USDA
United States
Department
of Agriculture
Forest Service
Rocky Mountain
Research Station
General Technical
Report RMRS-GTR-208
April 2008

Death of an Ecosystem:

Perspectives on Western White Pine Ecosystems of North America at the End of the Twentieth Century

Alan E. Harvey, James W. Byler, Geral I. McDonald,
Leon F. Neuenschwander, Jonalea R. Tonn

Harvey, Alan E.; Byler, James W.; McDonald, Geral I.; Neuenschwander, Leon F.; Tonn, Jonalea R. 2008. **Death of an ecosystem: perspectives on western white pine ecosystems of North America at the end of the twentieth century.** Gen. Tech. Rep. RMRS-GTR-208. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 10 p.

Abstract

The effective loss of western white pine (*Pinus monticola* Dougl.) in the white pine ecosystem has far-reaching effects on the sustainability of local forests and both regional and global forestry issues. Continuing trends in management of this forest type has the potential to put western white pine, as well as the ecosystem it once dominated, at very high risk in the future. Societal issues associated with natural resource management must be resolved early in the 21st century to allow restoration of this ecosystem so that the Interior Northwest's most productive forests can be sustainable at levels near their historical potential.

Keywords: white pine blister rust, ecosystems, *Ribes*, western white pine

The Authors

Alan E. Harvey is Supervisory Plant Pathologist, retired, U.S. Department of Agriculture, Rocky Mountain Research Station, Forestry Sciences Lab, Moscow, ID.

James W. Byler is Group Leader, retired, U.S. Department of Agriculture, Forest Service, Northern Region, Forest Pest Management Field Office, Coeur d'Alene, ID.

Geral I. McDonald is Principal Plant Pathologist, emeritus, with the U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Lab, Moscow, ID.

Leon F. Neuenschwander is Professor, retired, of Forest Resources, University of Idaho, Moscow, ID.

Jonalea R. Tonn is Forester with the U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Sciences Lab, Moscow, ID.

Acknowledgments

The authors are grateful for comments contributed by Dr. Dennis Ferguson, Dr. Russell Graham, Dr. Raymond Hoff, and Dr. Ned Klopfenstein. Thanks go to John Hanna for assisting with formatting the photographs. Funding for this work was provided by the USDA Forest Service, Rocky Mountain Research Station, Forest and Woodland Ecosystem Program, Moscow, ID. Use of trade names does not constitute endorsement by the USDA Forest Service.

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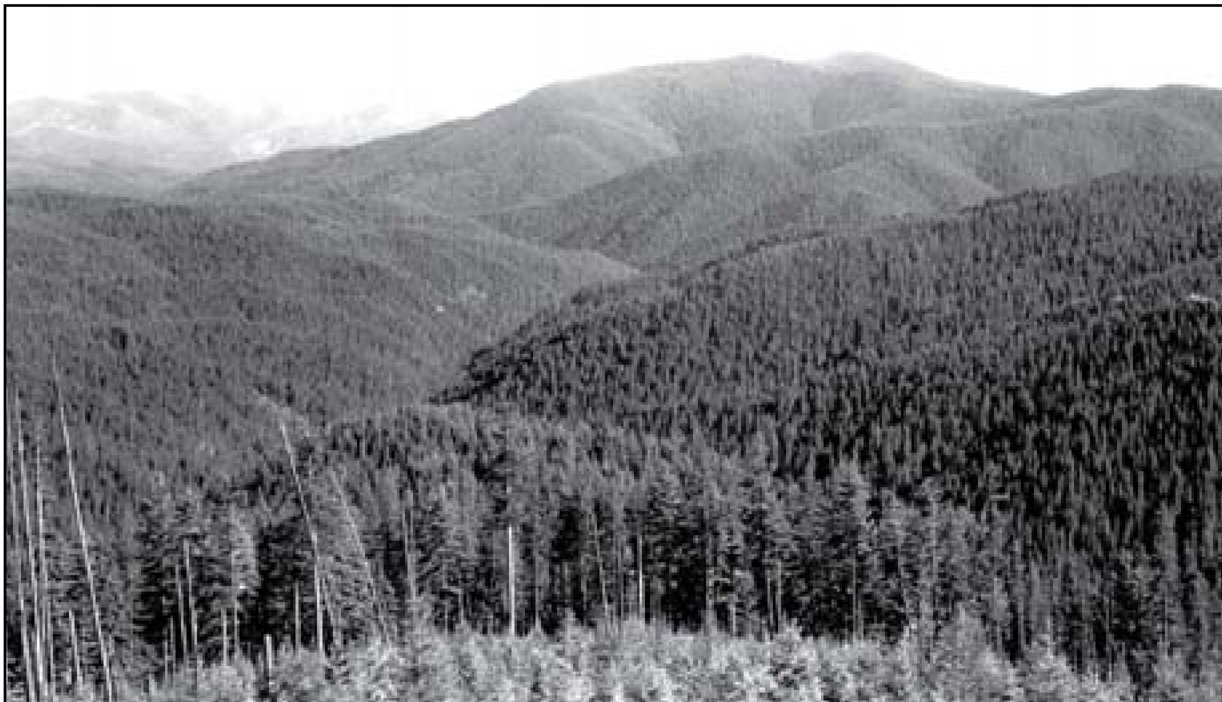

