or social values change.

Adaptive management allows managers to proceed systematically and responsibly in the face of uncertainty, gaps in understanding, and disagreement

Uncertainty and disagreement over the best course of action cannot be resolved if there are gaps in understanding about system function. Actually comparing the alternatives in management experiments that are well designed provides the most direct, and sometimes the quickest, answer about which is most effective. Managers can thus avoid wasting further time, energy, and resources in arguments that cannot be resolved with existing information, and do not need to postpone the implementation of potentially valuable alternatives until knowledge is complete.

Management experiments may provide the only opportunity for learning about large-scale, ecosystem-level relationships

Results from experiments done at small spatial scales frequently are uninformative about relationships and impacts over large spatial scales [15]. Results from independent experiments on individual variables may be similarly uninformative about ecosystem relationships and cumulative responses. Large-scale perturbation experiments that examine ecosystem relationships and cumulative effects of management activities may be possible only in an operational setting.

Adaptive management encourages more efficient and effective monitoring

Identifying thresholds in ecosystem response can help managers avoid widespread implementation of activities that may lead to abrupt and undesirable shifts in system function or composition. Well-designed management experiments, including rigorous monitoring, will help in determining which activities are sustainable and which are not [16].

Adaptive management is not a panacea

Although adaptive management has numerous benefits, it is not a panacea. It can resolve disagreements stemming from gaps in knowledge, but it cannot resolve conflicts over values. Similarly, it can help managers respond to changes in values, but it cannot predict them. Adaptive management is an approach for learning how to manage in a way consistent with an overall vision, but it is not a process for developing that vision.

What are the challenges to implementing A.M.?
Significant concerns remain about the use of adaptive management as an effective and appropriate management framework:

- Professional managers are sometimes reluctant to admit uncertainty, and reluctant to risk the less than optimal outcomes that may result from innovative management alternatives

- There is a lack of skill, expertise, and time to learn adaptive management approaches

- Adaptive management requires commitment to continuity of funding, monitoring, and involvement of key people over the time frames necessary to detect ecosystem responses to management activities

- To yield useful information, an adaptive management project must be rigorously implemented, as well as rigorously designed

- The need for multi-agency participation in an adaptive management program is important; however, the issues of traditional mandates, roles, and approaches will need to be resolved

- Adaptive management requires strong, explicit links between the results of management experiments, and the use of those results to modify regulations and future management practices

B. ADJUST THE LEVEL OF ORGANIZATION AS THE FOCUS OF THE DESIRED CONDITION

With altered ecological processes, such as fire regime, or with climate shifts, composition within a plant community may shift, but the structure (forest vs. shrubland) does not change; or the general landscape pattern of the vegetation does not change although patch dynamics may change dramatically. As examples, a community diversity index may become the most detailed level of prediction for what is desired in a forest, because species shifts, and resultant combination of actual species may be impossible to predict. Or, if ecosystem services emerge as a priority management paradigm, ultimate flow of water from a park may become the focus of management activities, instead of the heterogeneity of stream habitats, just as the extent of vegetative cover in a watershed may be emphasized over patch composition. From a management perspective, reclamation and remediation usually reflect coarse goals of plant cover and environmental quality. These may replace current ecological restoration goals that reflect more specific metrics for composition and species interactions. A detailed desired condition lays the framework for envisioning management targets at a coarser level of organization, or broader spatial scale. New approaches to scaling in ecology should contribute to this analysis.

C. MANAGING FOR RESILIENCY

Natural resources are dynamic, and increased future uncertainties makes predicted outcomes much more difficult. Understanding the nature of changes occurring within a particular place and conceiving of a range of possible outcomes helps managers devise strategies that are sensitive to what is essentially a "moving target."

An framework for managing dynamic resources – and managing for change - is resiliency. Although various definitions are found for it, resilience is the ability of a system to absorb disturbance and still retain its basic function and structure. A resiliency approach to resource management focuses on persistence of the system despite uncertainty, complexity, and unpredictability, rather than a more traditional perspective that seeks constancy and equilibrium conditions. Resiliency is a mental model based on the notion that disturbances are part of ecosystem dynamics. But there is some maximum level of disturbance that can be absorbed or accommodated before the system changes its composition, structure, and function to a fundamentally different state (e.g., a grassland becomes a shrubland community, or a forest becomes desertified). When a major disturbance either sets an ecosystem back to some earlier stage in succession, it gradually recovers toward its pre-disturbance state or it initiates positive feedbacks that push the system onto a different successional pathway leading to an alternative state. A more detailed discussion of resiliency, in the context of alternate persistent states and thresholds is found in Appendix B.

