Protecting People and Sustaining Resources in Fire-Adapted Ecosystems

A Cohesive Strategy

The Forest Service Management Response to the General Accounting Office Report GAO/RCED-99-65, April 13, 2000

Submitted By

/s/ Lyle Laverty
Lyle Laverty
Report Team Leader
Rocky Mountain Region
Regional Forester

/s/ Jerry Williams
Jerry Williams
Report Team Co-Leader
Northern Region
Director Fire Management

Concurred By

Hilda Diaz-Soltero
Associate Chief
Natural Resources

Phil Janik
Associate Chief
Chief Operating Officer

Recommended By

Mike Dombeck
Chief

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Resilience and the Effects of Restoration Treatments in Fire-Prone Forests

This photograph illustrates how a treated forest – the green strip running toward the crest of the ridge in the photo's center – can survive a severe wildfire. It shows the differences in *resilience* between treated and untreated forests. The untreated forest – the blackened areas located on either side of this green strip – burned in the Wenatchee National Forest's 1994 Tyee Fire.

In this example, treatment was in the form of a "shaded fuel break" (the photo's green strip) established several years before. Shaded fuel breaks were located in tactically important areas to provide firefighters an anchor from which to safely fight fire. These shaded fuel breaks left older-age trees overhead and thinned out the smaller trees beneath them – removing surface fuels to reduce potential fire intensities.

On the Tyee Fire, extreme conditions that included high winds and rapid fire growth, precluded safe attack. Therefore, no suppression actions were taken in this area. Nevertheless, because the fuels had been reduced and fire intensities could not burn hot enough to kill all of the older trees, the treated forest survived the fire – even without the efforts of firefighters.

The cohesive strategy described in this report attempts to achieve improved resilience – as illustrated in this Tyee Fire photo. The strategy reduces fuel loadings in fire-prone forests to protect people and sustain resources.

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Executive Summary

"The most extensive and serious problem related to the health of national forests in the interior West is the over-accumulation of vegetation."

General Accounting Office Report (99-65)

Preface

This report answers Congressional direction to provide a strategic plan to reduce wildfire risk and restore forest health in the interior West. It is based on findings reflected in the U.S. General Accounting Office (GAO) Report, *Western National Forests: A Cohesive Strategy is Needed to Address Catastrophic Wildfire Threats (GAO/RCED-99-65).*

The General Accounting Office report concludes that "the most extensive and serious problem related to the health of national forests in the interior West is the over-accumulation of vegetation." The General Accounting Office estimated that the this over-accumulation of fuels problem affects approximately 39 million acres in the interior West and would cost $725 million per year to treat.

In formal transmittal to the General Accounting Office, the Forest Service agreed with the principal findings of the report (File Code 1430, 3/22/99).

The strategy outlined in this report was chartered by the Forest Service Associate Chiefs for Operations and Natural Resources. The National Association of State Foresters and the U.S. Department of the Interior participated with the Forest Service in developing this report.

This is a strategic plan. At the national level it establishes:

- Agency-wide objectives and milestones that specifically address treatment expectations.
- Broad geographic area priorities, management direction, and performance measures for accountability.
- A preliminary 15-year treatment schedule and budget strategy to accomplish treatment objectives.

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A separate action plan, tiered to the strategy, will detail implementation steps at the organization's regional, forest, and ranger district levels.

The acreage numbers used in this report are preliminary. They were derived from coarse-scale assessments. Further refinement of these numbers will occur as site-specific assessments are completed.

Premise

The cohesive strategy outlined in this report is based on the premise that sustainable resources are predicated on healthy, resilient ecosystems.

In fire-adapted ecosystems, some measure of fire use – at the appropriate intensity, frequency, and time of year – must be included in management strategies intended to protect and sustain watersheds, species, and other natural resources over the long term.

The strategy is also based on the premise that within fire-adapted ecosystems, fire-maintained forests and grasslands are inherently more safe for firefighters and the public than ecosystems in which fire is excluded.

Purpose

The strategy restores and maintains health in fire-adapted ecosystems across the interior West. In accomplishing this, it is intended to:

- Improve the resilience and sustainability of forests and grasslands at risk,
- Conserve species and biodiversity,
- Reduce wildfire costs, losses, and damages, and
- Better ensure public and firefighter safety.

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Present Situation

Most forests and grasslands in the interior West and their associated species are fire-adapted. Some, known as "short interval" fire-adapted ecosystems, are able to survive frequent, low-intensity fires. In fact, they have adapted to these kinds of fires and rely on periodic surface burning to cycle nutrients, check the encroachment of competing vegetation, and maintain healthy conditions.

In the prolonged absence of low-intensity burning in these ecosystems, insect infestations, disease outbreaks, and severe wildfires are inevitable.

Before the turn of the last century, livestock grazing, selective logging, and curtailment of burning by Native Americans, began to alter the composition, structure, and function of natural ecosystems. In fire-adapted ecosystems, fire-tolerant species began to be replaced by fire-intolerant types. The composition of these forests changed from approximately 50 larger fire-tolerant trees per acre to more than 600 mostly small fire-intolerant trees per acre. As seedlings filled in beneath the old-age trees, open park-like forests became more dense. Without recurring underburns, nutrient cycles and other ecological functions were also interrupted.

Expanded human development, changes in climate, and organized fire suppression have all resulted in substantial accumulations of understory vegetation. This over-accumulated vegetation predisposes some areas to severe wildfires, potentially leaving watersheds, species, and people at risk.

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Today, many of the most serious wildfire threats and forest health issues are concentrated within fire-adapted ecosystems, principally as a result of prolonged fire exclusion.

The Strategy

This report outlines a cohesive strategy to reduce wildfire threats and restore forest health in the interior West. The strategy builds on the premise that – in fire-adapted ecosystems – reducing fuel levels and using fire at appropriate intensities, frequencies, and time of year is the key to restore healthy, resilient conditions; sustain natural resources; and better protect people.

The strategy introduces institutional objectives, establishes program management priorities and budgets, and confirms the importance of expanding constituency support. The strategy's success stands on the cohesion and collective strength of these elements.

The strategy places priorities where human communities, watersheds, or species are at risk. It relies on a variety of treatment options to achieve restoration objectives – including mechanical thinning, some harvest, and prescribed fire. Most treatment efforts are concentrated in the shorter interval fire-adapted ecosystems. These ecosystems are typically farthest outside the historic range of variability and are often in closest proximity to high human values at risk.

Strategy – Ties to GPRA Strategic Plan

The strategy ties to the Forest Service Government Performance and Results Act (GPRA) Strategic Plan (2000 revision) by establishing objectives, milestones, and performance elements for ecosystem restoration and maintenance, and conservation education.

At full implementation, the strategy attempts to treat approximately three million acres per year in the interior West. It incrementally increases to this level within a five-year period. This level of treatment was developed using regional input based on other more recent assessments. This level of treatment also responds to regulatory responsibilities for clean air, clean water, and threatened or endangered species.

The strategy does not attempt to treat all acres, nor does it eliminate all risks. However, while the strategy does not aim to return forests and grasslands to pre-European settlement conditions – it does reduce their susceptibility to damage.

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At the end of a 15-year period, the strategy treats 14 million acres in the interior West considered at highest risk of long-lasting damage. In other areas, where conditions are at low or moderate risk, the strategy treats an additional 26 million acres during the 15-year timeframe.

Across these total 40 million acres, accumulated fuel reduction treatment techniques range from maintenance prescribed burning, where fire is used to maintain forest conditions in lower-risk acres, to restoration treatments in higher-risk areas where mechanical thinning is followed by prescribed burning.

By comparison, at present rates, during the same time period, the current approach will have treated only 7.5 million acres. This present approach maintains lower risk areas at considerably less cost. Current fuel reduction treatments are not funded at a level needed to address the more expensive restoration work required on high-risk areas.

Strategy – Focus on High-Risk Acres

The strategy focuses treatment on high-risk areas, rather than least-cost acres. Of the total acres treated, approximately one-third is directed toward those areas in which watersheds, species, or human communities are at highest risk. In other areas, treatments are designed to prevent further increases to high-risk conditions, or to maintain current lower-risk conditions.

Some existing roads will be used to access high-risk areas. Where roads are scheduled for closure, consideration will be given to accomplishing ecosystem restoration objectives prior to closure.

While emphasizing *restoration* in the interior West, the strategy also supports ongoing efforts to *maintain* healthy ecosystems where they currently exist. For example, in the South where fuels can rapidly accumulate to dangerous levels without treatment.

Projected direct treatment costs at full implementation climb to approximately $825 million per year. Direct treatment costs include planning (e.g., project, consultation, NEPA compliance), mechanical thinning, prescribed burning, supporting research, invasive weed mitigation, and monitoring and evaluation.

Better integration of existing program budgets could reduce the need for new money and the large, additional appropriations that would otherwise be required. Some treatment costs could be offset by revenues generated from harvest receipts. In most cases, however, these revenues will not be significant

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due to the need to maintain larger, fire-tolerant trees and to reduce the disproportionately large number of smaller, sub-merchantable trees that dominate short interval fire-adapted ecosystems.

Strategy – Complements Other Efforts

The strategy complements other work, including the Forest Service Western Forest Health Initiative and the Western Governor's Association Policy Resolution. Both of these efforts recognize that restoring forest health in the Western states is essential to the safety of private property and the productivity of public lands.

The strategy also builds on the Joint Fire Sciences Program. It relies on adaptive management, monitoring, research, and the further integration of social sciences. It encourages development of risk assessment procedures that bring together and overlay agency objectives for watershed protection, species conservation, ecosystem resilience, and public safety.

The Consequences of Deferral

The costs of restoration and maintenance treatments outlined under this strategy are high. Yet, fire suppression costs, public resource losses, private property losses, and environmental damages accruing without treatment are expected to be significantly greater over time.

Throughout much of the interior West, dense vegetation and dead material is continuing to accumulate. Each year, in the absence of treatment, more forests become high-risk – choked with dense accumulations of small trees and dead wood. These accumulations fuel more damaging fires that are more dangerous and more costly to control – especially during drought years.

As the General Accounting Office report points out, many experts attach a sense of urgency to the management of these ecosystems. Because of the high proportion of total area classified as high-risk, combined with the fact that without treatment more vegetation will "grow" into these high-risk conditions, it is apparent that time is running out for a strategy to successfully avert high-cost, high-loss consequences.

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Successful Restoration and Maintenance Efforts

Collaborative planning, involving stakeholders in identifying and assessing values at risk, is an important component of the strategy. The Sierra Nevada Framework for Conservation and Collaboration and the Columbia River Basin Management Plan are examples of regional-scale planning that address values at risk and establish priorities for broad geographic areas.

More localized planning processes, including Land and Resource Management Plan (forest plan) revisions and amendments, will integrate specific concerns at a watershed or landscape scale within the context of regional plans and the Forest Service GPRA Strategic Plan.

Across the nation, awareness is growing about the fire-related consequences that occur in untreated forests and grasslands prone to wildfire. The following are two examples of citizen-based efforts that have been developed to reduce risks within the interior West's urban interface:

- The Grand Canyon Forests Partnership (joining Arizona Game and Fish, U.S. Fish and Wildlife Service, Arizona State Land Department, Coconino County, City of Flagstaff, Northern Arizona University, Grand Canyon Trust and the Nature Conservancy);
- The Priest-Pend Oreille Stewardship Project that focuses on 7,200 acres of wildland-urban interface lands in the Idaho Panhandle National Forest (joining two community project teams with the Forest Service).

While these efforts are achieving successful results, to improve forest health and reduce wildfire risks at larger, more meaningful scales, treatments need to be expanded over broader areas.

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Restoration and maintenance of fire-adapted ecosystems depends on:

- Valuing ecological processes as the means to sustain ecosystem health.
- An ability to evaluate options and weigh decisions for *long-term* outcomes.
- A tolerance for use of the tools needed to accomplish restoration goals.
- A commitment to monitoring and evaluation as the basis for adaptive management.

Successful implementation of this strategy requires strong support from Forest Service leadership, the Administration, Congress, and constituents.

I Premise, Purpose and Elements of a Cohesive Strategy

Premise

This cohesive strategy is based on the premise that sustainable resources are predicated on healthy, resilient ecosystems. In fire-adapted ecosystems, some measure of fire use – at appropriate intensity, frequency, and time of year – must be included in management strategies intended to protect and sustain watersheds, species, and other natural resources over the long term.

The strategy is also based on the premise that, within fire-adapted ecosystems, fire-maintained forests and grasslands are inherently safer for firefighters and the public than ecosystems in which fire is excluded.

Purpose

The strategy restores and maintains ecosystem health in fire-adapted ecosystems across the interior West. In accomplishing this, it is intended to:

- Improve the resilience and sustainability of forests and grasslands at risk,
- Conserve species and biodiversity,
- Reduce wildfire costs, losses, and damages, and
- Better ensure public and firefighter safety.

Elements

For the purposes of this report, the following are used as the elements of a cohesive strategy:

- Institutional Objectives and Priorities
- Program Management Budgets and Authorities
- Social Awareness and Support

The strategy is based on the alignment of these institutional, program management, and constituency elements. The cohesion of this strategy stands on the collective strength of these three core elements.

The Strategy's Three Core Elements

Institutional

The Forest Service is a functionally-oriented, decentralized organization, affording its decision-makers discretionary authority. Within this organizational structure, overarching stewardship goals and management controls form the basis for establishing priorities and reconciling competing responsibilities.

Program Management

The Forest Service budget structure, criteria for setting priorities, authorities, and workforce, comprise the basic elements of program management. Integrated program area budgets support common goals and objectives. Innovative and flexible use of authorities significantly influences treatment capabilities.

Social

Landscape-scale restoration of fire-adapted ecosystems requires broad constituency support. Restoration work may invariably conflict with some social values. *The need to better connect our publics to the dynamics of the land and, simultaneously, connect agency policies and practices with the values of our publics is clear.* Although forestry's history is anchored to the physical sciences, its future needs to better integrate the social sciences.