Figure 1—Continuous forest cover of nearly pure western white pine in northern Idaho, 1938 (USFS file photo).

Introduction

Early in the century, western white pine (WWP) was a dominant, highly valuable, and easily cultured species that spawned forest industries in the West and represented a primary economic strength for the region (Neuenschwander and others 1999) (fig. 1). It was the key to imparting many extremely important characteristics to Interior Northwest forests (Harvey and others 1995; Monnig and Byler 1992). Most important was its ability to form a stable, relatively long-lived, mixed species forest that was perpetuated by a combination of mixed-severity and stand-replacing wildfires (Zack and Morgan 1994). Even though fire often occurred in this forest type (25 to 30 yrs for mixed-severity and 150 to 200 yrs for stand-replacing fires), old-growth structures often persisted for several centuries. Although WWP remains potentially the most economically and certainly the most ecologically valuable species in much of the region, white pine blister rust (WPBR) has reduced it to a relic. Consequently, WWP is now largely represented as widely scattered trees with limited natural regeneration potential in areas it formerly dominated (Atkins and others 1999; Harvey and others 1995; Monnig and Byler 1992).

Western white pine will be difficult to re-establish without strong political will. In the absence of aggressive culture, it will shortly be lost as a significant ecosystem component throughout much of its range (Neuenschwander and others 1999). In its absence, forest ecosystems of the region will be much less productive. These ecosystems may only be sustainable as low productivity, unstable, and insect-pathogen-fire-prone forests of relatively low value for all amenities, including watershed protection and carbon sequestration (Atkins and others 1999; Harvey and others 1995; Monnig and Byler 1992).

Western White Pine: the Species

Western white pine is the key to a uniquely valuable, productive, and stable forest type that was once prominent in the Interior Northwest (fig. 2). In northern Idaho and contiguous portions of Washington, Montana, and British Columbia, the species often dominated most of the highly productive sites. It always functions as a seral component. It is a tall, straight tree that self prunes well with relatively open, low-density foliage (Graham 1990). When less than mature, it is highly tolerant of most endemic insects and pathogens, especially when compared with late seral and climax species that are its most common associates (Harvey and others 1995).

Where WWP has adequate light, it is a good seed producer (fig. 3). The cones are large, up to 33 cm (13 inches) long, and well filled with seed. The large seed germinates well in the spring. Germination and early growth are especially aggressive on burned surfaces. The seed is unique to the region in that portions can remain viable in the soil more than 1 year. Seedlings survive best with substantial sunlight, are deep rooted, and survive drought moderately well when compared to most of their common associates. As a mature tree, it is only moderately shade tolerant and does not produce seed well when not achieving at least a co-dominant position (Haig and others 1941; Miller and others 1927).

The species is effectively perpetuated only through stand-opening disturbances. Historically, this occurred through fire or insect and pathogen activities, mostly the latter, as they affected competing species. More recently, harvesting and subsequent management disturbances have been effective at propagating the species (Graham 1990; Neuenschwander and others 1999).