One of the key operational aspects of the resiliency approach is to identify and sustain the “slow-drivers” of a system. Slow-drivers are those underlying, slowly changing variables, or attributes that exert broad controls on system function. They tend to be related to climate, land use, and nutrient stocks, but also human values and policies. How NPS might apply resiliency might be found at Organ Pipe National Monument, where managers are attempting to maintain Sonoran Desert ecosystems in the context of indiscriminant activities of illegal immigrants, drug smugglers and the US Border Patrol. Resources incur damages, either direct or indirect, slight or severe, but certainly cumulative. It is unclear how long these activities will last, but currently, these activities remain unabated. For Organ Pipe managers, the desired conditions for resources should still reflect that of a high integrity Sonoran Desert system. But, management strategies in the near term should include protection of the most vulnerable resources, and slow-drivers such as soil stability and geomorphic structure of channels. This will be the most reasonable effort, outside of broader strategies to address border-crossing issues, to maintain the capacity of these systems to recover once perturbations have ceased.

Resiliency stresses the role of natural disturbance in ecosystems. If disturbance processes are removed or excessively controlled, systems lose resiliency in the event of uncharacteristic disturbance events. If fire management in prairies, for example, is limited to prescriptions for spring and established burn units, the prairie ecosystem will have less resiliency in the event of an unmanaged summer fire. Many of the species that evolved with hot summer burns might be absent in the system, leading perhaps to greater opportunity for the establishment of non-native species, and resulting shifts towards an undesirable, altered persistent state.

D. APPLY MODELS

Predictive models are a powerful tool to envision a resource system's response to a variety of management strategies based on different scenarios. In fact, scenario planning, as described below, can include the conceptual and quantitative models to analyze past and current conditions and predict possible future outcomes. These models must be a reflection of a shared understanding of the resource condition among all critical stakeholders. Once this shared understanding is created then it is possible, and hugely informative, to begin to explore logical consequences of different management activities and strategies.

Conceptual models are often easily converted into simple quantitative models using readily available software such as the vegetation dynamics development tool (VDDT), HARVEST, or STELLA. These quantitative outputs can be readily mapped within a park's boundaries to provide a visual representation of possible future conditions. Numerous decision support systems such as NED-2 [17] have yet to be adopted into NPS practices. (An expanded version of models in the context DCs is in prep, 2009)

E. MANAGE FOR INTERMEDIATE OUTCOMES AS POTENTIAL REPLACEMENT END OUTCOMES

Increasingly, there will be situations where resources are at risk of being lost, but there is still hope that stressors can be alleviated in the foreseeable future. So, in this case, the park maintains a desired condition for a high level of ecological integrity for that resource. But, at the same time, because threats have not been abated, it is clear that the desired condition cannot be fully achieved in the near term. Managers can apply strategies to manage resources in other than the desired condition. Working towards intermediate outcomes can maintain the capacity of the system to recover, or emerge as the desired condition in the future if efforts to maintain the original desired condition fail.

For example, the desired condition for eastern hardwood forests at Delaware Water Gap includes patches of eastern hemlock. The hemlock is in decline due to the continued spread of the Hemlock wooly adelgid (HWA) and other pests. While it is not clear that managers will be able to save the eastern hemlock, efforts are still underway to understand and control the HWA. It is important and logical to write the desired condition statements in a way to include the hemlock to show that:

- Managers have not given up on the resource; and
- Funding requests for control of the HWA and hemlock conservation are justified

