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Eastside Forest Management Practices: Historical Overview, Extent of Their Applications, and Their Effects on Sustainability of Ecosystems

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Eastside Forest Ecosystem Health Assessment

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ABSTRACT

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Forest management of eastern Oregon and Washington began in the late 1800s as extensive utilization of forests for grazing, timber, and irrigation water. With time, protection of these values developed into active management for these and other values such as recreation. Silvicultural and administrative practices, developed to solve problems at a particular time have lingered and created confusion and consternation when knowledge, values, and vegetation conditions have changed. The present condition of most eastern Oregon and Washington forests is the result of disturbance and regrowth processes coupled with historical management practices. Most areas contain high levels of insects, diseases, and fuels. Without many, diverse, creative, and active solutions, large fires and insect outbreaks will occur-with local loss of ecosystem and human values.

Keywords: Management practices, historical management practices, eastern Oregon, eastern Washington, ecosystem sustainability.

Contents

INTRODUCTION

This paper describes the history of forest management in eastern Oregon and eastern Washington. To do this, the area is divided into seven geographic subunits (fig. 1; table 1). The ecological patterns and landuse history are roughly similar in each subunit. Division into subunits allowed combining data based on National Forest areas and county areas. Sources of information are described in appendix A.

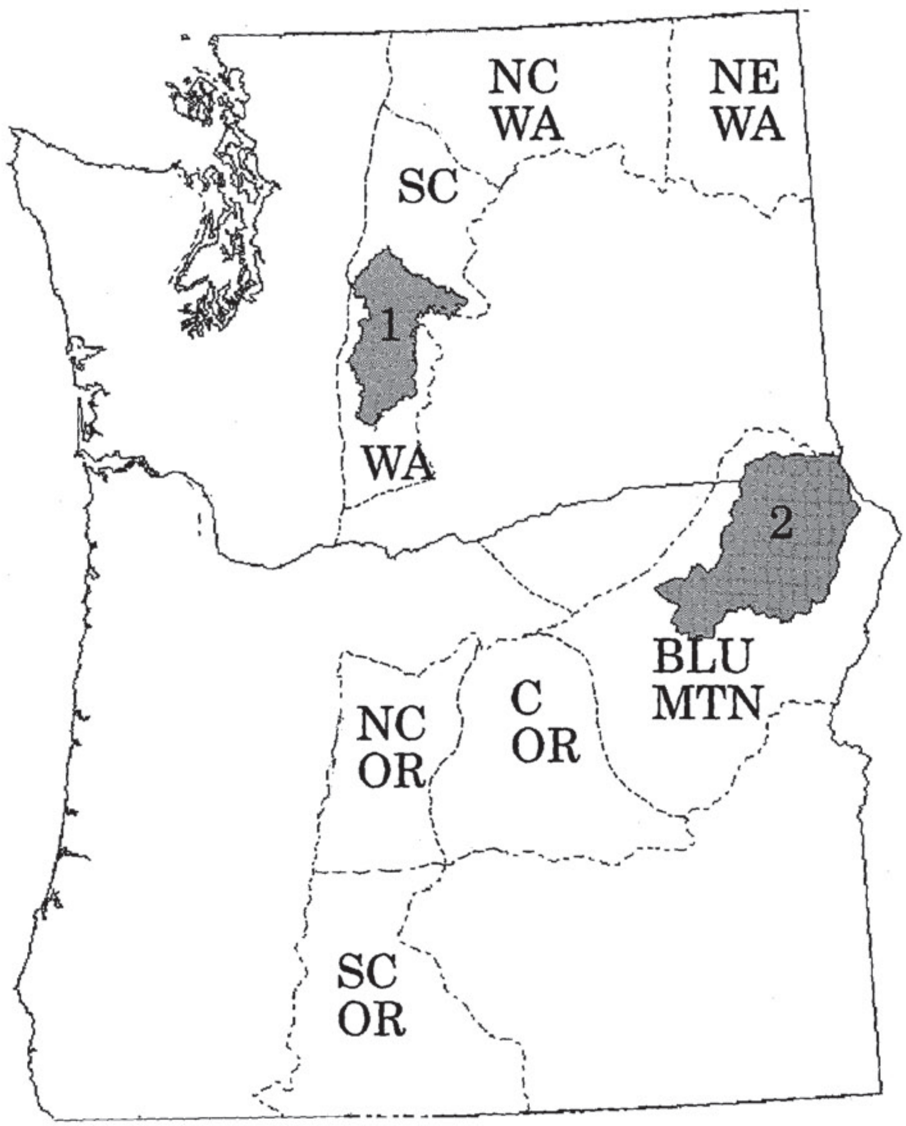


Figure 1. Subareas and subsampled river basins of eastern Washington and Oregon referred to in this report. Subareas, indicated by letters, correspond to table 1. Subsampled basins shown in dotted boxes. (1 = Yakima basin; 2 = Grande Ronde basin).

Table 1. Subareas of eastern Oregon and Washington (Figure 1), showing National Forests and counties associated with each area.

NORTHEAST WASHINGTON
Counties
- Ferry County
- Pend Oreille County
- Stevens County

National Forests
- Colville National Forest

NORTH CENTRAL WASHINGTON
Counties
- Okanogan County

National Forests
- Okanogan National Forest

SOUTH CENTRAL WASHINGTON
Counties
- Chelan County
- Kittitas County
- Yakima County

National Forests
- Wenatchee National Forest

NORTH CENTRAL OREGON
Counties
- Deschutes County
- Jefferson County
- Klamath County
- Lake County

National Forests
- Deschutes National Forest

SOUTH CENTRAL OREGON
Counties
- Klamath County
- Lake County

National Forests
- Fremont National Forest
- Winema National Forest

CENTRAL OREGON
Counties
- Grant County
- Harney County
- Crook County
- Wheeler County

National Forests
- Malheur National Forest
- Ochoco National Forest

BLUE MOUNTAINS
Counties
- Baker County (Oregon)
- Grant County (Oregon)
- Morrow County (Oregon)
- Umatilla County (Oregon)
- Union County (Oregon)
- Wallowa County (Oregon)
- Asotin County (Washington)
- Columbia County (Washington)
- Garfield County (Washington

National Forests
- Umatilla National Forest
- Wallowa-Whitman National Forest

The Area

Eastern Washington and Oregon consist of about 25,230,000 acres of forest. Forests with sufficient tree densities and growth to produce more than 20 cubic feet per acre per year are considered commercial forest lands and comprise 80 percent of the total (table 2, USDA Forest Service 1982). Most of the forest in eastern Oregon and about 46 percent in eastern Washington (fig. 2) is in National Forests. Because a large amount of land is in National Forests, Forest Service management policies and practices exert a strong influence on forestry activities, and trends reported on National Forests generally reflect management practices on other lands as well.

Table 2. Characteristics of eastern Oregon and Washington lands. (USDA Forest Service 1982,1991).

	EASTERN OREGON	EASTERN WASHINGTON
AREA (acres)		
Total	42,391,000	26,762,000
Range Area	20,313,700	7,236,200
Forest Area		
Total	14,656,000	10,574,000
Nonproductive 1	3,508,000	1,552,000
Productive	11,148,000	9,022,000
U.S.Forest Service	9,838,391	3,627,489
National Wilderness	1,040,330	1,276,034
National Wild & Scenic River	12,000	0
National Recreation	400,569	0

1 Land not capable of producing 20 cubic feet/acre/year in natural stands.

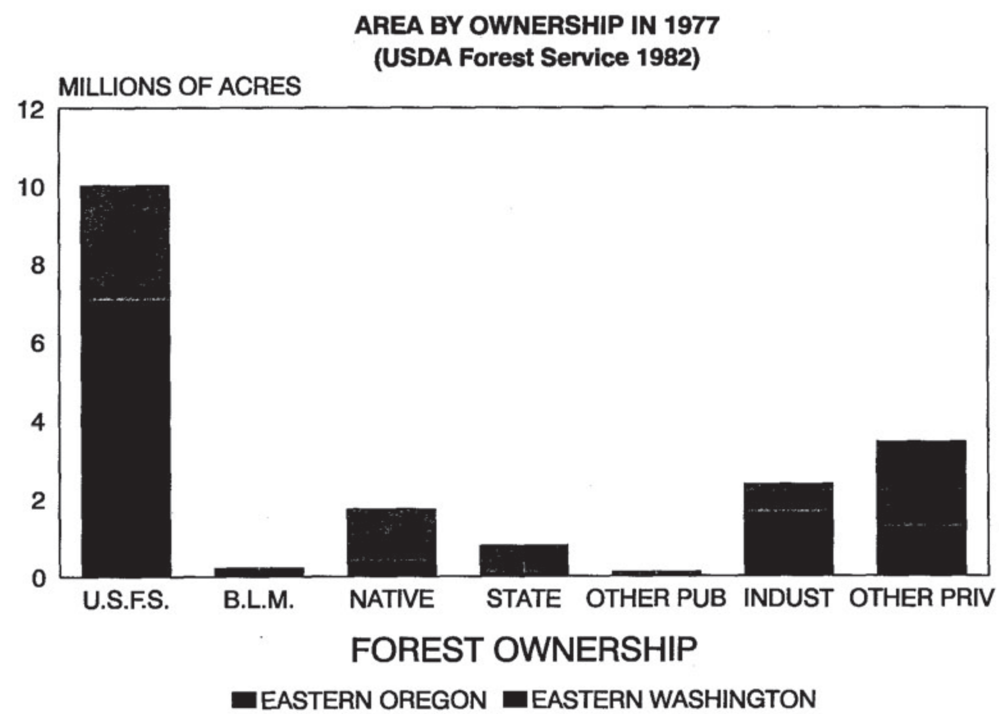


Figure 2. Most of eastern Oregon's productive forests are National Forest, as are about 35 percent of eastern Washington's productive forests. ("Productive" forest refers to land capable of growing more than 20 cubic feet per acre per year.) (USDA Forest Service 1982).

Forests contain a variety of species in both pure and mixed stands (fig. 3). Tree growth is poorest on forest lands at the low elevations where soil moisture is limiting, and at upper elevations, where the cold climate is limiting. In the middle elevations, where soil moisture is more favorable, tree growth is moderate or better. In addition, dry conditions and frequent droughts predispose trees to insects and diseases, especially if the stands become overcrowded. The stands can also become susceptible to fires if dead material accumulates. Historically, large and small disturbances-both stand-replacing and partially stand-replacing-affected forest stands, creating stand structures suitable for a variety of wildlife and plant species (fig. 4; Oliver and Larson 1990).

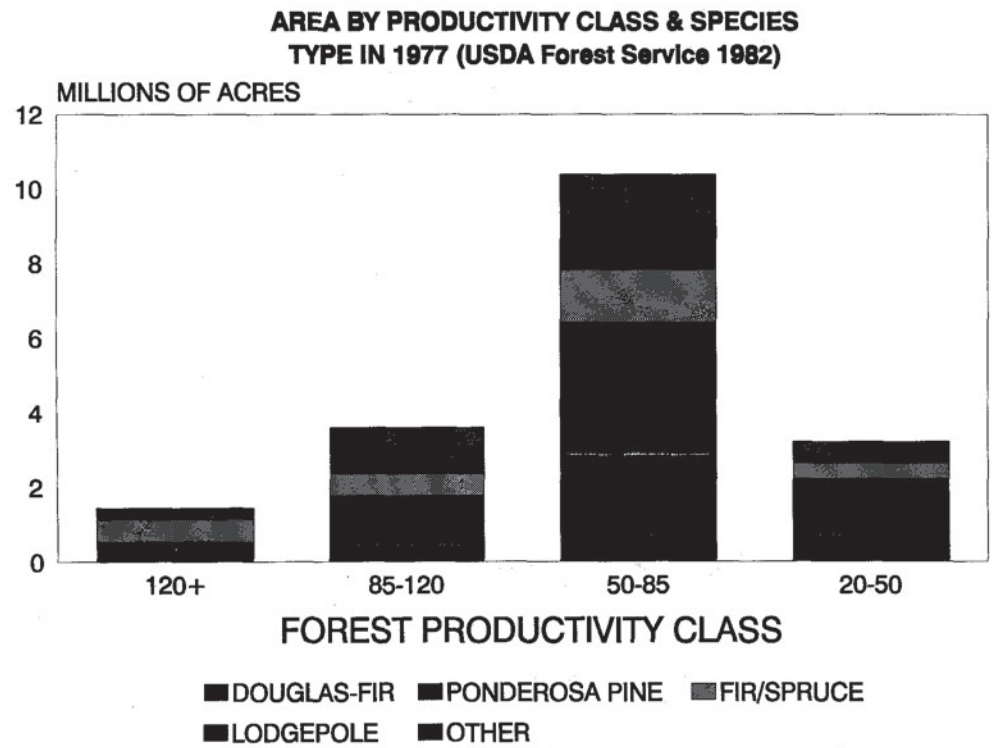


Figure 3. Most eastern Oregon and Washington forests are of relatively low productivity, but contain a variety of species (USDA Forest Service 1982).

Organization of This Report

This report is organized by management practices. Presentation of the history of each management practice will be subdivided into three periods: pre-1930, 1930 to 1960, and 1960 to the present. For each period, an overview of the forest condition and associated rural land-use practices will put management in context. Specific management activities will then be addressed according to their historical application and policy environment, the extent of application of the practice (as it is known or can be estimated), and the known and estimated effects of the management. Management activities listed below are those identified as most influential on current conditions by an interdisciplinary panel of scientists convened early in the project.

- Fire management-Fire management primarily consisted of fire suppression, but controlled burning is presented as well.

- Grazing-Horse, sheep, cattle, and elk grazing practices are presented as are associated range management practices.

- Mining-Methods of mining for minerals and precious metals and for gravel are presented.

- Timber harvest-Three aspects of timber harvesting are discussed: amount and type of harvest systems; equipment used in harvesting; and postharvest fuel treatment. For a description of timber harvest practices, see appendix B.

- Roading and access management-Road, railroad, and bridge construction and maintenance were done with varying degrees of quality control. Access allowed fire protection, insect and disease protection, timber harvest, and recreational opportunities.

- Pest management-Outbreaks of defoliators, bark beetles, and pathogens have been suppressed by various means. Outbreak and suppression histories are discussed.

- Riparian management-Three aspects of riparian management are discussed: flood control, irrigation, and riparian zone management.

- Wildlife management Activities presented include the killing of livestock predators, protecting and enhancing populations of game animals for hunting, protecting and enhancing populations of rare or endangered species, and enhancing habitats (such as by creating snags).

- Wilderness management-Aside from sheep grazing and some other special uses, wilderness areas were left alone, although fires were suppressed.

- Silvicultural operations-Silvicultural operations include those management activities that change stand structure and composition. Recently, silviculture has also been applied to managing landscape patterns. Silvicultural operations discussed include planting, release (weed control), regeneration, thinning, pruning, fertilizing, tree improvement, controlled burning, and other activities.

HISTORY

Pre-1930

Forests in eastern Oregon and Washington in the late 19th and early 20th centuries commonly contained open, parklike structures at low elevations. Frequent ground fires (Hall 1977, Volland and Dell 1981) maintained openness by burning most regeneration. The large trees were primarily fire-resistant ponderosa pine at the lower elevations, Douglas-fir and western larch at middle, and true firs at the higher elevations (LeBarron 1948). On cooler sites and at higher elevations, fires were less frequent; however, where they burned, all or nearly all of the trees were destroyed. Fires that burned hundreds of thousands of acres were common in the late 1800s (Walcott 1900, Gannett 1903) and occurred in northeast Washington as late as the 1920s. Where a hot fire did not destroy all overstory trees and ground fires did not quickly follow, stands of several cohorts (age classes) formed layered canopies with one or several species that resembled mixed-species stands that develop after a single, hot fire (fig. 4, Johnson and others 1993). Shade-tolerant true firs grew into stands and formed a dense understory where fire did not prevent them from doing so.

Forests in 1900 were a mosaic of many structures (fig. 4); open, recently burned areas and areas with dense stands in various conditions of regrowth after the hot fires. Pure or mixed species stands grew after the fires, creating a variety of layered or single-canopy forests. At various times, refugia of old stands were left in burned areas (Hessburg and others 1993) and refugia of open areas within regrown stands (Johnson and others 1993).

Settlements of Eastern Oregon began in 1843 as pioneers followed the Oregon Trail through the Blue Mountains (Skovlin 1991). Settlement of eastern Washington came later and settlement of northeastern Washington by cattlemen, farmers, and sheepherders came later still. Most rural residents lived on small farms, which increased in number until about 1920 to 1940 (U.S. Bureau of the Census). Farming and grazing were the main activities, and logging was limited to relatively accessible areas.

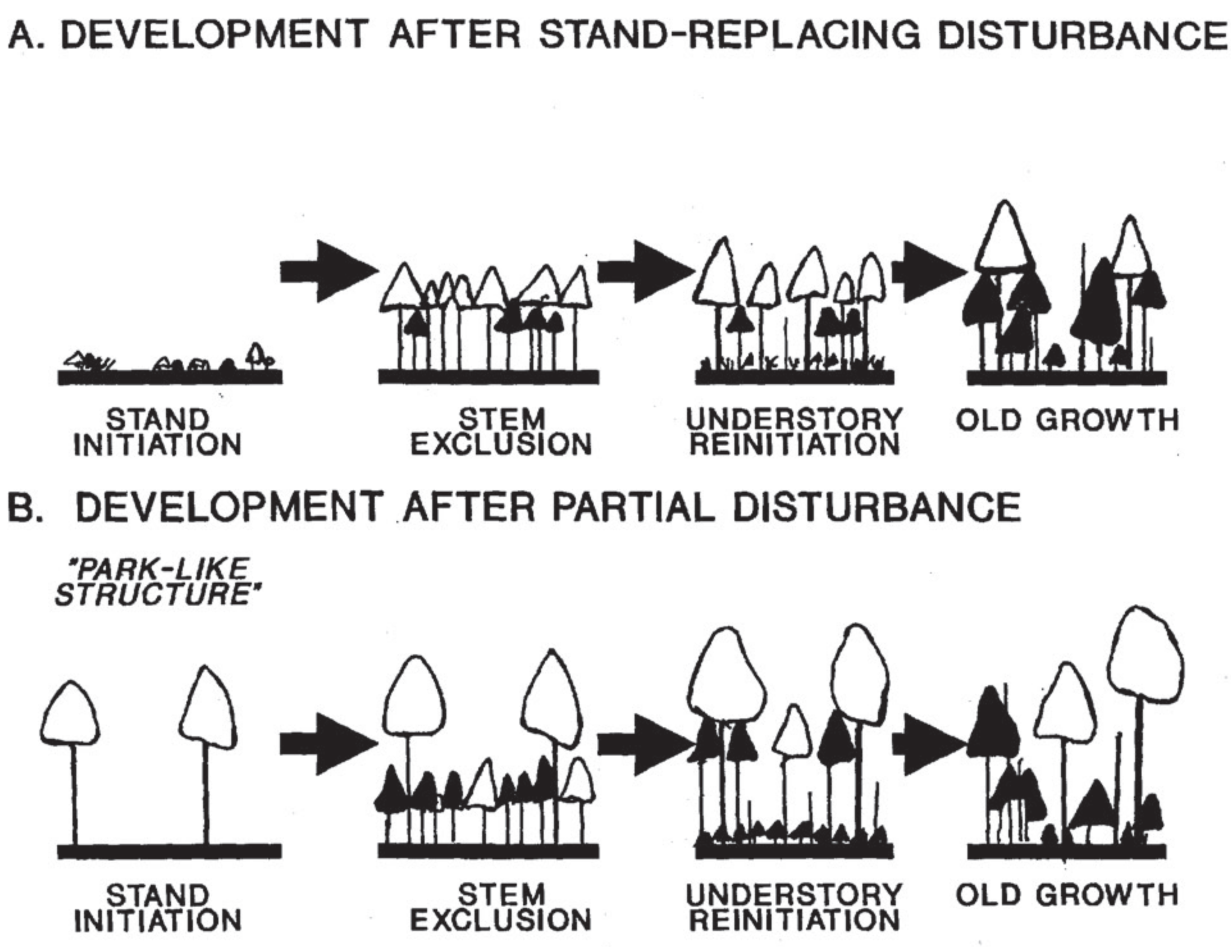


Figure 4. Historically, eastern Oregon and Washington forests developed after both stand-replacing and partial disturbances—usually fires. These disturbances and subsequent forest regrowth produced a variety of structures that were use by different animal and plant species (after Johnson and others 1993).

1930 to 1960

During this time, eastern Oregon and Washington underwent a great transition. Forests had begun to change with regrowth after earlier fires, and management became more intensive and effective on National Forests. Additionally, more and more people moved off the land and into the cities. They also began to view the forest as a source of beauty and thus became more interested in the activities that went on there.

In many places, the forests were similar to those of the earlier decades because harvesting had not been extensive. Some high-graded stands were becoming dense with many layers, and shade-tolerant true fir and other species were becoming more abundant in stand understories. Grazing was extensive in most areas (tables 3A, 3B; figs. 5, 6). Some large areas that had been previously burned were grazed, and others were developing as dense stands (Cobb 1988).

Improved mechanization, access, transportation, and communication meant foresters were able to inspect larger areas. Farm mechanization caused the number of farms and farm laborers to decline dramatically (U.S. Bureau of the Census), although farm size increased.

Rural land use and population changed dramatically. Some activities declined and others increased. Sheep grazing, for example, reached a peak, then declined (fig. 6), while cattle grazing and irrigation continued to increase. Trucks and automobiles continued to replace horses, and hydroelectric plants generated electricity. (Wissmar and others 1993).

1960 to the Present

Several decades of successful fire prevention have allowed a younger class of shade-tolerant tree species to grow beneath seral overstories, creating dense, closed stands. These stands, along with previously high graded stands, contain multiple cohorts and canopy layers, making them increasingly susceptible to diseases and insects. Stands growing after the fires during the late 1800s and early 1900s are overcrowded, as are the stands planted and thinned to close spacings in the 1950s and 1960s. Only small areas remain in meadow and grassy understories and open parklike stands in the forest are rare (fig. 7).

Land use has changed dramatically. The area of National Forests in either wilderness or spotted owl reserves (tables 3A, 3B, fig. 5) is much greater than the area grazed or harvested in the two subsample basins.

Table 3A. Extent of management activity per million acres for. sampled area in Yakima Drainage Basin. (Data available for subsample of about 350000 acres or less depending on activity.)					
ACTIVITY FIRE SUPPRESSION	**Pre-1900**	**1900-1920**	**1921-1945**	**1946-1966**	**1967-1992**
fire starts	20	2,529	1,337	811	1,828
# suppressed	NA	1,581	26,011	811	1,828
lightning fires	NA	92	520	305	644
human fires	NA	1,469	1,044	506	1,184
av. wildfire ac.	NA	248	135	31	40
tot. ac. burned	NA	95,383	2,075	4,833	18,790
TIMBER HARVEST					
ac. clearcut	NA	NA	1,976	11,588	16,375
ac. shwdlshdtr	NA	NA	3,161	1,877	40,975
ac. thinned	NA	NA	1,976	118	10,591
ac. sel. harv.	NA	NA	208,475	11,427	19,040
ac. tractor yd.	NA	NA	164,646	10,666	28,762
ac. cable yd.	NA	NA	0	7,566	22,306
tot. MBF	NA	NA	265,640	461,616	931,171
major spp. harv.	NA	NA	NA	PP DF	DF WL
GRAZING					
Sheep					
# sheep	NA	55,403	56,409	30,433	8,231
ac. grazed	NA	288,998	338,525	306,339	240,592
AUMs allotted	NA	16,927	21,685	10,680	6,626
Cattle					
# cattle	NA	3,964	4,220	1,877	3,519
ac. grazed	NA	212,235	178,312	195,130	199,902
AUMs allotted	NA	11,096	15,343	5,485	6,049
Elk					
# elk	NA	NA	NA	NA	NA
ac. grazed	NA	NA	NA	NA	NA
AUMs allotted	NA	NA	NA	NA	NA
ROADING					
mi. railroads	26	53	53	53	0
mi. roads	99	176	290	672	2,251
RESERVE AREAS					
ac. wilderness	NA	NA	NA	65,303	318,525
Mother	NA	NA	66,323	192,644	181,193
ac. WL/plant habitat	NA	306	NA	153	227,474
MINING					
# active claims	NA	NA	20	112	1,105
# prodt. claims	NA	NA	NA	NA	NA
ac. of claims	461	5,381	4,505	2,012	19,489
ac. by streams	NA	2,305	NA	NA	NA
FLOOD/IRRIGATION					
dams installed	NA	13	NA	NA	NA
mi. dikes installed	NA	NA	NA	NA	NA

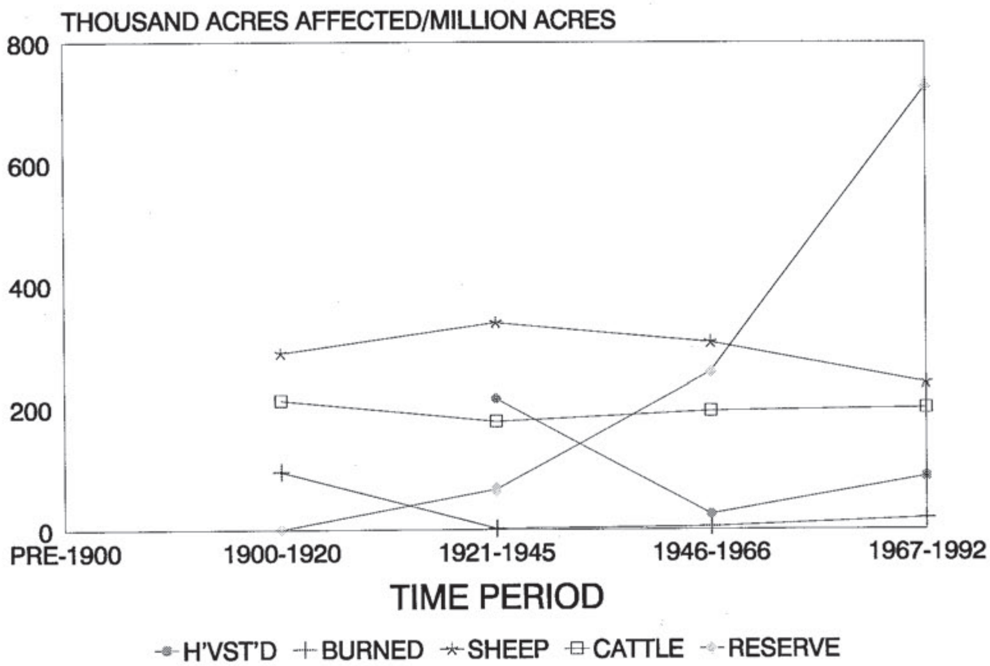
1 Values vary because of differences in areas of available information.

Table 3B. Extent of management activity per million acres for sampled area in Grande Ronde Drainage Basin. (Data available for subsample of about 350000 acres or less depending on activity.)

