Forest Fire History in the Northern Rockies

Stephen F. Arno

ABSTRACT—Recent fire-scar studies in the northern Rocky Mountains have documented forest fire history over the past few centuries. They reveal that in some forest types fire maintained many-aged open stands of seral trees. In other types, major fires caused replacement of the stands. Often, however, fires burned at variable intensities, creating a mosaic of stands differing in composition and structure.

Recently adopted fire management policies for most federal forestlands (Kilgore 1976) require that protection be continued, but also that fire—from either planned or unplanned ignitions—be used to maintain and enhance resources (see USDA Forest Service Manual 5100, 1978). Consequently, fire managers are being asked to develop prescriptions geared to land management objectives. When a prescription is approved for an area, managers are given the flexibility to use fire in accordance with specific guidelines. Fire history is important for management planning because it provides detailed information on how the vegetative complex of the area has been shaped.

Relevance of fire history is particularly strong in the northern Rocky Mountains, where biologists have long recognized that composition and structure of forests have been strongly influenced by fire for at least several hundred years (Leiberg 1899, Whitford 1905, Habeck and Mutch 1973). While investigating and classifying forest habitat types in much of the northern Rockies (Pfister et al. 1977), it became apparent to me that fire history varied considerably among these diverse forests. Until recently, however, little detailed information was available on the characteristics of fires occurring over the two to three centuries prior to the beginning of suppression in about 1910. (Suppression programs became quite effective during the 1930s.)

Since 1972, knowledge of fire history in the region has been expanded by more than a dozen detailed studies. These form the basis for this article, which is offered as a state-of-knowledge summary to aid fire management planning. Unlike earlier work reviewed by Wellner (1970), most recent studies have analyzed dates from large numbers of fire scars and age classes of trees (post-fire regeneration). Generally, these evidences of past fires have been sampled along transects throughout study areas having representative timber types and terrain. Because low-intensity fires do not always wound even the previously scarred trees in their paths, it is necessary to corroborate fire years and build chronologies from records on a few trees at each location. Past fires are often mapped on the basis of post-fire regeneration age classes (e.g., Tande 1979) as well as scar dates.

The nature of early fires can be deduced from the amount, species, and sizes of surviving trees. Individual trees of most species can record more than one fire (through datable scars) and remain alive. For instance, ponderosa pine *(Pinus ponderosa)*, Douglas-fir

