

## **FOREST HEALTH, RISK ASSESSMENT, AND THE NATIONAL FIRE PLAN**

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## Abstract

Forest health is the condition of forests relative to management objectives, which reflect the forest values managers intend to provide. Indicators of forest health condition in the National Report on Sustainable Forests—2003 (under Criteria 2 and 3) highlight the role of wildland fire and its associated risks in sustainable forest management (SFM). The data used to evaluate those indicators show that some forests are at higher risk of insect, disease, and wildfire damage than others. Risk is the potential for an adverse effect, and risks cannot be managed effectively until they have been assessed. Risk assessment brings specific values into consideration and can reveal which values are at greater risk. To better facilitate risk assessment, the National Report could use existing data more effectively by differentiating across four regions and four ownerships, rather than just two of each.

Large-scale assessments show that alterations in historic fire regime conditions pose moderate to high risks to ecosystem components on more than half of the nation’s forests and rangelands. The National Fire Plan (NFP) is an institutional framework for managing wildfire risks, including treating hazardous fuels that have accumulated partly as a result of elevated mortality from conditions in some forests. Smaller-scale assessments can focus on the trade-offs among management alternatives intended to improve forest conditions, and transparently connect SFM values, objectives, and decisions, including those involving species at risk of extinction. Risk assessment requires specificity and stakeholder involvement, and can therefore enhance the collaborative approach essential in NFP implementation in all forests. An integrated policy analysis framework built upon risk assessment can help link environmental and socioeconomic concerns by focusing on specific SFM objectives, problems, and potential improvements, including institutional changes that promote rather than discourage SFM.

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## **Introduction**

This paper evaluates the closely related topics of forest health, risk assessment, and the National Fire Plan (NFP). They are related because forest health indicators in the National Report on Sustainable Forests–2003 (USDA Forest Service 2004) reveal forest condition problems associated with uncharacteristically severe wildland fires. Risk assessment could help identify, prioritize, and support implementation decisions for SFM actions, especially through the collaborative process by which the NFP is implemented. These three topics also enhance sustainability assessments by focusing on things people care about: (1) the condition of forests relative to forest values associated with management objectives (i.e., forest health), (2) forest values at risk of damage from nature's forces as well as human actions, and (3) the environmental and socioeconomic effects of wildland fire management policy that protects some values while putting others at greater risk.

Key messages, concepts, refinements, and gaps are provided for these topics, plus discussion of policy review and analysis as an integrating function upon which conclusions about SFM ends and means can be drawn.

## **Forest Health**

### ***Key Messages***

The report says, "Sustainable forest management [SFM] is the stewardship and use of forests and forest lands in such a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, and vitality. . . (p. 128)." Some dictionaries define vitality by analogy—for example, growth, as a plant. Growth and mortality are indicators of forest health and sustainability (Norris et al. 1993). The report identifies three forest health problems—altered species composition, forest density, and reduced vigor (i.e., growth)—that along with mortality and removals can be assessed with existing forest inventory data.

According to the report, management actions provide means for attaining ecologically defined objectives: "Active timber management can sometimes promote forest health and reduce damage by enhancing the overall vigor of trees in a forest or by changing the forest composition. . . . Management that precludes natural processes or avoids timber management and favors preservation of forests for other purposes can alter species composition and create more dense or less vigorous forests that are conducive to some damaging agents" (p. 92). Ill-conceived action, as well as inaction, can also worsen forest conditions.

### ***Concepts***

Forest health is a perceived condition of a forest ecosystem (Helms 1998). Although value-laden, the concept communicates a useful idea. If people recognize unhealthy conditions, they may support appropriate management actions to improve them (O'Laughlin 1996).