ACTIVITY FIRE SUPPRESSION	PRE-1900	1900-1920	1921-1945	1946-1966	1967-1992
fire starts	46	75	203	651	1,382
fires suppressed	46	781	203	651	1,382
lightning fires	521	46	110	496	1,034
human fires	7	33	92	145	348
av.wildfire acres	282	192	2	1,039	1,050
tot. acres burned	1,971	7,826	4,385	17,368	45,383
TIMBER HARVEST					
acres clearcut	0	0	0	6,9 09	3,213
acres shwdlshdtr	0	0	0	11,604	37,216
acres thinned	0	0	0	5,992	22,651
acres sel.hvst.	0	0	32,435	17,963	27,031
acres tractor yd.	0	0	0	35,025	61,020
acres cable yd.	0	0	0	668	14,010
total M bd.ft.	0	0	729,782	53,973	717,532
major sp.hvstd.	NA	NA	PP	PP	PPDFWLGF
GRAZING					
Sheep					
# sheep	NA	301,153	420,253	510,535	327,062
acres grazed	NA	258,360	67,452	171,684	190,726
AUM's allotted	NA	107,484	93,273	470,518	1,653,176
Cattle					
# cattle	NA	190	59,363	66,139	368,429
acres grazed	NA	948	76,184	232,139	452,784
AUM's allotted	NA	1,137	444,277	414,294	1,536,512
Elk					
# elk	NA	0	0	352,543	1,891,434
acres grazed	NA	0	0	711,831	711,831
AUM's allotted	NA	0	0	2,115,258	11,348,605
ROADING					
miles railr'd	45	72	167	84	84
miles road	139	287	722	1,363	2,964
RESERVE AREAS					
acres wildern's	0	0	5,459	151,802	249,746
acres other	0	519,883	201,933	557	557
acres WL/pl hab.	0	0	0	0	5,489
MINING					
# active claims	123	357	168	0	8
# produc'g cl'ms	0	0	0	0	0
acres of claims	1,949	3,790	3,358	0	56
acres near stream	0	0	0	0	0
FLOOD/IRRIGATION					
# dams installed	0	0	3	0	0
miles dikes inst'd	0	0	0	0	0

1 Values vary because of differences in areas of available information.

MANAGEMENT ACTIVITY CHANGE BY AREA AFFECTED YAKIMA DRAINAGE BASIN SAMPLE



MANAGEMENT ACTIVITY CHANGE BY AREA AFFECTED GRANDE RONDE DRAINAGE BASIN

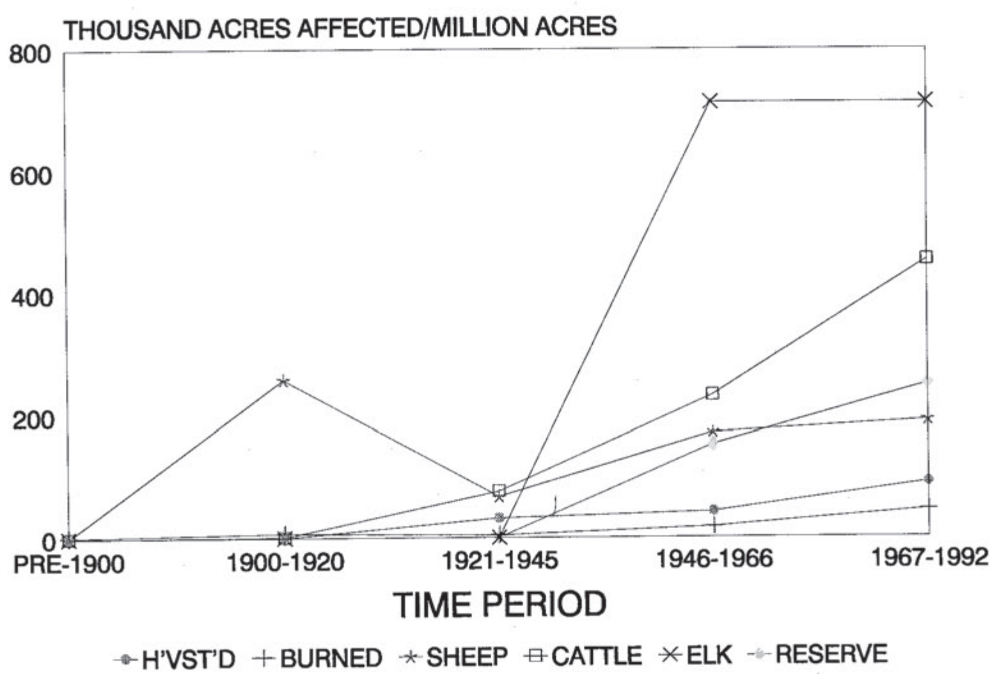
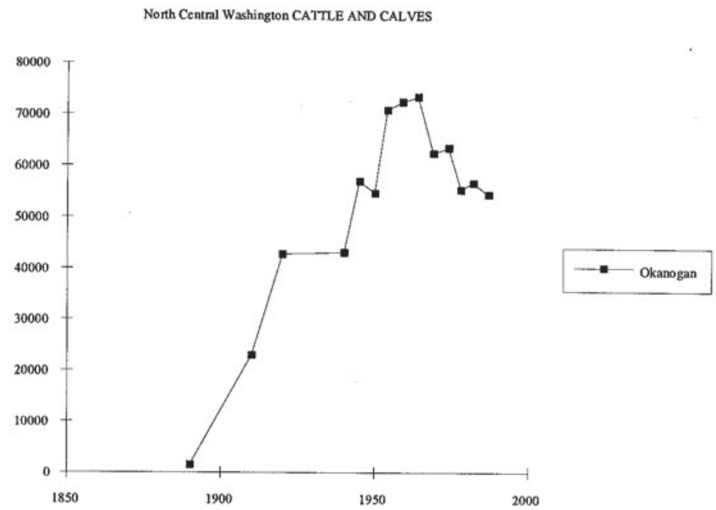
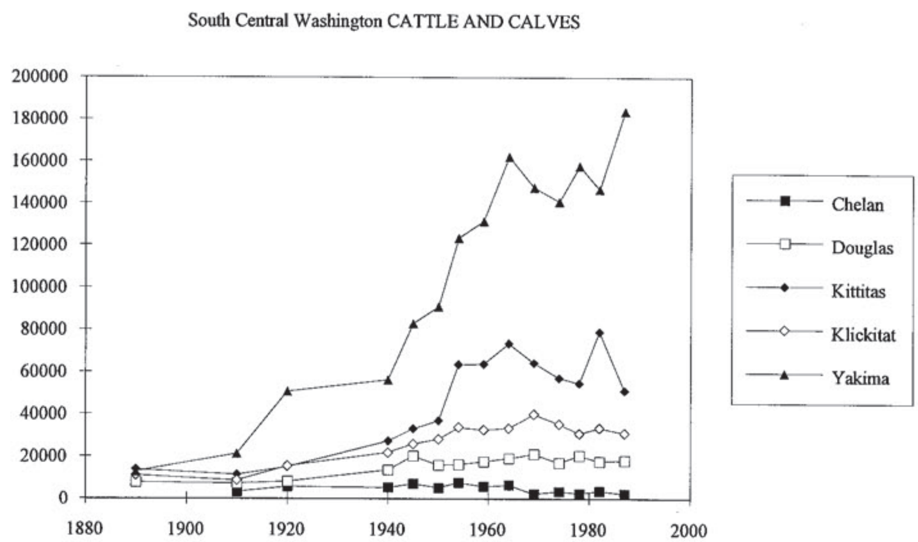


Figure 5. Change in acres affected by management activities in subsampled Yakima (5A) and Grande Ronde (5B) basins. (See fig. 1; tables 3A, 3B.)





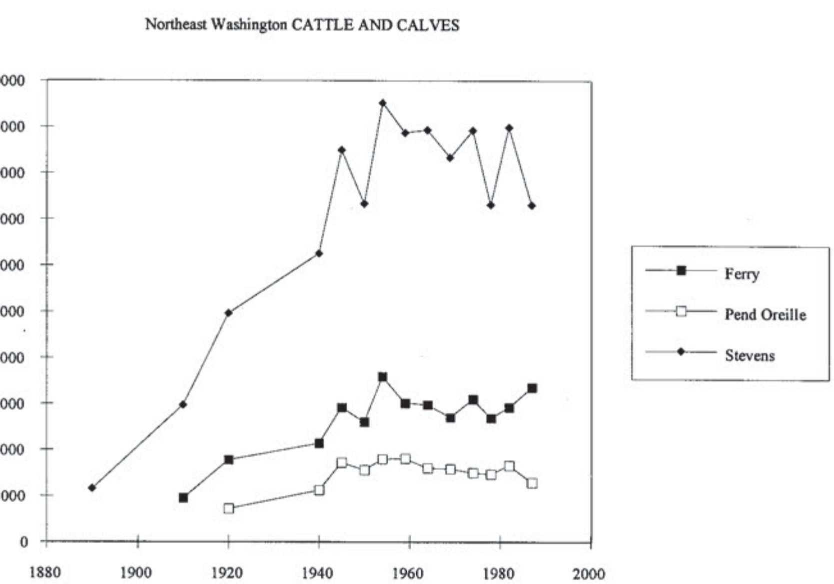
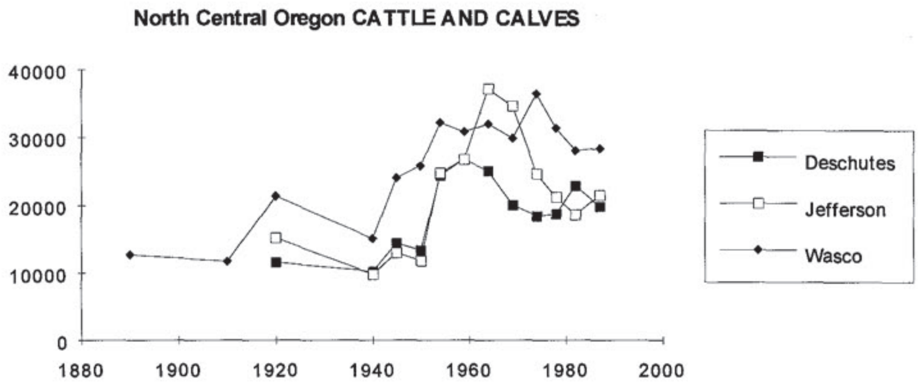
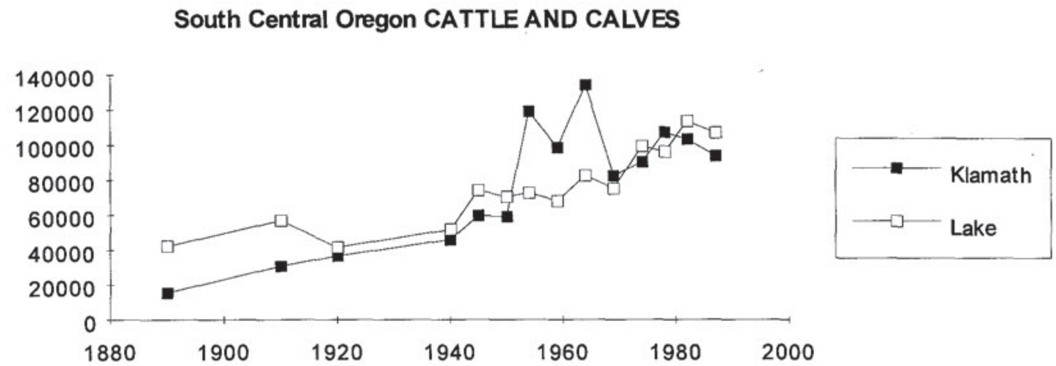
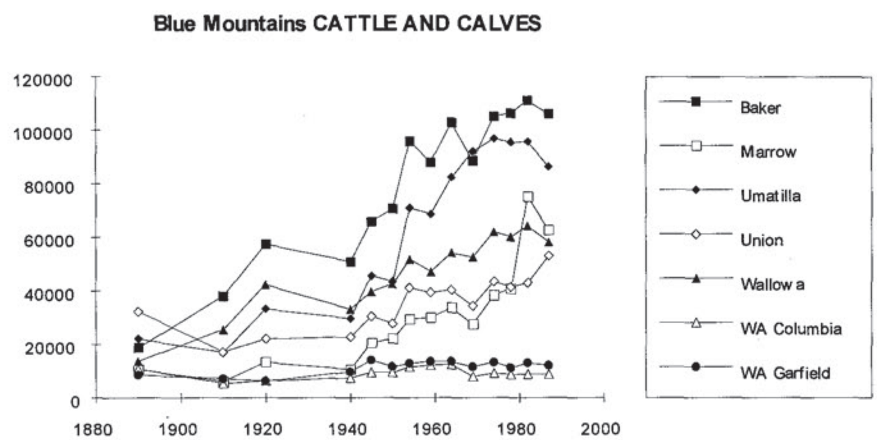


Figure 6A. Changes in cattle in eastern Washington during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; however, the trend shows changing pressure on use of forests for grazing. Number of cattle and calves has generally increased in eastern Washington.







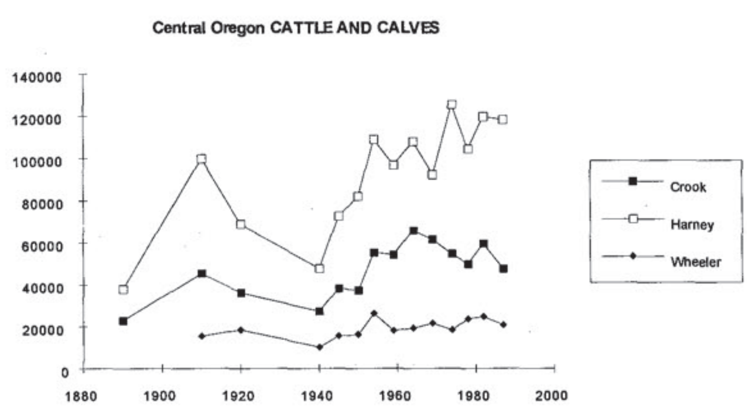
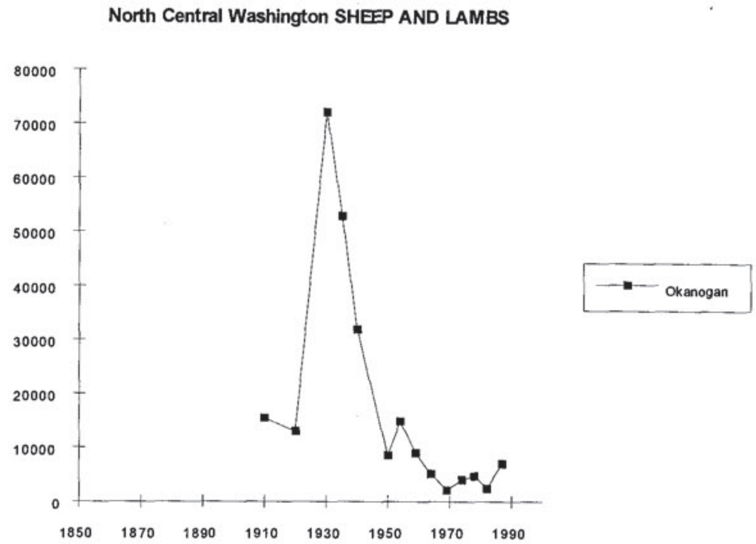
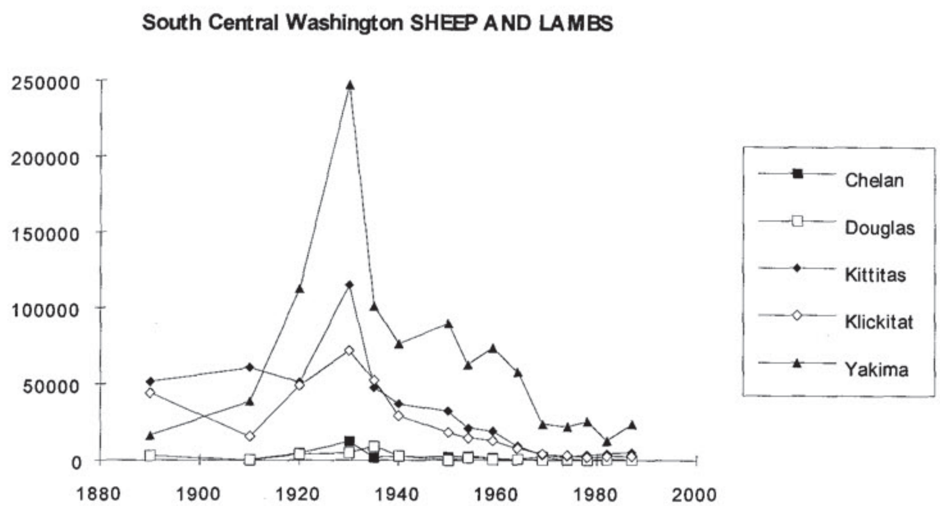


Figure 6B. Changes in cattle in eastern Oregon during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; howèver, the trend shows changing pressure on use of forests for grazing. Number of cattle and calves has generally increased in Oregon in the past century.





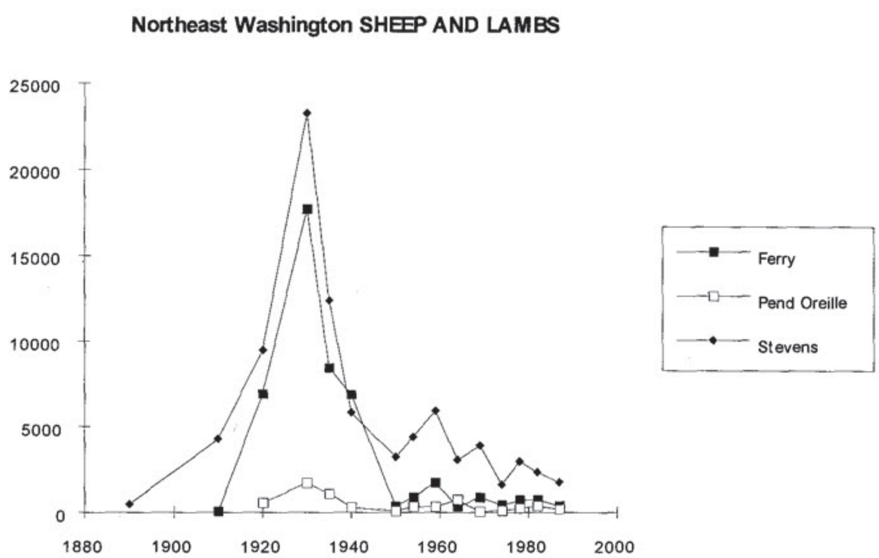
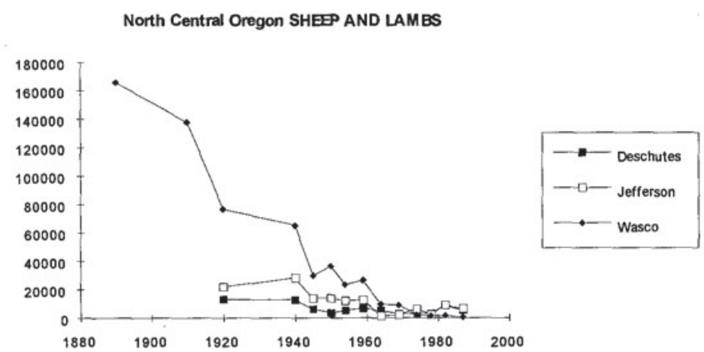
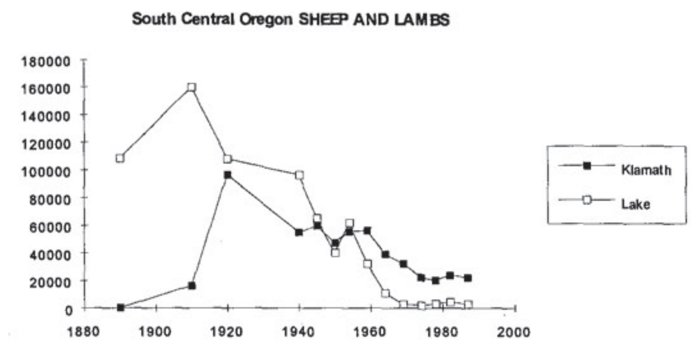
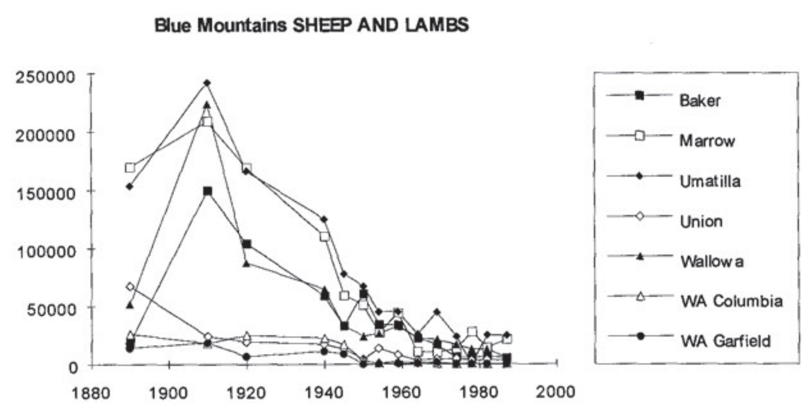


Figure 6C. Changes in sheep in eastern Washington during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; however, the trend shows changing pressure on use of forests for grazing. Number of sheep and lambs increased until about 1935, then decreased dramatically.







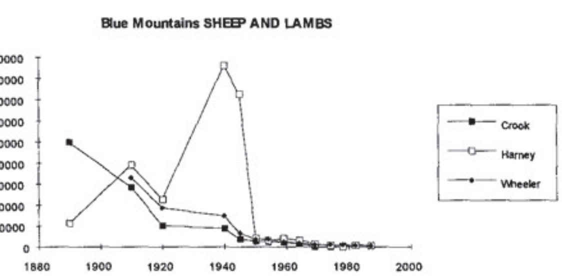
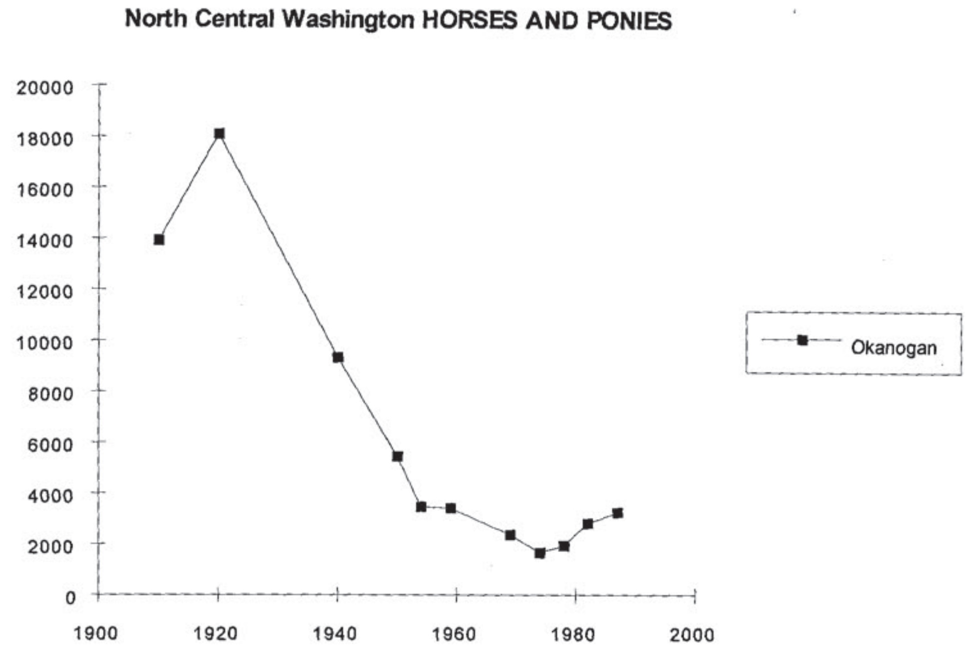
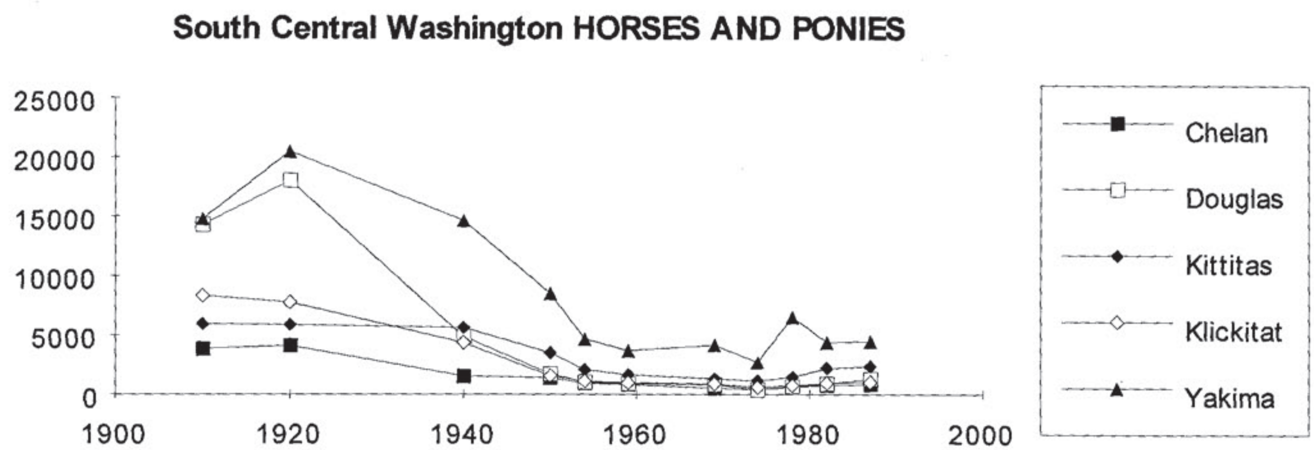


Figure 6D. Changes in sheep in eastern Oregon during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; however, the trend shows changing pressure on use of forests for grazing. Number of sheep and lambs increased until about 1935, then decreased dramatically.





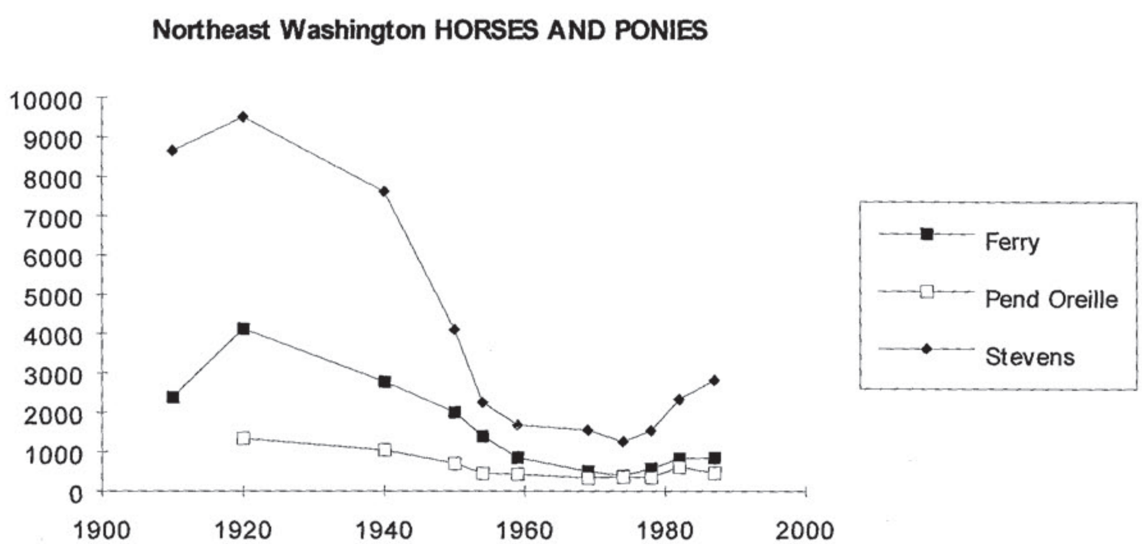


Figure 6E. Changes in horses in eastern Washington during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; however, the trend shows changing pressure on use of forests for grazing. Number of horses and ponies has decreased dramatically during the past century.

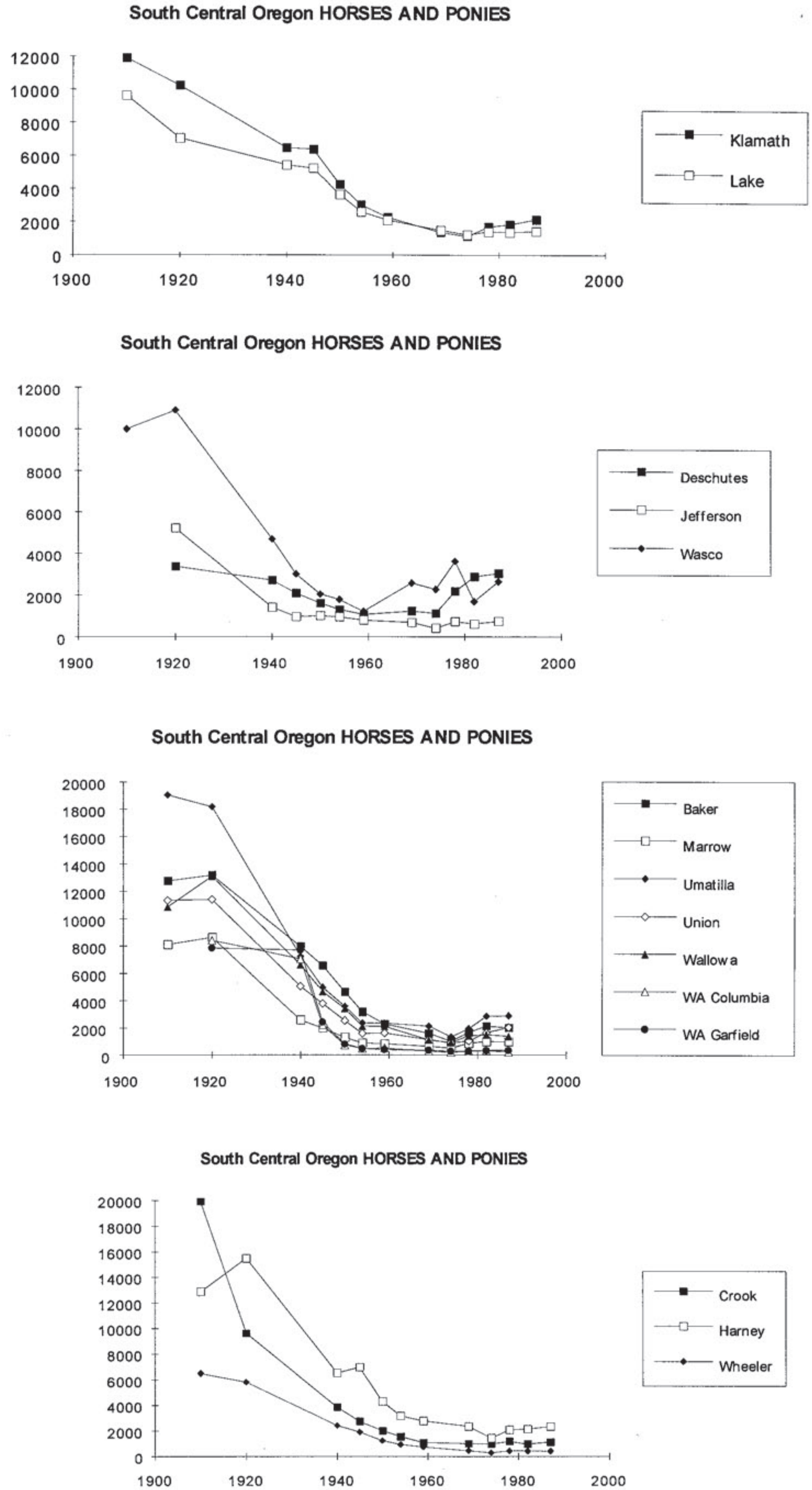
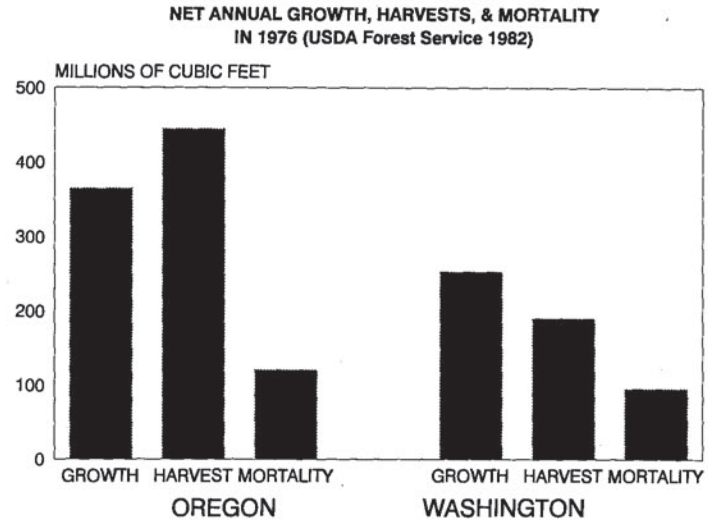
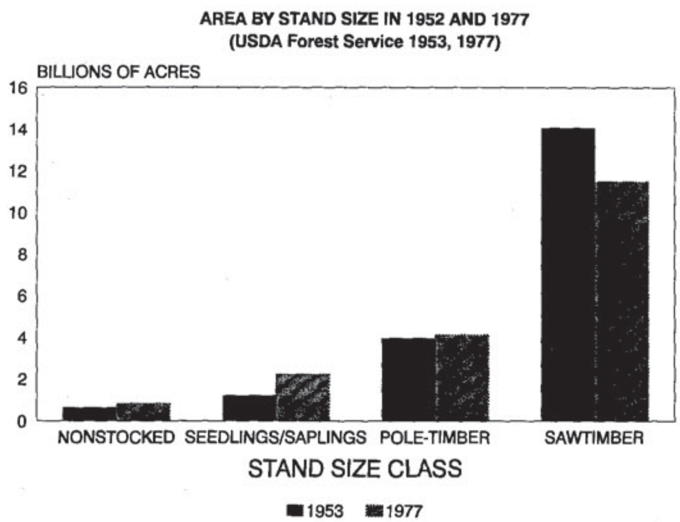


Figure 6F. Changes in horses in eastern Oregon during the past Century (U.S.Bureau of the Census). Not all animals were grazed in forests; however, the trend shows changing pressure on use of forests for grazing. Number of horses and ponies has decreased dramatically during the past century.