Within the Forest Service, ecosystem management concepts continue to evolve into practice. This report describes a cohesive set of actions that the Forest Service will take to achieve restoration and maintenance objectives for fire-adapted ecosystems.

II Introduction

"Ecosystems are not defined so much by the objects they contain, as by the processes that regulate them."

Norman L. Christensen
Duke University

This report responds to the United States General Accounting Office Report, *Western National Forests: A Cohesive Strategy is Needed to Address Catastrophic Wildfire Threats (GAO/RCED-99-65, April 1999).* The General Accounting Office report concludes that "the most extensive and serious problem related to the health of national forests in the interior West is the over-accumulation of vegetation."

Although the General Accounting Office (GAO) report acknowledged that the Forest Service has a general strategy for addressing the problem of fuel (vegetation) accumulation, it faulted the agency for lacking a cohesive approach. Specifically, it criticized the agency for not having clear goals, objectives, direction, and budgets that adequately address ecosystem restoration and maintenance needs. The General Accounting Office report also faulted the agency for lacking the means to reconcile stewardship objectives. In answering the report, the Forest Service agreed in principle with the GAO findings.

This strategy complements other work, including the Forest Service Western Forest Health Initiative and the Western Governor's Association Policy Resolution. Both of these efforts recognize that restoring forest health in the Western states is essential to the safety of communities and productivity of the forest.

For the past several years, awareness has grown among rural Western residents concerning fire's role in the ecosystem and the need to reduce fuels around their communities. Currently, several grassroots, citizen-based efforts – along with local, state and federal agencies – have collaboratively planned and executed fuel reduction efforts to establish and maintain fire-safe communities. This strategy builds on these efforts and simultaneously expands treatment objectives to better protect species at risk and watersheds at risk. The strategy attempts to increase the scale of fuel reduction and forest health restoration work.

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III Background, Land Use History and Ecological Change

Background

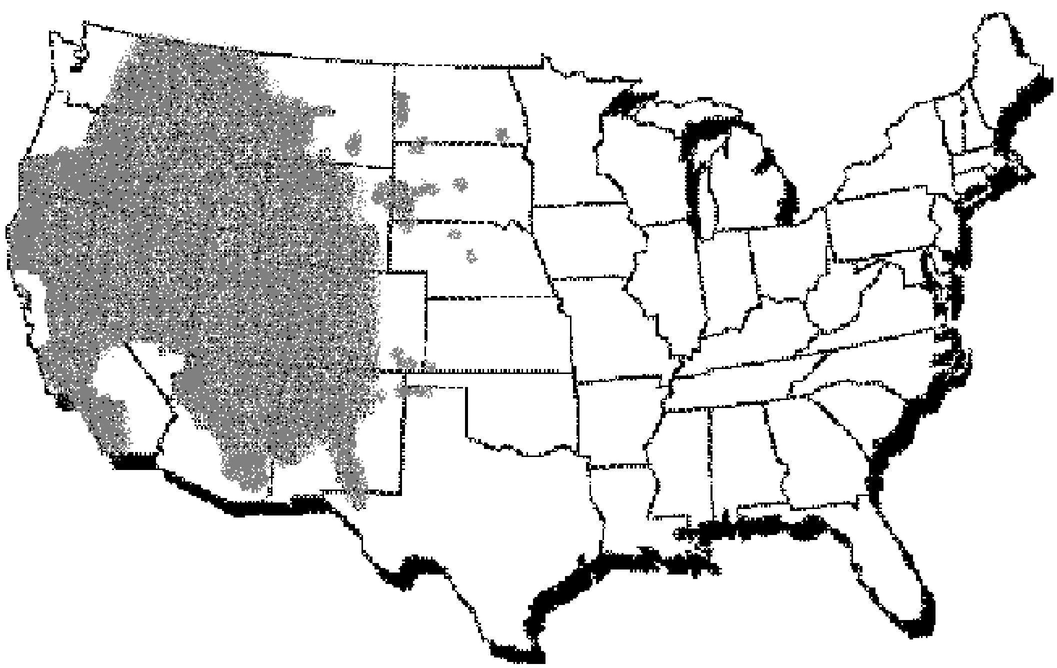

Figure 1 – General affected area within the interior West.

Approximately 134 million acres, or about 70% of National Forest System lands, comprise the interior West. The area is a fire-influenced environment. For thousands of years, the magnitude of burning that occurred in this area was much greater than today. In the upper Columbia River Basin alone – a small portion of the interior West – scientific assessments indicate that prior to European settlement, more than six million acres per year burned. Today, fewer than one-half million acres burn per year in this same area.

Nearly all forests and grasslands in this region evolved and adapted as a result of widespread fire from lightning and burning by Native Americans. These adaptations enabled plant species to survive and regenerate in the presence of fire. Some interior West ecosystems depend on frequently recurring, low-intensity surface burns to cycle nutrients, control pathogens, and maintain healthy, resilient conditions.

These are called "short interval" fire-adapted ecosystems. Before the turn of the century, these forested ecosystems were often described as open and savannah- or park-like, with well-spaced, older-aged trees. The understories of these forest communities were dominated by grasses and forbs. They were kept in this condition by frequent, low-intensity fires that swept the forest floor.

Land Use History

Many of the wildfire threats and forest health issues that confront us today were triggered more than 100 years ago. In the late 1800s and early 1900s, "high grade" logging selectively removed the largest, most valuable trees – often the fire-tolerant ponderosa and other long-needle pine species.

Across open landscapes, early livestock grazing also reduced grass cover and scarified the soil. In forested areas, the bare soil seedbeds that resulted from logging and intensive grazing allowed hundreds of trees to establish on each acre. Without grass fuels to carry surface fires, the number of trees (including fire-intolerant species) multiplied rapidly. These became dense tree stands that foresters termed "dog-hair" thickets. Elsewhere, grasslands often converted to brushlands and woodlands.

In the West, the notion of forest protection has historically been equated with fire exclusion. Thus, a primary function of the Forest Service's overall mission became forest fire suppression.

Ecological Change

The unintended consequences of early logging, livestock grazing, and fire control resulted in significant changes to species composition and structure – especially in the short interval fire-adapted ecosystems. These changes, in turn, predisposed extensive areas to many of today's wildfire and forest health problems in the interior West.

The following photos (figures 2-4), from the Lick Creek drainage in western Montana, illustrate the changes that have occurred in species composition and forest structure over an 80-year period in a short interval fire-adapted ponderosa pine forest ecosystem. Each photo was taken from the same place, looking at the same forest, at different periods in time. The photos therefore capture the differences that have developed in species composition and forest structure in the prolonged absence of periodic surface burning. Within these ecosystems, these changes become indicators of potential risk.

Changes in Species Composition and Forest Structure

Figure 2

1909 Photo
This serves as the baseline reference of forest stand conditions that evolved from regularly occurring, low-intensity surface burning. Analysis of living fire-scarred trees indicates that, on average, fire swept these forests at 5-15 year intervals. The fires were "hot" enough to restrict most encroaching vegetation, but "cool" enough to avoid killing most of the older-age trees. The forest was open and dominated by the larger fire-tolerant, fire-adapted ponderosa pine.

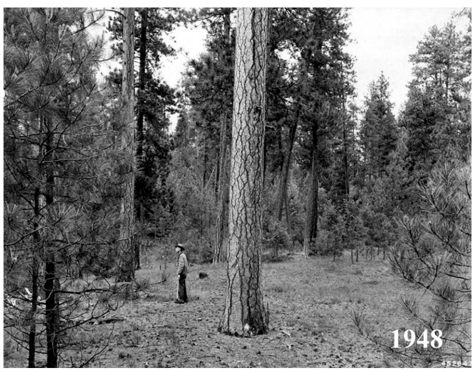

Figure 3

1948 Photo
By 1948, the forest is beginning to reveal changes in species composition and structure as fire has been excluded for several years. The fire-intolerant, late-successional species, including Douglas fir and white fir, are becoming established beneath the older-aged ponderosa pine. By this time, more small trees than larger trees occupy the site.

Figure 4

1989 Photo
By 1989, the forest has changed dramatically from the one that existed here in 1909. Over this 80-year period, small trees have established in dense thickets and fire-intolerant tree species now crowd the forest. During drought periods the overabundance of vegetation stresses the site, pre-disposing the forest to insect infestations, disease outbreaks, and severe wildfire.

In the prolonged absence of periodic surface burning, vegetative growth compounds and dead fuels accumulate. Within the forest, this biomass – in the form of multi-layered tree canopies – can carry flames from the surface where dead branchwood burns up into the tree crowns. In drought years, when vegetation dries, these "ladder fuels" contribute to severe, high-intensity wildfires.

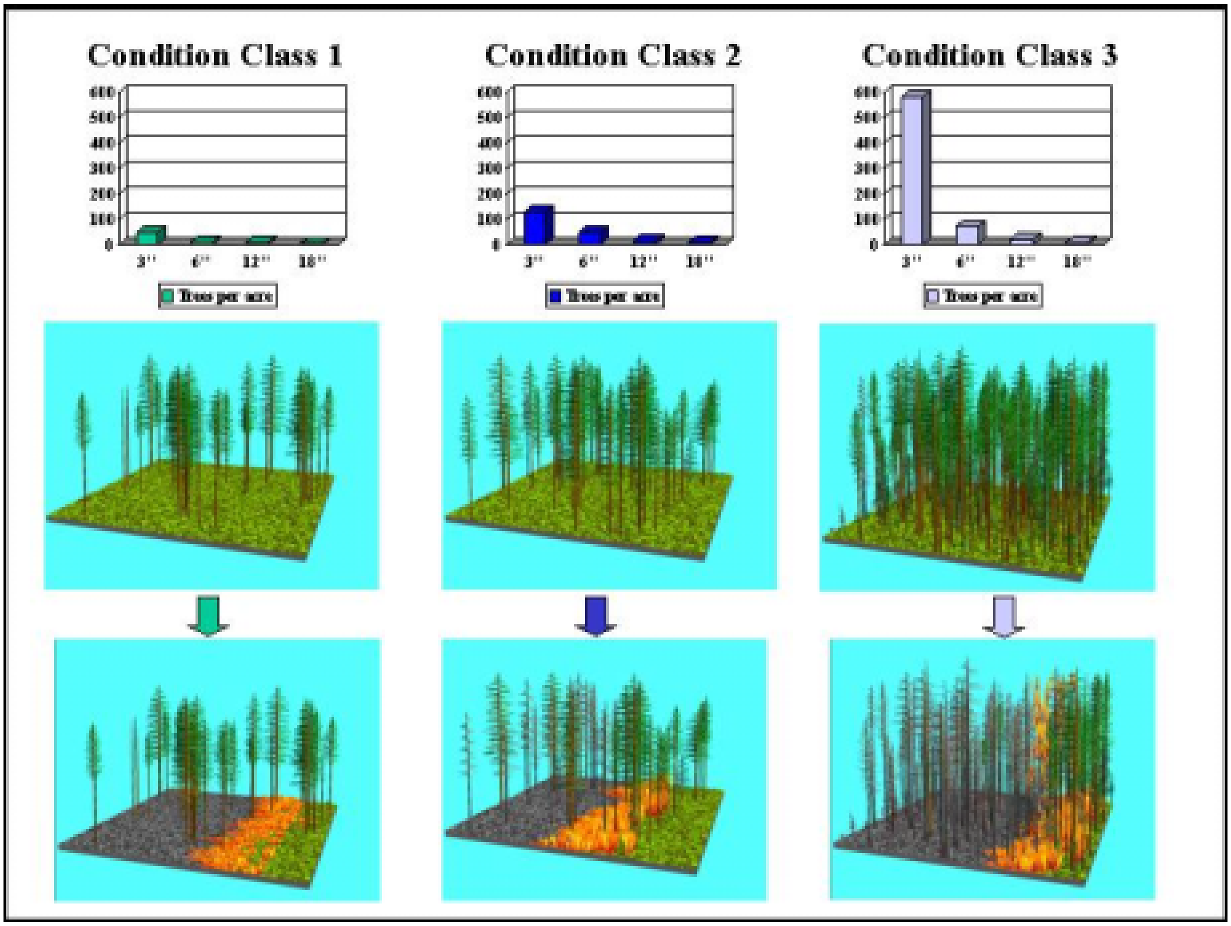

Figure 5 – Increased density of smaller trees provides fuel for vertical fire spread. (See page 22 for "Condition Class" definition.)

Under these conditions, wildfires exceed nearly all control efforts and often result in long-lasting damage to the soil and to the watershed.

In 1909, practically all of the short interval fire-adapted ecosystems in the interior West were considered to be relatively low risk. They were open and had little fuel. By 1989, the situation had reversed. This change in risk is apparent when evaluated in the context of Western wildfire trends (Figure 6). Since approximately 1987 – despite better firefighting capabilities – the change in fuel conditions has resulted in an increase in wildfire acres burned.

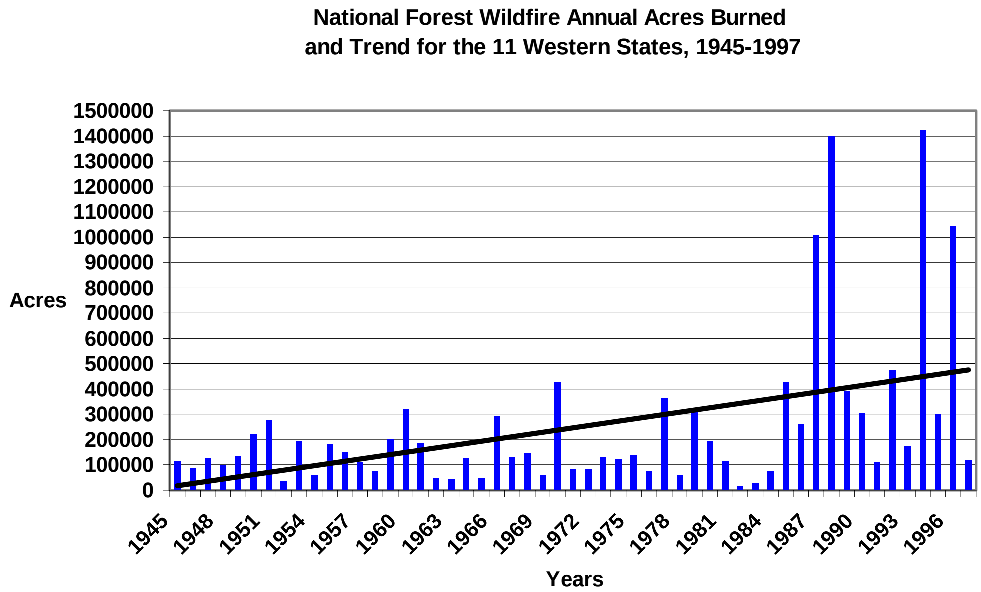

Figure 6 – National forest wildfire acres burned trend in the 11 Western states.