Western white pine was, and still can be, the most valuable commercial species in the region. It provides a light, strong, and straight-grained wood product that holds paint well, does not easily split, and is particularly amenable to production of high-value sash, paneling, and molding, as well as products such as matches and tooth picks. In the early part of the century (prior to the actions of WPBR), it was highly amenable to management, responding well to clear-cuts, seed-tree cuts, open shelterwood cuts, or similar systems popular at the time (Haig and others 1941; Miller and others 1927). It tends to be most prevalent on easily accessible, gentle slopes and on productive soils. For these reasons,

Figure 2—Interior of an old-growth western white pine stand, 1935 (USFS file photo).

Figure 3—Western white pine was an aggressive regenerator of clearcut on burned sites, 1910 (USFS file photo).

it has received considerable commercial attention and management in the region since the late 1800s (Graham 1990; Haig and others 1941; Neuenschwander and others 1999).

Historic Dominance of Western White Pine

A century ago, WWP was a significant component of, or more often dominated, most of the productive, high-resource (moist, fertile) sites in the heart of the Inland Northwest. Before the 1860s, it made up 25 to 50 percent of over 2 million ha (approximately 5 million ac) of forest lands in the region. It varied in composition from 15 to 80 percent of the stands, sometimes even more, especially in northern Idaho. Where the composition of WWP was more than 15 percent of total basal area or 15 percent of total stems in regenerating forests, it was considered to be "white pine type" because of the economic importance and high interest in managing the species throughout the region (Miller and others 1927).

Nature of Western White Pine Dominated Ecosystems

Over the long term, WWP grows well compared to most associated species, especially in northern Idaho.

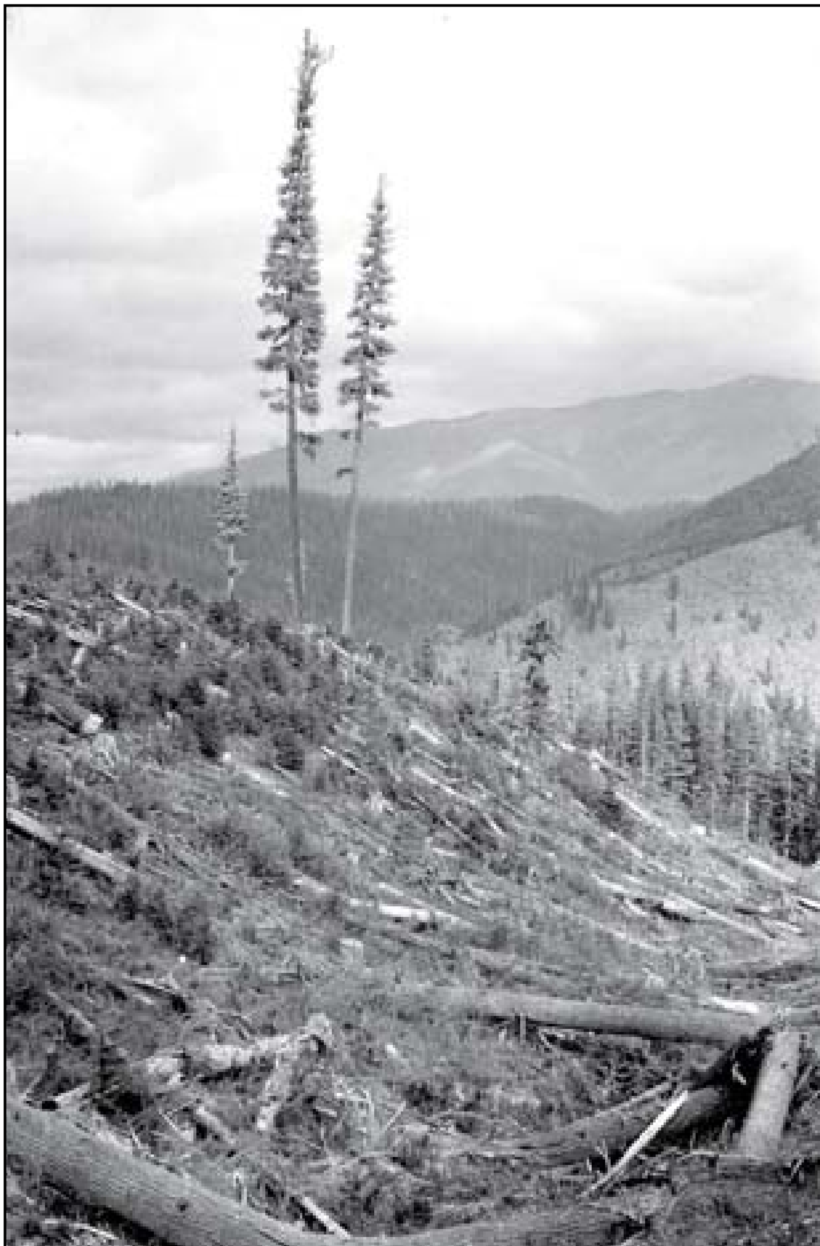

Figure 4—Western white pine is tall, with a well dispersed, narrow canopy that self prunes well (USFS file photo).