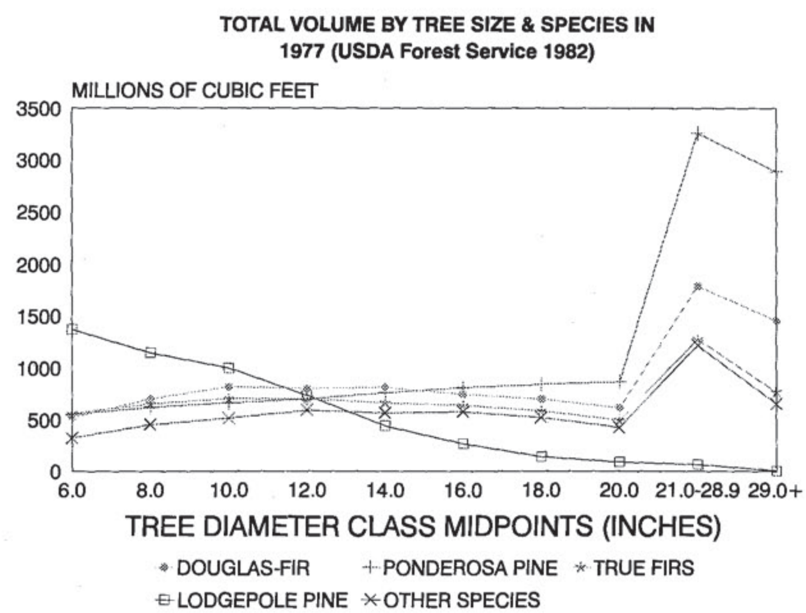


Figure 7. Effects of more intensive harvesting since the 1950s. (USDA Forest Service 1982). 7A: Mortality is still occurring—probably through suppression, insects and diseases, and fires. 7B: More area contains stands of small, crowded trees in the stem-exclusion stage (fig. 2). 7C: Trees of large diameters are still living in many places.

HISTORY OF MANAGEMENT PRACTICES

Fire

Pre-1930-People living in eastern and western Washington and Oregon in the late 19th century and early 20th century may have been responsible for large fires that swept through the forest at that time. Studies of regional fire patterns, however, suggest that fires also occurred naturally and in cycles (Agee 1993).

Ground fires that maintained parklike stands burned frequently at lower elevations. They were supplemented with settlement fires, early logging fires, and fires set by sheep and cattle herders when they left in the autumn to "green up" higher elevations for the next year (Plummer 1902). Early settlers complained about the smoke caused by these fires, and conservationists were concerned about loss of timber.

Forest Reserves-forerunners to National Forests-were created in 1891. A forestry commission was organized in 1896 to study the condition of the Forest Reserves and to suggest how they might be protected from fire (Steen 1976). Actual provision for management of the Reserves was made in the Organic Act of 1897; the precise meaning of "protection" and "management" evolved through time.

Fire suppression primarily protected resources and private property. Fire protection was recognized as necessary for investment in forest regeneration. Fires in western Washington in 1902 prompted the appointment of a State Fire Warden in 1903, and a State board of forest commissioners, formed two years later, was responsible for eastern and western Washington forests. Private groups contributed too, culminating in the Western Forestry and Conservation Association. The Federal government assisted States in forest protection through the Weeks Law of 1911 (Steen 1976). The Clarke-McNary Act of 1924 expanded on the Weeks Law and allowed further cooperation and funding among States and private landowners for fire protection.

One major obstacle to fighting fires was the enormous cash outlay needed to fight them. A single large fire had the potential to bankrupt a national forest. To prevent this, Congress passed an Act in 1908 that permitted the Forest Service to "deficit spend" in the event of forest fire emergencies (Agriculture Handbook 453 rev. 1983). The large fires of 1910 tested the Act, and the resulting deficit expenditures were approved by Secretary of Agriculture James Wilson. As a consequence, a system of double accounting was created: one set of economic criteria was applied to normal fire seasons, another to those seasons with major fires.

Another obstacle to fighting fires effectively was the lack of an organization and infrastructure. Forest Service permittees at the turn of the century were obligated to fight fire without compensation whenever their permit area was threatened. National parks could rely on U.S. Army troops to aid in fire suppression, but forest reserves had no ready pool of fire fighters (Pyne 1982). Fire guards were often called for small fires, and paid only for those days when they were working in the field.

The debate between those advocating strict control of all fires and those favoring "light burning" or prescribed fire began as early as the late 1800s when, for example, proponents of light burning in California spoke out in print (Pyne 1982), and they developed a following in areas with large expanses of pines, including eastern Oregon. The concept was favored by timber owners and others who saw light, periodic underburning as a method to reduce fuels, and therefore future conflagrations. Opponents saw the practice as nothing less than forest destruction because even "light" fires reduced humus and burned up reproduction.

Light burning was viewed by many in the Forest Service largely as a folk practice and not of any use to professional foresters. Systematic fire protection was called for by many of the agency's top officials. Coert duBois, an early Regional Forester, published *Systematic Fire Protection in the California Forests* in 1914, considered at the time to be the book on fire protection (Pyne 1982). His work helped give conceptual design to a Division of Fire Control created in 1915. Stuart Bevier Show and E.I. Kotok provided an almost constant flow of studies supporting the view that all fires damaged forests and should be suppressed while they were still small (Pyne 1982).

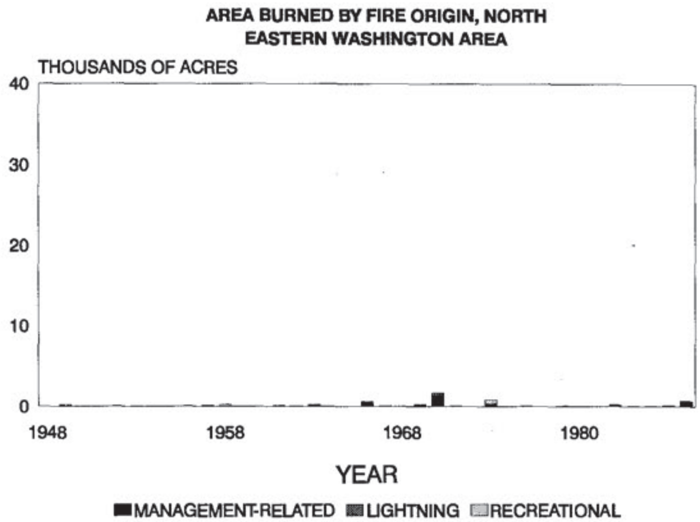
Lack of roads, mechanization, and an infrastructure of professionals and laborers limited early success with controlling fires. Tables 3A and 3B and figure 5 show that fires burned in some areas during this time. Fires covering hundreds of thousands of acres occurred in north-central Washington about 1900 ar in northeastern Washington in the 1920s. Major fire complexes in 1902 and 1910 were particularly influential. The 1910 fires, in fact, so traumatized the Forest Service that they helped shape the Agency fire policy for over 30 years.

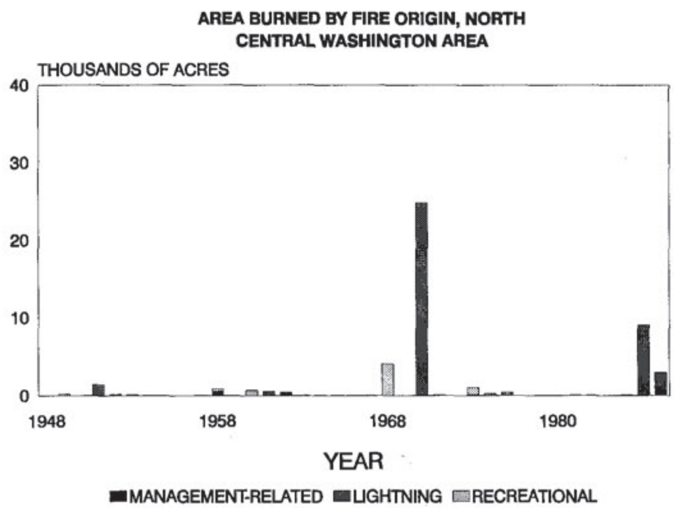
Early attempts at fire suppression successfully stopped many small ground fires near settled areas, and prevention efforts reduced the number of human-caused fires through a public relations program. Stands regrowing after burns of the late 19th and early 20th centuries did not have frequent ground fires to space trees; consequently, these stands are now overcrowded and susceptible to insects, diseases, and fires.

1930 to 1960-Fire prevention efforts became more intensive and effective with an expanded and improved road system. In 1933 the Civilian Conservation Corps (CCC) was created, which provided firefighting crews and presuppression programs, including roads. Chief Forester Silcox wrote in the 1936 annual report, "Perhaps the largest and most important contribution the Civilian Conservation Corps has made during the three years of its existence, has been in protecting the forests from fire" (Dyne 1982). Other specialty crews later supplemented and then replaced the CCC. The most important were smokejumpers, a corps especially adept at initial attack and the 40-man crew (later reduced to 20 firefighters and hotshots), a rapid deployment force for campaign fires. At about the same time, the Office of Civilian Defense organized the Forest Fire Fighters Service (FFFS). In 1961, after some experimentation with smoke jumpers, the Interregional Hotshot or IR crew program developed. It was composed of 20-man units that could be sent anywhere in the country to fight a fire. Cooperation among State and Federal agencies in fire fighting was enhanced through the Cooperative Forest Fire Prevention program (CFFP) begun in 1942. At the same time State and private industry created the "Keep America Green" program, which was initiated in the Northwest.

In 1935, flushed with CCC manpower and the Conservation programs of the New Deal, Chief Forester Silcox promulgated the so-called 10 a.m. policy, "an experiment on a continental scale" to break wildland fires in one massive effort. This policy stipulated that all fires must be controlled by 10 a.m. the next day. Efforts to promote prescribed burning continued to be dismissed. Not until 1943, did the Forest Service officially sanction even limited burning.

The fire- prevention activities have generally been described as successful. Nearly all fires that were started were suppressed and many traditional forms of burning were eliminated, but the total number of acres burned fluctuated greatly (tables 3A, 3B; figs. 5, 8), as did the total numbers of fires. Fires were small and frequent in eastern Oregon, and large and infrequent in eastern Washington (fig. 8). The proportion of the total forest area burned between 1946 and 1986 (table 4) is much less than the usual fire return interval (Agee 1993), indicating the period had relatively few fires. How much of the reduced fire frequency can be directly attributed to fire fighting efforts, and how much is the result of previous decades of large fires and grazing reductions to fuels is difficult to determine.





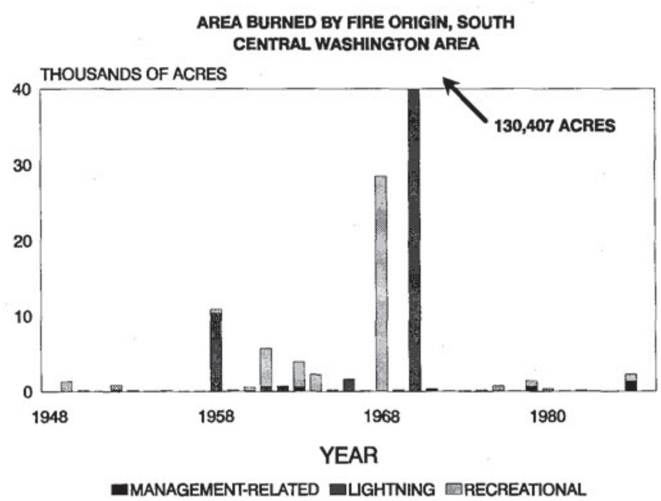


Figure 8A. Area burned in subregions (corresponding to fig. 1) of eastern Washington from 1948 to 1986. Fires were more frequent, but not as catastrophic in drier, southern areas. Northeastern Washington probably had few fires because much of this area was burned in the 1920s. ("Management-related" refers to escaped slash disposal burns, equipment-started, and railroad-started fires; "Recreational" includes campfires and smoking-caused fires.) (USDA Forest Service 1948-86)

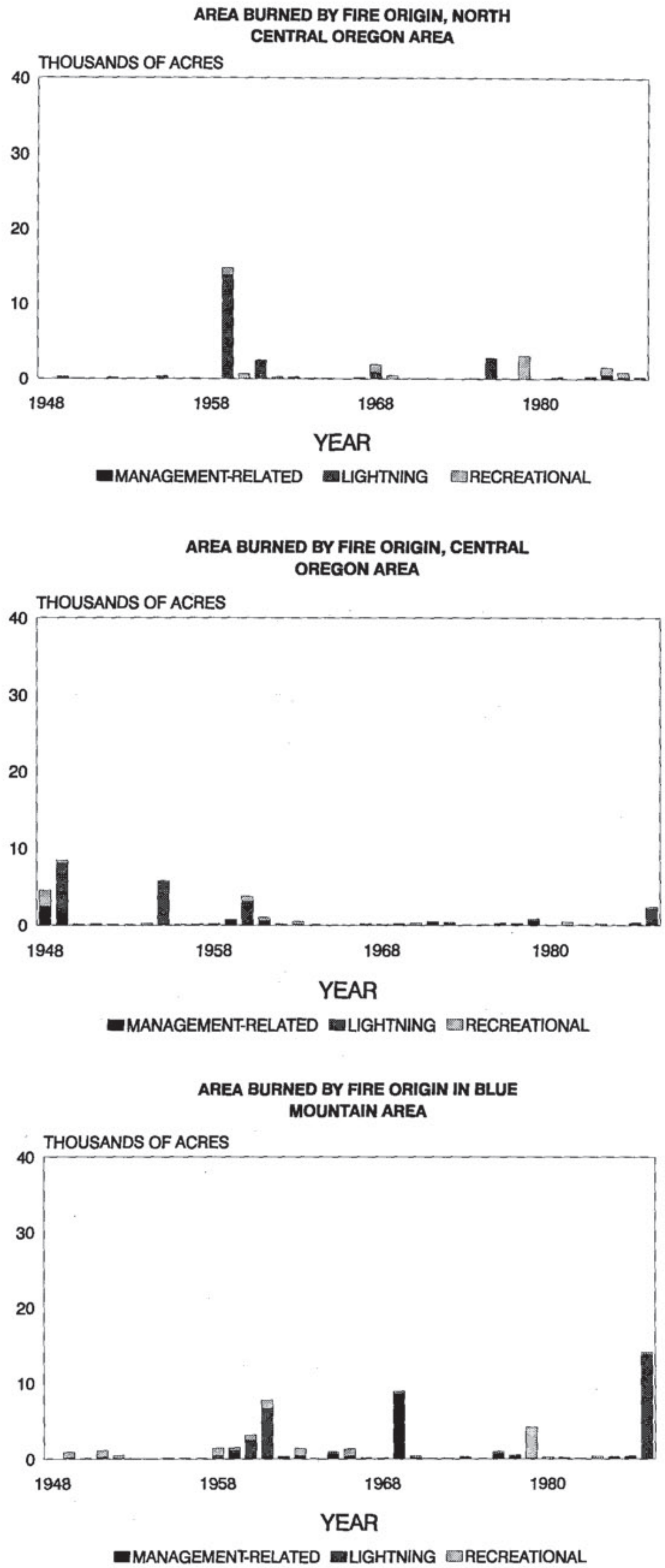


Figure 8B. Area burned in subregions (corresponding to fig. 1) of eastern Oregon from 1948 to 1986. Fires were more frequent, but not as catastrophic in drier, southern areas. Northeastern Washington probably had few fires because much of this area was burned in the 1920s. ("Management-related" refers to escaped slash disposal burns, equipment-started, and railroad-started fires; "Recreational" includes campfires and smoking-caused fires.) (USDA Forest Service 1948-86).

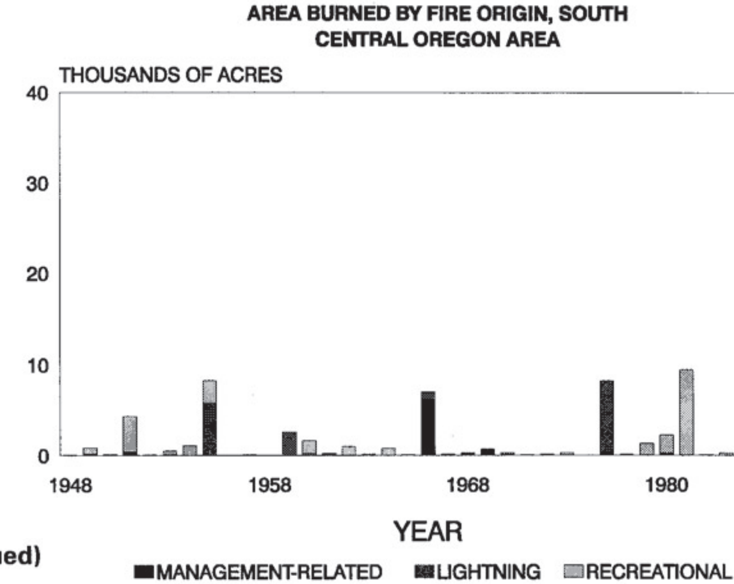


Figure 8B (continued)

Table 4. Cumulative total and percent of area burned between 1948 and 1986. (from USDA Forest Service 1948-1986).

SUBAREA (Table 1)	AREA OF NAT. FOR.	AREA BURNED 1945-1986	% OF TOTAL N. FOR. AREA	EST.FIRE1 RETURN INT.
N.E.Wash.	1,028,162	6,360	1	6,300 yr.
N.C.Wash.	1,536,958	58,420	4	1,000 yr.
S.C.Wash.	1,908,006	211,955	0	350 yr.
N.C.Oreg.	1,852,497	39,807	2	1,800 yr.
S.C.Oreg.	2,811,379	57,244	2	1,900 yr.
Cent.Oreg.	2,520,069	43,650	2	2,250 yr.
Blu.Mtn.	3,902,252	237,728	6	650 yr.

1 "Estimated fire return interval" assumed area burned between 1945 and 1986 is normal for 39-year period. In fact, fire return interval is much shorter; therefore, fires were (and will be) more frequent in long term.

Fire prevention allowed fuel buildup and development of dense stands susceptible to bark beetle attacks (Hessburg and others 1993), which in turn created more dry fuels and greater fire risk. Prevention of small fires may result in large, uncontrolled fires such as the ones in 1970 that burned in south-central Washington, north-central Washington, and Canada (fig. 8).

1960 to the Present-Since 1945, an average of about 9500 acres have burned annually in eastern Oregon and about 7000 acres in eastern Washington within National Forest boundaries (table 4), but these wildfires have not occurred regularly or evenly across landscapes; some years had essentially no fires; in others, vast areas burned (fig. 8). In the 40 years 1946-1986, between 0.6 percent and 11 percent of each subarea (fig. 1) of eastern Oregon and Washington has burned (table 4). If these low burning rates are to be maintained, eastern Oregon and Washington are presently on fire "cycles" of 6300 years in northeastern Washington, 350 years in south-central Washington, and 640 years in the Blue Mountains-much longer than occurred before fire protection began in the 1930s.

Maintaining this low fire frequency is unlikely without far more intensive effort and investment than is presently applied. Low fire frequency between 1940 and 1985 is partly because of fire suppression and partly because many forest areas burned in the decades before 1940, and so have been resistant to fires until recently. For example, hundreds of thousands of acres of forests burned in northeastern Washington in the 1920s and 1930s, accounting for a reduction in fires there until the 20,000-acre White Mountain fire in 1988.

A call for a reformed burning policy came with the 1963 Leopold Report, the 1964 passage of the Wilderness Act, and from a series of fire ecology conferences organized by the Tall Timbers Research Station from 1962 through 1975. Backers of wilderness legislation noted the beneficial role of fire, but the Tall Timbers Conferences focused on the beneficial role of prescribed fire in various environments. In 1967, the National Park Service revised its policy to encourage more fire, while the Forest Service reaffirmed the 10 a.m. policy for normal fire seasons, but allowed variance for some pre- and post-season fires. In 1971, the basic policy was amended by adding a 10-acre presuppression policy, the goal of which was to plan for the control all fires at no more than 10 acres. But policy also allowed for free-burning prescribed fires in select wilderness areas.

The 10-acre policy resulted in a wild surge of pre-suppression costs (Pyne 1982), but did not effectively reduce the average number of acres burned. With the increased costs, accumulating fuels and new ecological perspectives on fire, the use of prescribed fire began to look more attractive, and a new fire policy alternative was adopted at a Regional Forester Conference in 1977, becoming Forest Service policy in 1978. The revised policy encouraged fire by prescription and provided alternatives to wildfire the suppression if initial attack was unsuccessful. Current Forest Service policy says nothing about 10 a.m. rules or 10-acre minimum incident areas (Chapter 5130, Forest Service Manual).

Preventing wildfires completely is now widely recognized as impossible unless fuels are reduced. Without preventive silvicultural operations such as thinning and prescribed burning, large uncontrolled fires, such as the one in 1970 in south-central Washington, will periodically occur (fig. 8). Increasing human population and concerns about smoke pollution are making burning restrictions tighter which discourages prescribed burning. Even if begun now, a major effort would be needed to minimize current fuels through harvesting, controlled burning, or a combination of practices. With such mitigation activities, natural fires would burn smaller areas with less intensity. Without them the prospect is that fires will be more intense, frequent, and damaging.

Smoke volume and direction can be managed in prescribed fires by using proper timing and ignition techniques. If managed fires are to be used to avoid uncontrolled wildfires, the current restrictive smoke guidelines are likely to need revision

Many factors complicate any attempt to restore fire-legal liability, public suspicion, the removal of smoke, housing developments, the buildup of fuels, and the changed environment itself. Fire exclusion did not, by itself, cause all problems, and fire's return will not, unaided, restore an earlier landscape. Any reintroduction must accompany other practices and it must guard against escaped fires and unrestricted smoke.

Grazing

Pre-1930-Livestock were brought to eastern Oregon and Washington in the 1840s via the Oregon Trail, and cattle herds were well distributed by the 1880s. At that time, many parts of eastern Oregon and Washington were covered with lush grasses. Evidence of extensive range use was observed as early as the 1870s (Gordon and others 1883). Elk were indigenous to the Columbia Basin (McCorquodale 1985), but were not common before 1850. Market and subsistence hunting by European settlers nearly exterminated elk by 1900 (Bailey 1936, Shay 1954).

Sheepherders would make an annual migration with their flocks, following the snow from low elevations in the spring to high elevations in the summer, and back to low elevations in the autumn. Sheep grazing created enmity between the cattle ranchers and sheepherders because the sheepherders were often itinerants and because conventional wisdom held that sheep destroyed the range and streamsides.

The Forest Reserve Act of 1891 resulted in the first Federal regulations on livestock grazing in 1895. New regulations banned sheep grazing on Forest Reserves in the West, except in Oregon and Washington (Coville 1898). As a result, western sheepherders brought their herds to the Northwest (Carter 1990). As early as 1898, the National Academy of Sciences (1898) judged that such unregulated grazing led to widespread destruction of forage resources.

Livestock grazing on National Forests was sanctioned after creation of the Forest Service by the Transfer Act of 1905 (USDA Forest Service 1905). From 1903 to 1914, sheep and cattle ranchers supported range regulations, including fencing to protect range from overuse (Steen 1976). Grazing fees and other regulations were established in 1906. Little enforcement was possible, however, and livestock routinely trespassed on mountain summer ranges. Political pressure by powerful stockmen kept grazing fees on National Forests low, thereby severely reducing cash flow from range management, and subsidizing grazing.

Grazing was a primary issue of management. In 1907, 80 percent of the receipts from eastern Oregon National Forests and 40 percent from eastern Washington National Forests were from grazing; most of the rest was from timber sales (USDA Forest Service 1908). The Colville National Forest showed no receipts for this period. Sheepherders followed the large fires into north-central (1890s and 1900s) and northeastern Washington (1920s), where sheep could graze on young stands in the newly created "stand initiation" stage (fig. 2) after the fires.

Figure 6 shows trends in the number of sheep, cattle, and horses in Washington and Oregon counties from 1880 to 1990 (U.S. Bureau of the Census 1890-1990). The data are from census reports for agriculture and do not necessarily indicate numbers of livestock grazed on National Forests. Tables 3A and 3B, and figure 5 show similar trends in selected river basins. Production of domestic sheep generally peaked in eastern Oregon counties between the 1890s and the 1920s, and peaked in eastern Washington counties about 1930 (fig. 7). Tucker (1968) and Forest Service records provided a history of the Wallowa-Whitman National Forest, where livestock use declined by 70 percent from 1911 to 1945. Horses declined in all areas after 1920, as a result of increased use of automobiles.

Technical studies that supported management of Federal grazing allotments began in 1907 (Strickler 1980). The number of livestock grazed on National Forests increased slightly after World War I, reflecting a policy change to increased food production. The new policy led to abusive grazing practices, and the Forest Service allowed stocking "to the most optimistically accepted carrying capacity" (Mortensen 1978, cited in Carter 1990).

Heavy grazing resulted in:

- A general decline in range conditions in eastern Washington and Oregon.
- Excessive use of forage by 1909 on the Cle Elum Ridge area of the Wenatchee National Forest (USDA Forest Service 1909, cited in Carter 1990).
- Feuds among sheep and cattle producers over the dwindling forage resources.
- Removal of highly flammable fuels in some areas, reducing the ground fires that had previously controlled establishment of dense stands of tree seedlings (Hall 1977).
- Setting of fires by sheepherders and cattlemen that spread to other areas.
- Establishment of non-native plants, including noxious weeds in some areas, at least partly as a consequence of high stocking rates and associated loss of stable vegetation cover.
- Siltation of streams and reservoirs.

On the other hand, a thriving wool and meat economy had developed in eastern Washington and Oregon.

1930 to 1960-Several factors combined to dramatically change grazing practices on National Forests. The Dust Bowl and overgrazing made everyone more concerned with regulating grazing, and the Taylor Grazing Act of 1934 gave authority to the USDA Bureau of Land Management to regulate grazing on public rangelands. This law resulted in establishing districts, which coordinated with Forest Service grazing allotments; it also continued to keep grazing fees low. Later, the Granger-Thye Act of 1950 recognized grazing as an official use of National Forests and put the Forest Service in charge of range management.

Sheep herding was more difficult because of range wars, a declining price of wool, fences that restricted herd movements, government subsidies to kill sheep and thereby reduce overproduction, and policies by the King of Spain that increased the costs of keeping Basque shepherds. In addition, a report to Congress in 1935 showed that forage depletion had occurred on most mountain summer ranges in the West (U.S. Senate 1936).

To stabilize Midwest soils in the 1930s, Asian grasses were introduced to rangelands. These grasses were soon introduced to eastern Oregon and Washington as well. Mule deer and elk populations increased as a result of protection and conservative hunting. Hunting for bull elk was authorized in Oregon in 1933, and females became legal game animals in 1939 after 30 years of protection.

The total number of sheep declined dramatically during the 1930s (fig. 6) in eastern Oregon and Washington. The number of sheep in the Yakima River basin declined faster than the area grazed, indicating less grazing pressure on the land; however, the number of sheep in counties of the Blue Mountains continued to be high (tables 3A, 3B; figs. 5, 6).

The number of cattle in eastern Oregon and Washington increased during this period, as did both the number and acres grazed in the Grande Ronde River basin (tables 3A, 3B; fig. 5). The number of cattle in the Yakima River basin declined at a greater rate than the acres grazed, indicating a decline in grazing pressure (tables 3A, 3B; fig. 5).

Decline in grazing pressure allowed some rangeland recovery, although various intentionally and unintentionally introduced grasses grew in many areas, with both positive and negative effects. The effect of grazing on nutrient cycling is unclear, though it has apparently created nutrient shortages in some areas. Less grazing and fewer fires allowed forests to encroach on rangelands (Lehmkuhl and others 1993) and contributed to the development of dense understories of trees in previously parklike stands (fig. 4b).

1960 to the Present-Recent legislation has promoted stronger application of scientific principles for improving rangelands. The Rangelands Renewable Resources Planning Act of 1974 required the Forest Service to offer an assessment of renewable resources every five years beginning in 1975 (Rowley 1985). It also mandated that 50 percent of the fees from livestock use on public lands were to go toward rangeland improvements. The Federal Land Policy and Management Act of 1976 (FLPMA) provided funding for environmental impact statements for livestock grazing in the 11 Western States. The FLPMA also provided for a range-improvement fund, giving grazing on public lands a more secure tenure (Rowley 1985). The Public Rangelands Improvement Act (PRIA) of 1978 developed a stewardship program for combined management of large pilot projects on National Forests and BLM lands. The PRIA also authorized $2 billion for range improvements over the next 20 years. Another 1978 bill, the Forest and Rangelands Renewable Resources Act, authorized USDA research to be conducted on renewable resources (Joyce 1989).

Recently, elk populations have expanded (tables 3A, 3B) into areas where elk had not been common or abundant for at least 100 years, such as the arid lands reserve in central Washington (McCorquodale 1985). Forests have recently adopted recommendations for winter and summer thermal cover to enhance elk distribution (Thomas 1979) and to reduce harassment from heavy recreational use (Skovlin 1982). Habitat effectiveness models (Thomas and others 1988a, 1988b) are now standard for predicting the consequences to elk from forest management alternatives.