## *Refinements*

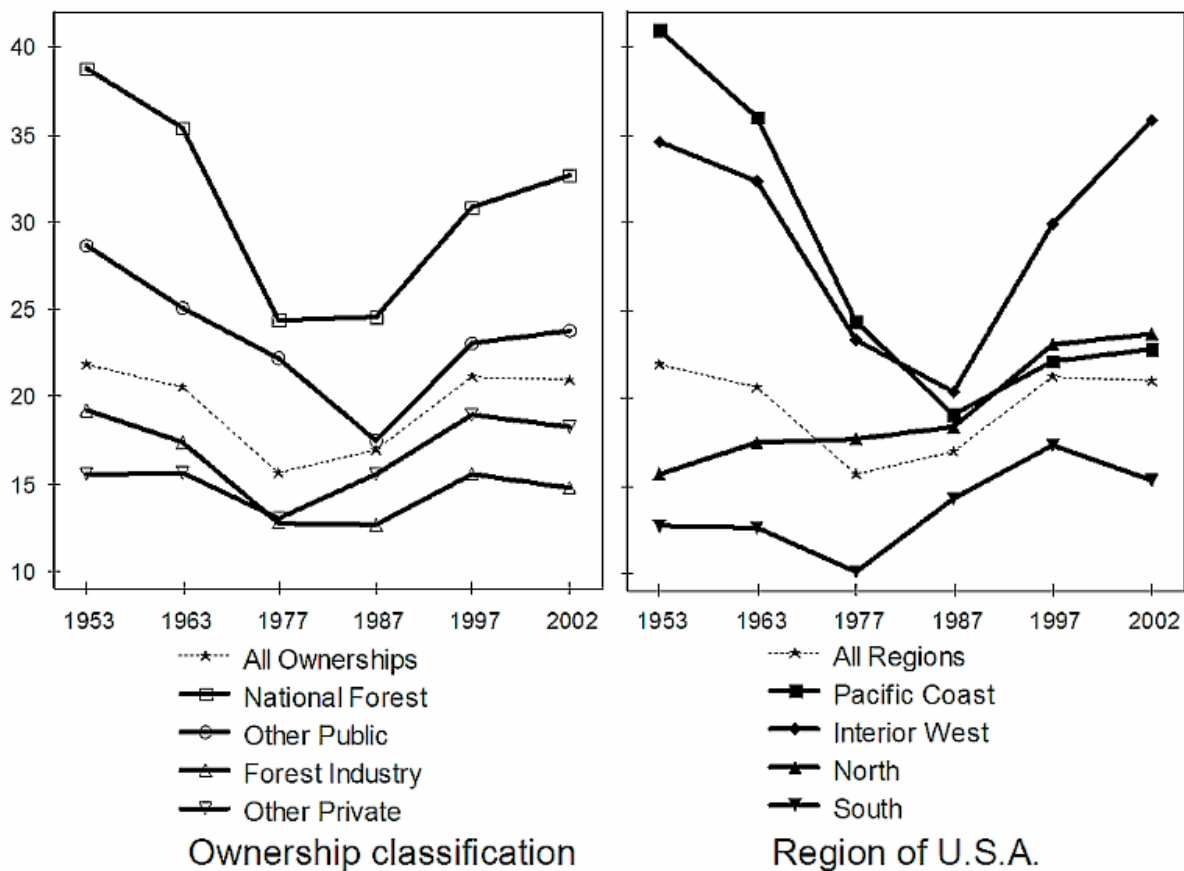
Indicator 49 suggests evaluating trends and conditions over a diverse variety of sectors (see Table 1 for a list of criteria and indicators referenced in this paper). Inventory data for timberlands have been used to compare 50-year trends across ownerships and regions (O’Laughlin and Cook 2003). Published data are classified in 16 sectors—four ownership categories in four regions (Smith et al. 2004). Regions reflect differences in forest types and growing conditions. Ownerships have different management objectives, which are of paramount importance in forest policy considerations (Cubbage et al. 1993). Data for Indicators 13, 15, and 17 exist and would be more useful if arrayed using the 16 inventory classifications. In the report, for example, Indicator 13 masks important information by aggregating published data into two ownership sectors (private/public) and two regions (East/West) (p. 27). The other two forest health indicators do not present such data but could with little effort. Two examples of such refinements follow.

Table 1. Specific Montreal Criteria and Indicators referenced in this paper.

Criterion 2	Maintenance of productive capacity of forest ecosystem
Indicator 13	Annual removal of non-timber forest products (e.g. fur bearers, berries, mushrooms, game), compared to the level determined to be sustainable
Criterion 3	Maintenance of forest ecosystem health
Indicator 15	Area and percent of forest affected by processes or agents beyond the range of historic variation (e.g. by insects, disease, competition from exotic species, fire, storm, land clearance, permanent flooding, salinisation, and domestic animals)
Indicator 17	Area and percent of forest land with diminished biological components indicative of changes in fundamental ecological processes (e.g. soil nutrient cycling, seed dispersion, pollination) and/or ecological continuity (monitoring of functionally important species such as fungi, arboreal epiphytes, nematodes, beetles, wasps, etc.)
Criterion 6	Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies
Indicator 40	Extension and use of new and improved technologies
Criterion 7	Legal, institutional and economic framework for forest conservation and sustainable management
Indicator 49	Provides for periodic forest-related planning, assessment, and policy review that recognizes the range of forest values, including co-ordination with relevant sectors
Indicator 58	Investment and taxation policies and a regulatory environment which recognize the long-term nature of investments and permit the flow of capital in and out of the forest sector in response to market signals, non-market economic valuations, and public policy decisions in order to meet long-term demands for forest products and services

**Mortality/growth rate.** Forests can be considered healthy when there is an appropriate balance between growth and mortality (Norris et al. 1993). Figure 1 tracks the mortality/growth rate (expressed as a percentage as in Indicator 17) on all U.S. timberlands over the past 50 years. The rate declined from 22% in 1953 to 15% in 1977, and then went back up to 22% in 1997, where it remains in 2002. An appropriate balance has not yet been identified, but comparing trends among ownerships or regions can identify forest condition problems that have SFM implications.