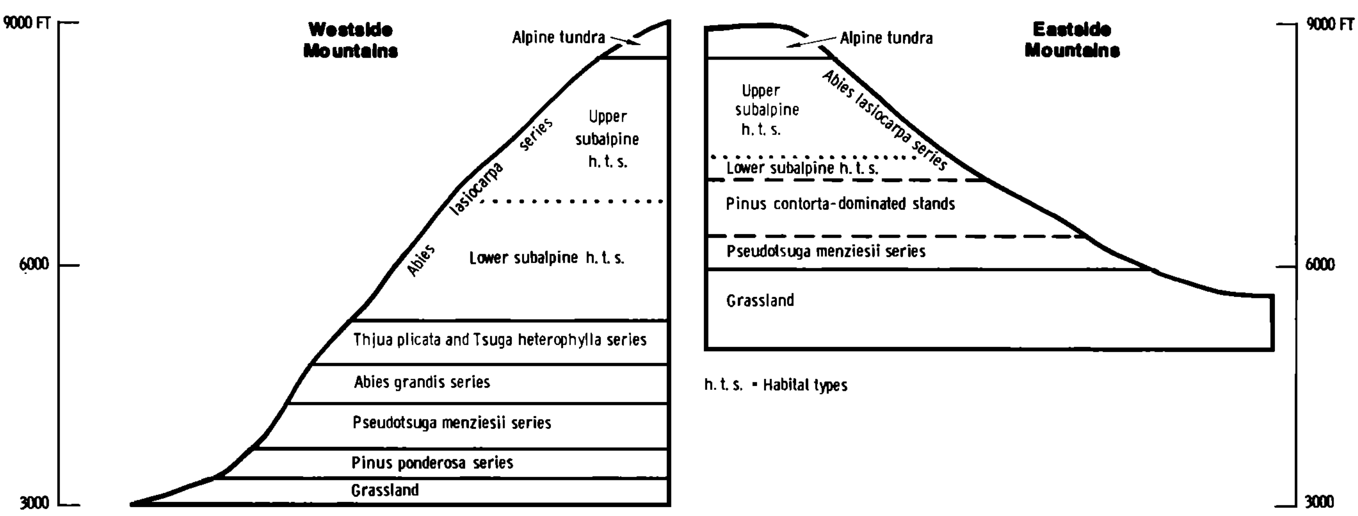

Figure 1. Two examples of forest zonation in the northern Rocky Mountains. The zones are defined by the potential climax trees, and thus by series and habitat types (h.t.s) of Pfister et al. (1977). The westside mountains (maritime climate) are comprised of those in northern Idaho, northwestern Montana, northeastern Washington, and southeastern British Columbia. The eastside mountains (continental climate) occur in eastern Idaho, Wyoming, central Montana, and southwestern Alberta.

Table 1. Mean fire-free interval (years) for small stands in the Northern Rockies. Asterisked intervals are general estimates; others are based on detailed studies. Intervals in parentheses indicate series of minor extent in study area.

eries otential climax) and pecies usually most avored by fire (#= nly in certain areas)	NW Wyoming 1550 A.D.[1]	Bitterroot Valley[2] South 1600	 North 1500	Lolo National Forest 1700[3]	Nezperce National Forest & Priest Lake 1730[4]	Bob Marshall Wilderness 1749[5]	Coram-Swan Valley 1646[6]	Kananaskis Provincial Park 1712[7]	Jasper National Park 1665[8]
inus ponderosa									
Ponderosa pine		12	6						
seudotsuga menziesii									
Ponderosa pine#	22	26	13	20*		(40)	(140)		18
Western larch#									
Lodgepole pine									
Douglas-fir									
inus contorta-dominated ommunities (seral or otential climax)									
Lodgepole pine	50* and 300	40	22			40			27
Western larch#									
bies grandis									
Western larch#			(18)		70-120*		150*		
Lodgepole pine									
Douglas-fir									
nuja plicata and *Tsuga* *eterophylla*									
Douglas-fir					70-120*				
Western larch									
Lodgepole pine									
Western white pine									
Western redcedar									
bies lasiocarpa—lower ubalpine types, not *inus contorta*-dominated									
Western larch#							130	90	
Douglas-fir									
Lodgepole pine									
bies lasiocarpa—upper ubalpine types									
Whitebark pine	300	63	(57)				(>150)	153	74
Lodgepole pine									
Subalpine larch#									

[1]*22-year intervals are from Houston (1973), 50* from Loope and Gruell (1973), and 300 from Romme (1979).*
[2]*Arno (1976 and unpublished report USDA For. Sci. Lab., Missoula, Mont.), data recalculated for application to smaller stands.*
[3]*Unpublished data collected by S. F. Arno, K. M. Davis, and D. Buck.*
[4]*Interpreted from field reconnaissance data on 35 habitat type sample stands from Steele et al. (1976) and from detailed field surveys by personnel of Priest Lake Ranger District, USDA For. Serv.*
[5]*Gabriel (1976).*
[6]Abies grandis *from Swan Valley (Antos 1977), other data from Sneck (1977).*
[7]*Hawkes (1979).*
[8]*Tande (1979).*

(Pseudotsuga menziesii var. *glauca),* and western larch *(Larix occidentalis)* can generally be found with sequences of scars dating back 300 years or more. Lodgepole pine *(Pinus contorta* var. *latifolia),* whitebark pine *(Pinus albicaulis),* western redcedar *(Thuja plicata),* and Engelmann spruce *(Picea engelmannii)* may have scars dating 200 to 250 years old. Snags and stumps of logged trees also provide long-term scar sequences. Techniques for investigating fire history have been synthesized for general field use by Arno and Sneck (1977).

Fire Occurrence by Forest Series

Findings are here presented by the potential climax forest type, or "series," defined by the most shade-tolerant tree species capable of occupying the site (Pfister et al. 1977, cf. Daubenmire and Daubenmire 1968). *Figure 1* shows examples of the distribution of forest series in different parts of the northern Rockies. The relative width of the elevational zone occupied by each series varies from one area to another, as do the general elevations where each occurs.