For the purpose of this strategy, risk conditions are assigned "condition class" descriptors. In short interval fire-adapted ecosystems, Condition Class 1[1] (which corresponds to the Lick Creek 1909 photo) represents low relative risk. As Figure 2 indicates, the Condition Class 1 trend has few small trees and little ground fuel. The scarcity of fuel tends to limit the intensity of wildfires. At low intensities, wildfires cannot kill the larger fire-tolerant trees but often consume small encroaching trees, other vegetation, and dead fuels.

At low intensities, fire is ecologically beneficial because nutrients are cycled. In addition, the soil's organic layer is not consumed at these low fire intensities. The remaining organic material stabilizes the soil surface and helps prevent erosion.

Because Condition Class 1 fires are low-intensity within these ecosystems, they leave the soil intact and functioning normally. These fires generally pose little risk and have positive effects to biodiversity, soil productivity, and water quality.

In Condition Class 3 areas within these same ecosystems, fires are relatively high risk. As Figure 4 indicates, the forest is littered with considerable amounts of dead material and is choked with hundreds of small trees that reach into the crowns of the larger, older-age forest above. During drought years, small trees and other vegetation dry out and burn along with the dead material – fueling severe, high intensity wildfires. At these intensities, wildfires kill all of the trees – even the large ones that, at lower fire intensities, would normally survive.

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[1] For complete definition, see Appendix A *The Coarse-Scale Assessment and Definition of Fire Regimes and Fire Classes*.

Within Condition Class 3 in these short interval fire-adapted ecosystems, wildfires usually damage key ecosystem components, including the soil. High-intensity fires consume the soil's organic layer and burn off or volatilize nutrients. When small twigs, pine needles, and other litter are consumed, water runs unimpeded over the surface. Under these circumstances, the soil becomes more susceptible to erosion (Figure 7).

Figure 7 – Buffalo Creek Fire
These photos, of Colorado's Buffalo Creek Fire aftermath, illustrate soil severely burned and left exposed to rain and runoff. This produced the subsequent 1996 flash flood event that claimed two lives. The ensuing erosion also washed topsoil off the hillsides, clogging downstream watercourses. This erosion reduced future storage capacity of reservoirs and silted-over the river's gravel beds – significantly reducing spawning habitat.

At extreme fire intensities, the soil's capacity to absorb water is often lost. The fine, powder-like ash that follows a severe wildfire on these sites makes water bead on the surface. These so-called "hydrophobic conditions" result in highly erodable soils.

Condition Class 3 is classified as high risk because of the danger it poses to people and the severe, long-lasting damage likely to result to species and watersheds when a fire burns – particularly in drought years. Firefighters are especially cognizant of hazards in Condition Class 3 situations. In a national survey (Tri-data, 1995), nearly 80% of all firefighters identified fuel reduction as the single-most important factor for improving their margin of safety on wildland fires.

In Condition Class 3, fires become costly when homes are involved. Throughout much of the interior West, short interval fire-adapted ecosystems are typically located in valley-bottoms where homes and human development are most concentrated.

Figure 8 – Homes burning in the Dude Fire, Arizona, 1990.

The Dude Fire burned in central Arizona in Condition Class 3 stand conditions. Although the fire only burned a few days, it resulted in the death of six firefighters and cost $7.5 million to control. It destroyed 75 homes, resulting in property loss of $12 million. No estimate is available on the resource losses involved.

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IV Ensuring Clean Air, Clean Water and Biodiversity in Fire-Adapted Ecosystems

Sustainability:

"Meeting the needs of the current generation without compromising the ability of future generations to meet their needs. Ecological sustainability entails maintaining the composition, structure and processes of a system, as well as species diversity and ecological productivity. The core element of sustainability is that it is future oriented."

Committee of Scientists Report, 1999

The Legal Basis for Sustainability

A suite of federal laws and regulations guide management of National Forest System lands and fire-related activities on those lands. These include the Clean Air Act, Clean Water Act, Endangered Species Act, National Environmental Policy Act, and National Forest Management Act. Long-term sustainability is a consistent theme embodied within these laws.

Sustaining natural resources in short interval fire-adapted ecosystems is a basis of the cohesive strategy outlined in this report.

Legal Basis for Sustainability

Endangered Species Act
"The purposes of this Act are to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved…"

Clean Water Act
"(a) Restoration and maintenance of chemical, physical and biological integrity of the nation's waters...The objective of this chapter is to restore and maintain the chemical, physical, and biological integrity of the nation's waters."

Clean Air Act
"(1) to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population."

National Forest Management Act (NFMA)
"(6) the Forest Service . . . has both a responsibility and an opportunity to be a leader in assuring that the nation maintains a natural resource conservation posture that will meet the requirements of our people in perpetuity."

National Environmental Protection Act (NEPA)
"(a) Creation and maintenance of conditions under which man and nature can exist in productive harmony."

The Forest Service Government Performance and Results Act (GPRA) Strategic Plan (2000 revision) bridges law and Forest Service activities. This report's cohesive strategy anchors to the following GPRA Strategic Plan's specific objectives:

- Improve watershed conditions and restore hydrological processes;
- Improve habitat quality; and conserve fish, wildlife and plant populations;
- Improve ecosystem resiliency associated with fire adapted ecosystems; and
- Reduce the relative risk of damage to human communities associated with wildfire.

The overarching purpose of the GPRA Strategic Plan, consistent with these laws, is to maintain healthy, diverse ecosystems that meet human needs on a long-term basis. Sustaining healthy, diverse conditions requires consideration of entire landscapes in the *context* of specific ecosystems and their ecological dynamics.

Adaptive Management:

"A system in which activities are designed at the outset to test clearly formulated hypotheses about the behavior of an ecosystem being changed by human use."

Kai N. Lee
Compass and Gyroscope, 1993

The Need for Adaptive Management

Increased human population growth, expanded land-use development, and changes in natural ecosystems (e.g., climate, vegetative succession) affect ecosystem dynamics and processes. In the short interval fire-adapted systems, over-accumulated fuels indicate that more wildland fires in the future will burn at uncharacteristically high levels of severity (outside the historic range of variability). This trend will result in higher corresponding threats to human life and property, as well as more degraded ecosystems.

Planning in fire-adapted ecosystems integrates an understanding of: fire history, potential fire behavior, land-use change, watershed needs, species viability, and relative risk to human communities. Uncertainties associated with these considerations are addressed through monitoring and adaptive management. During planning and implementation of restoration activities, the best available science must be used to reduce uncertainty and to facilitate learning.

While some ecosystems are adapted to infrequent high-intensity burning, the short interval fire-adapted ecosystems are not. The primary emphasis of the strategy is ensuring protection of human values and the sustainability of natural resources *in the context of short interval fire-adapted ecosystems*.

Supporting Scientific Evidence

Considerable scientific evidence supports use of prescribed fire and other management treatments in fire-adapted ecosystems to reduce risk of catastrophic wildfire, improve ecosystem resilience, and restore plant community composition, structure, and landscape patterns.

Several examples of small-scale watershed improvement projects exist in national forests in fire-adapted systems. Virtually all use prescribed fire and mechanical treatments to improve watershed conditions. Fuel reduction work reduces potential fire severity, which, in turn, reduces potential sedimentation. Conditions that favor low intensity burning on these sites help prevent erosion and leave more organic material that filters water and improves water quality characteristics.

At landscape scales, the effectiveness of treatments in improving watershed conditions has not been well documented. Many scientists, however, agree that careful application of treatments across larger scales will better restore water yield and quality.

Degraded air quality associated with long-duration wildfires has been widely experienced in the West. Because wildfires tend to occur at the driest time of year when dead fuels and vegetation is also driest, they are more completely consumed and typically produce three to five times more emissions than early or late-season prescribed fires.

In Condition Class 3 and some Condition Class 2 situations, the strategy relies on mechanical thinning of smaller diameter trees to reduce fire intensities and particulate emissions during prescribed burning. This practice, although expensive, opens prescription windows of opportunity – enabling managers to capitalize on better weather conditions for smoke ventilation and dispersal.

The extent to which management for ecosystem resilience can improve air quality over the long term is not completely known. Present regulatory policies measure prescribed fire emissions, but not wildfire emissions. The emissions policy tends to constrain treatments and – in short interval fire systems – may act to inadvertently compound wildfire risks. A growing body of scientific evidence suggests that mechanical treatments followed by prescribed fire can reduce the overall adverse impacts to air quality by reducing the amount of fuel that would otherwise be available during the wildfire season.

Adaptive Management Improves Habitat

Most research involving relationships between fire and wildlife has focused on mammals and birds, with an emphasis on habitat, rather than populations (Smith, 2000). The cause and effect relationships between fire and wildlife are only correctly understood in the context of specific ecosystems.

Research reveals that active management can improve habitat quality for species dependent on fire-adapted ecosystems, such as Kirtland's warbler (Probst and Weinrich, 1993) and the red cockaded woodpecker. In fact, the relationship between fire and bobwhite quail populations served as an important factor in initiating the prescribed burning program in the South's fire-adapted forests.

The effectiveness of ecosystem restoration in contributing to species conservation is dependent on the extent to which landscape patterns and processes support population persistence over the long term (Wilcove, 1999). For example, sage grouse population dynamics are dependent on landscape patterns (Knick, 1999); yet many factors affect the integrity of sagebrush ecosystems across landscapes following fire (such as the expansion of cheat grass).

Considering the extent of habitat alteration that has occurred over the past century, management for species conservation in fire-adapted ecosystems is complicated. In many areas, remaining habitat is currently at risk of long-term loss from severe wildfires. In some cases, further reduction of habitat due to severe wildfires may threaten species viability.

Integrating ecosystem restoration goals with species conservation priorities will require coordinated effort between planned land uses to improve the quantity and quality of potentially suitable, but presently unoccupied habitat. This must occur prior to treating any areas that serve as refugia for remnant populations (Noss et al. 1997).

Adaptive Management to Evaluate Activities

The intensity and frequency of management activity in fire-adapted ecosystems will influence the ability to provide for clean air, clean water, and biodiversity over the long term. A considerable amount of science supports an understanding of fire-adapted ecosystems. Some uncertainty, however, surrounds management treatments. It is therefore essential that an adaptive management framework be used in designing, monitoring, and evaluating activities. Assumptions associated with management approaches across broad landscapes need to be clearly identified and articulated as a part of the adaptive management process.

Implementation of the strategy will reduce major threats to important human values and natural resources. The strategy sustains watersheds, species, and ecosystems; and it better protects human communities. It also anchors to the Forest Service GPRA Strategic Plan as the means to establish quantifiable objectives and measurable milestones.

In developing regional and local level plans for implementing the strategy, it is essential that monitoring be conducted to validate assumptions, reduce uncertainties, and measure progress. While some uncertainties exist, implementing this strategy avoids serious consequences that are certain to occur if fuel reduction treatments are deferred.

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V A Cohesive Strategy to Protect People and Sustain Resources in Fire-Adapted Ecosystems

This cohesive strategy provides a broad national framework for aligning the social, program management, and institutional elements that will be required to restore fire-adapted ecosystems. These three elements underpin this strategy. Indeed, the strategy's success depends on the cohesive strength of these three core elements.

Implementation steps will be described in a separate, more detailed action plan – based on regional assessments, integrated planning processes, public input, and collaboration with other agencies. The action plan will contain many of the "how to" actions necessary to move the strategy forward.

The Three Cohesive Strategy Elements

Social

- Establish an objective for conservation awareness in the Forest Service Government Performance and Results Act (GPRA) Strategic Plan (2000 revision). Emphasize the need to increase public awareness of the role of ecological processes in ecosystem sustainability (Appendix B).

- Initiate collaborative planning with stakeholders to identify and evaluate ecosystem restoration and maintenance needs and opportunities. Utilize science-based assessments of present and projected ecosystem conditions as a basis for determining restoration needs.

- To promote fire-safe local planning, zoning, and building requirements, establish partnerships with other federal agencies (i.e., Housing and Urban Development), states, communities, and the insurance industry.

Institutional

Long-Term Policy Assessment

- Establish objectives, strategies, and milestones for restoration and maintenance of fire-adapted ecosystems in the Forest Service GPRA Strategic Plan. Emphasize integration in objectives for public safety, watershed protection, species conservation, and ecosystem resilience. (Appendix B.)

- Establish ecosystem restoration as a performance element in the Forest Service Annual Performance Plan. Use changes in condition class as the measure for annual performance and accountability. (Appendix B.)

- Establish assessment procedures that integrate considerations of status, risk and priority setting for stewardship objectives. Include objectives at the national, regional and local scales for: watershed protection, species conservation, ecosystem resilience, and public safety. Coordinate information across all program areas.

Program Management

At the National Level

- Concentrate most efforts in the shorter interval fire-adapted ecosystems (Fire Regimes I and II[1]), emphasizing treatments in Condition Classes 2 and 3[1]. (GPRA 1c.)
- Establish the interior West as a priority for restoration treatments. (GPRA 1c.)
- Direct treatments – in an integrated fashion – to highest values to be protected, especially for: watersheds (GPRA 1a), species (GPRA 1b), ecosystems (GPRA 1c), and human communities (GPRA 4b).
- Explore innovative use of existing authorities for grants, agreements, and contracts. Based on results of experimental land stewardship contracting authority, request new permanent authorities as appropriate.

