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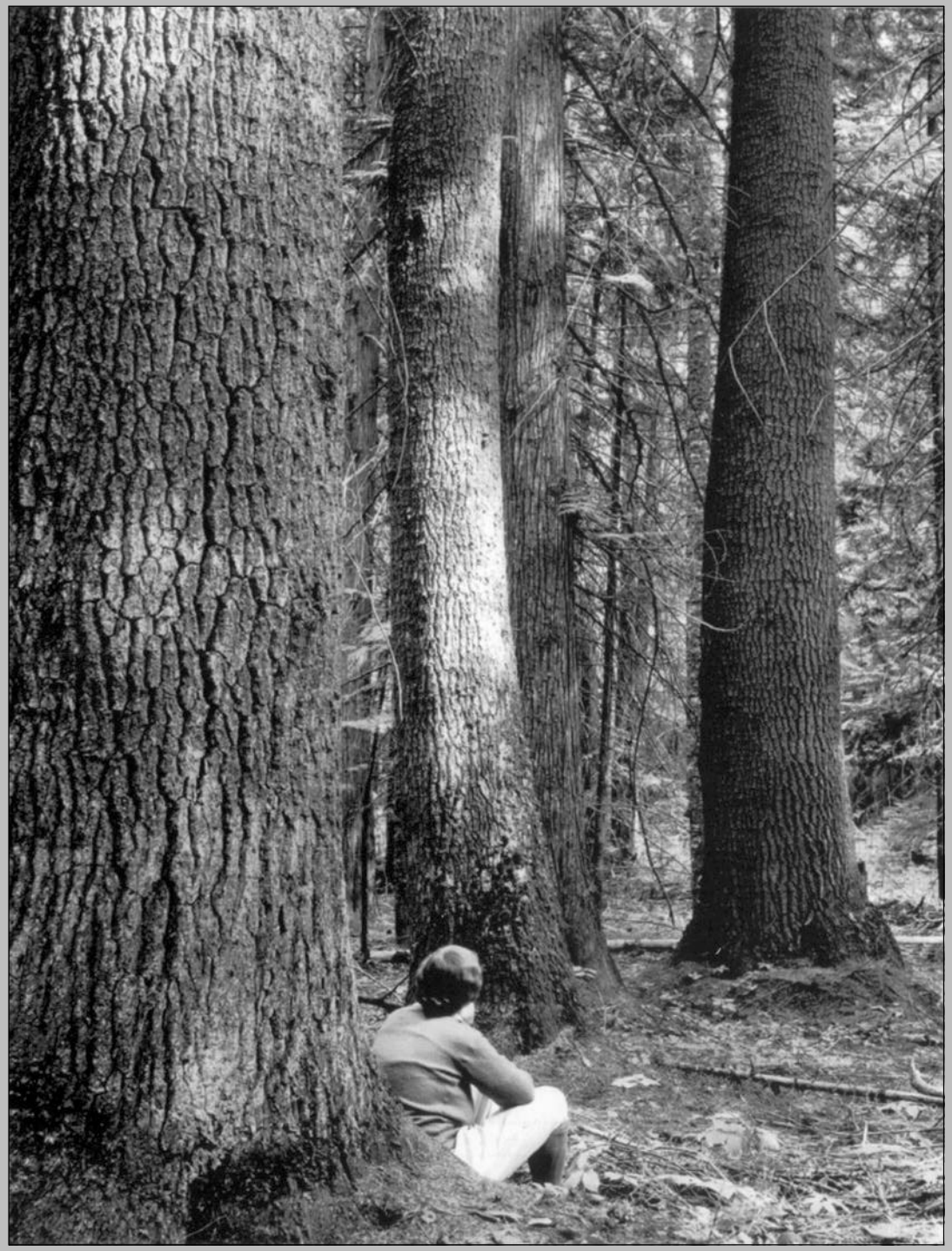

WHITE PINE

in the American West: A Vanishing Species—

Can We Save It?

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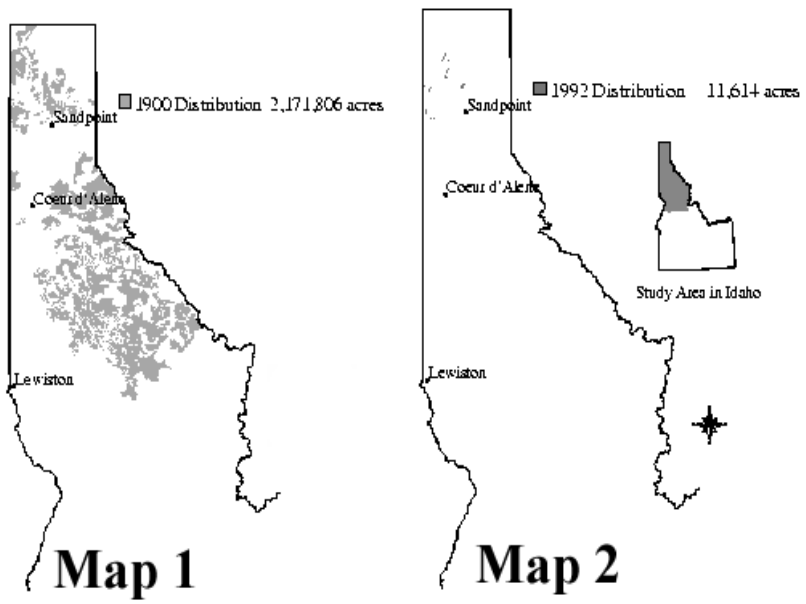
Forest scientists ask that everyone, from the home gardener to the forest manager, help revive western white pine by planting it everywhere, even in nonforest environments such as our neighborhood streets, parks, and backyards. White pine, long ago considered the "King Pine," once dominated the moist inland forests of the Northwest, eventually spawning whole industries and historical movements. Now—since the arrival of Euro-Americans and the stubborn blister rust disease—this sun-loving giant barely survives on about 5 percent of its former domain. This is the story of the decline of the magnificent western white pine.

White Pine in the American West:

A Vanishing Species—Can We Save It?



The distribution of western white pine has dramatically declined. In Idaho, for example, the historical (circa. 1900) areas covered by western white pine forests (map 1) compare markedly to those of today (map 2). Each map shows only stands with a composition greater than 15 percent western white pine with a minimal mapping unit of a square kilometer. (Data from Interior Columbia River Basin Ecosystem Assessment Project; map produced by Landscape Dynamics Lab, University of Idaho.)

Western white pine (*Pinus monticola*). For centuries white pine dominated the moist forest ecosystems of the Inland Northwest, and for decades Americans depended on these dense white pine forests. One of the region's largest species, white pine produces some of the world's most desirable wood. This species used to define the economic scene in Northwestern towns. Then its history began to parallel the human culture around it—boom, then bust. As the white pine population began to wither, it took a big chunk of history with it. White pine's decline put major timber companies out of business and spurred important shifts in forest management ideology. Now the future of western white pine is uncertain.

Not much of the former forest remains. The alliance of blister rust, beetles, and logging killed over 90 percent of white pines in less than 70 years. Lone white pines in forests crowded with smaller shade-tolerant species are often the only symbols left of the mighty woods that once dominated the Inland Northwest. And the mortality rate for these remaining trees is high.

How Did We Get Here?

The western white pine forests of the Pacific Northwest are today occupied by less stable, diverse, resilient, and productive species than they were a century ago. This is primarily because of an introduced fungus disease, and recent human activities—especially white pine logging and the suppression of natural fire. Today, most of the remaining mature white pine consist of individual, mostly dying trees scattered across forests they once dominated. A few of these mature trees survive, but the majority will eventually succumb to the rust, bark

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The western white pine is easily identified by its five needles together in what is called a "bundle." The western white pine has one of the largest cones of the Northwest—up to 11 inches long.

The western white pine prefers growing in open, sunny areas. This former cabin site at the Deception Creek Experimental Forest is ideal for newly emerging western white pine.

White Pine and Its Environment

Western white pine (*Pinus monticola*) was once the dominant forest type at elevations of 3,000 to 6,000 feet in areas receiving more than 30 inches of precipitation a year. It grows on the slopes of the Cascade and Sierra Mountains, and the interior section of the Northern Rocky Mountains. It is most abundant in the moist forests of northern Idaho, eastern Washington, western Montana, and southern British Columbia, together known as the Inland Empire or Inland Northwest.