Table 1 shows historic fire-free intervals—mean fire return intervals (Tande 1979)—by forest series in northern Rocky Mountain study areas for two to three centuries prior to fire suppression. Data are the estimated mean numbers of years between fires occurring within small stands (about 100 acres). Fire-free intervals at a given point within a stand would normally be somewhat longer. The maximum and minimum fire-free intervals are mentioned subsequently in the text. They vary considerably from the mean, and because of differences in lengths of record and variations in study approaches they cannot be compared on a region-wide basis. *Figure 2* shows location of the study areas.

A shortcoming of presenting findings by series is that it fails to convey the importance of the distribution of series on the landscape. For example, in steep mountains, some series occur as small units within a matrix dominated by either drier or moister series. Such small, isolated tracts of a series often have fire frequencies much like those found in surrounding major series; for example, *Abies grandis* series in the Bitterroot Valley and *Pseudotsuga* series in the Coram-Swan Valley area *(table 1)*. This situation has caused some of the apparent discrepancies among fire frequencies by series. In contrast, where one series covers a large area, it is characterized by more distinctive frequencies.

Fires in the same series behave differently in rugged, highly dissected terrain (commonly found west of the Continental Divide) than on broader slopes and more gentle topography. Climatic and fuel differences within some of these series also affect fire occurrence. For instance, especially long (300-year) intervals in the *Pinus contorta* series were found by Romme (1979) at high-elevation sites where tree growth is slow, undergrowth sparse, and fuel created by the mountain pine beetle less than in the other study areas in this series. Further refinement of *table 1* might be possible if data could be presented by habitat types, which are subdivisions within each series. Still, within one series or habitat type, stands exhibit different fire histories because of many chance factors, including the effects of previous fires.

In *table 1,* the north Bitterroot Valley data seem to represent unusually short fire-free intervals for the northern Rockies, possibly because of frequent Indian-set fires in the adjacent lowlands (Arno 1976). However, the data from several of the areas probably include some fires ignited by man, either American Indians or European Americans (Weaver 1974). It seems likely that Indian-set fires in the drier forest types occurred in late spring or early fall—largely outside of the severe mid-summer season—when they would have been less damaging to overstory trees. Investigations of scar formation in relation to the seasonal development of individual growth rings could be attempted to test this hypothesis.

Pinus ponderosa Series

Sites in this series support only ponderosa pine and, occasionally, Rocky Mountain juniper *(Juniperus scopulorum),* being too droughty for significant amounts of Douglas-fir. This series forms the forest zone of lowest elevation in the northern Rockies and much of the western United States *(fig. 1)*. Annual precipitation is about 11 to 17 inches at Montana sites (Pfister et al. 1977).

Studies in the Northern Rockies (Arno 1976, Dorey 1979, cf. LeBarron 1957) and elsewhere (Wright 1978) have found that wildfires occurred frequently prior to the advent (1910) and improvement (1930s) of suppression. Average fire-free intervals were from 5 to 20 years. Maximum fire-free intervals for three Bitterroot Valley stands between the years 1680 and 1910 ranged from 21 to 30 years (Arno 1976). Minimum recorded intervals were three and four years, but shorter intervals might have gone undetected.