Figure 1. Annual mortality as percent of gross annual growth rate on U.S. timberlands by ownership classification and region, 1953-2002



For 50 years, the mortality/growth rates for timberlands in both private ownership categories have been below the national average for all forests (Figure 1). Before 1977, forest industry timberlands had a higher mortality rate than did nonindustrial timberlands. Since 1977, that situation has reversed. The 50-year trends for timberland in both types of public ownership have been above the national average. National forest timberlands consistently had higher mortality than other public and private forests (Figure 1). Areas in national forests where timber harvesting is permissible are therefore not as healthy as timberlands in other ownerships. Management actions to enhance vitality can change this.

According to the same data organized by region, since 1977 only in the South has the mortality rate been below the national average, fluctuating between 10% and 17% and following the same trend as the national average. In the North, the mortality rate has steadily increased from 15% to 24%. In 1953, the Pacific Northwest had the highest mortality rate (41%); now it is only slightly above the national average of 22%. In the Interior West, where national forests are the predominant ownership class, the mortality rate declined from 35% to 20% between 1953 and 1987, but since then has gone back up to 36% (Figure 1).

***Growth-to-removals ratio.*** The relationship of forest growth to removals from growing stock inventory is a sustained yield rule-of-thumb that has guided forest managers for centuries. It is featured in the report (Indicator 13) and used to measure the rate of forest use consistent with the report's SFM definition (p. 128). Figure 2 refines the report's bar charts (p. 27) because some implications for SFM have been masked by aggregating published data.

Figure 2 illustrates 50-year trends for four ownership classes and regions. Forest industry timberlands have the lowest ratio, with slightly more removals than growth in every measurement period except 1963. While some might argue that forest industry timberlands are overcut and not sustainable, growth and removals are very close to the 1-to-1 balance point. Plantations on these lands, however, have provided substantial increases in volume removed while the ratio trend has remained constant. On nonindustrial timberlands, the ratio has been decreasing since 1977, indicating increased removals but remaining comfortably above the 1-to-1 benchmark.

