Forest Health and Fire

An Overview and Evaluation

National Association of Forest Service Retirees

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Executive Summary

The National Association of Forest Service Retirees (NAFSR) offers its experience and expertise to establish a factual basis on which to build public policy regarding forest health and fire mitigation; specifically:

1. To Identify Misconceptions about Forest Health and Fire

Misconceptions often influence public policy. We must challenge some of these, listed below, that hinder understanding the problem and steer discussion toward more productive courses of action.

- ***The Balance of Nature Myth:*** The imagined forest often consists of a continuous forest cover of large trees, individually having indefinitely long lives. This idea often ignores all the changes in vegetation states that the forest undergoes over time.
- ***Long-Term Care for the Aged, Sacrifice the Young:*** Many advocate managing fuels by removing only small material by "thinnings," "clearing underbrush," and removal of trees only up to a certain diameter. It would be a mistake to arbitrarily preclude removing trees above a given size or age.
- ***One Hundred Years of Aggressive Suppression Caused the Fuel Buildup:*** Fire suppression forces were few and the tools were primitive for most of the 20th century. Forest growth that greatly exceeded removals, and fifty years of cooler, wetter climate had an effect on forest biomass and burning conditions.
- ***Fires are Bigger and More Destructive than in the Past:*** There is little historical support for this assertion. Western North America has been beset with large fires since the glaciers receded.
- ***Selective Logging is the Answer:*** We must be wary of applying blanket prescriptions. Selective logging is appropriate only in certain forest types and under certain conditions.
- ***Only Protect Human Communities:*** While protecting communities must be a high priority, we must not neglect the other values of the forest.
- ***Big Trees Don't Burn:*** Large trees are only more fire-resistant. Hot ground fires and crown fires kill them also.

- ***Cutting Cookies:*** Forests are complex. Solutions must be temporally and spatially tailored to specific conditions.
- ***Prescribed Fire is THE Solution:*** Prescribed fire is not the total answer. There are many locations and situations that will render it infeasible.
- ***Logging is the Problem:*** Current use of best management practices has not had long-term detrimental effects.
- ***Let the Taxpayer Subsidize Forest Health:*** Maintaining forest health is a matter of establishing sustainable stand conditions and reducing risks. This has significant economic impacts, and forest products can help finance them.

2. To Examine the Three Independent Variables

The independent variables provide focal points for analysis and management action.

- ***Climate and Weather:*** Climatic records clearly show prolonged wet and dry, cool and hot periods.
- ***Human Impacts:*** The urban-wildland interface zone is one of America's worst fire protection problem areas.
- ***Forest Health and Adding Fuel to the Fire:*** Forest health is the key to how disturbance events such as fire or pest outbreaks perform.

3. To Offer Conclusions and Proposals for Action

Restoring forest health will be a huge task that must be accurately defined and intelligently managed.

- Avoid trying to force a forest into a static condition.
- Do not restrict action to any particular size or age of material.
- Concentrate on current conditions.
- Aggressive initial attack is still required.
- Use a systematic, diagnostic approach to anticipate forest health problems.
- Work with, not against, nature.
- Accurately account for forest health costs. Use long-term risk analysis.
- Prepare the forests for the inevitable periods of drought. Encourage research into climate/forest health relationships.
- Have forest products help pay for forest health measures.
- Aggressively work to increase installation of FIREWISE COMMUNITIES and other self-help protection programs.

Forest Health and Fire
An Overview and Evaluation

The current (2002) fire season and the one of 2000 generated intense public discussions about the impacts of wildland fire, perhaps unsurpassed in the history of the United States. Vivid media exposure, finger pointing, and armchair experts all added fuel to the fiery debate about why we're so vulnerable to wildfire and what we must do to mitigate its human and environmental effects. Any discussion about fires, however, must include considerations of forest health, for forest health is a major underlying cause of unusual wildland fire effects.

The National Fire Plan presents a comprehensive plan of action to address the fire problem. It is not, however, designed to frame the issues for public discussion of the matter in a way that will help the public and public officials understand the complexity of the components of forest health and wildland fire.

The National Association of Forest Service Retirees maintains a special interest in the subject and offers its experience and expertise to establish a factual basis on which to build public policy regarding forest health and fire mitigation. This paper represents a summary of our members' views on the matter. Its purpose is threefold:

1. ***To clarify some misconceptions about forest health and fire.*** Because misconceptions so often influence public policy, we must challenge some of these that hinder understanding the problem and steer discussion toward more productive courses of action.
2. ***To examine the three independent variables bearing on the subject.*** Climate, forest health (or stand conditions) and human impacts determine the space for decisions.
3. ***To offer conclusions and proposals for general lines of action.*** Our forests are a treasure-trove of untold spiritual and economic value. They are dynamic and diverse, requiring our best science and adaptive management for their perpetuation.

Misconceptions

The Balance of Nature Myth

An underpinning of public misconceptions about forests is the belief that they possess the attributes of order, constancy and stability. The mental picture many people seem to have of the forest comes from a particular experience, fixed in time, and analogous to a snapshot rather than to a movie. It is important to understand this concept, because it sheds some light on how public attitudes are formed about forests.

People imagine a forest from a mental image formed in the past, and not as an entity being essentially modified by past or future events or conditions. This imagined forest often consists of a continuous forest cover of large trees, individually having indefinitely long lives, and not experiencing all the changes in vegetation states that the forest undergoes over time.

This idea gives rise to typical viewpoints which represent "…a resurgence of prescientific myths about nature blended with early-twentieth-century studies that provided short-term and static images of nature undisturbed" (Botkin 1990). It would follow from this concept, then, that any human disturbance of a forest would be adverse to its inherent order and stability. Those who would reduce forest fuels but proscribe removal of large trees harbor this view. They either don't understand, or they choose to ignore, the fundamental processes of forest succession — what it looked like in the past, and how it may look in the future — and the role that disturbances play by creating openings in the canopy that encourage species diversity and forest regeneration.

Long-Term Care for the Aged, Sacrifice the Young

Many advocate managing fuels by removing only small material by "thinnings," "clearing underbrush," and "removal of trees only up to (x) inches in diameter." Unfortunately, bills are being considered in Congress to support this thinking and also a variation even more problematic than diameter limits — maximum age limitation.

A forest needs some openings for seedling establishment. As in any living population, it must have a variety of age classes to assure continuity. Younger age classes supply the trees that will eventually replace older trees lost through mortality. Along with diverse age classes is the need for diverse species. About 20 tree species inhabit the western forests. The overwhelming majority of plant diversity, with many hundreds of species in western forests, is in the understory. The diversity of the understory plants provides essential habitat for many species of native fungi, soil microorganisms, insects, mammals and birds. A continuous cohort of older trees would provide little chance for a diverse understory. Bonnicksen (2000) proposes the creation of a "clumpy" forest with varied age classes interspersed with openings as a way to restore diversity and more stable forest conditions.

The species of tree, in addition to size or age, is an important factor in how it responds to fire. While all seedlings and saplings display vulnerability to ground fire, larger true firs, hemlock, and other thin barked trees are more easily killed, even by relatively light ground fire, than the large thick barked trees such as ponderosa pine, Douglas-fir and giant sequoia. The thick barked trees are nevertheless susceptible to high intensity and/or repeated ground fires and to crown fires.

It would be a mistake to arbitrarily preclude removing some understory trees above a certain size or age limit that are growing into the crowns of larger trees. It's the height to live crown that is most correlated to fire severity and crown fires (Omi and Martinson 2002). Saving the understory could only jeopardize the overstory by providing "ladder fuel" to carry fire from the ground to the crowns of the dominant trees. One needs only to look at the present situation of the giant sequoia with its understory of white fir for a vivid example of a ready-made catastrophe. Covington (2000) had this to say about diameter caps on thinnings, "From an ecological restoration perspective, these diameter caps are not ecologically beneficial and, fundamentally, make no sense."

Past Aggressive Suppression Caused the Fuel Buildup

One hundred years of aggressive fire suppression, we are told, eliminated the role of fire in controlling fuel accumulation. This idea seems plausible enough, considering recent history and for those with short memories. Seldom mentioned in public discussion however is the additional fuel accumulation just from forest growth. Figure 14 (page 28) shows growth and removal data for the nation. The Sierra Nevada national forests alone are said to have an annual net growth of 2 billion board feet, while growth nationally is double removals.

While fire suppression became more aggressive following the 1910 fire year, it is doubtful whether it was effective enough to reduce significantly the number of large fires, at least for the first 50 years of the 20th century. Fire fighting forces were small at first until the members of the Civilian Conservation Corps built them up significantly in the late 1930s. Tools and technology remained primitive then, and the principal method of fighting fire was by throwing dirt at the flames. Up until the mid 1950s the typical initial-attack suppression force was one or two "smoke chasers" with a hand compass, a map, and fire packs on their backs. Contrary to the belief in 100 years of fire exclusion, the evidence clearly shows that the period from 1919 to 1950 experienced huge fire years (Figure 1).