Historic fires apparently kept the stands open with

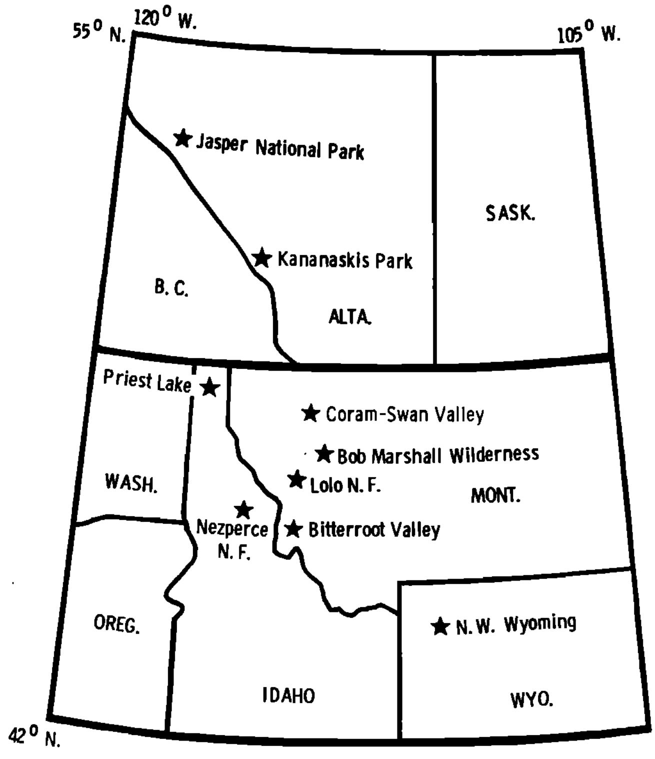

Figure 2. Locations of study areas listed in Table 1.

bunchgrass undergrowth, preparing the site for ponderosa pine regeneration but thinning or consuming many of the small pines and junipers established after previous fires. Large, stand-destroying fires were probably uncommon in this series prior to 1910, but extremely dense pole stands have now developed in some areas and seem more susceptible to crown fire (Weaver 1951) if suppression fails.

Additional insight concerning the nature of fire in this and other series can be gained from *figure 3,* which is based on stands examined during the Montana forest habitat type study (Pfister et al. 1977). About 70 percent of mature ponderosa pine/bunchgrass habitat type stands sampled in Montana had obvious evidence (charred tree bark, fire scar, abundant charcoal on the ground) of ground fire occurring after stand establishment. The actual percentage of stands experiencing ground fire was probably still greater. Observers often noted that evidence was inconclusive and that a low-intensity fire might well have occurred, but not be detectable any longer.

Pseudotsuga menziesii Series

The *Pseudotsuga menziesii* series is somewhat cooler and moister than the *Pinus ponderosa* series in the Northern Rockies (annual precipitation about 18 to 22 inches). It also borders grasslands in the higher valleys and areas having colder climates *(fig. 1)*. It forms an especially broad zone in Montana and central Idaho and, as indicated in *table 1,* supports four principal tree species. Mature lodgepole pines have moderate resistance to fire; the three other species (ponderosa pine, Douglas-fir, and western larch) have high resistance (Wellner 1970).

Ground fires of low to medium intensity were very common in the *Pseudotsuga* series (Houston 1973,

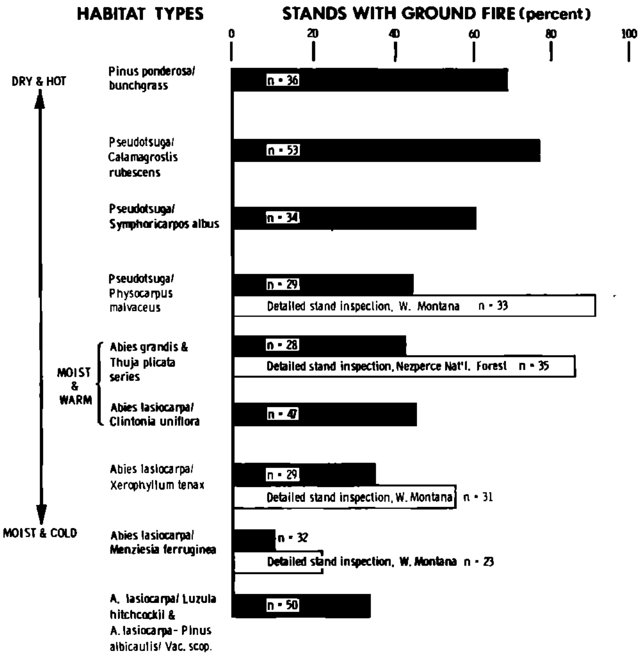

Figure 3. Percentage of mature stands (greater than 100 years old) having obvious evidence of ground fire after stand establishment. Fires were of low to medium intensity, with most of the dominant trees surviving. Data in black bars are from stands sampled on the Montana forest habitat type study (Pfister et al. 1977). Data in white bars are from more detailed investigations made by the author (n = total number of stands investigated for evidence of fire).