Its growth rate in the heart of its range is challenged only by western larch (*Larix occidentalis* Nutt.), but in a limited portion of that range. The tree is tall, often reaching over 60 m (200 ft) (fig. 4). It can easily grow over 1 m (39 inches) in a year. At 30 years, it can be 38 cm (l5 inches) in diameter and 20 m (65 ft) tall. At 300 years, it can be 152 cm (60 inches) in diameter, 60 m (200 ft) tall, and still be gaining height. It often produces 48 m^3/ha (50,000 bd ft/ac) in 100 years. Some old-growth stands produce over 95 m^3/ha (100,000 bd ft/ac) (Miller and others 1927).

In mature stands, not only is WWP tall, but it is also deep rooted (Minore 1979). Thus, its physical architecture is such that it spreads its resources from deep in the soil to high in the air. Both are desirable characteristics for a species that is regenerated primarily by fire and competes best on highly variable, high-resource sites. Additionally, its genetic architecture allows it to be highly tolerant of site and environmental variation, both typical throughout its range (Rehfeldt 1994).

One of the most striking characteristics of WWP is its capability to thrive in a wide variety of sites and environments. Throughout its range in the West, it has been previously divided into only two seed zones. Other seral species of the region (western larch and ponderosa pine [*Pinus ponderosa* Douglas ex Lawson and C. Lawson]) have moderately wide seed zones, but even they are nowhere near as ecologically "flexible" as WWP. In contrast, most late seral and climax species are not as flexible with respect to "home" habitat (Rehfeldt 1994).

Native insects and pathogens are powerful background forces in WWP-dominated ecosystems. They tend to remove the late seral and climax species, such as Douglas-fir (*Pseudotsuga menziesii* [Mirb] Franco), grand fir (*Abies grandis* Dougl. ex. D. Don.), and western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), from stands as they age. That process perpetuates WWP dominance, even at advanced ages, where other species might otherwise have an advantage (Harvey and others 1995). This creates a situation where the combination of disturbance-related initiation (primarily fire) and continuous pressure on other species by endemic biological forces generated a seral forest that was the most stable and productive forest type in the region. In the absence of a significant component of WWP or other seral species, current forests break up early and exhibit generally low productivity as a result of their incapacity to tolerate site/climate variation and susceptibility to endemic biological agents (Harvey and others 1995; Monnig and Byler 1992).

A strong tendency to be tolerant of endemic insects and pathogens is a characteristic generally typical of seral species in white pine country. This is particularly true of WWP. The species is usually quite tolerant of the myriad of foliar insects and root-rotting pathogens typical of the region. It is relatively susceptible to Armillaria root disease only when young (less than 25 years) and to mountain pine beetle largely at advanced ages (over 140 years). Historically, mountain pine beetle was the primary agent responsible for breakup of over-mature (200 to 250 years old) WWP stands (Miller and others 1927).

In a very real sense, WWP appears optimally equipped to deal with a native range that is highly diverse with respect to site, soil, and climate and was continuously disturbed by fire, wind, and endemic biological agents. It was positioned to dominate high resource forests in the Interior Northwest and did so, even in the face of aggressive harvesting, until the introduction of WPBR and imposition of strict fire controls early in this century (Arno 1980; Maloy 1997; Neuenschwander and others 1999).