The needles of this bluish-green tree with a whitish tinge occur in bundles of five, each 2 to 4 inches long. A whitish stem near the top distinguishes mature trees, with otherwise thin gray furrowed bark broken into small rectangular blocks curled at the edges. This distinctive color and bark pattern is not found in any other species associated with white pine (Douglas-fir, grand fir, western hemlock, and western redcedar). Young trees have a smooth gray bark or no bark at all.

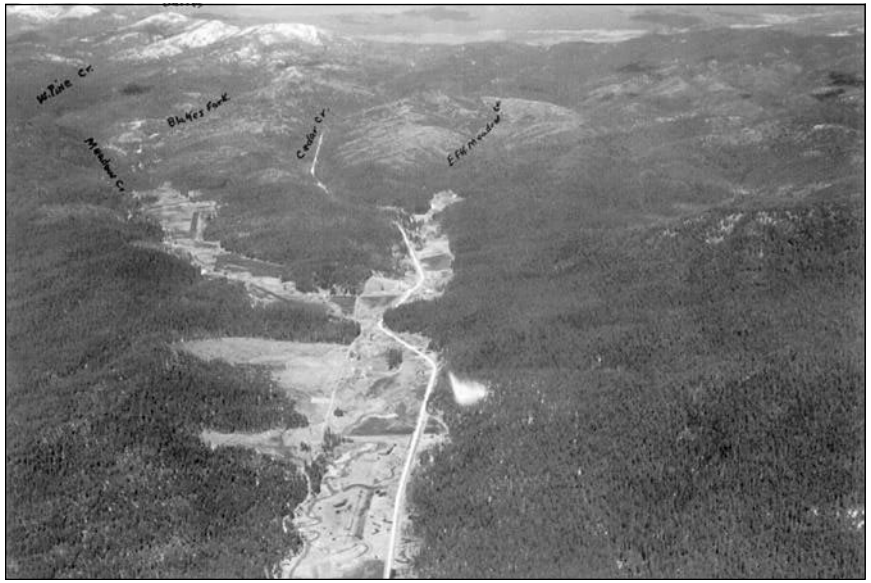
The tree is tall, reaching 150 feet or more—about the height of a 15-story building—and grows fast at 2 to 4 feet per year. A 30 year old may be 15 inches in diameter and 65 feet tall; a 300 year old might be 60 inches thick and still reaching for the sky at 200 feet.

The cones are the largest among pines in the Northern Rocky Mountains. Packed with seed, mature cones are about 2 inches wide and a full 13 inches long. After 2 years of ripening, cones drop seed in the fall, starting mid-September, to germinate in May or June the next year. High density, mature white pine forests produce more than a million seeds per acre.

Often growing alongside seven or more other tree species, western white pine regenerates well after wildfire, logging, or land clearing. Fire is so good for the species that 50 years after a fire its forests are dense again with thousands of trees per acre. Then the forest thins itself to about a third or half that number by age 100. Yields for a 100 year old white pine forest have been recorded at over 50,000 board feet (b.f.) per acre—enough to build five medium-sized houses. Old groves sometimes exceeded 100,000 b.f. per acre. In the same forests without white pine, yields often dip to less than half.

Seedlings do not do well in shady moist forest, hence their need for wildfires that clear the forest to allow full sunlight on the young trees. Without openings created by wildfire, even mature white pine eventually succumb to insects, fungi, or old age and are replaced by shade-tolerant species—grand fir, western hemlock, and western redcedar. As these competing species grow and the white pine die, the forest is gradually changed.

Because white pine seedlings tolerate frost, you often find them in the lower portion of the subalpine fir zone (*Abies lasiocarpus*), and frequently along cold air drainages, river bottoms, and mountain meadows.



This Washington Air National Guard photograph shows the landscape perspective of western white pine along Idaho Route 6, White Pine Scenic Drive. The year is 1935.

After 60 years, a ride on White Pine Scenic Drive shows that the texture of the once-dominant white pine forests has changed to that of the smaller, shade-tolerant trees of today.

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beetles, or both. The prognosis for **nonresistant** younger white pine is gloomy. The majority of these young trees will die before they have the opportunity to reproduce. The remainder consist of plantations that came out of a blister rust-resistance breeding program, and the prognosis for these blister rust-resistant plantations is hopeful. But a lot more work is necessary. Without action now, the reign of this popular United States native could end forever.

White Pine Country

Let's look at a brief history of the king of pines. Early explorers and settlers described with awe the Rocky Mountain-Inland Northwest landscape as dominated by a dense green forest of unusually large trees. Trees on the best sites were 150 to 200 feet tall and so dense that little light penetrated to the forest floor. There were about a dozen tree species, but the most prominent was the towering, long-lived western white pine, one of the largest trees in the woods.

The interior of the Western United States is generally desert-like or prairie-like with dry juniper or ponderosa pine forests. But the powerful jet stream winds in the Northwest carry moist marine air off the Pacific Ocean and over the Cascade Mountains to create a region unlike the rest of the Interior United States. The Northern Rocky Mountains of the Inland Northwest (northern Idaho, adjacent parts of western Montana, northeastern Washington, and British Columbia) make up the wettest area in the Interior West. The ecosystems of this interior wet belt support the largest, most productive, and most diverse forests in the western interior—the home of "King Pine."

Western white pine dominated many ancient moist inland forests before the 1860's, comprising 25 to 50 percent of the moist forest area and 15 to 80 percent of the forest's entire composition. Where the composition was more than 15 percent white pine, foresters considered the forest the western white pine type because of the economic importance of the species.

Timber surveys by the University of Idaho and the USDA Forest Service in Idaho (Miller and others 1927) indicate that normal timber yields for a 100 year old white pine forest could be over 50,000 board feet (b.f.) per acre. Old groves of white pine sometimes exceeded 100,000 b.f. per acre—enough wood to build 10 medium-sized houses. Western white pine stood with a variety of other conifers including western larch (*Larix occidentalis*), Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*). White Pine occupied a significant portion of the Inland Northwest and parts of the

Pacific Northwest and California's Sierra Nevada Mountains.

Historic Dominance of White Pine

Why was white pine historically the dominant tree in moist Northern Rocky Mountain forests? We know that white pine does not thrive in a shady forest. We also know that forest fires were common and extensive, often burning more than 10,000 acres in a single wildfire. High intensity forest fires tended to revisit a forest location about once every 200 years. Some areas burned more often and some took longer to burn. Western white pine owes its existence to these large wildfires of past centuries. Commonly living from 250 to 400 years or more, white pine was well adapted to regenerate and dominate after forest fire. So it is no surprise that when early settlers gazed across the landscape, they saw a forest dominated by white pine, a lush calico of different forest ages created by past wildfires.

By the 1930's things were changing for both the white pines and their admirers. The same settlers and their descendants who had delighted in the white pine dynasty brought with them the very instruments of its eventual decline: logging, a foreign disease, and wildfire suppression to protect people and property. Currently the regeneration long-lived pines and larches through natural fire is also limited. The most recent fire episode began in 1910 and ended in 1934. Since then, wildfires have been successfully suppressed with only two large fires in the Inland Northwest since that time.

Cultural and Management History of White Pine Country

Another major liability for the trees is their value to humans. Because of the high economic value of the species and its performance in building, staining, and painting, the demand for white pine logs continues even today. Starting in 1880, the far-reaching western white pine forests became the principal target for logging. The Inland Northwest's first timber mill was built in 1880, and the second followed in 1882. Logging removed massive white pine groves for more than 100 years. After the 1910 fire episodes and the onset of logging, the young trees then fell victim to yet another challenge: white pine blister rust, an Asian fungus introduced to western North America in 1921 by way of Europe.

The white pine species' ability to regenerate in diverse environments and following fire only made it more susceptible to blister rust when it arrived. Blister rust has intermediate hosts—the currant and gooseberry shrubs (*Ribes*) that share the forest floor with white pine and that, like white pine, also regenerate after fire and logging. The blister-rust-infected shrubs in burned areas killed most western white pine before they could produce seed.

White pine blister rust needs the Ribes plant to survive. The Civilian Conservation Corps of the 1930's employed thousands of men to eradicate this troublesome host in the western white pine forest. The CCC's methods included hand-pulling, spraying, and using a bulldozer.

In the 1930's, President Roosevelt's Civilian Conservation Corps (CCC) workers marched into Inland Northwest forests with the mission of finding and killing *Ribes* shrubs, an effort that largely failed. In the end, blister rust eliminated most of the white pine from logged and burned areas in the Inland Northwest.

