US FOREST SERVICE SCIENCE FORUM

Grounding the development of a new planning rule in science and fostering collaborative dialog

A Report on the Science Forum Held as Part of the New US Forest Service Land and Resource Management Planning Rule Development Process

March 29 – 30, 2010
Washington, DC

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EXECUTIVE SUMMARY

A two-day national Science Forum was convened by the US Forest Service (Forest Service) as part of a commitment by USDA to keep science and collaboration as the foundation for the development of a new Forest Service Land and Resources Management Planning Rule (planning rule) and to provide opportunities for public discussion on the points raised. Booz Allen Hamilton, an independent technology and consulting firm, was retained to design, organize and facilitate the Forum in order to maintain objectivity and transparency in the proceedings and the compilation of this report. Panels of scientists drawn from academia, research organizations, non-government organizations, industry and the federal government presented the latest science on topics relevant to the development of a new rule for developing National Forest plans.

Themes emerged around the concepts of restoration, resilience, landscape scale conservation, climate change, watershed health and water quality protection, biological diversity, and sustainability of national forest lands and contributions to rural economies. Collaborative approaches, questions of scale, and the role of uncertainty in decision-making were explored.

Four over-arching challenges emerged for the Forest Service

1. Developing a clear vision for the future of National Forests
2. Further defining the role of science in the policy development process on an on-going basis
3. Developing and integrating approaches for maintaining biological diversity on US Forest lands and across boundaries; and
4. Considering what additional principles beyond those listed in the Notice of Intent should also be addressed

INTRODUCTION

The National Forest Management Act (NFMA) of 1976 requires every national forest or grassland managed by the United States Forest Service to develop and maintain a Land Management Plan (also known as a forest plan). The process for the development and revision of the plans, along with the required content of plans, is outlined in the planning regulations, or "planning rule". The USDA Secretary recently directed the Forest Service to develop a new planning rule to supersede the current 1982 rule and the Agency's goal is now to complete and issue a final rule in November 2011.

> *"The rule development process must be transparent, open, and inclusive."*
> USDA Undersecretary Harris Sherman

Recognizing the critical importance of sound science and the need to collaborate with its many publics in managing US Forest lands, a two-day Science Forum, held March 29-30, 2010 in Washington DC, was designed to ground the development of a new planning rule in science and foster a collaborative dialogue among the scientific community, the US Forest Service and interested members of the public to identify planning principles for the rule.

This report was prepared by Booz Allen Hamilton, an independent technology and consulting firm and represents Booz Allen's effort to capture the science, perspectives, questions and comments offered by Forum presenters, attendees and other participants who watched the proceedings through a Forest Service webcast and provided input through online sources. The comments expressed herein do not represent the opinions of Booz Allen, its employees or consultants nor is it intended to be a verbatim transcript of the Forum proceedings.

The Forum focused on how science can help provide a framework for considering the principles that should be addressed in formulating a new

planning rule. The format was designed to allow scientists and practitioners to share the current state of knowledge in key areas and to encourage open dialog with interested stakeholders. Areas for discussion were identified in a Notice of Intent (NOI) from the Forest Service to prepare a draft Environmental Impact Statement (EIS) to analyze the environmental consequences associated with a new planning rule published in the Federal Register on December 18, 2009 (Appendix 1) and also were drawn from other sources.

Key themes and information from the science forum will be used by the Forest Service to help frame collaborative discussions on the rule's content at regional and national public stakeholder roundtables being held during Spring 2010 and also will be used by the Forest Service team that is writing the rule. No decisions regarding the eventual content of the draft environmental impact statement or draft rule were made during the Science Forum.

FORUM DESCRIPTION

USDA/Forest Service Speakers

The forum was opened on the first day by US Forest Service Deputy Chief Ann Bartuska, Associate Chief Hank Kashdan, and USDA Undersecretary for Natural Resources and Environment Harris Sherman. They emphasized that a new planning rule is necessary to respond to today's challenges for tomorrow's national forests. Each stressed the Department's commitment to keeping science and collaboration as two common threads throughout the rulemaking process and noted that a new rule depends upon sound science to be enduring, responsive, and implementable.

They emphasized that key focus areas for the Forest Service are currently: climate change, landscape scale management considerations, and the ability of landscapes to adapt to change, variability, and uncertainty. The speakers committed to a rule development process that would be open, transparent, and inclusive.