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1 See *Coarse-Scale Assessments for Wildland Fuel and Management*, Hardy, Bunnell, Menakis, Schmidt, and Long, 1999; also, Appendix A in this report.

At the Regional Level

- Conduct regional assessments, establishing priorities consistent with values to be protected (watersheds, species, human communities) in collaboration with other federal agencies, tribes, state and local government, and constituents.

At the National Forest and Grassland Level

- Establish treatment goals in Land and Resource Management Plan (forest plan) revisions and amendments for long-term risk reduction by condition class. Formally address the "no action" option in terms of risks, benefits, and consequences among the array of treatment options.
- Ensure that restoration programs and wildfire recovery plans are designed to achieve short and long-term GPRA Strategy objectives for watershed protection, species conservation, ecosystem resilience and public safety.
- Establish monitoring and evaluation programs and measures in Land and Resource Management Plan revisions for restoration activities in fire-adapted ecosystems.
- Consistent with Land and Resource Management Plans, develop fire management plans that provide for suppressing fires that would threaten pubic safety, communities, species habitat, or degrade ecosystems. Increase the management of natural ignitions for resource benefits where values and resources will be increased or improved.

Forest Service Research

- Strengthen Forest Service research programs to evaluate ecological, social, and economic tradeoffs; develop more effective prediction systems; and quantify disturbance effects and ecological interactions in fire regimes.

Funding

- Establish an integrated budget structure that facilitates an accomplishment of the GPRA Strategic Plan elements: Watershed Restoration, Species Conservation, Ecosystem Processes, and the Protection of Human Communities.
- During the treatment period, high-risk conditions that pose significant threats to human communities, watersheds, and species viability, will require full protection. Under this strategy, wildland fire preparedness funding requests are made at the most efficient level, as defined by the National Fire Management Analysis System.

- Establish a dollar-mix of ecosystem conservation, hazardous fuel reduction, and ecosystem planning funds based on fire regimes and values at risk in context with the GPRA Strategic Plan.

Actions Requiring External Collaboration

Long-Term Policy Assessment

Collaborate with the Environmental Protection Agency, National Marine Fisheries Service, and the U.S. Fish and Wildlife Service in addressing *long-term* impacts and tradeoffs to air quality, watershed resilience, species conservation, ecosystem integrity, and public safety as a result of each agency's respective policy in the *context* of fire-adapted ecosystems. Identify opportunities for improved alignment between regulatory and land management agencies in achieving restoration and maintenance objectives to protect people and sustain resources in fire-adapted ecosystems.

Economic Feasibility Assessment for Fuel Utilization

Understory biomass may become more economically feasible if assessments for their utilization more comprehensively evaluate tradeoffs and risks to watershed values, species values, public health and safety, and other factors that may benefit from reducing fuels in fire-adapted ecosystems. Projected wildfire costs, resource losses, and environmental damage, all suggest that developing and supporting markets for utilization of over-accumulated biomass may be desirable.

Collaborate with the Environmental Protection Agency, National Marine Fisheries Service, U.S. Fish and Wildlife Service, and Department of Energy to conduct economic feasibility analyses of increased biomass utilization. Examine options that include price supports.

Projected Budget Summary

Table 1 (below) provides an overall picture of program budgets necessary to accomplish three million acres of restoration and maintenance treatments in the interior West, and 1.2 million acres elsewhere throughout the United States.

Table 2 (on following page) details treatment and cost information for the Western Regions. Table 3 shows this information for the Eastern and Southern Regions. The basis for tables 2 and 3 is explained in Appendix D. Treatment goals and schedules were developed using regional input based on Land and Resource Management Plan and other assessments. Acreage goals were developed to remain within regulatory responsibilities for clean air, clean water, and threatened or endangered species.

Increased workforce capacity will be required at these treatment levels.

Table 1 -- Projected Direct Program Costs ($Millions)

Year	Western Regions (1-6)	Southern and Eastern Regions (8,9)	Research and Development	Total	Funds Available at Current Budget Level	New Funding Needs
Current	$75	$22	$10	$107	$107	$0
1	$137	$33	$20	$190	$170	$20
2	$345	$37	$40	$480	$250	$230
3	$525	$37	$60	$712	$325	$387
4	$708	$37	$80	$825	$325	$500
5	$708	$37	$80	$825	$325	$500
10	$708	$37	$80	$825	$325	$500
15	$708	$37	$80	$825	$325	$500

Table 1 assumes that the fuels budget prior to implementation of the strategy is at the $100 million level.

Table 2 – Western Regions 1 through 6

Preliminary Treatment Schedule and Projected Costs in Fire Regimes I and II, Condition Classes 1, 2, 3 Based on Coarse Scale Assessment—Western Regions(1-6)

(The displayed program does not constitute a budget request)

		Condition Class 1	Condition Class 2	Condition Class 3	Annual Acres Treated	Annual Program Cost Millions (1999 $)
		Acres in Millions				
	Distribution Before Treatment	8	32	24		
Present	Acres Treated	0.14	0.28	0.15	0.57	$75
Year 1	Acres Treated	0.15	0.45	0.20	0.80	$137
Year 2	Acres Treated	0.25	0.70	0.50	1.45	$345
Year 3	Acres Treated	0.40	1.10	0.75	2.25	$525
Year 4	Acres Treated	0.50	1.50	1.00	3.00	$708
Year5*	Acres Treated	0.50	1.50	1.00	3.00	$708
Year10	Acres Treated	0.50	1.50	1.00	3.00	$708
Year15	Acres Treated	0.50	1.50	1.00	3.0	$708

*Program continues at this sustained level through preliminary 15-year period. The 10th and 15th years are shown here to illustrate changes in condition as treatment progresses.

Table 3 – Regions 8 and 9

Preliminary Treatment Schedule and Projected Costs in Fire Regimes I and II, Condition Classes 1, 2, 3 Based on Coarse Scale Assessment for Regions 8 & 9

(The displayed program does not constitute a budget request)

		Condition Class 1	Condition Class 2	Condition Class 3	Annual Acres Treated	Annual Program Cost Millions (1999 $)
		Acres in Millions				
Distribution Before Treatment		15	7	4		
Present	Acres Treated	0.63	0.11	0.01	0.75	$22
Year 1	Acres Treated	0.75	0.20	0.03	0.98	$33
Year 2	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 3	Acres Treated	0.78	0.38	0.04	1.20	$37
Year 4	Acres Treated	0.78	0.38	0.04	1.20	$37
Year5*	Acres Treated	0.78	0.38	0.04	1.20	$37
Year10	Acres Treated	0.78	0.38	0.04	1.20	$37
Year15	Acres Treated	0.78	0.38	0.04	1.20	$37

*Program continues at this sustained level through preliminary 15-year period. The 10th and 15th years are shown here to illustrate changes in condition as treatment progresses.

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VI Consequences of Deferral

“. . . in many of the interior West forests, the costs and risks of inaction are greater than the costs and risks of remedial action.”

Concluding comments from
academic and agency scientists.
Assessing Forest Ecosystem Health in the Inland
West Workshop (November, 1993)

When the cohesive strategy outlined in this report is fully implemented, restoration and maintenance treatments in interior West fire-adapted ecosystems will increase significantly – from the present 0.75 million acres to approximately 3 million acres per year. Elsewhere, treatments will increase from 0.75 million acres to 1.2 million acres per year. Nationally, treatment costs will climb from $75 million per year at present, to approximately $825 million per year.

Is it worth it?

What happens if the current – lower – levels of treatment are simply maintained?

Fire protection programs consider public and firefighter safety first. Resource protection options are evaluated against expected costs and losses. This chapter projects suppression costs, natural resource and private property losses, and environmental damages expected under present treatment schedules and compares them with the strategy.

Most commodity values (such as timber) are well established. Other values, however, are more difficult to determine. Economic research is ongoing to better describe and quantify amenity values, ecosystem components, natural resources, and safety considerations involved in tradeoff analysis. Tradeoff analysis measures the costs, benefits, and risks under different protection strategies.

The fire-adapted ecosystems under discussion are dynamic. In the 15-year analysis period, live vegetation will continue to grow and dead wood will continue to accumulate. Risk conditions will continue to increase as some forests and grasslands migrate from lower-risk conditions to higher-risk conditions. During this same time period, severe wildfires will continue to occur – temporarily reducing high-risk acres, but also damaging ecosystem components and natural resources.

Areas at Risk

As human populations continue to grow, pressures will likely increase to species viability, watershed health, and ecosystem integrity. The situation will be exacerbated as forest fuels accumulate and fire risks increase. Even at current levels of treatment, risks to species, watersheds, forest health, and human communities throughout the interior West are escalating due to compounding rates of increasing fuels (vegetation) in fire-prone environments. The answer is not in bigger and better firefighting apparatus. At very high fuel loadings, fire behavior overwhelms even the best fire suppression efforts. Under extreme conditions, control of fire becomes dependent on relief in weather or a break in fuels.

Reducing fuels and restoring fire's ecological role in fire-adapted ecosystems will reverse many adverse trends that serve as important indicators of ecosystem sustainability. To demonstrate the strategy's benefits, graphs from a recent assessment of several indicators for the Western states were developed to illustrate trends (figures 9-13). These graphs reflect assessments from a recently completed national-scale evaluation (see Appendix E). They are based on coarse-scale data that model averages for the area under study. They cannot be directly applied to areas smaller in scale than the analysis area. The data are not directly applicable to fine-scale analysis; they serve to evaluate relative risk trends among different management options.

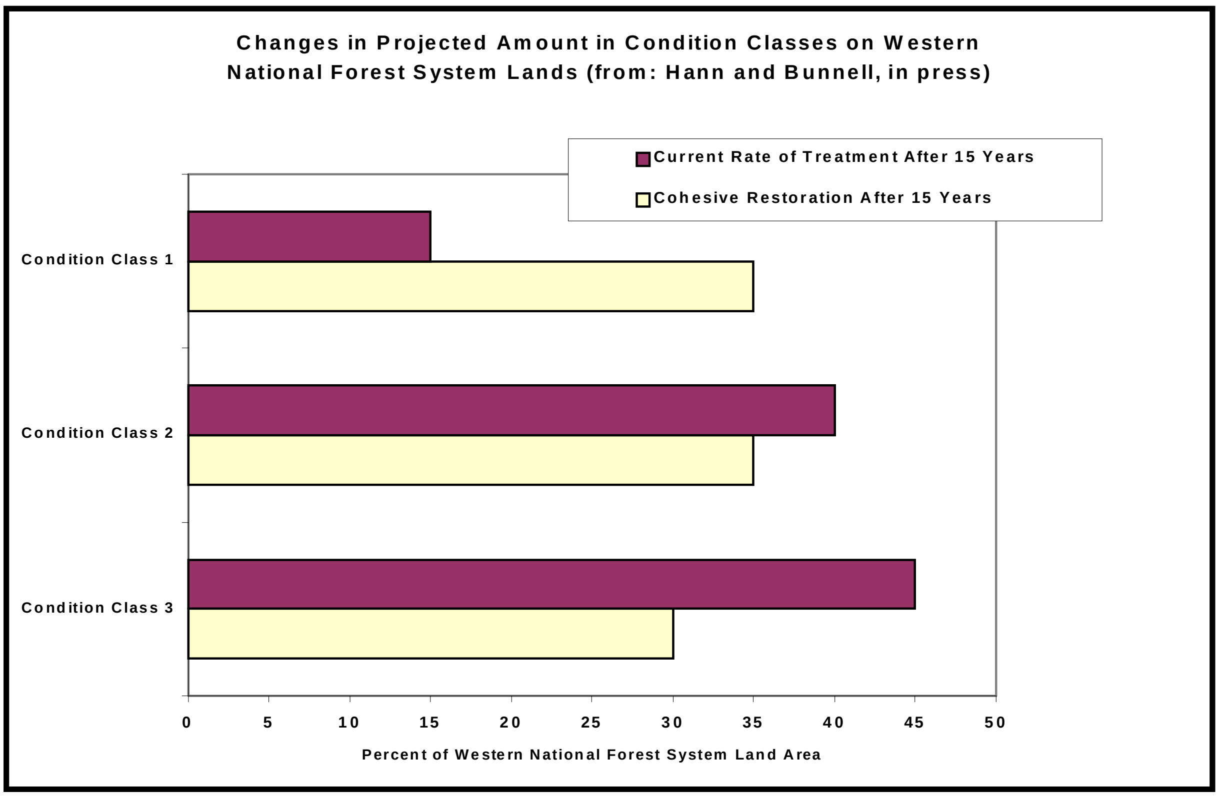

Figure 9

The assessment was based on a *15-year* projection, consistent with this strategy's treatment timeframe. *At 100 years, the social, economic, and ecological benefits of restoration treatments become exponentially greater.* And, as treatments shift from restoration to maintenance, treatment costs will go down.

At the current rate of treatment (0.75 million acres/year), the acres at high risk in the interior West will increase over the next 15 years. Implementing the strategy will increase levels of treatment and decrease moderate and high-risk categories (Condition Classes 2 and 3). It will restore proportionately more low-risk areas (Condition Class 1) after 15 years. The strategy therefore substantially reduces risk over the current rate of fuel reduction treatment.

Without increased restoration treatments in these ecosystems, wildfire suppression costs, natural resource losses, private property losses, and environmental damage are certain to escalate as fuels continue to accumulate and more acres become high-risk.

Suppression Costs

Suppression strategies (and their associated costs) are determined using the Wildland Fire Situation Analysis (WFSA), a required assessment process on federal lands. Under this system, suppression costs are calculated from an array of alternatives prior to a strategy's selection. The analysis weighs values to be protected. Firefighter and public safety always serves as the first criteria. As a general rule, depending on the circumstances surrounding a particular wildfire, resource or private values to be protected are typically two to five times greater than the expected suppression costs, as calculated using the WFSA.

The Line Officer selects the most appropriate strategy and, in doing so, approves the expected suppression costs. If the strategy fails or if costs exceed the expected level, the Line Officer must reevaluate alternatives and approve any changes.

