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Old-Growth Ponderosa Pine-Western Larch Forests in Western Montana: Ecology and Management

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Introduction

Since 1976, the United States Department of Agriculture (USDA) Forest Service, complying with the National Forest Management Act (NFMA), has pursued efforts to maintain landscape diversity in the northern Rockies, using the complete spectrum of vegetation types occupying western North America. Due to the influence of Euro-American settlers during the nineteenth century, however, present-day landscapes support a vegetation cover greatly modified from what was encountered before 1900. Nineteenth century vegetation cover throughout the northern Rockies was transformed by logging, grazing, farming, mining, roading, and altering the historic frequencies of wildfire (Habeck 1987).

Pre-settlement landscape diversity in western Montana included several old-growth forest types that were generally maintained by regular occurrences of natural fire (Habeck 1988). These include old-growth forest types dominated by Pacific ponderosa pine (*Pinus ponderosa* var. *ponderosa*) and western larch (*Larix occidentalis*). Forest ecosystems featuring old-growth ponderosa pine and western larch are considered "fire-dependent" because they are successionally replaced by the more shade tolerant Inland Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) when fire is not allowed to periodically intervene to clear invading Douglas-fir reproduction.

This paper reviews the historical occurrence of these old-growth forests, as well as Forest Service plans to maintain and manage the fire-dependent pine-larch type in this region.

In a public announcement (*The Missoulian*, February 3, 1990), the USDA Forest Service, Lolo National Forest, described its intention to implement the Pattee Canyon Vegetation Management Action Plan (USDA Forest Service 1989). The plan describes actions for

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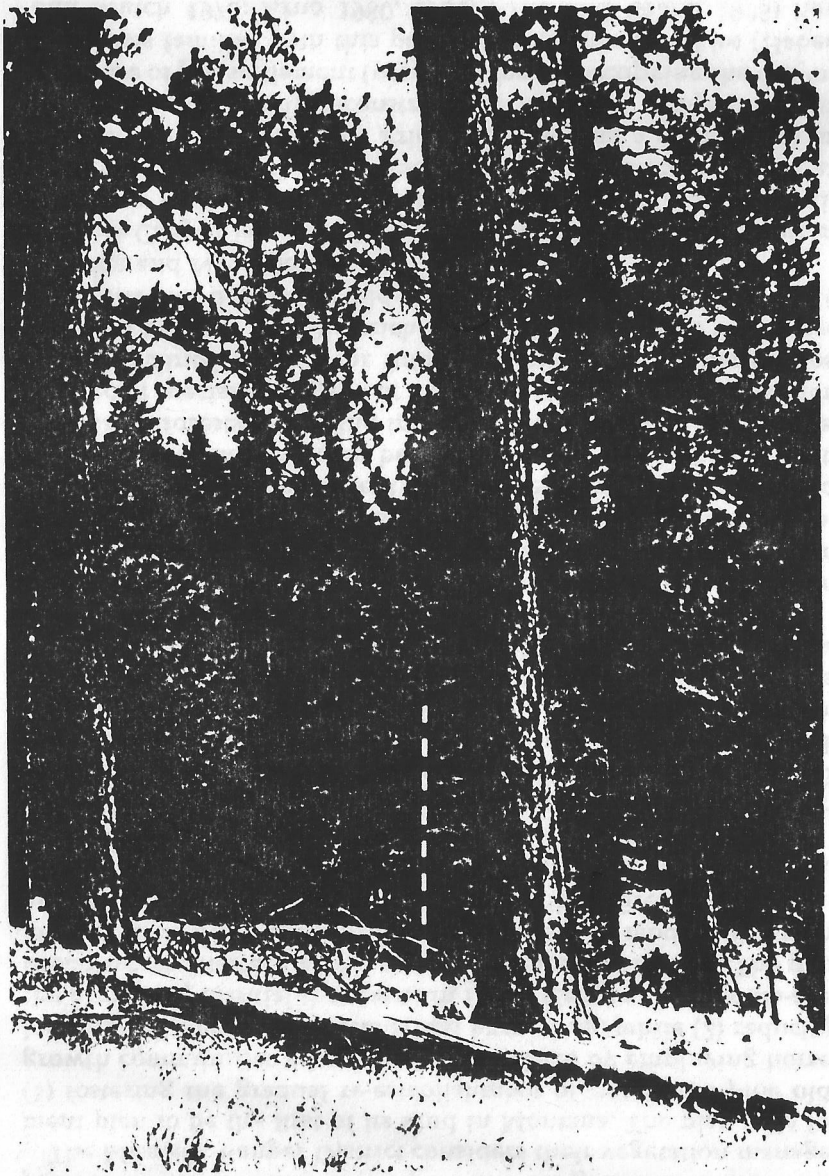

Ponderosa pine. Photo by J. Habeck.

restoring and protecting remnant groves of old-growth ponderosa pine, as well as mixtures of this pine and old-growth western larch.

The Missoula Ranger District considers their vegetation management plan to be the first of its kind in Montana. The plan calls for (1) fostering the gradual re-establishment of ponderosa pine old-growth communities where they once existed by employing horse-logging and low-impact mechanical harvesting, while (2) reducing the high fire potential that exists in Pattee Canyon, a Missoula-area urban-forest interface where many residences are located. The plan also permits, when appropriate, employment of modern fire-management methods, which include prescribed fire treatments to achieve management goals to perpetuate the tree species needing this protection and reduce fire potential in the Canyon.

The Missoula District's plan fits a federal Forest Service policy to manage old-growth for posterity. The remnant old-growth is located in the Pattee Canyon Recreation Area, adjacent to Missoula (Fig. 1, Lat. 46°50'N, Lat. 113°56'W). The Forest Service plan recognizes that preservation of landscape biodiversity must encompass the complete array of forest types, including old-growth types that were maintained and perpetuated by periodic fires before 1900.

If prescribed fire is to be employed as an effective management tool, detailed information is needed about past fires and their influence on present-day vegetation. This report centers upon an analysis of Pattee Canyon's recent fire and vegetation history (Habeck 1985*a*). Special attention has been given to the remnant old-growth pine-larch forests remaining in Pattee Canyon, which are believed in need of special management attention if this diversity component is to be maintained into the future. My efforts are similar to those reported by Moir and Dieterich (1988) whose objective was to preserve the fire-dependent old-growth ponderosa pine reserves in Arizona and New Mexico.

Pattee Canyon is believed to be representative of western Montana drainages located on the Lolo National Forest, where other relict groves of old-growth ponderosa pine and pine-larch exist and are scheduled for preservation. Prior to developing a plan, it was important to graphically reconstruct the historical composition and structure of pre-settlement (pre-1900) forests occupying the canyon. Ecologists familiar with this part of the northern Rockies (Habeck and Mutch 1973; Arno 1980, 1988; Arno and Gruell 1983) have concluded that pre-settlement forest cover consisted of a "fire-mosaic" comparable to that described by Lewis and Ferguson (1988) in Alberta, Canada. In western Montana, such mosaics are believed to have featured open, park-like ponderosa pine stands, with western larch and Douglas-fir as common associates, maintained by frequent, low intensity fires.