Introduction of White Pine Blister Rust

In the early 1900s, forest pathologists were highly aware of the WPBR threat to both eastern and western white pine (Spaulding 1911). Despite a dedicated attempt to keep it out of North America, WPBR was found on cultivated currants (alternate hosts in the genus *Ribes*) in eastern North America by 1906 and in western North America in 1921 (Mielke 1943). Unfortunately, by the time it was discovered in the West in the vicinity of Vancouver, British Columbia, it had already been in the area for 10 years. At the time of its discovery in the West, WPBR had already spread into domestic and wild populations of currants (*Ribes* spp.), several exotic white pines in the area, and native WWP (fig. 5). Despite sometimes heroic efforts to stop or eradicate WPBR on the domestic and wild currants that carried it, it rapidly spread southward and eastward to prime western white pine and sugar pine (*P. lambertiana* Dougl.) country (Mielke 1943). It reached Oregon and Idaho in the 1920s, Glacier Park by 1939, and the southern Sierras by 1961 (Maloy 1997). In the 1990s, it continued to move into the Southwest on high-altitude, five-needled pines, especially whitebark

Figure 5—White pine blister rust seedling infection showing aeciospore production (photo by Geral I. McDonald, USFS).

Figure 6—Lethal white pine blister rust stem canker (photo by John W. Hanna, USFS).

pine (*P. albicaulis* Engelm.), limber pine (*P. flexilis* James), and southwestern white pine (*P. strobiformis* Engelm.). Bristlecone (*P. aristata* Engelm.) and foxtail pines (*P. balfouriana* Grev. & Balf.) are also vulnerable (McDonald and Hoff 2000). It will likely place these resources at highly increased risk early in the 21st century.

Contrary to results achieved in eastern North America, control efforts centered on eliminating the wild currant hosts in the West, but they were not sufficiently effective to stop the rust and the effort was abandoned in 1968. Similarly, despite some early encouragement, treatment with the systemic antibiotics Actidione® and Phytoactin® (registered trademark products of UpJohn Corp. for cycloheximide derivatives and Pabst Brewing Co. for polyamidohygrostreptin, respectively) were also found to be ineffective and were abandoned (Ketcham and others 1968; Maloy 1997). Potential alternatives for the latter approach are available but have not been widely used (Bérubé 1996; Harvey and Grasham 1979) (fig. 6).

Fortunately, early observation of resistance to WPBR in the native populations of WWP in the Interior Northwest proved correct. Beginning in the 1950s, a systematic search for heritable resistance was undertaken and was successful. WPBR-resistant seed stocks derived from materials discovered in this effort became available in significant quantities in the 1980s (Bingham 1983). These materials, and others discovered since, have become the linchpins of efforts to combat this destructive exotic disease (DeWald and Mahalovich 1997; Hagle and others 1989; McDonald and others 1991).

Current Status of Western White Pine

In effect, the introduction of WPBR completely changed the function of one of the most productive, stable, and tolerant (in terms of both management and natural disturbances) ecosystems in North America, if not the world. As a result, the ecosystem has changed to one dominated by other species. Current forests have quite different characteristics than those they replaced (fig. 7).

In terms of population size throughout its range (in the Interior Northwest), WWP is now estimated to be less than 5 percent of what it was at the turn of the 20th century (Neuenschwander and others 1999). Where risk of WPBR is extremely high, the current

