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Relationship of Indian-caused fires to the ecology of western Montana forests

Stephen W. Barrett
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RELATIONSHIP OF INDIAN-CAUSED FIRES

TO THE

ECOLOGY OF WESTERN MONTANA FORESTS

by

Stephen W. Barrett

B.S., University of Massachusetts, 1977

Presented in partial fulfillment of the requirements for the degree of

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The objectives of this study were to detail, in qualitative and quantitative terms, the role of Indian-caused fires in the historic fire regime of western Montana, and to relate findings to modern forest management.

When combined, findings from five research methods indicated that frequent Indian fires before 1860 were important ecological factors in ponderosa pine/Douglas-fir forests. First, interviews and journals indicated that unsystematic underburning occurred usually in the fall, primarily to aid hunting, food plant production, and horse-grazing; unintentional fires also were common. Second, fire-scar data from paired sample stands indicated substantially shorter Mean Fire Intervals (MFIs) in Indian habitation zones than in remote zones before European settlement in 1860; MFI differences between paired stands varied during the Settlement Period (1861-1910); MFIs were markedly increased in most stands during the Fire Suppression Period (1911-1980). Third, for two sample stands, comparison of fire occurrence for two periods in a stand revealed pre-1860 MFIs that were about one half the length of those that were estimated for lightning fires from 1931-1980. Fourth, examination of 946 fire scars suggested that an unusually large percentage of pre-1860 fires occurred in other than mid-summer months, in contrast to modern lightning fire occurrence. Fifth, reconstruction of presettlement stand characteristics indicated that, in 12 of 16 sample stands, succession is progressing away from previous fire-maintained ponderosa pine dominance toward climax Douglas-fir dominance in the absence of frequent fires. These stands probably are becoming more vulnerable to fires of greater severity than were characteristic in the same stands before fire suppression because of increased amounts of horizontal and vertical fuels. Continued fire exclusion could promote decreased stand vigor, thereby increasing stand vulnerability to insects and diseases.

Implications for management are to restore fire to a semblance of its previous role to enhance forest protection, silviculture, wildlife and livestock habitat, and recreation.

DEDICATION

To William F. Barrett and Helene C. Barrett: Your many years of selfless sacrifice, example, and integrity have made the following treatise possible.

This thesis also is dedicated to the past Salish and Kootenai tribes whose land of 10,000 years we now are trying to husband.

"Louis Malmon and 2 Squaws"

(ca. 1905 photograph from Edward Boos Collection, University of Montana Archives, Mansfield Library)

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My own "karma," for safely seeing me through more than 150 lone, dangerous chain saw assaults on some of the oldest ponderosa pines on some of the most rugged slopes in the northern Rockies;

And, finally, my most heartfelt thanks are reserved for Stephen F. Arno, a truly dedicated professional without whose initial and continuing inspiration, infectious enthusiasm, logistical support, technical and professional advice, and exhaustive constructive criticism, this study never would have come to fruition.

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CHAPTER I

INTRODUCTION

Fire was an important process in many western Montana ecosystems before the advent of efficient fire suppression in the early 1900s (Arno 1980). Low-intensity surface fires were common in lower-elevation forests such as those dominated by ponderosa pine (*Pinus ponderosa* var. *ponderosa*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), and western larch (*Larix occidentalis*). Frequent fires in these forests resulted in a number of ecological effects (Arno 1980) such as (1) maintenance of thinned and vigorous stands which are resistant to insect and disease outbreaks, (2) prevention of fuel buildups that can lead to stand-destroying fires, (3) perpetuation of shade-intolerant tree species, (4) recycling of soil nutrients, (5) conifer seedbed preparation and (6) stimulating the production of game browse.

These effects generally are desirable from the standpoint of multiple-use forest management. However, research (Buck 1973, Loope and Gruell 1973, Arno 1976, Gabriel 1976, Dorey 1979, Tande 1979, Gruell et al. in press) has shown that these benefits of fire have been largely eliminated from forests because of efficient fire suppression. Recognizing the problems associated with fire exclusion, federal agencies adopted policies in the late 1970s which directed managers to systematically reintroduce fire into certain ecosystems. Detailed information about fire's past role in ecosystems is vital to proper fire management planning, and fire history research is the means of gathering such information.

In many parts of North America, Indians' widespread use of fire often influenced forests and grasslands in ways that modern managers consider beneficial (Stewart 1954, Reynolds 1959, Weaver 1974, Lewis 1977). However, before 1979, the importance of Indian ignitions in western Montana was not well understood. Several sources of evidence suggest that Indian-caused fires may have been an important process in the region's ecosystems before European settlement in the late 1800s. Schaeffer (1940) Malouf (1969), and Arno (1976) all cite persons who said the Salish and Kootenai Indians often set purposeful fires in the region. Arno (1976) completed a fire history study on the Bitterroot National Forest. He found that fires occurred on the average of less than every 10 years from the late 1400s to the late 1800s, in several lower-elevation stands. He speculated that these intervals possibly were more frequent than could be caused by lightning fires alone. Mehringer et al. (1977) examined pollen cores which were extracted from Lost Trail Pass Bog, at the head of the Bitterroot Valley. A 12,000-year sample showed a marked increase in airborne charcoal deposits during the past 2,000 years, suggesting a substantial increase in low-intensity fires. However, there was no indication of a change in vegetation or climate during the past 4,000 years that might account for an increase in lightning ignitions. The researchers speculated that Indian-caused fires could have been responsible for the phenomenon.

Study Objectives

In 1979, I began a two-year study of Indian fire practices in western Montana. The objectives were as follows:

1. To determine whether the Salish or Kootenai Indians set purposeful or accidental fires in western Montana's forests before intensive European settlement about 1860.

2. If such fires occurred to a significant extent, to determine reasons for burning, seasons of burning, methods of application, weather conditions, duration of fire-use, and other details.

3. To interpret findings in relation to current forest management concerns and to suggest applications to ecologically based management.

Study Area

Study sites were located in the portion of Montana west of the Continental Divide (Fig. 1). The physiography of the region is characterized by north-south trending mountains of the Northern Rocky Mountain complex. The highest elevations range from 7,000 to 10,000 feet (2,297 to 3,281 m) above sea level. The mountains are interspersed with broad grassland valleys ranging from about 2,000 to 4,000 feet (656 to 1,640) above sea level.

The region's lowland climate ranges from warm and semiarid (less than 15 inches [38 cm] annual precipitation) in west-central Montana, to Pacific maritime-influenced cool and moist conditions (more than 30 inches [76 cm] annual precipitation) in northwestern

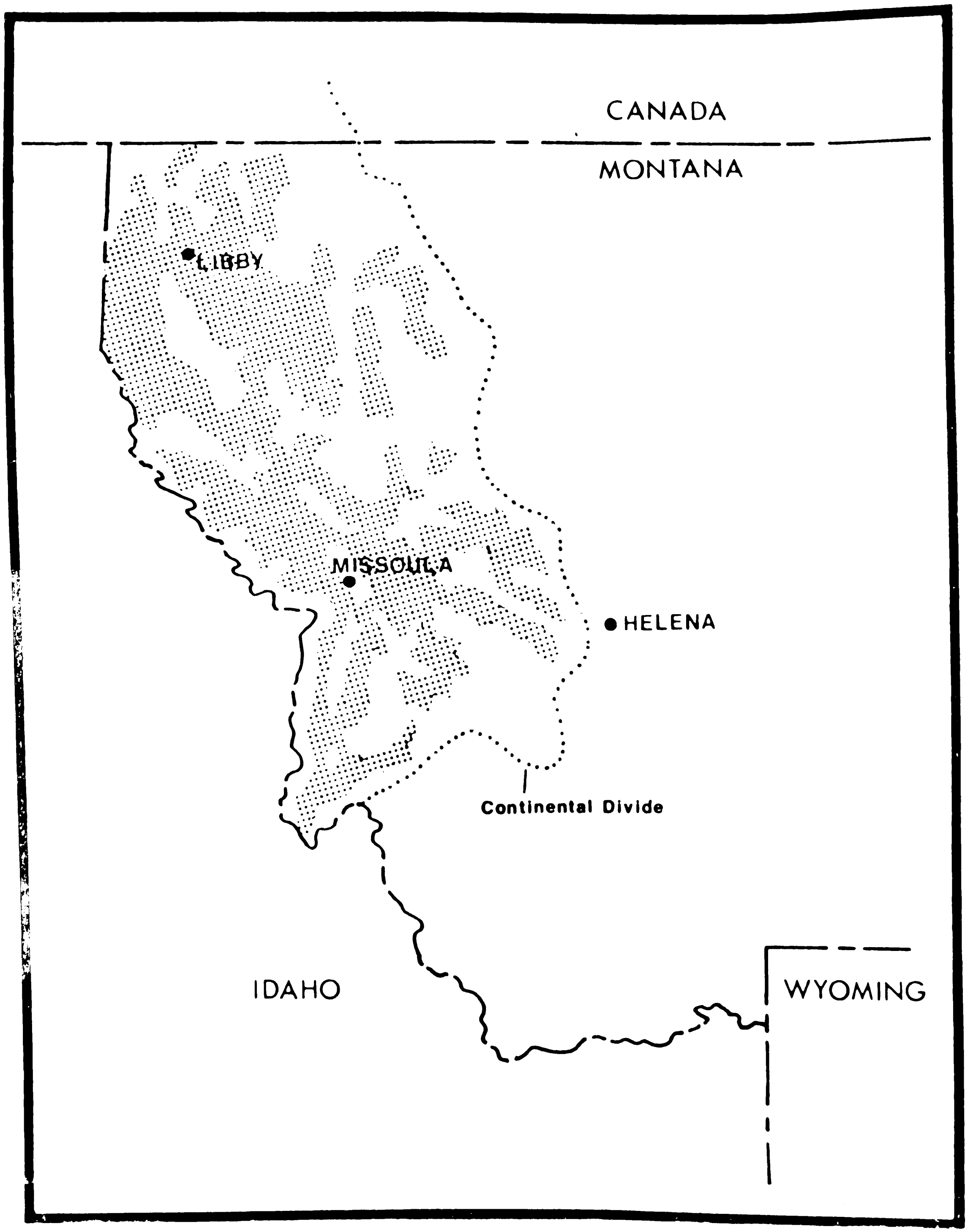

Figure 1. General distribution of ponderosa pine/Douglas-fir forests in the study area (map slightly underrepresents the moist types of the Douglas-fir series (source: unpublished map by M. Morris, School of Forestry, University of Montana, Missoula).

Montana (Arno 1979a). The lower-elevation forest vegetation reflects primarily moisture gradients. The study focused on the area's extensive Douglas-fir series forests (Pfister et al. 1977) (Fig. 1). These forests usually are found on well-drained soils and extend from the lower timberline to about 6,000 feet (1,969 m) in west-central Montana, and to about 5,000 feet (1,640 m) in northwestern Montana.

Dominant trees on the dry sites range from nearly pure stands of ponderosa pine to mixed ponderosa pine/Douglas-fir. Moist sites often support mixed ponderosa pine, Douglas-fir, western larch, and occasionally lodgepole pine (*Pinus contorta* var. *latifolia*). Frequent wildfires in the past helped perpetuate ponderosa pine, western larch, and mature Douglas-fir because they are adapted to withstand low- to medium-intensity fires and the species regenerate well after disturbance. Douglas-fir is the only species of the four which regenerates well in the absence of disturbance, thus it often assumes dominance in undisturbed stands.

Common understory species on the driest sites are grasses such as bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), rough fescue (*Festuca scabrella*), forbs such as balsamroot (*Balsamorhiza sagittata*), and such shrubs as big sagebrush (*Artemesia tridentata*), chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier alnifolia*), and bitterbrush (*Purshia tridentata*). Understories on moist sites usually are dominated by additional grasses such as pinegrass (*Calamagrostis rubescens*) and elk sedge (*Carex geyeri*), and low shrubs such as huckleberry (*Vaccinium caespitosum*) and kinnikinnic (*Arctostaphylos uva ursi*). These understories also can be dominated by large shrubs such as ninebark (*Physocarpus malvaceus*), spirea (*Spiraea betulifolia*), blue huckleberry (*Vaccinium globulare*), and snowberry (*Symphoricarpus albus*).

CHAPTER II

LITERATURE REVIEW

Indian Fire Studies

Numerous historical accounts exist regarding Indian burning practices in North America and few studies have described the environmental consequences of Indian-caused fires. However, most studies relied solely upon interpretations from historical accounts or informants; ecological research usually was not possible because too much time had passed since the period of direct Indian influence. Most of the literature concerns burning in western North America; however, aboriginal burning has been an important ecological factor in many other parts of the world such as Africa, Australia, China, and South America (Stewart 1956).

Stewart (1956) stated that over 100 tribes in North America used fire for at least 15 different purposes including hunting, native food plant production, improvement of horse-grazing, and communication. With few exceptions, studies and historical journals have concluded that frequent burning maintained vegetation in the early successional stages--grasslands were created or maintained by preventing tree encroachment, and lower-elevation forests were kept in open park-like conditions.