Suppression costs and wildfire acres burned (1980 to 1999), although more episodic during a period of drought, have increased due to over-accumulation of fuels and a corresponding increase in high-risk acreage. Recently, large fires have become more damaging and more costly. *Unless the rate of restoration is increased, larger burned acreages and higher wildfire suppression costs should be expected.*

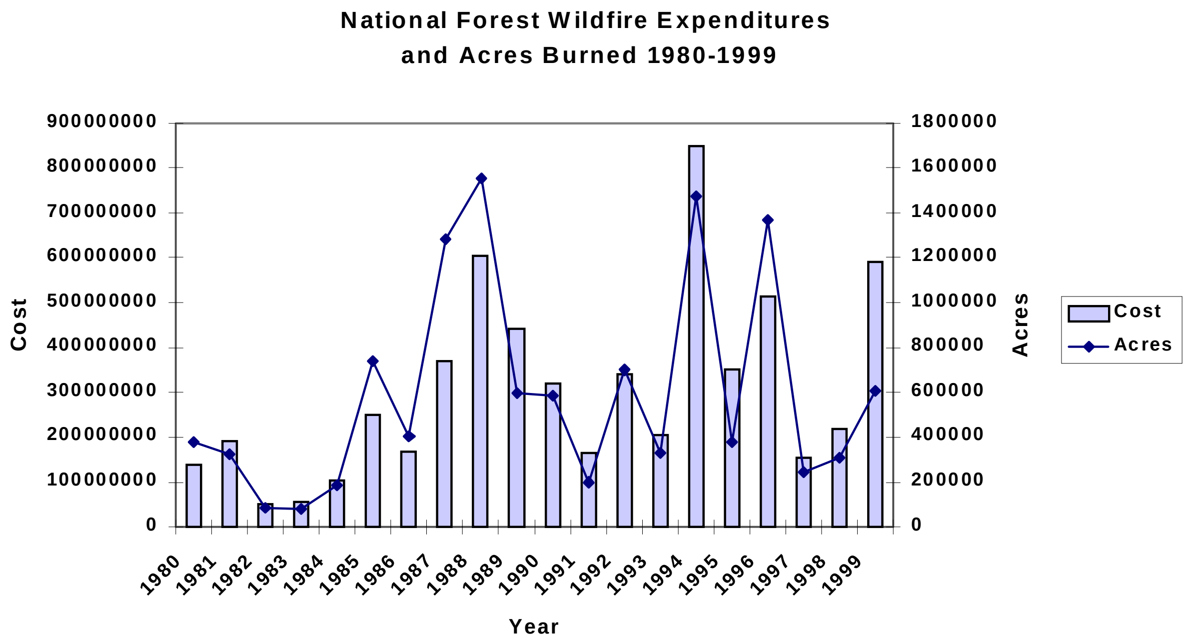

Figure 10

Loss to Private Property and Resource-Based Commodities

As human populations grow and shifting demographics concentrate more people in or adjacent to wildlands, more private property losses will be at risk to catastrophic wildfires. According to the National Fire Protection Association, wildland-urban interface fires from 1985 to 1994 destroyed 8,925 homes. During dry years or under adverse weather conditions, because they occur in high-risk fuels, many wildland-urban interface fires exceed firefighting capabilities. When fuel loadings are reduced, protection of life and property is significantly improved.

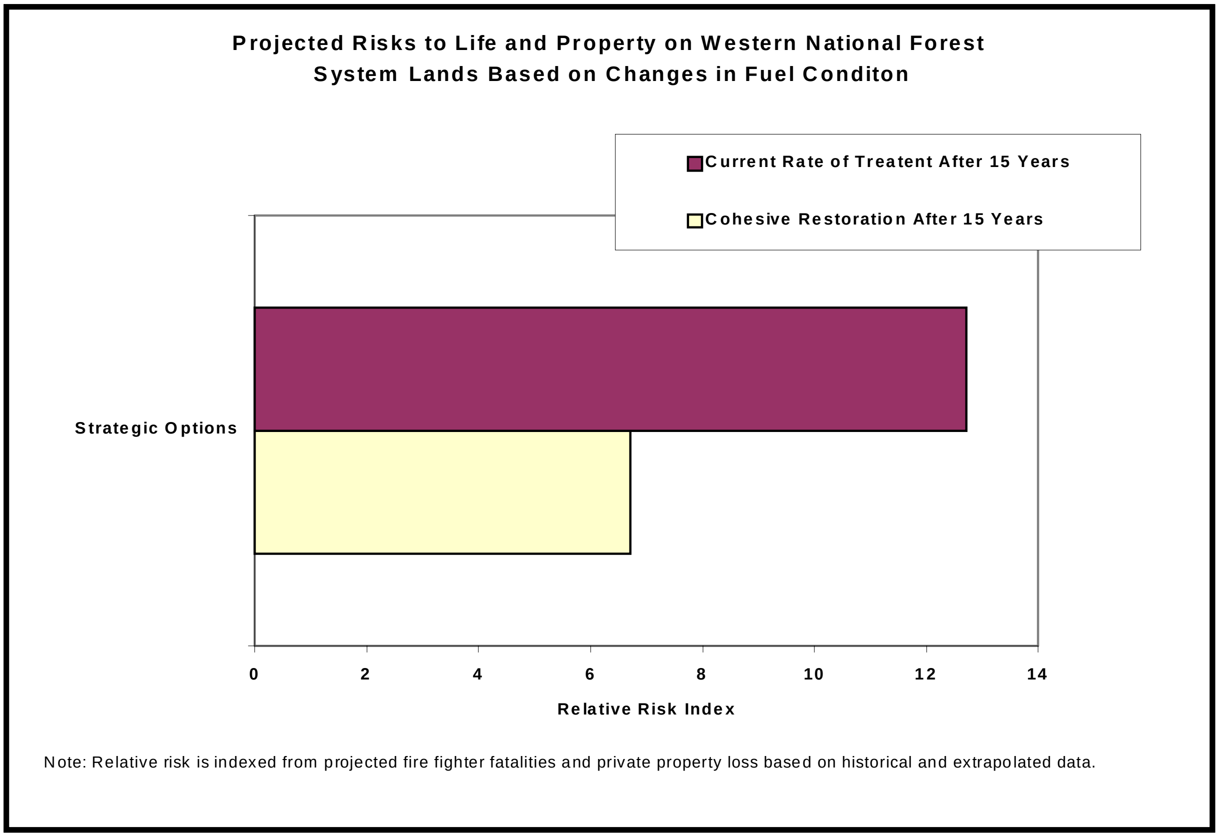

Figure 11

The National Research Council and the Federal Emergency Management Agency (FEMA) recognized wildland fires in California (1993) and Florida (1998) as among the defining natural disasters of the 1990s. In terms of damage, the magnitude of these catastrophic fires were compared with the Northridge earthquake, Hurricane Andrew, and flooding of the Mississippi and Red rivers.

The 1991 Oakland, California fire was ranked by insurance claims as one of the ten most costly all-time natural catastrophes. More wildfire disasters of this scale can be expected in the absence of an aggressive mitigation strategy. FEMA is emphasizing mitigation and prevention to address the growing losses from natural disasters. The strategy outlined in this report complements the efforts to forestall disaster-related costs and losses.

Damage to commodity resources such as wood fiber and watersheds often result from severe wildfire. These losses can be significant. For example, the Big Bar Fire Complex, consisting of five fires that burned during the late summer of 1999 in northern California. The Complex burned 141,000 acres on and adjacent to the Six Rivers National Forest. The Big Bar Complex cost $81 million to suppress and $6 million for burned-area rehabilitation. It resulted in a preliminary estimate of $122 million in resource losses, including loss of marketable timber.

Environmental Damage

Some people believe "letting nature take its course" is the best strategy to restore fire-adapted forests and grasslands. Any restoration strategy, however, should be evaluated in the context of the ecosystem under consideration.

Wildfires occurring in the shorter interval fire-adapted ecosystems where fuels have accumulated over several missed fire cycles often burn beyond the natural range of variability. Consequently, habitats, soils, and watersheds are burned beyond their adaptive limits. The severity of these fires pose threats to species persistence and watershed integrity. The damage from these fires is often long-lasting and, within some ecosystems, may be irretrievable.

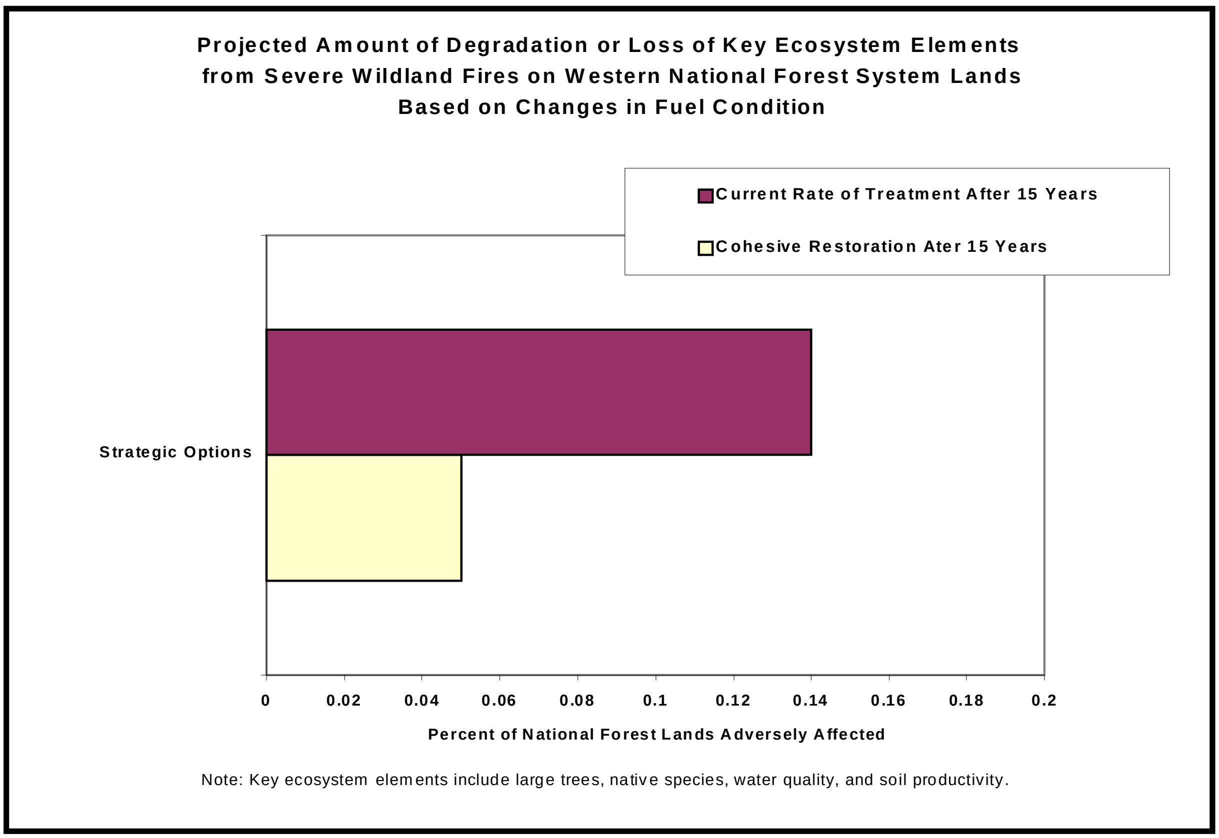

Figure 12

With an increasing number of large, uncharacteristically damaging wildfires in short interval fire systems, we can eventually expect:

- Loss of critical habitat for fish, wildlife, and plant species at risk.
- Soil erosion and loss of site stability and productivity.
- Changes in temperatures and moisture regimes on certain sites.
- Increased spread of invasive weeds or non-native plants.

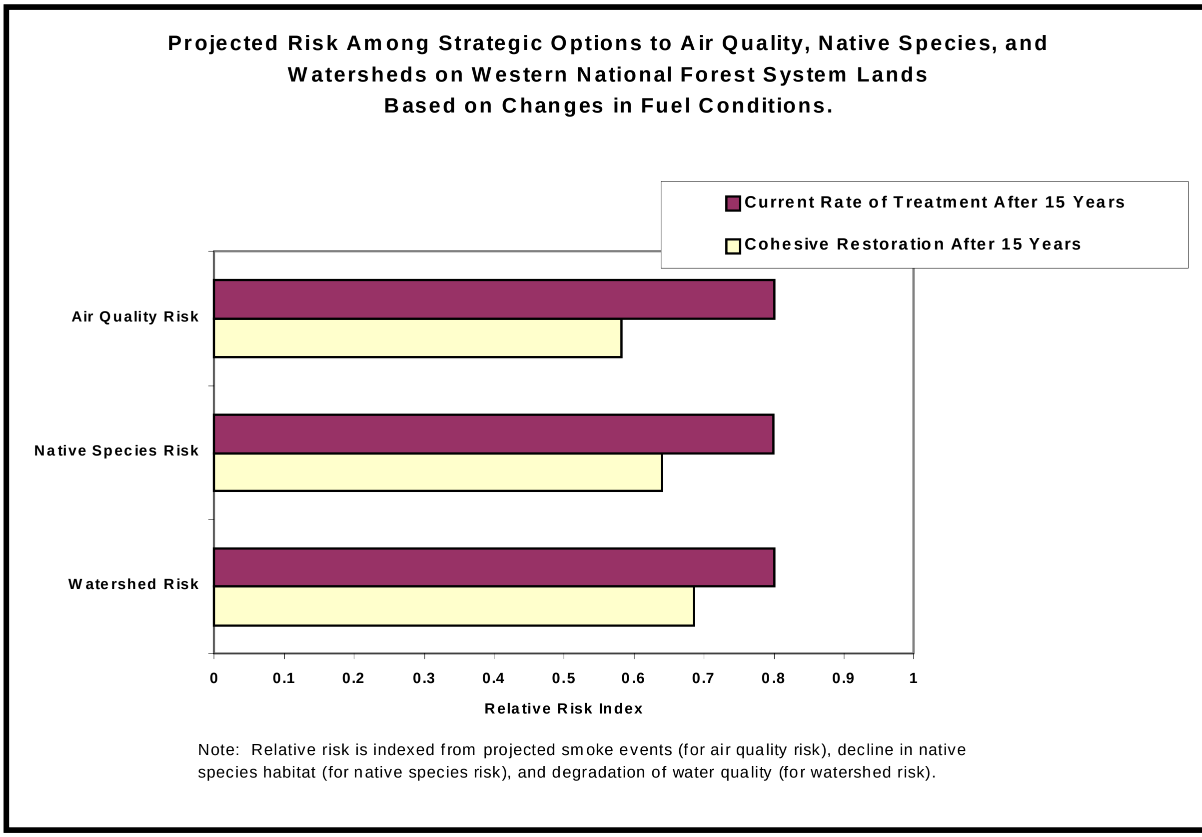

Figure 13

On the 1999 Big Bar Complex, adverse effects were most commonly found where the fires burned at higher intensities. Impacts from the fires included:

- Prolonged exposure of local communities to unhealthy smoke concentrations.
- Increased soil erosion and stream course sedimentation.
- Loss of old-growth trees that provide significant wildlife habitat.
- Degradation and loss of fish habitat, especially in the New River's tributaries.