Considering the tremendous loss of life to wildfire toward the end of the 19th century and the start of the 20th, perhaps seeing fire as a threat to be met was the most prudent

Figure 1. Number of Fires and Acres Burned by Decade. Source: NIFC

Dates	**Average No. of Fires**	**Average Acres Burned**	**Average Acres/Fire**
1919-1929	97,599	26,004,567	266
1930-1939	167,277	39,143,195	234
1940-1949	162,050	22,919,898	141
1950-1959	125,948	9,415,796	75
1960-1969	119,772	4,571,255	38
1970-1979	155,112	3,194,421	21
1980-1989	163,329	4,236,229	26
1990-1999	106,306	3,647,597	34
2000 only	122,827	8,422,237	69
2001 only	84,109	3,570,911	42
2002 to 9/15	67,561	6,444,305	95

public policy. The initial-attack policy may have been responsible for preventing much loss of human life and property.

Curiously, the wildfire literature seems to have little to say about weather and the effects of periodic climatic fluctuations, either as related to periodicity of fire return or the rate of fuel accumulation. Beginning around 1950, the average size of fires decreased dramatically until increasing about 2000 (Figure 1). The current year (2002) appears likewise to show an increase in average size. Considering the cooler and wetter climates in the last 50 years of the 20th century, we could surmise that the smaller size of fires then was weather-driven, especially now that the average size in the last few years appears to be increasing along with drought conditions and despite improved fire fighting technology.

The big fire years of the first half of the 20th century coincided with a severe and long period of drought and high temperatures across the western United States during the “Dust Bowl,” starting about 1930 — the fine vertical line on Figure 2. The last fifty years of the 20th century experienced a long cooler period and declining burned acres.

Data collected from streamflows in the American River in California from 1901 to 2000 showed 34 years of declining rainfall, followed by 30 years of average rainfall, then 25 years of variable rainfall due to “El Niño” and “La Niña” (Citizens for Water, 2001). The declining rainfall period includes the “Dust Bowl” era mentioned earlier. This recent period of 50 years of relatively cool wet climate has likely contributed to the unusual undergrowth and ladder fuels, now the *bete noir* of many fire experts.

We will have more to say later about weather patterns and their effects on fire size and occurrence. Suffice it now to say that the weather may have contributed to a significant increase in the fuel loading contributing to current period large fires.

In addition to variations in climate, we should consider that Native Americans drastically reduced their burning of the forest before the turn of the century — another episode that could have added to the buildup. Clearly, in the dry forests in the interior west, and in places such as the giant sequoia groves in the Sierra Nevada, where the fires were normally low in severity and their return interval was usually short, decades of fire exclusion jeopardize the existing forest values.

The facts, however, seem to point to a more complex scenario than just "100 years of fire exclusion by aggressive suppression." The climate fluctuated wildly (and still does); Native Americans, sent to their reservations, stopped modifying the forest environment by the use of fire; and the American public viewed wildfire as an enemy and acted accordingly. Whatever the reasons, we must squarely face the fuel situation in our forests.

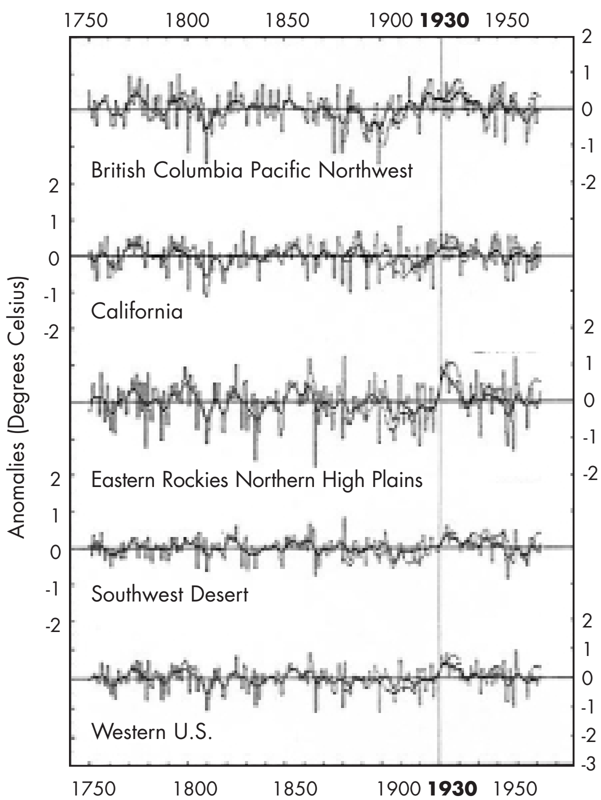


Figure 2. Reconstructed summer half-year temperatures for 1750-1982. Note the correlation with Figure 1; the high temperatures in the 30s and 40s with big fire years followed by lower temperatures and smaller fire years. From Briffa et al.1992.

Fires are Bigger and More Destructive than in the Past

Except for the dry forests of the interior West, there is little historical support for this assertion. Western North America has been beset with large fires since the glaciers receded. Current discussion of this subject seems to focus on the history of the last one or two generations. This may be too short a time span from which to draw definitive conclusions. Much of the forested area in the West is often characterized as fire dependent ecosystems that evolved over thousands of years, along with weather conditions that assured the periodic return of fire. The earliest inhabitants of the continent reinforced the effects of naturally ignited fires by torching off the forests for various cultural and subsistence reasons. The severity of both human and naturally ignited fires depends on the weather conditions at the time, and, we note again, the annual burned area is closely correlated with temperature and precipitation. Figure 3 clearly shows that large, destructive fires have been with us for much of our history, and that the recent large fires are not unique to our times.

The "Tao" of Selective Logging

Much of the discussion about improving forest health and reducing effects of disastrous fires recommends "a path of virtuous conduct" (Webster) of managing the forest by selective logging. We must, however, be wary of applying blanket prescriptions.

This "virtuous path" of selective logging has virtue only in certain forest types and under certain conditions. It has little chance of successfully maintaining the health of some forest types. The usual idealized western forest model is of the ponderosa pine, or similar type, on easy ground, where the historic fire return is short and the ground allows access for prescribed fire, mechanical treatment and uneven-age management. Selective logging, more properly called the "selection method" of silviculture, with uneven aged forest structure as its objective, can work in this kind of forest. However, what too often happened in the past, on easy ground in the ponderosa pine type, was the practice of selective logging that amounted to high grading, cherry picking, or "select the best and leave the rest."

There were a number of reasons for the

Figure 3. Some Historic Large Fires of Note.

Year	Name and Location	Acres	Human Losses and Effects
1825	Miramachi - Maine & New Brunswick	3,000,000+	
1871	Peshtigo - Wisconsin & Michigan	3,780,000	1.500 deaths
1881	Michigan	1,000,000	169 deaths
1894	Hinkley - Minnesota	undetermined	418 deaths
1894	Wisconsin - Wisconsin	several million	undetermined - some deaths
1902	Yacoult - Washington & Oregon	1,000,000	38 deaths
1903	Adirondack - New York	637,000	
1910	Great Idaho - Idaho & Montana	3,000,000	48 hour blowup, 85 deaths
1933	Tillamook, '33, '39, '45 - Oregon	355,000	13 billion board feet of timber
1947	Maine - Maine	205,678	16 deaths
1967	Sundance - Idaho	56,000	9 hour blowup
1970	Laguna - Southern California	175,425	382 structures
1987	Siege of '87 - California, Various	640,000	
1988	Yellowstone - Montana & Idaho	1,585,000	Much acreage unburned
1991	Oakland Hills	24,174	25 deaths, 2,900 structures lost
1992	Foothills - Idaho	257,000	1 death
1999	Dunn Glen - Nevada	288,220	
2000	Valley Complex (Bitterroot)- Montana	292,070	
2000	Clear Creek - Idaho	216,961	
2002	Hayman - Colorado	137,760	
2002	Rodeo and Chediski - Arizona	468,636	as of 8/9/2002

practice, some inexcusable, others a response to the need for wood for public consumption, others a reflection of the lack of understanding of biological processes. The consequences of creaming off a healthy overstory were a legacy of residual diseased trees and an understory of shade tolerant, thin barked species that were less resilient to fire and insect and disease attacks. The practice additionally tended to encourage prolific regeneration resulting in excessive numbers of small diameter trees. Much of the troublesome stand conditions now decried in the ponderosa pine forests are the result of selective logging, without a clear cut objective of maintaining a forest with specific attributes, such as a variety of species, varied age composition and resiliency.