The Old-Growth Management Policies of the Forest Service

Forest Service planning policies, partially founded in the National Forest Management Act (NFMA) of 1976, require forest managers to provide for the conservation of biodiversity. Forest Service planners have interpreted the NFMA regulations to include retention of wildlife species that use and/or depend upon old growth as habitat (Habeck 1988). As foresters pursued these management goals, the need arose to inventory all vegetation types in the northern Rockies and elsewhere, including surviving examples of old-growth forests. In meeting these goals, a broadly based and widely accepted generic definition of the term *old-growth* has been used.

The Forest Service's Old-Growth Task Group, headed up by Franklin and Spies (1989), solicited input from forest ecologists. They derived and distributed (October 11, 1989) a definition and description of *old growth*, and provided a list of structural attributes that characterize old-growth forests. The definition and characteristic attributes of old growth were purposely left broad to allow inclusion, as efforts continue, of the widest assortment of forest types. With the Task Group's general definition serving as a starting point and guide, forest habitat type classifications, such as the one developed by Pfister et al. (1977) for western Montana, have been employed to develop preliminary old-growth definitions for all habitat type groups in the northern Rocky Mountains.

Old-growth forests occupying moderately warm and dry sites in the Lolo National Forest, including Pattee Canyon, are characterized by the presence of mature-sized individuals; the preliminary old-growth definition (unpublished USDA Forest Service Northern Region, Old-Growth Committee Report, July, 1990) calls for the pine and larch to be at least 170 years old, and to have at least eight trees over 21 inches (52 cm) dbh (=diameter at breast height) per acre. Another descriptive criterion is the presence of at least 60 square feet (5.7 square meters) per acre of basal area (a tree stem area dimension), distributed in trees over 9 inches (22 cm) dbh. Other qualitative features will be added to the final version of the Northern Region's old-growth definition.

Other forest structural attributes also define mature old growth. Franklin and Spies (1989) state that old growth "is the late stage stand development which differs ... from earlier stages." Their definition avoids implying that "old growth" is exclusively late successional (climax) forests: "old-growth encompasses older forests dominated by early seral species, such as fire-dependent species ... as well as shade tolerant species;" the latter includes the remnant old-growth ponderosa pine–western larch in Pattee Canyon.

The Lolo National Forest Plan (available at Lolo National Forest office, Missoula, Montana, February 1986), pre-dates the current efforts to develop specific old-growth definitions. The plan calls for the provision of well-distributed old growth in tracts that are "at least 30–40 acres in size, that are decadent, multistoried, fully stocked, contain snags with dead and down material greater than 15 tons per acre, and contain 15 trees per acre greater than 20 inches dbh." Fire-dependent, seral, old-growth pine-larch stands are not specifically differentiated in this set of stand characteristics, but elsewhere the forest plan calls for wildfire control "to protect old-growth qualities and resource objectives . . .", but still allow for the use of prescribed burning "to maintain or restore the composition and structure of plant communities" including old-growth types.

Overview of Western Montana's Old-Growth Forests

In western Montana, some of the pre-1900 forest cover was composed of old-growth forests occupying infrequently burned moist lowland sites, and featured 300–500 year old western redcedar (*Thuja plicata*) and western hemlock (*Tsuga heterophylla*). When such forests did burn, at intervals of several centuries, fires were often of high, "stand-replacement" intensities, initiating seral stands of western white pine (*Pinus monticola*) and/or western larch; magnificent old-growth stands of white pine and western larch also were present at the time of Euroamerican settlement (Habeck 1976, 1985*b*).

At high elevations (6,000–9,000 ft/1,800–2,700 m), old-growth forests featuring Engelmann spruce (*Picea engelmannii*) and subalpine fir (*Abies lasiocarpa*) existed; these were replaced by lodgepole pine (*Pinus contorta*) following high intensity fires. The upper timberline zone experienced fire infrequently, and its forests were dominated by old-growth whitebark pine (*Pinus albicaulis*) and alpine larch (*Larix lyallii*) (Habeck 1987).

Elsewhere in western Montana, at lower elevations (3,000–5,000 ft/900–1,500 m), the warmer and drier forest zones featured old-growth ponderosa pine and western larch. These forests, open and park-like, were the result of frequent, low-intensity surface fires occurring at 10–30 year intervals (Habeck and Mutch 1973; Lunan and Habeck 1973; Arno 1976, 1980, 1988; Freedman and Habeck 1985; Habeck 1985*a*, 1987). Alluvial benches and terraces of major western Montana rivers also supported old-growth ponderosa pine in association with black cottonwood (*Populus trichocarpa*). Fire-scars on surviving bottomland ponderosa pines attest to the historic occurrence of fire on river terraces.

Fires, started by random lightning or Indian ignitions are believed by Barrett (1981), Barrett and Arno (1982), Gruell (1983), and Arno and Gruell (1986) to have constituted a major ecological influence throughout western Montana's lower forest zones. After 1730, the Indians may have intentionally employed widespread underburning in pine-larch forests to expand and improve native pastures for their horse herds. Frequently burned pine-larch forests would probably have had lower accumulations of coarse organic materials and fewer signs of stand decadence in the form of standing snags or downed logs.

A century of logging and fire control has contributed to structural alterations to much of the old-growth pine-larch in western Montana (Habeck 1987, 1988). On valley bottoms, ponderosa pine on riparian sites was harvested soon after settlement; few intact examples remain today in western Montana. Unlogged old-growth pine-larch occupying the montane ("Douglas-fir") zone were successionally invaded by the more shade tolerant Douglas-fir; logging actually accelerated this forest conversion (Arno 1988, 1990).

As forest ecologists made progress in understanding the role wildland fires played in shaping the pre-1900 forest cover in western Montana, Forest Service managers were improving their methods for reintroducing prescribed fire to achieve specific management goals (Arno and Brown 1989; Martin, Kauffman, and Landsburg 1989). One such goal has involved the restoration of forest types which were subject to frequent fires before 1900 (Arno, Simmerman, and Keane 1985; Kilgore and Curtis 1987; Losensky 1989).

The following approaches were used in this old-growth study: (a) interpretation of written western Montana pre-settlement historic accounts, (b) analysis of pre-settlement federal land survey notes, (c) assessment of early settlement photographs, and (d) direct field interpretations of surviving remnant old-growth forests. Each approach is discussed below.

Interpreting Pre-Settlement Written Reports

Excellent historical descriptions of early-day old-growth ponderosa pine forests in the northern Rockies are found in a series of turn-of-the-century government reports from the U.S. Department of the Interior and the U.S. Geological Survey. They were specifically prepared to evaluate the natural resources found in the United States' then newly established forest reserves (Leiberg 1899, 1900; Ayres 1900, 1901). Ayres and Leiberg provide detailed narratives of the forest cover, accompanied by high quality maps and photographs.