In the Northeast, Bromley (1935) and Day (1953) examined journals written in the early 1600s and both researchers concluded that

Indian fires played an important role in maintaining, open-grown coastland pine/oak and inland oak/chestnut associations. However, Raup (1937) felt that the climatic-edaphic complex, rather than fires alone, was primarily responsible for maintaining these vegetative patterns.

In the Midwest, Curtis (1959) concluded that Wisconsin's presettlement oak openings, oak/pine barrens, bracken-grasslands, true prairies, shrub prairies, and pine forest owed their existence and perpetuation to the occurrence of frequent fires. He felt that the relatively low level of lightning occurrenc in the region was not capable of igniting the large areas that were influenced by fire. Historical accounts indicated that Indian subsistence burning was largely responsible for the treeless condition of many areas of midwestern prairie, and Curtis concluded that Indian burning was a very important ecological factor in the region.

Stewart's (1954) pioneering work documented a number of reasons why Indians set fires on the Northern Great Plains, including burning for game forage improvement, game drives, insect control, and warfare. He believed that Indian fires were primarily responsible for creating and maintaining the treeless condition of the plains, although he did not have firm ecological evidence to support his contention. Nelson and England (1971) concluded that the past role of Indian plains-burnin is difficult to assess because records are scarce, but burning apparent was frequent and the control of wildlife movements probably was a prime reason for setting fires. They concluded that lightning fires and man-caused fires must have maintained early grassland successions. Loscheider's (1975) ethnohistory of Indian burning practices agreed with Stewart's documentation of Indians' reasons for burning.

In northern boreal forests, Lutz (1959) examined historical accounts and concluded that Indians in south-central Alaska often set fires for wildlife forage and browse improvement and for communication. He also concluded that many forests were severely burned by unintentional fires which spread from campsites. Lewis (1973) interviewed Cree and Slavey informants who recalled burning in northern Alberta. He found that Indians had acquired much ecological knowledge through centuries of carefully planned, methodical burning. The Indians created and maintained meadows with fire until the 1930s, when burning was prohibited by local authorities. Informants said that forest vegetation has advanced markedly into the meadows since that time.

A number of studies have described the effects of past Indian burning in California ecosystems. Burcham (1959) and Clar (1959) felt that Indian fires were not an important factor in the oak/woodland zone of the Sierra Nevada foothills; they speculated that burning would have occurred only on a small-scale, local basis because Indian populations were low. Other studies did not support their contentions. Reynolds (1959), Lewis (1973), and Kilgore and Taylor (1979) all agreed that Indian fires were influential in maintaining open-grown oak/woodland and coniferous forest ecosystems because the tribes frequented many areas in their subsistence activities.

There have been few Indian fire studies in the Northwest.

Ross (1981) recently began an anthropological study to document the ethnohistory of Salishan burning practices on the Columbian Plateau in eastern Washington. Regional historic journals are scarce, and Ross relied upon two informants for his information (personal communication). Ross said that the informants' oral histories went back to about 1830. They told him that the Spokan and Colville tribes often conducted systematic burning in grasslands and ponderosa pine forests, and that burning had religious significance. Ross's informants said Indians burned primarily to stimulate browse, forage, and seral food plants, and sometimes for wildlife hazard reduction or to promote easier traveling. They said annual burning occurred somewhere in general areas but probably not in specific stands, and Ross concluded that early successional stages were maintained in many forest understories. Burning apparently was done until the 1920s, when local authorities put an end to the practice.

Early accounts of Indian burning in Oregon's Blue Mountains are of particular interest because the ponderosa pine/Douglas-fir forests and semiarid climate of the region closely resemble conditions found in much of western Montana. Cooper (1853) mentioned that forest encroachment was beginning to occur in small grassland valleys of the Blue Mountains. He said these valleys previously were treeless largely because of Indian burning. Shinn (1980) compiled historical accounts and concluded that Indian fires were very frequent in habitation zones. He speculated that subsistence burning may have begun thousands of years ago in the inland Pacific Northwest. Shinn mentioned several studies (Sauer 1944 and 1950, Martin and Wright 1967) that suggested that very early hunting cultures used fire. These studies speculated that the Indians may have contributed to the rapid decline and extinction of several species of large Ice Age mammals toward the close of the Pleistocene Epoch, about 10,000 years ago.

Tribal Histories

My study focused on the Salish and Kootenai Indians, whose tribal territories encompassed the study area (Fig. 2). The term "Salish" refers to several tribes of the Salishan linguistic group, primarily the Flatheads and the Pend d'Oreilles (Teit 1928). To a lesser extent, other Salishan tribes such as the Spokans and Coeur d'Alenes frequented the area, although their main territories were to the west. The Kootenai Indians are the only tribe of the Kootenai linguistic group.

Human habitation of western Montana began at least 6,000 years ago (Malouf 1969) and recent evidence (Choquette and Holstine 1980) suggested that habitation may have begun about 10,000 years ago. The earliest ancestors of the Salish Indians apparently migrated east from the Columbia Plateau. The first identifiable tribe in the area may have been the Pend d'Oreilles, whose range encompassed from the Bitterroot Valley to around Flathead Lake.

Around the same time, the Kootenai Indians occupied the region northwest of the Pend d'Oreilles, in the area drained by the Kootenai River. Before 1800, at least one band of this tribe may have lived on the plains east of the Rocky Mountains (Turney-High 1941). Their eventual westward migration over the Continental Divide apparently was

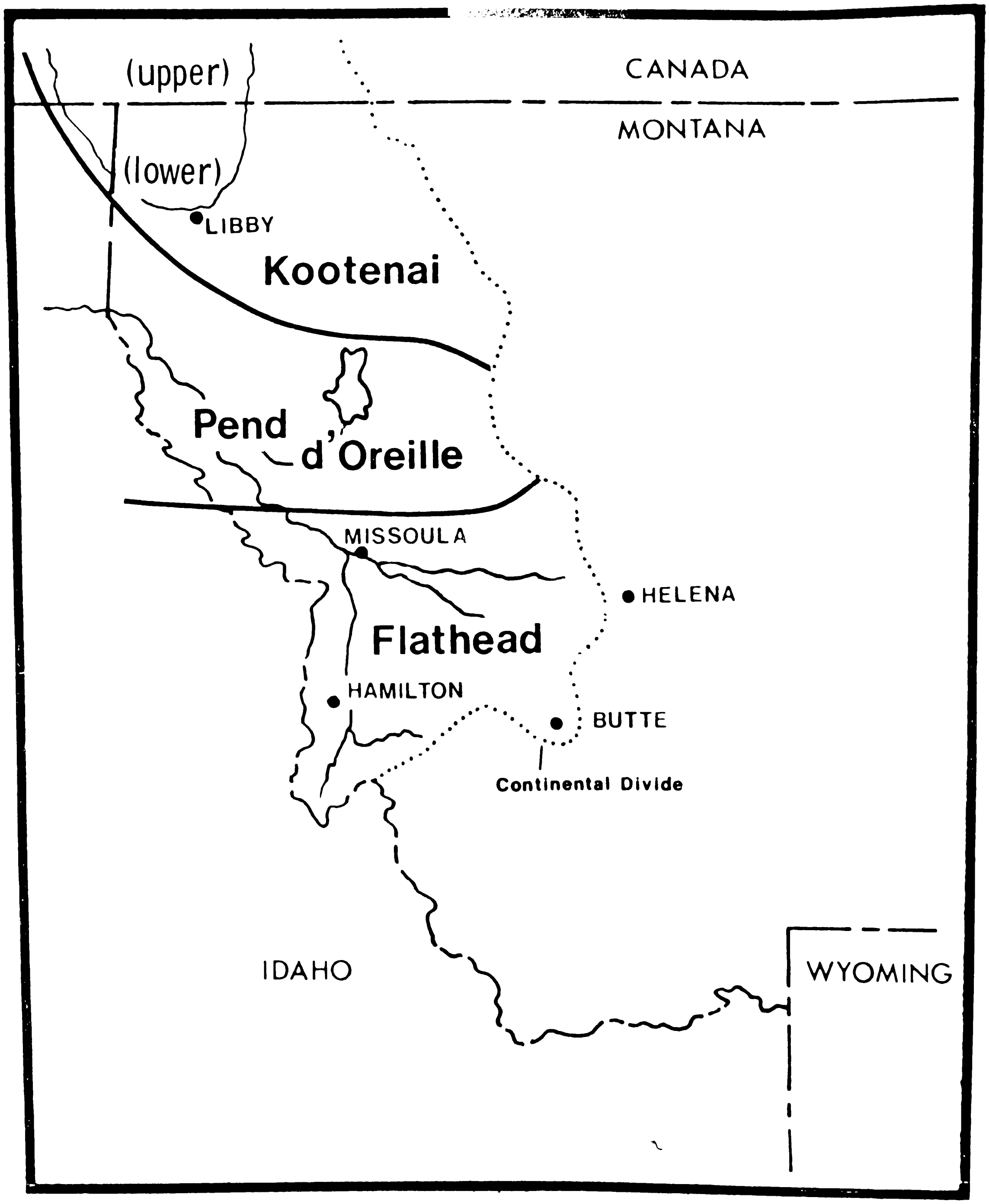

Figure 2. Salish and Kootenai tribal distributions in western Montana as of 1855 (the treaty-making period) (source: Malouf 1974).

forced by increasingly frequent territorial conflicts with other plains tribes. Plains cultures were, themselves, migrating westward because of European expansion in eastern North America.

The Flathead tribe also originally was a plains culture (Teit 1928).[1] The Flathead's ancestral territory apparently was located around present-day Three Forks, Montana. However, pressure from migrating eastward tribes also forced the Flatheads to relocate west of the Continental Divide, in what is now western Montana. This migration is estimated to have occurred around 1700 (Teit 1928). The Flatheads thus displaced their Salishan kin, the Pend d'Oreilles, from the Bitterroot Valley to the area around Flathead Lake.

Before the period of tribal migrations, the Flatheads and at least one segment of the Kootenai tribe devoted most of their economic activity to hunting bison on the plains (Teit 1928, Turney-High 1941). Like other plains cultures, these Indians were nomadic, following herds for great distances. After their westward move into the mountains, the Flatheads and Kootenais still were dependent upon plains bison, although to a much lesser degree. Great distances then had to be traveled to reach the herds, but the tribes still crossed the Continental Divide to hunt bison at least twice yearly, in fall and spring (Turney-High 1941).

Between bison hunts, Salish and Kootenais subsisted on local

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[1]Turney-High (1941) disputed this theory, claiming that the Flatheads migrated east from the Columbia Plateau as had the Pend d'Oreilles. However, Teit's contention is more widely accepted as being the correct one (personal communication with C. Malouf, Anthropologist, University of Montana, Missoula).

game and native food plants west of the Continental Divide in the home territories. The tribes divided into small bands, dispersed, and traveled from one temporary campsite to another during the summer. These sites were numerous and usually were located in the valleys or major river canyons. Large, permanent occupation sites were few by comparison. The mountain tribes' retention of previous nomadic ways may be important in helping explain patterns of fire-use.

Estimates of past Salish and Kootenai ribal populations vary according to time periods and references cited For example, Teit (1928) reported that there were fewer than 2,00 Kootenais and approximately 1,600 Pend d'Oreilles, 600 Flatheads, and 600 Spokans in the are at the time of Lewis and Clark in 1805. Territorial Governor Isaac Stevens reported that there were about 1,000 Pend d'Oreilles, 800 Kootenais, and 450 Flatheads in western Montana before the signing of the Treaty of 1855.[2] Accordingly, population densities were very low in the region. Malouf (1974) estimated that densities were probably no more than one person to every six square miles as of 1855. This factor also may be important in helping explain patterns of fire-use.

Indian influence of the landscape markedly diminished after the signing of the Treaty of 1855. The advent of settlers in the region about 1860 (Lieberg 1899, Lindgren 1904), seriously hampered the tribes ability to continue traditional subsistence activities. By the 1800s, most of the Salish and Kootenais had moved to the current reservation

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[2]Stevens did not mention Spokan Indians in this estimate; however, it is likely that he did not distinguish them from other Salishan tribes. This occurs often in early accounts of Indians.

that was established north of Missoula. After that time, Indians occasionally traveled to traditional hunting and gathering areas outside the reservation. However, by the close of the 1800s, their span of influence in western Montana was largely over.

CHAPTER III

INFORMANTS AND JOURNALS

Methods

I sought out and interviewed the most-knowledgeable descendants of the Salish and Kootenai Indians, and of early settlers in the region, to document the details of Indian burning. Informants were identified and contacted with the help of historical societies, tribal councils, and by referral by knowledgeable people. During interviews, I used an oral history outline (Baum 1974) (Apendix A) and a tape recorder, or I simply recorded information by hand. Information later was transferred to data forms for ease of retrieval and analysis.

In addition to interviews, historical journals and early-day newspapers were researched to document details of Indian burning. Wherever possible, information gathered on Indian burning was corroborated between informants and journals. In terms of judging validity, more consideration was given to corroborated evidence than to single sources of information, although all information was recorded and referenced.