Livestock on National Forest allotments in the Pacific Northwest have increased since 1969, primarily as a result of an increase of about 30 percent in permitted cattle use (Joyce 1989: 42; see also tables 3A, 3B); permitted sheep use declined sharply. Livestock use on the Wallowa-Whitman National Forest did not change so dramatically.

Range research after 1960 determined proper seasons of livestock use, developed grazing systems, and set appropriate stocking rates for various ecosystems (Skovlin and others 1976, Svejcar and Vavra 1985). For example, in 1950, fewer than 20 percent of National Forest cattle allotments in eastern Oregon and Washington were managed by systems other than season-long grazing. By 1970, over 60 percent of Federal allotments were managed by deferred rotation systems. Recent research has determined appropriate livestock grazing systems for riparian and wetland habitats (Galen and others 1985, Kauffman 1982, Skovlin 1984).

Application of scientific recommendations has partially restored some rangelands that had been abused (Reid and others 1980, Reid and others 1991, Strickler 1969, Strickler and Hall 1980). The Wallowa-Whitman National Forest (1980, 1981) recently found that rangelands in allotments in two wildlife management units were generally in satisfactory condition. Many allotments in the Snake River and Chesnimnus unit were in unsatisfactory and declining condition, a result of poor livestock management practices before the National Forest was established.

Management of big game populations traditionally kept densities low relative to the capacity of habitat to provide nutritional forage (Thomas and Toweill 1982); however, mule deer populations declined precipitously in the 1960s and early 1970s in eastern Washington and Oregon, similar to patterns in other Western States (Schommer 1991, Workman and Low 1976). Conservative harvests have been instituted, and mule deer populations have not rebounded and continue to show low fawn production in many populations.

Rocky Mountain elk populations increased significantly between 1960 and 1981 in eastern Oregon (Edwards 1992, tables 3A, 3B). Population estimates indicated that the aggregate winter population for 20 management units in northeastern Oregon rose to 58,500 (ODFW 1982). Elk populations in southeastern Washington numbered about 24,000. Oregon adopted management objectives in 1981 that limited the size of some populations. Current elk populations may be as high or higher than any time in history.

Hunter numbers increased with increasing elk populations, and concerns about overharvest led to limited-entry permit hunts for elk in the early 1970s. Concern has also grown regarding vulnerability of elk to hunting, which is influenced by increased hunter access through road building, loss of security cover because of timber harvesting (Christensen and others 1991), and high densities of hunters (Vales and others 1991). As elk populations increased, private landowners complained about damage to their lands (Vavra 1980). On the other hand, wildlife biologists are concerned about heavy livestock use on big game winter ranges in summer and fall (Gowan and others 1989). At some point, an acceptable tradeoff and objectives will be set for productivity of elk herds and cattle in relation to objectives for vegetation composition and productivity.

Mining

Pre-1930-Mining activities peaked at different times on the eastside between 1850 and the present (U.S. Bureau of the Census). Gold and silver mining were prevalent in north-central and northeast Washington in the late 1800s. Mining was prevalent in the Yakima (south-central Washington) and Grande Ronde (Blue Mountains) River basins in the early 20th century (tables 3A, 3B). The Forest Service could not prohibit mining or prospecting, according to the 1902 Manual on Administrative Procedures (U.S. Department of the Interior; Steen 1976).

The extent of early mining was variable. The Yakima and Grande Ronde basin samples show mining before 1920 affecting less than 0.6 percent of the area (tables 3A, 3B). Mining near streams, as in the Yakima River basin (tables 3A, 3B), created problems where running water was used in mining. The result was extreme siltation of streams (Wissmar and others 1993).

1930 to 1960-Mining activities fluctuated during this period, although extensive stream diversion projects aimed at moving mining waste diminished. As road construction increased, gravel was taken from stream and river beds, creating turbid water conditions that adversely affected fish populations (Wissmar and others 1993).

1960 to the Present-Mining is still relatively uncontrolled in National Forests. The 1955 Multiple Use Mining Act returns surface rights of claims to the National Forest unless the claim is proved valid (Steen 1976); however, little regulation is done of the mining itself. Mining effects are addressed by the National Environmental Policy Act.

Mining increased in both subsampled basins in recent years (tables 3A, 3B). Chemical mining (for example, using cyanide with gold mining) has increased concerns about ecosystem hazards. Gravel mining of streams for road-building materials is more restricted to minimize the extreme degradation of fish habitats (Wissmar and others 1993).

Timber Harvest

Pre-1930-Early timber harvest was in accessible areas near settlements, mines, and railroads. Large ponderosa pine and some Douglas-fir were harvested because of their fine wood qualities and the abundance in parklike stands at low elevations.

Timber was to be protected and grown "on land unfit for agriculture," according to the *1902 Manual on Administrative Procedures* (U.S. Department of the Interior, Steen 1976). Specific guides were established for allowing private individuals to harvest timber and for selling it to timber companies.

In 1906, in lieu of paying taxes, 10 percent of the receipts from National Forests were to be returned to the States to benefit public roads and schools. The amount was increased to 25 percent in 1908 (Steen 1976). As National Forest receipts increasingly came from timber revenue, greater incentive was created for local communities to encourage timber harvest. Other values, goods, and services that are currently provided free to the public by the National Forest do not generate receipts or this rate of income to local schools and roads.

Harvest systems-Both uneven-aged methods (selective cutting and high grading) and overstory removal were used in eastern Washington and Oregon. Forests were layered, either because they comprised several fire- or harvest-related age classes, or they were single cohort (even-aged), stratified, and well-differentiated. Both overstory removal and uneven-aged management promoted shade-tolerant species (Agee 1993, Hessburg and others 1993, Johnson and others 1993, Lehmkuhl and others 1993).

Foresters often marked trees susceptible to insect attack for removal, resulting in selective harvesting and overstory removal. Foresters were also occupied with keeping loggers from destroying the forests through their logging practices, although the foresters were often unsure what the best practices were. The lack of silvicultural knowledge was recognized, and many forestry guides were promoted, (for example, Carter 1908; cited from Mustian 1976), as temporary solutions until the foresters could gain more knowledge. Foresters vacillated between promoting even-aged management (shelterwood, seed tree, clearcutting, and overstory removal cutting methods) and uneven-aged management through selective cutting. As much as possible, foresters discouraged uneven-aged "high-grade" logging practices, which were most economical for timber companies. A relatively minor volume of timber was removed during this period compared with later periods.

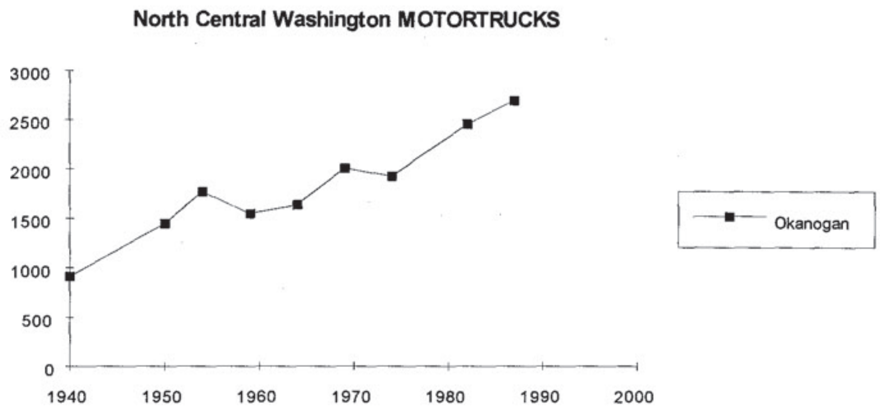
Equipment-Railroad logging was not done in many places in eastern Oregon and Washington because high timber volumes per acre were needed to pay for their installation (Williams 1989). Spur railroads were developed in parts of the Blue Mountains, and ox teams yarded logs to these spurs (Skovlin 1991). Smallgauge railroads in south-central Washington also suggest that some railroad logging was done there (USDA Forest Service 1908). Logging was sometimes done with splash dams, streams were temporarily dammed, the resulting reservoirs filled with logs, and the dams were opened to allow the logs to flow downstream with the ensuing flood (Skovlin 1991). Such practices severely altered streams and riparian zones.

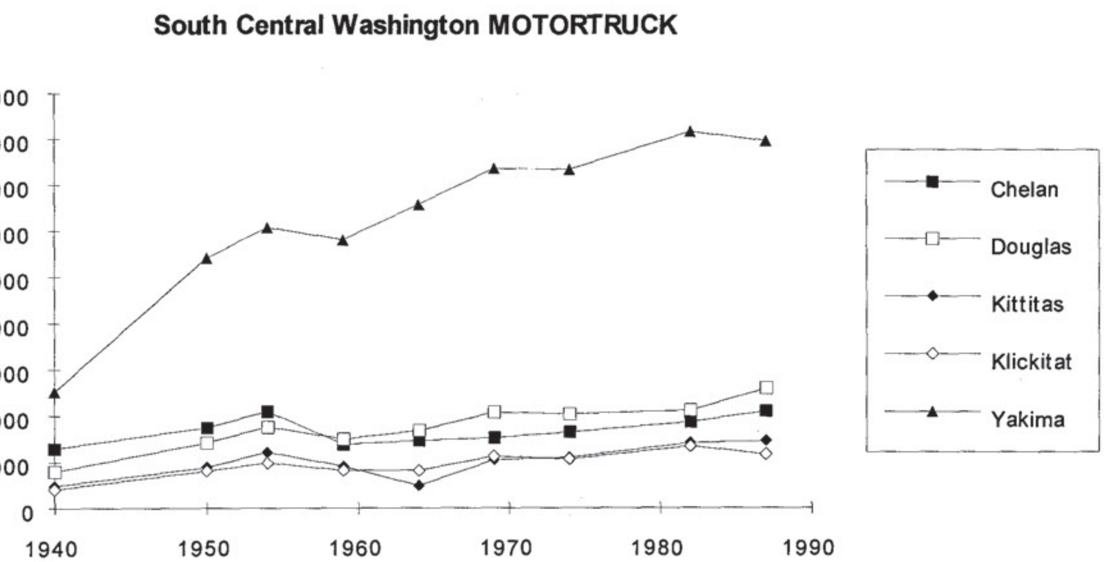
Post-harvest fuel treatment-Although controlled slash burning was practiced by the Forest Service in western Washington and Oregon during this period, the few clearcut stands in eastern Washington and Oregon (tables 3A, 3B) did not allow as much opportunity for controlled burning. This lack of burning to reduce logging slash, combined with dry growing seasons and slow rates of decay, produced the current high fuel loads.

1930 to 1960-Because trucks made trees easier to get to (fig. 9), and the newly invented chainsaw made cutting trees down easier, timber harvest increased in eastern Oregon and Washington during the late 1940s and early 1950s (fig. 10). Timber harvest increased in part to meet the demand for new housing after World War II. Timber harvest increased dramatically in this period (tables 3A, 3B; fig. 10), with only a small decline in total conifer growing stock (fig. 11). Harvesting reduced tree mortality from other causes also abundant at that time (fig. 11). At first, ponderosa pine and Douglas-fir were harvested; later, as these species became less abundant, other species in middle and upper elevations, including grand fir, white fir, lodgepole pine, and western larch, were harvested (fig. 10, Hooser and Keegan 1985). Once the largest trees had been harvested, progressively smaller trees were used. The effect was to reduce the numbers of large diameter trees (fig. 10).

Harvest systems-Forest managers continued to be concerned about proper ways to harvest the many and varied stands (Moss 1953, Rapraeger 1940, Weidman 1936). Ecological theory of the day emphasized stable forests, free of large disturbances, growing naturally to a climax condition of tolerant species. Uneven-aged harvesting was promoted in western Washington and elsewhere in the 1930s and 1940s, but by the mid-1950s, even-aged management was considered more biologically appropriate and simpler to administer since the weak, diseased, and injured trees were not left after the harvesting and the newly regenerated trees grew most vigorously in the full sunlight provided by the clearcut.

In the early part of the period, most harvesting was still done using overstory removal or uneven-aged cutting methods (tables 3A, 3B; fig. 12) because of the multiple canopy layers and irregular nature of stands (fig. 4). With selection cutting, many acres were entered with relatively little total volume removed (for example, compare the acres harvested between 1921 and 1945 with the acres harvested in the Yakima River basin (tables 3A, 3B). The effect of uneven-aged cutting was to promote multiple canopy layers further and to encourage a lower stratum of shade-tolerant trees in areas where shade-intolerant and fire tolerant species had previously grown. In other areas, dense stands of small trees were established where large fires of the late 19th and early 20th centuries had occurred. By this time, it was becoming obvious that fewer parklike stands were in the stand initiation stage (fig. 4).





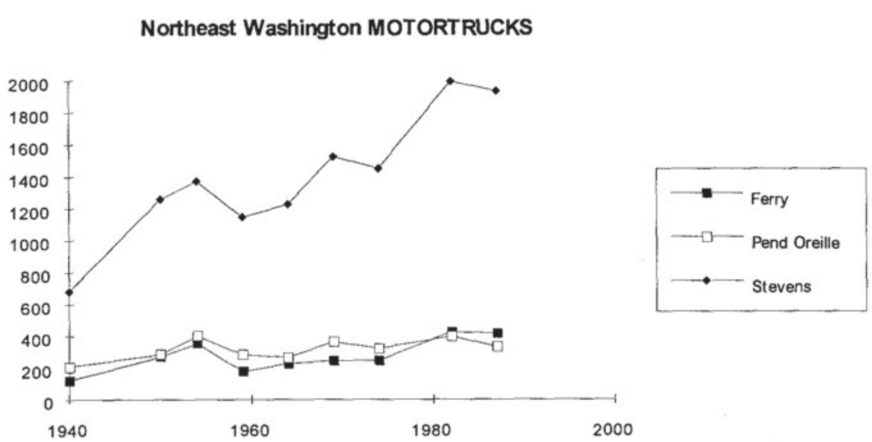
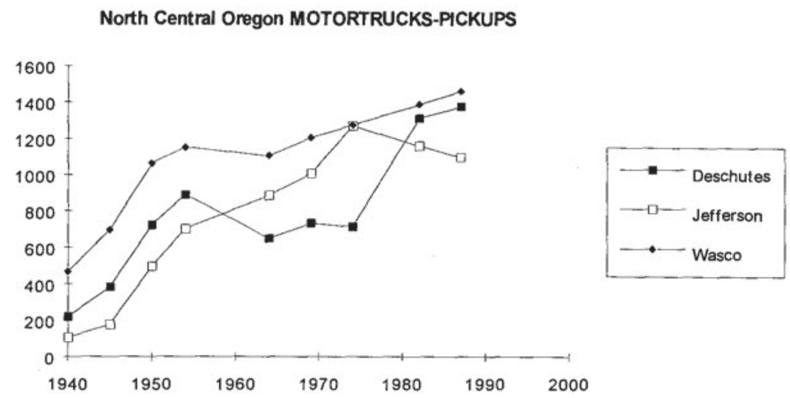
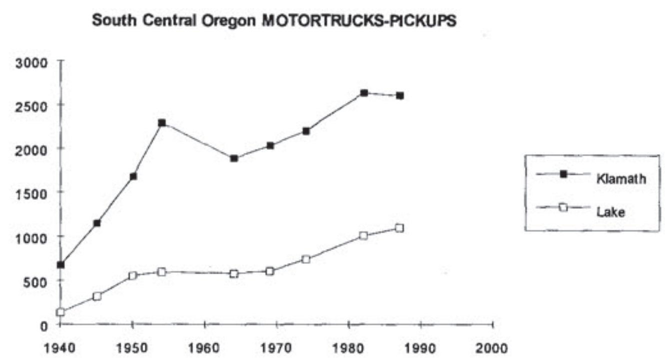
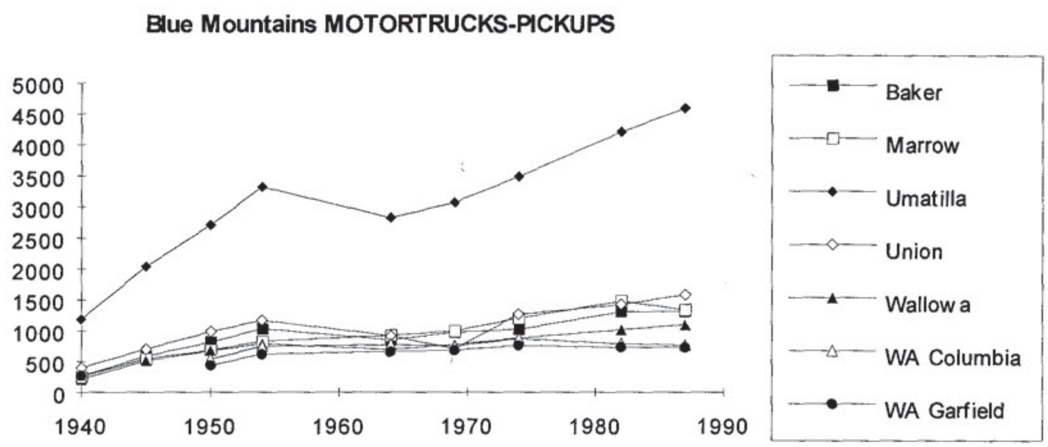


Figure 9A. Motortrucks increased dramatically in eastern Washington, increasing the ability to log previously inaccessible areas. (U.S. Bureau of the Census)







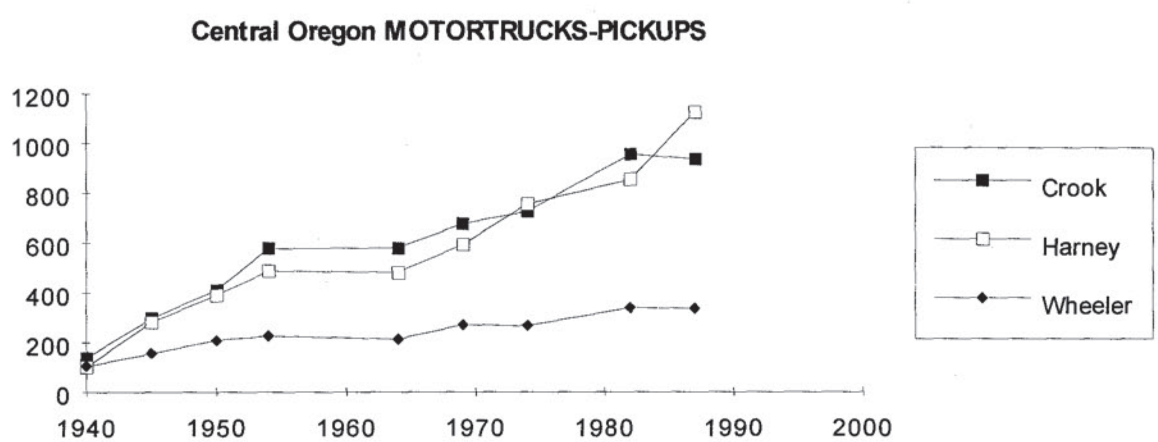


Figure 9B. Motortrucks increased dramatically in eastern Oregon (9B), increasing the ability to log previously inaccessible areas. (U.S. Bureau of the Census)

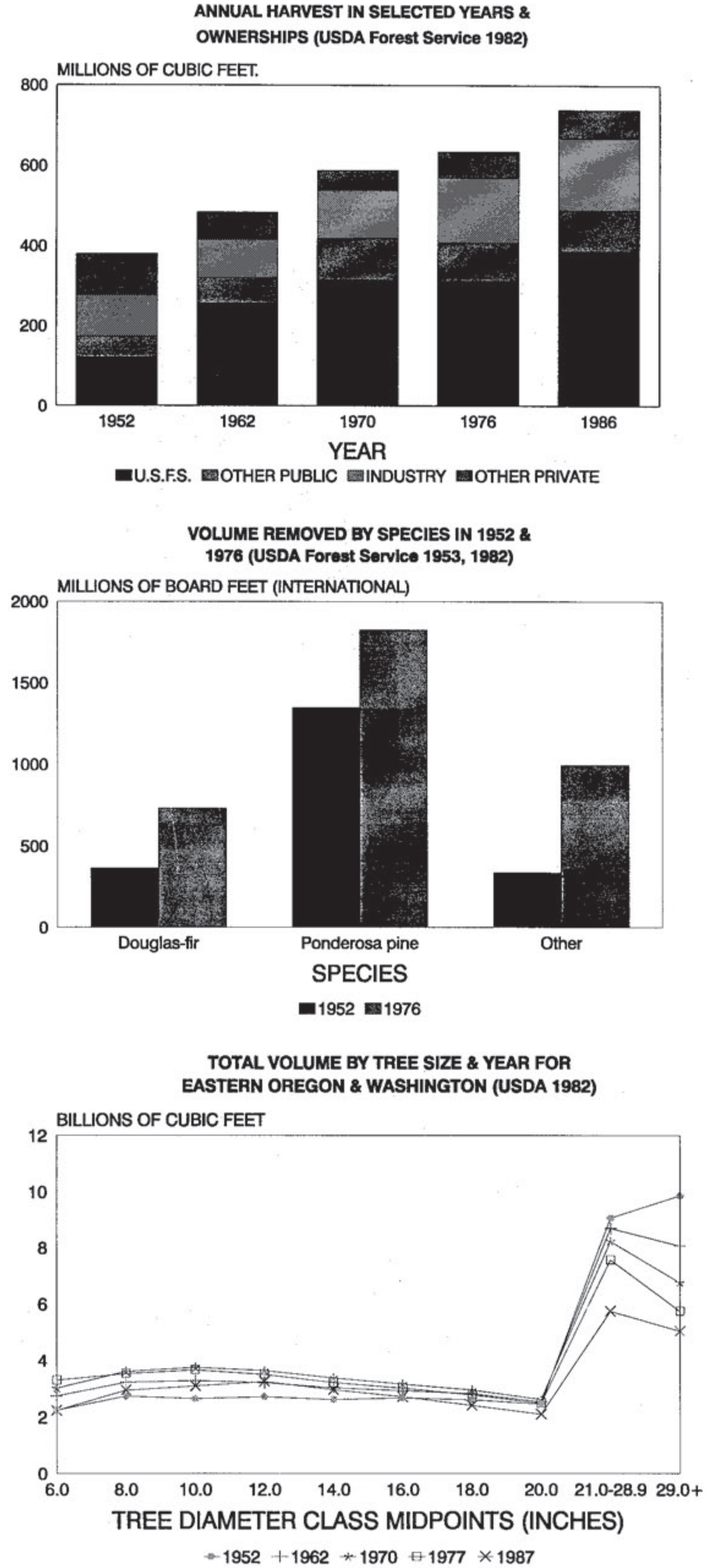


Figure 10. (10A): Timber harvest has increased since 1950 on nearly all ownerships in eastern Oregon and Washington. 10B: Early harvest was of ponderosa pine, then Douglas-fir; more recently, true firs, lodgepole pines, and others have been cut as well—as areas with these species became accessible and as available stands of ponderosa pine and Douglas-fir were reduced. 10C: Trees became smaller and stands became more crowded in eastern Oregon and Washington as larger trees were harvested and then succeed by crowded stands of small diameter not thinned by fires or silvicultural operations. (USDA Forest Service 1982, Waddell and others. 1989)

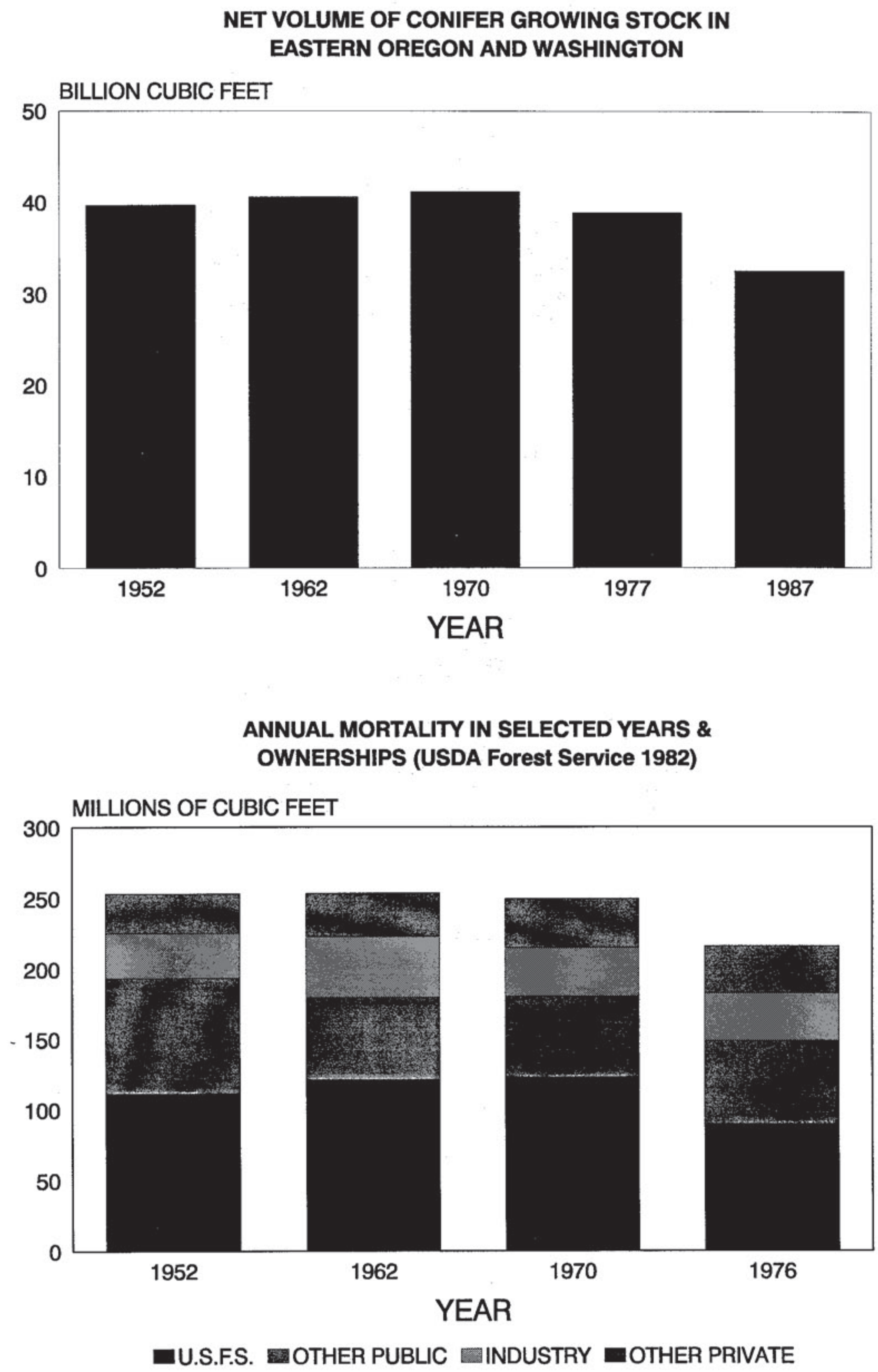
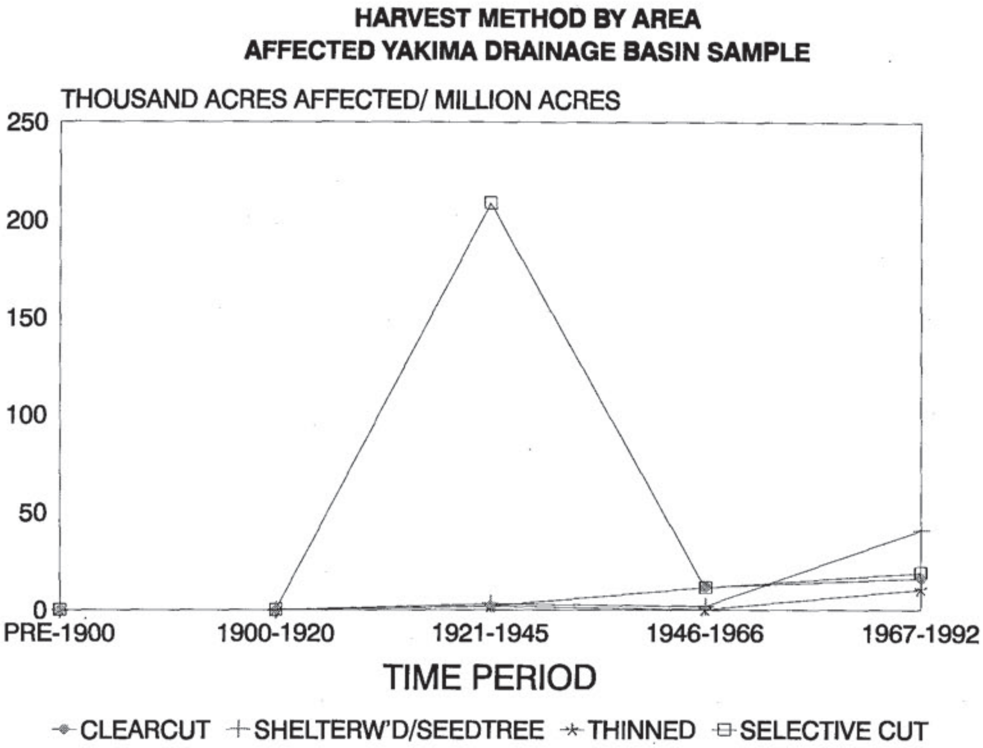


Figure 11. The volume (A) and mortality (B) of trees in eastern Washington and Oregon have been reduced since 1950 by increased timber harvest (USDA Forest Service 1982, Waddell and others 1989).