In the late nineteenth century, Leiberg (1899) described the forest cover of the Bitterroot Valley in western Montana as being composed of two forest zones: (1) the "yellow-pine" [ponderosa pine] zone extended from the valley floor at 3,500 ft (1,060 m) upslope to 5,800 ft (1,760 m), and (2) the subalpine fir zone from 5,800 ft (1,760 m) to upper timberline, at 9,000 ft (2,730 m). Although Douglas-fir also was present at elevations below 5,800 ft (1,760 m), the distinctive and dominant presence of ponderosa pine, often forming pure stands, caught Leiberg's eye. He described the frequent occurrence of fires in the "pine forest zone," suggesting that frequent fires were responsible for extending and maintaining ponderosa pine's dominance into forest zones where Douglas-fir is the potential climax species.

Leiberg's photographs portrayed the fire-maintained pine forests as open and park-like, with bunchgrass understories, scattered standing snags, downed logs, and fire-scarred pines in view. In some parts of the Forest Reserve, 50% of the ponderosa pine exhibited physical defects caused by repeated fires; defects in the form of fire scars extended 6–10 feet (2–3 m) up the tree stem. According to Leiberg, the groundlayer in the pine stands was ". . . always covered with a thin layer of pine needles, never a proper humus, and is usually free from undergrowth, or has but a minimum." The light load of accumulated organic debris favored low intensity fires in which the thicker-barked ponderosa pine saplings more readily survived than the thinner-barked Douglas-firs. However, after a pine had been burned and scarred a number of times, Leiberg observed, "the resinous-wood patch grows larger with each recurring fire, until the tree finally yields and is entirely consumed, or so weakened that the first heavy wind breaks it off." However, there are surviving ponderosa pines with over 30 fire scars accumulated over 400 years.

Ayres (1900) provided comparable descriptions for the Flathead Forest Reserve which encompasses Glacier National Park and northern portions of Flathead National Forest. He described ponderosa pine and western larch stands that were "very open and easily navigated on horseback," and the frequent occurrence of fire-scarred pines. In 1901, Ayres prepared a similar report for the Lewis and Clark Forest Reserve (today encompassing the Bob Marshall Wilderness Complex, west to the Mission Mountains). His words described and his high quality photos illustrated, the fire-maintained ponderosa pine–western larch stands occupying the Swan and Clearwater valleys in western Montana.

Ayres described the Swan and Clearwater valleys as regions of frequent, low intensity fires. "Creeping slowly along, they have killed much of the vegetation and even some large trees, but the

lightest of them have merely thinned the forest, injuring many trees, but still leaving many seed trees and a favorable surface for seeds to start."

Photos taken before 1900 of old-growth ponderosa pine located near Placid Lake and Holland Lake in the Clearwater River drainage illustrate large, widely spaced trees, scattered snags, a few down logs and grass-shrub understories.

Elsewhere in his 1901 report, Ayres described the role fire played in maintaining open ponderosa pine stands as part of a dynamic landscape mosaic:

> The yellow-pine lands, both about the headwaters of Swan River and in the Clearwater drainage, are, as usual, more free from young stock than forests of other species, yet some of these tracts have a fair sprinkling of red fir [Douglas-fir], larch and Engelmann spruce coming in underneath the pine. As a rule these species do not reach tree size, being killed while small by repeated fires, while the yellow-pine standing over them, protected by its thick bark, remains and furnishes favorable conditions for a new lot of seedlings, such as those just destroyed, to start again.

The Swan Valley area was more recently re-examined by Freedman and Habeck (1985), who developed and presented a graphical technique of illustrating the structure and composition of these forests before 1900; this methodology also was used in Pattee Canyon.

Analysis of Federal Land Office Survey Records

Another valuable source of historical information on old-growth forests in northwestern Montana are written notes compiled by federal land office surveyors employed to subdivide the pre-settlement landscape. The surveying involved the selection and documentation of "witness trees," used to describe township and section corners, and in Pattee Canyon, the boundary intersections of the earlier established Fort Missoula Timber Reserve. Because tree species are identified, their diameters recorded and their compass bearings and distances from the corners are measured, it is possible to reconstruct the original forest cover wherever such survey notes are available.

Survey notes for Pattee Canyon are dated between 1870 and 1900. The 1,600-acre (648 ha) Fort Missoula Timber Reserve was established in the 1870s as an Army timber supply. The timber reserve was transferred to the Lolo National Forest, Missoula Ranger Dis-

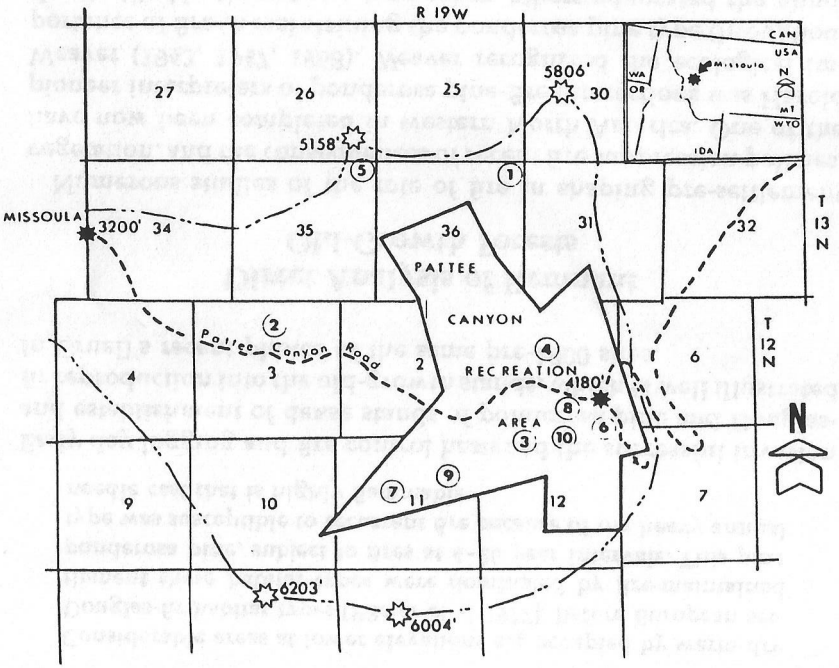

Fig. 1. Location of USDA Forest Service's Pattee Canyon Recreation Area, formerly the Fort Missoula Timber Reserve, near Missoula, northwestern Montana. The Pattee Canyon drainage is outlined by the dash-dot line. Locations of forest history plots are shown by numbers within circles.

trict, in 1926, and is now managed as the Pattee Canyon Recreation Area. The timber reserve's unusual shape (Fig. 1) encompasses the canyon's best pre-settlement old-growth pine-larch stands. The surveyor notes provide details on general landscape features and forest conditions. The notes reveal the frequent use of ponderosa pines as witness trees, and that many such witness trees (generally the nearest mature tree in each of the four quadrants around a section corner) were 25–50 ft (8–15 m) or more from the surveyed corners; this distance between trees, being so far apart, supports the belief that much of Pattee Canyon was previously dominated by an open pine-grassland cover, rather than a continuous forest (with touching canopies).

The descriptive narratives provided at the end of each surveyed mile also suggest the canyon's pre-settlement forest cover was a mosaic of vegetation types, but distinctly an open forest. The following descriptions are quoted from the Pattee Canyon pre-1900 survey notes: "scattering fir [Douglas-fir], pine [ponderosa pine] and

TABLE 1. Diameter size class distributions for witness trees (n = 124) used in Pattee Canyon, western Montana, federal land survey notes, 1870–1900.