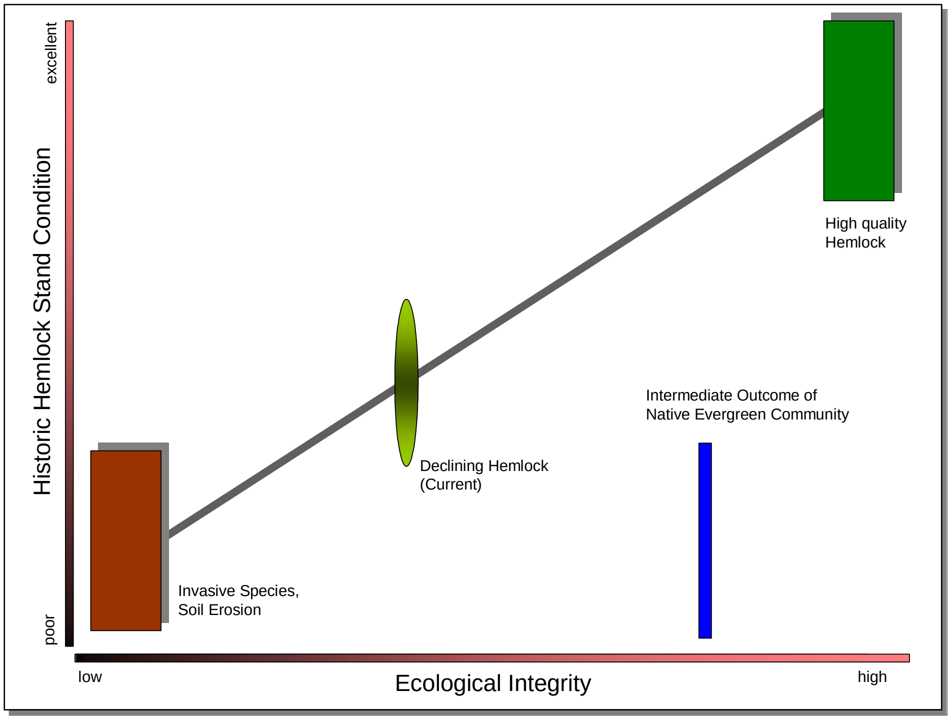

Figure 1. Scenario for management target definition at Delaware Water Gap.

In the meantime, managers must address sites where the resource (hemlock) is declining or has been lost, to prevent a cascade of negative effects at these sites (i.e., invasive plant establishment, soil erosion, loss of habitat for select species) and maintain sites to facilitate potential recovery of the hemlock. In this case, management target definition at Delaware Water Gap includes a desired future condition for high integrity hemlock stands, and also targets for "intermediate outcome" stands of native evergreens and understory shrubs (e.g., *Pinus strobus* with a subcanopy that can include *Hamamelis virginiana, Kalmia latifolia, Rhododendron maximum, Vaccinium angustifolium*, and *Viburnum acerifolium)*. These "restored" stands can also be assessed for ecological integrity (Figure 1). In this way, managers can develop and implement contingencies without abandoning the hemlock as the desired condition. In this case, the role of the hemlock's dense canopy as measured by stream temperature, shading, and winter cover can be identified as the key attribute that managers should maintain with a replacement canopy species.

This approach can also be applied to scenario development, with scenarios taking the place of intermediate outcome conditions. Scenario planning is described below. As managers contemplate some of the approaches to address uncertainty found in this document, they should consider one effort to put these tools in context of knowledge of a system and ability to control variables within (and outside) the system (Figure 2).

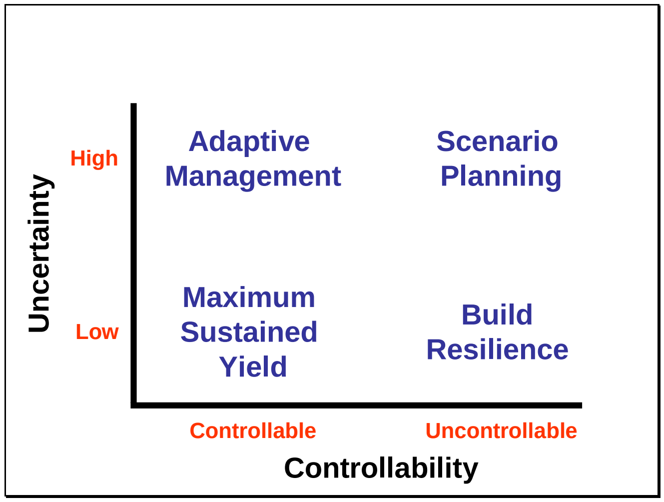

Figure 2 Strategies reflect levels of uncertainty of resource response and ability to manipulate external factors (from Peterson:http://www.geog.mcgill.ca/faculty/peterson/scenarios.html)

In an example provided in Figure 3, scenarios are described in advance of condition shifts, and the preferred scenario, which could also be an intermediate outcome, is adopted as the desired condition as it becomes clear that managers cannot maintain the initial desired condition.