Results and Discussions

One hundred and seven persons were contacted from June through September 1979. Of that number, 58 persons proved to be adequately qualified to be considered informants (Table 1) (Appendix B). Sixty-five percent gave information that pertained to the Salish tribes. Thirty-five percent discussed the Kootenais. For reasons which will be discussed later, it is useful to stratify "Kootenai" informants. Sixty-six percent discussed the ways of the Upper Kootenais and the remaining 44 percent discussed those of the Lower Kootenai Band.

TABLE I

RACE OF INFORMANTS BY NUMBER AND PERCENT
ACCORDING TO TRIBES DISCUSSED

	Salish		Kootenai		Totals	
	No.	%	No.	%	No.	%
Native American	17	45	14	70	31	53
White	21	55	6	30	27	47
Totals	38	100	20	100	58	100

The number of "Kootenai" informants is small (20) compared to the number of "Salish" informants (38). There are several reasons for this. First, there are no longer many persons who possess knowledge about the early Kootenais because many tribal elders have died in recent years. Second, the present Kootenai population is much smaller than that of the Salish, thus the number of Kootenai informants of any age is limited. Third, European settlement of the traditional Kootenai range in northwestern Montana occurred later, and much less intensively, than did settlement of Salish territory. Thus, the number of white informants also is limited. For these reasons, less confidence can be expressed in data on Kootenai fire practices than in the data regarding the Salish. However, the combination of interview data, historic journals, and inductive reasoning should allow for a fairly accurate picture of past Kootenai practices.

When asked about past fire-use, 41 percent of all informants said that broadcast burning occurred (Table 2). Twelve percent denied that broadcast burning was practiced. A relatively large percentage of informants did not know if deliberate burning occurred (47%). Knowledge of past Indian burning was quite limited more than 100 years after the tribes' decline, and the era of being able to gather such information is rapidly coming to a close. For example, at least two of my informants have died since the interviews in 1979.

TABLE 2

NUMBER AND PERCENT OF INFORMANTS ACCORDING TO TYPE OF RESPONSE: "DID SALISH OR KOOTENAI PRACTICE DELIBERATE BURNING?"

Response	Re: Salish		Re: Kootenai				Totals	
			Lower		Upper			
	No.	%	No.	%	No.	%	No.	%
Yes	17	44	2	15	5	71	24	41
No	0	0	7	54	0	0	7	12
Don't Know	21	56	4	31	2	29	27	47
Totals	38	100	13	100	7	100	58	100

It is important to consider responses according to the tribe that was discussed. Forty-four percent of the informants who discussed the Salish said these tribes practiced deliberate burning. None of the informants denied that burning occurred. The remaining informants did not know if fire practices existed.

Data obtained on the Upper and Lower Kootenai bands differed markedly. Regarding Upper Kootenai fire-use, 71 percent of the informants said burning occurred. No "Upper Kootnenai" informants denied that fire was used. The remaining 29 percent did not know. In contrast, when asked if the Lower Band practiced deliberate burning, 15 percent of the informants said "Yes." Fifty-four percent denied that fire-use occurred--these seven people vigorously denied that fires ever were set by the Lower Kootenais. This was the only case where a group of informants said that Indians did not set fires. The remaining 31 percent did not know if burning occurred.

Locations of Indian Fires

Seven informants who verified fire-use identified locations where burning occurred. Dan Longpre (Missoula, now deceased) said that in the 1880s his father saw Flatheads burning whenever they passed through the Ninemile Valley west of Missoula. Harold Whitley (Hamilton) and Lawrence Humble (Hamilton, now deceased) both said that annual burning was done by Flatheads in the West Fork of the Bitterroot River drainage, southwest of Darby. They said this occurred after the traditional fall hunt of the mule deer (*Odeocoileus hemonius hemonius*) migration from the Bitterroot Valley over the Bitterroot Divide into Idaho (Whitley acquired this information from an old, now deceased, Flathead informant; Humble was told by his father, who homesteaded up

the West Fork). Pete Stasso (Elmo) said Kootenai family bands habitually burned around the long-used Hog Heaven campsite west of Elmo. He said burning also occurred in the West Fork of the Fisher River drainage south of Libby. Thompson River homesteaders told Irwin Puphal (Thompson Falls) that in the 1880s [Lower] Kootenai Indians burned the meadows each year around Indian Creek, northeast of Thompson Falls. Burt Wilke's (Fortine) father saw Indians (probably Upper Kootenais) burning the meadows each fall near the traditional Wolf Creek campsite east of Libby. Charlie Husec's (Fivemile Creek, northeast of Libby) father told him [Upper] Kootenai Indians burned each spring in the Tenmile Creek drainage, which was a favorite hunting area northeast of Libby.

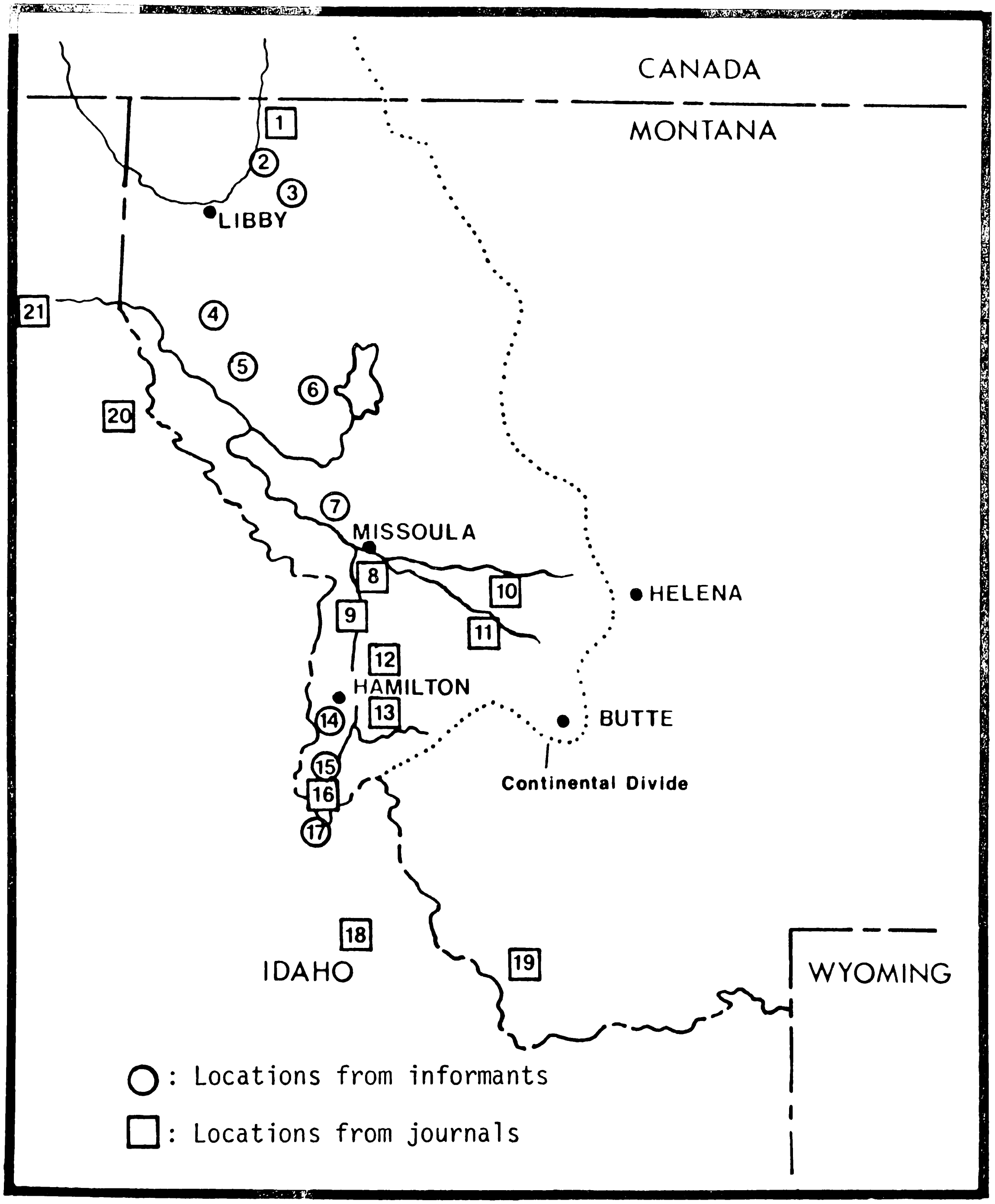
In addition to these locations from informants, a number of historical journals identified Indian fire locations (Fig. 3). Both sources indicated that Indian fire practices were geographically widespread in the region.

Ecosystems Affected by Indian Fires

From the descriptions provided by informants and journals, it is possible to identify the vegetative types that were either deliberately or accidentally burned by Indians. Informants indicated that burning either occurred in, or was initiated from, intermountain valley grasslands or lowland forests. This is logical, since almost all native habitation, hunting, food gathering, and horse-grazing took place in such locations. Thus, Indian fires affected primarily grasslands and lower-elevation forests dominated by ponderosa pine, Douglas-fir, or

Figure 3. Locations of Salish or Kootenai ignitions in western Montana and adjacent areas between approximately 1805 and 1920.

1. Tobacco Plains, 1880s (Shea 1977:99)
2. Tenmile Creek, 1880s-1900 (personal communication with informant Charles Husec)
3. Wolf Creek, 1880s (personal communication with informant Burt Wilke)
4. West Fork of the Fisher River, 1900-1920s (personal communication with informant Pete Stasso)
5. Thompson River, 1880s-1900 (personal communication with informant Irwin Puphal)
6. Hog Heaven, 1900-1920s (personal communication with informant Pete Stasso)
7. Ninemile Valley, 1880s (personal communication with informant Dan Longpre)
8. Vicinity of Missoula, 1860 (Mullan 1861:37)
9. Vicinity of Lolo Pass, 1806 (DeVoto 1953:83)
10. Vicinity of Deer Lodge, 1832 (Phillips 1940:106-107)
11. Vicinity of Phillipsburg, 1853 (Mullan 1855:342)
12. Vicinity of Stevensville, (date not given)(Malouf 1969:270)
13. Vicinity of Hamilton, 1833 (Phillips 1940:215)
14. Vicinity of Hamilton, 1880s (personal communication with informant Henry Grant)
15. West Fork of the Bitterroot River, 1880s (personal communication with informant Lawrence Humble)
16. West Fork of the Bitterroot River, 1880s (Jacquette 1888:3)
17. West Fork of the Bitterroot River, 1880s (personal communication with informant Harold Whitley)
18. Vicinity of Lemhi River, 1805 (Thwaites 1969:49)
19. Vicinity of Bannock Pass, 1832 (Phillips 1940:103)
20. North Fork of the St. Joe River, 1860 (Mullan 1861:151-152)
21. Lake Coeur d'Alene, 1858 (Chittendon and Richardson 1969:1021-1022)


CANADA
MONTANA
LIBBY
MISSOULA
HELENA
HAMILTON
BUTTE
Continental Divide
IDAHO
WYOMING
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
: Locations from informants
: Locations from journals

western larch. Some fires occurred in other ecosystems, such as signal fires in high-elevation forests, but apparently most subsistence burning took place in the lower elevations.

Characteristics of Indian Fires

When asked to describe the characteristics of Indian burning, the informants who verified fire-use implied that fires were low-intensity underburns (the term "low intensity" refers to surface fires which seldom kill overstory trees). All of these informants said Indians were careful not to set fires during summer or other hot and dry periods which could be conducive to conflagrations. However, historical journals indicated that Indians occasionally caused severe, possibly stand-replacing, fires during the summer (Mullan 1861, Phillips 1940).

Informants usually could not describe the areal extent of Indian fires, but historical sources indicated that fires often covered large areas and burned for weeks or even months (Mullan 1861, Jacquette 1888, Phillips 1940). Several informants said small, controlled fires were set at certain infrequent times.

Many informants volunteered remarks concerning supposed beneficial effects of Indian burning. Most often these descriptions centered around the well-documented fact that many lower-elevation ponderosa pine stands were maintained in open, park-like conditions (Lieberg 1899, Ayres 1899, Gruell et al. in press). Informants related facts told to them by their parents; however, many informants were in their 80s and such stands still existed in these persons' younger days.

Many people further said that they had never heard of large, destructive wildfires occurring in ponderosa pine stands during the early days. If this was true, then it probably would have been a result of the small accumulations of light fuels that were characteristic of frequently burned forests. All of these fire effects, of course, would have been the result of both lightning fires and Indian fires. Lieberg' (1899) early Bitterroot Forest Reserve report described typical fuels and fire behavior in many past ponderosa pine stands (largely Douglas-fir series as described in Pfister et al. 1977):

> The fires in the Bitterroot Basin have been as extensive as elsewhere in the West, but [they] have done far less damage to the merchantable timber. This is due to the resistance offered by the yellow pine [to fire damage] and to the small quantity of litter and humus in the forest. The ground in this kind of growth is always covered with a thin layer of pine needles--never a proper humus--and is usually free from undergrowth, or has but a minimum. Grasses or sedges in bunches cover the ground thinly, hardly ever forming a continuous sod. In consequence fire runs through the forest rapidly. (Lieberg 1899:275)

Reasons for Fire-Use

The Salish and Kootenais evidently had many purposes for setting fires. Informants and journals revealed 13 reasons for fire-use (Table 3) in addition to the occurrence of unintentional fires. Many of the reasons are closely related and they are described in the following pages under ten categories.