Only Protect Human Communities

We fully support prudent action to make residences and communities in the urban/wildland interface safer from fire. While protecting communities must be a high priority, we shouldn't neglect the other values of the forest. Covington (September, 2002) testified that the ecosystems of frequent-fire forests "are so degraded and fragile that they are no longer sustainable, and a liability rather than an asset to present and future generations." He urges that we think much bigger than just the urban interface, and "…act at the scale of greater ecosystems — large chunks of the landscape that include not only wildlands but also embedded human communities." He proposes considering treating landscapes of 100,000 to 1,000,000 acres.

Much of the sentiment behind confining treatment to the urban interface involves concern that mechanical treatments, such as timber removal, would result in adverse effects on threatened and endangered fish and wildlife. Discussing the matter, Mealey and Thomas (2002) note the regulatory agencies' (U.S. Fish and Wildlife Service, National Marine Fisheries Service) proclivity to use the "precautionary principle driven, short-term risk-averse policy" in their determination of risks to threatened and endangered species.

In so doing the regulators discourage action to restore forest health because of possible short-term risks to listed species, while ignoring the likely long-term harm of habitat degradation from hot, large scale stand replacement fires. Mealey and Thomas urge "a new vision and an altered approach," supported by research, which would use relative risk assessments to determine the trade-off between long- and short-term effects on wildlife when manipulating forest components. This would strike a balance between the "no action" alternative and modifying forest conditions to achieve optimal function.

Stand replacement fires can have dramatic effects on the health of fish and wildlife populations. Especially critical are habitats for threatened and endangered species. Agee and Edmonds (1992) reported that: "There is a very low probability that any spotted owl reserve created in the East Cascades subregion will avoid catastrophic wildfire over a significant portion of its landscape over the next century."

Gaines et al. (1995) evaluated the effects on northern spotted owls on the 1994, 43,000+ acre Hatchery Complex Fires in the Eastern Washington Cascades. They reported an average habitat loss by direct effect of the fire at 31% and a significant loss induced by delayed tree mortality and mortality due to insects, for a total average habitat loss of 55%. This amounts to about a 24,000-acre diminution of available spotted owl habitat within a 1.8 mile radius of the six owl activity centers affected by the fire. They further say: "Fewer spotted owls occupied and reproduced at these sites than in previous years."

Newspaper accounts quote Forest Service officials claiming that Southwestern Oregon's 500,000 acre Biscuit Fire of 2002 "only" burned 30% of the land inside the fire boundary. A rough estimate, using the 55% figure from above, and assuming similar vegetation conditions and burn pattern could conclude that this fire may have consumed 82,500 acres of spotted owl habitat. We should expect continuing losses of critical habitat to stand replacement fires without active management at the landscape level.

Stand replacement fires, the expected future impact on much of our forested land, can also cause serious damage to native fish and their habitat. An analysis done in Oregon (Mealy and Thomas, 2002) of fisheries at risk lists 13 species of salmon, nine species of trout, and seven other species of fish, all threatened or endangered, that use habitat with either moderate or high fire risk (Figure 4). Oregon's Biscuit Fire overran many of the streams shown in the lower left of the map below.

Seventy five percent of the water in the West originates in national forests. These watersheds are particularly vulnerable to wildfire. They are critically important to domestic and agriculture water users who depend on adequate supplies of quality water. Destructive soil movement and flooding following fire are common experiences. Hot fires render certain soils impermeable to water, resulting in overland flow, flash flood-

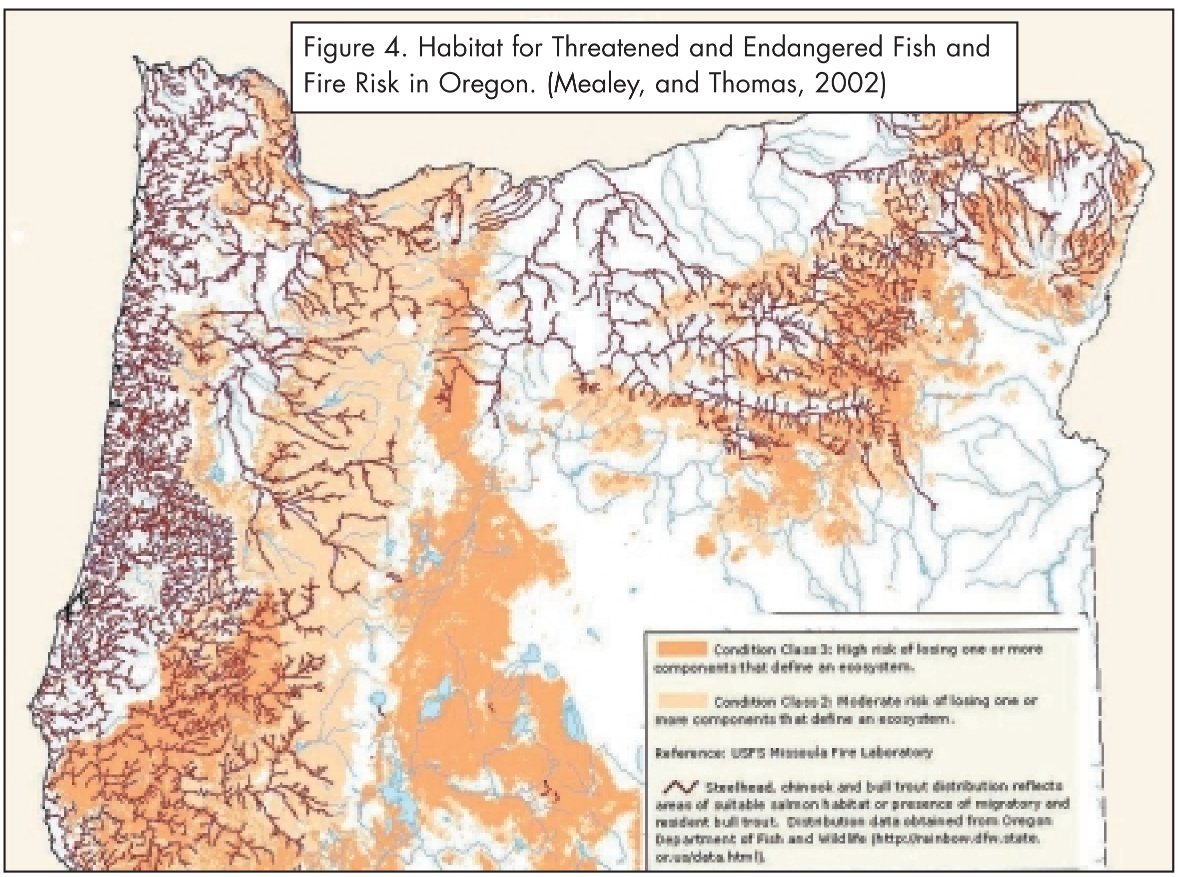


Figure 4. Habitat for Threatened and Endangered Fish and Fire Risk in Oregon. (Mealey, and Thomas, 2002)

ing, destruction of stream profiles and excess silting of reservoirs to the point of rendering them useless. Illustrations of the impacts of the Hayman Fire of 2002 on Denver's Cheesman watershed and reservoir, after only a minor rainstorm event, are displayed in Figure 5.

The concept of defensible space around communities and human habitation is valid. It provides an area where engine crews can safely and effectively work to protect structures. But when fires emerge on massive fronts such as seen in Western forests in the last several years, there will simply never be sufficient fire forces to protect the threatened structures. The Jones Valley fire in 1999, near Redding, California, started in the forest interior near Shasta Lake and ran through a rural community for about 20 miles, destroying 250 homes. Nearby Happy Valley lost 85 homes under the same circumstances (Fitch, 2002).

The big fires of 2002, Chediski, Hayman, Biscuit and others came roaring out of interior forests and nothing but a change in the weather stopped them. To prevent fires emerging on massive fronts, the entire fuel picture must be considered, starting with highest risks and working back into the interior with fuel modification to where the costs of fire and values at risk reach some sort of equilibrium. The consequences of inaction will be to give residents a false sense of security that may put property and their very lives in danger.

We also must not ignore interior forest stand conditions related to insect and disease susceptibility. Large-scale pest problems change the fuel component and increase the risk of spilling the problem over into communities. It goes back to the erroneous "no action" premise that if we do nothing, nothing bad will happen. Insects, particularly, migrate quickly and do not respect political or habitation boundaries.

Decisions about whether to attempt to control bark beetles must be prompt. Small populations of bark beetles in modern times have been kept in check by manipulating stand densities and trapping adults when they're flying. Once the population builds up, the only options are to sacrifice the forest until the population crashes due to weather, lack of susceptible trees, or to remove the larva-infested trees before the adults develop and fly (Figure 6).