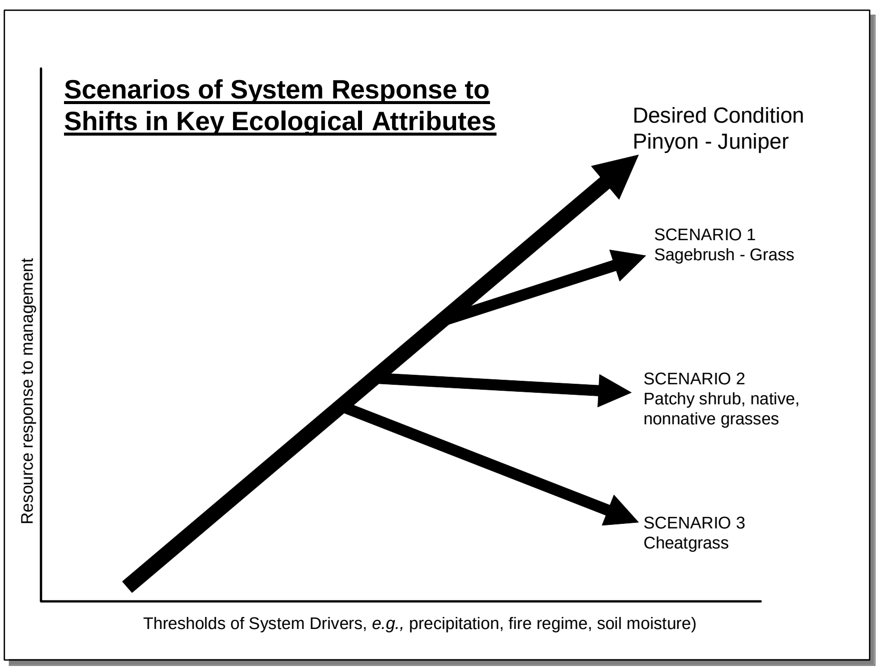

Figure 3 Desired conditions can be developed through the scenario planning process, or used to complement scenario building. In this case, a desired condition has been established for a piñon-juniper (PJ) plant community. Scenarios of what might happen to this resource under novel climates are developed, and then key attributes are identified to develop thresholds for condition shift. Managers respond to the shift away from the desired condition by managing towards the most appropriate scenario that can still persist within the range of variation of precipitation, fire regime and soil moisture. So, future prescriptions for PJ burned area revegetation may focus on species that comprise a Sagebrush community.

F. Scenario Planning—A Tool for Identifying and Applying Desired Future Conditions

Traditional approaches to planning and decision making typically involve careful analyses of what is known and thoughtful projections into the future. This has been called "forward planning" because the thinking process has a forward direction: descriptions of current trends derived from analysis of past and present conditions allow projections regarding future conditions, which in turn allow development of several competing alternatives for action (see Figure 4). These traditional tools have been described as part of predict-control management.

Desired future conditions are commonly addressed with traditional tools of forward planning. If projected future conditions differ from desired future conditions, alternatives for action aim to close that gap. If projected conditions are the same as desired future conditions, alternatives aim to maintain current trends.

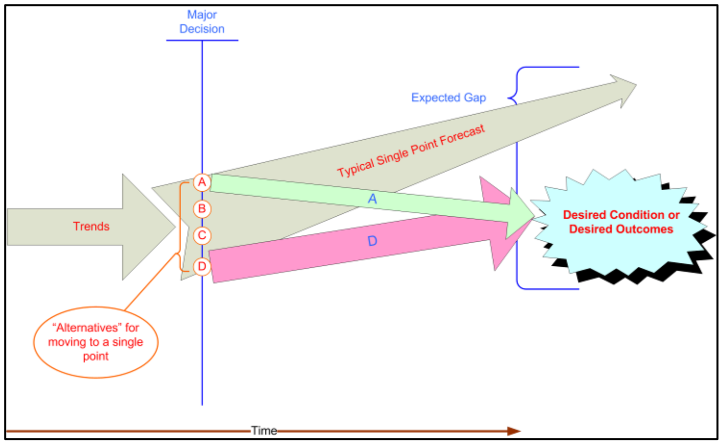

Figure 4. Traditional *Forward Planning* analyzes conditions and trends, often producing a single-point forecast, and then develops competing alternatives (shown as A – D) for closing any projected gap between forecast conditions and Desired Future Conditions or Desired Outcomes.