Diameter classes	Ponderosa pine		Douglas-fir		Western larch	
	No.	%	No..	%	No.	%
5–10" (12–26 cm)	24	32.9%	22	59.5%	2	14.3%
11–15" (27–38 cm)	9	12.3%	11	29.7%	6	42.9%
16–20" (39–50 cm)	15	20.6%	4	10.8%	5	35.7%
21–25" (51–63 cm)	6	8.2%	0	0%	1	7.1%
26–30" (64–75 cm)	12	16.4%	0	0%	0	0%
Over 30" (75 cm)[1]	7	9.6%	0	0%	0	0%
Totals	73	100.0%	37	100.0%	14	100.0%

[1] Range: 32–56" (80–140 cm).

tamarack [western larch]," "mountains covered with good grass," "heavy open timber," "thick small timber," "grassland and no timber" and "a few scattering fir and pine." The mention of "old choppings" or "old cuttings" in parts of the Fort Missoula Timber Reserve indicate military woodcutting entry into the canyon's old-growth forests before the land survey was undertaken.

The diameters of 124 witness trees were recorded in the Pattee Canyon survey notes (Table 1). Witness trees recorded range from 5 to 56 inches (12–140 cm). It is uncertain whether the surveyors estimated witness tree diameters at their bases or higher; modern tree diameter measurements are taken at a standardized 4.5 ft (1.4 m) above groundline. Ponderosa pines were abundant everywhere in the canyon, and pines were recorded in a wide range of diameters, suggesting an all-aged pine community. Douglas-firs were less commonly recorded as witness trees; 90% were less than 15 inches (38 cm) in diameter, and very few over 20 inches (50 cm). Probably the smallest diameter trees (5–8 inches/12–20 cm) were selected as witness trees only when trees 8–10 inches (20–25 cm) or larger were not present or at convenient distances from the section corners.

Western larch has the lowest occurrence as witness trees, and those recorded were of intermediate sizes. In Pattee Canyon, western larch is confined to moist, north-facing slopes. An analysis of witness tree densities, derived from distance measures between section corners and witness trees, reveals that on the canyon's warm, dry south-facing slopes, witness tree densities were about five per acre, clearly suggesting more grassland vegetation than forest cover. On the moist north-facing slopes, densities were also low (10–15 trees per acre), reflecting widely spaced trees. Tree saplings (3–5 inches/7–12 cm), were not recorded as witness trees, but likely were present in unknown densities.

Assessment of Settlement-Era Photographs

Gruell (1983) made use of settlement-era photographs to compare turn-of-the-century vegetation with modern landscapes. He described changing vegetation patterns following settlement and fire suppression throughout the northern Rockies. His report includes western Montana; the photographs, spanning the 1870s to the 1980s, illustrate the presence of widely-spaced, old-growth ponderosa pine stands occupying elevations below 5,000 ft (1,500 m), and encompassing the western Montana Douglas-fir zone. The original pine stands appear very open, with trees present in a range of diameter classes, reaching diameters well over 20 inches (50 cm) dbh, with perennial bunchgrasses dominating the understories. Figure 2 illustrates examples of the park-like ponderosa pine forests that seemed to prevail before settlement, extensive logging, and wildfire exclusion; the Forest Service photos were taken in 1940, and illustrate some young conifer invasion taking place.

Gruell (1983) stated, in reference to western Montana:

> Considerable areas at lower elevations are occupied by warm-dry Douglas-fir habitat types [Pfister et al 1977]. Before European settlement these habitat types were dominated by fire-maintained ponderosa pine, subject to fires at 4–20 year intervals. This pine type was susceptible to recurrent fire because of the heavy annual needle cast that is highly flammable.

Early day logging and fire control hastened the successful invasion and establishment of dense stands of ponderosa pine and Douglas-fir reproduction into the old-growth stands, which is well illustrated in Gruell's recent photos of the same pre-1900 sites.

Direct Analysis of Remnant Old-Growth Forests

Numerous studies of the role of fire in shaping pre-settlement vegetation, and the consequences of recent fire suppression policies, have now been completed in western North America. One of the pioneer interpreters of ponderosa pine-fire interactions was Harold Weaver (1943, 1947, 1968). Weaver recognized the ecological importance of fire in maintaining the ponderosa pine type throughout the Pacific Northwest at a time when others advocated the elimination of fire from the landscape. Northern Rocky Mountain fire-vegetation studies have been reported by Lunan and Habeck (1973), Habeck (1976, 1985*a*, *b*), Freedman and Habeck (1985), Arno and Gruell (1983, 1986), Arno (1988) and Haagenson (1988). Fischer and Bradley (1987) have summarized the extensive fire effects literature