TABLE 3

REASONS FOR BURNING BY NUMBER AND PERCENT OF VERIFICATIONS ACCORDING TO INFORMANTS AND JOURNALS

Purpose of burning	No. of Verifications		Percent of total
Forest Protection		13	21
Improve Hunting		14	22
Increase browse and forage	(6)		
Facilitate stalking	(4)		
Drive game/surround	(4)		
Enhance Plant Species		7	13
Increase berry production	(6)		
Favor medicine plants	(1)		
Facilitate Gathering		1	
Improve Horse-Grazing		6	10
Campsite-Clearing		6	10
Communication		7	11
Trail-Clearing		2	3
Agricultural Land-Clearing		3	5
Rituals/Entertainment		1	2
Unintentional		2	3
Totals		62	100

Some informants thought the Indians had only one purpose for burning, but apparently most fires were set to achieve several objectives at the same time. Informants and journals gave many closely related but separate reasons why underburning occurred. Their differing statements probably reflect that Indians were aware of the various ecological effects and potential benefits that certain fires could produce. The following reasons for fire-use were obtained from informants or journals.

Forest Protection. Thirteen people said Indians set fires to help maintain open stands. They said these fires also helped protect the forest from damaging agents such as large wildfires, or from insect and disease epidemics. For example, several Indians told Dan Longpre's father that they knew that burning the brush killed insects and disease which could spread to trees. Similarly, Salish informant Louise Combs (Arlee) said that her mother-in-law and others ignited the black lichens (*Alectoria* spp.) that hang from trees in favorite food-gathering areas. Combs said that this was done to reduce the threat of wildfires spreading into the forest canopy. Although the period described was after 1900, she said that the practice had been passed down through generations. If this actually happened, such burning probably was not widespread. It does not seem logical that large areas would have been treated with fire in this manner, given the tedious nature of such a project.

Some persons seemed to portray the Salish and Kootenais as having been "wise ecologists" when they set fires. This may have been true to some extent. However, journals indicate Indians also caused careless, destructive fires (Phillips 1940, Johnson 1969, Malouf 1969). Some of these informants may have had inaccurate perceptions of Indian fire practices, possibly because of modern biases. Although vigorous stands may have resulted from frequent man-caused and lightning fires, it does not seem likely that Indians set fires just to benefit the forest. I did not find any journals that corroborated informants' statements about burning for forest protection.

Improvement of Horse-Grazing. Six informants said Indians set fires to improve forage for horses. The mountain tribes first acquired horses around 1730 (Roe 1955) and the tribes kept large herds after that time (Mullan 1861, Phillips 1940, DeVoto 1953). For example, Dan Longpre said that as many as 100 horses accompanied only a few Indians when they passed through the Ninemile Valley in the 1800s. He said improvement of grazing was one of the major reasons Indians set fires in the valley. Similarly, Salish informant Larry Parker (Ronan) indicated Flatheads not only burned to "sweeten up the grasses" for horses, but also to facilitate the animals' grazing. He said old, dense grasses make it harder for horses to reach nutritious, young shoots. Parker said Indians knew that fire recycled the old plant growth and stimulated the sprouting of new shoots.

The following passage was written by Lieutenant John Mullan in March 1860 near present-day Missoula. Mullan and his company of soldiers were constructing a wagon road from Fort Benton on the Missouri River to Fort Walla Walla, Washington. He did not directly state that Indians burned grasslands to improve pasturage, but this may have been their motive:

> [Winter] has proved most disastrous to our animals, which, being thin and reduced when winter set in, were not in a condition to reach the Bitter Root Valley in safety through the snow and cold, when grass and browsing were covered up.
>
> The grass had all been burnt by the Indians along the Bitter Root river when we reached the Bitter Root crossing, and to reach the main Bitter Root Valley, with the range of the thermometer forty-two degrees and snow two feet deep, was a physical impossibility (Mullan 1861:37).

Mullan was ordered by superiors to meticulously record daily observations from his intensive regional explorations during the 1850s. I found five references in his journals regarding Indians' burning of valley grasslands. He repeatedly described the "luxuriant" grass growth that was found in many valleys, and he often referred to the large numbers of horses usually kept by Indians. In each case Mullan was very casual in his statements about burning, as if it were so common as to be unremarkable.

Improvement of Hunting. Twelve informants said Indians used fire in various ways to improve or aid hunting. First, five persons said the Salish and Kootenais set fires to stimulate the growth of big-game browse plants. In previous pages, I noted that 13 informants said dense underbrush was burned for forest protection. They did not know if the purpose of underburning was to improve game browse, but this actually may have been one of the real motives.

Lawrence Humble said that the Flatheads set fires during the 1880s near the West Fork of the Bitterroot River. His father was a homesteader in the area and told him that burning regularly occurred after the fall hunt of the mule deer which migrated westward over the Bitterroot Divide. Wildlife Biologist George Gruell (USDA Forest Service, Northern Forest Fire Laboratory, Missoula) believes that there is some reason to question the accuracy of part of this statement. He said that mule deer probably would not have migrated until after a heavy snowfall; thus it may not have been possible to burn after that time. Still, two informants and a journal (Jacquette 1888) indicated burning occurred sometime in the fall in that river drainage.

In his Bitterroot Forest Reserve report, Lieberg (1899) speculated about Indian-caused fires:

> It is a well known fact that deer and elk exhibit a special liking for tracts freshly burned, due to profuse growth of various kinds of weeds springing up there, which constitute a favorite browse for them. Large tracts of forest doubtless were burned [by the Indians] with the intent of thus causing the

> game to congregate in considerable numbers in some particular localities (Lieberg 1899:387).

Fires a~~lso were used for the~~ ancient hunting technique known as the "fire-~~surround.~~" Schaeffer (1940) described the Upper Kootenais' use of this method, based upon information he derived from informants:

> The fire surround was held in some level region where deer were known to be abundant. The drive leader called the men of the camp together and asked them to prepare a quantity of pine-wood torches. The following morning the hunters assembled, and lighted torches were given out to a number of them. Carrying these, they then began to move out, in two directions, to form a large circle, setting fire to the brush and trees along the way. Others with bows and arrows were stationed at intervals around the fire circle, to shoot any animals that might try to escape through the flames. At the starting point a small area was left unfired. As the deer fled around the inside of the fire ring, they arrived at this opening where other bowmen were waiting to shoot them. White tail and mule deer, as well as bears, were secured in the surround. Elk, ranging at higher altitudes during these months, were never taken in this way (Schaeffer 1940:13).

Informant Irwin Puphal told me that Kootenai Indians also used fire for a similar hunting technique. Puphal said two Thompson River homesteaders told him that in the 1880s the Kootenais set fires in meadows to "drive" deer. One end of a meadow was set on fire to flush deer toward bowmen waiting at the other end. This method was similar to the surround except that fire was not used to encircle the animals. The settlers also told Puphal that these fires had the dual purpose of driving game and maintaining open ponderosa pine stands for easier traveling and hunting.

The following excerpt from P. M. Engle's journal entry of July 31, 1860, described an Indian's use of fire to influence wildlife movements. Engle was an Army Topographical Engineer assigned by Lt. John

Mullan to explore the area near present-day Lookout Pass, northwest of Missoula:

> Mr. Shohon, myself and one Indian guide ascended today the mountain, but before reaching the summit we were convinced that we would have no distant view, and therefore retraced our steps. At one p.m. the smoke of the burning timber [from a nearby wildfire] enveloped the whole country, and our Indian guide assured us that we would have no view until after a heavy rain. In returning, the Indian set fire to the woods himself, and informed us that he did it with the view to destroy a certain kind of long moss which is a parasite to the pine trees in this region, and which the deer feed on in the winter season[3]. By burning this moss the deer are obliged to descend into the valleys for food, and thus [the Indians] have a chance to kill them (Mullan 1861:151-152).

Enhancement of Valuable Plant Species. During the Late Hunter Period (ca. 2,000 years B.P. to 1900) the Salish and Kootenais used wild plants for as much as 50 percent of their diets (Malouf 1974). Plants and plant products also were used for ~~medicine,~~ tanning hides, smoking, dyes, insect repellent, and other purposes (Hart 1974). My results and those of other studies (Stewart 1954, Lewis 1977) indicate that many tribes in North America knew that burning could favor, increase the growth of, and perpetuate certain plants.

Six informants said the Salish and Kootenais deliberately burned forest understories to encourage the growth of food plants. Berry-producing species were cited as the food plants most often enhanced by fire, but other seral species probably were included in this objective. However, no other specific food plants were named by informants.

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[3] Members of genus *Alectoria* are not mosses and parasites, but are epiphytic lichens.

One informant said fire was used to protect certain plant species that were valued by shamen ("medicine men"). Pete Stasso said family bands often set small ground fires to protect areas where medicine plants were collected. He said this usually was done near campsites and that these fires were doubly useful because they also helped keep the areas clear of brush. Stasso was told by his father, who was a shaman, that fires were set to clear an area of unwanted vegetation and to favor certain plants. Stasso identified one medicine plant, known in the Kootenai dialect as /áyut/, that was protected in this way. This plant has been identified by Hart (1974) as lovage or licorice-root (*Ligusticum verticillatum*). Indians smoked this plant to relieve sore throats, mashed it and rubbed it on sore wounds, or made it into a tea and drank it for "heart ailments" (Hart 1974).

Campsite-Clearing. Six informants said Indians set small ground fires in and around campsite locations to clear tall grasses, weeds, and brush. This was the only time during my interviewing that informants said burning was conducted in a quasi-systematic manner.

When Adelaide Matt was a young girl, her grandmother and aunt told her it was the responsibility of the Flathead women to clear areas with fire before camps were set up. This was done whenever sites became overgrown. Matt said several small strip-fires were set simultaneously to burn out high grasses and shrubs. There may have been several reasons for this type of burning. First, clearing an area with fire meant increased visibility. This probably was important because enemies often attacked camps or stole horses by crawling through dense thickets (Mullan 1855). Second, Matt said sites were cleared of potential fuels and were thus protected from natural fires and enemy-caused fires. Third, strip-burning created a potential supply of small firewood for camps (Lewis 1977). Finally, burning apparently was important for eliminating undesirable plants and insects near campsites (Lewis 1977). Salish informant Larry Parker reiterated most of the above reasons for strip-burning and said that Kootenai Indians told him of this technique.

Four of these six informants said Indians also burned upon leaving campsites. Dan Longpre said one of the reasons Flatheads set fires when they were leaving the Ninemile Valley was to "clean up" around campsites. Fires consumed any refuse that was discarded in the area and stimulated the growth of new grasses for the next season. In contrast to controlled precampsite burns, these fires apparently were not set in any systematic way, and they were not lit for camp-clearing alone. Informants said that this and other previously described objectives were accomplished at the same time during these general understory burns. Thus, probably only this latter type of burning affected forest ecosystems to any degree.

Agricultural Land-Clearing. Two informants said Indians set fires to clear land for agriculture. However, agriculture was not practiced by western Montana tribes to any considerable extent, although some crops were raised toward the end of the 1800s. Both people said field-burning was common into the 1900s and that this type of burning possibly resulted because of European settlement. Settlers began to arrive in the territory about 1860 and began to raise crops intensively. Missionaries instructed the Indians in agriculture, and field-burning might have begun after that time.

The following passage was written in 1882, and it describes an Upper Kootenai family's use of fire for agriculture. This burning occurred in the Tobacco Plains Valley of northwest Montana, near Eureka:

> Members of the Tom Michelle, Pete Pierre, and Ambrose Gravelle families often told of setting fire to the thick willow bottoms along (Indian) creek in order to clear land for raising hay for their ponies, or tobacco and corn for themselves (Shea 1977:99).

Trail-Clearing. Salish informant Charles McDonald's (St. Ignatius) aunt told him that whenever a section of a trail became heavily overgrown with brush, Indians set the area on fire.

After the U.S. Geological Survey reconnaissance of the Lewis and Clark Forest Reserve (presently Flathead National Forest) north of Missoula, Ayres (1899) speculated:

> There is no doubt that some of the fires, especially on the higher ranges, are due to lightning, but most of those in the valley seem to have been set by Indians and other hunting parties or by prospectors. The trails most frequented by Indians, such as the Jocko and Pend d'Oreille, are noticeably burned especially about the camping places (Ayres 1899:257).