Director of Ecosystem Management Coordination Tony Tooke, whose office is responsible for writing the rule followed, and defined success for the session as having gained a better understanding of the latest science and what it suggests for the planning rule; identifying key scientific themes for future dialog; building relationships that carry over to forest plan development; and creating plans that respond to current needs and improve the national forests.

> *"Our shared vision begins with restoration."*
> Secretary of Agriculture
> Tom Vilsack

On the second day, Secretary of Agriculture Tom Vilsack addressed the forum participants and reinforced the importance of collaboration in the development of a new rule and the Department's commitment to an open, transparent process and meaningful dialog. He noted the importance of ecological restoration to

protect water resources, make forests more resilient to climate change and improve forest health while creating jobs and opportunities. He further cited the need for a new all-lands approach based on collaborative management working with private forest owners and other interested publics to sustain forests on a landscape scale.

Forum Structure

A series of five panel discussions featured presentations by subject matter experts, followed by dialog among panelists and with the audience.

- Panel 1 addressed drivers of ecosystems and the state of the science.
- Panel 2 focused on using current science to plan, manage and measure at a landscape scale.
- Panel 3 discussed the current science behind planning for; managing to maintain, and restore; and monitoring plant and animal diversity.
- Panel 4 considered the relationship among social, cultural and economic sustainability and addressed how these dimensions should be factored into the planning rule guidance
- Panel 5 explored how the current science discussed during the first session on day one can be brought forward into the rule-writing process to produce a planning rule that is durable, widely-supported, and can be implemented on the ground in a timely way.

The detailed agenda for the Science Forum can be found in *Appendix 2*. *Appendix 3* describes the panels, the framing questions that each panelist was asked to answer, and lists questions used to stimulate for further dialog. The panelists' presentations and biographies are included in *Appendix 4*. Questions from the audience and the Forest Service online Planning Rule blog are captured in *Appendix 5*.

The entire Science Forum was available via live webcast during the sessions.

Clips from the webcast as well as this report and all appendices are available at www.fs.fed.us.

THEMES AND DISCUSSION

The following discussion points from panelist presentations and follow-on dialog among the panelists and the forum attendees have been captured and organized according to the five substantive principles identified in the Notice Of Intent (NOI) that appeared in the Federal Register. Information was categorized in this manner to make it easier to analyze and reference by the participants in the public and regional roundtables that began after the Science Forum and to allow more comprehensive cross-referencing by the Forest Service rule writing team.

1. RESTORATION AND CONSERVATION TO ENHANCE RESILIENCE

There was general agreement among all panelists on multiple points. First, that restoration of ecosystems to any particular historical condition is probably impossible. Secondly, uncertainty about future conditions in light of the unknown future effects of climate change and human activities further complicates decision-making. And thirdly, since it will be necessary to make decisions about conservation in the absence of complete certainty, better ways are needed to inform decisions.

> *"We can't afford to practice random acts of restoration."*
> Dr. James M. Vose
> USDA Forest Service
> Southern Research Station Laboratory

There was a dichotomy of opinion regarding the application of the "precautionary principle." This principle is based on the premise that if an activity raises threats of harm to the environment or human health, precautionary measures should be taken even in the absence of clear scientific evidence demonstrating a cause and effect relationship. Some felt that caution comes first; others felt that too much caution can lead to

inaction even when action might be the only way to ensure that the precautionary principle is followed.

Key Themes from the Panels

- Consider "restoration" in terms of sustainability and resilience
    - There is a need to understand how to best use "historic range of variation" e.g. characterizing the change over time and space in the condition of major vegetation types and the ecological processes that shape those types.
    - There is a need to better define ecosystem resilience in terms of managing for sustainability
- Understand fire as a key ecological driver
    - Fire effects differ at various scales of time and space
    - The roles of fire are complex
    - Fire interacts with climate change, human activities, invasive species
- Define the role of uncertainty in decision-making
    - It makes more sense to focus on the metrics that can be measured and analyzed rather than those that can't
    - Uncertainty can be minimized through the use of comparisons rather than absolutes since absolutes are often impossible to measure
    - Concerns over uncertainty can lead to decision paralysis when decisions are deferred in the absence of absolute certainty
    - There often is a cultural divide between scientists and the public especially in terms of understanding and accepting a degree of uncertainty
    - The Forest Service can't afford to practice "random acts of restoration," rather it will be necessary to prioritize actions to address the most pressing needs