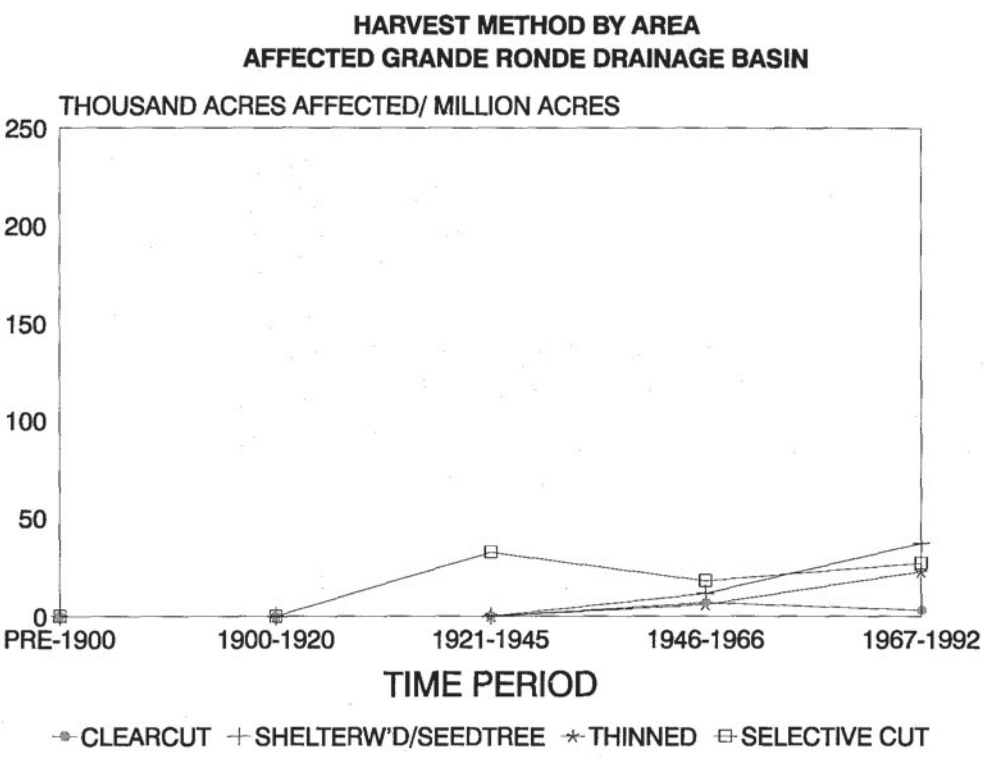


Figure 12A & 12B. Early harvesting generally consisted of selective cutting of stands. Because only large trees and few species were used, early logging often consisted of selectively removing the large trees (fig. 4) and leaving vigorous trees ("silvicultural selection cutting") or leaving weak, low vigor trees susceptible to diseases ("high grading" by loggers). Now, shelterwood and seed-tree harvesting are most prevalent, creating parklike stands of figure 4. Clearcutting and selective cutting are less common. (Overstory removal is probably included with selective cutting.)

Equipment-Technological advances in belt tractors (for example, Caterpillars and crawler-tractors) in the 1930s and in automobiles and trucks in the 1940s allowed machines to do the work people used to do on farms and in the woods (U.S. Bureau of Census). Tractor logging using crawler-tractors to yard logs increased dramatically during this period (tables 3A, 3B).

Post-harvest fuel treatment-The 1943 ruling that allowed broadcast burning did not affect stands in eastern Oregon and Washington to any major degree because these stands were still almost entirely selectively logged or thinned (overstory removal).

1960 to the Present-Timber management from 1960 until very recently has been dominated by concerns of an "impending timber shortage" (Oliver 1986), increased harvesting rates in eastern Washington and Oregon (fig. 10), harvesting of small-diameter trees, and more varied species (fig. 10), intensive management practices, increased risks from diseases, insects, and fires (Hessburg and others 1993), and greater public involvement and distrust. The amount of timber harvested has differed greatly between subregions (fig. 13).

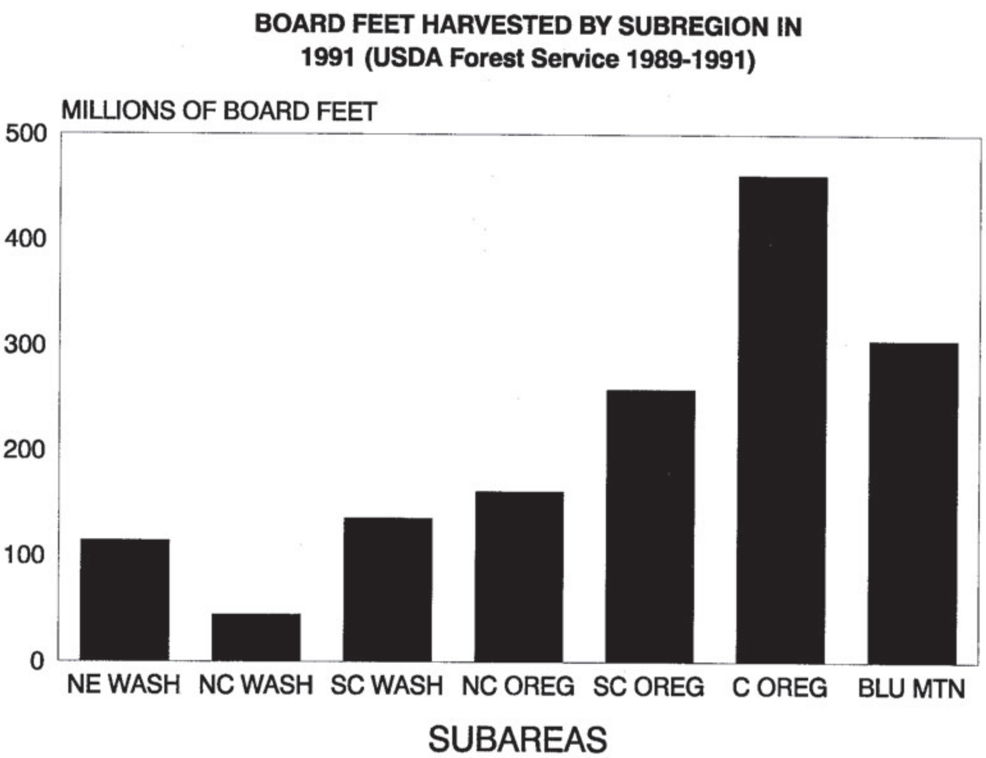


Figure 13. The amount of harvest varied among regions in 1991 (USDA Forest Service 1989-91).

Harvest systems-By the early 1960s, even-aged (single cohort) management including clearcutting was accepted among foresters as a biologically and economically acceptable management technique. Foresters continued to manage most stands in eastern Washington and Oregon with overstory removal, selection, shelterwood, or seed tree systems (fig. 12). Although these treatments could be termed even-aged, where the effect was to leave standing trees after harvest, the resulting stands often grew more like multiple cohort (uneven-aged) stands, with the multiple canopy layers, diseased residual trees, and favoring of shade-tolerant true firs species. As a result of these harvesting practices and fire protection, relatively few stand initiation areas, favoring species utilizing these areas, have been created in the past few decades. A very high proportion of stands on non-Federal lands in eastern Washington was also managed with overstory removal, selection, seed tree, or shelterwood systems (CINTRAFOR 1993). Where scattered overstory trees remained, these areas .were commonly treated with an overstory removal cut. Sometimes selective harvesting was still done because foresters knew they could not regenerate an area using evenaged cutting methods.

Loggers sometimes defined clearcutting as removing the merchantable trees-leaving unmerchantable trees and in effect creating a high graded stand-"cutting the best, leaving the rest." In response, foresters termed this "commercial clearcutting" and recommended "silvicultural clearcutting" or "cleancutting," in which the unmerchantable stems were felled to allow a vigorous stand to regrow. At times, some foresters had to be reminded that clearcutting may not always be the only or best way to manage forests (Franklin and DeBell 1973). As foresters became comfortable with clearcutting, society was becoming concerned with it. Unsightly clearcuts on the Bitterroot National Forest (Burk 1970) and the Monongahela National (Minckler 1973) Forest further aroused public concern and attention to clearcutting. Ecologists of the day questioned the scientific and ecological merits of clearcutting.

Forest harvesting policies have varied in eastern Washington in recent years, with restrictions placed on the sizes of harvesting units and much more consideration given to aesthetic appearances of forest landscapes. Forest management has improved and roads, equipment, and skilled labor has increased dramatically, but at the same time society has become more concerned about endangered species and forest health.

Although timber is one by-product of the management of ecosystems, timber production alone cannot economically justify the silvicultural activities needed in many eastside forest ecosystems to control or prevent catastrophic insect and disease outbreaks, wildfires, and reduction in habitat diversity over large areas. If other values are also considered, such as maintaining or restoring biodiversity; long-term site productivity; habitats; fire, insect, and disease risks; employment, and recreation-active management of eastside ecosystems using a variety of silvicultural techniques could easily be justified (Lippke and Oliver 1993). Analyses such as these are being initiated in forest planning and in the TSPIRS program (USDA Forest Service 1989-1991).

Equipment-During the 1960s, rubber-tired skidders were developed that could rapidly yard trees on gentle terrain (slopes less than 30 percent); however, these machines adversely affected wet soils high in silt or clay. With increasing education and technical experience of forest managers, yarding equipment is now prescribed for specific weather, soil, and terrain.

Yarding equipment and yarding systems are now engineered to minimize soil disturbances. Cable yarding systems are more commonly used in the subsampled river basins in eastern Oregon and Washington (tables 3A, 3B). Helicopters, mechanical shears (feller-bunchers), and other ground-based yarding machines have also been used on a limited basis.

Post-harvest fuel treatment-With improved burning standards, slash is left to rot in place; crushed and chopped and added to the soil; hand or machine piled and left to rot; or hand or machine piled, allowed to dry, and burned in the spring or fall.

Machine piling and burning has been widely practiced since about 1950. It often causes more soil disturbance than the initial logging, volatilizes more nutrients than broadcast burning, concentrates available nutrients and organic material at the location of the burn piles, and concentrates heat transferred to soil beneath the piles.

Extensive fuel loads created by thinning entries temporarily creates an extreme fire hazard, which further discourages foresters from thinning dense stands. Before dense stands are thinned, they are often highly susceptible to fire because of the many small, dead trees. Fire danger is extremely high immediately after thinning because of the accumulated dead slash on the forest floor; however, fire danger declines several years later as slash rots and the overstory casts more shade, creating moist conditions near the forest floor. The cost of thinning and slash disposal is very high if slash is treated (for example, piled or burned) immediately after thinning.

Early stand spacing with herbicides has been done with moderate success; cool, slow burning ground fires provide better results. Using fire as a thinning tool results in trees with smaller diameters than manual thinning.

Roading and Access Management

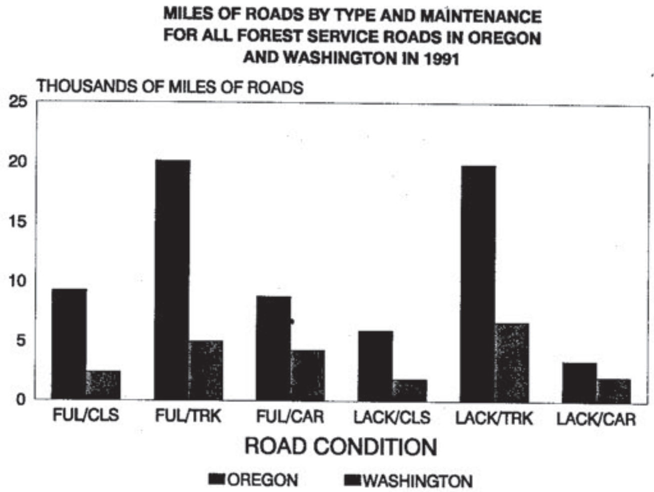
Pre-1930-The earliest concerns of Federal land managers were essentially custodial-controlling grazing, illegal timber harvesting, and forest fires. Forest patrols were reported in different parts of eastern Oregon and Washington, with one person patrolling from 100,000 to 200,000 acres in summer, and from 200,000 to 300,000 acres in winter (USDA Forest Service 1908). More access roads and trails were built which were credited with stopping fire spread (Steen 1976). Roads were obtained without direct appropriations-loggers built roads to the harvest units and then deducted the cost from the final payments to the Forest Service. This arrangement began a long practice of allowing timber revenues to pay for, and thus indirectly control, many management practices on National Forests.

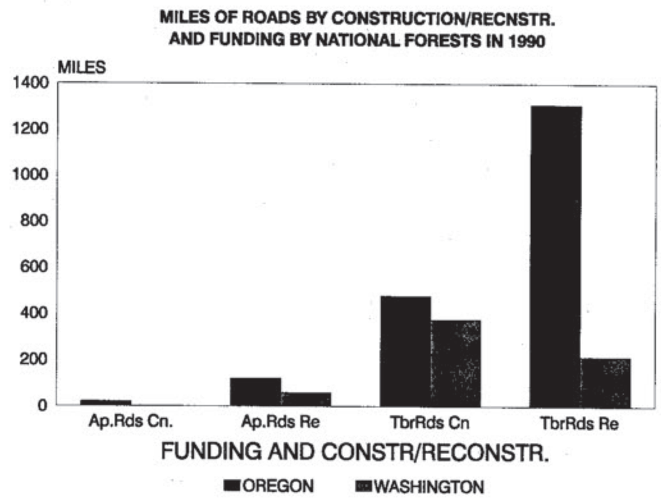
By 1907, only 360 miles of road had been built in all of Oregon's National Forests; 147 miles in all of Washington's National Forests (USDA Forest Service 1908). These roads were largely considered privately owned. By 1920, the Yakima River basin contained 176 miles of road per million acres; the Grande Ronde River basin had 287 miles per million acres (tables 3A, 3B). Railroads were also built into some areas, but not others. Increased roading allowed greater access and allowed protection of the forest from fires and catastrophic outbreaks of insects. It also allowed greater inventory of the extent of the resources. Access by recreationists also increased.

1930 to 1960-Attempts to have more direct control over the road network-rather than have it indirectly controlled by timber revenues-were made between 1953 and 1956, when the Chief of the Forest Service asked for direct appropriations for road building (Steen 1976). This direct appropriation would not have cost more than the current method of subtracting costs from timber revenues. The direct appropriation method would have allowed road placement to serve many uses, rather than placement directed by most efficient timber harvest. Road construction in National Forests increased between five-and ten-fold between 1900 and 1966 in the Yakima River and Grande Ronde River basins.

Many early logging roads were poorly constructed and subsequently collapsed. Road failures have been one of the biggest causes of erosion and stream degradation associated with timber harvesting (Seaton and others 1973).

1960 to the Present-Despite some direct appropriations for road construction (pre-roading dollars), most road construction and reconstruction in National Forests is done by logging companies that finance that work through deductions from timber payments (fig. 14). Consequently, taxpayers still pay the full cost of road construction. The decision of where and when to build them, however, hinges on the logistics of timber harvesting.





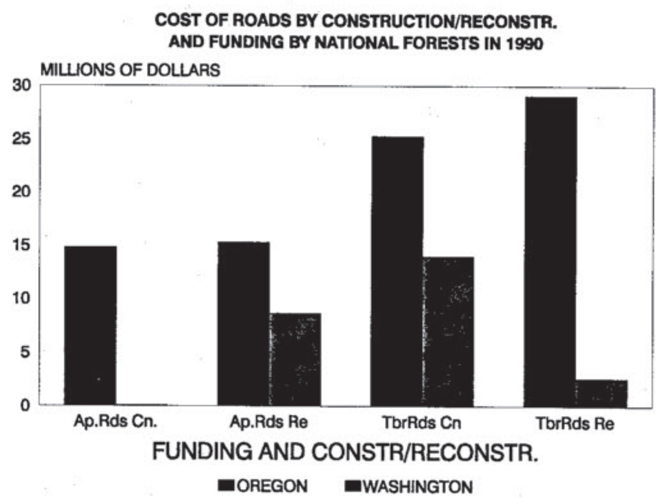


Figure 14. Most Forest Service roads in Oregon and Washington, built and maintained by timber purchasers, are suitable for trucks. Highest costs/mile of roads were from appropriated funds; greatest lengths were by timber purchaser (USDA Forest Service 1975-91). 14A: Miles of U.S. Forest Service roads by type and maintenance for all of Oregon and Washington (eastern and western), 1991. Most roads are high clearance and open; about one half are fully maintained:

FUL/CLS = fully maintained, closed
FUL/TRK = fully maintained, high clearance
FUL/CAR = fully maintained, passenger car
LACK/CLS = lacking full maintenance, closed
LACK/TRK = lacking full mnt., high clearance
LACK/CAR = lacking full mnt., passenger car

14B. Total miles of roads.
14C. Total cost of roads.
Ap.Rds.Cn = Constructed from appropriated funds
Ap.Rds.Re = Reconstructed from appropriated funds
TbrRds Cn = Constructed by timber purchaser
TbrRds Re = Reconstructed by timber purchaser

From 1975 to 1991, Oregon and Washington experienced a dramatic increase in road construction. During each of those years, about 1800 miles of roads were built, and 500 miles of roads reconstructed in each state along with about 10 bridges in Oregon and 6 in Washington (USDA Forest Service 1975-91; roading figures for eastern Washington and Oregon were not readily available). This dramatic increase in road construction is reflected in the data from the subsampled watersheds of the Yakima River and Grande Ronde River basins (tables 3A, 3B). Most roads are suitable only for truck traffic (fig. 14).

Pest Management

Pre-1930-Outbreaks of insects occurred before intensive settlement of the interior West (Hessburg and others 1993), although their intensity and duration were probably much less than the fires that periodically erupted.

The Organic Act of 1897 that created the present Forest Service also provided for a mandate to control insect outbreaks. Surveys for mountain pine beetle (*Dendroctonus ponderosae* Hopkins) and western pine beetle (*D. brevicomis* LeConte) occurred as early as 1899, with systematic surveys in south- central Oregon from 1911-20 (Dolph 1967, Miller and Keen 1960). One effective and inexpensive method of controlling beetles was to fell beetle-infested trees and then peel the bark to expose the infested tree to the sun. Another method was to burn beetle-infested trees. In 1908, the first reported major outbreak of the mountain pine beetle in lodgepole pine in the Blue Mountains (Wallowa National Forest) prompted the first bark beetle control project in the Pacific Northwest. Another beetle outbreak struck ponderosa pine in the Blue Mountains (Whitman National Forest). In 1910, thousands of trees were felled and peeled, or burned.

With limited funds, personnel, technology, access, and knowledge, the primary tool for avoiding large scale insect and disease mortality was to harvest infested or susceptible trees. This harvest of infested or weak tree-often not just large, high quality dominant trees in a stand-was in conflict with the interest of timber companies that could profit more by harvesting the large dominant trees and leaving the smaller, weaker ones. Foresters often enforced removing weaker trees and leaving vigorous, upper canopy trees; otherwise, a high-graded stand resulted, with the characteristics described earlier. In both cases, the residual overstory favored the regeneration and release of shade-tolerant conifers where ponderosa pine had previously grown. These shade-tolerant understory trees competed with residual overstory pines for limited water, depressing their vigor, and making them more susceptible to bark beetle attacks. As more pines died and were harvested, shade-tolerant trees grew larger. Resulting stands had multiple layers and were more susceptible to certain defoliating insects (Hessburg and others 1993). Detection of defoliating insects was difficult, and suppression did not occur before aircraft were operationally available after World War II.

Outbreaks of defoliating insects occurred before European settlement (Wickman and others 1993). Between 7 and 10 outbreaks of either western spruce budworm or Douglas-fir tussock moth have been detected in the Blue Mountains since 1790. Budworm outbreaks occurred from 1775-85, 1822-30, 1838-42, 1870-78, and, the most severe of these, from 1898-09. Tussock moth outbreaks occurred from 1843-45, 1852-54, and in 1875. One outbreak killed 300 million board feet of Douglas-fir and grand fir in northeast Washington in 1929-30 (Furniss and Carolin 1977, Gast and others 1991). Minor outbreaks occurred in the Blue Mountains at about the same time.

The pine butterfly was reported attacking ponderosa pine near Spokane in 1882. Between 1893 and 1895 the pine butterfly infested 150,000 acres in south-central Washington (Yakima Indian Reservation) and, with the help of bark beetles, killed 90 percent of infested trees-nearly one billion board feet of timber (Keen 1952).

1930 to 1960-With more human resources and infrastructure, forest managers were becoming more concerned about protecting forests from insects and diseases. State officials and private landowners were encouraged to cooperate in pest-control efforts through the Forest Pest Control Act of 1947 (Steen 1976). Between 1930 and 1960, the Forest Service began conducting aerial surveys of insect outbreaks and issuing periodic reports.

Forest managers devised plans to control mountain pine beetle infestations in lodgepole pine; western pine beetle infestations in ponderosa pine, western spruce budworm and Douglas-fir tussock moth outbreaks in Douglas-fir and grand fir, and white pine blister rust infecting western white pine and sugar pine. Not every plan worked, however. The white pine blister rust pathogen, not native to these forests, was introduced early in the century and quickly decimated the western white pine population.

Large outbreaks of the mountain pine beetle in north-central Oregon (Deschutes National Forest) and in the Blue Mountains lasted from the late 1940s until the mid-1950s. The outbreaks occurred primarily in lodgepole pine in the Cascade Range, and in ponderosa pine in the Blue Mountains. In 1950, 52,000 acres were infested, with 30,000 acres on the Deschutes National Forest. Another 42,000 acres were infested in eastern Washington. “Salvage” logging removed infested trees.

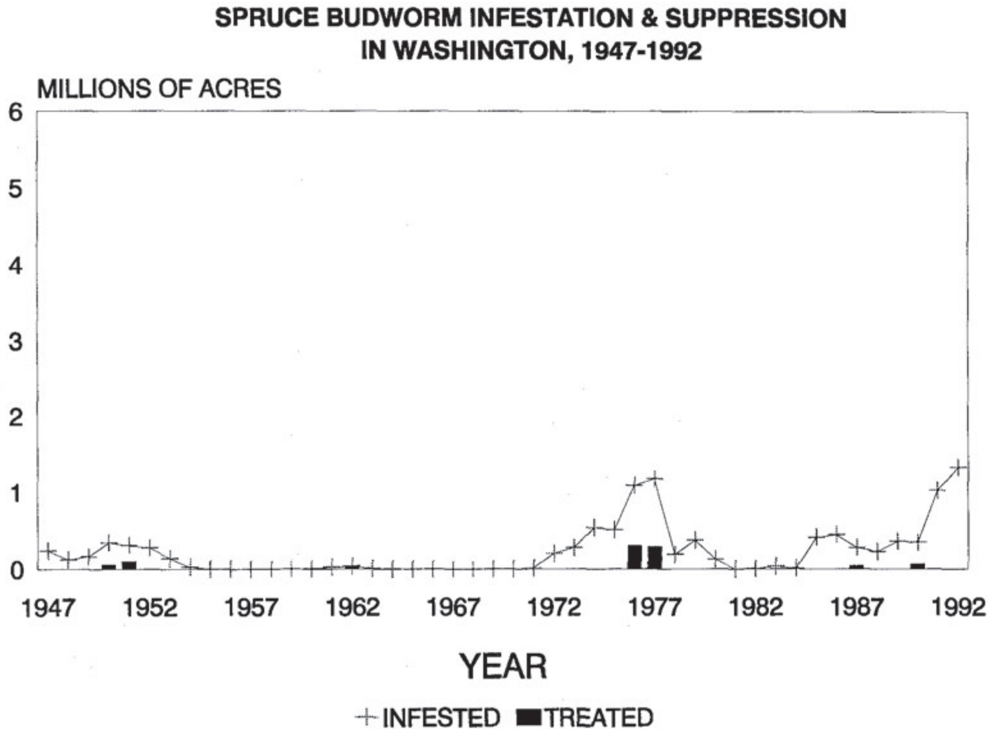
From 1955 to 1966, more than 800,000 acres of lodgepole pine were infested by the mountain pine beetle, with 82 percent of those acres in central Oregon. In Washington, most of the infestation was in the northeastern (Colville National Forest) and north-central (Okanogan National Forest) regions of the State. The emphasis in mountain pine beetle management had been to avoid infestations by maintaining healthy, vigorous stands with regular thinning. In 1960, one chemical control project was completed in southwestern Oregon (Fremont National Forest) in which several thousand trees were sprayed with ethylene dibromide (Dolph 1967, USDA Forest Service 1938-91).

Sanitation and salvage logging for the control of western pine beetles came into general use in the late 1930s. Tree selection was based on the tree “risk rating system” of Keen (1936). Toxic oils and organic insecticides such as DDT were developed during World War fI. Major outbreaks of the western pine beetle in 1932 destroyed 1.8 million board feet of timber. As many as 33,800 trees-often large, “yellow-belly” ponderosa pines-were treated (felled-peeled-burned) on public and private ownerships in south-central Oregon. In 1953, western pine beetle outbreaks increased from 303,000 acres in 1951 to more than 1 million acres in south-central Oregon, north-central Oregon, and south-central Washington. The Yakima Indian Reservation had an estimated 200 to 400 dead trees per section (640 acres) during this time. Another outbreak in south-central Washington, north-central Oregon, and the Blue Mountains increased from 16,000 acres in 1956 to 294,300 acres in 1959. Control measures included both sanitation salvage logging as well as ethylene bromide treatments (Miller and Keen 1960).

Outbreaks of the Douglas-fir beetle, usually a problem in western Oregon and Washington, have occurred in eastern Oregon and Washington in trees previously weakened by western spruce budworm. Douglas-fir beetle outbreaks occurred from 1952 to 1954 in the Blue Mountains of north-central Oregon, and south-central Washington, and in northeast Washington from 1955 to 1956 (USDA Forest Service 1938-91). Outbreaks were handled primarily by salvage logging.

From the 1930s to the 1950s, an unsuccessful effort was made to control white pine blister rust in northeastern Washington, Idaho, and Montana by eradicating currant (*Ribes* spp.) plants, the alternate host of the disease (Bingham and others 1972, Matthews and Hutchinson 1948, Moss 1953).

A tussock moth outbreak in 1937 killed large amounts of timber throughout 80,000 acres (Gast and others 1991) and another outbreak in 1946-47 covered 500,000 acres in eastern Oregon and Washington, and northern Idaho. An insect damage control program began in 1947 and included a regionwide aerial survey and a standardized method of coding severity of defoliation. In 1947, the largest suppression project up to that time was also undertaken; DDT was applied on 15,000 acres of National Forest and private land (Perkins and Dolph 1967) at a rate of 1 pound per gallon of oil per acre (fig. 15).



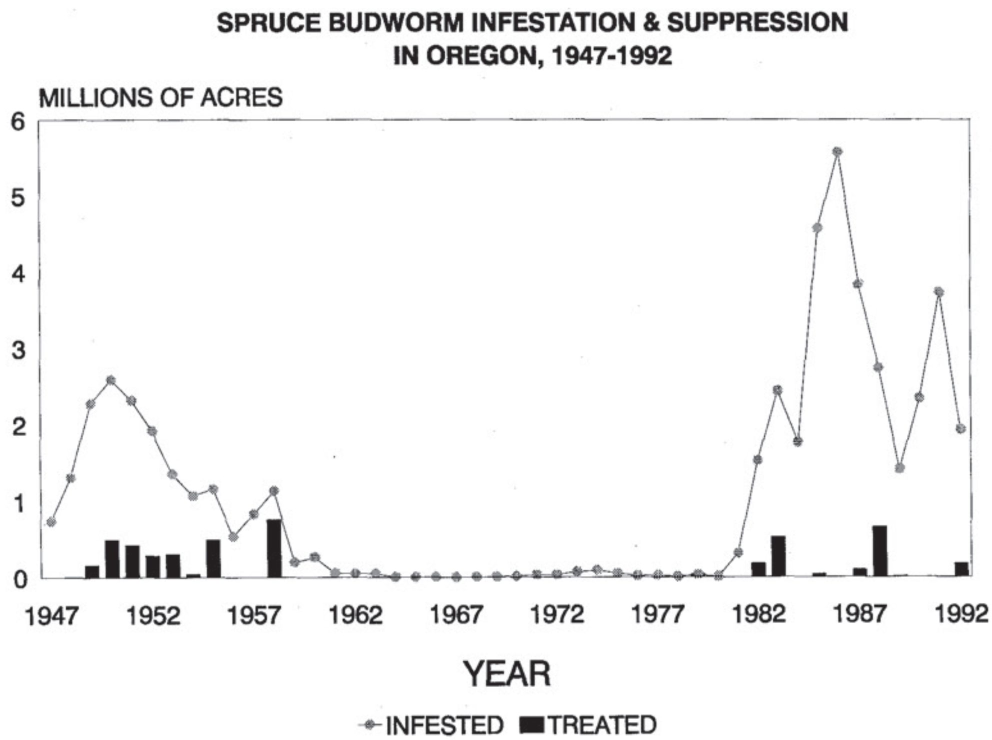
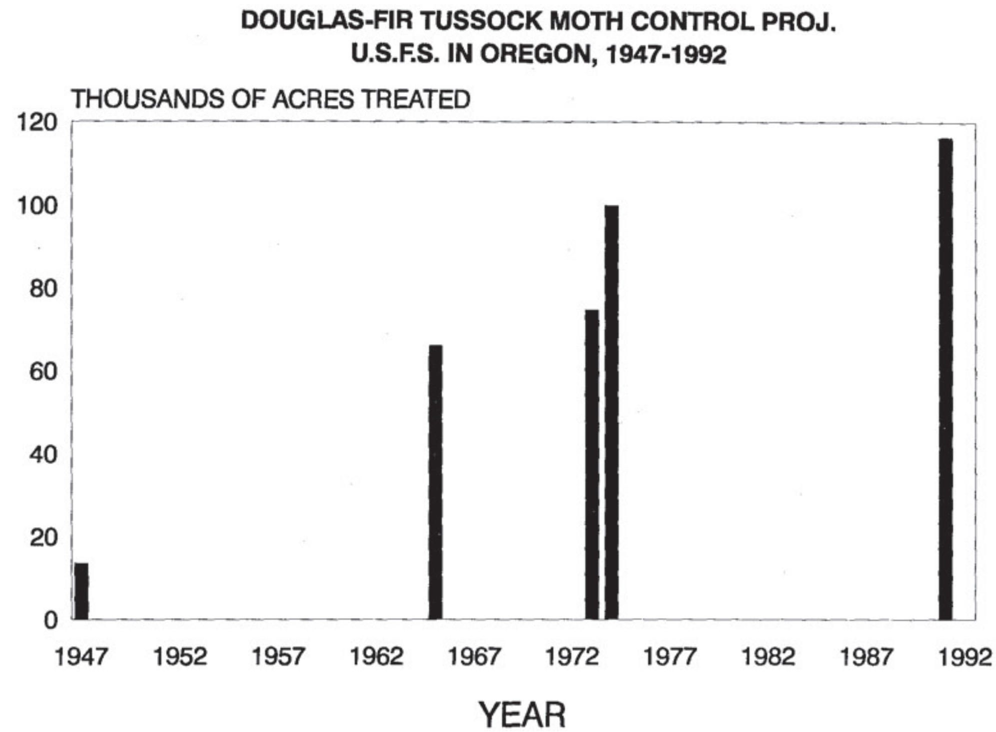


Figure 15. **Spruce budworm infestations in eastern Oregon (15A) and Washington (15B) were partly treated with aerial chemical spraying. DDT was used in early sprays. 15C: Most spray programs for tussock moth control have generally been in Oregon. 15D: Recent spray programs for defoliating insects (budworm and tussock moth) have been concentrated in the Blue Mountains, central Oregon, and south-central Washington. (Data from Dolph 1980 and unpublished data, USDA Forest Service, Forest Pest Management Program, Portland, Oregon, 1993)**



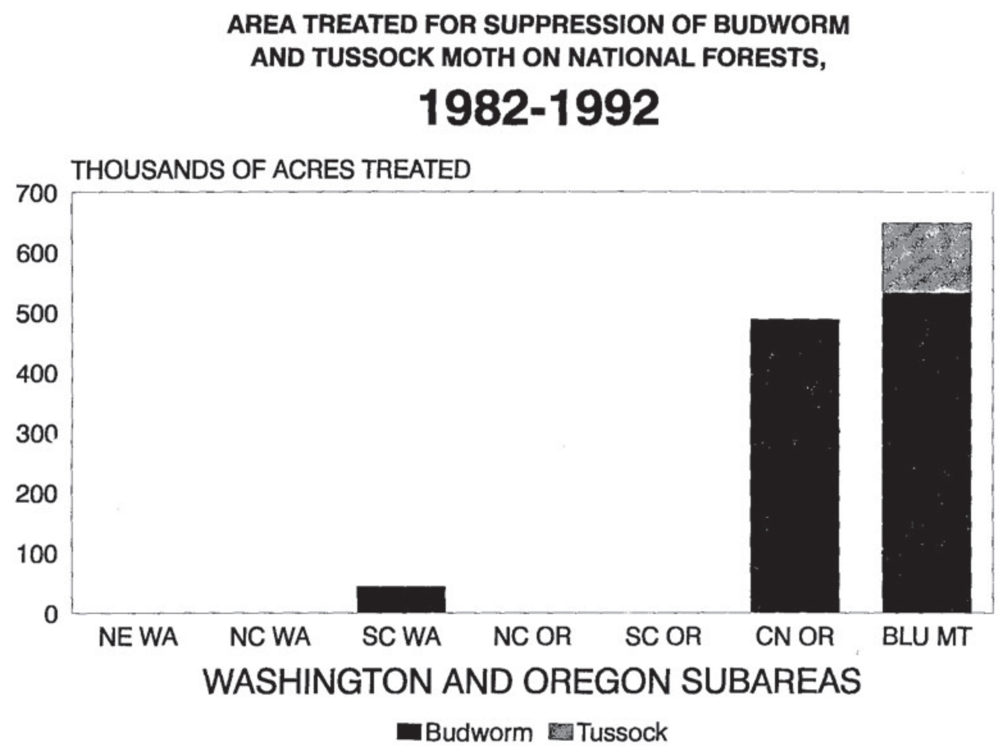


Figure 15 (continued)

Western spruce budworm activity increased in the late 1940s, and one outbreak in eastern Oregon an Washington covered 2,941,744 acres prompting aerial applications of DDT (fig 15). Forests were spr for defoliators with DDT throughout most of the 1950s. The number of acres treated for both spruc budworm and tussock moth infestations was far less than the acres infested. Although the treatment; were considered a success, how much of the budworm's collapse in the 1950s was caused by spraying how much was caused by natural mortality is difficult to determine (Dolph 1980).