Public and Firefighter Safety

In fire-adapted forests adjacent to human communities, concerns for public *health* often compete with concerns for public and firefighter *safety*. Treatments that use prescribed burning raise health issues related to smoke. Although this strategy uses mechanical thinning prior to prescribed burning in some areas to reduce particulate emissions, air quality will remain an important concern.

Current regulatory policies “count” prescribed fire emissions in measuring air quality, but do not include wildfire emissions. Perhaps ironically, constraining prescribed fire use in fire-adapted ecosystems to ensure public health may inadvertently increase risks to human safety.

Stagnant atmospheric conditions during the late summer and early fall often inhibit smoke dispersal from wildfires. Although these episodes are exempt from regulatory control, they exceed public health standards. In 1977 and 1987, southern Oregon and northern California experienced long-term, unhealthy smoke concentrations. The 1999 Big Bar Fire Complex in northern California and the 1994 Wenatchee, Washington wildfires also caused prolonged exposure of local communities to unhealthy smoke levels.

In recent years, several tragedies have occurred as firefighters tried to control wildfires threatening human developments. In 1991, the Dude wildfire near Payson, Arizona killed six firefighters as they attempted to protect a rural subdivision. The South Canyon fire in 1994 resulted in the death of 14 firefighters who were suppressing a wildfire that was approaching homes near Glenwood Springs, Colorado.

Among the general public, loss of life due to wildfire is rare but not unknown. In 1991, 25 lives were lost, 150 people injured, and more than 3,000 structures were destroyed in a wildfire in the hills near Oakland, California. On March 8, 2000, three motorists lost their lives and many more were injured in a multi-car pileup in Florida – the result of wildfire smoke obscuring visibility on a highway.

At the current rate of fuel treatments across the interior West, losses to watershed health, species viability, and ecosystem resilience will only continue. Human communities will also continue to be increasingly threatened by catastrophic wildfire.

VII Conclusions and Next Steps

"Moving toward sustainability is a two-part process:

First, revising the uses of the ecosystem so that environmental values take an economically relevant place in policy and practice;

Second, incorporating the well-being of the ecosystem into the way management is conceived and implemented."

Kai N. Lee
Compass and Gyroscope, 1993

At $825 million per year, this is an expensive strategy. The costs, losses, and damages that will occur without this strategy are not always quantifiable or precisely known. When evaluated against recent trends and projections, however, wildfire costs, loses, and damages, are expected to compound and exceed treatment costs – unless the rate of treatment is accelerated.

This strategy acknowledges that large wildfires will continue to occur. It aims to reduce losses and damages from these wildfires by concentrating treatments where human communities, watersheds, and species are at risk.

In short interval fire-adapted ecosystems, characterized by over-accumulated fuels, "letting nature take its course" is not economically wise nor ecologically appropriate.

Modern resource management principles hold that ecosystem health is requisite to the long-term viability of key ecosystem components and natural resources – whether soil, air, water, wildlife, or wood fiber. Sustaining key ecosystem components and a wide variety of resources is also basic in meeting and protecting human needs. In some ecosystems, disturbance processes – like fire – perform a fundamentally important role in maintaining healthy, resilient conditions.

Resource management perspectives are evolving as we learn more about the ecological functions and complex interactions of fire-adapted forests and grasslands.

The cohesive strategy outlined in this report is based on the premise that, within fire-adapted ecosystems, fire – at the right intensities, frequency, and season – is fundamentally essential for healthy, sustainable resources and the protection of nearby human communities. The strategy recognizes that stewardship of these systems is arguably among the most formidable forest management challenges that confront the American public today.

Until restoration efforts are significantly expanded in fire-adapted ecosystems, the risks to watersheds, species, and people will continue to increase. Restoring these ecosystems, however, will be costly and contentious.

At full implementation, the strategy treats approximately three million acres per year in the interior West. It takes incremental steps – within a five-year period – to reach the acreage target. This goal was developed using regional input based on Land and Resource Management Plan (forest plan) and other more recent assessments. The goal is responsive to regulatory responsibilities for clean air, clean water, and threatened and endangered species. Over the long term, the strategy better ensures ecosystem integrity for the benefit of future generations. The strategy does not attempt to treat all acres, nor does it eliminate all risks. While it does not aim to return forests and grasslands to pre-European settlement conditions – it does reduce risks by reducing over-accumulated fuels.

The strategy directs treatments to high-risk areas. Within a 15-year timeframe, it reduces the area in the interior West considered at highest risk of loss or damage from an estimated 24 million acres to approximately 10 million acres. It treats additional acres to prevent them from developing into high-risk conditions. It relies on a variety of treatments – including mechanical thinning, some harvest, and prescribed burning – to reduce fuels and the consequent risks of loss or long-lasting damage resulting from wildfire.

The strategy is based on over 50 years of science. Aldo Leopold commented on the consequences of fire exclusion in these ecosystems as early as 1924. Over this time period, much has been learned about fire's ecological role, particularly in the short interval fire-adapted systems. We have also experienced the consequences of trying to keep fire out of these ecosystems. Although our knowledge base is firm, it is not absolute. Monitoring and evaluation – as the basis for adaptive management – is critical to the implementation of this strategy.

The Joint Fire Sciences program should be continued. A strengthened research program will provide the information needed to improve our understanding of the economic tradeoffs, social sciences, and ecological interactions that will influence our ability to manage these ecosystems.

The strategy clarifies agency goals and objectives, establishes milestones and performance measures, outlines an approach for setting restoration priorities, and schedules estimated out-year budgets in support of planned treatments.

The strategy also maintains that constituency support and collaboration with tribal, other federal, state, local agencies, and the public is an essential cornerstone for restoration work. It is consistent with the guiding principles of the Federal Wildland Fire Management Policy (approved by the secretaries of Interior and Agriculture in 1995). In addition, it supports federal and state initiatives aimed at improving forest ecosystem health on public lands.

Successful restoration and maintenance of fire-adapted ecosystems – to sustain resources and protect people – will depend on:

- Valuing ecological processes as the means to sustain ecosystem health.
- An ability to evaluate options and weigh decisions for *long-term* outcomes.
- A tolerance for use of the tools needed to accomplish restoration goals.
- A commitment to monitoring and evaluation as the basis for adaptive management.

Restoration Strategy is Departure from Traditional Protection Strategy

This cohesive strategy also represents a significant departure from the more traditional notions of wildfire protection. It places protection strategies in the context of specific ecosystems – the short-interval fire-adapted forests and grasslands of the interior West. It recognizes that *fire inclusion* (at the appropriate intensity, frequency, and time of year) – not just *fire exclusion* – is a fundamentally significant basis for long-term protection within these ecosystems.

The scope and extent of the protection challenge in the interior West is enormous. The current condition of many of this region's forests renders them susceptible to insect attack, disease outbreak, and severe wildfires. This situation is becoming more widely recognized as the most serious threat to these forests' long-term health, resilience, and productivity.

Among managers, publics, and regulatory agencies, many express apprehension concerning the potential costs and risks of restoration. This strategy, while recognizing these concerns as significant, has attempted to demonstrate that the costs and risks of deferral are most certain to be greater.

The strategy has drawn on established science. It can also draw on an ecologically similar circumstance in the southern United States. The South's lobolly, slash, and long-leaf pine ecosystems respond to fire – or its absence – in ways similar to the ponderosa and other long-needle pine types of the West.

This year marks the 60^{th} anniversary of the Forest Service's prescribed burning program in the South. The Forest Service's Southern Region presently accomplishes approximately 75% of all prescribed burning performed on National Forest System lands. More remarkably, the State of Florida, alone, prescribe burns on over two million acres annually. For years, part of the country's prescribed burning benefits have been measured in terms of improved wildlife habitat, stable soils, and sustainable yields of wood fiber.

In 1998, wildfire protection capabilities in Florida depended entirely on the preceding use of prescribed fire. During perhaps the most difficult fire season on record, the density, structure, and fuel loading of these fire-adapted forests determined the safety of nearby communities and the resilience of these forests that had been periodically prescribed with underburning. By reducing live vegetation and dead fuel, this treatment provided protective buffers for adjacent homes. On the other hand, those Florida forests in which fires had been excluded burned at extreme intensities, resulting in severely damaged resources and destroying homes.

To date, these lessons learned from the South have only been acknowledged and applied on a limited basis in the West.

This strategy outlines the means to restore fire-adapted ecosystems to better protect people and sustain natural resources on National Forest System lands in the interior West. Within these ecosystems, the strategy *does not* attempt to recreate pre-European settlement conditions. It *does* aim to reduce severe insect, disease, and wildfire risk (Figure 14).

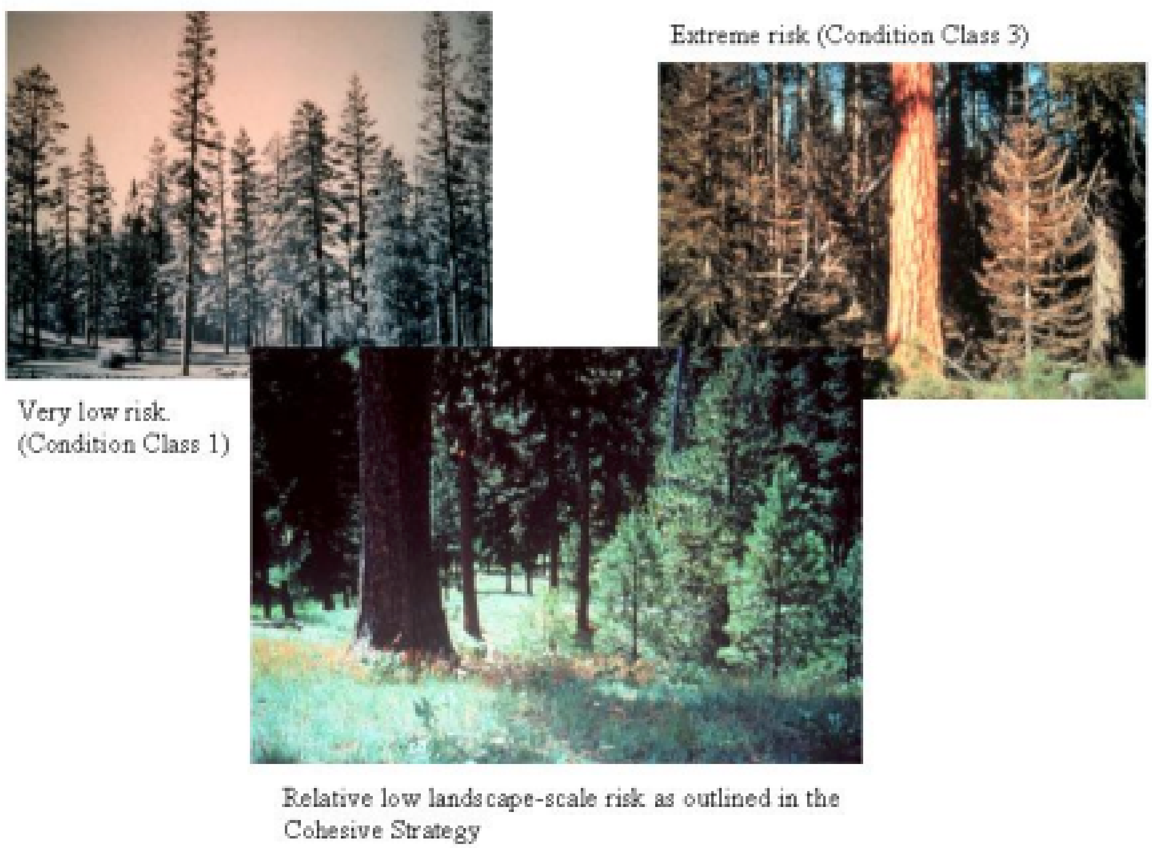

Figure 14 – The Cohesive Strategy aims to reduce severe insect, disease, and wildfire risk.

Next Steps

This report provides a broad, national framework for aligning social, program management, and institutional elements into a cohesive strategy that will restore fire-adapted ecosystems and protect human values.

The coarse-scale assessments that establish the basis for the strategy will be refined and implementation steps will be detailed in a separate action plan. More accurate risk assessments, integrated planning processes, public input, and collaboration with other agencies are all included in the work ahead.

Strategy actions to be addressed immediately:

- Refine coarse-scale assessments for wildland fuel risks.
- Develop regional implementation plans, integrating the status and risk information included in the Western Watershed Initiative, Human Population Density Maps, and Species at Risk Analysis.
- Incorporate recommended adjustments to the Forest Service Government Performance and Results Act (GPRA) Strategic Plan (2000 revision).
- Incorporate funding recommendations into proposed out-year budgets.
- Frame a research program to strengthen monitoring and evaluation during the strategy's implementation.