Lieberg (1899) did a considerable amount of speculating about Indian fires after his similar reconnaissance of the Bitterroot Forest Reserve:

> Most of the fires that can be traced to the period of Indian occupancy appear to have originated along the lines of trails [crossing the Bitterroot Mountains].
>
> The probability is that many fires spread from their camps and others were set purposely to destroy the forest and encourage grass growth. This latter seems to have been the case in the alpine fir type of forest along their trails, where now occur so many of the bald or grassy mountain slopes (Lieberg 1899:387).

Communication Fires. Indians often set fires for communication. Salish informant Eneas Pierre (Arlee) said one of the reasons fires were set on ridgetops was to signal that a battle was going to take place and to call the young men to fight.

The journals of trapper W. A. Ferris (Phillips 1940) provided more insight into this use of fire. In the following passage, Ferris described an incident which occurred in August 1833 near present-day Hamilton, Montana:

> On the 13th, we continued down this [Bitterroot] river, till evening and halted on it. The [Flathead] Indians with us, announced our arrival in this country by firing the prairies. The flames ran over the neighboring hills with great violence, sweeping all before them, above the surface of the ground except the rocks, and filling the air with clouds of smoke (Phillips 1940:215).

Ferris described a similar event which occurred in August 1832 near Bannock Pass in southwestern Montana:

> From the summit of Cota's Defile we saw a dense cloud of smoke rising from the plains to the southeastward, which we supposed to have been raised by the Flatheads, who accompanied Fontanelle to Cache Valley, and who were now in quest of the village to which they belong. The Indians with us answered the signal by firing a quantity of fallen pines on the summit of a high mountain (Phillips 1940:103).

On August 31, 1805, members of the Lewis and Clark Expedition saw large communication fires set by Salish Indians near the Lemhi River in Idaho:

> This day warm and Sultry, Prairies or open Valies on fire in Several Places. The countrey is set on fire for the purpose of collecting the different bands [of Pend d'Oreille], and a Band of Flat Heads to go to the Missouri where they intend passing the winter near the Buffalow (Thwaites 1969:49).

Apparently communication fires usually were built rather large so that they could be seen for long distances. Communication fires in this region were not small campfires with sophisticated blanket-signalling, and they seem to have had a great potential for affecting forest ecosystems.

Rituals/Entertainment. None of my informants recalled fires that were set for rituals or entertainment. However, Captain William Clark of the Lewis and Clark Expedition wrote the following in June 1806 while camped near Lolo Pass, southwest of present-day Missoula:

> Last evening the [Flathead] indians entertained us with seting the fir trees on fire. they have a great number of dry lims near their bodies which when Set on fire create a very suddon and emmence blaize from bottom to top of those tall trees.[4] they are a bountifull object in this situation at night. this exhibition reminded me of a display of fireworks. the nativs told us that their object in Seting those trees on fire was to bring fair weather for our journey (DeVoto 1953:83).

The event witnessed by Clark can be characterized as being more of a careless use of fire rather than a ritualistic use. Ritualistic use of fire apparently was not common in these cultures.

Unintentional Fires. I did not find any informants who could verify unintentional fires. However, W. A. Ferris' journals indicated that accidental fires often occurred across the landscape. In 1832, Ferris saw the following incident near present-day Deer Lodge, Montana:

> A careless [Flathead] boy scattered a few sparks in the prairies, which, the grass almost instantly igniting,

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[4]DeVoto (1953) noted that these trees were "clearly the highly inflammable alpine fir, *Abies lasiocarpa*."

> was soon wrapped in a mantle of flame. A light breeze from the south carried it with great rapidity down the valley, sweeping everything before it, and filling the air with black clouds of smoke. . . .[The fire] however occasioned us no inconsiderable degree of uneasiness as we were now on the borders of the Blackfoot country, and had frequently seen traces of small [war] parties, who it was reasonably inferred might be collected by the smoke, which is their accustomed rallying signal, in sufficient force to attack us. . . . Clouds of smoke were observed on the following day curling up from the summit of a mountain jutting into the east side of the valley, probably raised by the Blackfeet to gather their scattered bands, though the truth was never more clearly ascertained (Phillips 1940: 106-107).

Lieberg (1899) wrote the following:

> An educated Nez Perce, with whom I conversed regarding the matter stated that forest fires were never started through design, but might have accidentally spread from signal fires kindled by different bands or individuals while on the hunt, that they might know the whereabouts of one another (Lieberg 1988:387).

This statement by Lieberg's informants is partly inaccurate. Logically, accidental fires probably were quite common during the centuries of Indian occupancy. However, corroboration of my findings between informants and journals, and the results of a number of other studies of Indian burning in western North America (Schaeffer 1940, Stewart 1954 and 1955, Reynolds 1959, Stewart 1963, Loscheider 1975, Lewis 1973 and 1977) indicates that a very large proportion of Indian-caused fires were purposeful.

Seasons of Fire-Use

Informants who verified Indian fire practices were asked during what season purposeful fires were set (Table 4). Thirty-two percent said fires were set in the fall. Twenty percent said Indians burned in the spring. Sixteen percent said fires were set whenever necessary.

Annual burning in a given stand probably would have eliminated most shrubs in a few years and thus would have been detrimental to wildlife browse. Further, big game cover would have been depleted by such frequent burning. Since improvement of hunting apparently was a major reason for burning, it appears unlikely that Indians burned stands annually. If annual burning in stands had been a tradition, then interviews and journals probably would have revealed supporting evidence. However, no such evidence was found.

Seventeen percent of the informants indicated that Indians set fires whenever they thought it was necessary, without any particular regularity. This probably was more characteristic of the way Indians burned, considering their nomadic ways of life, their low population densities, and the large territory they traveled. Single-stand management would not seem to have been necessary given these facts.

Methods of Application

Three informants described how Indians carried out burning. All three situations cited were localized, campsite-area ignitions. I did not obtain any information on techniques for broadcast burns and this seems to be more supporting evidence that such burning was not done methodically.

Adelaide Matt and Larry Parker concurred on techniques used in the precampsite burning. They said small strip-fires were lit simultaneously to kill tall grasses and thick brush and that strip-burning was done to insure small, manageable fires. Matt and Parker said that these fires were controlled and extinguished with green brush or wet buckskin. Matt also said that dense willows or other brush patches could be permanently eliminated by burning out the root systems. This was done by placing a bundle of burning sticks into the center of brush patches to penetrate and burn deeply into the center. Pete Stasso said similar strip-burning techniques were used by his father's and other other family bands to protect the valuable medicine plants around campsite areas.

Interpretations

Caution must be used when interpreting fire history from the writings of early travelers and even scientists. Generalizations, inaccurate statements, and speculation can appear in the literature. For example, Lieberg (1899) devoted a considerable portion of his Bitterroot Reserve report to the supposed causes and effects of fires in the region. Apparently he had a strong anti-fire bias, especially where man-caused fires were concerned. First, throughout his description, he precisely listed many thousands of acres allegedly destroyed by fire, without mentioning his method of calculation. Second, the causes of fires always were attributed to man, either Indians or whites, and these fires usually were characterized as destructive and without purpose. He apparently did not recognize that lightning had caused many fires in the region (Habeck 1972). Lieberg perhaps reflected the sentiments of a growing number of whites of that period when he reported that "the after effects of fires in this region are various, but are always evil, without a single redeeming feature" (Lieberg 1899:388). It can be seen that corroboration is very important in any interpretation of history.

It is difficult to determine the duration of Indian fire practices. Informant data went back only as far as the 1880s. Conclusions about the duration of fire-use before that time must be derived from journals, information from other research, and through induction. The Salish and Kootenai Indians had no system of recording extended time periods, thus Indian informants could not give many details about the presettlement period (pre-1860s). When asked about the duration of fire practices, linguist Larry Parker said Indians only abstracted time on a "long-time-ago" basis. He said that, when an Indian described something as occurring a long time ago, it could refer to a centuries-old occurrence or merely something that happened decades ago. The results of my interviewing support this concept; Indian informants could not give any idea about duration of fire-use. Most simply said that these and other cultural practices were handed down through generations.

The total time frame of Indian burning that was established from interview data spans, at most, 40 years. The earliest possible recollections described the occurrence of Indian fires in the 1880s. Two informants said fire-use continued until the 1920s. However, the frequency of Indian burning probably declined substantially after around 1860 with the subsequent decline in traditional tribal economies.

Before the period of intensive settlement in western Montana, the journals of a few pioneers provided some idea of the duration of Indian fire practices. In fact, written records provided the only positive means of showing that fire-use existed before the period covered by informants. These sources verified that fire practices existed at the time of the first whites in the region (the Lewis and Clark Expedition of 1805).

There is only fragmentary evidence to suggest that Indian fire practices existed before 1805. Before my 1980 field research, the findings of Arno (1976), Mehringer et al. (1977), and Choquette and Holstine (1980) provided the only basis for speculation about fire-use in prehistoric western Montana. Arno concluded that Indians could have contributed to the previously described high fire frequencies that occurred from the 1500s to the late 1800s in several ponderosa pine/ Douglas-fir stands that border the Bitterroot Valley. The only implicating evidence of aboriginal burning before 1500 comes from the Mehringer bog study. The authors concluded, from a 12,000-year pollen core sample, that Indian fires could have contributed to the marked increase in airborne charcoal deposits that occurred during the past 2,000 years. At the Libby Re-regulation Dam site in northwestern Montana, Paleoecologist Wayne Choquette did not find a similar pattern of charcoal lenses in soil profiles dating back 8,500 years (personal communication). However, artifacts from the same excavations on the Kootenai River floodplain showed evidence of human habitation immediatel following large, relatively infrequent fires in the period from about 8,500-5,500 B.P. The evidence did not indicate human occupation coinciding with frequent small fires.

In the period from about 10,000-6,000 B.P., aboriginal cultures in the Inland Northwest depended almost entirely upon hunting of large mammals for subsistence (Sauer 1944, Martin and Wright 1967). The predominant vegetation of the period apparently shifted from subalpine coniferous forest (between 11,500-7,000 years B.P.) toward a cool, lowland pine/grass association (7,000-4,000 years B.P.) (Mehringer et al. 1977). From 6,000 years B.P. until the late 1800s, aboriginal economies greatly diversified to hunting and gathering with the concurrent vegetation change to essentially modern types (personal communication with Wayne Choquette, Paleoecologist, Bonneville Power Administration, Cheney, Washington). This change apparently was interrupted by a minor spruce/fir association which occurred between 3,700-3,500 years B.P. (Mehringer et al. 1977).

Paleoecologist Wayne Choquette felt there was little reason to doubt that purposeful fires were set throughout the 10,000-year period. In the earlier, largely hunting period, burning may have occurred for such purposes as game drives or for influencing wildlife migration patterns. Burning also may have occurred for wildlife habitat improvement, although this may not have been important or desirable in the earlier period of subalpine coniferous forest domination. Fire-use could have become even more widespread during the later period of hunting and gathering because diversified economies presumably would have had more potential to benefit from fire. Also, Mehringer et al.'s (1977) anomolous findings may well be explained by Indian-caused fires, as the researchers have speculated. Lightning fires may not have occurred frequently enough during the mesic period to produce widespread subsistence benefits. It seems to be a reasonable assumption that accidental fires also occurred in the region from the time humans first arrived, perhaps as much as 10,000 years ago (Choquette and Holstine 1980).

The acquisition of horses about 1730 was a major event that changed many facets of mountain tribal cultures (Roe 1955) and increased and more widespread use of fire may have been one element of change after that time. My data indicate that burning to improve horse-grazing was an important reason for fire-use (Table 3). Large numbers of horses could have impacted forage resources in frequently used areas and burning was a way to renew or prolong an area's grazing capabilities. Also, acquisition of horses meant that tribal migrations could be expanded tremendously; therefore, Indian-caused fires may have become more geographically widespread. Finally, the Indians may have considered it undesirable to set many fires before 1730 because of the tribes' dependence upon foot travel. Fire had potential to render an area uninhabitable and this would force the necessity of moving to another area.

Cooper (1853) took part in early northwest explorations for the Stevens Survey, the goal of which was to find a feasible railroad route from the Mississippi River to the Pacific Ocean. After examining the area around the Blue Mountains of northeastern Oregon, he remarked:

> The Indians [tribe unidentified], in order to preserve their open grounds for game, and for the production of their important root, the camas, soon found the advantage of burning . . . . The introduction of the horse about the beginning of the 1880s in this area was a further inducement for burning, and doubtless also caused an increased settlement in the prairies by these people, hitherto accustomed to travel mostly by water, and to depend upon fishing for their subsistence (Cooper 1853:23).

Indian-caused fires evidently were common in the forests and grasslands of western Montana. However, burning apparently was not a highly significant cultural element of the Salish and Kootenai tribes, in the sense of being long-established in tradition or ceremony. Many techniques were used by Indians in their subsistence quest, and fire-use probably was just another tool. Fires evidently were unremarkable in the early days, especially to Indians (personal communication with C. Malouf, Anthropologist, University of Montana, Missoula); therefore, some details of burning may have been lost with time. This probably accounts for the relatively large percentage of informants who had never heard of fire practices occurring (47%). Also, the unremarkability of fires to Indians probably explains why more white than Indian informants were able to verify fire-use. Modern white cultures seem to fear wildfires and, presumably, white informants would be more likely to recall Indian-caused fires.