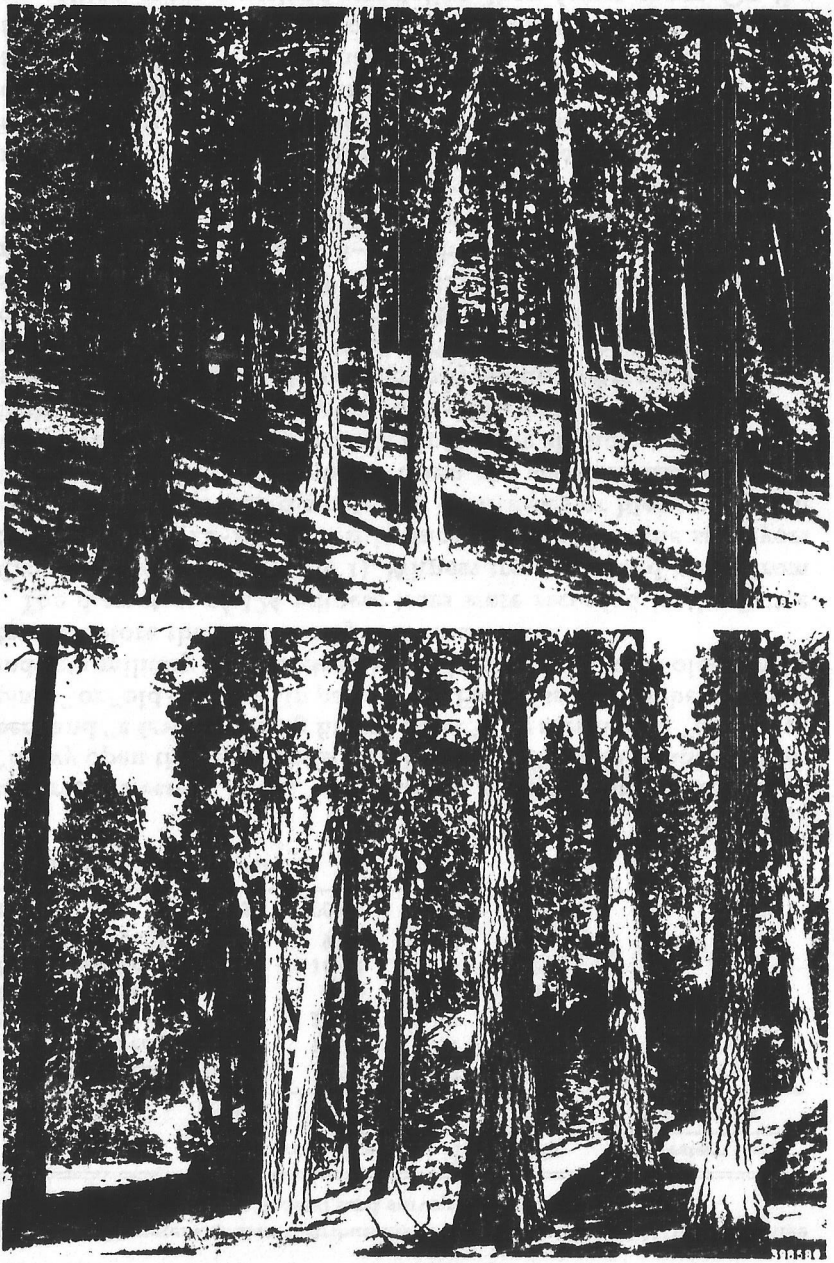

Fig. 2. Remnant fire-dependent old-growth ponderosa pine stands in western Montana, exhibiting savanna/grassland appearance. Invasion of ponderosa pine and Douglas-fir reproduction is evident in these May 1940 pictures taken near Darby, Montana, 4,000 ft. Photos by K. D. Swan, USDA Forest Service.

on the forest habitat types found in Pattee Canyon, including the effects of fire on bird and mammal populations.

The Pattee Canyon studies included an interpretation of pre-1900 structure of old growth by the use of field macroplots positioned within an assortment of remnant groves where human influences, other than fire suppression, have been light or absent. Many of the old-growth macroplots were located within the former Fort Missoula Timber Reserve (see Fig. 1 for macroplot distributions). Selective tree harvesting took place in the timber reserve before 1900, but some old-growth pine-larch groves were left untouched.

Fire History

The occurrence of pre-settlement fires in Pattee Canyon, which fostered the open, park-like pine-larch type, was also investigated by Habeck (1985*a*). Ninety-four fire-scarred trees and stumps (mostly ponderosa pines) were discovered during a search throughout the canyon. Fire scars were used to determine the specific dates of past fires, as well as the number of years between fires (fire intervals). Fire chronologies of several canyon subunits were constructed and these were combined into a single canyon-wide fire chronology, employing methods described by Arno and Peterson (1983) and Freedman and Habeck (1985).

The oldest fire scar found in Pattee Canyon dates to 1557, over 430 years ago, with numerous fires occurring between the mid 1500s and 1900. Specifically, 51 distinct fire dates were identified between 1557 and 1918, yielding an overall canyon average fire interval of 7.1 years. For the period between 1750 and 1850, fires affected large parts of Pattee Canyon at 5–10 year intervals. From 1850 to 1900 the canyon's wildfire intervals lengthened to 10–20 years. After 1900, fires were effectively reduced in number and size until 1977 when a severe 1,200 acre (485 ha) human-caused fire occurred on the canyon's north slope; another of comparable size swept the upper south-facing slopes in 1985. Both were high intensity and killed many of the trees in their paths. These modern fires signal the threat that faces the surviving remnant old-growth forests in Pattee Canyon.

Forest History Plots

During 1984, a set of small remnant old-growth ponderosa pine-western larch groves was selected for an analysis of their pre-1900 structure. None selected showed evidence of having been logged. The stands represent the range of Pattee Canyon sites, both south

and north-facing slopes, supporting old-growth remnants (Fig. 1). One circular macroplot, with a 100 ft (30 m) diameter (0.18 acre/.07 ha) was subjectively positioned in each stand, so old-growth trees were featured within the plot boundaries. All trees, one inch (2.5 cm) dbh and larger, present in 1984, were recorded by species; all trees were mapped and recorded by diameters and species. A representative assortment of trees was aged by coring. Average tree densities within stem diameter size classes are based on data taken from four south slope (warm, dry) macroplots and six macroplots positioned on north aspects (cool, moist) (Table 2).

The macroplots feature a matrix of old-growth pine-larch, and a few old-growth Douglas-firs. Some standing dead snags and a few down, decaying logs were usually present in or near most plots. Recently established conifers surround and crowd the old growth. An average of 4.9 (range: 3–7) old-growth trees per macroplot, exceeding 20 inches (50 cm) dbh, existed in the south aspect plots (Table 2); in contrast, north aspect plots averaged 8.4 (range: 7–10) old-growth trees each. These trees originated prior to 1850. Collectively, the ponderosa pines over 26 inches (65 cm) dbh, averaged 31 inches (77 cm) dbh (range: 27–38 inches/67–95 cm) in size, and averaged 215 years (range: 175–340 years) in age. Western larches recorded averaged 30 inches (75 cm) dbh (range: 27–35 inches/67–87 cm) in size, and 305 years (range: 265–335 years) in average age.

Trees less than 13 inches (32 cm) dbh (Table 2) generally have years of origin post-dating 1900. Trees over 14 inches (35 cm) dbh, in contrast, frequently were present before 1900, but in smaller diameter sizes. Increment cores taken from 20 inch (50 cm) dbh and larger pines and larches were used to determine average radial growth since 1900. Old-growth ponderosa pine and western larch have added an average of nearly 3 inches (7 cm) (range 1–4 inches/2–10 cm) to their stem radii since 1900. Thus, on average, only trees 26 inches (65 cm) or larger would have been at least 20 inches (50 cm) dbh in pre-settlement Pattee Canyon.

Translating the 1984 plot data, pre-1900 old-growth individuals (trees over 20 inches/50 cm dbh) had an estimated density of 13 trees per acre (32 per ha) on the canyon's south slope, and about 27 trees per acre (67 per ha) on north aspects. Smaller-sized trees co-occurring with these old-growth trees before 1900, would have included many of the present-day 14–19 inches/35–48 cm dbh and 20–26 inches/50–65 cm dbh trees recorded in the 1984 census; these average 25 per acre (63 per ha) on south slopes, and 43 per acre (106 per ha) on north slopes. Thus, south slope sites supported an estimated 38 trees per acre (93 per ha) prior to 1900; north slopes supported about 70 trees per acre (172 per ha).

Table 2. Structural composition of remnant pre-settlement old growth in Pattee Canyon, western Montana, 1984. Values are average densities per 0.18 acre (.07 ha) macroplots determined from four south slope, warm, dry habitat types,[1] and six north slope cool, moist habitat types[2] (after Pfister et al. 1977). Pine = *Pinus ponderosa*; Fir = *Pseudotsuga menziesii*; Larch = *Larix occidentalis*.

	Average number of trees per diameter class					
Species	0–3″ 0–7 cm	3–7″ 8–19 cm	8–13″ 20–35 cm	14–19″ 36–49 cm	20–26″ 50–65 cm	Over 26″ Over 65 cm
I South Slope, Warm, Dry Habitat Types[1] (n = 4 plots):						
Pine	39.0	5.5	4.8	2.0	2.5	2.2
Fir	67.5	31.2	5.8	0	0	0.2
Totals	106.5	36.7	10.6	2.0	2.5	2.4
II North Slope, Cool, Moist Habitat Types[2] (n = 6 plots):						
Pine	20.6	2.2	1.2	0.4	2.6	2.2
Fir	69.2	8.4	6.2	3.4	0.2	0.2
Larch	5.6	6.4	1.0	0.4	0.8	2.4
Totals	95.4	17.0	8.4	4.2	3.6	4.8

[1] *Pseudotsuga menziesii/Symphoricarpos albus* h.t., and *P. menziesii/Agropyron-Festuca* h.t.
[2] *P. menziesii/Physocarpos malvaceus* h.t.