Observations and Discussion Points

- North America is experiencing increases in fire size and intensity
- Resilience can be thought of as the dynamic capacity of an ecosystem to absorb change without changing state
- Species have differing abilities to shift their range in response to climate change
- Fire occurrence breaks inertia and hastens the movement of leading and trailing edge populations
- Calculations of carbon emissions from fire need to factor in regrowth of vegetation
- Historic range of variation (HRV) is useful information but should not be viewed as an absolute condition or goal
- People are major stressors of ecosystems
- Disturbance is essential to species and ecosystems
- Invasive exotic species are changing ecosystem dynamics
- Ecological flows of water, nutrients, species and other things cross boundaries and can be quantified
- Scientists have a responsibility to help the public think about uncertainty
- Analysis should be conducted at the scale at which key ecosystem processes operate
- The precautionary principle cuts both ways (there can be consequences of inaction)
- Predictive science is getting better
- Landscape ecology can help simplify management rather than confound it
- Many habitat models do not factor in the role of fire in sustaining the ecosystem

2. CLIMATE CHANGE ADDRESSED THROUGH MONITORING, MITIGATION AND ADAPTATION

Most panelists agreed that climate change is and will be an important driver of ecosystem conditions. Because of this, some of the scientists said that it will be important to consider all aspects of climate change on US Forest Service lands and the interactions that occur among these aspects at various scales in time and space. With regard to monitoring requirements, there were differences of opinion and no majority consensus on an approach. Some felt monitoring always requires large sample size, statistical power and high precision. Others felt that the degree and scale of a specific, planned monitoring effort should be determined according to an estimate of risk and uncertainty (i.e. what are the "costs" of being wrong?)

> *"Climate is a fundamental architect of ecosystem change."*
> Dr. Constance I Millar
> USDA Forest Service
> Pacific Southwest Research Station

Key Themes from the Panels

- Consider factoring into the planning process the ways climate change acts as an ecosystem driver
  - Climate change has many aspects and should be examined holistically
  - Reducing greenhouse gas emissions are not the only consideration
  - Climate should be treated as a macro disturbance process
- Consider how management actions taken today can affect ecosystem response to climatic conditions in the future
  - More effective use of models that make use of new data sources should be explored
  - Lack of knowledge about effects is not a valid reason to

not consider those effects in analyses

- Consider refining adaptive management* monitoring approaches to better address questions of uncertainty
    - Monitoring can (should) be linked to thresholds of change or conditions that can be identified and used to help to set boundaries for management
    - Monitoring effort should be linked to estimates of risk and uncertainty with greater effort called for when the likelihood and cost of error (in terms of outcomes) are high

** Booz Allen Note: According to the Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management (Federal Register 65, no. 202, October 18, 2000, p. 62571), "Adaptive management is a type of natural resource management in which decisions are made as part of an ongoing science-based process. Adaptive management involves testing, monitoring, and evaluating applied strategies, and incorporating new knowledge into management approaches that are based on scientific findings and the needs of society. Results are used to modify management policy, strategies, and practices."*

Observations and Discussion Points

- Climate change is hydrologic change
- Anthropogenic centered change has been superimposed on natural change
- Today's forests are still responding to past climatic changes
- Local climates and responses may operate independently from regional trends
- Adaptive management does not mean the same thing as management flexibility; a structured approach may actually constrain decision-making space
- When evaluating drivers of and responses to climate change, focus on spatial and temporal scales most appropriate for

what is being analyzed and account for interaction among drivers

- Monitoring is the foundation of adaptive management
- Good monitoring requires representative data, appropriate scale, and standardized protocols
- Models without data are not compelling, data without models are not informative
- Climate often changes in nested cycles at different scales
- Climate is a fundamental architect of ecosystem change
- Models are better at predicting the range of future conditions, rather than individual events

3. WATERSHED HEALTH, MAINTENANCE AND RESTORATION

There was general recognition of a need to assess the effects of management practices on watershed health, particularly water quality and quantity. Considering such effects at the appropriate scale was viewed as important, but complicated by land ownership patterns.