Then from 1929 to the mid-1950's, a lesser assault, this time from white pine pole blight that killed trees 6 to 10 inches in diameter, further reducing the population. Pole blight is a tree disease that attacks pole-sized pines on drought-prone soils, reducing their growth and foliage, and scarring their trunks with lesions.

By the late 1950's, Inland Northwest National Forests accelerated timber harvests to meet timber demand resulting from the post-World War II housing boom. At the same time, despite *Ribes* control efforts, blister rust mortality accelerated in mature white pine. By the late 1960's it became obvious that the war against *Ribes* was lost. In 1968 the Forest Service officially abandoned both its *Ribes* control efforts and its antibiotic treatments of white pine. The 1968 Forest Service policy

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Riverpigs Got the Logs Out

Early white pine loggers called themselves "riverpigs."

For the perfect dream of a riverpig
Is a river smooth and flat,
Where a log will ride like a ship at tide,
And a man can float his hat.
And they love their work as a sailor his,
And they come back year by year
To answer the call where the big jams haul,
As the spring flats lure the deer.

For it is a work they love and know
That none can do so well
As a riverpig, with his snoose and swig
And a hearty scorn for hell.

Paul Croy, "The Riverpig"

Excerpt from *Idaho's Poetry, A Centennial Anthology*, R. E. McFarland, W. Studebaker, eds.
University of Idaho Press, 1988

White pine logs at a railroad siding await transport to an Idaho mill.
Photo courtesy of Potlatch Corporation.

The glory days of white pine harvest were the days of big timber, big men, and big money. Towering stands of virgin white pine literally enveloped the Coeur d'Alene, St. Joe, and Clearwater River valleys and moist slopes of the Inland Northwest before 1900, stands that produced a versatile wood good for match sticks, fruit boxes, door and window parts, trim and molding, and fine finish lumber.

By the early 1900's, the major Eastern railroads, financed by grants from timberlands along the route, finally reached the West Coast, in the process touching the lakes and river margins of the untapped "White Pine King." Late 1890's loggers and small-time lumbermen had eaten away at the margins of these white pine forests for the better part of a decade. Farther east the Great Lakes lumbermen, encountering the end of white pine in Minnesota, Wisconsin, and Michigan, were eager to move on. The time was right, the pine were big and ripe, and railroads provided easy routes to Western, Midwestern, and Eastern markets. All that was needed was big money to build the mills and the transportation system to "get the logs out."

One late night in 1899 in a fashionable St. Paul, Minnesota, neighborhood, Frederick Weyerhauser purchased 900,000 acres of West Coast Pacific Northwest timberlands from Northern Pacific Railroad magnate James J. Hill for $6 per acre. Then, between 1899 and 1908, Weyerhauser and his Midwestern lumber associates, sometimes known as the "Weyerhauser Syndicate," put their money into seven Idaho ventures, five of them in the white pine region. The first big blocks were railroad lands, willingly sold to lumber companies in a race against other lumbermen, sometimes in the dead of night. The spoils often went to the fastest horse and to timber cruisers and land agents with somewhat questionable ethics. Nevertheless, a new timber empire was born. All that remained was to get the logs out, a challenge for the strong, fleet-of-foot "riverpigs."

The ground they worked was steep, sometimes rocky, and winter stayed on the mountains for 5 to 6 months. When the warm spring rains came, riverpigs, dancing from log to log with sharpened, steel-caulked boots, herded, pried, and poled millions of board feet of logs down flumes, chutes, and racing rivers to log booms waiting on

sheltered lakes. Other logs went directly to mill by logging railroad on the hundreds of miles of rail lines that crisscrossed the forests.

The colorful days of logging were from 1900 to 1925 when men and animals—first oxen and then horses—literally wrestled logs from steep hillsides, often using more wood for transporting logs than they got to the mill. They might also build bridges to reach creek-bottom pines using enough wood to construct a medium-sized house…or 2,500 to 4,000 rail ties per mile. Massive white pines and other valuable species such as ponderosa pine, Douglas-fir, larch, and redcedar were cut with two-man crosscut saws, limbed with an ax, and bucked to log lengths. Horse teams pulled the logs directly to the river bank, to the waiting railroad car, or along greased wooden log chutes that led to river flumes or to railcars.

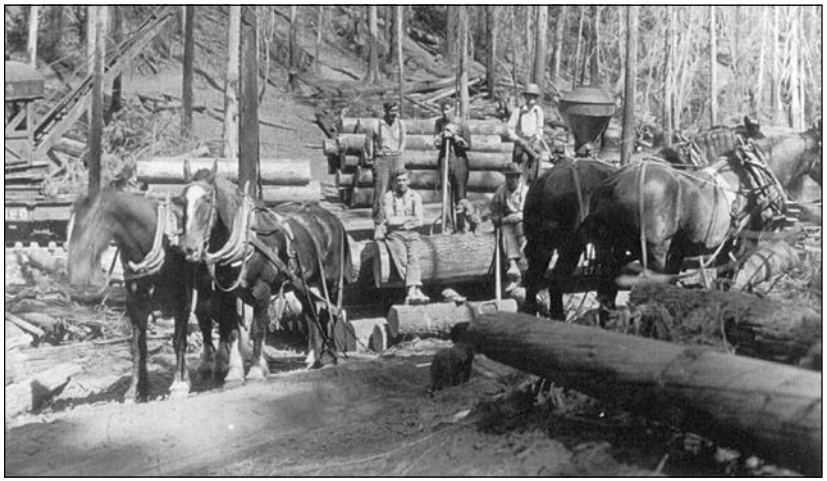
In some areas logs were skidded to the mountain stream where a series of splash dams had been constructed to hold water and logs. Periodically these dams were flushed down the stream in a savage flood of water and logs, mud, rocks, and fish and frogs, all headed in the direction of the sawmill. Occasionally a logger or riverpig would slip and fall into the rush, only to be caught and lost in the flood. The last Idaho log drive was on the Clearwater River in 1962.

The stream environment suffered greatly from erosion of banks and streambeds as most of the stream's vegetation had been removed so logs would not hang up. Men lived in camps, sometimes far back in the woods. Though the pay was good, the work was demanding and extremely dangerous. After an extended stay in a logging camp, hard drinking, hard fighting loggers would typically "blow into town" to be accommodated by brothels and taverns.

With the introduction of crawler dozers and heavy logging trucks in the early 1930's, the glory days of logging ended, leaving behind hundreds of miles of dry chutes, water flumes, logging railroads, and their supporting cabins and camps. Also left behind were a legacy of scoured stream channels, entrenched skid trails, and deforested mountains. Forest historians have gone to great lengths to search the recovering forest to locate and document the old camps, railroads, steam donkeys, and other remnants of this era of big timber, big men, and big money. Much white pine remained on the upper slopes, far back in the hills, and on the tougher ground, but modern logging methods and extensive road construction eventually reached those trees too. Today's loggers are more likely to live in their camper trailers during the week and spend the weekend back in the local towns with their children and wives—or their husbands, as today's logger workforce has also changed with the times.

In 1890, the forests of the Inland Northwest seemed endless and inexhaustible, sometimes even a barrier to settlement and development. Then World War II saw an end to the timber exploitation phase and a recognition that other values such as wildlife, water quality, and scenic attributes of forests were also important. People had more leisure time and the automobile and interstate highway system allowed easy access to the forest. The multiple use of forests escalated along with an increasing demand for wood and paper products. Tree farming cropped up, and the philosophy that trees and other resources should be managed for the maximum good ushered in the practice of reforestation after harvest. "Forestry gardens" created by clearcutting and then replanting offered an environment friendly to western white pine regeneration, but the king of pines had other survival worries (see Blister Rust and Mountain Pine Beetle sidebars).

The current view is that forests are places where the human, biological, and physical dimensions of natural resource management are blended together. Sustainable forests involve more than just growing wood and getting the logs out. "Ecosystem management" is the new way of thinking, with the goal of sustaining all the resources in the forest.



Western White Pine was prized for its beautiful and abundant wood. Following a forest fire in the 1920's, western white pine loggers salvaged by horse and steam donkey to get the wood to the mill. (Photo courtesy of Potlatch Corporation.)