Aerial spraying seems to have reduced defoliator populations in extreme outbreaks. Outbreaks are recurring, however, because of climate flux and landscape composition and structure, among other things. Because these insects are native to the region, populations will always fluctuate, sometimes causing outbreaks. Past natural and human activities have created forest stand structures which are presently very conducive to insect outbreaks over large areas of eastern Oregon and Washington (Hessburg and others 1993). Silvicultural manipulations, including prescribed fires, can reduce the extent of susceptible stands and thus help lessen outbreak extent and duration, and likely diminish the probability of large wildfires.

1960 to the Present-Integrated pest management (IPM) is now the method used to protect forests from insect outbreaks. With IPM,

> . . . all aspects of a host-pest system are studied and weighed. The information considered in selecting appropriate management strategies includes the impact of the unregulated pest population on various forest values, alternative regulatory tactics and strategies, and benefit/cost estimates of these alternative strategies. Regulatory strategies are based on sound silvicultural practices and the ecology of hosts and pests, and consist of a combination of tactics such as timber stand improvement plus selective use of pesticides. An underlying principal in the choice of a strategy is that it be ecologically compatible or acceptable (36 CFR 219.3).

Mountain pine beetle outbreaks in the Blue Mountains in 1964 and mid-1970s were treated with the fell-pile-burn method. More recent outbreaks in north-central Oregon in the mid-1980s and in southcentral Oregon and north-central Washington in. the late 1980s, and early 1990s have destroyed lodgepole and young ponderosa pines (USDA Forest Service 1938-91). Some salvage logging has occurred, but the primary treatment has been to thin hazardous stands to increase tree vigor and resistance to insect attack.

Western pine beetle outbreak areas increased from 106,000 acres in 1959 to 392,000 acres in 1962, with most outbreaks in Oregon. Some sanitation/salvage treatments were used for outbreaks occurring in 1974 and 1988 to 1990 (Smith 1990). Mortality has recently occurred in second-growth ponderosa pine as well as older trees, and is generally attributed to drought stress and overcrowding.

Douglas-fir bark beetle outbreak increases were found in the Blue Mountains and in northeast and northcentral Washington in 1963. Populations also significantly increased in the Blue Mountains between 1988 and 1990, with beetles attacking trees already stressed by western spruce budworm defoliation and persistent drought. The primary treatment has been salvage logging (USDA Forest Service 1938-91).

Since 1960, three projects were conducted to suppress outbreaks of the tussock moth in eastern Oregon and Washington (fig. 15). In 1964 and 1965, more than 150,000 acres were treated in central Oregon using aerial applications of DDT. Those populations collapsed partly as a result of spraying and partly because of a virus epizootic (Perkins and Dolph 1967). Four chemicals were tested on the tussock moth in 1973: bioethanomethrin, carbaryl, mexacarbate, and trichlorfon. In 1973, the tussock moth infested 689,760 acres in eastern Oregon and Washington and killed 17,270 acres of trees (Pettinger and Johnson 1974). In Washington in 1974, about 91,000 acres were treated with DDT, after special permission was obtained from the Environmental Protection Agency to use the pesticide (Graham and others 1975). In 1991, an apparent increase in tussock moth populations detected by a pheromone-based early warning system installed about 12 years before (Willhite 1993) prompted officials to treat 116,344 acres with *Bacillus thuringiensis* (B.t.)-a biological control agent. Tussock moth populations were reduced, but this may have been because of natural causes.

DDT was still used to suppress outbreaks of western spruce budworm in the early 1960s. In 1976, about 305,000 acres were treated using malathion ultra-low volume. An additional 7700 acres were treated with carbaryl. Carbaryl was used on about 325,000 acres in eastern Oregon and Washington in 1979 and again on 170,000 acres in 1982. Since 1987, B.t. was used in south-central Washington and central Oregon.

Forest diseases are generally combated by favoring resistant stand structures and resistant or tolerant species in thinnings and plantings-generally ponderosa pine, western larch, western white pine, and lodgepole pine. Stump removal to minimize inoculum of *Armillaria* root disease has been attempted in a wide range of settings, but has usually been found to be more expensive than other alternatives. Forest diseases, especially dwarf mistletoes, account for substantial growth and mortality losses, but because mortality each year from mistletoe is not spectacular, mistletoe infestations are often ignored. Still, mistletoes as a group are responsible for greater growth reduction and mortality losses to timber production than any other insect or disease. Dwarf mistletoes are readily treated by using conventional silvicultural techniques. Mistletoe suppression projects such as removal of inoculated trees, have been funded by the National Forests both in coordination with timber harvesting and at separate times.

Many forests in eastern Oregon and Washington are now susceptible to, or presently under attack by various insects and diseases (Hessburg and others 1993, Lehmkuhl and others 1993), exacerbating the current high fire risks. Some stands can be made more vigorous and less susceptible to insects, diseases, and fires by using well-planned silvicultural operations, such as thinnings or regeneration harvests. Some stands are already too weak to benefit from treatment as for the others, methods have been developed that can aid in determining if the stands that can be invigorated. Furthermore, silvicultural operations that can strategically pattern landscapes to avoid the worst catastrophes. These operations include thinning some stands by timber removal or controlled ground fires, regenerating some stands to a more robust condition using controlled hot fires or regeneration harvest methods, maintaining some stands with high relative density to create shaded fuel breaks that will slow or stop ground fires. These operations may not be economically justified on the basis of timber revenues alone, but money received from thinning and harvesting these stands can help defray the costs.

Riparian Management

Pre-1930-The public grew concerned about the effects of grazing on siltation of irrigation reservoirs and watersheds. Deforestation associated with grazing promoted flooding, causing even more concern. Managing forests for flood control was one of the founding principles of National Forests (Steen 1976). Floods were controlled by regulating grazing, harvesting, and, in conjunction with irrigation, damming streams.

The first irrigation systems in eastern Oregon and Washington were developed by early missionaries, and by private individuals or companies. Irrigation increased rapidly in the early 1900s after the creation of irrigation districts that cooperated with the government (Perala and Collins 1990). Fish ladders were installed in some streams as early as 1915 when some people voiced concern about the salmon that were unable to return to spawning areas (Wissmar and others 1993).

Farmers in the Blue Mountains, central Oregon, and south-central Washington were among the first in the region to irrigate, a practice that spread to other areas (fig. 16). For example, in 1902, an estimated 250,000 acres were irrigated in eastern Washington. By 1938, 5 million acres were under irrigation in the Columbia basin (Pacific Northwest Regional Planning Commission 1938; Resner 1938). Between 1900 and 1920, dams were built in the subsampled area of the Yakima River basin (tables 3A, 3B), the only dams built in this area. One effect of the dams was to hinder fish migration. To prevent siltation of the irrigation reservoir, grazing and harvesting were regulated, and stream channels were straightened to prevent streambank erosion. This straightening appears to have adversely affected riparian and stream habitats by dewatering, streambed scouring, and reduction of silt below desirable amounts for fish breeding (Wissmar and others 1993).

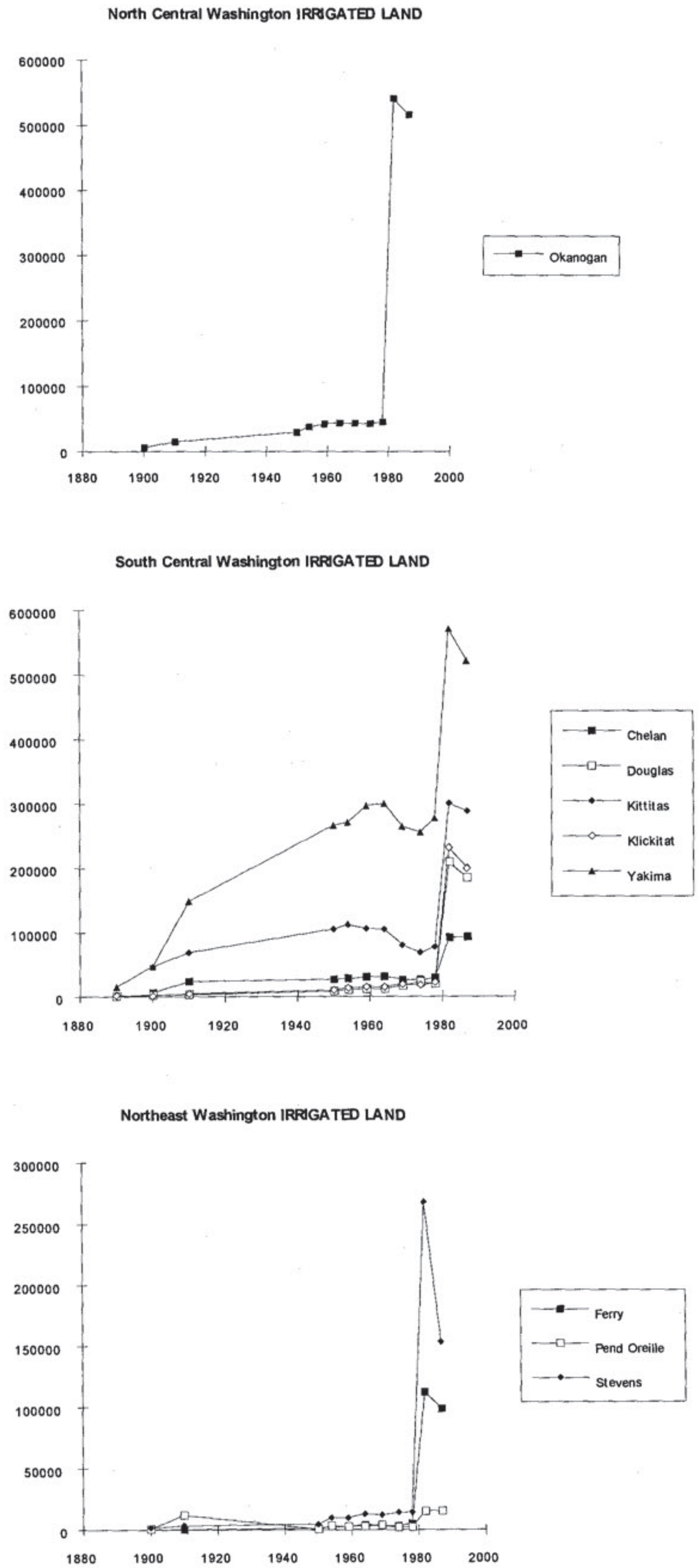
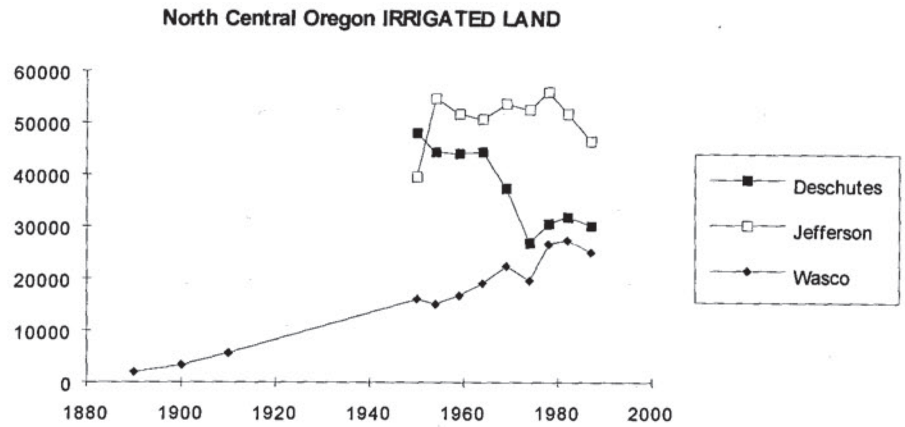
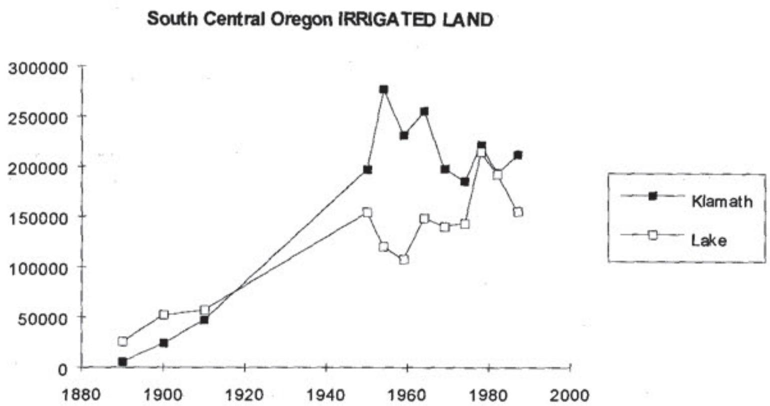
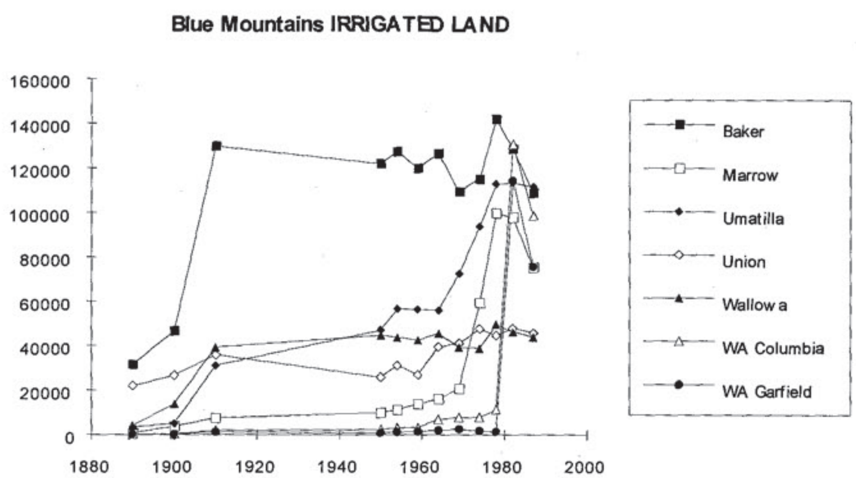


Figure 16. Irrigation occurred early in places such as the Blue Mountains, central Oregon (16B), and south-central Washington (16A) (U.S.Bureau of the Census). Irrigation was not extensive until much later in other places. Early irrigation involved damming of rivers and streams; later irrigation also used well water.







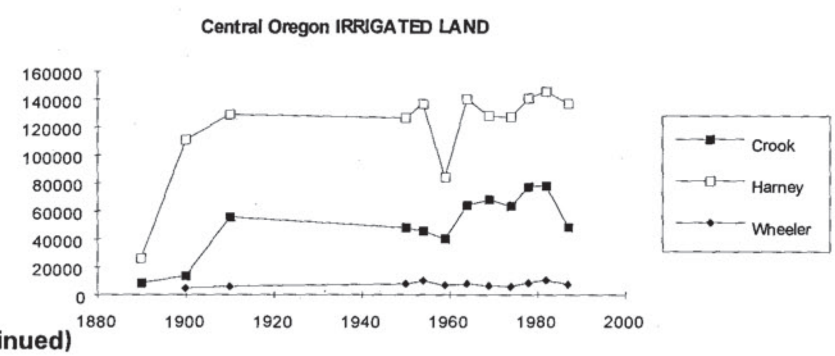


Figure 16 (continued)

Just as managers had no concept of an ecosystem, at the time no concept defined "riparian zones" as specific entities to manage or safeguard. Consequently, managers addressed specific issues; they did not try to protect the basic patterns and processes of riparian habitats or streams. For example, streams were not protected from sheep and cattle, animals that often removed vegetation from the stream banks, trampled the wet soil, caved in the stream banks, and created wide, shallow streams with little shade or pools for fish.

1930 to 1960-Flood control efforts continued with the channeling of streams, which coupled with grazing and road building, worked to reduce riparian habitats. Fish habitats were degraded through scouring of fine sediments. Irrigation efforts increased in many areas (tables 3A, 3B; fig. 16); however, the ecological and social costs of flood control and irrigation did not go unnoticed, and some people called for action to remedy the problems. For example, fish ladders were installed at dam sites (Perala and Collins 1990). The importance of riparian zones was still not understood, and these habitats continued to decline as a result of dewatering, straightening of channels, and fragmentation by roading.

1960 to the Present-Riparian zones are now recognized as habitats highly interconnected with streams; consequently, the practice of leaving streamside buffers strips of undisturbed or less disturbed vegetation began. Relatively little is known about riparian zone management. Evidence suggests that the quantity and quality of riparian and stream habitats for aquatic and amphibious species are reduced by such practices as channeling rivers and streams, eliminating access to side channels, damming, removing woody debris, and preventing the flow of sediment down the channel. Erosion, mass wasting, and siltation cannot be prevented, but they can be brought within ranges which do not eliminate other ecosystem values. Preventing small siltation events may simply create conditions for larger events in the future, in the same way that preventing small fires leads to fuel buildup and the increased likelihood of large fires. Some sand, silt, and gravel in the stream channel is necessary for many aquatic species, and some thrive after large siltation events. Others require habitats that have not been disturbed for a long time.

Little is known about riparian and aquatic species and their habitat needs. Current management practices attempt to prevent or avoid most disturbances in riparian zones. More research will be needed to determine appropriate types, timing, and rates of disturbances for maintaining stream and riparian biodiversity.

Besides direct stream manipulation, forestry-related activities that contribute most to stream siltation are poor road and bridge construction and maintenance, and poor grazing practices (Seaton and others 1973). Many old roads and bridges were improperly constructed, and need extensive reconstruction to maintain their usefulness and to mitigate their adverse effects on streams.

Wildlife Management

Pre-1930-Early wildlife management programs emphasized both protection and enhancement. For example, sheep and cattle were protected against natural predators such as wolves and grizzly bears (Steen 1976). Game species were managed to produce a harvestable surplus. Numerous species were introduced or reintroduced, and populations were protected against overharvesting. Severe restrictions were placed on the harvest of mule deer and elk on the eastside in the early 1900s to allow populations to rebuild. Elk were transplanted from Yellowstone National Park and Jackson Hole, Wyoming, between 1912 and 1931 to supplement small local herds (Couch 1953, Robbins and others 1982). Control of some native predators has made these predators locally extinct or endangered. Game management has increased some elk populations well above those encountered by early settlers.

1930 to 1960-With increased deer and elk herd sizes, more active game management occurred (discussed earlier), along with fish management (Perala and Collins 1990). At times, elk were transplanted to areas where they previously had been scarce. For the most part, however, wildlife management was restricted to animals hunted for sport and fishing.

1960 to the Present-Recent concerns for wildlife have extended beyond protecting game species and controlling predators, to include efforts aimed at protecting and conserving all species. The Endangered Species Act attempts to protect all species, yet protection measures are generally initiated only after species are already in serious trouble. A conflict that may soon emerge in eastern Oregon and Washington involves threatened or endangered species that have conflicting requirements. Historically, stand structures were maintained in a dynamic state across landscapes-through natural growth and disturbance regimes. Thomas and others (1979) were among the first to suggest an integration of non-game wildlife species in managed forests. Recent studies have shown a strong association between many non-game wildlife species and late successional forests. People often react to species in danger by wanting to curtail all management activities-with little incentives or funds available for active or preventive management.

Wilderness Areas

Pre-1930-*The Forest Service Use Book* of 1905 specified that the "prime object of the forest resources is use" (Steen 1976). A change of philosophy is reflected in 1924, when the first USDA Forest Service wilderness area was designated (Steen 1976) (not in Oregon or Washington).

1930 to 1960-No wilderness areas were established in eastern Oregon and Washington during this period; however, parts of National Forests in eastern Oregon and Washington became National Parks.

1960 to the Present-Other amenity and aesthetic values are encouraged and required by society on National Forest lands. Both recreational use and wilderness have increased substantially on National Forests (figs. 17, 5), although most types of recreational (fig. 17) use are not suitable to wilderness areas. Fires have been excluded from both wilderness and nonwilderness areas, and fire hazard in wilderness mirrors that of nonwilderness. In fact, wilderness areas may have higher hazards than nonwilderness because wilderness areas were commonly designated in high-elevation vegetation types that still retained their pristine qualities, and lacked prior harvest entry. These high-elevation types more often than not have high fire-severity regimes.

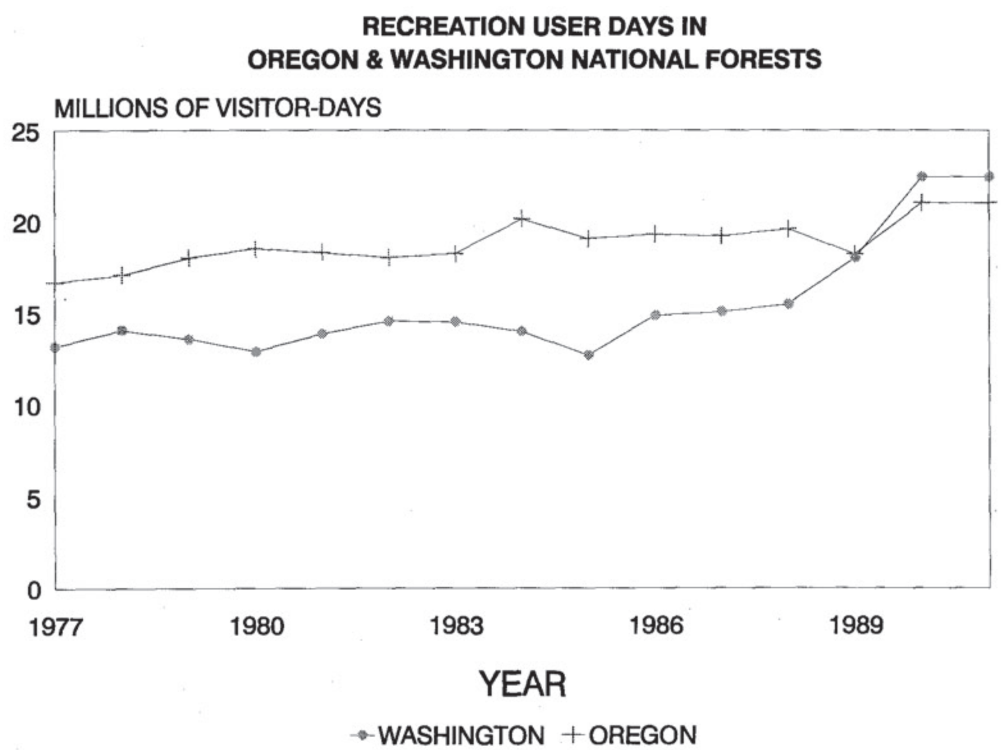


Figure 17A. Recreation visitor-days on all National Forests in Oregon and Washington (eastern and western). Recreation use of National Forests has greatly increased in Washington since 1985 (USDA Forest Service 1975-91).

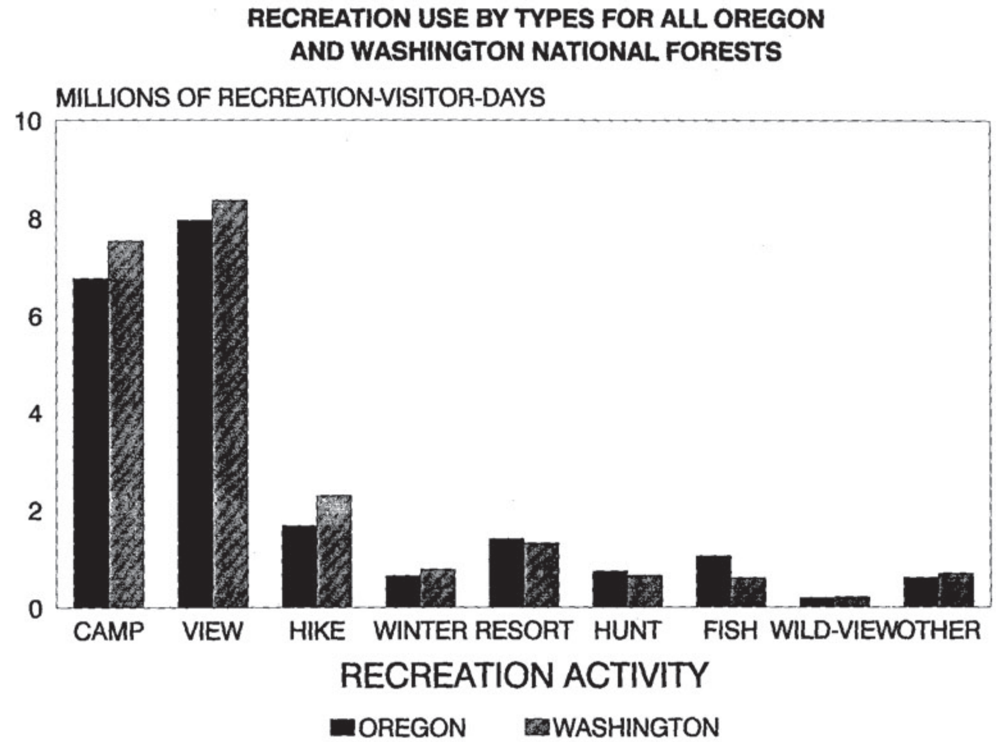


Figure 17B. Recreation use in Washington and Oregon by activity (both eastern and western parts; more specific data were not available) in 1991. Most recreational activity is viewing (near automobile) and camping, picnicking, and swimming (USDA Forest Service 1975-91):

Camp = camping, picnicking, and swimming
View = mechanized travel and viewing scenery
Hike = hiking, horseback riding, and water travel
Winter = winter sports
Resorts = resorts, cabins, and organization camps
Hunt = hunting
Fish = fishing
Wild-view = nonconsumptive fish and wildlife use
Other = other recreational activities

Silviculture Practices

Pre-1930-Silvicultural operations, such as active regeneration and stand tending, were generally absent in the late 1800s and 1900s; timber was simply extracted. Harvesting patterns were sometimes adjusted to promote regeneration through partial cutting and seed-tree harvesting. By the 1920s silvicultural practices were still not very intensive in eastern Oregon and Washington. In 1923, trees were planted on only 1615 acres in National Forests in Oregon and Washington-none were planted in eastern Oregon or Washington (USDA Forest Service 1923, 1952-62).

1930 to 1960-Funding for silvicultural activities was provided through a revolving fund from timber receipts by the Knudtson-Vandenberg Act of 1930 in an effort to ensure that silvicultural activities were continued to provide future timber supplies. By tying silvicultural activities to timber production, silvicultural activities to enhance other values but not justifiable on the basis of timber production were not done.