> *"If we consider water as a stand-alone ecosystem service, the forest plan will fail."*
> Dr. Steven McNulty
> Research Ecologist
> USDA Forest Service

Key Themes from the Panels

- Consider factors other than climate that control water availability at the landscape scale
    - There are multiple stress impacts that should be considered
    - There are conflicting interactions among ecosystem services that should be considered, e.g. increasing carbon sequestration may decrease water yield
- Expand efforts to work across scales to quantify effects of management
    - The scale of analysis should be matched to the question in order to put predicted effects in the proper context
    - Extreme events such as very large wildfires should be modeled at large scales
- Consider watersheds as logical boundaries for analysis but recognize that sometimes other boundaries (e.g. ecological units) may be more appropriate

Observations and Discussion Points

- There is a long history of watershed research that provides a strong basis for predicting outcomes of actions.
- There is a significant amount of recent watershed data available at local and macro scales however, translating to larger scales what is understood from the extensive amount of data collected in monitoring small-scale processes will be challenging.
- Land ownership patterns complicate the task of managing for watershed health at larger scales.
- Watersheds are connected by the movement of materials and species. Planning should consider this.

4. DIVERSITY OF PLANTS AND ANIMALS, WILDLIFE HABITAT

A view widely-shared by the panelists was that traditional population viability analyses do not yield reliable predictions despite intensive data collection. A coarse filter/fine filter approach* could be more reliable and cost effective. Such an approach might use vegetation data at the broadest scale, presence-absence data obtained through non-invasive genetic sampling, and more intensive monitoring for species of special concern. Some panelists felt that having more data was always preferable. Others felt that more data did not necessarily ensure better decisions.

> *"We can't know, much less control everything in a system"*
> Dr. Gary Morishima
> CEO of MORI-ko LLC

* Booz *Allen note: The course filter/fine filter approach has been discussed in various papers authored by US Forest Service scientists and can be summed up as follows: A course filter is the concept of conserving species diversity by providing adequate representation (distribution and abundance) of ecological land units considering the historical range of variability based upon an understanding of the natural disturbance regimes of the ecological units across the landscape over time. Fine filter Individual species assessments are conducted to evaluate whether a sufficient amount and distribution of habitat for certain species is provided under the type of course filter strategy discussed above.*

Key Themes from the Panels

- Recognize that restoration must provide for change and address at risk species
    - Diversity is dynamic and depends upon disturbance
    - Managers can (should) make better use of recovery plans

- Managing to avoid the need for recovery is preferable to waiting until recovery is necessary
- Diversity is dynamic and depends upon disturbance

- Traditional species monitoring and planning for biodiversity is not reliable
  - A combination of presence/absence modeling* and genetic sampling may be the answer
  - A coarse filter/fine filter approach is widely accepted by scientists
  - A well-distributed, well-connected population is likely to be viable
- Recognize that species (except those with extremely limited ranges of occurrence) and ecosystems cannot be sustained solely within administrative boundaries
- Preservation may require collaboration at local, state and regional levels
  - May mean sharing decision-making

Booz Allen note: Presence/absence modeling can be used to map and predict species distribution, help model habitat requirements and support conservation management objectives by using occurrence data to help estimate the probability of a species being present in sustainable numbers within a geographic area. Genetic sampling, e.g. drawing DNA from physical species evidence collected at sites under evaluation can be used to acquire data for this approach.

Observations and Discussion Points

- There is a long history of watershed research that provides a strong basis for predicting outcomes of actions
- Modeling and monitoring tools are evolving fast and getting cheaper to use

- Falling costs for collecting and analyzing genetic material may offer new approaches for population monitoring
- Forest Inventory and Analysis (FIA) plots* may provide an inexpensive way to sample vegetation and predict species occurrence at broad scales
- Indicator species are not reliable surrogates for other species in most cases
- Biological diversity includes the variety of genes, species, communities, and their interactions
- Ecosystem diversity includes vegetation cover types, seral stages, stand structure, landscape patterns, and disturbance regimes
- Monitoring method and intensity should be linked to risk and uncertainty
- It is not prudent to defer action until biological diversity is fully understood
- An expanding population is probably healthy
- Maintaining species is not the same as maintaining ecosystem function
- Disturbance change, diversity, and evolution are all related
- Extinctions are forever; it takes a long time for new species to evolve
- Partnerships for recovering endangered species are more important than ever
- For many species, viability cannot be provided on National Forest lands alone; wide-ranging species operate at landscape scales

* Booz Allen note: The USDA Forest Service Forest Inventory and Analysis (FIA) program is the Nation's forest census. It is FIA's job to determine the extent and condition of forest resources and analyze how these resources change over time. FIA consists of a nationally consistent core program, which can be enhanced at the regional, state, or local level by collecting additional data to address special interests.