Blister Rust—An Alien Disease Becomes a Mortal Enemy

In 1910, a timberland owner in Vancouver, British Columbia, determined that western white pine planting stock could be more cheaply produced in France than on Vancouver Island. He shipped seed to France and in return received infected seedlings, which he outplanted. Upon taking root, the seedlings produced spores that then infected the nearby currant and gooseberry shrubs—the perfect alternate host for a disease-causing fungus, and shrubs usually growing in western white pine ecosystems. From this single location, blister rust spread throughout the white pines of Western North America, continuing to infect the region until 1943 when it was officially considered a universal epidemic.

Despite the hardy endurance of the tree species that created 200- to 300-year-old white pine forests, in blister rust the great white pine had met its match. White pine is fairly tolerant of native root diseases common among the young trees of any species, and the pine was less likely to be killed by root disease. But blister rust was a fungus and a disease from another ecosystem in another part of the world.

White pine blister rust begins in the needles and stems, eventually working its way into the tree trunk.

Forest managers knew immediately how serious the situation was for they had witnessed blister rust infection in the Eastern United States where it had been introduced in 1895 and was well established there by 1910. Both eastern and western white pine, from botanical gardens stretching across Europe, carried blister rust from its Siberian home to North America.

An obvious option for controlling blister rust was the eradication of currant and gooseberry shrubs. Such eradication had been relatively successful in the East. So in 1926, forest managers began large-scale eradication via hand-pulling of shrubs in white pine stands of the West. But by 1968 they realized that the Inland Northwest's topography, landscape scale, and climate prevented their success with this method, so they stopped. In the meantime, two other control options emerged: applications of antibiotics to trees, and the development of rust-resistance in trees. Antibiotic treatment did not meet expectations and was discontinued, but genetic development of resistant trees showed great promise. It remains the strongest hope for a renewed future for white pine forests.

The Forest Service in 1950 began the first large-scale breeding of rust-resistant white pine, starting with only 400 trees that had survived in areas of intense infection. Researchers selected trees without the characteristic canker sores on their bark from areas throughout the Inland Northwest that supported thousands of cankers per tree. The probability these trees were simply accidentally clean was about 1 in 10,000. After a host of genetic tests, scientists found about 100 resistant parent trees that could transmit high levels of resistance to their offspring. Studies even found about 12 kinds of resistance mechanisms in the seedlings. Since then, a breeding arboretum and seed orchards supply resistant seed for field testing and production of seed for commercial plantations. Over the last few decades most trees and seedlings have generally survived under conditions of low to moderate disease levels. In the most hazardous situations where there are lots of *Ribes* shrubs in moist environments, resistance may have eroded somewhat. Planting seedlings from the rust resistant seed orchards continues to look encouraging. The USDA Forest Service and the Inland Empire Tree Improvement Cooperative continues with a breeding program designed to further improve resistance.

Another possible treatment option being explored is the potential for saving white pines by pruning off branches with cankers, a practice actually begun in the 1930's and fairly successful, although labor intensive.

Currant shrubs act as an alternate host in carrying the disease-causing fungus.

For now, the best option seems to be integrated management that considers all factors affecting a tree's potential infection. Using computer models, managers now look to (1) match resistance to disease hazard on a site-by-site basis, (2) remotely track disease development in specific plantations to provide early warning of high infection years, and (3) predict damage to assess potential for pruning, stocking control, and management of infected host-shrubs.

Fire and the Evolution of a Forest

While powerful forest fires often appear as disasters to humans, fire has shaped the evolution of plants and forests. Most plant species have adapted to fire in some way, and some depend upon fire for their reproduction. Some plants need the heat of a fire to germinate their seeds. Others need the sunlight in openings created by fire, or the soil nutrients released by fire to make their growth successful. White pine is one of these fire-dependent species. Historically, it has relied upon large openings in the forest to regenerate, and without these openings, its seedlings cannot thrive in the heavy shade of the forest. Thus the white pine owes its dominance to a cycle of wildfire and other disturbances.

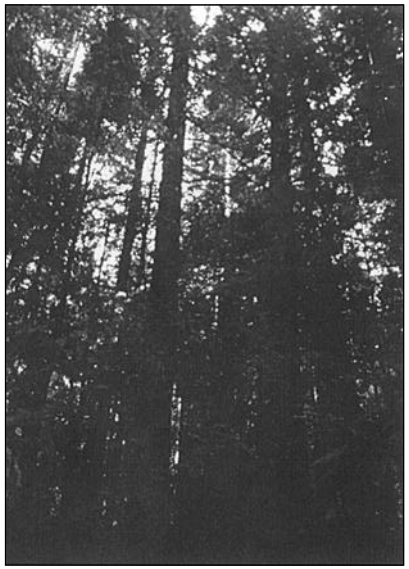
The Northern Rocky Mountains—home of the white pine—is one of the most lightning-prone areas in the Western United States. During the dry summer season when the jet stream shifts upward to Canada and weak air masses become thunderstorms, there can be more than 150 lightning fires per million acres (Barrows and others 1977). During drought years, individual lightning fires can scorch tens of thousands of acres or more. During the extremely dry summer of 1910, some 3.5 million acres of the Northern Rockies burned in forest fires.

Fire was common and necessary for western white pine to grow, creating natural openings in which seedlings thrived. This August 1925 photograph (above) shows the aftermath of a typical wildfire on the Clearwater National Forest in Idaho.

Research in the Coeur d'Alene River Basin of northern Idaho documents large forest fires to as far back as 1542 (Zack and Morgan 1994), and climatic evidence indicates this pattern is thousands of years old. There was a major forest fire in the 570,000-acre Coeur d'Alene Basin once every 19 years on average. In individual forests, fire replaced the entire stand about once every 200 years

A Place in the Sun

A big factor in tree survival is tolerance to shade. White pine is a shade-intolerant tree, meaning it cannot grow well under the shade of other plants. In sunny openings white pine can establish quickly, outgrow most other tree species, and eventually dominate the forest. Add to that its tallness and abundant wind-carried seed and you have a species well adapted to regenerate after forest fires. White pine germinates easily on a burned surface. Another shade-intolerant species is Douglas-fir, which also reproduces and grows in forest openings but does not grow as fast or tall as white pine, nor is it as long-lived.



Typical of forests today, dense stands of trees allow little light for the western white pine to grow in. These shady forests favor trees such as western redcedar, grand fir, and western hemlock.

Conversely, grand fir, western hemlock, and western redcedar are shade-tolerant species, meaning they are capable of reproducing and growing in the shade of other forest plants. Because they require high moisture and may not grow as fast or as tall as white pine in open sunny areas, they occupy mostly the understory position in white pine forests. Periodic droughts slow their growth and create stress that increases their susceptibility to insects and diseases.

This open forest encourages young white pines to grow (Kaniksu National Forest in northern Idaho, 1937).

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discontinued planting of non-blister rust-resistant white pine, emphasized regeneration and thinning of species mixes that did not include white pine, and focused major commercial timber harvests on white pine groves threatened by blister rust. Commercial harvests after 1968 were clearcuts planted with Douglas-fir. Most of the remainder were partial harvests that removed white pine and left other trees in the forests. Not only were dead and dying white pine harvested, but entire populations of white pine were removed—effectively also removing any blister rust-resistant genes that might have remained. From the late 1960's through the mid-1970's the areas formerly holding the best mature white pine groves were being converted to other trees—predominantly Douglas-fir, grand fir, and hemlock.

Discovery of Resistance

The fact that some white pines survived blister rust suggested that some trees might be genetically resistant to the rust. In the 1950's the search began for blister rust-resistant parent trees to produce rust-resistant seedlings. Tests showed that some of the surviving white pine were indeed resistant to the rust. These trees became the foundation for a breeding program aimed at producing blister rust-resistant white pine seedlings for reforestation. Tree genetic research, and especially tree breeding, takes a long time. Thirty years after the genetics effort began several seed orchards were producing rust-resistant seed.

By the early 1980's significant amounts of blister rust-resistant white pine seed became available for reforestation. White pine reforestation accelerated on Forest Service, State, and private lands, peaking in 1991.