These estimated densities are higher than those derived from the federal land survey records, but, some of the present-day trees would have been much smaller at the time of the surveys (1870–1900) and rejected as witness trees, lengthening the distances between witness trees, and yielding lower calculated densities. By 1984, the canyon's southern slopes had average densities of trees over 3 inches (7.5 cm) dbh of about 302 trees per acre (746 per ha); the north slopes, an estimated 211 trees per acre (521 per ha). The 1984 presence of numerous invading Douglas-fir and ponderosa pine seedlings below 3 inches (7.5 cm) dbh expand the total tree densities even more. Figure 3 illustrates the typical crowded forest conditions in Pattee Canyon, where tree densities now average about 500 stems per acre (1,235 per ha).

The pre-settlement old-growth pine-larch forests in Pattee Canyon were probably uneven-aged, but this is only partially supported by the 1984 data. The presence of residual bunchgrasses (*Festuca scabrella, F. idahoensis* and *Agropyron spicatum*) and grassland forbs in many of the 1984 macroplots, support the historical accounts that grassland vegetation was commonly associated with the frequently burned pine-larch forests. Figures 4 and 5 represent two of the old-growth macroplot reconstructions which serve to illustrate the pre- and post-fire suppression impacts on old-growth structure and composition over the past century. Each circular graph depicts the

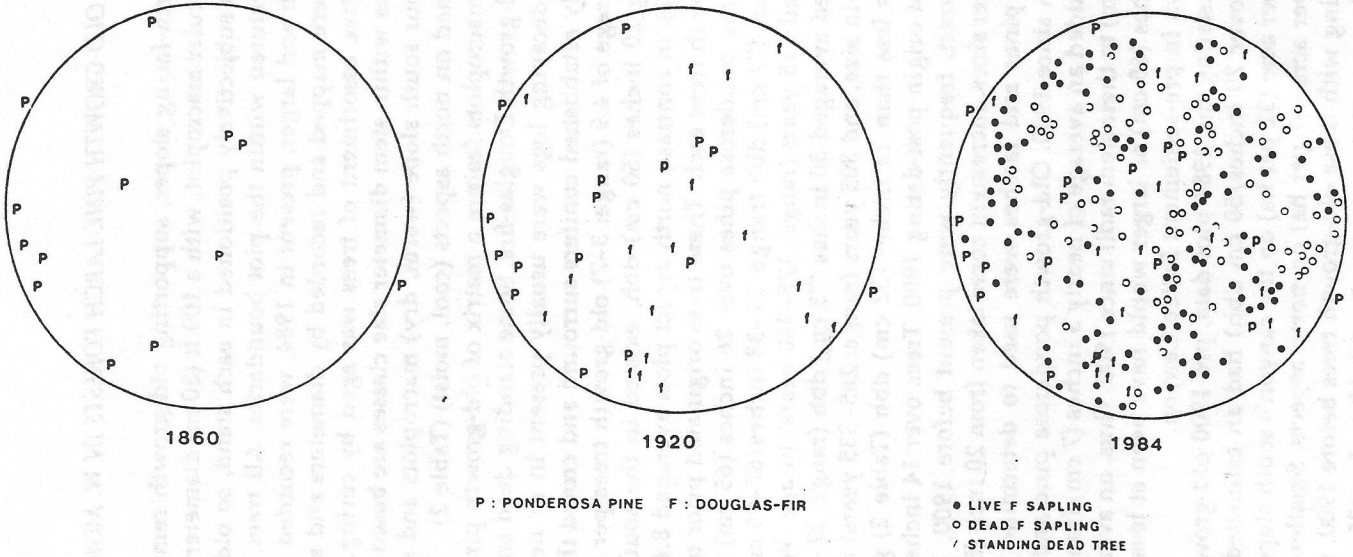

Fig. 3. Reconstruction of the forest overstory (capital letters) and understory trees (lower case) in Pattee Canyon macroplot 04 (Fig. 1) during three time periods: 1860, 1920, and 1984. Pre-1900 fires maintained this warm, dry habitat type as a ponderosa pine parkland. Post-1900 fire exclusion has favored Douglas-fir invasion.

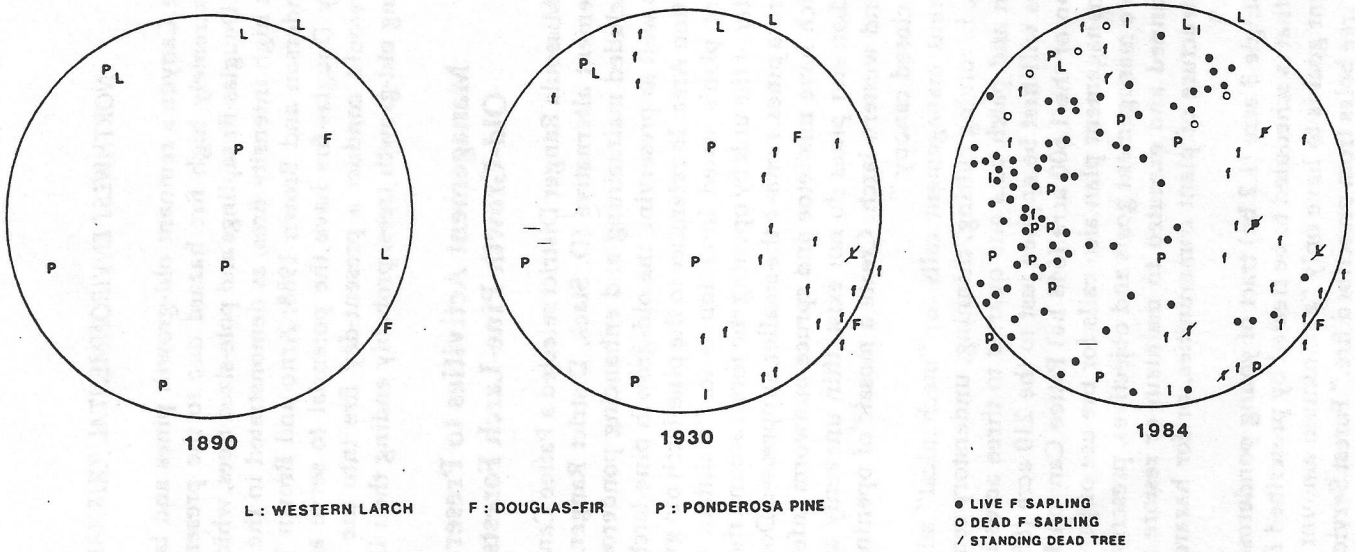

Fig. 4. Reconstruction of the forest overstory (capital letters) and understory trees (lower case) occupying macroplot 08 (Fig. 1) in 1890, 1930 and 1984. This cool, moist habitat type supported a ponderosa pine-western larch open forest before modern fire exclusion.