In 1998, the Forest Service's Forest Health Management staff recommended that the Black Hills National Forest in South Dakota treat Beaver Park silviculturally to remove mountain pine beetle infested trees and thin the residual stands to prevent further buildup of the beetle population. Controversy erupted over the proposal, and no action was taken. By the summer of 2002 mountain pine beetle pockets were visible near Beaver Park, and pockets of infested trees were beginning to show up in urban interface areas. The amount of dead and dying trees caused concern about potential large-scale catastrophic fires that could sweep out of the interior of the forest and into adjacent communities.

In this instance only, the situation was resolved by a political solution. Sustaining forest health however will require broad understanding and support of science-based forest restoration treatments. Managing stand density through the application of good silvicultural prescriptions provides additional benefits of increasing available moisture within the treated stand. Reducing

Figure 5. Cheesman Watershed and Reservoir, Colorado. F.S. Photos

Clean Shoreline. Burn above reservoir shore.

Creek Bedload. Upstream bedload accumulation after a minor rain event.

Impacted Shore. Stream bedload transported into reservoir.

Figure 6. The first step in western pine beetle control — felling the infested tree. (U.S. Dept. Agr. Bur. Entmol. Plant Quar. Photo c.1935 by Patterson)

the stocking increases stand resistance to a variety of insect problems. Some examples are so dramatic, such as stand density relationship to mountain pine beetle attack, that the quickest way to resolve a mountain pine beetle outbreak is through the application of thinning treatments throughout the area of concern.

Failure to deal with interior forest pest problems has been especially visible in the western spruce-fir types. In the later 1970s, entomologists observed a buildup of spruce beetle on the Kenai Peninsula of Alaska. Recommendations to thin and treat the outbreak were ignored. Twenty years later the outbreak affected nearly every community on the Kenai, and despite a massive but belated effort to treat the problem, the spruce beetle has pretty well dictated how forest cover will appear on the Kenai for the next hundred years. This situation is not unique. The dry inland forest ecosystems of the West, with their spruce and mountain pine beetle infestations and greater susceptibility to fire, continually add beetle-killed fuel into the equation for fire potential.

Regarding treating whole landscapes and not just the urban interface, Lewis (2001) put it well when he said "There are many reasons to minimize the frequency and impact of uncharacteristically intense fires including ecological values, aesthetic conditions, business and infrastructure, human health, quality of life and efficient use of taxpayer's dollars. Home protection and landscape health should fit together in an integrated protection strategy supported by scientific advances on all fronts."

Big trees don't burn

Much of the current rhetoric against cutting big trees for forest health and fuel management purposes claims that large trees are resistant to fire.

While it's correct to say that big trees tend to be more fire resistant, it's also true that this applies primarily to the thick barked trees such as Douglas-fir, ponderosa pine, and giant sequoia. True firs and hemlock are more easily killed by ground fire because their bark is thinner. However even the more fire resistant trees are only resistant, not fire proof. Hot ground fires and crown fires kill them, especially if litter has accumulated around their trunks and root crowns. Great stand replacement fires such as the Tillamook Burn (Figure 7), the Yacoult Burn and the Idaho fires of 1910 swept though many hundreds of square miles of old growth "resistant" trees in a few days, leaving little living behind.

Art Smyth's account of the Millicoma forest (2000) tells of some 200,000 acres of even-aged old growth Douglas-fir that must have had its origin from a large fire around the year 1765. In the 100-year period from 1846 through 1945, about 2.6 million acres burned just in Oregon and the adjacent Yacoult Burn in Washington. These fires consumed immense areas of old growth forests containing large "fire-resistant" Douglas-fir.

Big trees not only burn, they also reburn. Opponents of salvage logging of the Bitterroot fires of 2000 argued that the Forest Service could not justify salvaging killed trees as there was no research proving that dead trees exacerbate intensity and behavior of subsequent fires. This position defies reason. The 1910 Idaho, the Tillamook and the Yacoult Burns all reburned with great intensity. So many tons of dead fuel per acre are still so many tons until they decompose.

Experienced observers often note the post-fire flush of easily ignited fine fuel, which carried the subsequent fire to large fuel. See Figure 8 for a vivid example of conditions of fine and heavy fuel in an old burn about to reburn in 1911. It illustrates both the remnants of large trees from a previous burn and the flush of dense smaller vegetation, following a previous fire, that will carry fire to the larger fuels. The light fuel in the picture is the factor for determining rate of spread, and the heavy fuels determine the resistance to control. In combination they present an impossible situation for the fire fighters.

Cutting Cookies

Forests are not like cookie dough that is homogeneous and can be rolled out flat to produce identical products. Forests are com-

Figure 7. Tillamook Burn. Thirteen billion board feet of large trees burned up in this 355,000-acre fire.
Source: http://www.tillamookforest.org/the story.htm

Figure 8. U.S. Forest Service, Aug. 1911. Bordering on Mt. Hood N. F., Oregon. "Type of inflammable material in front of fire. Utterly hopeless to try to stop a fire in such material." Photo and caption by Benedict, 1911.

plex, and while it would seem that this would be well understood, we constantly see proposals that would treat all, or individual forests, similarly. Bills introduced in congress and solutions suggested by various interest groups seem to reflect this prevalent view of the forest as a homogeneous entity. The reality is that there are many forests in dynamic stages of development, on a variety of terrain, subjected to different weather influences, each with an expansive scale of values at risk.

The U.S. Forest Service (2000) list of 11 major forest cover types in the West only hints at their complexity. Each of these types has a variety of stand conditions that present unique responses to external influences. The terrain each segment occupies further complicates the picture, and intermixed among all of this complexity are the many values that are important to people. Toss all this in with weather cycles influenced by planetary and cosmic phenomena, and it becomes abundantly clear that solutions must be temporally and spatially tailored to specific conditions.

These situations and questions about the interaction of forest dynamics with insect and disease are so complex that they can only be resolved by considering site-specific conditions and how they will change over time under any given management and climatic regimes. Prescriptive direction by legislation and the courts will only lead to problems of large magnitude. The solutions call for a case-by-case honest public discourse, utilizing the best science available and execution of adaptive management practices by competent forest workers with strong understanding and experience in silviculture.

Prescribed Fire is THE Solution

Prescribed fire is an important tool. In addition to reducing forest fuel to a manageable level, it can recycle nutrients, eliminate unwanted vegetation and control pests. But prescribed fire, like any tool, has its limitations. Fire, either wild or prescribed, impacts air quality. Prescribed fire falls under the requirements of the Clean Air Act which puts limits on emissions. The Western Regional Air Partnership, covering 13 western states, produced estimates of prescribed fire emissions for 1996 and projected them to 2018 (EPA 1996). They based the projection on the area that agencies said they needed to use prescribed fire to meet their established fuel objectives. Figure 9 shows the increases in emissions anticipated for 1996 and 2018.

These projected emission increases could pose legal problems for meeting fuel reduction targets, but the PM 2.5 (particulate matter equal to or less than 2.5 microns in diameter) increase of more than 11 times the 1996 emissions is especially troublesome because the small particulates pose the greatest risk to human health.

The science behind predicting effects on human health from atmospheric emissions is still evolving, but there is considerable evidence that serious health effects are associated with exposures to ambient levels of particulates found in contemporary urban airsheds. Studies also show a two to eight percent increase in daily mortality for a 50 micron/cubic meter increase in particulates at or under 10 microns (EPA 1996). Clearly, the notion of depending on widespread use of prescribed fire, with a projected elevenfold (over a million tons annually) increase in particulates, shown in Figure 9, raises serious questions the about public health implications of prescribed fire.

Though prescribed fire plays an important part in the picture, many of our forested areas have unusually high fuel accumulations that

Figure 9. Estimated Prescribed Fire Emissions for the Years 1996 and 2018. Source: EPA 1996

	Annual Tons		
Emissions	**1996**	**2018**	**Factor***
Volatile Organic Compounds (VOC)	27317	216187	7.91
Nitrogen Oxides - (NOX)	16688	391906	23.48
Carbon Monoxide - (CO)	504815	5598679	11.09
Sulfur Dioxide - (SO2)	4572	36008	7.89
Particulates - < PM10 (MICRONS)	50057	602321	12.03
Particulates - < PM2.5 (MICRONS)	44379	510441	11.5
Ammonia - (NH3)	2489	78375	31.49

* 2018 emissions divided by 1996

Data from: Western Regional Air Partnership: <www.wrapair.org/committee/emissions>

inhibit opportunities for its use (Schmidt et al. 2002). The U.S. Forest Service (1993) points out that in long-needle pine types where high fuel loading and multistoried canopies have developed, "…chances increase that burning will exceed acceptable risk." Attempting to burn in high fuel loads, especially when intermixed with human structures, could result in unacceptable damage such as in the case of the Cerro Grande escaped fire of 2000. Prescribed burning requires fuel moisture windows, stable weather and smoke dispersing conditions to coincide. Many of these areas will need mechanical removal of fuel before introducing prescribed fire.