Forward planning has weaknesses that planners should consider. For example, incorrect assumptions lead to inaccurate projections. This obvious problem is commonly recognized. Yet, forward planning rarely if ever includes a mechanism for surfacing and testing assumptions, suggesting even some obvious weaknesses are ignored.

Other weaknesses with forward planning, however, are less obvious. Forward planning encourages attention to conditions and trends of resources, yet this attention often distracts from thinking about how resource conditions and trends are affected by interactions between management actions and other influences. Even if attention to interactions occurs as part of traditional forward planning, the thinking about those interactions is often based on false confidence, or what some call "creeping determinism," regarding assumptions about the trend in resource conditions and the effects or effectiveness of management actions.

When a projection based upon tenuous assumptions becomes treated with more certainty than is deserved, determinism has crept into the thinking, determinism with little basis in science. Much of forward planning occurs through a process that seems like science, but all the untested assumptions and the creeping determinism, among other things, make the process far less scientific than many realize.

Instead of forward planning, Desired Future Conditions (DFCs) could be approached in a way that avoids these and other problems with traditional planning. One alternative is to apply some version of what is called "backwards planning." Backwards planning occurs when discussions about DFCs involve a process of thinking backwards from where you want to go to what it would take to get there given where you are now. That process, when done well, includes explicit attention to *assumptions* of stakeholders and participants and explicit attention to the reasons for thinking the DFC is plausible. The process also includes explicit attention to *counter-assumptions* and the reasons for having concerns that perhaps the DFC is less plausible than assumed.

Unlike forward planning that merely mimics the scientific process, backwards planning is actually more scientific and science-based. Backwards planning makes use of what science knows about confidence limits, assumption testing, decision making, and uncertainty. The best known and most widely used tool for backwards planning is called "Scenario Planning."

What is Scenario Planning?

Scenario planning is a tool for strategic planning applied operationally first in the 1970's by some of the largest and most successful international companies, including Royal Dutch Shell. It is built on the idea that "alternative actions" by an organization occur in a broader context marked more by uncertainty than predictability; that "alternatives" are different from the "scenario" contexts within which an alternative occurs; and that anticipating plausible scenarios can prepare an organization to respond to emerging threats and opportunities (see Figure 5). In contrast to predict-control management, scenario planning is more associated with planned flexibility and adaptive resiliency, which are especially valuable when dealing with highly uncertain and largely uncontrollable futures. Such challenges often elude the best efforts of predict-control management.

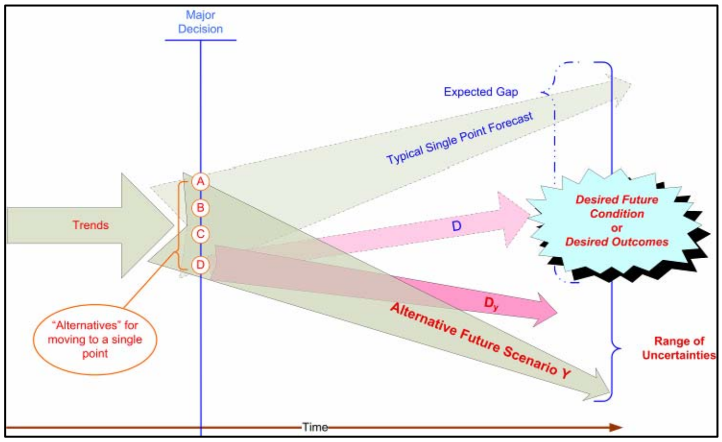

Figure 5. *Scenario Planning* addresses uncertainty by anticipating plausible scenarios (alternative futures) and establishing a learning-oriented monitoring program so timely adjustments can occur.

Scenario planning was studied and improved as a planning tool during the 1980's, when it was used by an increasing number of companies to anticipate possible futures for which the company might want to have the resiliency in which to compete. And, as it was improved, the tool became more cost-effective as it forced attention to data and information that allowed testing of assumptions and early recognition of which scenario was actually playing out. Within scenario planning, the purpose of monitoring became less descriptive and more action-oriented. As a result, scenario planning became more scientifically valid, more financially feasible, and more managerially relevant.