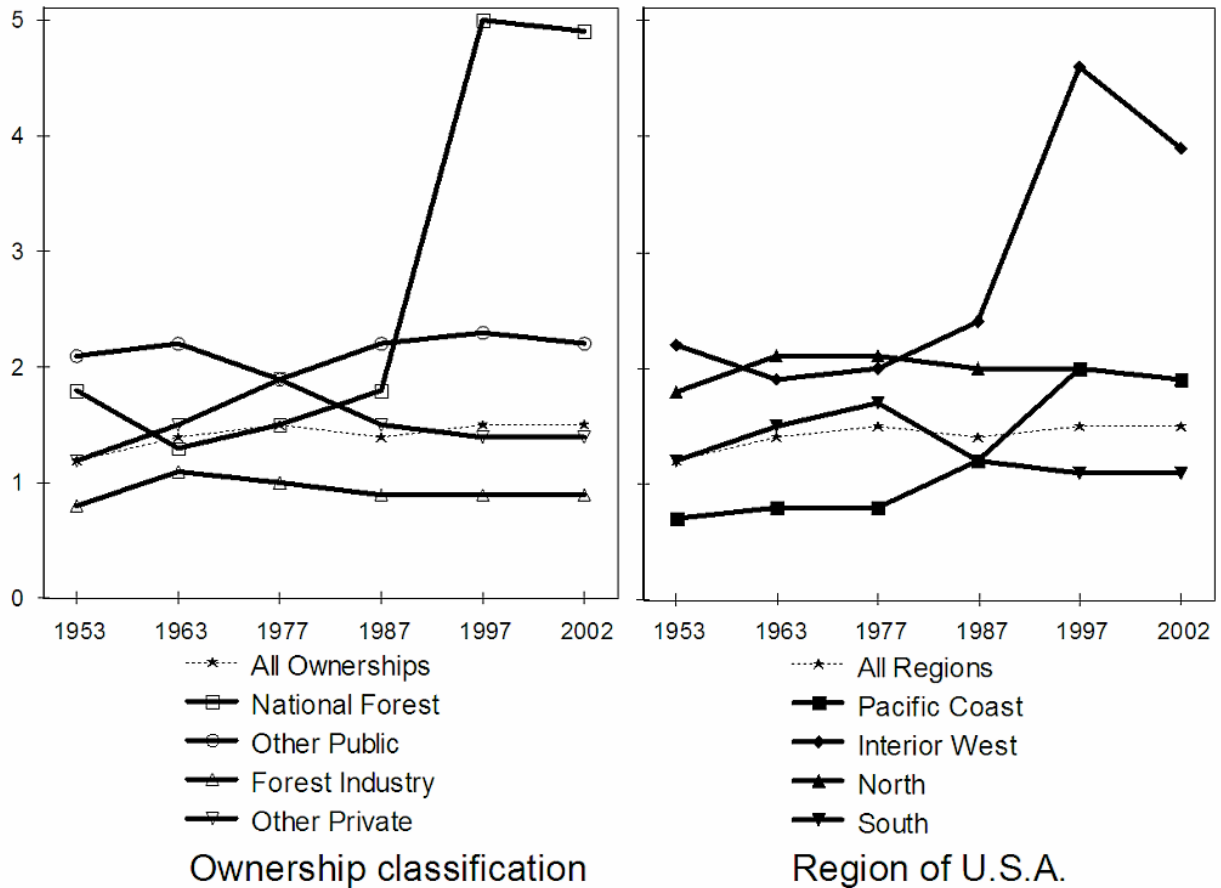
The ratio for other public forests has been remarkably steady over 50 years, with only one dip below a 2-to-1 ratio in 1977. The national forests' ratio more than doubled between 1987 and 1997 from less than 2-to-1 to almost 5-to-1 (Figure 2). The explanation is not increased growth, but rather a timber harvest decline of 75%, which, according to Haynes (2003), was primarily due to northern spotted owl conservation efforts in the Pacific Northwest. The doubling of the ratio in the Interior West reflects the large proportion of national forest ownership and the decline in timber harvest to protect a variety of species at risk of extinction.

The sustainability question is: What does the annual net growth increment on national forests portend for the future, particularly in the Interior West? The annual increment of wood added to forest inventory can be an asset or a liability (Pfilf et al. 2002). In Arizona and New Mexico, for example, two-thirds of the timberlands are in the national forests (Smith et al. 2004). According to USDA Forest Service Chief Dale Bosworth (2003), current net annual growth in these states would cover a football field with a mile-high stack of solid wood, and only 13% of it is removed each year. These forests "are overcrowded with trees. Beset by drought and under stress from competition, the trees are more susceptible to insect attack and catastrophic fire than ever before" (Bosworth 2003).

In Idaho and Montana, timberland extent and ownership are similar to that of Arizona and New Mexico, but forests are much more productive. The annual net growth increment is 4.5 football fields with a mile-high stack of wood, and only one-third of it is removed. More than one-third of the federal forests in Idaho and Montana are dry forests (Hann et al. 1997)—somewhat

analogous to Arizona and New Mexico forests but with different dynamics. The remainder consists of moist forests or cold high-elevation forests, in which stand-replacing fires are not unusual. Extensive areas in Idaho and Montana are expected over the next 15 years to have at least 25% higher mortality than the historic range of variability (USDA Forest Service 2003a).

Figure 2. Net annual growth to annual removals ratio on U.S. timberlands by ownership classification and region, 1953-2002.



Throughout the Interior West, Covington et al. (1994) anticipate an acceleration of recent changes, including increased fuel accumulations, lengthened fire seasons, and intensified burning conditions, all contributing to larger and more catastrophic wildfires. They concluded that “the consequences of inaction far exceed those of action” (p.50).

### Gaps

“Health” is mentioned 110 times in the report, but the glossary does not define it. A complete definition of forest health has two parts: one describes ecological conditions, and the other recognizes the intended purposes or objectives for a forest (Helms 1998, USDA Forest Service 2003a). Objectives reflect the values forest owners and/or managers intend to provide. For SFM use, a definition of forest health should recognize social and economic as well as ecological

values. Oliver et al. (1997) provided in a compact table a comprehensive list of 35 forest values that could enhance SFM discussions.