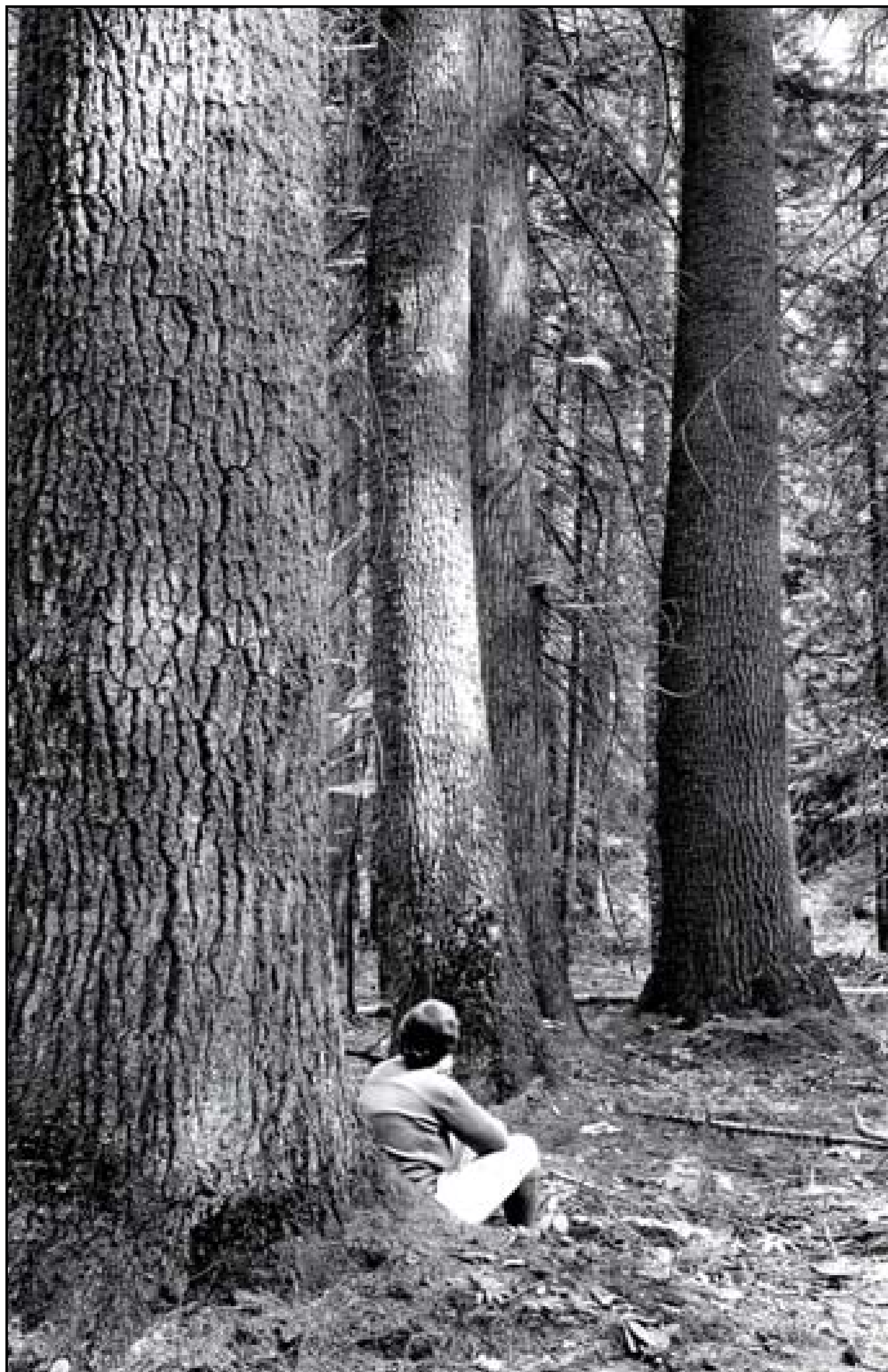

Figure 7—Old-growth western white pine stands had notably sparse understories with little fine fuel (USFS file photo).

population may be as little as 1 percent of what it once was (Hann and others 1997). Where risk of WPBR infection is low, the population may be as high as 10 percent of that earlier in the 20th century.

Despite high growth potential, formerly WWP-dominated forests are now one of the lowest storage compartments for fixed carbon in the northern Rocky Mountains (Birdsey 1992). Further, the first generation of resistant stock is performing to expectations only on low-risk sites. On high-risk sites, even resistant early stock types are suffering high mortality, though strikingly less than that of native stock types (McDonald and Dekker-Robertson 1998). Newer materials should fare better on high-risk sites (DeWald and Mahalovich 1997).

Comparative Nature of Replacement Forests

With the possible exception of western redcedar-dominated (*Thuja plicata* Donn) stands on especially moist sites, productivity, value, and stability of WWP-dominated ecosystems exceeds that of other species combinations throughout the heart of its range. As a result of frequent actions of a variety of insects and pathogens, dominance by alternative species leads to significant losses in both productivity and longevity with associated accumulations of vegetative debris (Harvey and others 2000) (fig. 8). This change, in concert with the shallow rooting and low-density crowns

Figure 8—Replacement forests now tend to have large volumes of fine "ladder" fuels (USFS file photo).

of replacement (climax) species (Minore 1979), appears to lead to a more strongly horizonated soil with larger accumulations of litter on the surface than characteristic of forests dominated by seral species (Harvey and others 2000). These situations will likely lead to rapid immobilization of nutrients, especially nitrogen, in surface horizons. Located at the surface, it is then subject to loss associated with any severe disturbance, especially fire. In the absence of disturbance, higher water tables and nutrient tie-up can quickly lead to vegetative stagnation in moist, cool forests, perhaps with in a single generation (Bormann and others 1995; Kimmens 1994).