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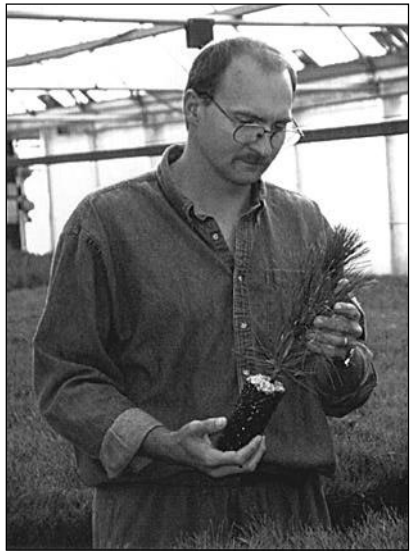

Past genetic research helped produce seedlings with a better chance of survival today. These "disease resistant" seedlings grew from the seeds of parent trees raised in special orchards of white pine.

Change is the Name of the Game

Scientists measure forest characteristics in the number of tree species present, their size, and the relative abundance. Diversity in these characteristics is achieved through natural changes in a forest, or disturbances. Every ecosystem has these natural disturbances, and the plants and animals evolve to adapt to those disturbances. In fact, the whole ecosystem incorporates disturbances into the long-term way it functions.

Forest succession—how vegetation changes over time—is the primary way the forest responds to disturbance. For example, following a lethal forest fire the forest is a skeleton of dead trees called snags. Starting the next spring after the fire, grasses and small plants may dominate the site for a couple years, then shrubs for a decade or two, then tree species that need open sunlight, and ultimately (if no new disturbance resets the successional clock) slower growing tree species that can regenerate in the shade. This entire process may take hundreds of years.

During the past 70 years, succession in white pine forests has changed. Wildfire suppression has reduced opportunity for natural regeneration. White pine blister rust killed many existing tree stands and prevents most naturally regenerating trees from living to maturity. Although some forms of harvesting provided the opportunity to plant rust-resistant white pines, much of it selectively removed white pine and other high value species. The net result is a continuing loss of seral white pine, western larch, and ponderosa pine—species that once grew to towering size and prominence in our early history.

The interaction of disturbances and forest succession determine the mix of successional stages present across the landscape. A landscape with some grassy openings, some shrub fields, some young forest, and some older forest is more diverse than a landscape with all young or all old forest. More diverse forests also provide habitats for a wider variety of animals.

Scientists do not know what we lost when the white pine began to die off. A truly white pine-dominated forest could present us with flora, lichens, and possibly different wildlife populations than we are used to today.

Efficiently growing white pines at Deception Creek on Idaho's Panhandle National Forests, 1929.

The War on *Ribes*

It is a tribute to Northwestern foresters of the turn of the century that they recognized the importance of white pine to the ecosystem and the gargantuan threat of the blister rust. Would those Victorian-era foresters have guessed we would still be fighting the blister rust today?

Researchers and managers determined that getting rid of *Ribes*—currant and gooseberry shrubs—would help prevent the spread of the rust to western white pine. Eradication of alternate host species, those surrounding plants that first contract a disease and then spread it to the important crops around them, was already being used against the black stem rust that afflicted wheat. In that case the alternate host was both the cultivated and wild barberry species. To this day, the U.S. Bureau of Plant Quarantine regulates cultivation of barberry. Against this historical and scientific background were played out the first efforts to control blister rust infection of western white pine trees.

Canada's West Coast at Point Gray first saw the rust in 1910. From there, it radiated east to infect white pines in Washington State's Puget Sound region and Interior British Columbia by 1922. The infection reached eastern Washington and then Idaho by 1923. Because host eradication had worked with pines in the Eastern United States, and scientists were similarly fighting black stem rust successfully in wheat, the natural choice for curing western white pine of blister rust was eradication of host shrubs. But the eradication effort in the West would be different, shaped by the magnitude of the problem and by human events, specifically the Great Depression of the 1930's. The Depression released thousands of job-searchers who would become the labor force making such a huge eradication attempt feasible.

Starting with an annual expenditure of $300,000 in 1932, the western rust control effort grew to $1.2 million in Public Works Administration (PWA) dollars. In 1934 the eradication effort received an infusion of PWA and Civilian Conservation Corps (CCC) workers. These programs, together with regular appropriations, put 13,000 men to work in the "War Against *Ribes*." By 1935 the CCC in the Inland Northwest alone employed 7,000 men. From 1930 to 1946, a work force averaging 2,500 men annually would dig, bulldoze, and spray *Ribes* shrubs on over 2.5 million acres of the 5 million-acre Inland Northwest white pine forest. All told they destroyed 444 million *Ribes* plants.

Ribes along streams were treated differently from *Ribes* elsewhere in the forest. About 5 percent, or 36,000 acres, of these sensitive areas were treated by hand and sown with 1.8 million pounds of sodium chlorate (50 pounds per acre). Although the effort was labor-intensive, scientists now know that the number of bushes eradicated in those years still left 100 times the density that would have secured safe conditions for growing susceptible western white pine.

The second half of the eradication story would unfold over the subsequent 20 years, from 1947 to 1968. Some 20,000 man-years of effort (1,000 men per year) removed 70 million plants from 900,000 acres. By 1949 the eradication program was ready to mount a full-scale stream and upland assault armed with a new weapon: the plant hormone herbicides 2-4-D and 2-4-5-T . For the first time a tool was available that would kill all species of *Ribes* and could be transported by backpack across the forest landscape. From 1949 to 1966 workers sprayed 41,000 acres of stream and forest with 13.3 million gallons of herbicide. This reduced *Ribes* populations to about seven bushes per acre, 10 times the efficiency of the previous eradication, but still 10 times away from what it needed to be. In the end, the eradication program had impacted almost half the 2.5 million acres originally targeted.

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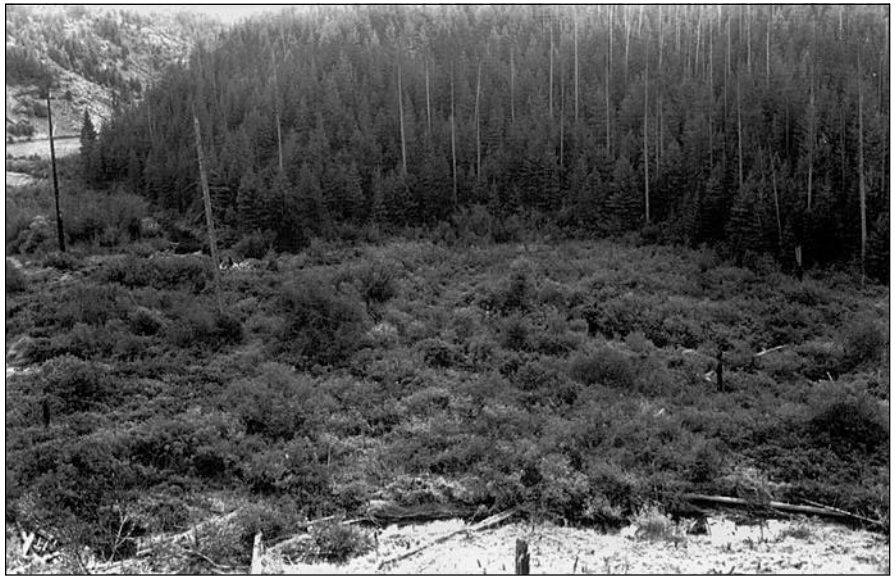
The Civilian Conservation Corps employed thousands of people in the 1920's and 1930's to pick, pull, spray, dig, and scrape out Ribes shrubs from the western white pine region.

Why was the war on *Ribes* so difficult? Understanding the shrub species may provide an answer. Sometimes the worst adversary is the one whose habits are just like yours. Like white pine, *Ribes* shrubs (currant and gooseberry) grow along streams, in moist open forests, in drier forest woodlands, and on subalpine woodlands. Almost all forest types that are open and contain deciduous shrubs contain *Ribes* and the possibility of pine-killing blister rust. The two species most commonly acting as alternate host for the rust (*Cronartium ribicola*) are *Ribes lacustre* and *Ribes viscosissimum*. They are found on the best growing sites for western white pine. And like the white pine, *Ribes* shrubs regenerate well after forest fire.

Part of the reason the *Ribes* survived the CCC's herbicide attacks during the 1930's is that it is well adapted to long intervals between forest fires. Fire kills the trees and provides a chance for *Ribes* to regenerate from seeds placed by the previous generation…seeds used to waiting a long time for an opportunity to grow. The mother plants also regenerated after wildfire, a wait of perhaps 300 years.