Logging is the Problem

There are two elements to this assertion. One is that logging caused forest health problems and the excessive fuel situation in the first place; the other is that salvage logging of fire-damaged trees is more detrimental to the site than leaving the burn to recover without human intervention.

Some influential individuals and organizations mislead the public into believing that Federal timber sales are just a matter of turning loggers loose on the forest with little or no control. This is a departure from reality. The Forest Service and Bureau of Land Management, over the last 50 years, have developed a constantly improving timber sale process with sophisticated technical analyses, professional sale preparation, competitive bidding and award, followed by strict contractual compliance control by trained sale administrators and contracting officers.

In the last 30 years, the National Environmental Policy Act has added requirements to include proper environmental considerations in timber sale activities. Also, activities for improvements the sale areas, such as planting, thinning and habitat improvement follow harvest operations. Regarding cleanup, national forest timber sales routinely provide for the collection of slash disposal funds to reduce fire hazards.

Lewis (2001) states that "Modern harvesting operations, based on scientifically sound silvicultural prescriptions, use material more efficiently and follow up rapidly with burning or mechanical reduction of residues…" The techniques vary but in all cases the work is done to bring the tons of fuel to an acceptable level and arrangement that discourage fires, once started, from generating enough energy under normal burning conditions to turn into a conflagration.

Regarding post fire, or salvage logging, the Pacific Northwest Research Station of the U.S. Forest Service, in response to many opinions about the detrimental effects of logging following fires, performed a literature search with an annotated bibliography for evidence that would support the various contentions (McIver et al. 2000). Their review covered the dry, forested intermountain West. They found numerous commentaries, some by advocates and others by scientists, but only 14 research studies that had an unlogged control site (that could compare logged with unlogged areas), and only seven of these were replicated experiments (which would allow the results to be generalized to other similar biophysical types). Replicated experiments produce the most reliable evidence. Commentary, such as the often-cited "Beschta Report" (Beschta et al. 1978), produces the least.

One replicated experiment by Chou et al. (1994), cited by McIver, found no detectable differences in sedimentation in 22 small watersheds, between logged and unlogged basins, or among treatments. Another replicated experiment by Chou (1993), cited by McIver, found that sedimentation was correlated with surface disturbance on steeper slopes. On gentler slopes, sedimentation was correlated with watershed characteristics seemingly independent of logging.

The report by McIver et al. (2000) indicates that rigorously designed and executed experiments, carried out in dry western forest types, do not support the contention that logging with best management practices has long-term detrimental effects on other forest values.

Let the Taxpayer Subsidize Forest Health

Maintaining forest health is a matter of establishing sustainable stand conditions and reducing risks. This has significant economic implications.

Fuel breaks created with prescribed fire or by mechanical removal become another capital investment. As with any capital investment, they require systematic maintenance, in this case in the form of repeated prescribed fire or mechanical treatment. Lack of periodic maintenance will result in the loss of the investment. Observation of how federal appropriations are disbursed leads us to believe that maintenance of improvements usually takes a back seat to new initiatives, so means must be found to solidify funding for maintenance.

Restoring forest health nation-wide will not be cheap. Secretaries Veneman and Norton, in their September 5, 2002 testimony to the House Committee on Resources, mentioned that 150 million acres of public forest are at risk. One can put any reasonable treatment cost per acre to these figures. The Forest Service budget for hazardous fuels treatment for fiscal years 2002, 2003, and its request for 2004 totals over $700 million. This amount is meant to treat 4.5 million acres of fuel both within and outside the urban interface, for an average estimated cost per acre of a little over $155.

Treating the 150 million high-risk acres at an average cost of $155 amounts to $23.25 billion. Even if restoration is limited only to at-risk communities, the additional unit costs for the careful planning and execution in these locations could amount to billions of dollars. This would mean big subsidies to protect communities. But fuel reduction is temporary; the forest continues to store solar energy. Periodic maintenance adds interminable annual costs. Nevertheless, many insist that trees must not be sold, even to help finance forest health and protect at-risk communities.

Rationale to both treat the fuels and help pay the costs of forest health is outlined in the study by Fiedler et al. (2001), which assessed the fire hazard in Montana's short-interval, fire-adapted ecosystems by evaluating the results and costs of different treatments. They found that a "comprehensive" treatment that both treated the fuels and established sustainable stand conditions resulted in a low hazard condition while yielding net revenue of $624 per acre. The other options, removing 50% of the basal area and thinning from below were marginally and poorly rated for reducing fire severity and had net costs of $294 and $664 per acre. Financing improvements may be feasible by using the "dividends" of forest growth while still maintaining the "capital" of a sustainable forest.

Independent Variables

Everybody Complains About the Weather but Nobody Does Anything About It
Although predictions of future climate variability are uncertain, climatic records clearly show prolonged wet or dry, cool or hot periods. Analysis of sediment deposits in lake beds suggests that severe, long lasting droughts were more frequent in the past, from about 2,300 to 800 years ago (Laird et al. 1996). This condition could return.

The severe drought period generating the "Dust Bowl' coincided roughly with the severe fire years of 1910 to 1950. Briffa et al. (1992) cite the 1930s decade as the warmest since 1600, again correlating with the big fire years of the period shown in Figure 1. Since the 1930s, however, annual precipitation around the world has increased an average of about 2.4 mm per decade, with much of the increase in North America (Dai et al. 1997). Along with an expected global rise in temperature, scientists believe we will experience swings of more extreme "wet" and "dry" events more often in the future (Dai et al. 1998).

Briffa et al. (1992), in reconstructing temperatures in Western North America by analyzing chronology of tree ring densities from 1600 to 1982 found widespread warmth in the 1790s, the 1820s, the 1850s, and, especially, in the 1930s

Currie (1981) suggests that enhanced drought conditions in the Western United States are periodic in 18.6-year intervals and generated by an atmospheric lunar-induced tidal wave influenced by irregularities in the earth's surface. His analysis indicates that the most severe drought between 1800 and 1981 started about 1931 and peaked in the 1936 (Dust Bowl) epoch. This compares to another, but milder nodal drought of 1910, the year of the big Idaho fire. Subsequently, Currie (1984) suggests that the intensity of 18.6-year periodic drought is modulated by an 11-year cyclic drought "induced" by solar events.

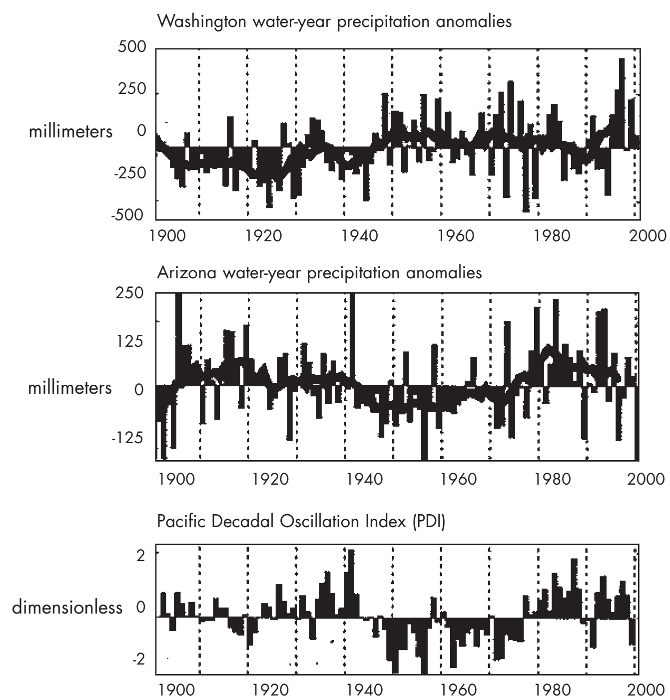


Figure 10. Precipitation anomalies for Washington (top), Arizona (middle), and the Pacific Decadal Oscillation (PDO) (bottom). Arizona typically is in-phase with PDO while Washington typically is out-of-phase.
Source: NOAA (data courtesy M.D. Dettinger)

The systematic precipitation patterns of the westernmost part of the continent are reflected by the periodicity of still another influence; the Pacific Decadal Oscillation, or PDO (Figure 10). Variation in the temperatures of surface waters in the northern part of the Pacific Ocean, the PDO influences the amount and timing of precipitation levels along the Pacific Coast. The state of Washington down to central California should expect abundant rainfall when the coastal waters are cold, and southern California and Arizona should experience drier years. The moisture pattern flip-flops when coastal waters are warm.