As Kees Van der Heijden, former head of Royal Dutch Shell's Business Environment Division, describes them, "… scenarios are a set of reasonably plausible, but structurally different futures." Scenarios are a broad-brush picture or story about what is thought to be driving these structurally distinct and anticipated futures. Each story succinctly describes at least three points:

- What is most important or distinct about that scenario
- Where is the least confidence in the scenario
- What is the source of greatest risk associated with the scenario

Scenarios are used for "Scenario Building" and "Scenario Planning," which are processes for making informed decisions about information to gather, people and groups to contact, or analyses to conduct. Scenario planning involves addressing questions such as,

- How do different people see current circumstances and anticipated futures, including different technical experts and scientists?
- What assumptions are these people making that lead them to think that way?
- How much confidence do they and others place in these assumptions?

Scenario planning is not a way to assess the probability or likelihood of different scenarios. Assessing probability of scenarios would be a goal associated with predicting and controlling movement towards a single objective, which is a characteristic of traditional planning. Instead of focusing on the probability of one scenario compared to another, scenario building aims to create "resilience" in the sense of adaptive capacity and stewardship capacity. This capacity for adaptation and stewardship allows progress in a desired direction while avoiding undesired conditions even as scenarios change. Focusing on a single objective, such as a single preferred alternative for moving towards a DFC, often leads to overconfidence and tunnel vision followed by a loss of resiliency just when needed most. When faced with an uncertain future, Scenario planning encourages humility and action, caution and learning. Instead of a plan based upon untested assumptions, scenario planning integrates monitoring, planning, and management actions into a coherent, resilient whole.

What happens during Scenario Planning?

Scenario planning is a flexible process. An especially useful version consists of 12 phases. Rather than sequential steps that only build on previous ones, each scenario planning phase also benefits from the subsequent phases in an iterative process of feedback and learning. The resulting understanding is often more focused and immediately applicable than those produced by traditional approaches and it typically takes less time to develop.

Scenario Planning Activity	Activity Outcome
1. Identify focal issue or decision	Focused attention on what really matters
2. Identify key forces in the local environment	Early identification of where there is agreement and disagreement about the system; more like a "bin" of ideas than a scientific model.
3. Identify driving forces	Early identification of where there is agreement and disagreement about what should drive scenarios; also more like a "bin."
4. Rank driving forces by importance and uncertainty	Surfaces competing meanings of "importance" and competing perceptions of certainty to identify possible questions that need

	testing; keys on forces that are managerially relevant or responsive to management action
5. Select 'scenario logics'	Identification of how different individuals, groups, and disciplines think different scenarios might be distinguished
6. Flesh out scenarios	Adds driving forces and scenario logics
7. Assess implications for strategy	Desired Future Conditions based upon comparison of how alternative decisions might respond to different scenarios and how the scenarios might affect decisions considered
8. Select leading indicators	Identifies indicators that allow early recognition that a particular scenario is occurring or not, as well as indicators that allow early recognition that management actions are moving towards Desired Future Conditions
9. Feed scenarios back to participant builders	Validates scenarios, scenario logics, and driving forces in light of indicators
10. Discuss strategic options	Identifies management actions most resilient to competing scenarios and most likely to retain resiliency in the system
11. Establish implementation plan	"Backwards planning" for actions and timing of actions
12. Publicize range of scenarios and role in monitoring & strategy	Establishes the multiple scenarios upon which the management plan is based and the monitoring activities that will help ensure early detection of need for change in strategy

What does Scenario Planning do for National Park management?

Scenario planning offers much to National Park management and National Park Service managers, as well as to other public land management efforts. For one thing, it offers a flexible process for identifying different assumptions about what is known and unknown, about what is driving or affecting the focal decision, and about what is more or less certain. Instead of these assumptions becoming points of debate and disagreement, which is common in traditional planning, scenario planning uses them as the basis for plausible scenarios. Alternatives are then built to be as resilient as possible to multiple scenarios and a monitoring program is designed to assess whether an especially surprising scenario is occurring, as well as evaluating whether management actions are working as intended. Each scenario describes a plausible context for future public land management efforts. The scenarios are not alternatives for action, yet each alternative is designed to retain resiliency to multiple scenarios where possible, often by careful monitoring of leading indicators (identified during activity 8; see table) so early recognition of a scenario can occur.

Attention to management resiliency is accompanied by attention to resiliency in the system where the management is occurring.