## **Risk Assessment**

### ***Key Messages***

The National Report recognizes that current forest conditions and wildfire regimes pose risks to many environmental and socioeconomic values. According to the report, “Alteration of historic fire regimes (Indicator 17) often causes serious changes in forest ecosystem processes, resulting in unusually intense, large fires . . . trends have emerged of increasing fire size and severity over the past 20 years” (p. 91-92, 103). The report also says, “To the extent that [various factors] threaten forests, the associated economies and communities are threatened” (p.12).

The report further states, “Because sustainability issues involve multiple scales, achieving the national goals of sustainability rest, in large part, on actions that are carried out at the local or forest management unit scale” (p. 128). Wildland fire risk reduction is a national goal that depends on landscape-level planning and project-level actions. Temporal scale is also important. However, proposed projects that could produce benefits by reducing risks in the long term are sometimes considered unacceptable because they pose a small amount of risk in the short term (Irwin and Thomas 2002, Maguire and Albright 2005, Mealey and Thomas 2002). For example, in some situations, pre-fire hazardous fuel reduction treatments can reduce post-fire smoke and sedimentation in the long term, but in the short term such treatments produce additional quantities of smoke and sediment some people may consider unacceptable, no matter how small (Cook and O’Laughlin 2004, O’Laughlin 2005a, c, d). In the West, simulation modeling results indicate that on average, a wildfire will produce 70 times more sediment than thinning to restore historic conditions; prescribed fire produces more sediment than thinning (USDA Forest Service 2003b).

### ***Concepts***

Risk gives meaning to things, forces, or circumstances that pose danger to people or what they value (NRC 1996). All management actions involve risk, including decisions to take no action (Thomas and Dombeck 1996). The report ignores risk analysis and its component parts—assessment, characterization, communication, and management . Risks cannot be effectively managed until they have been assessed, and some form of model is the best assessment method (Haines 1998). Risk assessment is controversial because it brings values into consideration (Slovic 1999). If done systematically and transparently, risk assessment can help build trust (Slovic 1993). The USDA Forest Service and US Bureau of Land Management (BLM) have been advised to adopt a systematic approach for assessing risks (USGAO 2004). Risk assessment can be associated with each component of the report’s general sustainability model—risk of losing ecosystem components, economic investment risk, and social risk in communities facing forest-based change (O’Laughlin 2004).

## ***Refinements***

Indicator 49 calls for assessments over a range of forest values and sectors. Formal risk assessment adds transparency to forest decision-making processes (Hollenstein 2001), and can improve endangered species conservation efforts by making the connection between values, objectives, and decisions more transparent, thereby increasing public trust (NRC 1995). Comparative ecological risk assessment of management alternatives can be developed from a simple conceptual model diagram illustrating decision trade-offs. One example compares post-fire sedimentation with and without fuel treatment. The risk management hypothesis is that the benefits of post-fire sediment reduction from fuel treatment exceed the pre-fire sediment produced by fuel treatment (O’Laughlin 2005a, d).

## ***Gaps***

Managing resources involves managing risks. According to the US Government Accountability Office (2004), “Without a risk-based approach, [the USDA Forest Service and BLM] cannot target their fuel reduction projects across landscapes or make fully informed decisions about which effects and project alternatives are more desirable” (unnumbered Highlights page). Several policies require risk-based decisionmaking in federal land and resource management, including the National Environmental Policy Act’s (NEPA 1969) balancing of short- and long-term environmental effects, and the Endangered Species Act’s (ESA 1973) judgments about extinction risk and risks of unnecessary expenditures or land-use changes arising from uncertainty (NRC 1995). The Healthy Forests Restoration Act (HFRA 2003) requires courts to consider risk trade-offs before issuing stop-work injunctions on HFRA fuel treatment projects. These policies offer no guidance on doing risk assessment (O’Laughlin 2005b).

Risk assessment can be used to support many SFM decisions, including comparing wildland fire risks with and without fuel treatments (O’Laughlin 2005a, Lee et al. 2005). A risk engineer recommends that instead of treating risk analysis as an add-on process, it should be fully integrated into decisionmaking processes (Haimes 1998). When integrated with NEPA processes, risk assessment could result in more meaningful environmental impact analyses (Fairbrother and Turnley 2005). Comparative risk assessment concepts have been applied to private forestlands that provide habitat for species at risk of extinction (Roloff et al. 2005). Outputs from the USDA Forest Service’s Comparative Risk Assessment Framework and Tools(CRAFT) project promise internet-based access to tools managers can use for comparative ecological risk assessment (Lee et al. 2005). The National Report could encourage the integration of risk assessment into decisionmaking processes.