The weather message is ambiguous but important. Though the understanding of climatic processes is much advanced in recent years, the near future does not have much hope for accurate long-range forecasting of precipitation that would help managers develop tactical plans to prepare for and defend against fire. This is due in part to a distinct lack of in-depth research on the connection between periodicity of climate cycles and wildfire risks. Strategic planning, however, could be much enhanced by integrating what is known about periodic weather cycles and their dimensions.

Human Impacts

People love to live in the "wilderness," and for the past five decades they have moved in increasing numbers to forest and range areas across the United States. However, in many areas this migration has been to land that is prone to wildfire, and the new settler's dream home becomes part of one of America's worst fire protection problems, the urban-wildland interface zone. A mixture of flammable homes and flammable vegetation makes the interface a "design for fire disaster." When wildfires occur firefighters often have to sacrifice natural resources in order to save people and homes.

Since 1970 more than 12,000 homes and 25,000 other structures have burned in wildfires in interface areas. The cost of suppressing fires by local, state and federal fire forces exceeds $22 billion and has taken the lives of more than 100 firefighters. The insurance industry has paid over $6 billion in restitution, and damage to natural resources also runs into the billions of dollars. The fire risks and losses continue to increase as more and more people pursue their dream of living in the "wilderness."

The problem created by people moving to fire prone areas is more complex than just fire protection. It is also a forest health issue because the ability of natural resource managers to carry out scientifically sound practices is often severely limited by public safety concerns and by public outcry over activities perceived to be destroying the "wilderness." In many parts of the country these two factors have virtually stopped management activities on public and private resource lands. Many of these management proposals would have reduced wildfire hazards.

But even if resource managers were able to carry out major hazard reduction programs, interface fire risks will not decrease substantially until people living in fire prone areas accept the responsibility of self-protection. The tradition of self-sufficiency is still needed in fire areas.

To help people protect themselves and their property 20 national organizations representing fire organizations, the banking industry, insurance companies, home builders, utilities, government leaders, emergency managers and environmental scientists have joined together to develop a self help fire protection program called FIREWISE COMMUNITIES. The program uses people-friendly technology to help individuals and communities assess their fire risk and design self-help protection programs.

The FIREWISE matrix also provides suggestions for individuals and communities to link up with public and private resource managers for successful cooperative fire protection efforts.

FIREWISE evolved from a national fire initiative developed by the National Fire Protection Association, state foresters and federal land managing agencies in the mid 1980s promoting citizen participation in interface fire protection.

Forest Health, and Adding Fuel to the Fire

Managing forests is about managing change. Forests, like all ecosystems, are constantly changing. Rate, intensity and magnitude of change vary with location and time. These components of change are somewhat regulated by current conditions. Some forest types are subject to frequent fire, insect or disease attacks. These forests generally show a high degree of resiliency, or ability to recover rapidly from these events. Other types of forests experience fire, insect or disease attacks on a less frequent basis. Often in these types a change initiated by one of these elements is of such magnitude that recovery is very slow.

We must examine at this point some important specific differences in forest types because the differences will dictate the type of treatments. One type, often in the ponderosa pine and associated species, evolved with high frequency, low intensity ground fire. Another, including mixed conifers (grand fir, larch, Douglas-fir and western white pine), generally occurs in warm-moist, intermediate elevation habitats, and evolved with mixed severity fire regimes including both non-lethal, relatively frequent ground fires, and lethal, infrequent, stand replacing fires.

The western white pine type in Idaho is an example of the latter. Fins, et al. (2002) report that there are about 500,000 out of an original five million acres of white pine type left in the Inland Empire of Northern Idaho and Eastern Washington, remnants of depredations from high grading (selective logging), blister rust and bark beetles. Furthermore, they report that more disturbance-prone Douglas-fir, grand fir, and western hemlock have replaced white pine. The half-million acre remnant of the white pine type, and much of the replacement types, are at risk for destructive stand replacement fires.

Figure 11 depicts the risk classes in Idaho, with the areas with highest risks to fire, insects and disease in red (Condition Class 3). Much of the high-risk areas in northern Idaho are white pine and its replacement cover types. Areas that once had mixed severity fire regimes now have lethal, or stand-replacing fire regimes. Imminent burning of 500,000 acres, and probably more, by stand replacement fires in northern Idaho presents a sobering thought. The 1910 fires in the Bitterroot mountains, and the succession of reburns, were so intense that today there are still large areas depleted of topsoil and left unforested because of thin soils and a lack of a seed source. These kinds of fires are the most destructive, “stand terminating” type, where the forest does not recover for decades.

Most of the terrain in high risk areas on the Clearwater and Panhandle National

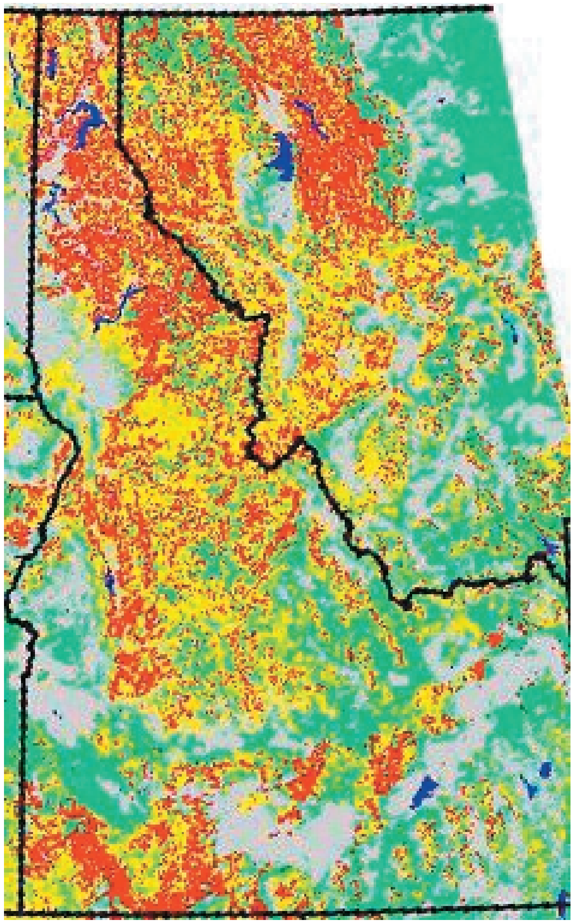


Figure 11. Current (2000) Condition Class, Idaho. Source: U.S. Forest Service

Legend

- Condition Class1: Low risk of losing one or more components that define an ecosystem.
- Condition Class 2: Moderate risk of losing one or more components that define an ecosystem.
- Condition Class 3: High risk of losing one or more components that define an ecosystem.
- Water
- Agriculture and non-vegetative areas

Forests in Idaho (as depicted in Figure 12) is steep, rugged and unstable. Careful planning and utmost skill are called for in these situations to minimize the many adverse effects probable with massive stand replacement or stand termination fires.

Often with over 100 tons per acre of standing dead and down fuel, as in the example in Figure 13, these stand conditions pose serious threats to adjacent communities and to the many inherent forest values.

Expectations of the use of prescribed fire being feasible here are surely unrealistic. Thinning, and the selection method of silviculture are infeasible also. The ground is too steep for ground-based removal systems. There aren't enough live trees to "select" and still leave a seed source. Reducing the fuels by removal of dead and down timber without destruction of the remaining stand is equally improbable. Heavy fuel loading, steep terrain and unstable soils present particular challenges to attaining forest health. The alternative to cleaning it up is the inevitable high intensity stand replacement fire that would likely spread over a large area, destroy the advanced reproduction, adversely impact valuable fish and wildlife habitat and soil and watershed values.

The forest types classified as having "mixed severity" and "stand replacement" fires, discussed above, comprise about 94 million acres (Schmidt et al. 2002). While current discussion and research seems to focus on the dry forest, we must not neglect

Figure 12. North Fork Clearwater River Drainage, Idaho. Much of this area is ready to burn, with a high dead-to-live-fuel ratio. U.S. Forest Service Photo

Figure 13. Proposed Fish Bate Salvage Timber Sale, Clearwater National Forest, Idaho. Fuel loads like this are common in North Idaho. Intense fires here will damage soil, watersheds and critical habitat for endangered species. U.S. Forest Service Photo

the types with mixed and stand replacement severity, even though some, Covington for example (September, 2002), seem to be willing to consign them to the inferno.