Loscheider (1975) agreed that burning was not a ceremonial element in her discussion of Indians' portrayal of tribal lifeways in pictographs and petroglyphs. Early rock art often displays scenes of important cultural elements such as the hunt, warfare, and rituals. Evidence of fire practices in Montana has not been found in Indian art. Likewise, mention of burning has not been found in the tribes' passed-down ceremonies or songs.

Evidence indicated that either not all Indians in the region practiced burning, or that burning was done to varying degrees. Most Lower Kootenai informants were adamantly opposed to the idea that burning occurred (Table 2) and they said that these Indians did not believe in manipulating nature. This was the only case in the interviewing where a group of informants denied that fires were ever ignited by Indians. There is some evidence to support their contentions. For example, an informant of Schaeffer (1940) denied that the Lower Kootenais used fire for the surround. He said that while the Upper Band may have used this technique, the Lower Band was engaged in fishing activities at the time of year when burning sometimes occurred (summer). The Lower Kootenais were a riverine-oriented culture (Mullan 1855, Turney-High 1941, Johnson 1969) and this band was unique among the mountain tribes because it subsisted on fish at least as much as game, if not more. However, the Upper Kootenais relied primarily upon the hunt for subsistence and they presumably would have had more reasons to set fires. Also, the Lower Kootenais were one of the few mountain groups which used canoes as a major form of transportation. The horse was much less important to the Lower Kootenais than it was to other Indians such as the Salish (Mullan 1855, Roe 1955) and burning to improve horse-grazing was an important reason for fire-use. Finally, the Upper Kootenais are known to have set some fires for clearing agricultural land (Shea 1977). The Lower Kootenais did not practice agriculture to any extent (Johnson 1969), so they did not need fires for this purpose. Thus, intratribal differences in fire-use may have existed among the Kootenais.

In contrast to the findings of other studies (Reynolds 1959, Lewis 1977), the Salish and Kootenais apparently did not practice burning with any degree of sophistication. This is not to say that these Indians did not possess ecological awareness of fire's effects. However, aside from campsite-clearing or weather considerations, Indian fires probably were set arbitrarily and unsystematically. While informants did not say this, journals (Phillips 1940, Johnson 1969, Malouf 1969) indicated that random ignitions were characteristic. The idea of rigorously planned, methodical burning programs seems inconsistent with traditional Salish and Kootenai lifestyles. The concept of land "management" probably did not exist in the minds of these early people, since cause and effect seem to have characterized their behavior. Apparently there was no necessity for these tribes to manage fires, in view of their nomadic lifestyles. Most informants said that fires simply were set and allowed to burn freely because the Indians usually were passing through or leaving an area and often did not return for extended periods. An occasional destructive fire probably was of small consequence to nomadic tribes, even before the acquisition of horses (the tribes still were somewhat nomadic before 1730 [Teit 1928, Turney-High 1941]). Lewis (1977) found that Cree, Slavey, and other Indians who lived in Alberta's northern boreal forest conducted planned, methodical burning to maintain man-made clearings. In contrast to the nomadic ways of Montana tribes, these tribes' mobility was restricted by the impenetrable "bush." Therefore, it was to their benefit, and much more necessary, to systematically manage the environment.

Controversy exists over whether North American Indians had ecological insight and whether they set fires to aid tribal economies, or whether subsistence benefits derived from their fires simply were incidental results of carelessness (Lewis 1973). Both cases probably were true with the Salish and Kootenais. There is little doubt that these Indians set many fires with specific goals in mind. They also set fires carelessly or by accident. I feel that the roots of confusion and controversy become evident when one examines the way these Indians caused many fires. Aside from campsite-clearing fires, fire surrounds, or other specialized circumstances, many fires apparently spread from unextinguished campfires (Lieberg 1899, Ayres 1899). It is easy to see how these fires could be interpreted as having been the result of just carelessness. However, some camp fires probably were not put out for a reason. Many anthropological studies, and journals (Mullan 1855 and 1861, Phillips 1940, Schaeffer 1940, Stewart 1954, Malouf 1969, Lewis 1973, Malouf 1974, Lewis 1977) have described Indians' acute ecological awareness which was acquired through centuries of observation and experience. It follows that Indians necessarily knew that certain fires could facilitate subsistence. Logically, these hunter-gatherers would not simply have waited for lightning fires to randomly achieve certain objectives. Lewis (1973) described this concept:

> Arguments vary from seeing the Indian as having been an aboriginal conservationist to viewing him as an indifferent but generally ineffectual incendiary. . . . however, because their subsistence strategies are more directly and immediately linked to environmental imperatives they must soon make accomodations or else become one more evolutionary failure. We do not have to drag forth Rousseauean assumptions that hunter-gatherers do (or in the past did) live in 'primeval harmony' with nature, or that they possess mystic insights about the workings of natural phenomena. The argument simply assumes that men must sooner or later, with varying degrees of effectiveness, adjust to their surroundings. The various strategies of hunting and gathering--whether adapted to dry deserts, the subartic, or tropical forests--require that it be sooner rather than later (Lewis 1973:6).

CHAPTER IV

ANALYZING FIRE OCCURRENCE BY TIME PERIODS

Methods

Sample-Stand Selection

Reconnaissance sampling was conducted in 20 old-growth ponderosa pine/Douglas-fir stands to characterize pre- and post-settlement fire history. A paired-stand approach was used in which ten pairs of stands were located subjectively in two types of locations. The stands were paired on the basis of similar vegetation, habitat type, aspect, elevation, and size (Appendix C). The first stand in each pair was located in a zone of past Salish and Kootenai habitation (hereafter, "heavy-use" stands) and the second stand was located in the general vicinity, but in an area remote from concentrated Indian use ("remote stands"). This approach was used to determine if past fire history was similar in stands in the two types of areas.

Indian heavy-use zones comprised a large part of the study area (Fig. 4). These zones were easily identified through journals and through archaeological maps obtained from the University of Montana Anthropology Department. Remote zones were identified more subjectively by visually examining areas likely to be unattractive to human use. Also, archaeologic maps displayed all known Indian occupation zones in the region, so it seemed possible to predict the pattern of remote zones. As examples, heavy-use stands usually were located in forests

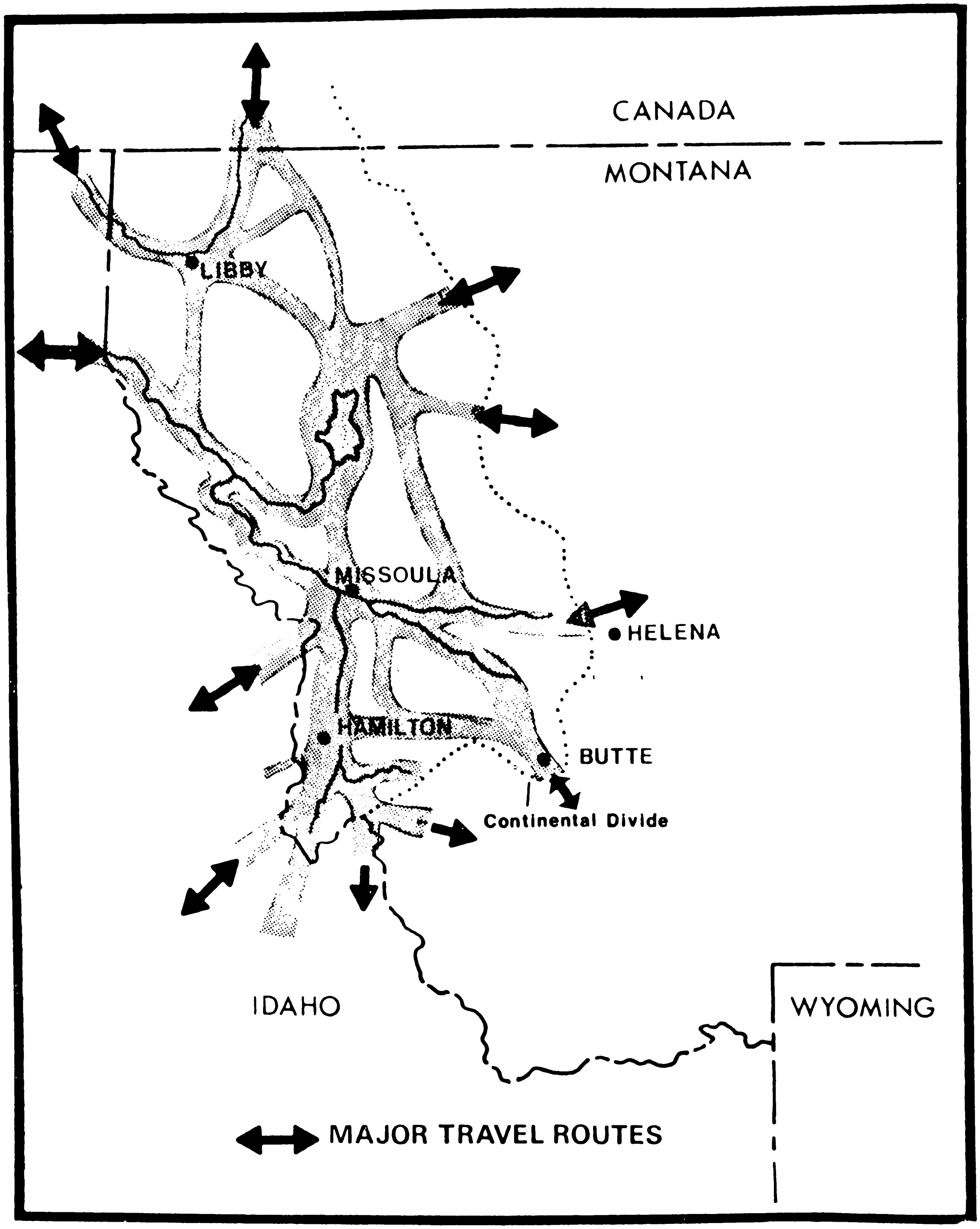


Figure 4. General distribution of past Salish and Kootenai habitation zones in western Montana.

bordering intermountain valleys, and remote stands usually were located in small, secondary canyons stemming from valley tributary canyons. Stand size usually ranged from about 200 to 600 acres (80 to 240 ha).

Fire-Scar Sampling

I used a variation of the method described by Arno and Sneck (1977). I subjectively searched for fire-scarred trees, rather than sampling by transect which is more appropriate in large study areas such as entire stream drainages. Subjective searching in small stands allows for optimum detection of trees with the most complete fire-scar records, which allow accurate characterization of stand fire history. This method also results in a minimum of destructive sampling.

In all 20 sample stands, usually from five to seven of the oldest trees with the largest number of basal fire scars were partially cross sectioned with a chain saw. Arno and Sneck (1977) indicated that this sample number usually is sufficient to document most fires of appreciable size, provided sample trees are well distributed in the stand. In a few cases, fire-scarred stumps were sectioned if the logging date was determinable.

Laboratory Analysis

I air-dried the fire-scarred cross sections in laboratory for one week, and prepared each sample for microscope examination by disk-sanding with progressively finer grades of sandpaper. I determined fire-scar years by using a 7X to 25X binocular microscope to aid the tree-ring count from the known cambium year (year of sampling or logging) to each fire scar. I did not "cross date" the ring counts, as is done in Southwestern dendrochronology studies (Stokes and Smiley 1968, Fritts 1976, Stokes 1980). However, two counts usually were made on each partial cross section and I counted the opposite side of complete cross sections whenever they were obtained. If several stand samples had ring counts that were within two or three years of each other, these scars usually were considered to indicate the same fire year. These variable ring counts were adjusted to the sample with the clearest and most complacent (Fritts 1976) rings, and the count from this sample was used to indicate the fire year. In a few cases, I interpreted scars which were only one or two years apart to indicate different fire years. This was done only if the ring counts from several clear or complacent samples indicated separate years.

After determining fire years for an entire stand, I constructed a Master Fire Chronology (Arno and Sneck 1977). A Master Fire Chronology was considered to begin when at least two samples from a given stand had started to record a stand's fires. I calculated mean fire intervals (MFIs) by dividing the number of fire intervals into the number of years during the period in question.

MFI Time-Period Comparisons

I used three historically significant periods to compare MFIs between each pair of heavy-use and remote stands: (1) the Presettlement Period (pre-1860s), (2) the Settlement Period (1861-1910), and (3) the Fire Suppression Period (1911-1980). The beginning date of the first period was defined as the latest beginning date among a pair of stands' chronologies (this was done so that fire history could be assessed for the same periods of time). For example, if stand A's chronology began in 1500 and stand B's began in 1600, then 1600-1860 is the mutual comparison period. For each pair of stands during each time period, I formulated the hypothesis that there was no difference in past fire occurrence and tested MFI differences for significance ($\alpha = .05$), using the weighted t-test for unpaired plots (Snedecor and Cochran 1967). I used the same hypothesis and test for a ten-stand comparison of mean differences during the three periods. I did this by compiling the fire intervals from all ten stands in each type of Indian-use zone, calculating two ten-stand MFIs, and testing the differences for significance.