Loope and Gruell 1973, Arno 1976, Tande 1979, Parminter 1978), as is indicated by *figure 3.* However, under severe burning conditions, especially with strong winds, fires sometimes crowned and covered sizeable areas. When conditions moderated, fires would creep along the ground, with occasional flare-ups. Often the major fires burned at several intensities in reaction to changes in stand structure, fuel loadings, topography, and weather. The result was a mosaic of fire effects on the landscape, which tended to be self-perpetuating.

Mean fire-free intervals ranged from about 15 to 30 years in most areas where this series is abundant (*table 1*). Maximum fire-free intervals for 18 Bitterroot Valley stands between the years 1600 and 1910 were mostly between 35 and 60 years (calculations based upon data from Arno 1976). Corresponding maximum intervals for Yellowstone Park stands were about 40 to 50 years (Houston 1973). Maximum intervals for Jasper National Park stands ranged from 39 to 66 years, and minimums were 1 to 10 years (Tande 1979).

After an exceptionally long fire-free interval, either dense conifer understories or overstocked pole-sized stands develop. These situations are more susceptible to crown fire (Dodge 1972, Kilgore 1973). In contrast, relatively open forests of ponderosa pine, Douglas-fir, western larch, sometimes augmented with lodgepole pine, were maintained in that condition for several centuries by frequent ground fires (Arno 1976, Hall 1977).

Photographs and descriptions in the early U.S. Geological Survey annual reports (circa 1900) confirm that ground fires maintained open stands in the valleys of western Montana. Also, a series of 12 photopoints established in 1909 at Lick Creek on the Bitterroot National Forest illustrates the transition of open ponderosa pine-dominated forests to denser stands with Douglas-fir after several decades of fire suppression. The mean fire-free interval at Lick Creek between the years 1600 and 1900 was seven years. (One pine recorded approximately 32 fires.)

Pinus contorta-dominated Communities

Nearly pure lodgepole pine stands occur near the upper limits of the *Pseudotsuga* series and in or near the lower portion of the *Abies lasiocarpa* series (Pfister et al. 1977), especially on drier sites. Lodgepole pine stands are found throughout most of the Northern Rockies at middle elevations and are especially well developed on the broad ridges and high valleys near and east of the Continental Divide and in central Idaho.

Fire was more frequent (generally at mean intervals of 25 to 50 years, *table 1*), and less intense in areas having dry summers. Ground fires of low to medium intensity were common in several areas (Loope and Gruell 1973, Arno 1976, Gabriel 1976, Despain and Sellers 1977, and Tande 1979), especially on gentle slopes. Maximum fire-free intervals for stands in Jasper National Park ranged from 31 to 88 years, while corresponding minimum intervals were 1 to 16 years (Tande 1979). Fire was less frequent and more intense in areas having moist summers (Hawkes 1979, Gabriel 1976, Sneck 1977, Romme 1979). Large, stand-replacing fires were prevalent in the moist-summer areas, although they occurred to some extent in all study areas.

Studies of lodgepole pine stands on a high-elevation plateau (8,000-8,500 feet) in Yellowstone National Park suggest that 300 years of fuel accumulation may be necessary to sustain a spreading fire, but that fires usually replace the stand when they do occur (Romme 1979). Similarly, Stephen Cooper (USDA Forestry Sciences Laboratory, Missoula, Montana) observed no evidence of ground fire in the extensive, high-elevation lodgepole pine forests on the Wind River Reservation in central Wyoming. These slow-growing (poor-site) lodgepole forests have very sparse undergrowth, slow-developing tree understories, and few mountain pine beetle-created fuels in comparison with most stands farther north or at more moderate elevations. In lodgepole pine forests of northern Utah, there is abundant evidence of nondestructive ground fires, more intense burns that "thinned" stands, stand-replacing fires, and severe double burns (personal communication with James Elms and John Robatcek, Region 4, USDA Forest Service, Ogden, Utah).