Silvicultural practices for timber production increased dramatically during this period, with a variety of planting, seeding, thinning, and pruning practices successfully attempted (fig. 18). Planting and thinning efforts during the 1950s and 1960s, however, were closely spaced, and many stands treated during that period are still overcrowded-a common problem throughout the United States (Oliver 1986). In the mid-1950s, pruning was the preferred method of stand improvement in eastern Oregon and Washington, and was done during seasons when other operations were not feasible. The increasing wages, increasing mechanization of other operations, and concomitant movement of people to urban areas in the 1950s reduced the forest labor force and increased costs, thus making pruning uneconomical.

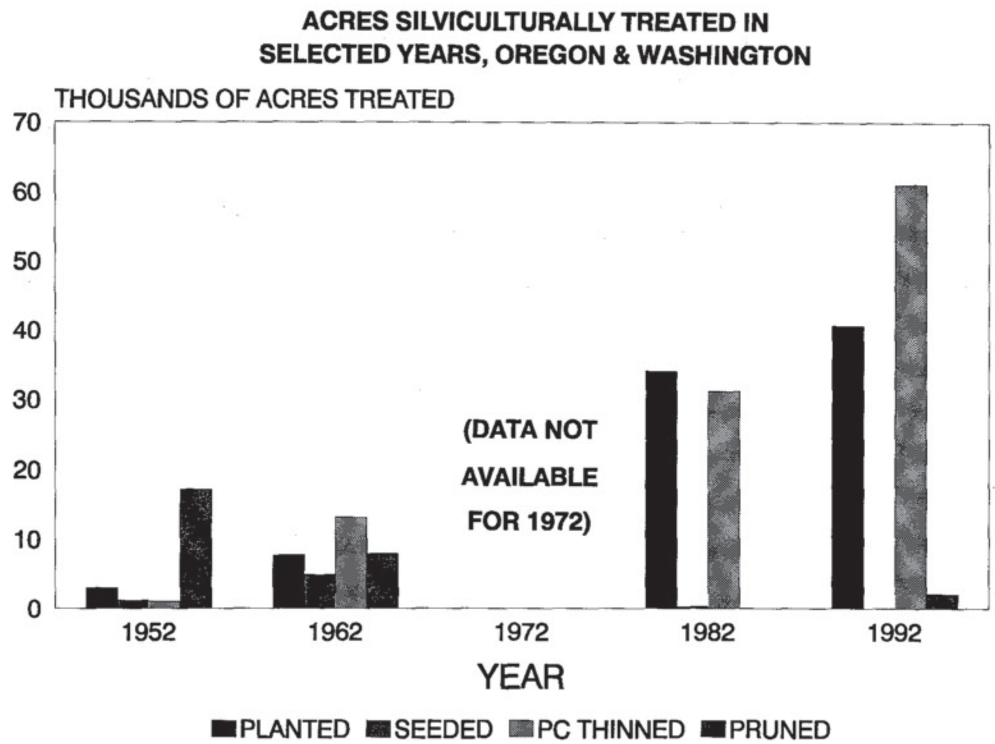


Figure 18. Silvicultural activities have generally increased dramatically in eastern Oregon and Washington since 1950. Planting and precommercial thinning have increased, and pruning has declined (USDA Forest Service 1923 and 1952-62; USDA Forest Service 1975-1991).

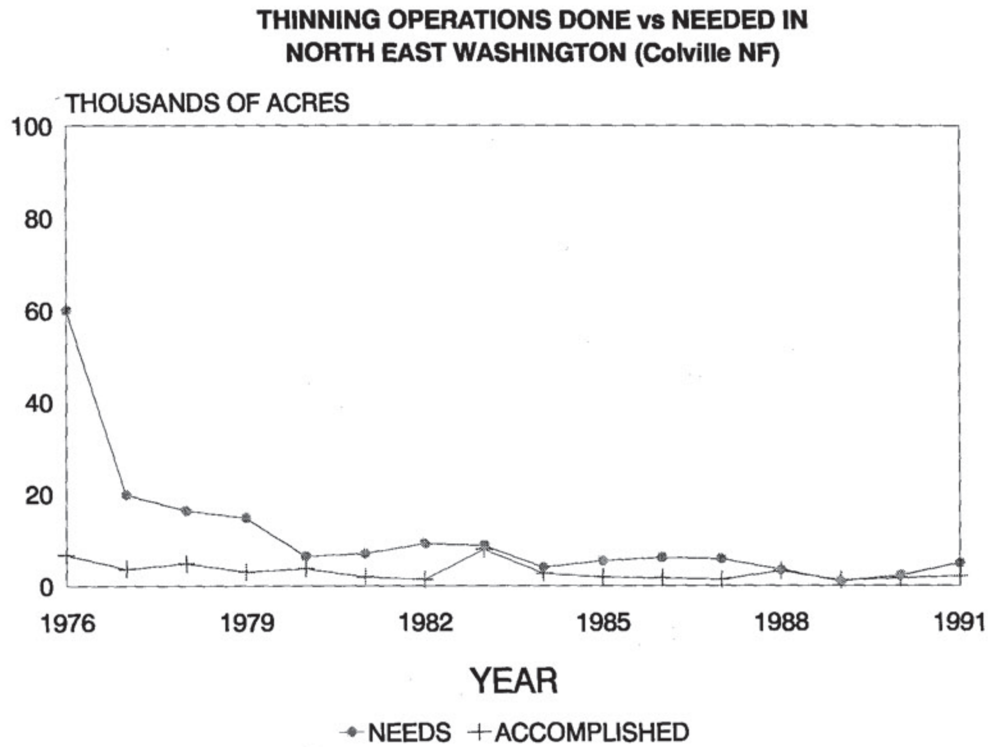
Increased silvicultural activities from 1930 to 1960 were primarily experimental in nature, but infrastructure and experience was developing to allow more intensive and extensive silvicultural activities in the coming decades.

1960 to the Present-Most silvicultural activities to date are funded from timber sale receipts under the Knudtson-Vandenberg Act of 1930. These receipts were made available to fund other resource management objectives with the National Forest Management Act. Presently, the Silviculture section in Forest Service organizations is a subset of the Timber Management division. Historically, silvicultural treatments were primarily considered where they yielded a financially acceptable economic return; this consideration is changing.

Eastern Oregon and Washington contain many overcrowded stands that should be thinned to prevent increasing susceptibility to insects, diseases, and fires and to create a greater diversity of plant and animal habitats. Many of these stands have not been reported as silviculturally in need of thinning by local National Forest managers; consequently, funding has not been considered by higher-level managers for treating these stands. Reasons for not reporting these stands are unclear.

Specific silvicultural operations and the extent of their application: early spacing (precommercial thinning)-one of the greatest problems in the forests of eastern Washington and Oregon is the large area of stands of overly crowded, small-diameter trees. These stands should be thinned before the trees grow tall, to allow remaining trees to grow large in diameter to avoid insect and disease attacks, and to avoid snow breakage by improved height-to-diameter ratios.

The area reported as needing and receiving thinning in eastern Oregon and Washington from 1976 to 1991 is shown in figure 19. Many more stands are overcrowded and will decline in vigor if not thinned, but were not reported. Thinning will reduce fire danger in the long run, increase habitat diversity, and produce jobs. Thinning has historically been justified for economical production of timber. This economic consideration gives lowest priority to poor (in growth potential), dry sites, and so these sites are often not thinned (fig. 20). Poor sites are often droughty and prone to insect attacks and fires-especially if not thinned. These poorer sites, created by catastrophic fires many decades ago, contain the largest areas of overcrowded stands on the eastside.



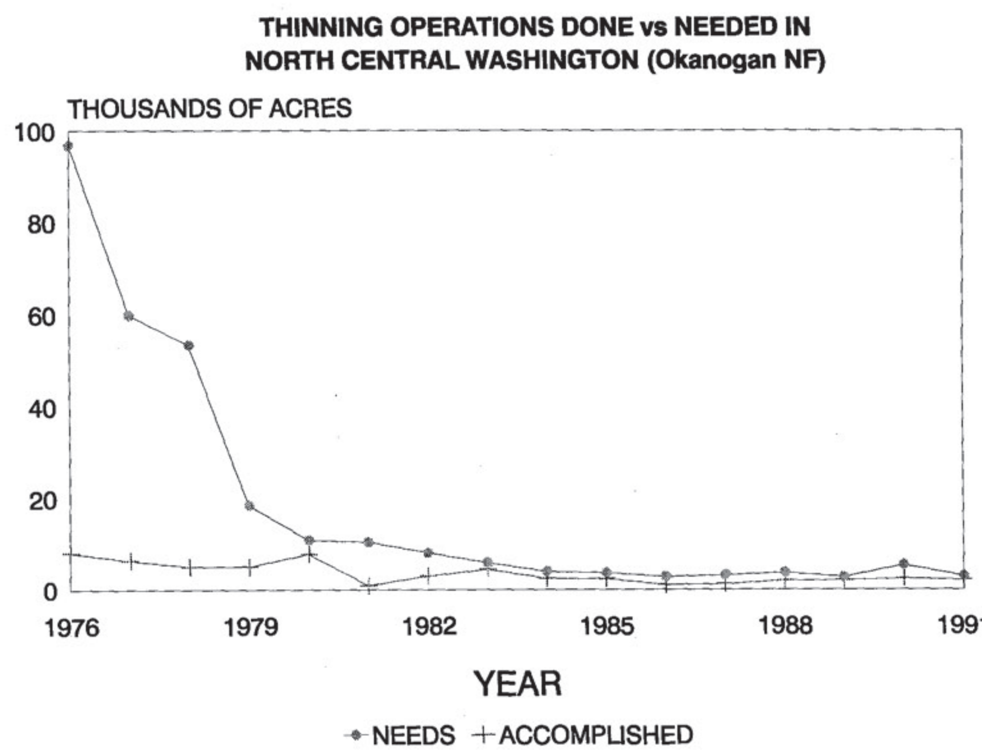
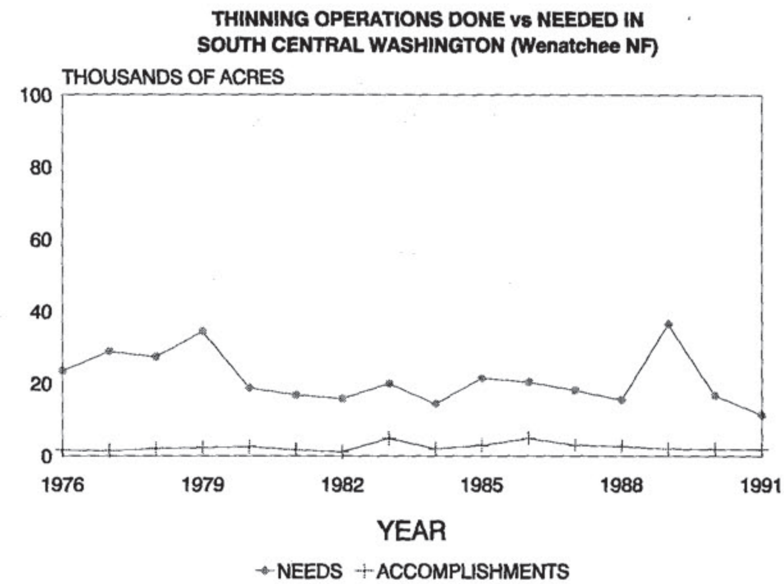
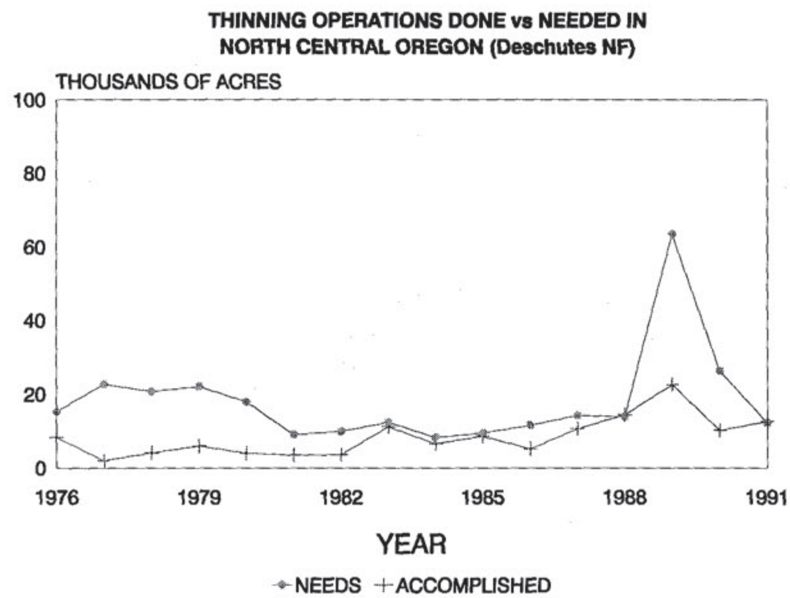
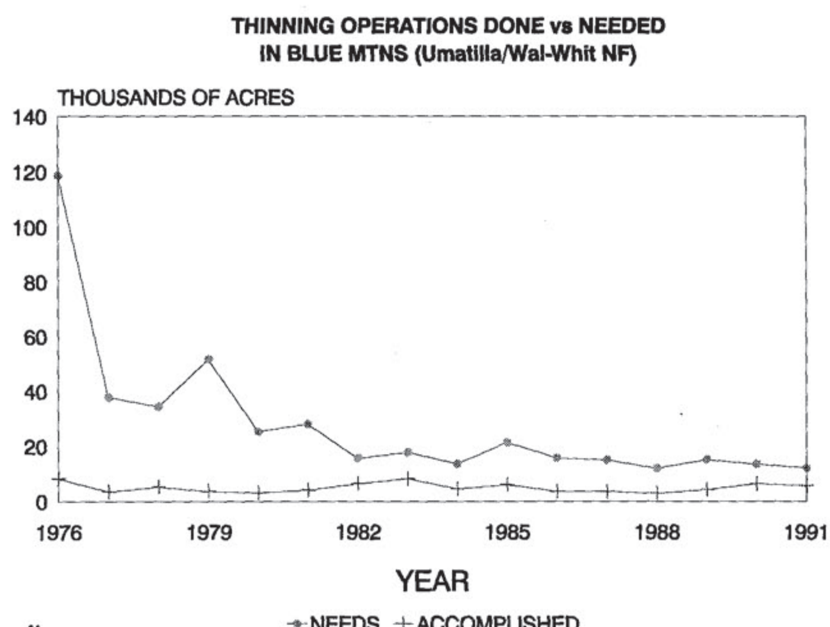


Figure 19. Thinning operations needed and accomplished by subregion and year in eastern Washington (19A) and Oregon (19B) (data on file, Regional Silviculture Office, USDA Forest Service, Portland, Oregon).







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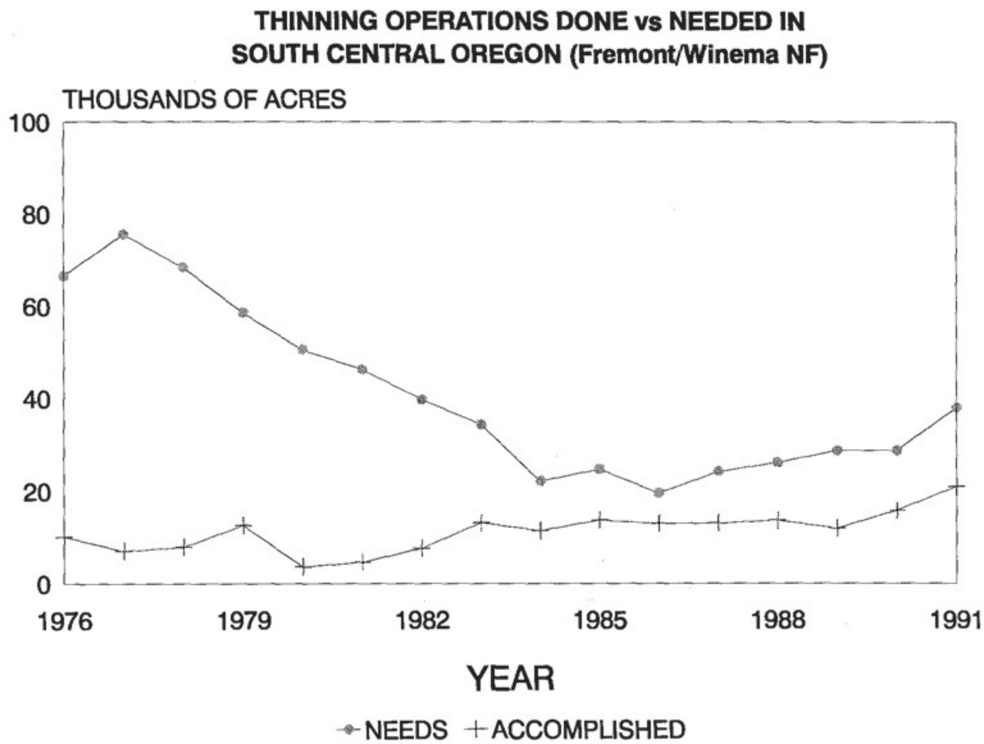


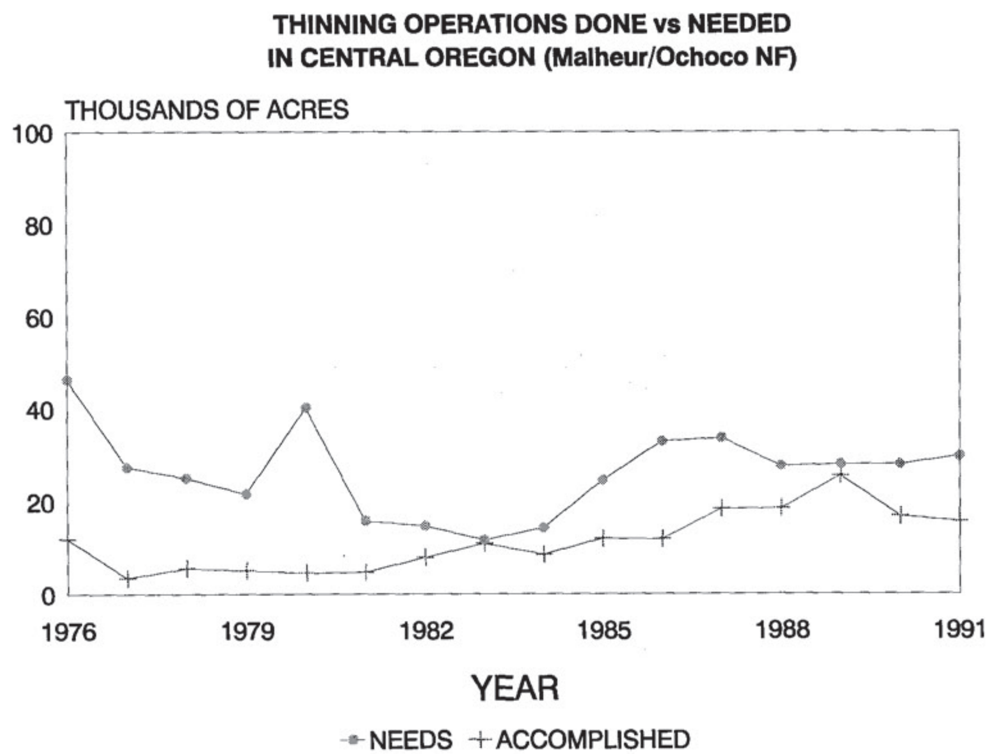


Figure 19 (continued)

Some stands are thinned with a reasonable financial return on investment by removing small-diameter, merchantable, understory trees and allowing the larger, vigorous overstory trees more growing space. Stands of two or more canopy layers are often thinned (overstory removal) with a financial return to the landowner from the overstory trees-usually with varied success in stimulating the understory to grow. This practice may be of questionable value, however, if overstories consist of seral species resistant to disease and insects and understories are species more susceptible to insects and diseases. Overstory removal would amount to a high-grading of resistant species, leaving residual stands that are susceptible to root diseases, defoliators, stem decays, and some bark beetles and dwarf mistletoes.

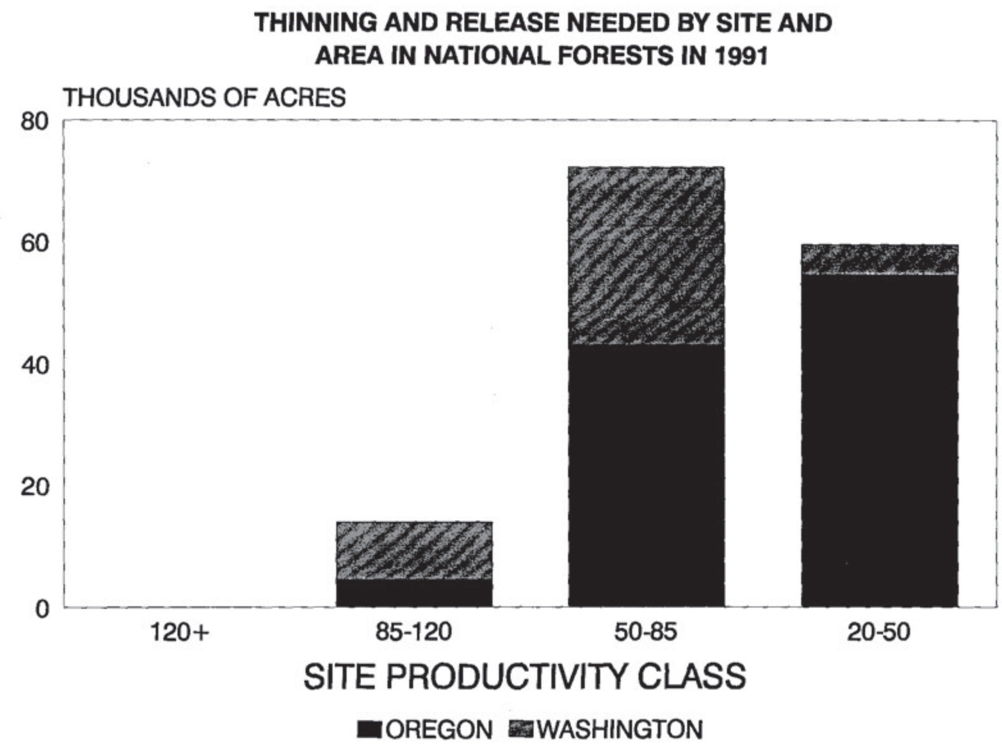


Figure 20. Most thinning and release needs are listed on poor sites. If these stands are not thinned, they become susceptible to insects and fires (USDA Forest Service 1975-91; data from 1991 report).

Weed control-weed control operations are generally done on fewer acres than thinning (fig. 21), and on only a portion of the total area needed each year. The purpose is not necessarily to kill competing plants, but to hinder them long enough to allow trees to outgrow them. Under ecosystem management, weed control may not be desirable in all stands. Shrubs mixed with trees, for example, can provide for habitat diversity or nitrogen-fixation. Weed control by sheep and cattle grazing has been suggested and tried but is not commonly practiced.

Regeneration-Where both even-aged and uneven-aged management are practiced in National Forests in eastern Oregon and Washington, many areas are artificially regenerated by planting seedlings to ensure an adequate mixture of tree species (fig. 22). Lodgepole pine and true firs regenerate well naturally. Nearly all areas in eastern Oregon and Washington that are harvested are regenerated within five years. Sometimes regeneration fails (fig. 22) because of certain critical site variables. Further harvest is often stopped on National Forests in areas where regeneration is found not to be successful.

In artificial regeneration a variety of seedlings sizes and hand planting equipment is used. Most trees planted are Douglas-fir and ponderosa pine, although genetically improved western white pine, western larch, lodgepole pine, and other species are also used.

Fertilization-Fertilization of forest lands is possible, but only recently has been done in eastern Oregon and Washington and only to a limited extent. Of the 4647 acres in eastern Oregon and Washington listed in 1991 as needing to be fertilized (justifying the need based on economic return to timber production), only 2058 acres were fertilized. Fewer acres were fertilized in 1990.

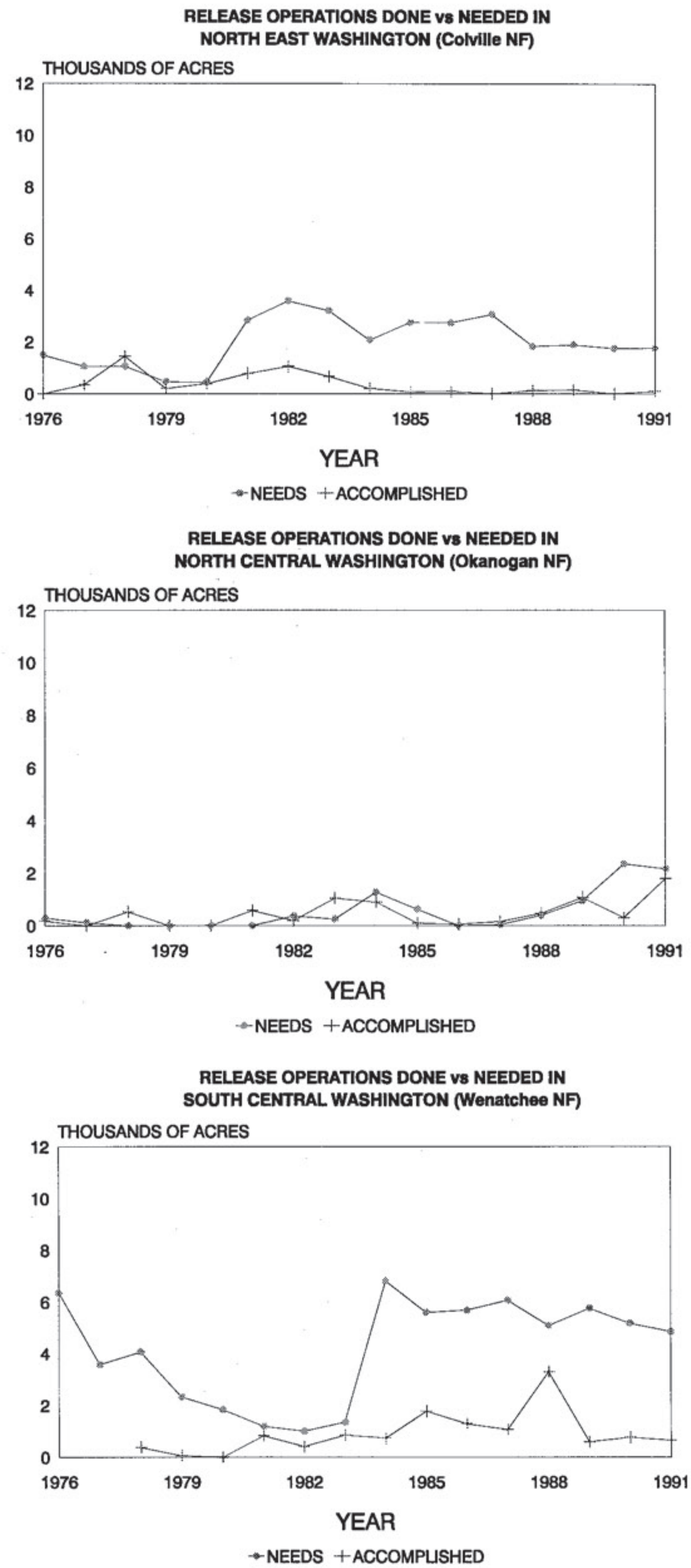
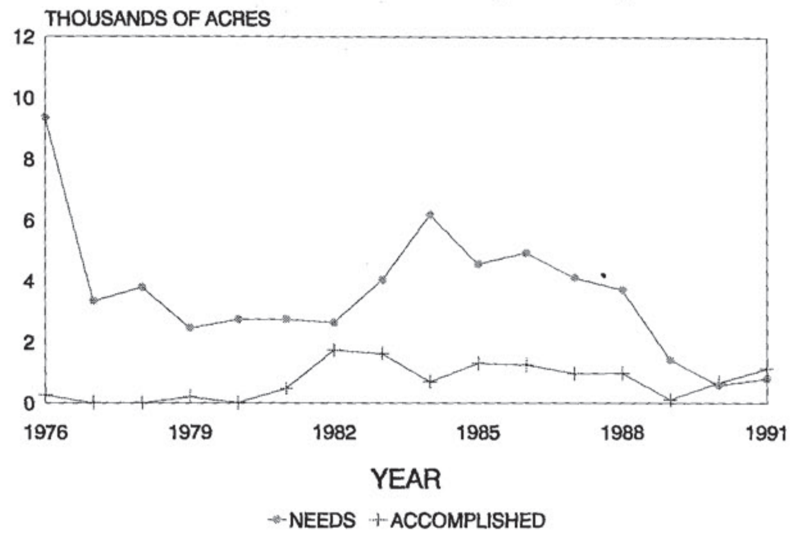
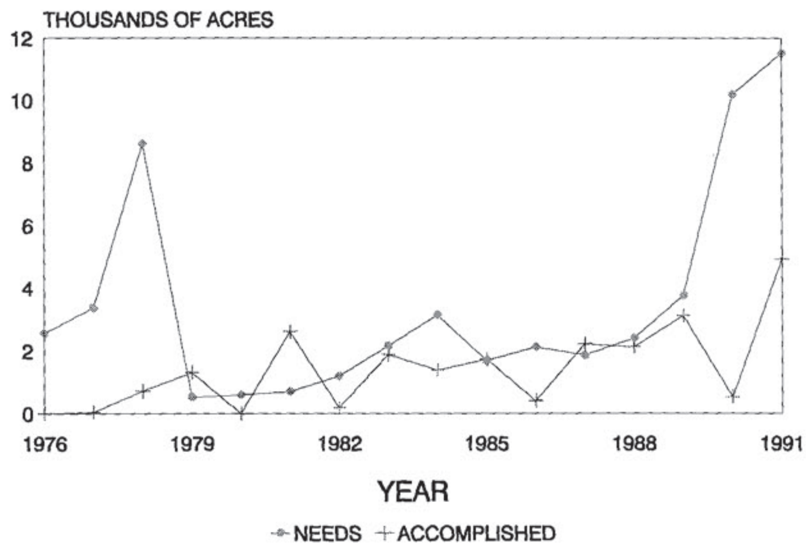


Figure 21. Release operations needed and accomplished by subregion and year in eastern Washington (21A) and Oregon (21B) (data on file, Regional Silviculture Office, USDA Forest Service, Portland, Oregon).