## **National Fire Plan (NFP)**

### ***Key Messages***

According to the National Report, “Today, there is considerable public debate about how best to prevent fires and reduce property damage. This is an area in which our perceptions about sustainability are being informed by new knowledge, and the institutional framework surrounding how we manage forest fires is evolving” (p.103). The public debate about wildfire

management often revolves around reducing risks. Although the report does not mention the National Fire Plan, it is an institutional framework with a collaboratively developed action plan for managing wildfire risks, and therefore is directly related to the SFM debate, if not directly at the center of it. The NFP continues to evolve in response to policy issues (O’Laughlin 2005c).

### ***Concepts***

The NFP is a collection of policies and documents for actively responding to severe wildland fires and their impacts to communities while ensuring sufficient firefighting capacity for the future. The NFP addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability (USDA/USDI 2005). Large-scale analysis reveals that more than half of the nation’s forests and rangelands face moderate (38%) or high (15%) risks of losing key ecosystem components from wildfire (Schmidt et al. 2002). Without active management of fuels, many forests will continue to be subject to uncharacteristically severe fires, and the costs of firefighting will continue to increase (Stephens and Ruth 2005). Because wildfire management tasks are so extensive, part of NFP implementation involves prioritizing efforts by identifying forest sectors facing high risks.

### ***Refinements***

Assessment of how fire is affecting forests would be enhanced if agencies reported the area burned by low-, mixed-, and high-severity fire and the proportion that is outside the desired trend or range of conditions for each forest type (Stephens and Ruth 2005). Wildfire data could be assembled into a useful information base for NFP implementation by arraying data on the historic area burned in the four regions and ownerships that are used for timber inventory data. Comparing current data with historic ranges of variability would provide information pertinent to Indicator 15 (area and percent of forest land affected by processes or agents beyond the range of historic variation). Integrating analysis of area-burned data with forest condition data would help identify priorities for management action

### ***Gaps***

NFP implementation has implications for SFM that were unrecognized in the National Report. Indicator 49 encourages cooperation among sectors. The NFP’s 10-year implementation strategy relies on collaboration among sectors (WGA 2002).

Meeting the NFP fuel treatment goal will generate large quantities of small diameter wood in the western states (USDA Forest Service 2003b). Economic implications relevant to Indicators 40 and 58 include funding some fuel treatments through commercial timber sales and establishing long-term contracts for quantities of noncommercial biomass material sufficient to encourage capital investments in wood-processing or biomass energy-producing facilities.

However, “Without adequate emphasis on the restoration of ecosystems and the development of capacity and incentives through community assistance [two more NFP goals], it is unclear how sustainable, long-term solutions to the wildfire problem will be feasible” (Steelman et al. 2004). To help meet the NFP’s community assistance goal, and pertinent to community development

discussion in the report (p. 112), assessments of communities-at-risk have been conducted and a process for developing community wildfire protection plans is in place (NASF 2003, Communities Committee et al. 2004). Progress toward the NFP's ecosystem restoration goal remains problematic (WGA/FHAC 2004) and would be assisted with a more complete region and ownership sectoral analysis of existing data for Indicator 15.

## **Policy Analysis Integration**

### ***Key Messages***

The National Report states that “Sustainable forest management is a highly integrated and interdependent concept. The environmental, economic, and social spheres exert joint, simultaneous, and inextricable influences on forests. Opportunities to shape one sphere affect the others. We need to think more about sustainable forest management in the context of linkage among the three spheres” (p. 113). A starting point for an integrated approach to such thinking is Indicator 49: “. . . policy reviews that are sensitive to a range of forest values and are coordinated with a variety of forest-related sectors.” Such an approach is crucial for SFM assessment because “[w]hether existing legal [policy] capacity is actually being translated into meaningful plans and their subsequent implementation is largely unknown” (p.63). The report notes that “Using a collaborative approach, a conceptual model provides a vehicle for resolving differences and reaching consensus among various stakeholders” (p.116).

### ***Concepts***

Consistent with the report's discussion of conceptual models (p.116), figure 3 presents a policy analysis framework for SFM. Review and analysis of policies supporting SFM (p.63) provides a method for identifying linkages among the sustainability spheres. Integrated linkage is evident in the following statement: maintaining forest health involves establishing sustainable stand conditions, reducing risks, and utilizing forest products to help finance activities (Pfilf et al. 2002). What policies either encourage or inhibit establishing sustainable forest conditions? Policy analysis is pragmatic, focusing on problems rather than principles or programs, and contributes to SFM by defining problems in social and decision contexts to generate sustainable management options through synthesis of multiple perspectives (O'Laughlin 2004). Scale issues are accommodated by limiting analysis to a location appropriate to the problem and context, including, as Oliver (2003) suggested, institutional arrangements (Criterion 7) and spatial and temporal concepts of fairness as perceived by stakeholders. In short, sustainability is attained by focusing on specific cases, triangulating on the problem from different perspectives (Roe 1998).