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VIII Team Members

Team Leaders

Lyle Laverty, Regional Forester, Rocky Mountain Region, USDA Forest Service

Jerry Williams, Director, Fire and Aviation Management, Northern Region, USDA Forest Service

Team Facilitator

Joe Michaels, Field Representative Forester, State and Private Forestry, Northeast Area, USDA Forest Service

Core Team

Michael Hilbruner, Applied Fire Ecologist, Washington Office, USDA Forest Service

Timothy Sexton, Fire Ecologist, Fire Program Management Program Center, USDI National Park Service

Monica Schwalbach, Assistant Director, Wildlife and Terrestrial Ecology, Washington Office, USDA Forest Service

James Morrison, Staff Assistant, Interregional Ecosystem Management Coordination Group, Northern Region, USDA Forest Service

Andrea Tuttle, Director, California Department of Forestry and Fire Protection

David Burich, Assistant Director, Financial Management, Washington Office, USDA Forest Service

William Bradshaw, Assistant Director, Strategic Planning and Assessment, Washington Office, USDA Forest Service

David Cleaves, Program Leader, Forest Fire Systems Research, Washington Office, USDA Forest Service

Support Team

Doug MacCleery, Assistant Director, Forest Ecosystems and Planning, Washington Office, USDA Forest Service

Gene Blakenbaker, Staff Specialist, Legislative Affairs, Washington Office, USDA Forest Service

Michael da Luz, Branch Chief, Fire Ecology and Operations, Rocky Mountain Region, USDA Forest Service

Mark Beighley, Applied Fire Ecologist, Washington Office, USDA Forest Service

Marlin Johnson, Assistant Director of Forestry, Southwestern Region, USDA Forest Service

Galen Hall, Regional Budget Officer, Northern Region, USDA Forest Service

Paul Keller, Writer-Editor, Pacific Northwest Region, USDA Forest Service

Lindon Wiebe, Applied Fire Ecologist, Washington Office, USDA Forest Service

IX Acknowledgements

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X Glossary

Adaptive Management
Adaptive management is a continuous process of action based on doing, learning, sharing and improving. It encourages the development and testing of technical and social approaches to achieve desired ecological, economic, and other social objectives. Adaptive management coordinates goals and plans across ownerships and administrative boundaries to promote partnerships to get things done. It focuses management on the *whole* system, rather than focusing on single species or elements of the system. It recognizes that ecosystems occur at multiple scales. Adaptive management also recognizes that people are a part of the ecosystem and, in fact, define what is to be sustained, for whom, where, and for how long.

Ecosystem Process
The actions or events that link organisms and their environment, such as predation, mutualism, successional development, nutrient cycling, carbon sequestration, primary productivity, and decay. Natural disturbance processes often occur with some periodicity *(From Webster's dictionary, adapted to ecology.)*

Ecosystem
The complex of a community of organisms and its environment functioning as an ecological unit in nature. *(Webster's dictionary.)*

Ecosystem Integrity
The completeness of an ecosystem that, at multiple geographic and temporal scales, maintains its characteristic diversity of biological and physical components, spatial patterns, structure, and functional processes within its approximate range of historic variability. These processes include: disturbance regimes, nutrient cycling, hydrologic functions, vegetation succession, and species adaptation and evolution. Ecosystems with integrity are resilient and capable of self-renewal in the presence of the cumulative effects of human and natural disturbances. *(Proposed Rule, Section 219.36, 1999.)*

Ecosystem Management
The careful and skillful use of ecological, economic, social, and managerial principles in managing ecosystem integrity and desired conditions, uses, products, and services over the long term.

Fire-Adapted Ecosystem
An ecosystem with the ability to survive and regenerate in a fire-prone environment.

Fire Regime
A generalized description of the role fire plays in an ecosystem. It is characterized by fire frequency, seasonality, intensity, duration and scale (patch size), as well as regularity or variability. *(Agee, as modified by Sexton.)*

Fire Frequency (Fire Return Interval)
How often fire burns a given area; often expressed in terms of fire return intervals (e.g., fire returns to a site every 5-15 years).

Interagency Wildland Fire Policy
The Federal Wildland Fire Management Policy and Program Review was chartered by the secretaries of the Interior and Agriculture to ensure that federal policies are uniform and programs are cooperative and cohesive. For the first time, one set of federal fire policies will enhance effective and efficient operations across administrative boundaries to improve the capability to meet challenges posed by current wildland fire conditions.

The policy review team reexamined the role of fire in ecological processes and the costs associated with fighting fire. An interagency product has resulted in changes in terminology, funding, agency policy, and analysis of ecological processes.

Landscape
An area composed of interacting and inter-connected patterns of habitats (ecosystems) that are repeated because of the geology, landform, soils, climate, biota, and human influences throughout the area. Landscape structure is formed by patches (tree stands or sites), connections (corridors and linkages), and the matrix. Landscape function is based on disturbance events, successional development of landscape structure, and flows of energy and nutrients through the structure of the landscape. A landscape is composed of watersheds and smaller ecosystems. It is the building block of biotic provinces and regions.

Restoration
In the context of this report's cohesive strategy, restoration means the return of an ecosystem or habitat toward: its original structure, natural complement of species, and natural functions or ecological processes.

Sustainability
Meeting the needs of the current generation without compromising the ability of future generations to meet their needs. Ecological sustainability entails maintaining the composition, structure and processes of a system, as well as species diversity and ecological productivity. The core element of sustainability is that it is future-oriented. (*Committee of Scientists Report, 1999.*)

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XII Appendices

Appendix A

The Coarse-Scale Assessment and Definition of Fire Regimes and Condition Classes

Current Condition Class Attributes

Current condition is defined in terms of departure from the historic fire regime, as determined by the number of missed fire return interval – with respect to the historic fire return interval – and the current structure and composition of the system resulting from alterations to the disturbance regime. Five combinations of fire frequency are defined, expressed as fire return interval, and fire severity to create the map of Historic Natural Fire Regimes (Table 1). **Groups I** and **II** include fire return intervals in the 0-35 year range. **Group I** includes ponderosa pine, other long-needle pine species, and dry-site Douglas fir. **Group II** includes the drier grassland types, tall grass prairie, and some chaparral ecosystems. **Groups III** and **IV** include fire return intervals in the 35-100+ year range; and **Group V** is the long-interval (infrequent), stand replacement fire regime.

Table 4 -- The Five Historic Natural Fire Regime Groups.

Fire Regime Group	***Frequency (Fire Return Interval)***	***Severity***
I	***0-35 years***	***low severity***
II	***0-35 years***	***stand replacement severity***
III	***35-100+ year***	***mixed severity***
IV	***35-100+ year***	***stand replacement severity***
V	***>200 years***	***stand replacement severity***

Three ***Condition Classes*** have been developed to categorize the current condition with respect to each of the five historic Fire Regime Groups. The relative risk of fire-caused losses of key components that define the system increases for each respectively higher numbered condition class, with little or no risk at the Class 1 level. Features of each condition class are defined through a qualitative description of the current state of five key ecosystem attributes: ***disturbance regime***; effects of ***disturbance agents***; potential ***production of smoke*** emissions; ***hydrologic function***; and ***vegetative composition, structure, and resilience***.

FIRE REGIME GROUPS I AND II

These first two fire regime groups occupy nearly all the lower elevational zones across the U.S. They have been most affected by the presence of human intervention and our analysis shows that these types demonstrate the most significant departure from historical levels. The departures are affected largely by housing development, agriculture, grazing, and logging. These areas are at greatest risk to loss of highly valued resources, commodity interests, and human health and safety. It is expected that these areas will receive primary focus of wildland management agencies in the future.

Condition Class 1 (Groups I and II)

Disturbance Regime—The historic disturbance regime is largely intact and functioning as defined by the historic natural fire regime.

Disturbance Agents—The effects of insects and disease as well as the potential intensity and severity of fire are within historic ranges, but are increasing with length of current fire return interval.

Smoke Production—Smoke production is relatively frequent, but is low in volume and short in duration.

Hydrologic Function—The hydrologic functions are within normal historic range.

Composition, Structure, and Resilience—Vegetative composition and structure are resilient to disturbances from wind, insects, disease, or fire and DO NOT predispose the stand or its key components to a high risk of loss.

Condition Class 2 (Groups I and II)

Disturbance Regime—Moderate alterations to the historic disturbance are clearly evident, such as one or more missed fire return intervals.

Disturbance Agents—The effects of insects and disease as well as the potential intensity and severity of fire pose an increased threat to key components that define the system.

Smoke Production—Smoke production has increased both in volume and in duration and has increased potential to effect health and visibility values.

Hydrologic Function—Riparian areas and their associated hydrologic functions show measurable signs of adverse departure from historic conditions.

Composition, Structure, and Resilience—Both the composition and structure of vegetation has shifted towards conditions that are less resilient and are therefore more at risk to loss from wind, insects, disease, or fire.

Condition Class 3 (Groups I and II)

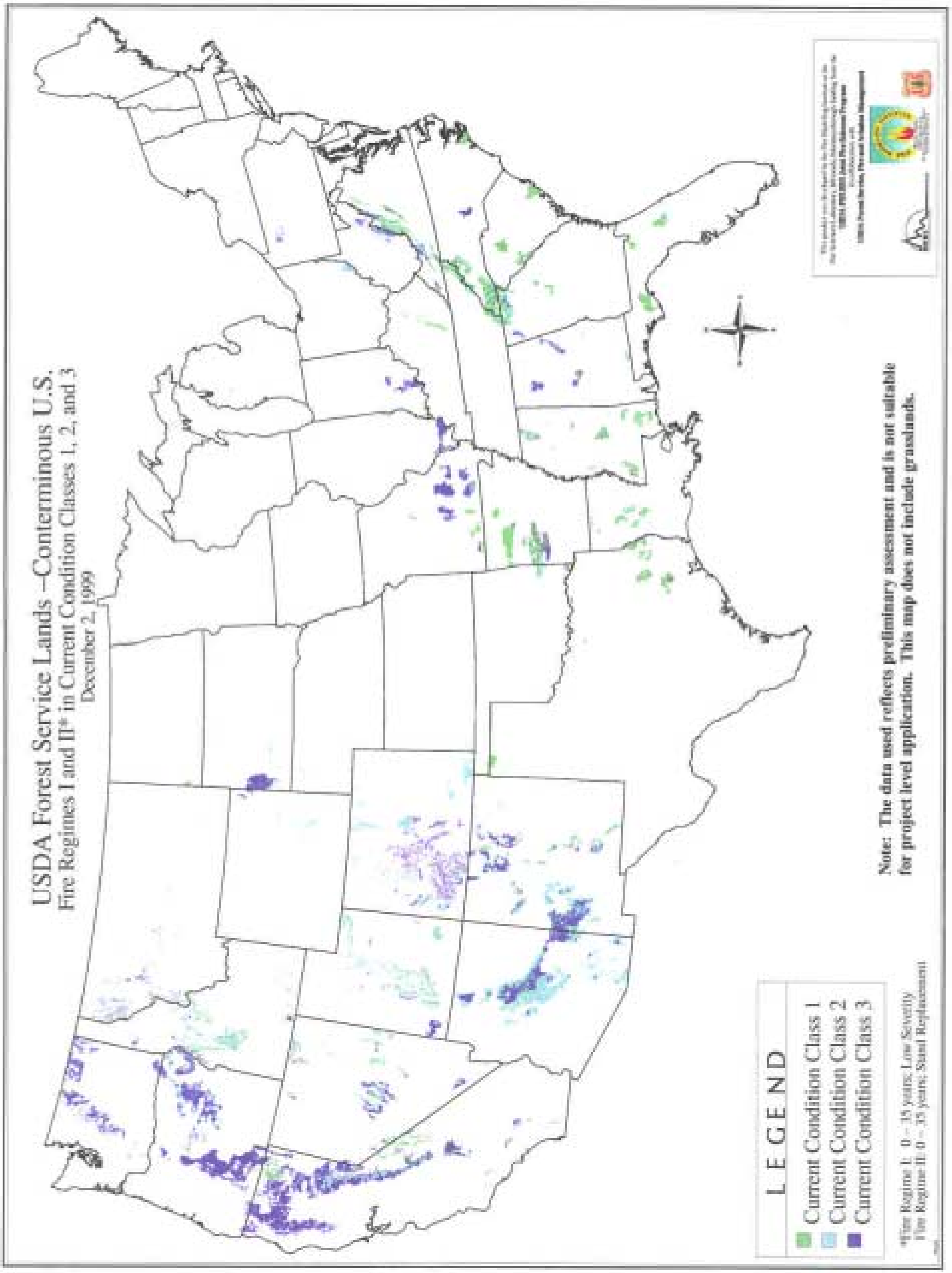
Disturbance Regime—The disturbance regime has been significantly altered and historic disturbance processes and effects may be precluded.

Disturbance Agents—The effects of insects, disease or fire may cause significant or complete loss of one or more defining ecosystem components.

Smoke Production—Episodic smoke production is unpredictable and of high volume and long duration, posing significant impacts to human health, safety, and societal values

Hydrologic Function—Hydrologic functions may be adversely altered, with significant increases in sedimentation potential and measurable reductions in streamflows.

Composition, Structure, and Resilience—The highly altered composition and structure of the vegetation predisposes the stand or ecosystem to disturbance events well outside the range of historic variability, potentially producing changed environments never before measured.


USDA Forest Service Lands –Conterminous U.S.
Fire Regimes I and II* in Current Condition Classes 1, 2, and 3
December 2, 1999
L E G E N D
Current Condition Class 1
Current Condition Class 2
Current Condition Class 3
*Fire Regime I: 0 – 35 years; Low Severity
Fire Regime II: 0 – 35 years; Stand Replacement
Note: The data used reflects preliminary assessment and is not suitable for project level application. This map does not include grasslands.

Appendix B

Recommended Adjustments to the Forest Service GPRA Strategic Plan

Objective 1.c — RESTORE ECOSYSTEM HEALTH AND RESILIENCE WITHIN THE CONTEXT OF NATURAL DISTURBANCE PROCESSES.