In lodgepole pine forests of northwestern Montana, frequent low- to medium-intensity ground fires served to delay the stand-replacing burns (Gabriel 1976). In many areas, a continuum of fire intensities and sizes occurred in lodgepole pine forests (Loope and Gruell 1973, Arno 1976, Tande 1979), depending upon weather and fuel conditions. Massive overstory mortality caused by previous fires or by epidemics of mountain pine beetle (*Dendroctonus ponderosae*) results in large build-ups of dead fuel, which favors stand-replacing fires (Wellner 1970, Loope and Gruell 1973).

Abies grandis Series

The *Abies grandis* series occurs at low to middle elevations, like the *Pseudotsuga* series, but is wetter, receiving more than 25 inches of precipitation annually. This zone is well developed in the western portion of the Northern Rockies, where Pacific Coast air masses bring abundant moisture and mild temperatures.

Though data are limited, fires appear to have occurred frequently (mean intervals of 25 to 50 years) in some of the drier sites (cf. Hall 1977), especially on steep south- and west-facing slopes. These fires maintained open, seral stands of large ponderosa pine, Douglas-fir, and western larch. On cooler and wetter sites within the series, historic fires were less frequent (probably with mean intervals of 70 to 250 years); thus, *Abies grandis* became a dominant. Fires occurred in a full range of intensities throughout the series. During extreme burning conditions, fires crowned and covered large areas.

Thuja plicata Series and *Tsuga heterophylla* Series

These highly productive types occur within the dampest (most oceanic) climate in the entire Rocky Mountain system. They are found up to about 5,000 feet in elevation in areas of northeastern Washington, northern Idaho, northwestern Montana, and southeastern British Columbia, where annual precipitation exceeds 32 inches (Daubenmire and Daubenmire 1968, Pfister et al. 1977). Extreme summer droughts occur every few years, however, setting the stage for occasional large, destructive fires, the most recent of which was the 56,000-acre Sundance Fire of 1967, near Bonners Ferry, Idaho (Anderson 1968). Massive crown fires in 1889, 1910, 1919, 1926, and 1934 collectively burned several million acres, including large amounts in the *Thuja* and *Tsuga* series.

Such spectacular fires have been associated with strong winds and extremely dry conditions. In several cases, the dead fallen timber created by one fire predisposed the area to one or more successive burns within 25 years or less (Wellner 1970). These double burns often retarded tree regeneration and initiated shrubfields that have persisted for a few decades. Untreated logging slash enhances the intensity of wildfires in these forests.

No detailed studies had been made in these forests until 1979, when L. A. White and D. H. Davis applied the methodology of Arno and Sneck (1977) on two tracts, totaling more than 30,000 acres, of the Priest Lake Ranger District, Idaho Panhandle National Forests.

Analysis is not yet completed, but the survey evidence shows that low- to medium-intensity ground fires visited most mature and prelogging stands. One to three fire years during the 1700s and 1800s were detected on older trees in most upland forests in these types. Hotter stand-replacement burning was also common, usually in a patchy pattern. The lower duff layers and large fuels apparently remain relatively moist, even during dry summers, beneath a forest canopy. More drying of these fuels occurs in open, logged areas. Along the valley bottoms and in other wet forest sites, fires were apparently less frequent and usually of low intensity.

Two other sources of evidence suggest that fires sometimes stayed on the ground and functioned mostly to open or thin the stands. Marshall (1928) described two stands and mentioned two others that had had two or more ground fires since their origin (presumably in a replacement burn) 275 to 400 years earlier. Reconnaissance data for *Thuja* habitat types in northwest Montana and the Nezperce National Forest of Idaho (*fig. 3*) indicate that ground fire was common in mature stands.

Mature stands in these series usually have a dense crown layer high overhead and sparse ladder fuels below. Thus, they seem less susceptible to crown fire (except during extreme burning conditions coupled with high winds) than young stands with a dense vertical structure.

Abies lasiocarpa Series

This series forms the broadest forest zone in much of the Northern Rockies, stretching from middle elevations (or even from lower elevations in cold valleys) to the alpine timberline. Pfister et al. (1977) divide it into lower and upper subalpine belts.

Lower subalpine types.—This category covers the lower and middle portion (elevations) of the series, where *Pseudotsuga, Larix occidentalis,* or *Pinus monticola* are present to some extent in seral communities. *Figure 3* summarizes evidence of ground fire in mature stands for three of these habitat types in Montana. The drier habitat types within this portion of the series (*Abies lasiocarpa/Xerophyllum tenax* and *Abies lasiocarpa/Vaccinium scoparium*) often maintain the *Pinus contorta*-dominated communities which were discussed previously.