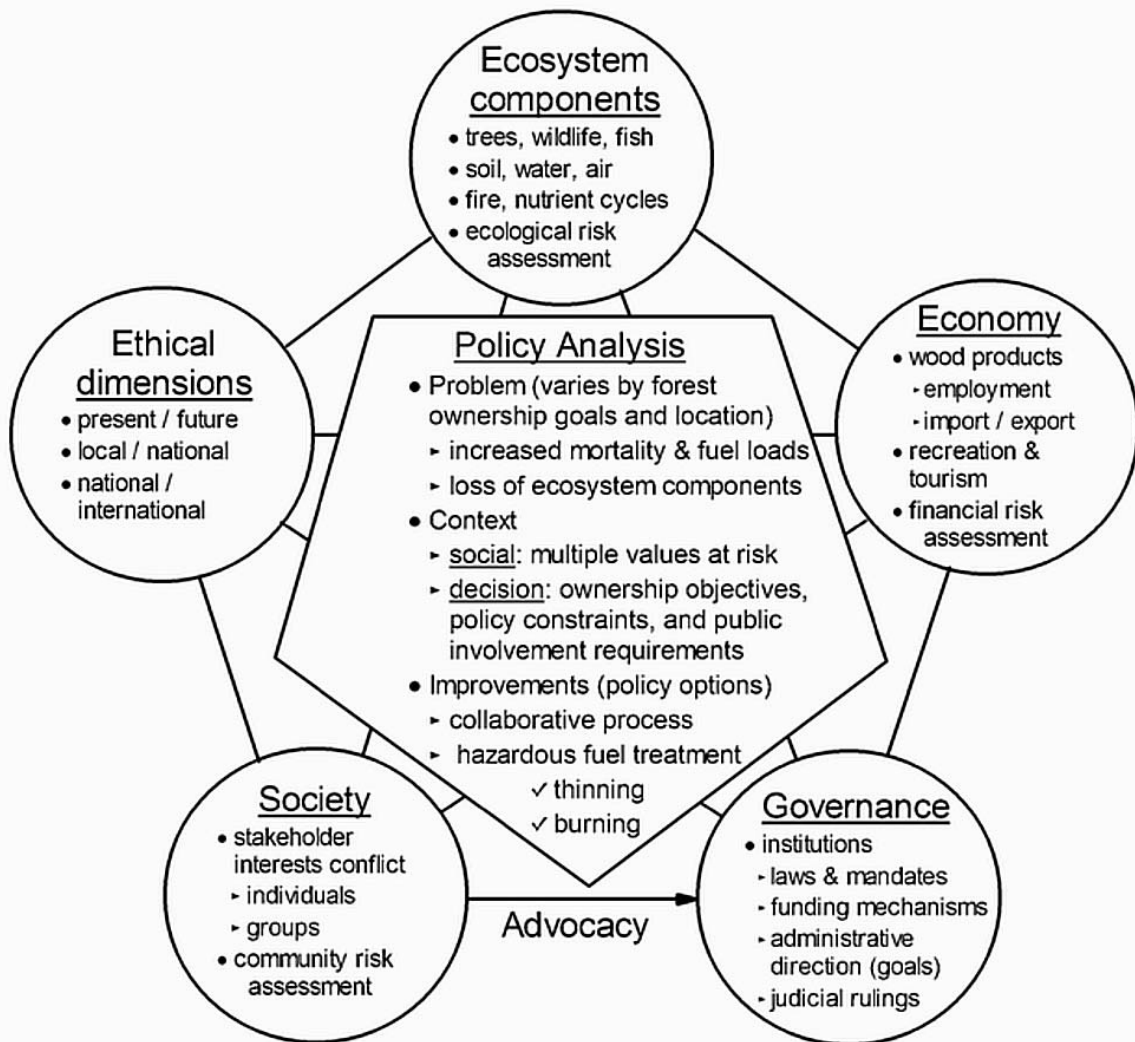
### ***Refinements***

Fundamental value disputes sometimes keep stakeholders from attaining consensus. Instead of engaging in collaborative processes, they press their advocacy for a particular outcome on policymakers (figure 3). The specificity required by risk assessment may encourage movement away from value positions toward interest-based SFM improvements. Risk assessment is associated with each of the three SFM components—ecological, economic, and social (O'Laughlin 2004).