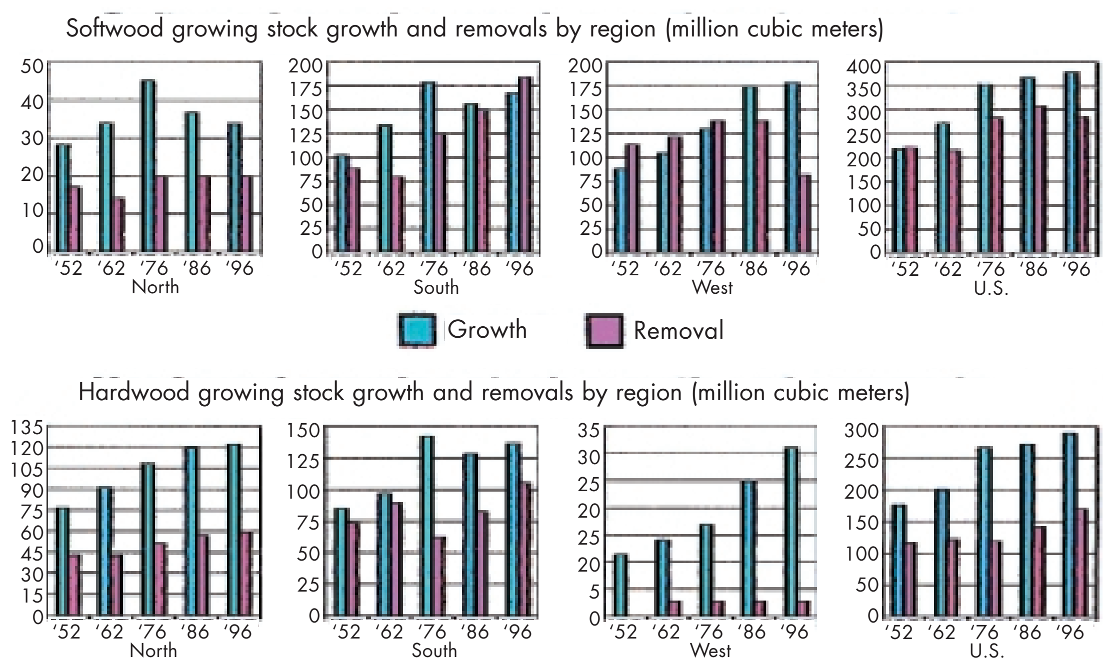
The other type mentioned above is the more than 77 million acres of high-risk, dry forest (typically ponderosa pine and its associated species) that historically experienced frequent low-severity, non lethal surface fires (Schmidt et al. 2002). This forest type, with an historical fire return of 0-35 years, is particularly vulnerable to uncharacteristic stand replacement fires due to an unusual buildup of fuels. Schmidt et al. cited above, propose a number of reasons for the buildup, including fire exclusion which resulted in several missed fire sequences, and timber harvesting. We note once more the practice of ignoring climate as a contributing factor affecting fuel conditions and fire severity. Whatever the reason, the situation calls for aggressive action to restore the type to its historical condition.

Another contribution to the buildup is the tremendous net biomass increment in the nation's forests on all ownerships (Figure 14).

Net growth in 1996 of softwood and hardwood stock in the North and West was more than double the removals, and hardwood growth in the West was about eight times removals. This tremendous increment of growing stock can be either a boon to forest health and human utility, or a liability. Much of the forest is already overcrowded with excessive fuel. Rampant net growth will increase the perils of insects, disease and catastrophic fire.

Defoliating insects can also increase fuels. Active large-scale outbreaks result in the needles being severed from the twigs, changing the character of the fine fuels. The fine fuels created by the dying needles accumulate on the forest floor in several years. Bark beetle attacks result in outright mortality of

Figure 14. Growth and Removals. Source: U.S. Forest Service, April 2002



the tree. Eventually the accumulation of dead trees standing and fallen creates an increase in the larger fuel component.

The same effect occurs with disease, though the rate of mortality and extent is often slower. More often than not, insects and disease are working together in a forest. The addition of this mortality within the forest at some scale begins to affect the rate, spread and intensity of fire.

While we have emphasized our concern about fuel, it is only one component of forest health and stand condition. Stand condition is the key to how disturbance events such as fire or pest outbreaks perform. Ignoring stand condition is tantamount to ignoring the health of the forest community.

The answer to all this complexity of conditions and values is not to be found in simplistic notions. Answers first need the right questions posed:

- What are the objectives for a particular area?
- What are the area's assets and limitations?
- What are the environmental and financial benefits and costs?
- What values are at risk, including non-market values?

Conclusions and Proposals

Perpetuating the myth of constancy and stability will result in damage to the beauty and productivity of the forest. The idealized notion of a homogeneous forest of all large trees seems to have its roots in the urban sector of society. Most people living within or in proximity to the forest, if they remain for a while, eventually seem to come to the realization that the forest has many ever-changing aspects. Attempts at forcing a forest into a static condition are bound to fail.

Restrictions on harvesting a given size or age of trees interrupt the succession necessary to maintain the basic health of the forest. Each generation of living organisms has a finite life span defined by its evolutionary history. Improved environments, proper attention to healthful living conditions and defense from attack by external agents may extend their lives. But eventually each cohort must move on to make room for its replacement. A population of trees all of a given advanced age would be analogous to a population of humans all in their declining years. Youth and vigor must be reintroduced systematically to avoid a crash of the entire population.

Our approach to action should be to recognize forest conditions as they exist today, regardless of their origin. The idea that there had been 100 years of effective fire suppression causing dramatic fuel buildup has gained such following that it has virtually become dogma. It may have been the case in the dry forests in the West. These forests are where human populations tend to concentrate, and they have missed several normal fire return sequences. They pose especially dangerous levels of risk. But over-all, the frequency of big fire years and the primitive nature of the tools and transportation system of the first 50 years of the 20th century imply the ineffectiveness of fire suppression during that period. Nor was there then a fuel reduction program adequate to take out some of the natural growth of the forest. The last 40 years or so have been relatively wet and cool and may have been a significant element encouraging fuel accumulation

We should continue aggressive initial attack on fires, especially during extreme burning conditions. That is what helps keep fires from blowing up into conflagrations and destroying communities. Aggressive initial attack includes not only suppression but also making a conscious decision ***early, by the responsible official,*** to "watch" a fire under prescribed conditions specified in an approved fire plan and conforming to the decisions in the Forest Plan.

The same wellness principles that apply to people also apply to forests: both need periodic checkups, accurate diagnosis, and skillful treatment. Fires have been large in the past, receded in size for a time, and seem to be getting larger again recently (Figure 1). That seems to be the nature of "fire dependent" forests in the West. Accepting this, we must find ways to mitigate the most pernicious effects of large fires and prioritize actions accordingly.

The realistic approach is to use sound silviculture and proven forestry methods, including naturally ignited prescribed fire, to encourage a mosaic of age classes, including openings. That will assure both sustainability of all components of the forest and at the same time discourage disastrous incursions of the destructive agents of fire and insect and disease epidemics. This monumental task needs substantial and persistent effort. Public agencies and private forest owners must have a real-time running account of timber stand conditions and fuel buildup. The activity that was once known as compartment inventory and analysis provides a framework for monitoring the health of the forest.

The silvicultural idea should be to work with nature, not try to force the forest into an uncharacteristic mode. The selection method of silviculture, or "selective logging" in today's parlance, if done correctly, provides one useful approach to managing an uneven aged forest. It is not a panacea, however. Many forests evolved with circumstances resulting in even aged characteristics. Westside Douglas-fir forests appear to have been formed by large stand-replacing fires recurring very infrequently, in some places in intervals as long as 500 years or more.

Exact replication of natural events by human manipulation is of course impossible, but science can help identify the essential biological processes to be maintained. Forest managers, armed with this information would then be able to take adaptive measures where necessary to improve forest conditions.

Account for the total losses associated with fire and other forest health situations. The wildland fires of 2002 consumed as yet-uncounted homes and other structures. Numerous communities were evacuated. The total bill will be only partially reflected in insurance claims and casualty loss figures, and they will run into many millions of dollars. A missing element in the accounting is the cost of lost natural resources. All of the components of

Figure 15. Bitterroot Burn after two years. Note the exposed rocks with the soil mantle consumed by the hard burn. Removal of excess fuel could have moderated the fire temperature and reduced soil and watershed damage. (RJP Photo)

the forest are worthy of consideration. The Forest Service estimates 209 million recreation visits to national forests each year. These visistors engage in activities such as skiing, hunting, fishing, camping and hiking. Fire can destroy valuable recreation facilities. In addition, the value added to the economy is diminished when massive fire outbreaks keep people away, as in Western Montana in 2002.

The importance of water to western society, and the hydrologic function of watersheds to deliver it, makes protecting watershed values among the most important matters concerning forest health. (Figure 15). Watersheds destroyed, valuable timber consumed, habitat lost along with its inhabitants, shortened lives of reservoirs by siltation, as well as loss of human facilities, all have value and should be in the total reckoning.