The small *Ribes* seeds have a hard seed coat and over time are buried by the litter of trees and shrubs that make up forest soil-building processes. One plant can produce many thousands of seeds. Not all seeds survive, but after the next fire or other disturbance such as logging, wind, or ice storm, the seeds germinate and the young plants quickly grow to sexual maturity within 7 years, producing more seed. Once established, *Ribes* grow to about 6 feet high and about the same width. If topped, the shrub sprouts new, quick-growing shoots from latent buds at the base of the plant. However, the tenacious plant that can live for 50 years or more may not be as fortunate as it appears. The forest itself also begins to grow after fire or disturbance. As soon as the trees outgrow the shrubs and produce shade, *Ribes* parent shrubs die. Mostly they leave only their seed to wait in the shady forest for the next fire.

Although the war on *Ribes* was sound in concept, it needed to reduce a hazard so vast that success was virtually unattainable. That the forest professionals of the time would make such a massive attempt is powerful testimony to their understanding of the importance of western white pine to its ecosystem—and to American culture. It is also powerful testimony that society may need to rethink the prevailing attitude that humans can control nature.



Removing Ribes shrubs with bulldozers along riparian and floodplain areas was a common approach during the eradication effort. The top photo shows an area before bulldozing; the bottom photo reveals the aftermath.

This western white pine tree trunk is infected with the white pine blister rust. The tree produces resin in an effort to defend itself.

Continued from page 10…

The species' fate again intertwined with changes in human activities. Between the 1970's and the 1990's, Federal policy led to a decline in support for white pine research and breeding programs. Meanwhile, public priorities for National Forests shifted away from producing commercial wood products and toward endangered fish and wildlife species, esthetics, and recreation. Clearcuts fell into disfavor, harvest levels were drastically scaled back, and many of the harvests that did take place were partial cuts that failed to provide adequate openings for successful white pine regeneration. These partial cuts favor regeneration of shade-tolerant grand fir, redcedar, and hemlock. Regeneration of rust-resistant white pine on National Forest lands had fallen below 1991 levels, and the trend continues downward. Currently, a lack of research dollars dedicated to white pine and, more significantly, the lack of appropriate habitat, threatens the survival of white pine.

On Federal lands, harvest rates that create openings seem headed for such low levels that it appears questionable whether significant white pine restoration can take place. Without some sort of disturbances that create openings, forest succession will lead to the replacement of white pine by other species.

For economic and policy reasons, planting of rust-resistant white pine has also declined significantly on most State and private lands. On some of these lands, the desire for short-term economic returns dictates short rotation timber harvests. Economic timber rotations on these lands have some potential for producing young white pine plantations but will not create the full range of successional stages and white pine forest types that existed historically.

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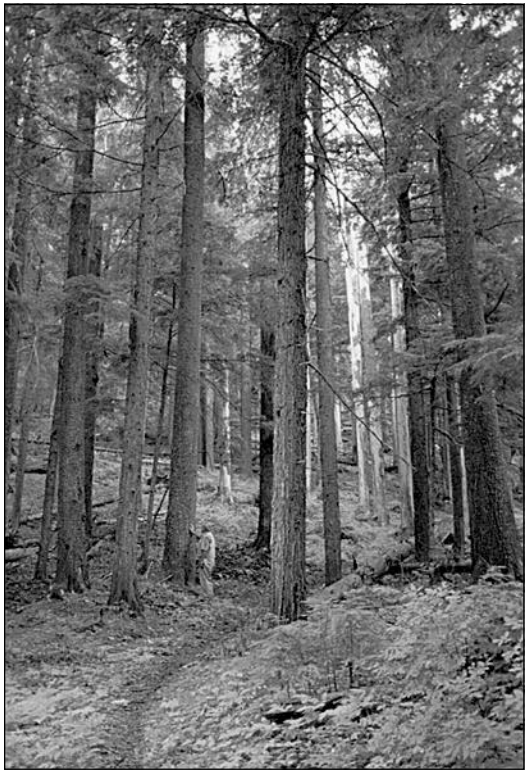
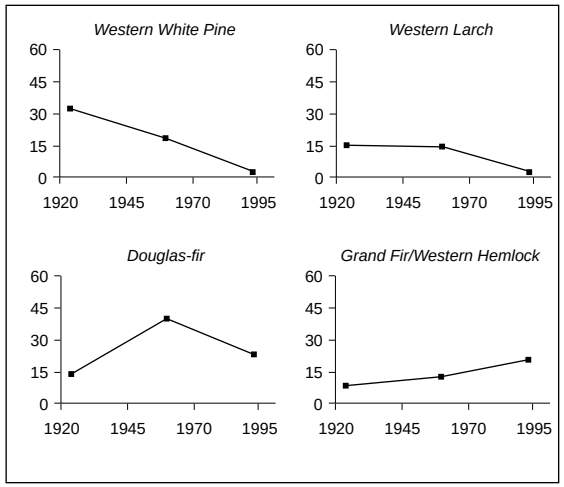


Blister rust often kills the tops of large trees to the point they cannot defend themselves against other forces of nature. Once weakened, a white pine stands vulnerable to insects and root rotting fungi.



Tree inventory data taken from the Panhandle National Forests (Idaho) illustrates the decline of white pine relative to its companion species.

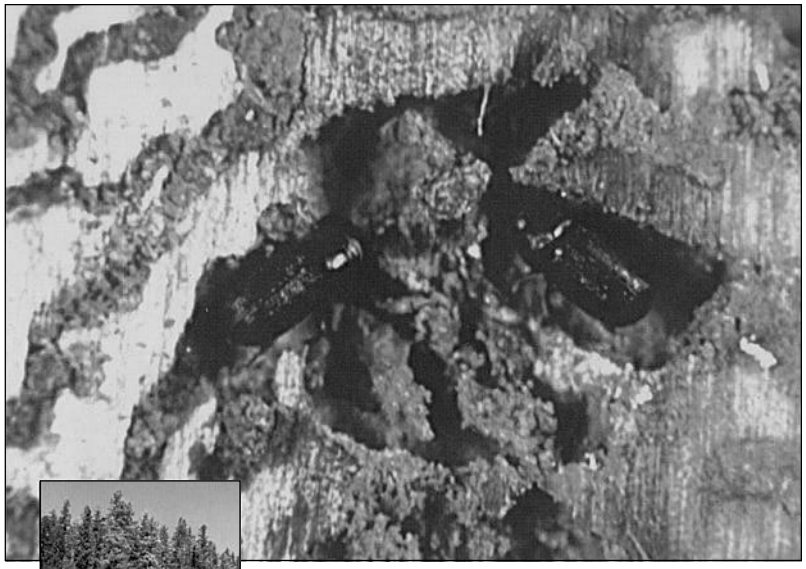
How Do Bark Beetles Kill Trees?

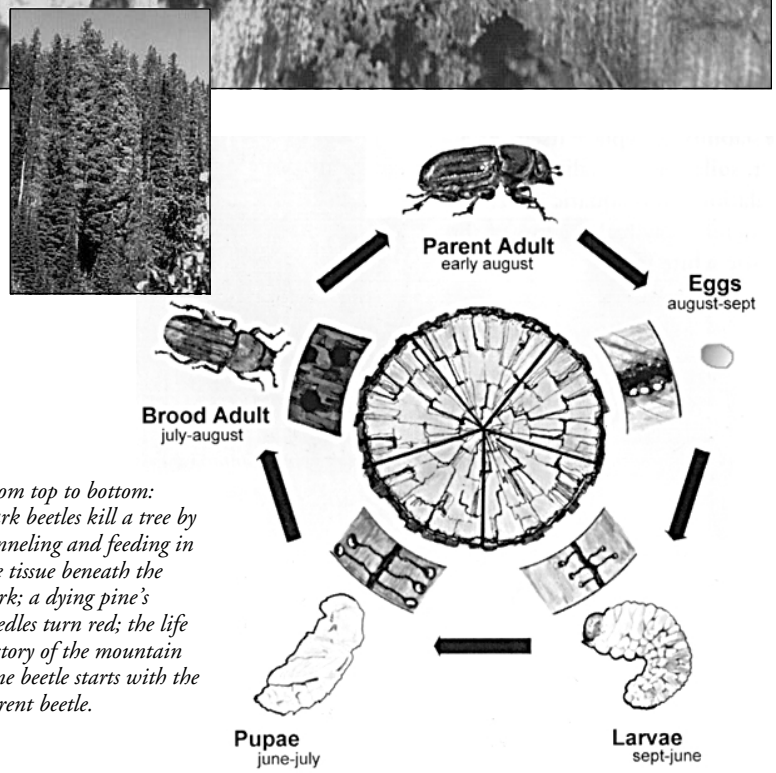
A tiny black insect with a huge appetite and a big family, the mountain pine beetle is a major killer of all pine species in its range. Native to the West, it kills trees by mass-attacking them, feeding on them, girdling them, and introducing fungi into the sapwood. Beetle populations may increase rapidly to cause tremendous tree mortality over large areas in just a few years.