Fig. 5. Pictures of present-day, remnant ponderosa pine old-growth in Pattee Canyon, surrounded by invading Douglas-fir. The Douglas-firs have increased the fire hazard to this remnant old growth. Photo by James Habeck, 1990.

occurrence and arrangement of trees on the macroplot sites at three different dates.

Consequences of Fire Suppression

The successional prediction models for western Montana pine-larch forests, developed by Arno (1988) and Keane, Arno and Brown (1990), have been validated by the results of the Pattee Canyon macroplot data set (Habeck 1985*a*), wherein the potential climax dominant, Douglas-fir, has invaded the open, old-growth forests during the fire exclusion era. In some of the macroplots, invading ponderosa pine reproduction is mixed with the Douglas-fir. Often canyon sites dominated by invading pine are currently subject to mortality caused by mountain pine beetle (*Dendroctonus ponderosae*). Douglas-firs have become heavily infested with western spruce budworm (*Choristoneura occidentalis*) and dwarf mistletoe (*Arceuthobium douglasii*) throughout Pattee Canyon. The levels of these infestations may be the consequence of changes associated with modern fire suppression (McCune 1982, 1984; Anderson, Carlson, and Wakimoto 1987).

Pattee Canyon's remnant old-growth pines and larch now exist in an extremely high fire hazard due to the presence of densely stocked Douglas-fir saplings and pole-sized trees, which today would support high intensity fires, as demonstrated in the canyon's 1977 fire (Anderson and Brown 1988; Arno and Brown 1989). The understory Douglas-firs have the potential to serve as fuel ladders, which would conduct a present-day fire into the crowns of the surviving old-growth trees, probably ending their lives.

Management Activities to Preserve Old-Growth Pine-Larch Forests

The Missoula Ranger District selected a Pattee Canyon vegetation management alternative (D. Stack, District Ranger, July 18, 1989) that included maintaining and enhancing ponderosa pine in general, as well as preserving the old-growth pine-larch located in the Recreation Area. In reference to the pine-larch old growth, the management plan's stated intention is to, "maintain the old-growth character of the unit by opening the forest around the large diameter ponderosa pines, remove the smaller, suppressed Douglas-firs, many of which have mistletoe and spruce budworm infestations. Where large diameter pines do not exist, thin unevenly around available pine and western larch. Create a mosaic of openings amid the existing closed canopy."

Current management calls for "mechanical" silvicultural treatments, involving cutting, thinning, understory removal, group selection and patch cuts one quarter to three acres in size. Such activities will first be applied just to the 210 acre (85 ha) picnic area portion of the 1,600 acre (648 ha) Pattee Canyon Recreation Area. The management plan also calls for the use of prescribed fire: "To achieve management goals and objectives, prescribed burning may be planned and executed to maintain or restore the composition and structure of plant communities, or for hazard reduction purposes."

A single 3 acre (1.2 ha) tract of young ponderosa pine, however, is all that is scheduled to be treated by prescribed fire. The district's present goal is to have only "a minimum amount . . . of fire blackened tree boles from prescribed fire." Forest Service managers must deal with the "social acceptability" of the vegetation management techniques that involve the use of prescribed fire, including the possibility of escaped fire and the generation of smoke in Pattee Canyon. The Forest Service thus intends to employ only "cultural practices" to reduce fire potential, while maintaining natural appearances. These techniques will include chain-saw cutting and

harvesting with "mechanized equipment or horse logging" rather than prescribed fire to achieve vegetation management goals.

Recommendations for Old-Growth Management

In western Montana, research results indicate that the long-term management of old-growth pine-larch in Pattee Canyon needs more, not less prescribed fire in combination with other silvicultural treatments. It is necessary to reduce the present-day fire potential faced by the remaining old-growth pine and larch, as well as to prepare the physical site conditions needed for ponderosa pine and western larch establishment and maintenance (Weaver 1968; Fischer and Bradley 1987; Arno 1988). Martin, Kauffman, and Landsburg (1989) provide an excellent review of the use of prescribed fire in western North America to reduce wildfire potential. They present examples in which prescribed fire has been employed to reduce fuel quantity and continuity at microscale (within forest), midscale (between forests) and macroscale (within drainage-sized units) levels. The Forest Service needs encouragement to alter its position that ". . . fire cannot be allowed to play its natural role in [Pattee Canyon] and prescribed burns . . . are too risky."

The risks associated with reducing wildfire potential in Pattee Canyon are certainly real. However they must be addressed to reduce the impacts of the inevitable destructive wildfires, and preserve Pattee Canyon's old-growth pine-larch type. These views are supported by Arno and Brown (1989), who discuss fuel and fire management problems in "residential wildlands"—the forest-urban interfaces such as Pattee Canyon, where people and semi-wild landscapes intermix. The use of specific silvicultural methods and prescribed fire treatments is necessary to decrease wildfire potential. Without careful planning the remaining old-growth pine-larch populations in Pattee Canyon and perhaps similar old-growth remnants in western Montana may not survive over the long term.

Other reports (Fischer and Bradley 1987; Kilgore and Curtis 1987; Anderson and Brown 1988; Arno 1988; Losensky 1989) also recommend that silviculture-fire prescriptions might be applied to areas such as Pattee Canyon to assure natural regeneration of species requiring fire treatment. Anderson, Carlson, and Wakimoto (1987), referring to western Montana areas, also recommend "judicious use of ground fire, thinning and other silvicultural treatments" that would favor seral ponderosa pine and western larch, while improving the health of the insect-damaged Douglas-fir populations."

Arno and Brown are fire science researchers with the U.S. Forest Service. They conclude (1989) that modern technical knowledge in

fire science and in forest fuel management are now at such a stage that foresters could be applying more "innovative" techniques to reduce fire potential, protect natural resources, and improve forest health and aesthetics. More "research" and "studies" are not called for and would be disadvantageous, they feel. They point out (pers. comm., unpublished ms., 1990) that this can be achieved by designing more innovative management alternatives that mimic natural processes, and realizing the futility of excluding fire. As other surviving examples of fire-generated old-growth pine-larch are discovered and inventoried in western Montana, it only makes sense to apply state-of-the-art forest management techniques to assure their maintenance and perpetuation.

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References

Anderson, H. E., and J. K. Brown. 1988. Fuel characteristics and fire behavior considerations in the wildlands. Pp. 123–130 *in* W. C. Fischer and S. F. Arno, compliers. *Protecting people and homes from wildfire in the interior West*: Proc. Symp. and Workshop, Oct. 6–8, 1987, Missoula, Montana. USDA Forest Service (Gen. Tech. Report INT-251).

Anderson, L., C. E. Carlson, and R. H. Wakimoto. 1987. Forest fire frequency and western spruce budworm outbreaks in western Montana. *Forest Ecology and Mgt.* 22:251–260.

Arno, S. F. 1976. The historical role of fire on the Bitterroot National Forest. USDA Forest Service (Res. Paper INT-187).

———. 1980. Forest fire history in the northern Rockies. *J. Forestry* 78:460–465.