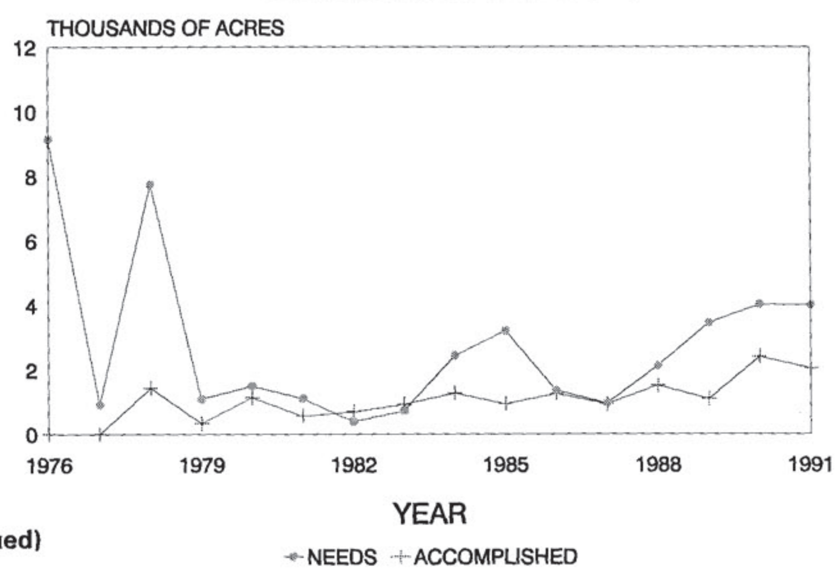
RELEASE OPERATIONS DONE vs NEEDED IN NORTH CENTRAL OREGON (Descutes NF)



RELEASE OPERATIONS DONE vs NEEDED IN SOUTH CENTRAL OREGON (Fremont/Winema NF)



RELEASE OPERATIONS DONE vs NEEDED IN BLUE MTNS (Umatilla/Wal-Whit NF)



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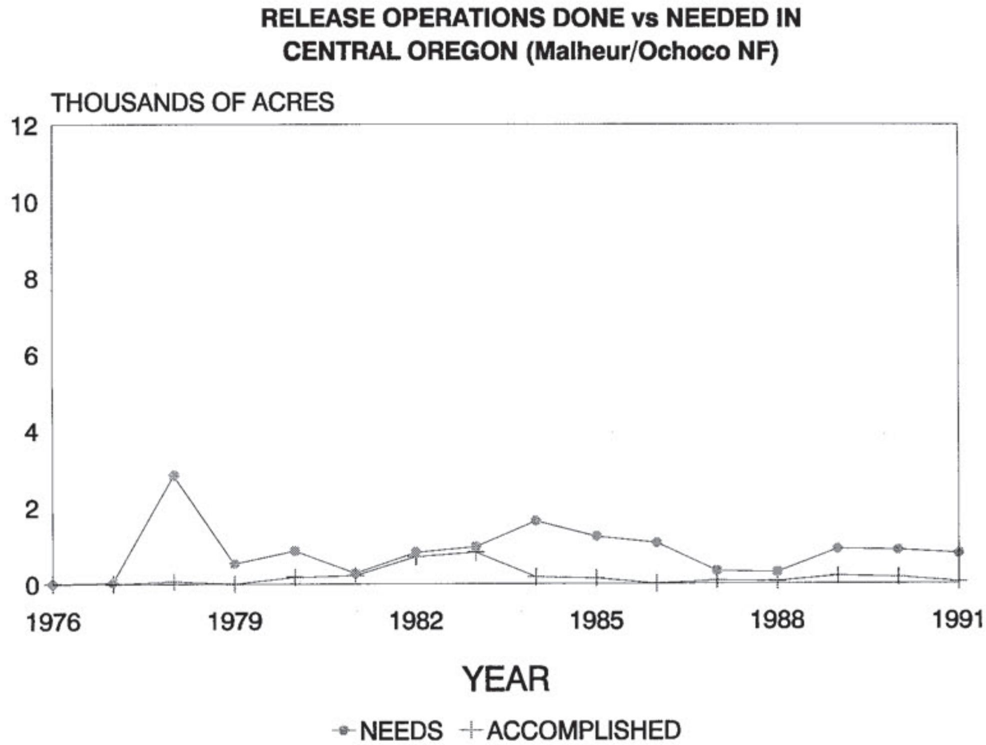

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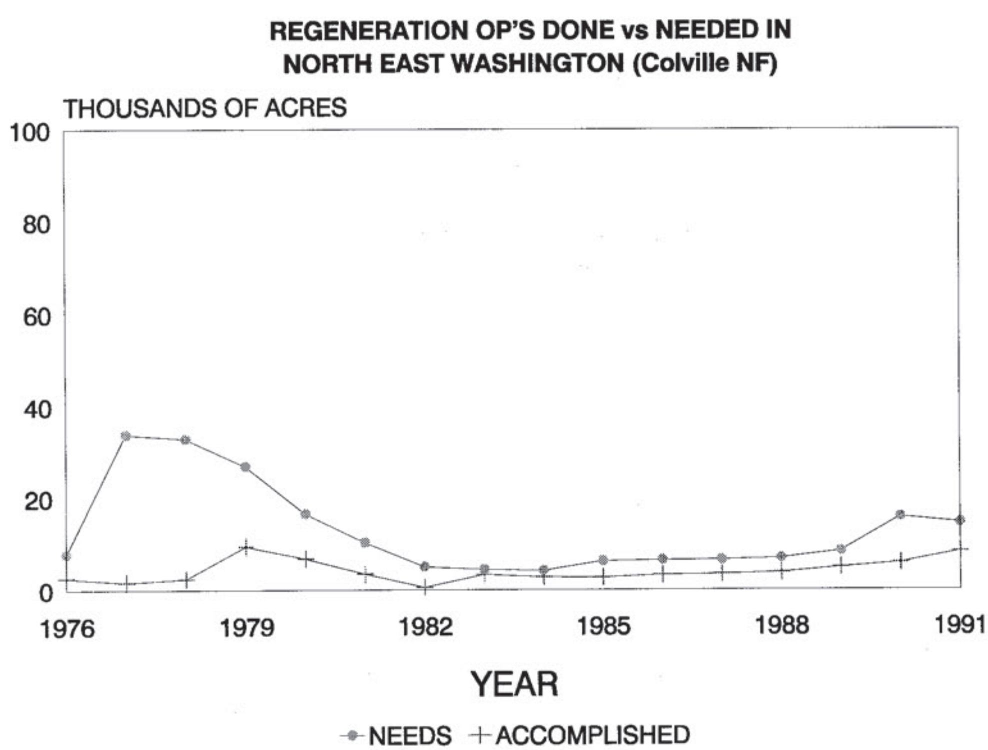
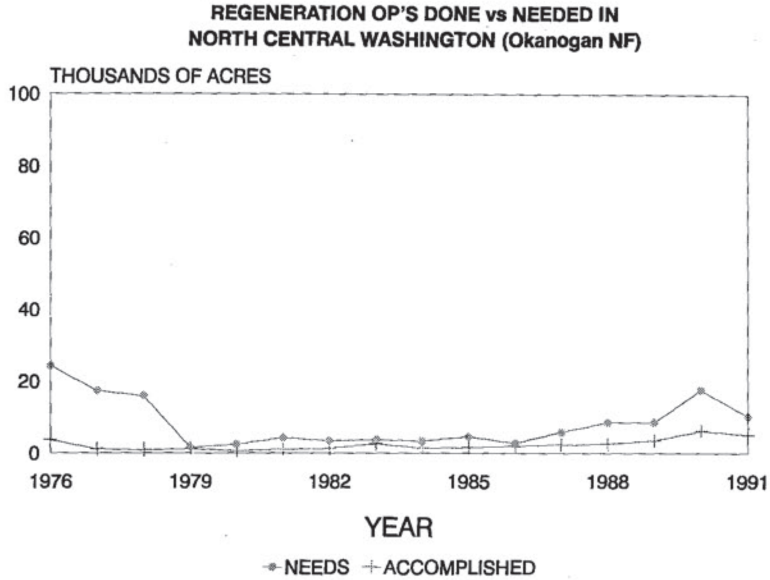
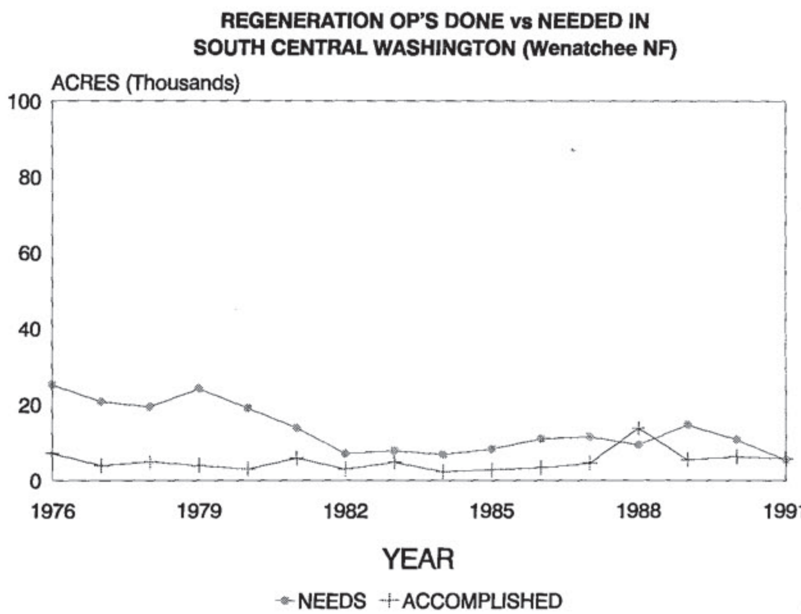
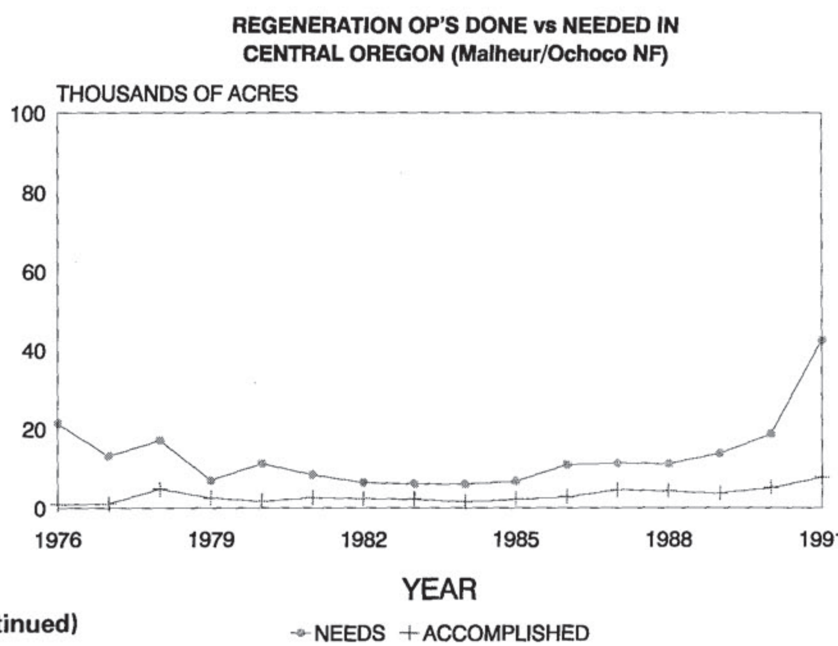


Figure 22. Regeneration operations needed and accomplished by subregion and year in eastern Washington (22A) and Oregon (22B) (data on file, Regional Silviculture Office, USDA Forest Service, Portland, Oregon).







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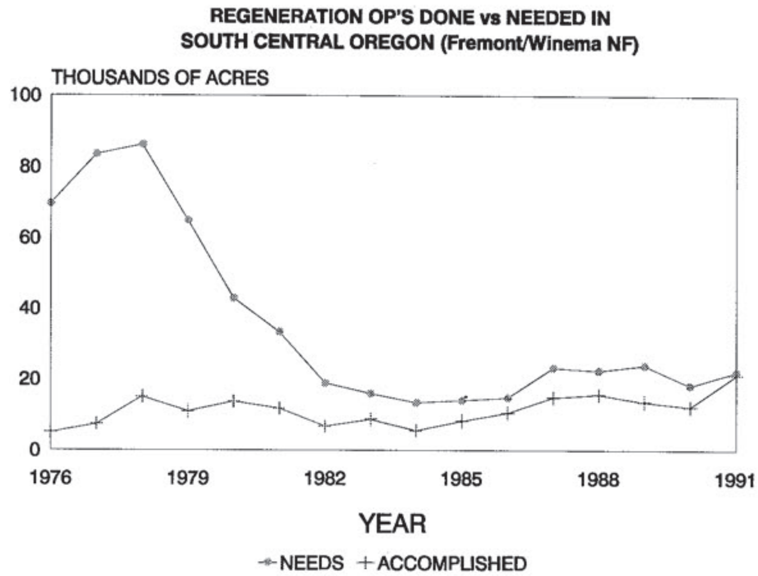

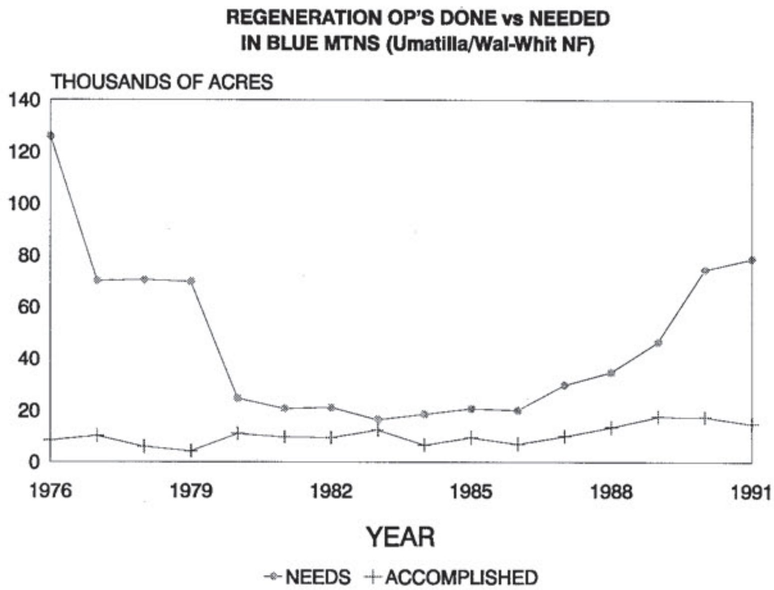

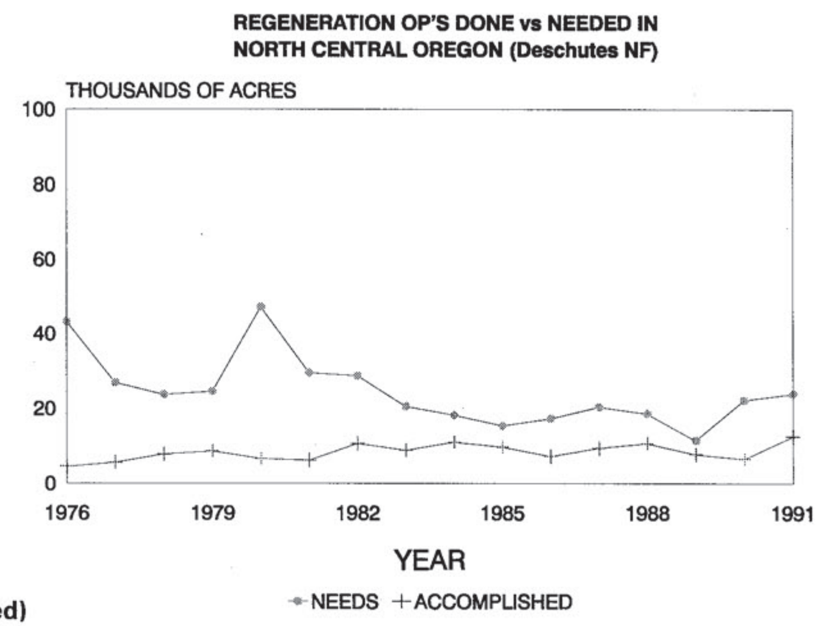

Figure 22 (continued)

Tree improvement-The Forest Service currently has an extensive genetic resource program in eastern Oregon and Washington with the goals of providing leadership in genetic conservation and resource management, integrating genetic principles into management, maintaining tree-improvement programs, educating and transferring technology, and improving cooperative efforts.

For 15 tree species, 32,334 parent trees are included in the Tree Improvement Program. In addition, seed orchards presently cover 549 acres in eastern Oregon and Washington. These orchards are for seven tree species with a total of 6284 families ponderosa pine, Douglas-fir, western white pine, sugar pine, lodgepole pine, Engelmann spruce, and western larch. Even planted seedlings not taken from selected trees are taken from known, local seed sources. In the future, all species should be screened for resistance or tolerance to insects, diseases, and sensitivity to environmental stresses to broaden the adaptability of the genetic resources.

Pruning-Pruning was done in eastern Oregon and Washington in the early 1950s. Pruning is once again being recognized as a useful silvicultural activity (Fight and others 1992. In 1989, two National Forests in eastern Washington and Oregon reported 1937 acres in need of pruning, yet no pruning was done. By 1991, 11,090 acres were listed as needing pruning, but very few acres were actually pruned. Pruning is generally done with hand and pole saws. Various mechanized pruning machines have been tried but none are used operationally. Pruning, in combination with thinning to remove suppressed trees, may be a useful technique to enhance the value of young, dense stands for northern spotted owls. These techniques could be especially effective if used in combination with prescriptions for snags and woody debris.

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APPENDIX A

Information Sources

Information for this history came from a variety of sources and covered different geographic units. U.S. census data were collected for various counties and so included nonforested and forested areas. USDA Forest Service Resource Reports included all forest lands, regardless of ownership. USDA Forest Service Annual Reports and unpublished data (available courtesy of the USDA Forest Service Regional Office, Portland, and elsewhere) covered primarily activities on National Forest Land. USDA Forest Service fire suppression data and similar pest-control information included both National Forests and other forest land within the fire or pest control area. Some information on non-Federal forest lands was taken from unpublished data (CINTRAFOR 1993).

Systematic sources of data described above were more available for recent decades; early management information was taken from a variety of direct and indirect sources. Various scientific and technical publications (books, journals, and reports) describing management practices were used to supplement more specific information.

In addition, two drainage basins were subsampled in depth for very area-specific information (fig. 1). These basins were the Yakima River basin in south-central Washington and the Grande Ronde River basin in the Blue Mountain area. Fifteen (Yakima) and twenty (Grande Ronde) selected watersheds within these basins were chosen, with watershed size varying from about 15,00 to 30,000 thousand acres. Detailed history of various, selected practices were reconstructed from past records wherever possible (tables 3A, 3B; figs. 5, 12; the authors are grateful to Donald Spurbeck, Bonnie Java-Sharpe, Elizabeth Goulet, and John Beebe for the Yakima basin information and to Todd Welter, Ken Williamson, and Charles Ernst for the Grande Ronde information). Some data were unavailable for all watersheds; therefore, the information for each area was adjusted to reflect the extent of practices per million acres of forest land. Specific information was provided by experts in the following areas: fire management, Erik C. Christiansen; bark beetle management, Iral Ragenovich; defoliating insect management, Dave Wallez Bruce Hostetler; genetic resource program, Sheila Martinson; silvicultural activities, Ernie Meisenheimer and Don Connett. All are with the USDA Forest Service. The authors are also grateful to Dr. Stephen J. Pyne of Arizona State University for his review and editing of the fire section of this paper.

Consistencies among management trends from census data, Forest Service Resource Reports, Forest Service annual reports, fire and pest-management information, various technical and scientific journals, and sampled data from the selected drainage basins suggest that the trends reported in this paper are relatively accurate.

APPENDIX B

Timber Harvest Practices

Timber has generally been harvested in both even-aged and uneven-aged systems. Even-aged systems include clearcutting, seed-tree cutting, and shelterwood cutting. They mimic stand-replacing disturbances (with occasional trees left in seed-tree and shelterwood stands) because essentially all trees begin after the single harvest disturbance. Clearcutting removrs all trees of the pre-disturbance age; seed-tree cutting leaves a few, vigorous trees to provide seeds for regenerating the new stand; shelterwood cutting leaves more overstory trees after the initial harvest to prevent extremes of heat and cold on the regeneration. Residual trees can be removed in seed-tree systems, and are generally removed in shelterwood systems to prevent their shade from reducing growth and vigor of the regenerating stand.

Uneven-aged systems mimic partial disturbances because they leave many living trees within the harvested area but allow regeneration of a new stand. Uneven-aged systems are considered high grading when the most vigorous trees are removed and small, weak (and often scarred and diseased) trees are left, or when the largest, highest value species are removed. Silvicultural selection systems promote vigorous trees of a variety of ages and species by removing weakened trees-as opposed to high grading.

Group selection systems generally leave larger openings than traditional uneven-aged systems and leave a mosaic of stands of many species and structures.

Thinning removes some trees-either from upper canopy layers (high thinning) or lower canopy layers (low thinning). Thinning can be done in conjunction with both even-aged and uneven-aged systems, but with no expectation of obtaining regeneration after a thinning. Much harvesting in eastern Oregon and Washington has been overstory removal, removing scattered, large, older trees in stands in the stem exclusion or understory reinitiation stages after partial disturbances (fig. 4). Technically, overstory removal removes the large, old overstory trees, and so converts the stand to a more even-aged stand. Overstory removal is also technically thinning because it does not create enough disturbance to allow a new age class to regenerate.

Various equipment has been used in harvesting, including horses and oxen, cable systems, railroad systems, rivers (with splash dams), tractors (both track and wheel types), trucks, and helicopters. Often combinations of equipment were used. Horses and oxen were used to drag (yard) logs to a road or stream; they were also used to haul logs to a processing facility.

Cable systems were used to yard logs to a road, often suspending part of the log to reduce ground friction and soil compaction. Rivers were used to move logs to processing plants. Sometimes, logs were accumulated behind a small dam or splash dam; then, the dam was broken and the logs floated downstream on the released water.

Tractors have been used to yard logs. Tractors with treads compact less than tractors with round tires but are slow, and tractors with round tires (rubber-tired skidders) are faster but can compact wet soils of fine texture. Temporary railroads (specially built) have been used to haul wood from yarded areas to processing facilities. Helicopters have been used to yard wood to roads.

Tree branches and limbs are usually left in an area after harvest and can be burned, piled, or piled and burned under controlled conditions to prevent a wildfire. But this practice can prove quite harmful to a site because bulldozers used to pile woody debris disturb the soil, and burning concentrates the nutrients in one place, volatilizes nitrogen, and overheats the soil beneath the slash pile.

GLOSSARY

Advance regeneration-Trees of certain species that grow very little and remain small, near the forest floor beneath a closed forest, but can grow rapidly after the larger trees are removed.

AUM-"Animal Unit Month" One mother cow or sheep with calf or lamb, grazing for one month.

Bark beetles-Beetles that attack tree stems.

Browsing-Browsing and grazing are used interchangeably in this report.

Canopy-The part of the stand containing.the tree crowns.

Channelling of streams-Creating a single (usually straight) channel for a stream, so it does not meander and erode the stream banks; at first, channelling was viewed as enhancing riparian and aquatic habitat; now, it is viewed with less favor.

Clearcutting-Harvesting where all trees (except advance regeneration) are removed from the stand.

Cohort-The trees entering a stand after a single disturbance; cohort is used interchangeably with "age class" in this report.

Controlled fire-A human-set fire under controlled conditions, so the area burned, smoke, and intensity of fire can be controlled. (Same as prescribed fire.)

Crown-The part of the tree containing living foliage.

Defoliating insects-Insects that feed on leaves or needles.

Early spacing-Trees spaced by cutting excess ones in overly crowded stands when the harvested trees cannot be sold.

Economic feasibility-Capable of a reasonable return on investment (for example, 3 percent to 9 percent, depending on circumstances).

Even-aged systems-Harvest (and subsequent silviculture) systems in which nearby trees growing after the harvest are about the same age; even-aged systems include clearcutting, seed tree cutting, and shelterwood cutting.

Fertilization-Adding fertilizers to the forest.

Fire cycle-Average time between fires revisiting the same stand in a given area.

Fuel-Dry, dead tree parts that burn readily.

Game-Animal species hunted for sport or food.

Grazing-Grazing and browsing are used interchangeably in this report.

Ground fire-A fire that burns along the forest floor and does not affect trees with thick bark or high crowns.

Harvest-Cutting and removing parts of trees (usually the stem) from the forest.

Harvest systems-Patterns of harvesting trees, which mimic either partial or stand-replacing disturbances.

Haul-Carrying cut tree stems from the forest to a processing location.

High grading-Uneven-aged harvesting systems, where the most valuable trees and species are removed and diseased, weakened, and scarred trees of less valuable species are left to grow.

Intolerant species-Species that are not tolerant of shade or fire (see tolerant species).

Low thinning-Removing trees that are becoming less vigorous to keep the stand from becoming overly crowded; sometimes the trees can be sold at a profit to pay for the operation.

Mixed stand-A stand consisting of two or more tree species.

Old growth-A forest that contains many canopy strata (layers), a variety of tree sizes and species, and dead woody material.

Overcrowded stands-Stands with too many trees for vigorous growth; consequently, some or all trees become weakened and die, become susceptible to insects or diseases, fires, and wind or snow breakage. Trees grow larger as a stand ages, so the stand becomes more crowded -with age.

Overstory-An upper canopy layer (stratum) of trees.

Overstory removal-Removing large trees in an overstory to release a lower stratum (canopy layer).

Park-like structure-Stands having scattered, large trees and open growing conditions (low=growing vegetation), usually maintained by ground fires.

Partial disturbances-Disturbances that kill some but not all trees.

Pile and burn-Putting logging slash into a pile, and burning it under controlled conditions.

Prescribed fire-Fire set by people under controlled conditions, so that the extent and intensity of the fire and the amount of smoke it produces can be controlled.

Pruning-Removing (usually cutting) limbs from trees to allow knot-free wood to grow; pruning also changes the stand structure which affects wildlife.

Pure stand-A stand consisting primarily of one tree species.

Release-Impeding competing vegetation to allow desired tree species to grow.

Riparian-Referring to banks of a pond, lake, or stream.

Rubber-tired skidders-Large tractor-like vehicles with round, rubber tires used for yarding.

Seed-tree harvesting-Removing all trees except a few left to provide seeds for regenerating the next stand.

Selection systems-Uneven-aged harvesting systems where vigorous trees are left to grow.

Shelterwood harvesting-Removing all trees except several (more than seed-tree harvesting) to provide protection of the regenerating stand from extremes of heat and cold; after the new age-class has regenerated, these trees are often removed.

Silviculture-The practice of manipulating stand structures to attain the objectives of the landowner.

Siltation-Adding sediment to streams and reservoirs.

Silvicultural systems-For this report, silvicultural systems, harvesting systems, and regeneration systems will be used interchangeably, because silvicultural systems and harvest systems are named after their regeneration method.

Slash-Residues-usually limbs, foliage, and small logs-remaining after tree stems have been yarded during harvesting.

Splash dam-A temporary dam used to accumulate logs and water; later broken to allow logs to float downstream to a processing facility.

Stand-A spatially continuous group of trees and associated vegetation with similar structures and history and growing under similar soil and climatic conditions.

Stand initiation-The condition after a disturbance, when many trees, shrubs, and other vegetation are invading the stand.

Stand-replacing disturbances-Disturbances that remove all trees previously existing on the stand.

Stem exclusion-The condition several decades after a disturbance when the trees (or other vegetation) have grown large enough both to kill smaller vegetation and to exclude new vegetation from entering the stand.

Stratum-A canopy layer of trees or other vegetation.

Structure (stand structure)-the physical and temporal distribution of trees and other vegetation in a stand; the distribution can be by species, by vertical and horizontal spatial patterns, by size of trees or tree parts (crown volume, leaf area, stem, stem cross section), by tree ages, or by combinations of the above.

Thinning-Removing some trees from a stand without creating a new age class; thinnings include early spacing (precommercial thinning), low thinning, and overstory removal.

Tolerant species-Species that can survive shaded conditions (light tolerant) or fires (fire tolerant).

Tree improvement-Genetically breeding trees for certain characteristics.

Underburn-Burn by a low fire.

Understory-A lower canopy layer (stratum) of trees.

Understory reinitiation-The condition after stem exclusion when the overstory trees begin to allow new vegetation to enter the understory.

Uneven-aged systems-Harvesting a few trees in a stand both to allow remaining trees to grow and new trees to regenerate, creating trees of many ages; uneven-aged systems include selection systems and high grading.

Wildfire-A fire not planned or controlled by people.

Yarding-Moving the cut trees from where they fell to a centralized place (landing) for hauling away from the stand.

Oliver, Chadwick D.; Irwin, Larry L.; Knapp, Walter H. 1994. Eastside forest management practices: historical overview, extent of their applications, and their effects on sustainability of ecosystems. Gen. Tech. Rep. PNW-GTR-324. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 73 p. (Everett, Richard L., assessment team leader; Eastside forest ecosystem health assessment; Hessburg, Paul F., science team leader and tech. ed., Volume III: assessment).

Forest management of eastern Oregon and Washington began in the late 1800s as extensive utilization of forests for grazing, timber, and irrigation water. With time, protection of these values developed into active management for these and other values such as recreation. Silvicultural and administrative practices, developed to solve problems at a particular time have lingered and created confusion and consternation when knowledge, values, and vegetation conditions have changed. The present condition of most eastern Oregon and Washington forests is the result of disturbance and regrowth processes coupled with historical management practices. Most areas contain high levels of insects, diseases, and fuels. Without many, diverse, creative, and active solutions, large fires and insect outbreaks will occur-with local loss of ecosystem and human values.

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