Results and Discussions

The field sampling was conducted from June to September 1980. "Catfaced" sample trees were abundant throughout most of the 20 sample stands (Figs. 5 and 6). The oldest sample trees in most stands were 300 to 400 years old, although some dated back more than 500 years. The oldest tree encountered was about 627 years old (pith date: approximately 1353).

Nine hundred and forty-six fire scars from 120 samples resulted in what apparently were 469 individual fire years. Ponderosa pine was superior to Douglas-fir or western larch as a source of high-quality scar samples--95 of 120 cross sections were cut from this species (Fig. 7). The two latter species generally were poorer sample species because they are more susceptible to heart-rot and boring insects than is ponderosa pine. These factors can make it difficult to identify and date fire scars in the laboratory.

Figure 5. Sample stand distribution.[1] The majority of stands are clustered around the Bitterroot and Missoula Valleys, a past major habitation zone of the Salish for several thousand years.

1. Fairview
2. Doak Creek
3. Fivemile Creek
4. Rainy Creek
5. Hog Heaven
6. North Bassoo Creek
7. Hay Creek
8. Thompson Creek
9. Sixmile Creek
10. Rock Creek
11. McCalla Creek
12. Cutoff Gulch
13. Goat Mountain
14. Sleeping Child Creek
15. Hughes Creek
16. Hog Trough Creek
17. McCartney Creek
18. Two Bear Creek
19. Indian Trees
20. Railroad Creek

[1]See Appendix C for specific locations and other stand information.

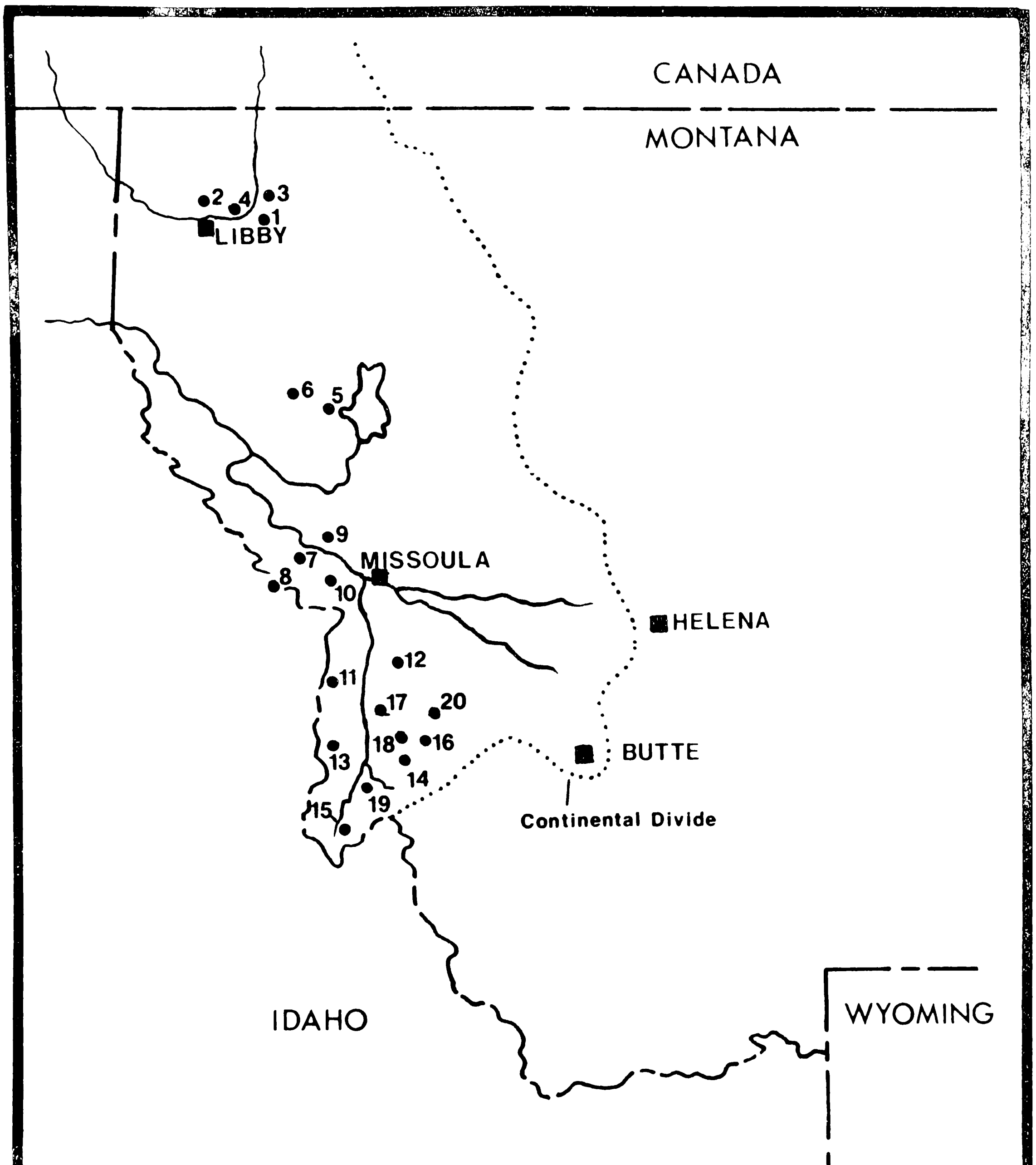

CANADA
MONTANA
2
4
3
1
LIBBY
6
5
9
7
MISSOULA
8
10
HELENA
12
11
17
20
18
16
13
14
BUTTE
19
15
Continental Divide
IDAHO
WYOMING

Figure 6. The dry-to-moist gradient which is characteristic of the region's ponderosa pine/Douglas-fir forests.

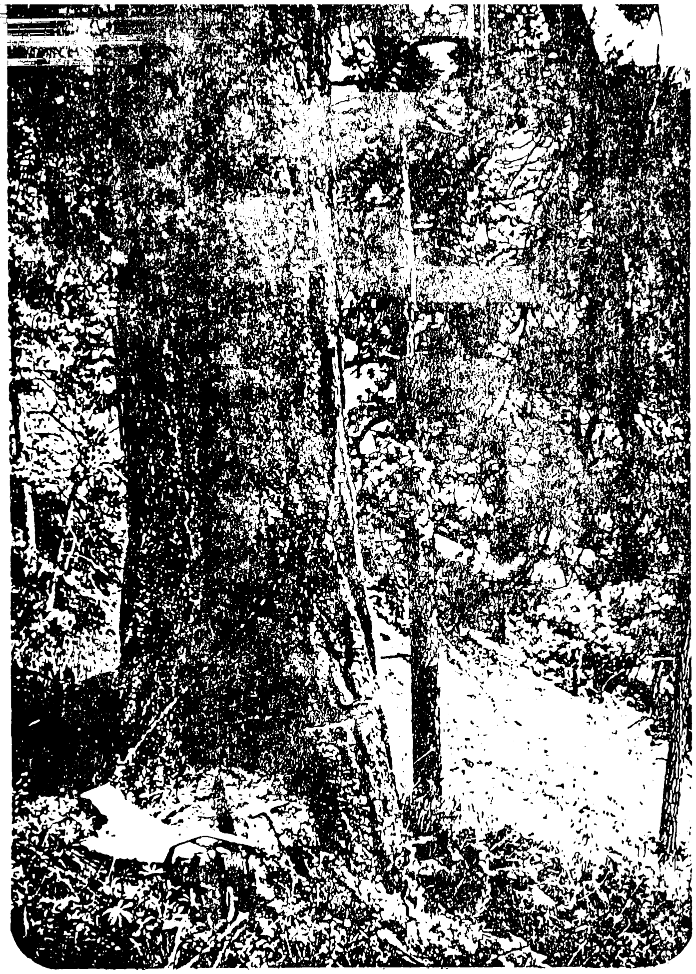
Top: Very dry southwest-facing McCartney Creek stand with light stocking of predominantly ponderosa pine and an open grass/forb understory.

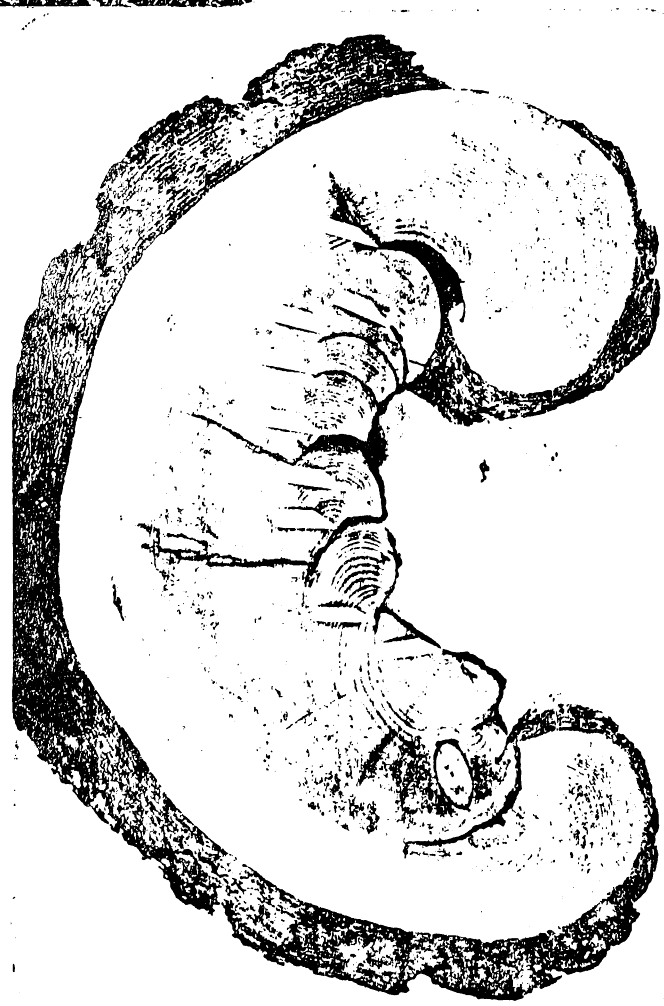
Bottom: Moist Doak Creek stand with heavy stocking of ponderosa pine, Douglas fir, western larch, and a predominantly shrub understory.

Figure 7. The fire-scar sampling process.

Top: Typical "catfaced" ponderosa pine and chain saw cut (stand: McCartney Creek).

Bottom: Close-up of ponderosa pine cross section which revealed 8 fire scars after laboratory preparation. White tags indicate year of pith (1701) and fire-scar years (1715, 1742, 1754, 1767, 1793, 1810, 1828, 1889).





The number of scars per sample cross section ranged from 1 to approximately 26; the average was 8 scars per sample. Sixty-six percent of the samples (79) had fewer than 10 scars, 22 percent (26) had 10 to 14 scars, 10 percent (12) had 15 to 20 scars, and 2 percent (3) ha more than 20 scars.

I examined ages at which sample trees were first scarred by fires. The youngest age appeared to have been 4 years, although this is somewhat questionable because rodent activity or mechanical scarring may have been responsible for the scarring. However, ring-release on cored adjacent trees corresponded to the date of the scar, indicating that a fire probably had occurred. In other stands, definite fire scars at age 10 to 15 years were recorded on a number of trees.

I examined the data to see how often a given fire year was recorded by multiple sample trees in a stand. Sixty percent of the fire years (281) were recorded by only 1 sample tree, 30 percent (139) were recorded by half of the sample trees in a stand, and 2 percent were recorded by all of the sample trees in a stand.

In terms of accurately characterizing fire history in this forest type, the above facts illustrate the importance of subjectively searching out multiple sample trees which: (1) are the oldest, (2) have the most complete scar records, (3) are well distributed, and (4) preferably are ponderosa pine. I often was able to date relatively complete fire-scar sequences back to the mid-1600s, although the earliest non-sequential fire years dated back to the 1400s (1443 was the earliest verifiable fire year). The most common mutual beginning date for comparison of paired-stand chronologies was approximately the year 1700. As an example of non-sequential fire-scar records, a given tree may have recorded a very early fire scar but the tree then succeeded in growing new wood over the wound. This situation can lead to large gaps in a stand's fire year pattern; therefore, only relatively sequential fire-year patterns from several sample trees are counted in MFI calculations.

The Presettlement Period (Pre-1860) Fire History

Lightning or Indians clearly were the major ignition sources in western Montana before about 1860. Mean Fire Intervals (MFIs) for this period were substantially shorter for 9 of 10 heavy-use stands than their remote paired stands (Table 6). Three of the heavy-use stands were located in areas specifically identified by three informants as having been repeatedly burned by Indians. These stands had some of the shortest MFIs of any stands (cf. Sixmile Creek, Fairview, and Hog Heaven). Other studies (Buck 1973, Arno 1976, Dorey 1979, Gruell et al. in press) document similarly short, single-digit MFIs for the same forest types in past Salish and Kootenai heavy-use zones (Table 7). There have not been any regional studies that examined fire history in what can be considered "remote" areas. The one remote stand with a higher incidence of fire than its heavy-use mate might be a function of poor sample-stand selection. This is because hot springs about three miles (2 km) downstream from the remote stand probably were attractive to Salish Indians (cf. Two Bear Creek and McCartney Creek).