As a concrete example of what scenario planning might do for National Park management, consider that a major concern for today's National Park managers is global climate change. Scenario planning is particularly good at addressing uncertainty, which, in the case of global climate change, is greatest in local areas. A planning process especially suited for addressing uncertainty would be especially valuable for addressing the local effects of global climate change. While there is high confidence that climate change is occurring, there is great uncertainty regarding how this global phenomena may affect a particular National Park unit or a particular ecological process. For example, as climate change affects habitat, the historical range of some species may no longer contain the habitat to support those species; yet, that habitat may become more common north of those historic locations. A National Park unit may need to plan for plausible scenarios that include migration of entire habitats, not just the migration of species.

Traditional forward planning is incapable of encouraging the thinking necessary when matters like the historic range of variation are changing in such a potentially rapid and fundamental manner. In practice, traditional forward planning may encourage costly and inevitably doomed efforts to resist powerful drivers like global climate change. Scenario planning, however, offers a proven tool for meeting such powerful challenges in a mature and thoughtful way.

Perhaps one of the most significant contributions of scenario planning is that, when combined with attention to DFCs, the four most important activities of ecological stewardship become integrated—planning, doing, checking, and acting. With scenario planning, science and monitoring are combined with management actions and planning, all in as collaborative a manner as is needed and appropriate locally. This combination becomes most meaningful when, as scenario planning does, external perspectives are sought, welcomed, and made a central part of ongoing learning based in scientifically valid methods.

A final point to consider is that scenario planning appears to require a different, perhaps more valuable approach to monitoring. Instead of monitoring conditions and trends based upon traditional indicators intended to describe the system of a National Park unit and its context, a more focused and deliberate selection of indicators can occur. This focused and deliberate selection makes monitoring activities less costly and more relevant. Traditional forward planning tends to rely on monitoring results to describe the system. Scenario planning, however, relies on monitoring for timely recognition that a meaningfully different scenario is occurring than the one around which management alternatives were framed. The results of monitoring then become the basis for evaluating whether the current management strategy is appropriate for the circumstances or, alternatively, that a need for change exists. Under scenario planning, scientific monitoring plays a greater role in planning decisions and assessing management actions based on financially feasible and managerially relevant criteria.

Contact: Peter B. Williams, PhD
National Proof-of-Concept Implementation Manager
Ecosystem Management Coordination
USDA Forest Service
970-295-5708 -- peterwilliams@fs.fed.us

G. DEFINING STANDARDS BASED ON STRESSOR MITIGATION

The following 2 approaches present a shift to professional judgement, where managers have less of an information base, and available tools with which to work. These approaches are less desirable with regards to making actions with real confidence of why the actions are being made (Figure 5).

> "It has been shown that air pollution can reduce tree growth rates (Adams and Eagar 1992). We may be unable to define a standard for future tree growth rates because (1) future growth rates will differ from current rates due to natural climate change and (2) all trees in the future may be adversely affected by air pollution. However, this problem may be circumvented by using the knowledge derived from studies of pollutant effects on tree growth rates to set maximum acceptable levels of air pollutants. By keeping human activity inputs (air pollutants in this case) to acceptable levels, we should keep resultant outcomes within acceptable levels.
>
> A key to making this approach work is developing the knowledge of cause-and-effect relationships necessary to model the outcomes likely to result from different levels of input.
>
> Similarly, the maximum allowable number of animals has often been used to define the acceptable level of grazing impact rather than defining acceptable compositional or soil change in meadows. For fire management, we could define a standard for the number of natural ignitions that are suppressed, rather than for the forest structure and composition we really care about. In practice, this approach has been used to write a standard that says, "lightning fires are suppressed only when one or more of the following criteria are met: likely to escape wilderness boundaries resulting in loss of valuable resources outside wilderness, creates unacceptable smoke in communities, protection of life is not assured, there are inadequate fire personnel to manage the fire." Such a standard might be improved by incorporating an acceptable degree of risk within each of the criteria." (excerpt from [20])

H. FOLLOWING TRENDS: IDENTIFYING DIRECTION OF DESIRED CHANGE WITHOUT SETTING STANDARDS

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

Fire management provides a good example. In many wildernesses, it is clear that forest structure has changed markedly as a result of fire suppression. In many places we know that a forest structure with fewer saplings, fewer total trees, fewer vertical layers, and more discrete spatial aggregations of trees would be closer to "natural" than the existing structure (Kilgore 1987). We also know that fire characteristics have changed. Before the recent era of fire suppression, fires in some vegetative types were more frequent and typically smaller and less intense than they are today (see for example Swetnam 1993). From analysis of historic ecological data (Stephenson et. al.1991) we can develop past forest structure and fire process descriptors that might make reasonable short-term targets. Even though desired long-term forest structure or process objectives are uncertain, there is often agreement that more fire in the landscape is desirable. Therefore, we can develop management prescriptions that will provide for more fire in the landscape and can be easily adjusted as more is learned." (excerpts from [20])