Abies lasiocarpa/Clintonia uniflora includes moist, highly productive forests below 5,500 feet elevation west of the Continental Divide in Montana and northern Idaho. These stands are often dominated by seral, but long-lived, western larch. On Coram Experimental Forest east of Kalispell, largely in this habitat type, Sneck (1977) found that most fires were moderately intense, usually staying near the ground, but occasionally crowning, especially near ridge tops. Most of those at Coram were small (45 to 200 acres). Large stand-destroying fires and double burns have occurred farther to the north and south in somewhat drier habitats, especially those merging with the *Pinus contorta* communities. Sneck found that mean fire-free intervals were about 130 years (*table 1*). Hawkes (1979) noted that stand-replacing fires (often extensive) had occurred at average intervals of 90 years in the relatively moist lower subalpine types—composed of subalpine fir (*Abies lasiocarpa*), spruce (*Picea*), and lodgepole pine—in Kananaskis Provincial Park south of Banff, Alberta.

Subalpine fir-Engelmann spruce (*Picea engelmannii*) timber types usually develop in cool, moist habitat types (such as *Abies lasiocarpa/Menziesia ferruginea*) where fire-free intervals are long (probably averaging 150 years or more). Fires that do occur (other than spot fires) are usually stand-replacement burns of various sizes (note minor evidence of nonreplacement fires in the *Abies/Menziesia* habitat type, *fig. 3*).

Upper subalpine types.—These include the highest elevation forests where whitebark pine is a major seral species, as well as the timberline zone. Evidence of ground fire was found in about one-third of the mature forest stands sampled in Montana (lowermost bar in *figure 3*). Moist, north-slope communities burned much less frequently than is suggested by the data from the Bitterroot Valley and Jasper areas in *table 1* (largely from dry slopes) (cf. Tande 1979 and Hawkes 1979). Tiny spot fires were undoubtedly the most common type, but are of little ecological consequence. Other fires usually remained small and were of low to moderate intensity. A remarkable example is the grove of whitebark pines on a dry ridge in western Montana in which individual trees have open fire scars dating from approximately 1608 and 1892, with nothing in between (Arno 1976). However, some nearby ridgetop stands were burned off by the 1892 fire, evidently under extremely dry, windy conditions. Regeneration after such exceptionally hot burns often requires several decades for establishment.

A Decision for Managers

Although wildfires were a major agent of change throughout the diverse northern Rocky Mountain forests prior to the advent of organized protection, recent studies support the contention that the effects of fires varied considerably by forest type. For more than half a century, all types of fires have been routinely extinguished as quickly as possible. Ironically, some low-intensity fires might have postponed the occurrence of severe fires by reducing fuel loadings or have otherwise benefited forest management (Kilgore 1976). For example, fire has been demonstrated to be silviculturally useful even in dense standing timber in the Northern Rockies (Norum 1977). Conversely, higher-intensity burns often create heavy fuel loadings or initiate dense, even-aged stands that invite destructive fires.

Now that some of the less threatening wildfires have been monitored and allowed to burn in Yellowstone (Despain and Sellers 1977) and Grand Teton national parks, the Selway-Bitterroot Wilderness, and the Kootenai National Forest (Bailey 1980), we have increased opportunity to learn about the behavior and effects of common types of fires that used to be extinguished. Some of these fires have continued to creep at low intensities, with occasional hotter runs in heavy fuels and dry, windy weather, burning from midsummer until October or November.

Evidently, in many forests of the western United States, the fire regime in operation for at least several centuries prior to European settlement included both lightning- and Indian-caused ignitions, some of the latter being purposeful burns. Conversely, in many forests, lightning alone may have been the principal ignition source. Modern managers should determine the causes and types of past fires in their areas and then evaluate the effects of these fires in terms of forest and fuel development. To the extent that these fires produced desirable effects, managers may wish to initiate or substitute for them. ■

THE AUTHOR—Stephen F. Arno is plant ecologist at the Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station, USDA Forest Service, Missoula, Montana.

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