Part of the accounting should be determining the cost of management inaction to restore forests and reduce the unusual risks of fire, insect and disease. Relative risk assessments would allow an analysis of the possible long-term environmental harm due to the absence of forest health restoration treatment. Results could be compared with assessments of possible short-term adverse environmental effects of proposed forest health treatments. Such a comparison could aid decision-makers contemplating forest restoration while considering the implications to the Endangered Species Act and the Clean Water Act.

Without this kind of analysis, we are hiding the true cost, and today we have a certain sensitivity about covering up losses by questionable accounting methods.

We should ask if a "take" of threatened or endangered species would include a lack of diligent defense of individuals of the species, or their habitat, from unnecessary losses from wildfire. Along with the cost of the loss of individuals and habitat come the legal requirements of protecting them. The Endangered Species Act provides for rigorous enforcement measures against a "take" of a listed species caused by human activity adversely impacting the species and its habitat. The consequences of not acting because of short-term effects must be assessed and compared to the long-term risks of "no action." The effect of a sin of omission (failing to protect species and their habitat) may have a worse effect than the sin of commission (deliberate destruction of individuals or their habitat).

We can prepare the forests to a degree of tolerance to the unpredictable, but inevitable, drought by manipulating its fuel. It is the climate that produces the fuel, and it is the climate that takes it away. Available moisture is the most subtle change agent. It is the key both to forest growth and forest destruction and renewal. Each tree species has evolved over time with an ability to exploit a unique moisture regime. Induce conditions that change the moisture regime of the species and change begins to happen to the species. Leaves, needles, branches and whole trees die and add their stored energy to the dry fuel load.

Drought predisposes forests to an increasing number of insect and disease problems as well as reducing the moisture within the living trees to a level where ignition is easier to achieve. Variable and erratic as it is, weather nevertheless displays long-term periodic trends of hot/cold and wet/dry periods. Forest managers must be able recognize these trends and proactively adjust growing stock and dead fuel. More research about the relationship of forest health to long term climate variability is critically needed. Otherwise forest managers will continue react to the vagaries of climate.

Forest products should help pay for forest health. It matters little how and why the fuel buildup happened. What's important is that we recognize it and then be prepared to act. We can do something about fuels and forest structure to make them more resilient to climate changes. We must, however, be realistic about the quantity and type of existing fuel, the projected increases, and what that implies in the way of costs, local risks to communities and all the other inherent values of the forest. The costs, as we have seen, will be significant. Forest products not needed for critical biologic processes are available to help foot the bill. Call them "co-payments."

Managing fuels around communities, sensible restraint imposed by local officials avoiding helter-skelter development, and reasonable building and maintenance codes can go a long way in keeping the forest and its communities compatible. The American people's love affair with its forests is a happy situation, and it bodes well for the possibility of restoring forest health. The question before us is how to preclude the public from loving it to death. The self-help fire protection program called FIREWISE COMMUNITIES helps individuals and communities assess their fire risk and design self-help protection programs. FIREWISE provides suggestions for individuals and communities to link up with public and private resource managers for successful cooperative fire protection efforts. Free information about FIREWISE is available on the Internet at: www.firewise.org/communities or by contacting the National Fire Protection Association at 617-770-3000.

Concluding Thoughts

The forest is ever dynamic and ever changing. The recent widespread wildfire events dramatically demonstrate the impossibility of maintaining the forest as it is. Humans can use their knowledge of forest dynamics and act in ways to maintain the biological processes necessary for the health of the forest.

But the huge job of designing, establishing and maintaining a healthy forest may be the largest, most complex program ever undertaken by agencies managing our public forests. To make matters even more problematic, a report on agencies' capacities by the National Association of Public Administration (2001) found that "…few management and accountability mechanisms were in place to effectively implement the Fire Policy."

A report by the General Accounting Office (2002) found similar problems. Along with the scientific and technical knowledge required to design this massive program must come managerial sophistication of unprecedented capacity to implement it. Failure to perform will not be tolerated by the public.

The practice of forestry is part science and part art. Stephen Jay Gould (2002), writing about the role of art in human use of natural resources, defined the art as: "…caring, tasteful, and intelligent *modification* of nature for respectful human utility" (Gould's emphasis). With science providing the understanding of the local conditions and the limitations they impose, we can engage in serious public discussions about what cluster of values society wants in its forests. We can then have the forest managers apply the art.

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About the Authors

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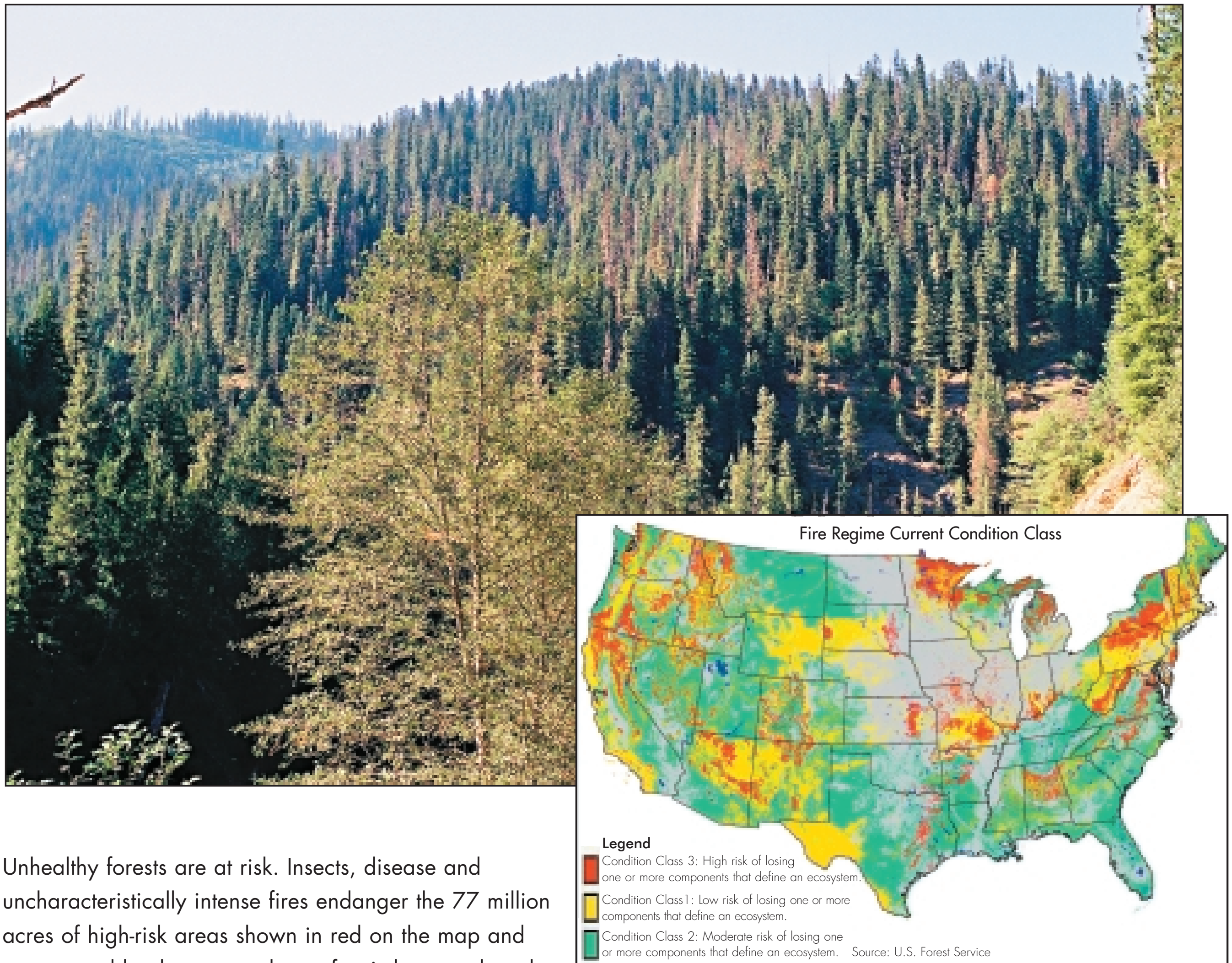

Unhealthy forests are at risk. Insects, disease and uncharacteristically intense fires endanger the 77 million acres of high-risk areas shown in red on the map and represented by the recent photo of a timber stand on the Clearwater National Forest in north Idaho. The road back to healthy forests will be long and arduous. This report offers suggestions for those establishing policy to help provide direction in harmony with reliable science and extensive forest management.

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The Association's purpose is to use its members' knowledge and experience in forestry, range and other natural resource management, allied research and state and private forestry matters, to provide sound professional advice and public education relating to critical issues involving forestry and related specialties.

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