Outbreaks of mountain pine beetle were recorded in white pine as early as 1910. Historically, the beetle killed large, mature, old-growth white pine. Forests sustaining the most damage contained 40 to 60 percent white pines over 160 years old growing in dense forests. The beetle also targeted younger trees, but mortality generally occurred only in trees older than 80 years (Terrell 1962). "The mountain pine beetle caused a serious loss of timber," lamented the 1910 report of a beetle epidemic in Idaho white pine forests at that time. Beetles killed an average of 20,000 mature trees per year on 80,000 acres of north Idaho white pine from 1928 to 1950. From 1934 to 1953, it was estimated they killed at least half the mature white pine volume on the Clearwater National Forest. Over the past 30 years, the pine beetle has killed an average 500 trees per acre, many of them the last remnant old-growth trees. Recently, the insect has begun attacking younger trees—60 years old—that are 12 to 14 inches diameter in second growth stands. Often these stands are also infected with white pine blister rust or root disease.

The Forest Service attempted to control beetles in white pine starting in 1929 and continuing until 1951. Bark beetle-infected trees have red tops, so foresters conducted red top surveys by counting fading trees from a distance (from an observation tower, for example), then did ground surveys to estimate the number of currently assaulted trees. Treatments consisted of falling and peeling, falling and burning, or falling and treating with chemicals.

But the mountain pine beetle isn't always a bad guy. Like other native pests, the pine beetle was a major driver of change in the mature white pine forests of the past. Like fire, the beetle can be a recycling agent, returning nutrients to the soil when it kills trees. In historic white pine forests, beetle-kill created openings and fuels in the forest, predisposing it to larger fires that favored white pine regeneration. In today's fireless, mixed conifer woods, the loss of white pine allows more shade-tolerant species to dominate, species also less fire-resistant and less disease-resistant. The role of the beetle combined with blister rust has changed from that of a recycler to an eliminator of white pine.





From top to bottom: Bark beetles kill a tree by tunneling and feeding in the tissue beneath the bark; a dying pine's needles turn red; the life history of the mountain pine beetle starts with the parent beetle.

Continued from page 14…

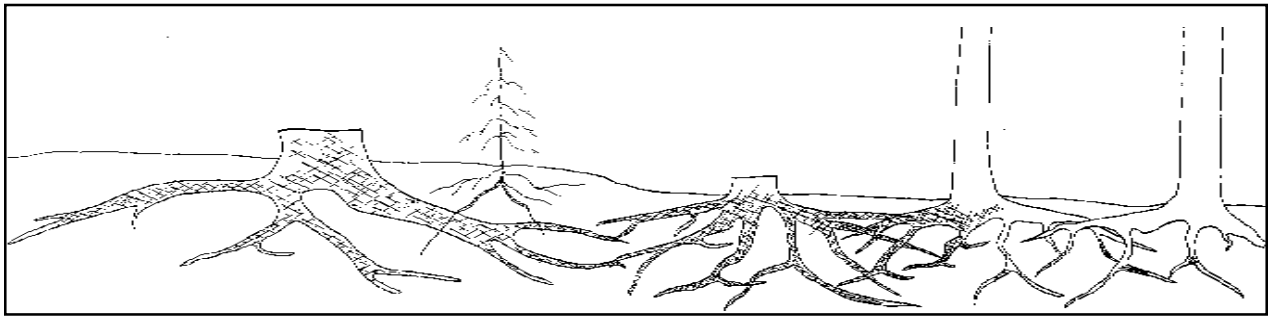
The Replacement Forest

When it goes, white pine is replaced by grand fir, western hemlock, and western redcedar. This climax forest of shade-tolerant, slow-growing, and shallow-rooted trees is not tolerant of insects, root disease, drought, wind, or fire. This results in high rates of change, forests in a constant widespread state of death and renewal. Such a cycle is normal for healthy forests, but the western white pine is not experiencing the renewal—only death. The tragedy of blister rust is not so much the demise of large white pines in existing forests but the end of the white pine's ability to replace itself. As a result, soils, water quality, wildlife populations, and aquatic systems will increasingly feel the loss of the majestic white pine.

These young 10-year-old white pines grow at Deception Creek Experimental Forest located near Coeur d'Alene, Idaho. Several other rust-resistant white pine plantations exist in the area as well.

Native Diseases—Both a Problem and an Asset

Disease in trees is as dangerous and contagious as it is to humans. A tree "catches" root rot caused by fungi and then passes it along to other trees through contact with their roots. Every root rot has a fungus that caused it. Common Northwest root rots are laminated root disease, *Armillaria* root disease, brown cubical rot, and butt rot. It is common for more than one species of root pathogen to occur on one stand or even in a single tree.



Root rot spreads in the forest through tree-to-tree contact. Outbreaks of this fungus vary from the infestation of a single tree to several acres of trees.

Like children holding hands in a classroom during flu season, the roots of a diseased tree touch the root of a healthy tree, causing a bridge that allows transmission of the fungus from one tree to another, under the soil. Pathogens can live several decades in the roots of even dead trees or stumps, so young trees can be infected when their roots simply touch those of diseased and dead trees from the previous generation. Death results in a few years in young trees while older trees may survive several decades after infection.

Root diseases were actually in part responsible for creating the 200- to 300-year-old white pine forests so abundant when the first Euro-American settlers arrived. Although some mortality from root diseases is common among the young trees of any species, western white pine and other pine species are normally quite tolerant of disease and thus less likely to be killed. Certain pathogens prefer certain tree species, so the range of infection varies according to the forest's make-up. In general, Douglas-fir, grand fir, and subalpine fir are most susceptible to the mix of pathogens common to northern Idaho.

Native to the white pine region, root pathogens served a number of successional and nutrient recycling functions in historic forests. They weeded susceptible trees from stands in mixed species forests, thus helping convert mixed stands to white pine and larch a long time ago. When fungus outbreaks did this, they opened up some of the otherwise closed forests by removing small patches of trees—white pine prefers forests open to the sunlight. Thus, a common theme in Northwest forests: when some trees die they make room for others.

With fewer disease-tolerant trees such as white pine and more and more forests made up of mostly disease-susceptible trees, root diseases cut bigger gashes across larger areas of forest than is healthy and desirable. Root disease is now less frequently a weeding agent in mixed-conifer forests, but now it removes the entire canopy in some places, causing extensive deforestation. In the absence of disturbances such as wildfire or appropriate human-managed activities, and without seed sources for white pine and other seral species, this condition could last indefinitely.

Root rots attack tree roots, weakening them to the point they eventually fall in wind storms.

How We Can Help Recovery

The human element began the death cycle for white pine, and human actions could help save it. The re-establishment of viable populations of white pine in part depends on the pine's ability to adapt to current circumstances. It will also depend on whether naturally occurring and human-created blister rust-resistant white pine is given a chance to persist over the long term.

Potentially, forests much like those of the past can be re-established. But that will require changing management practices so they are more in concert with natural disturbance and succession. It will also mean dealing with the special problems created by introduction of the rust.

The character of our inland forests has changed, perhaps forever. If western white pine is to return to us, we must create a long-term strategy for its recovery. We must:

- Conserve and protect the remaining old groves and determine which trees are rust-resistant.
- Conserve and maintain genetic diversity by collecting seeds and storing them for the future.
- Use blister rust-resistant seedlings in reforestation.
- Provide opportunities for natural regeneration to promote gene conservation and natural selection.
- Continue genetic research and tree improvement programs aimed at rust-resistance.
- Treat existing young forests to maintain white pine (that is, apply integrated management).
- Plant white pine in *Ribes*-free areas.

We must adopt this strategy or our opportunities become greatly reduced. Even the non-forester can help, the landowner, school, or municipality. Plant white pines along your streets, or in your yards, parks, conservation reserve areas—anywhere. All you have to do is plant white pine and you can be part of the salvation of a species. Let's restore this important piece of our region's natural history.