———. 1988. Fire ecology and its management implications in ponderosa pine forests. Pp. 133–139 *in* D. M. Baumgartner and J. E. Lotan, eds., *Ponderosa pine: The species and its management*, Symposium Proceedings. Pullman, Wash.: Washington State Univ. Coop. Ext.

———. 1990. Ecological relationships of interior Douglas-fir forests. *In Interior Douglas-fir: The species and its management*. Symposium Feb. 27–March 1, 1990, Spokane, Wash. (in press).

Arno, S. F. and J. K. Brown. 1989. Managing fire in our forests—time for a new initiative. *J. Forestry* 87:44–46.

Arno, S. F., and G. E. Gruell. 1983. Fire history of the forest-grassland ecotone in southwestern Montana. *J. Range Mgt.* 36:332–336.

———. 1986. Douglas-fir encroachment into mountain grasslands in southwestern Montana. *J. Range Mgt.* 39:272–276.

Arno, S. F., and T. D. Peterson. 1983. Variation in estimates in fire intervals: A closer look at the history on the Bitterroot National Forest. USDA Forest Service (Res. Paper INT-301).

Arno, S. F., D. G. Simmerman, and R. E. Keane. 1985. Forest succession on four habitat types in western Montana. USDA Forest Service (Gen. Tech. Report. INT-177).

Ayres, H. B. 1900. The Flathead Forest Reserve. 20th Annual Report, U.S. Geol. Survey, Part V (1898–1899):245–316.

———. 1901. The Lewis and Clark Forest Reserve. 21st Annual Report U.S. Geol. Survey, Part V (1899–1900):35–80.

Barrett, S. W. 1981. Relationship of Indian-caused fires to the ecology of western Montana forests. Master's thesis, School of Forestry, Univ. of Montana.

Barrett, S. W., and S. F. Arno. 1982. Indian fires as an ecological influence in the northern Rockies. *J. Forestry* 80:647–651.

Fischer, W. C., and A. F. Bradley. 1987. Fire ecology of western Montana forest habitat types. USDA Forest Service (Gen. Tech. Report INT-223).

Franklin, J. F., and T. A. Spies. 1989. Position statement on national forest old-growth values. USDA Forest Service (Old-Growth Task Group Report, October 11, 1989).

Freedman, J. D., and J. R. Habeck. 1985. Fire, logging, and whitetailed deer interrelationships in the Swan Valley, northwestern Montana. Pp. 23–35 *in* J. E. Lotan and J. K. Brown, compilers. Proc. Symposium: *Fire's effects on wildlife habitat.* USDA Forest Service (Gen. Tech. Report INT-186).

Gruell, G. E. 1985. Fire and vegetation trends in the northern Rockies: Interpretations from 1871–1982 photographs. USDA Forest Service (Gen. Tech. Report INT-158).

Haagenson, K. M. 1988. The effects of tree invasion on the structure and composition of a western Montana grassland. Master's thesis, Department of Botany, Univ. of Montana.

Habeck, J. R. 1976. Forests, fuels and fire in the Selway-Bitterroot Wilderness, Idaho. *Proc. Tall Timbers Fire Ecology Conf.* No. 14:305–352.

———. 1985a. Changes in stand structure related to fire history in ponderosa pine/Douglas-fir forests in Pattee Canyon, Missoula County, western Montana. Contract Completion Report 27-C-3-INT-132 to the USDA Forest Service.

———. 1985b. Impact of fire on forest succession and fuel accumulations in long-fire-interval wilderness habitat types. Pp. 110–118 *in* J. Lotan, B. Kilgore, W. Fischer and R. Mutch, tech. coords. Proc. Symp. on Wilderness Fire, USDA Forest Service (Gen. Tech. Report, INT-182).

———. 1987. Present-day vegetation in the northern Rocky Mountains. *Annals Missouri Bot. Garden* 74:804–840.

———. 1988. Old-growth forests in the northern Rocky Mountains. *Natural Areas Jour.* 8:202–211.

Habeck, J. R., and R. W. Mutch. 1973. Fire-dependent forests in the northern Rocky Mountains. *J. Quaternary Research* 3:408–424.

Keane, R. E., S. F. Arno, and J. K. Brown. 1990. Simulating cumulative fire effects in ponderosa pine/Douglas-fir forests. *Ecology* 71:189–203.

Kilgore, B. M., and G. A. Curtis. 1987. Guide to understory burning in ponderosa pine-larch-fir forests in the intermountain west. USDA Forest Service (Gen. Tech. Report INT-233).

Leiberg, J. B. 1899. The Bitterroot Forest Reserve (Montana portion), 19th Annual Report (1897–1898), U.S. Geol. Survey, Part V:253–282.

———. 1900. The Bitterroot Forest Reserve (Idaho portion), 20th Annual Report (1898–1899), U.S. Geol. Survey, Part V:317–410.

Lewis, H. T., and T. A. Ferguson. 1988. Yards, corridors, and mosaics: How to burn a boreal forest. *Human Ecology* 16:57–77.

Losensky, J. B. 1989. Development and implementation of an ecosystem maintenance burning system. Pp. 3–6 *in* D. M. Baumgartner, D. W. Breuer, B. A. Zomora, L. F. Neuenschwander, and R. H. Wakimoto, compilers and editors. *Prescribed fire in the intermountain region: Forest site preparation and range improvement*. Symposium Proceedings. Pullman: Washington State Univ., Coop. Ext.

Lunan, J. S., and J. R. Habeck. 1973. The effects of fire exclusion on ponderosa pine communities in Glacier National Park, Montana. *Can. J. For. Research* 3:574–579.

Martin, R. E., J. B. Kauffman, and J. D. Landsburg. 1989. Use of prescribed fire to reduce wildfire potential. Pp. 17–22 *in* N. H. Berg, tech. coordinator. Proc. Symp. Fire and Watershed Management, Oct. 26–28, 1988, Sacramento, Calif.: USDA Forest Service (Gen. Tech. Report PSW-109).

McCune, B. 1982. Fire-frequency reduced two orders of magnitude in the Bitterroot Canyons, Montana. *Can. J. For. Res.* 13:212–218.

———. 1984. Forest dynamics in the Bitterroot Canyons. Montana. *Can. J. Bot.* 63: 377–383.

Moir, W. H., and J. H. Dieterich. 1988. Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico. *Natural Areas Jour.* 8:17–24.

Pfister, R. D., B. Kovalchik, S. Arno, and R. Presby. 1977. Forest habitat types of Montana. USDA Forest Service (Gen. Tech. Report INT-34).

USDA Forest Service. 1989. Pattee Canyon Vegetation Management Action Plan. Missoula Ranger District, Missoula, Montana. Unpubl. Report. July, 1989. 10 p.

Weaver, H. 1943. Fire as an ecological and silvicultural factor in the ponderosa pine region of the Pacific slope. *J. Forestry* 41:7–14.

———. 1947. Fire: Nature's thinning agent in ponderosa pine stands. *J. Forestry* 45: 437–444.

———. 1968. Fire and its relationship to ponderosa pine. *Proc. Tall Timbers Fire Ecol. Conf.* 7:127–149.