Strategies to Achieve the Objective	We will . . .
	• Identify priority health restoration needs through national and regional environmental monitoring and ecological risk assessments. Including:
	  ▪ social and economic factors and
	  ▪ sensitive species habitats at risk.
	• In regional, Land and Resource Management Plan, and landscape scale assessments, clearly identify values to be protected, relative risks, benefits, and costs of all treatment options for restoring fire-adapted ecosystems.
	• Research ecosystems (composition, structure, and process), social and economic values at risk, and the role of disturbance processes.
	• Design and implement systematic methods for broad-scale and landscape scale assessments of the history, status, and traje ctory of ecosystem conditions; values at risk; and management opportunities for maintaining and restoring ecosystem integrity. Develop an ecological integrity rating system by ecoregion to improve the ability to monitor ecological conditions and trends.
	• Apply the latest knowledge to develop and implement landscape scale protection and restoration projects.

Measure	Trends in acres at extreme risk from fire, insects, diseases, and invasive species.
FY 2006 Milestones	• A 5% decrease in acres at extreme risk from insects and diseases. • Restore and maintain fire-adapted ecosystems in fire regimes I and II. Reduce high risk areas by 25 percent. • Acres infested with targeted invasive species remains unchanged or is diminished.
Key External Factors	Baseline data on acres at risk was collected in an inconsistent manner in the past. Well-defined methods of data collection and storage are being developed. Fires, insect and disease epidemics and other unplanned large natural disturbances can radically alter the landscape and rapidly change management strategies, priorities, and budget allocations Local jurisdictions regulate homebuilding. As development extends into wildlands, areas can experience higher intensity fires that increase risks to human life and property and contribute to the spread of invasive species.

Objective 3.e

Increase awareness among employees and constituents about the need for restoration and management for ecosystem sustainability.

Strategies to Achieve the Objective

We will . . .

Develop corporate training module for conservation awareness, and ensure all employees participate in this training module.

Strengthen interagency conservation education efforts to emphasize the importance of watershed protection, species conservation, and management for long-term ecosystem integrity and resilience.

Design and implement conservation awareness products that facilitate understanding about natural disturbance processes, particularly fire, and the potential values at risk when fire regimes are altered.

Measure

Increasing trend in employee and public awareness of relationships among natural disturbance processes, ecosystem integrity and social values

FY 2006 Milestone

- Complete corporate training module for conservation awareness and require all employees to participate in this training, by 2002.
- Develop an MOU with the Department of Interior to strengthen interagency conservation education to focus on the importance of watershed protection, species conservation, and management for ecosystem integrity and resilience, by 2002.
- Provide conservation awareness products in conservation education packages and programs at all levels of the organization, by 2002.

Key External Factors

Appendix C

Reconciling Stewardship Objectives – Assessing Values at Risk

Considerable progress can be made in reconciling stewardship objectives by assessing values at risk at national, regional, and local scales. Emphasizing the agency's strategic objectives, a framework for assessing values at risk can be developed. Specifically, agency objectives for ecosystem health and public safety define national priorities for values to be protected. These objectives and their associated values are:

- Public safety (GPRA SP Objective 4b)
- Watershed protection (GPRA SP Objective 1a)
- Species conservation (GPRA SP Objective 1b)
- Ecosystem resilience (GPRA SP Objective 1c)

At a national level, we are working to integrate information on human development, watershed condition, species and ecosystems of concern, noxious weeds, insects and disease, roadless areas, and plant community/ecosystem conditions by fire regimes. This requires compilation of information on historic disturbance regimes, watershed condition information, and development of a watershed-at-risk map, and completion of the species-at-risk map. An integrated map of relative risk to these values will provide broad-scale context of the challenges for protecting people and sustaining ecosystems at the national level. A standard process for integrating and interpreting this information needs to be developed. national leadership will use this information to refine priorities for annual and long-term performance and accountability.

In conducting risk assessments at the regional level, we need to integrate information including, but not limited to: human development, historic disturbance regimes, watershed condition, species and ecosystems of concern, invasive weeds, insects and disease, roadless areas, plant community/ecosystem conditions by fire regimes. This will require compilation of appropriate information at finer scales of resolution than that compiled for the national risk assessments. Based on regional assessments, priorities for landscape scale analyses and management action can be developed. On-the-ground treatment priorities are then identified by the goals, objectives, and strategies that are linked up through the agency to GPRA strategic goal for restoring and maintaining ecosystem health.

Appendix D

Basis For Values in Tables 2 and 3 in Chapter V

In tables 2 and 3 (Chapter V), the number of acres in each "Condition Class" representing current conditions are taken from Hardy et al, 2000.

Annual program costs are estimated based on current Forest Service direct project expenditures. Included within these estimates are planning, consultation, thinning (modified), prescribed burning, and invasive weed mitigation. Indirect costs are not included.

Average cost estimates were developed for each Condition Class with different estimates for the Western Regions (1-6) than the Eastern Regions (8 and 9). Because these costs can vary widely – depending on slope, access, and efficiency of scale variables – a range was defined. Next, to perform the calculations, a single value was selected. The ranges and values used are shown below.

	Western Regions (1-6)		Eastern Regions (8 and 9)	
	Range	Value Used	Range	Value Used
Condition Class 1	45-85	65	15-25	20
Condition Class 2	100-300	200	25-45	35
Condition Class 3	275-600	375	150-250	200

Each annual program cost estimate shown in tables 2 and 3 is based on the above table and the acres to be treated by Condition Class. For example, the annual program cost in the Western Regions for years 4 through 15 of program implementation was calculated as follows:

	Acres to Treat (Millions)	Cost per Acre	Acres X Cost per Acre
Condition Class 1	.5	65	33
Condition Class 2	1.5	200	300
Condition Class 3	1	375	375
		Sum	708

Appendix E

Brief Summary for Future Projections of Condition Classes and Risks

Introduction

The methods, results, and confidence in the future projections of Condition Classes and associated risks in section VI, "Consequences of Deferral," are discussed in detail in a paper by Hann and Hilbruner (2000) titled "Protecting People and Sustaining Resources--Assessment of Management Options for the Western U.S." This paper can be found on the www web site "fs.fed.us/fire/fuelman." Methods for this analysis were based on adjustment and re-calibration for Forest Service lands in the Western U.S. of a vegetation and disturbance dynamics model developed by Hann and Bunnell (In Press) for the contiguous Lower 48 States.

This appendix provides a brief overview of methods and limitations of the modeling projections.

Methods

A landscape succession and disturbance network model was developed for the assessment of the cohesive strategy options in the Western U.S. (Hann and Hilbruner 2000) using the Vegetation Dynamics Development Tool (VDDT) (Beukema and Kurz 2000). The model that was developed used Condition Classes as states and incorporated probabilities for succession, unplanned disturbances (such as fire), and planned disturbances (such as mechanical and prescribed fire restoration).

The concepts of this type of model of multiple succession and disturbance pathways were first developed by Egler (1954). These concepts were incorporated with other information into the development of conceptual succession and disturbance models by Noble and Slatyer (1977). Conceptual succession and disturbance models were combined with ecosystem specific information into computer models by Kessell and Fischer (1981) and Keane et al. (1989 to predict response over time of the interactions of vegetation succession and disturbance dynamics. As space and time pattern and process concepts developed in the field of landscape ecology, these models were further advanced (Forman and Godrun 1986, Turner et al. 1989). State and transition model concepts were further expanded with findings on multiple pathways and steady states in rangelands by Tausch et al. (1993).

The accumulation of this long history and wide variety of kinds of spatial and temporal landscape modeling were fully implemented to support an assessment of management implications that included characterization of the historical range and variation, as well as future outcomes of management option for the Interior Columbia Basin Ecosystem Management Project (ICBEMP) by Keane et al. (1996) and Hann et al. (1997 and 1998).

Dynamic relationships of basic landscape vegetation, disturbance, and hydrologic regimes were then linked with aquatic and terrestrial habitat and species population characteristics to characterize basic relationships and project future outcomes (Lee et al. 1997, Raphael et al. 1998, Wisdom et al. 2000). Similar linkages were developed with social and economic variables to characterize basic relationships and project future outcomes (Haynes and Horne 1997). Further developments have resulted in development of the Tool for Exploratory Landscape Scenario Analyses (TELSA) (Kurz et al In Press) and the LAND and fire planning model which have been designed to support assessment of ecosystem status and risk variables, and prioritization of restoration opportunities to improve status and reduce risk (Hann and Caratti 2000).

Much of the understanding developed from the comprehensive scientific assessment and evaluation of management alternatives for the ICBEMP (Quigley et al. 1996, 1997, 1999) became the foundation for the modeling effort described briefly in this appendix and by Hann and Bunnell (In Press) for the Lower 48 states and Hann and Hilbruner (2000) for the western U.S. The modeling effort used the description of the present conditions for the western U.S. from Hardy et al. 2000.

Succession and disturbance probabilities were developed by determining average rates for the Fire Regimes and between each Condition Class. The model was calibrated for the historical range and variation (HRV) by repeating 10 runs per simulation (to get average, maximum, and minimum) until succession and disturbance probability combinations were found that could represent the fire regimes. The model was then calibrated from the late 1800s to the present by activating disturbances associated with post-Euro-American settlement, fire suppression, and management activities. The methods for this calibration were similar to those for calibration of HRV in that 10 runs per simulations were conducted until the projected conditions at the year 2000 and the trends of Condition Class and wildfire graphs were similar to those of the published literature (Agee 1993, Hardy et al. 2000).

Two future options were calibrated using the combined understanding gained from the HRV and post-settlement calibration, with adjustments for future management option projections. The two future management options were: 1) continuation of current management using the current levels of prescribed fire and fuel management combined with current levels of other activities (such as timber management, range improvement, wildlife habitat restoration, watershed restoration); and 2) implementation of the cohesive restoration strategy. In comparison to the HRV and post-settlement calibrations, these were relatively simple to calibrate, since the current levels of activities and the cohesive strategy level of activities were known entities.

Attributes for projections of loss of life and property, severe event degraded ecosystems, and relative risks of smoke/air quality, native species endangerment, and stream/watershed were developed using correlation of trends in landscape Condition Classes and assumptions similar to relationships found within ICBEMP (Quigley et al. 1999), but adjusted for conditions in the western U.S. (Elmore et al. 1994, Flatherer et al. 1994 and 1998, Hann and Caratti 2000, Hardy et al. 2000, Leenhouts 1998, Mangan 1999).

Loss of life and property was based on the relationship between firefighter fatalities and property losses correlated with amount of uncharacteristic wildfire events. The amount of severe event degraded ecosystems was projected based on the correlation of uncharacteristic wildfire events with high risk conditions. Relative risk of smoke/air quality was correlated with tons of particulates produced for both wildfire and prescribed fire events. Native species endangerment patterns were correlated with the number of species of concern in the western U.S. and cumulative effect patterns of association with loss of habitat quality. Stream and watershed risk was correlated with effects of uncharacteristic wildfires in cumulation with other effects. Many of the risks (such as land use or human disturbance on adjacent lands) that cause cumulative negative effects to native species, air quality, and streams and watersheds are not reduced by restoration on Forest Service lands. This was factored in to the model relationships.

Three key assumptions served as a basis for the Condition Class, disturbance, and associated attribute modeling:

Assumption 1—based on the landscape pattern and causes of fragmentation findings from ICBEMP, it was assumed that a step-down prioritization would occur that would identify priority watersheds to be restored. The watersheds would be selected based on high composition of Fire Regimes I and II and opportunities for maintenance of low risk or reduction of high risk conditions. However, once a priority watershed was selected, restoration activities would be designed to restore habitats and regimes across all Forest Service lands within the watershed, irrespective of the Condition Class and Fire Regime. This would achieve a landscape approach to restoration. This would avoid a fragmented outcome associated with the fragmented landscape pattern of Fire Regimes I and II that often occur in association with variation in elevation, terrain, road access, or history of land use within the watershed. In turn this would restore wildlife and fish habitats, and hydrologic and air regimes at a watershed scale, thus providing a positive outcome to those resources.

Assumption 2—based on aquatic native species strongholds and vulnerability of wildlife species, air quality and hydrologic regimes to the combination of land use, human activities, and proposed restoration; the step-down prioritization would result in an integrated design as described by Reiman et al. (2000). This would assure that vulnerable native species or ecosystems would not be selected for restoration activities that could cause a decline in these resources. This would also assure that watersheds selected for restoration would be restored in an integrated fashion, such that vegetation and fuel restoration activities would *be paralleled with the necessary road, stream, and watershed restoration activities that would cumulatively result in a healthy watershed.*

Assumption 3—the future projections assumed a minor level of continuation of increasing drought and warming temperatures in both management options. However, for the future projections of the cohesive strategy it was assumed that a landscape approach to restoration would occur. This would result in a re-patterning of the fuels and vegetation such that the present contiguous high risk fuel bodies would be restored to a pattern somewhat similar to that of HRV, thus resulting in lower risk of uncharacteristic wildfire event continuity or continuation of uncharacteristic succession/disturbance momentum. For the cohesive strategy, this assumption resulted in the slowing of succession rates to higher risk Condition Classes and lowering of probabilities of large uncharacteristic wildfire events.

Limitations of Modeling

There are considerable limitations to this type of general modeling at a scale that accounts for all Forest Service lands in the western U.S. Modeling could be much more precise with more detailed pixel modeling using refined stratification of succession, disturbance, and attribute parameters, such as accomplished by Keane et al. (1996) with the Columbia River Basin Succession Model. However, given experience with validation of this and other detailed spatial and temporal geographic information systems, it is unlikely that the relative differences between the outcomes of the two options would change substantially with more detailed modeling. This appears to be particularly true at the broad scale of Forest Service lands in the western U.S.

One key caution is emphasized relative to use of the projected outcomes:

Caution—the strength of this type of modeling is in reliance on relative differences and not on the absolute. The absolute value of the area for a Condition Class, disturbance effect, or associated attribute class does not have high confidence at this scale. However, the relative difference (percent difference) between management options for the Condition Class, disturbance effect, or associated attribute class has fairly high confidence. This is because the confidence in relative differences between management options for the same attribute class increases with increasing size of summary area, while the confidence in the absolute area of an attribute class decreases with increasing size of summary area (Hann et al. 1997).

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