## Gaps

The report's lack of a conceptual model (see p.116) will continue to inhibit effective communication among stakeholders and decisionmakers about the integrated nature of SFM problems and potential solutions.

Figure 3. Sustainable forest management policy analysis framework.



## Conclusions

Several conclusions can be drawn from this attempt to integrate forest health, risk assessment, and the National Fire Plan in a policy analysis framework. . First, hazardous fuel treatments can

reduce forest health and wildfire problems, and risk-based analysis can support decisions by transparently and graphically demonstrating trade-offs among management alternatives. This would be especially useful in ESA consultations and in court to defend challenges to land management projects.

Second, the Montreal Process and the report use one vague concept (forest health) to describe another (forest sustainability). Many people are confused rather than enlightened by such ambiguity. Risk analysis forces specific identification of at-risk values and hazards posing the risk, thus deals directly with tangible things people care about, like fish and wildlife. Effective risk assessment is driven by stakeholder involvement and explicitly avoids ambiguous terms like integrity and sustainability (USEPA 1998).

Third, whether on private or public lands, a collaborative approach is essential for dealing with multiple perspectives. The balancing of social values through such democratic processes determines what should and does happen in our forests (Cook and O’Laughlin 2000). Indicator 49 encourages cooperation among sectors, and the NFP’s 10-year implementation strategy is based upon collaboration (WGA 2002). Although essential, collaboration is the weakest part of NFP implementation (WGA/FHAC 2004).

Fourth, America’s forests are too extensive and variable to address meaningfully in the SFM context as a single aggregated entity. According to the National Commission on Science for Sustainable Forestry (2005), “The bottleneck in effective selection and use of indicators is not a lack of good indicators or good science, but rather the lack of (1) clearly articulated management objectives for the values to be sustained and (2) a clear process for selecting indicators to reflect specific values and objectives. Therefore, although stakeholders may repeatedly select certain indicators for different situations (e.g., forest types, scales of application), a universal ‘core set’ isn’t useful” (p.29). This reinforces the need for case-by-case analysis of SFM problems.

Fifth, the report says that “a definitive statement about sustainability cannot be made within the context of these 67 [Montreal Process] indicators” (p.113). Nonsense. We know intuitively that some forests are more sustainable than others, and for some indicators adequate data exist to support such conclusions. For example, forest density is closely correlated with mortality, and national forests are much denser than forests in other ownerships and have higher mortality (O’Laughlin and Cook 2003). Projections over the next 50 years show that at current harvest levels, western national forests are expected to become 50%–60% denser (Haynes 2003). Discussion of the SFM implications of this trend would illuminate policy discussions. Consider, for example, the sustainability assessment by USDA Forest Service Chief Bosworth (2003): “We have some 73 million acres of national forest land at risk from wildland fires that could compromise human safety and ecosystem integrity. . . . The situation is simply not sustainable—not socially, not economically, not ecologically.” This conclusion would not be more compelling with additional data or analysis. The Society of American Foresters agrees and recommends a clarified mission and purpose for these forests, as well as a framework for management (Helms 2005). Although the USDA Forest Service has developed a decision framework, it has not been widely adopted by planners and managers; adding risk assessment and eliminating some other protocols may make the decision framework more useful (Lee et al. 2005).

Finally, the report says “sustainability should be viewed as more of a journey than a destination” (3). At this point on the journey, building trust to enable management action would seem to be a better investment of scarce resources than building databases. Somewhat paradoxically, however, adaptive management action relies on monitoring data to demonstrate progress toward collaboratively determined objectives that are consistent with desired forest values and reflected by the indicators being monitored. Whether objectives are called desired future conditions or something else, they provide the basis for building the trust needed to accomplish SFM in all its dimensions across all forest sectors.

### **Acknowledgments**

My colleague Philip Cook’s substantial contributions to SFM policy analysis are acknowledged (see Cook and O’Laughlin 1999, 2000, 2003, 2004; O’Laughlin and Cook 2003). Thanks to Jim Granskog for inviting review of Indicator 49 during preparation of the National Report and to Al Abee and Dave Cleaves for enabling me to present some of these ideas at a March 2004 SFM colloquium at the USDA Forest Service’s Washington office. Thanks also to the Western Governors’ Association—executive director Pam Inman and staffers Paul Orbuch and Jay Jensen—for moral support and to several of my colleagues on the WGA Forest Health Advisory Committee for comments on an earlier draft, including Bob Alverts, Carol Daly, Craig Kenworthy, and Jonathan Oppenheimer. I invited and received comments from others, including Chad Oliver and Scott Wallinger. Comments by anonymous reviewers for the Multiple Perspectives Project also improved the paper.

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