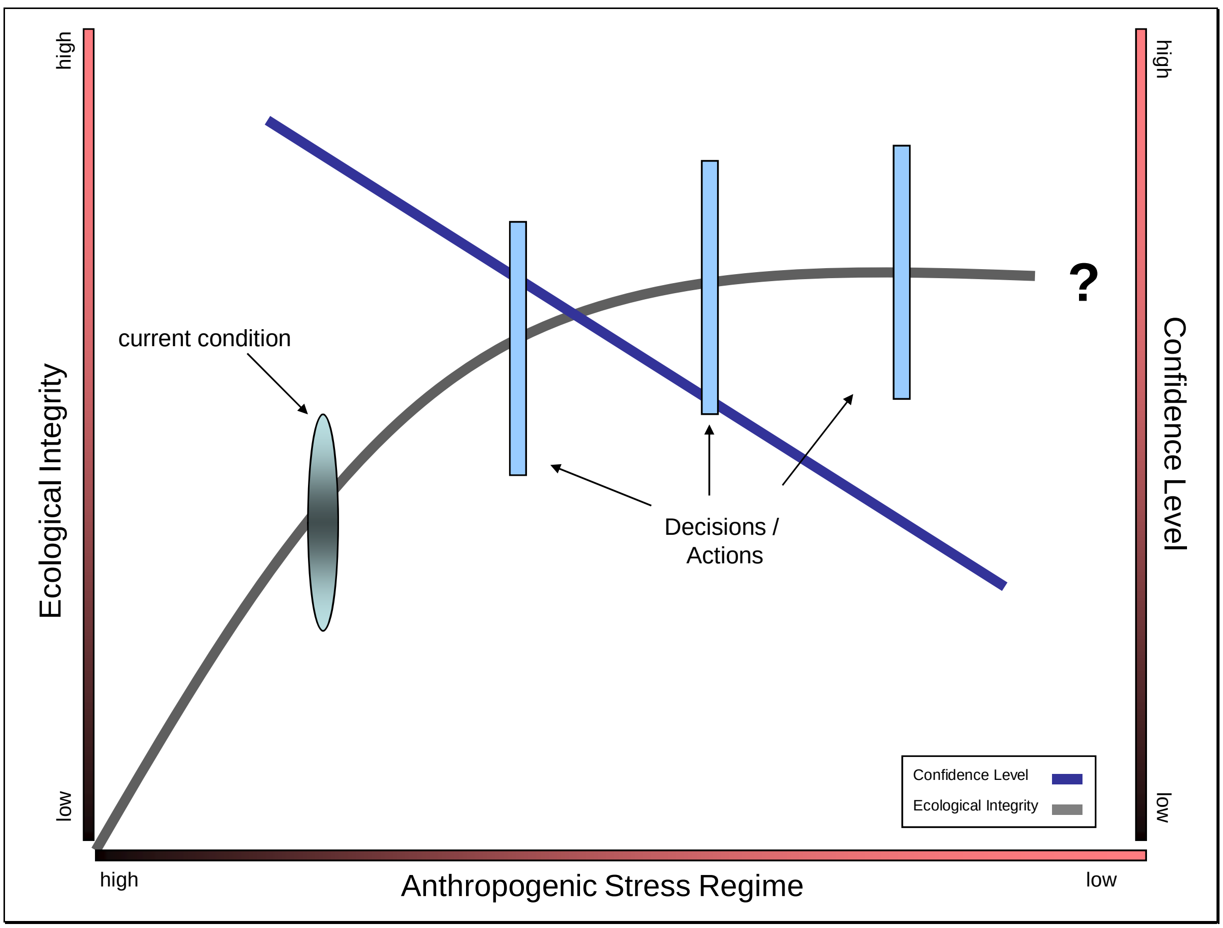

Figure 6. Under a Trend or Stressor Mitigation approach to working with uncertainty, managers initially act with a reasonable level of confidence, but this decreases with additional decisions and actions.

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