For Information:

- USDA Forest Service, Rocky Mountain Research Station, Idaho (208) 882-3557
- USDA Forest Service's State and Private Forestry Program, Idaho (208) 765-7342

For Seedlings:

- University of Idaho Forest Research Nursery (208) 885-3888
- The Inland Empire Tree Improvement Cooperative, University of Idaho (208) 885-7016
- Idaho Nurseryman's Association, 1-800-INAGROW or PO Box 2065, Idaho Falls, ID 83403

The Deception Creek Experimental Forest Station shows the change in western white pine forest condition over the years. The 1936 photograph (top) shows emerging western white pine in a former clearing behind the cabin. Sixty years later (bottom photograph), the forest shows dramatic change. Most of the western white pine trees are dead and have been replaced with grand fir, western redcedar, and subalpine fir. Notice that in both photos, the center trees are western white pine. Today they are a remnant, dying as the other western white pine have.

Photo Credits

Cover—Matured white pine, Kaniksu National Forest (Priest Lake), Idaho circa 1920. Courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Montford Creek Natural Research Area, Panhandle National Forests; Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Back Cover—250-year-old stand of western white pine on the Clearwater National Forest, circa 1930's. Courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 2—Western White Pine distribution maps. Data Source: Interior Columbia Basin Ecosystem Assessment Project, USDA Forest Service, Pacific Northwest Research Station, and USDI Bureau of Land Management, OR, WA, ID and MT State Offices.

Page 3—White pine needles - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

White Pine cone - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

White pine and Ray Boyd - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Page 4—Looking up Mannering Creek, circa 1935. Photo: Washington Air National Guard. Courtesy of University of Idaho Special Collections Library. (#95-49:WG45:4; Camp #39).

(1996 photo) - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Page 5—CCC worker eradicating *Ribes* courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 6—Old logging photo - courtesy of Potlatch Corporation.

Page 7—Horse logging photo - courtesy of Potlatch Corporation.

Page 8—Blister Rust on seedling - photo courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Ribes leaf - photo courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 9—Burned forest above Martin Creek, Clearwater National Forest, 1925.

Fire photo - courtesy of Jim Byler, USDA Forest Service, Panhandle National Forest, Idaho, USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 10—Top photo: dense forest - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Bottom photo: open forest - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Blister rust-resistant seedlings at University of Idaho Forest Research Nursery - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Page 11—1929 photo of white pines at Deception Creek, Panhandle National Forests (Idaho).

Page 12—CCC worker eradicating *Ribes* - photo courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 13—Before bulldozer - photo courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

After bulldozer - photo courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 14—Infected white pine trunk - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Blister rust-weakened white pine forest at Deception Creek, Panhandle National Forests (Idaho) - Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Tree inventory data from Panhandle National Forests (Idaho) - Chart prepared by Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

Page 15—Mountain pine beetle galleries - photo courtesy of USDA Forest Service, Panhandle National Forests, Idaho.

Dying tree - courtesy of USDA Forest Service, Northern Region.

Bark beetle life cycle chart - courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

Page 17—(root diagram)- original artwork, Susan Hagle, 1988, USDA Forest Service, Panhandle National Forests, Idaho. Digitally enhanced by Gerry Snyder, Natural Resources Communication Lab, University of Idaho. 1996.

(root wad)- Roots of tree affected by root rot. Courtesy of Dr. Art Partridge, College of Forestry, Wildlife and Range Sciences, University of Idaho. 1996.

Page 18—1936 - former Northern Rocky Mountain Experimental Station, Deception Creek, Panhandle National Forests. Sept. 1996. Gerry Snyder, Natural Resources Communication Lab, University of Idaho.

1996 - Northern Rocky Mountain Experimental Station, Deception Creek, Panhandle National Forests. Oct. 1936. Courtesy of USDA Forest Service, Rocky Mountain Research Station, Moscow, Idaho.

References/Suggested Reading

Barrows, J.S., D.V. Sandberg, and J.D. Hart. 1977. Lightning fires in Northern Rocky Mountain Forests. Unpublished report. USDA Forest Service, Intermountain Fire Sciences Laboratory, Missoula, MT. 192 p.

Baumgartner, D.M., J.E. Lotan, and J.R. Tonn. 1994. Interior cedar-hemlock-white pine forests: ecology and management. March 2-4, 1993, Spokane, WA. Symposium Proceedings, Washington State University, Cooperative Extension, Pullman, WA.

Bingham, R.T. 1983. Blister rust resistant western white pine for the Inland Empire: the story of the first 25 years of the research and development program. Gen. Tech. Rep. INT-146, USDA Forest Service, Intermountain Research Station, Ogden, UT.

Bingham, R.T., A.E. Squillace, and J.W. Duffield. 1953 Breeding blister-rust resistant western white pine. Journal of Forestry. 51:163-168.

Evenden, J.C., W.D. Bedard, and G.R. Struble. 1943. The mountain pine beetle, an important enemy of western pines. Circular 664, USDA, Forest Service, Washington, D.C.

Farbo, T. 1996. White pine, wobblies and wannigans, A history of Potlatch logging camps, north central Idaho 1903-1986. Steeley Print and Binding, Lewiston, ID. 356 pp.

Hagle, S.K., G.I. McDonald, and E.A. Norby. 1989. White pine blister rust in northern Idaho and western Montana: alternatives for integrated management. Gen. Tech. Rep. INT-261, USDA Forest Service, Intermountain Research Station, Ogden, UT.

Haig, I.T., K.P. Davis, and R.H. Weidman. 1941. Natural regeneration in the western white pine type. Tech. Bull. 767, USDA, Washington, D.C.

Hubert, E.E. 1950. Rootrots of the western white pine type. Northwest Science. 24:5-17.

Leaphart, C.D., and A.R. Stage. 1971. Climate: A factor in the origin of the pole blight disease of *Pinus monticola* Dougl. Ecology. 52:229-239.

McDonald, G.I., and R.J. Hoff. 1991. History and accomplishments of white pine blister rust research in the USDA Forest Service. INF Rep., NOR-X-317, Proceedings IUFRO Rusts of Pine Working Party Conference, Sept. 18-22, Banff, Alberta, Forestry Canada, Northwest Region, Northern Forestry Centre.

Milke, J.L. 1943. White pine blister rust in western North America. Bulletin No. 52, Yale University School of Forestry, New Haven, CT.

Miller, F.G., R.N. Cunningham, S.V. Fullaway, Jr., C.N. Whitney, and C.B. Morse. 1927. The Idaho forest and timber handbook. School of Forestry, University of Idaho, Moscow, ID. 155 p.

Peterson, K.C. 1987. Company town, Potlatch, Idaho and the Potlatch Lumber Company. Washington State University Press, Pullman, WA. 284 pp.

Shiplett, B., and L.F. Neuenschwander. 1993. Fire ecology in the cedar-hemlock zone of north Idaho. In: Interior Cedar-Hemlock White Pine Forests : Ecology and Management, Proceedings. Washington State University Cooperative Extension System, Pullman, WA. pp. 41-51.

Strong, C.C. and C.S. Webb. 1970. White pine: king of many waters. Mountain Press Publishing Company, Missoula, MT. 212 pp.

Terrell, T.T. 1962. Mountain pine beetle infestation, Clearwater National Forest, 1961. Unpublished survey and control Report. USDA Forest Service, Region 1. 6 p.

Zack, A.C., and P. Morgan. 1994. Fire history on the Idaho Panhandle National Forests. Review draft, March 22, 1994. Coeur d'Alene, ID: USDA Forest Service, Idaho Panhandle National Forests. 44 p.

DEFINITIONS USED IN THIS PUBLICATION

Seral, Climax: Forest succession refers to the stages of development in forest communities. The early stage is called the pioneer. The last (mature) stage is called the climax, hence a "climax forest." The phases between pioneer and climax are called the seral stages.

Efficient/Thrifty growing white pine: Refers to the ability of white pine to utilize available resources (water, nutrients, and light) effectively, especially in the early stages of forest development. This ability tends to produce excellent growth, stability, and longevity of forests where white pine is a significant component.

Canopy: Foliar cover in a forest, may consist of one or several layers, any of which may be dense or sparse.

Overstory: Uppermost canopy layer, may be one or several lower layers (understories). Thus, can be multistoried or multilayered. Also referred to as "laddered" or "ladder fuels" when referring to multiple layers as fuel for forest fires.