5. SUSTAINABLE LANDS AND CONTRIBUTIONS TO VIBRANT RURAL ECONOMIES

> *"Sustainability can be defined as meeting the needs of the present generation without compromising the needs of future generations." (The Brundtland Report)*
>
> Mike Dockry
> US Forest Service Liaison to
> College of Menominee Nation

The focus of the Science Forum emphasized hard science but there was general agreement among participants both on the panels and within the audience that land resource management decisions could not and should not be made in a scientific vacuum. Successful management also requires collaboration, partnering, and consideration of social values. Much of the discussion centered on the notion that decisions regarding sustainability are as much (or more) about social rather than science questions. There was agreement that a local context for these decisions was essential and that decisions about the future of national forests should also have regional and national contexts. Collaboration across boundaries and greater sharing of decision-making was a central premise.

Key Themes from the Panels

- Recognize that sustainability requires on-going learning partnerships
    - Sustainability decisions are primarily social decisions
    - They should be defined by the local context, but have regional and national contexts as well
    - This means balancing tensions through an iterative, open, collaborative process
- Providing ecosystem services may be the future focus of national forests
    - Ecosystem services can address:
        - Ecological Health
        - Economic Development
        - Social Equity
        - Community Capacity
        - Cultural Heritage
    - Quantitative valuation of ecosystem services is challenging
    - Forest value for carbon sequestration can be priced because carbon can be valued
    - Same value analysis can be made for a wetland's value in filtering water
    - Biodiversity is harder to value
- Balancing of local interests with national priorities is necessary when managing US Forest Service lands
    - Management plans should have a local context, but
    - The national forests are national assets that belong to all citizens
    - Ecosystem services are generated by ecosystems that do

not recognize administrative or jurisdictional boundaries therefore, effective management of those services requires thinking broadly and across administrative or jurisdictional values

- Recognize that recreational options need not become a choice between carrying capacity of the land and ecosystem sustainability
    - Impacts of and on recreation should be fully accounted for in the planning analysis
    - National forests and grasslands have a unique niche within the Nation's overall land resources

Observations and Discussion Points

- Do not confine thinking to administrative or jurisdictional boundaries
- The ability of both ecological and social processes to self-organize is needed to maintain resiliency
- Sustainability relies on successful adaptation across time, location, context
- Understanding the present can help create a vision for the future
- It seems that fire-suppression has become the de-facto mission of the Forest Service
- One of the best ways to get multiple owners to think across boundaries is to share commonly collected data
- Tribal perspectives, given their long-standing cultural affiliation with sustainable natural resource management practices, offer a source of information that can lead to new and better understanding of sustainable best management practices

6. THE PLANNING PROCESS AND SCIENCE

There were differences of opinion on the most appropriate role for the planning rule. Some panelists thought a planning rule should limit agency discretion and set thresholds. Others felt that flexibility was more appropriate and the focus should be on resiliency rather than on establishing thresholds. Several participants felt that setting expectations regarding the characteristics of good science was more appropriate than attempting to mandate the actual science. Concerns were expressed regarding the best mechanisms for providing continued science input into the rule-writing and forest planning processes.

> *"Science should inform, not dictate decisions"*
>
> Dr. Tom Sisk
> Northern Arizona University

Key Themes from the Panels

- Considerations for how to incorporate the best science
    - It's better to define characteristics of the best science not the science itself
    - Joint fact finding encourages collaboration
    - Adaptive governance works
    - Process principles should be a high priority
    - It's better to define the characteristics of a best process not the process itself
- Focus on making forest plans more meaningful, financially realistic, and collaborative
- Ideas for how to do this represented differing viewpoints but included:
    - Limiting agency discretion
    - Allowing more agency flexibility
    - Institutionalizing collaboration as a management process

best practice

- Use advisory committees (or not – they need not be official FACA bodies)
- Establish a process to identify issues and affected parties so collaboration is meaningful and open
- Establish a timeline for planning and adhere to it