The potential, and perhaps ultimate outcome, is a forest dominated by species with high nutrient demands where nutrient storage and cycling rates are increasingly depressed. This will likely lead to ever-increasing stress, with associated endemic insect and pathogen activities creating a domino effect that destabilizes the ecosystem (for example, excessive mortality and more frequent fire). The destabilized ecosystems exhibit inappropriate sensitivity and long-term damage from the same disturbances that once created a highly productive and stable forest ecosystem that was well adapted to both the characteristic long fire cycles and the activities of native insects and pathogens.

As WWP increasingly loses its ability to attain a codominant position, it will lose its ability to produce seed. Without substantial openings, any of the shade intolerant pine seedlings that are produced will quickly lose out to competition from large numbers (4 to16,000 ha [10 to 40,000 ac]) of shade-tolerant fir and hemlock (Graham 1990). Therefore, even without the ravages of WPBR, low numbers of scattered WWP may not be sustainable in these forests over the long term.

Perhaps most important in this species conversion process is the resulting change in genetic strategy of the primary vegetative components. This change, from one of wide adaptability and tolerance for endemic insects and pathogens to one of narrow adaptive capacities likely predisposed to stress, renders these forests highly susceptible to destabilization by native insects and pathogens (fig. 9). In historic WWP-dominated forests, insects and pathogens probably served as a stabilizing agent, removing maladapted late seral and climax species relatively early in stand development. Most likely, this preserved only the best of the climax species and generally encouraged dominance of WWP (Harvey and others 1995). Such a radical change of endemic processes in a major ecosystem is likely to have far reaching ramifications for the productivity, stability, and management (or lack thereof) of regional forests (Atkins and others 1999; Harvey and others 1995; Monnig and Byler 1992).

Management Implications

Since we are continuing to lose ground with WWP and other five-needled pines in the Western United States, it is evident that current approaches have not been, and will not be, sufficient to reverse losses. Discussions from a series of workshops attended by regional plant pathologists and geneticists concluded that we must at least accomplish the following activities for WWP, and the ecosystems it dominated, to be restored to even a small portion of its historical range (Fins and others 2001):

Figure 9—Collapse of an old-growth western white pine stand at Deception Creek Experimental Forest in northern Idaho, 1995.

1) Create more opportunities (and improved rust-resistant materials) for artificial regeneration.

2) Create opportunities for "natural" selection, in other words, maintain as much as possible of the surviving WWP in current forests and provide openings for its regeneration in subsequent second-generation stands.

3) Develop a broader understanding of alternate host ecology and potential resistance.

4) Continue to create opportunities for expanding the genetic base for WPBR-resistant stock.

5) Develop a better understanding of the current WPBR pathogen potential for adapting to changing environments or developing new races.

6) Emphasize coordinated, aggressive management with strong Integrated Pest Management components (Hagle and others 1989).

7) In non-forested areas, more aggressive planting and the use of WWP would at least help maintain an extended genetic base for possible future use.

Doing nothing assures that recovery of the western white pine ecosystem will **not** occur for centuries, if ever.

Perspectives About the Future of Western White Pine

As previously outlined, long-term survival of WWP throughout its historical range, except as an occasional component of that landscape, may be in jeopardy.

Short-term survival of WWP is not likely in jeopardy (Graham and Jain 1999); however, a substantial portion of its genetic breadth may be.

Loss of WWP as a significant component of the landscape throughout a substantial portion of its historic range has already occurred (Atkins 1999; Harvey and others 1995; Monnig and Byler 1992; Neuenschwander and others 1999).

Loss of WWP abundantly clear. It has occurred as a result of (1) salvage logging of infected trees, (2) large trees (infected in the 1940s and 50s) gradually succumbing to a combination of the effects of WPBR and pine beetles during the 1980s, and (3) lack of opportunities for regeneration.

The largest tree on "white pine drive" in northern Idaho died and was removed as a hazard to the public in 1999. In 1975, that area was still deserving of the name. Subsequently, today, there is hardly a white pine to be seen.

Without aggressive intervention sufficient to change current trends, the outlook for this magnificent tree and, perhaps more importantly, the ecosystem it once supported, is obviously dismal. Although current efforts have had much success, they have not been widespread enough to turn the tide in this battle.

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