- Expand the use of modern planning tools
  - Tools should be open, collaborative, practical, easy to use
  - Examples of tools:
    - Ecological Sustainability Evaluation Tool (ESE)
    - Template for Assessing Climate Change (TACCIMO)
    - Human dimensions toolkit
- Recognize than plans represent a set of value judgments
  - Development assumes capability to implement
  - Implementation and development is a shared vision
- Understand what planning is/isn't
  - Primarily a process (not a science)
  - Planning should focus on vision, goals, policy (not regulation)
  - "End state" plans don't work
  - The plan is not worth doing if it is not implementable
  - There will be aspects of forest planning where collaboration may not be appropriate

OBSERVATIONS AND DISCUSSION POINTS

- More/better science does not ensure better decisions
- The Forest Service can learn from other organizations and agencies
- Application of science should be collaborative
- It is important for the public to "own" the science
- Science must be transparent but robust
- Planning tools cannot be used as a "black box" that the public

does not understand or they will not accept them

- Science should inform, not dictate decisions
- There is a need for a cadre of research/management "boundary spanners"
- Monitoring can be (should be) science-based
- The Forest Service should be sure to clearly define terms
- No amount of data is a substitute for good planning
- The value of planning will only be realized if the Forest Service can build the social capital to implement it
- Forest planning is not the place to start collaboration
- Avoid "rigidity traps"
- It may be more appropriate to plan for a range of desired states rather than "desired future conditions"
- Generally, what is measured is what gets done
- A plan is probably a good one if stakeholders actually engage in its implementation

CONCLUSIONS

Over the course of two days a tremendous amount of information regarding the state of science relevant to the development of a new planning rule was presented and discussed. While there was often agreement regarding the application of this information, there were also differing points of view.

Several over-arching questions for the Forest Service relating to the role of science emerged. Panelists urged that careful consideration of these questions will be needed to develop an effective and implementable planning rule.

1) **How can science be effectively applied to the development of a planning rule in the absence of a clearly shared vision for the future of national forests?**

   Several panelists pointed out that while science can help inform decision-making processes, it is most appropriately applied first in a context of shared agreement on the agency goals that will drive management decisions. The extent to which objectives such as resilience, ecological sustainability, ecosystem services, water quality/quantity, carbon sequestration, local economies, questions of scale, collaboration across boundaries, and consideration of climate change will define this vision appears unclear to the stakeholders interested in national forests.

2) **How should the new rule address the role of science?**

   If, as some suggested, the role of science is to inform, not dictate management decisions, questions for the Forest Service are:

   - How should the planning rule address the use of models, development of monitoring protocols, and the role of

uncertainty in decision-making and collaborative approaches to science?

- How can science continue to inform rule-making throughout the development of the rule and what is the role of science in the development and implementation of forest plans?
- How much discretion vs. direction in the application of science should the rule allow/provide?

3) Are there new approaches to planning and monitoring biological diversity that would be more effective than current approaches and have broad support?

Several panelists shared the perspective that current approaches to planning for biological diversity that require assessment of population size and viability do not work very well. Furthermore, it was noted that approaches which use certain species as surrogates for assessing impacts on others are no longer widely supported by the scientific community.

Is there an approach that utilizes modern sampling and modeling and considers ecological sustainability that can be widely-supported as a better way to meet NFMA requirements for providing for the diversity of plant and animal communities?

4) Are there additional important principles not addressed in the NOI that should receive more attention?

Two major points were raised but received limited attention during the Forum because of its hard science focus. First, the point was made that the focus on recreational uses of Forest Service lands should be elevated to the level of a "substantive principle". This raises the question should the planning rule require that forest plans fully account for impacts of and on recreation?

Although there was much discussion regarding the importance of disturbance in ecosystems and the role of fire in shaping most North American ecosystems, there was little discussion about the role of fire suppression. Should the planning rule address the relationship of fire management policy to land management planning?

Some terms in need of shared understanding regarding their meaning in a forest planning context:

- Implementable
- Durable
- Transparency
- Uncertainty
- Resilience
- Sustainability
- Landscape level
- Collaboration
- Disturbance
- Thresholds
- Best science
- Ecosystem services
- Precautionary principle
- Historic range of variation
- Viability
- Watershed