In 8 of the 9 heavy-use stands, MFIs were about half as long, or less, as those of remote mates (Fig. 8). After statistical testing,

TABLE 6

MEAN FIRE INTERVALS (MFIs) AND INDIVIDUAL FIRE-YEAR INTERVAL RANGES FOR 20 PAIRED STANDS IN WESTERN MONTANA, ACCORDING TO THREE TIME PERIODS (FIGURES REPRESENT YEARS)

Paired Stands	Approximate Mutual Beginning Date[a]	(x)-1860[b] Heavy-Use MFI	(x)-1860[b] Heavy-Use Range	(x)-1860[b] Remote MFI	(x)-1860[b] Remote Range	1861-1910[c] Heavy-Use MFI	1861-1910[c] Heavy-Use Range	1861-1910[c] Remote MFI	1861-1910[c] Remote Range	1911-1980 Heavy-Use MFI	1911-1980 Heavy-Use Range	1911-1980 Remote MFI	1911-1980 Remote Range
FC/RAC	(1776)	7.6	2-13	39.5	5-59	8.2	3-15	10.0	4-11	35.0	7-35	17.5	9-33+
MC/CG e/	(1697)	8.3	2-19	21.0	6-38	24.5	3-21	12.2	2-16	*(1889)	69+	11.9	2-18+
SC/ROC	(1704)	7.5	3-12	17.0	6-73	6.7	1-9	16.3	10-20	23.3	6-25+	*(1890)	69+
GM/SLC e/	(1737)	6.9	1-11	15.0	3-22	5.6	1-6	24.5	9-30	17.5	5-36+	35.0	17+-51
F/DC	(1797)	6.3	3-11	12.8	4-20	8.2	4-12	10.0	4-21	35.0	7-32+	#(1939)	28-41+
HAC/TC	(1700)	8.6	3-15	15.7	4-62	24.5	2-35	16.3	4-25	23.3	15-33+	*(1901)	69+
HC/HT e/	(1722)	10.5	5-19	19.6	5-43	12.2	4-19	16.3	5-31	23.3	4-26	35.0	4-31+
HH/NB f/	(1710)	7.9	2-32	13.3	5-23	7.0	3-14	16.3	7-16	17.5	7-27+	35.0	4-49+
IT/RC	(1695)	12.2	3-35	18.0	6-36	11.4	6-16	16.3	6-30	35.0	8-36+	#(1918)	7-62+
McC/TB	(1792)	14.0	5-26	10.2	5-26	7.0	3-15	10.0	5-18	23.3	9-48+	*(1896)	69+
Mean (all stands)		9.1	±2	18.2	±8	11.5	±7	14.8	±5	25.9 (9 stands)	±7	26.9 (5 stands)	±11

a/ For the stand with earlier fires, MFI calculated on the basis of nearest fire to date in parentheses.
b/ General date of beginning of white settlement in western Montana; MFI calculated on basis of nearest fire to 1860.
c/ General date of beginning of fire suppression in western Montana.
d/ "+" indicates interval length to 1980; number is either shortest or longest interval in period.
e/ Mean differences for (x)-1860 are significant ($\alpha = .05$).
f/ Mean difference for 1861-1910 is significant ($\alpha = .05$).
* No fires occurred in the period; date in parenthesis indicates last fire year.
\# Only one fire occurred in the period; date in parenthesis indicates fire year.

Sample Stand Key:

FC - Fivemile Cr.	SC - Sixmile Cr.	F - Fairview	HC - Hughes Cr.	IT - Indian Trees
RAC - Rainy Cr.	ROC - Rock Cr.	DC - Doak Cr.	HT - Hog Trough Cr.	RC - Railroad Cr.
MC - McCalla Cr.	GM - Goat Mountain	HAC - Hay Cr.	HH - Hog Heaven	McC - McCartney Cr.
CG - Cutoff Gulch	SLC - Sleeping Child Cr.	TC - Thompson Cr.	NB - North Bassoo Cr.	TB - Two Bear Cr.

TABLE 7

MEAN FIRE INTERVALS (MFIs) AND INDIVIDUAL FIRE-YEAR INTERVAL RANGES FOR 6 SALISH AND KOOTENAI "HEAVY-USE" STANDS FROM OTHER FIRE HISTORY STUDIES ACCORDING TO 3 YEAR TIME PERIODS (FIGURES REPRESENT YEARS).

Study	Heavy-Use Stand	Chronology Beginning Date	(x)-1860		1861-1910		1911-(x)		Chronology Ending Date
			MFI	Range	MFI	Range	MFI	Range	
Buck (1973)	Lubrecht	(1704)	9.8	5-25	#(1863)	50+	7.9	2-23+	(1973)
Arno (1976)	Onehorse Ridge	(1631)	5.2	2-16	5.1	3-8	16.5	2-39+	(1975)
	West Fork	(1695)	7.5	2-25	8.5	3-16	33.0	8+-31	(1975)
	Tolan	(1658)	6.7	2-13	7.1	5-10	*(1908)	66+	(1975)
Dorey (1979)	Tobacco Plains	(1813)	6.7	4-9	4.9	3-10	17.5	7-39+	(1979)
Gruell et. al. (in press)	Lick Cr.	(1640)	6.5	3-15	8.5	4-15	*(1895)	69+	(1980)
	Mean (all stands)		7.1	±2	6.8 (5 stands)	±2	18.7 (3 stands)	±10	

Key:

"+' Indicates interval period length to ending date; number is either shortest or longest interval in period.

* No fires occurred in the period; date in parenthesis indicates last fire year.

\# Only one fire occurred in the period; date in parenthesis indicates fire year.

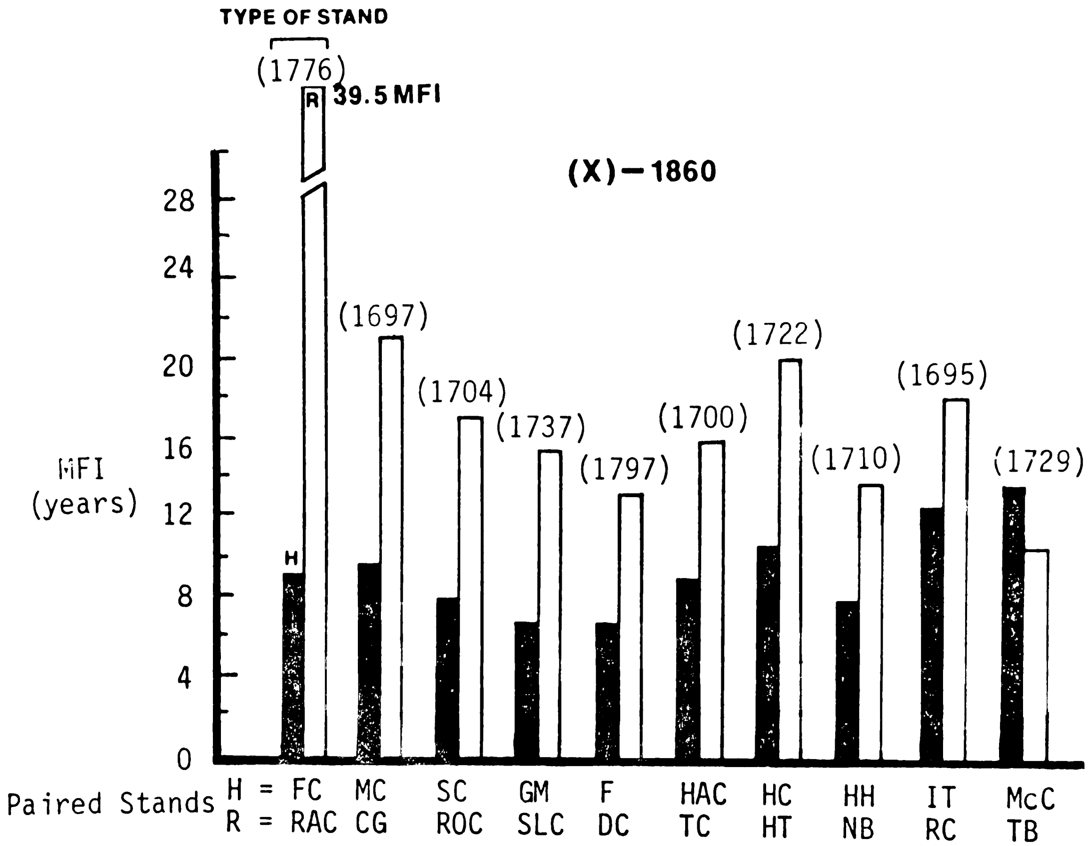


Figure 8. Mean Fire Interval (MFI) comparisons for 20 paired stands[1] during the Presettlement Period. Dates in parentheses indicate mutual beginning dates for paired Master Fire Chronologies.

H = Heavy-Use Stands
R = Remote Stands

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[1]Stands abbreviations key to Table 6.

3 of the heavy-use stands had significantly shorter MFIs before 1860 and mean differences for the remaining 7 pairs were not significant at the .05 level. I then averaged the individual fire intervals from 1797-1860 for all 10 stands in each type of zone, and tested the mean difference for significance (1797 was the earliest chronology date that was common to all stands). The combined MFI for all heavy-use stands was 7.5 years and this was significantly shorter than the MFI of 13.9 years for the remote stands.

Intervals between individual fire years in the heavy-use stands usually ranged from about 5 to 12 years, although 15-to-20-year intervals sometimes occurred. Individual intervals in remote stands were highly variable, with many intervals ranging from about 15 to 20 years in length. However, remote stand intervals of less than 10 years and more than 25 years also often occurred. I interpreted the shortest interval in any of the stands to be 1 year, but such short intervals are difficult to identify if fire-scar samples are not dendrochronologically cross dated. The longest pre-1860 fire intervals in any of the stands usually were less than 35 years although three remote stands had intervals of 59, 62, and 73 years, respectively.

One possible reason heavy-use stands had shorter MFIs than remote stands is that the heavy-use stands often face or border broad valleys; these stands may have been more susceptible to both stand-specific fires and lightning fires which spread in from other locations. Conversely, remote stands in side canyons may have been more likely to record only those fires ignited in the immediate vicinity because these stands often are bordered by fire barriers such as streams and moist vegetation. However, it seems doubtful that such large MFI differences could be entirely attributable to this factor. These results suggest that Indians were the contributing factor in these differential frequencies.

With only a cursory examination of the data, large differences appear to exist between heavy-use and remote stand fire occurrence. However, close examination of individual fire-year intervals (Appendices D and E) and the results of statistical testing, indicate that the overall difference in fire occurrence was not so dramatic. The longer MFIs in remote stands usually were caused by a few long fire intervals which were interspersed with relatively short intervals of variable length. Temporal variability seems characteristic of the chance occurrence of lightning fires. The heavy-use stands consistently lacked long intervals and the stands also lacked much variability in interval length--fairly uniform, often single-digit intervals were characteristic. Uniform fire frequency probably indicates that another ignition source besides lightning was operating, providing further supporting evidence that Indian-caused fires were influential in the heavy-use stands' pre-1860 fire histories.

Logically, the Indians would not have allowed long fire intervals to occur in favorite heavy-use areas. By setting frequent fires, the Indians could assure that successional stages did not develop to the point where subsistence benefits began to decline.

MFIs probably represent a conservative estimate of fire occurrence because some fires presumably either missed sample trees or were not of sufficient intensity to scar the trees. Small accumulations of primarily light fuels probably were characteristic of frequently burned stands, especially in the heavy-use stands which lacked long fire intervals. Therefore, heavy-use stands could have been subjected to even more frequent fire than MFIs indicate, and fire frequency differences between heavy-use and remote stands could be larger than is apparent.

The Settlement Period (1861-1910) Fire History

Informants and journals (Jacquette 1888, Lieberg 1899, Ayres 1899) indicate that Indian fires still occurred in western Montana after 1860. However, burning presumably occurred to a lesser degree because of the impact of settlement upon traditional Indian lifestyles. Apparently prospectors and other whites caused many fires from the late 1800s (Lieberg 1899, Ayres 1899) possibly up until the early 1900s, when fire suppression generally began in the Northwest (Wellner 1970).

Eight of the 10 heavy-use stands had shorter MFIs than the remote stands during this period, but differences are smaller compared with pre-1860 figures (Tables 6 and 7). Three of these 8 heavy-use stands had MFIs that were about half as long as those of remote mates and 1 remote stand had an MFI that was about as long as that of its heavy-use mate (Fig. 9). After statistical testing, 1 heavy-use stand had a significantly shorter MFI than its remote mate and mean differences for the other pairs were not significant at the .05 level. The 10-stand heavy-use MFI of 9.1 years was significantly shorter than the 10-stand remote MFI of 13.7 years. MFIs generally were similar to those of the pre-1860 period, except that 2 heavy-use stands had much

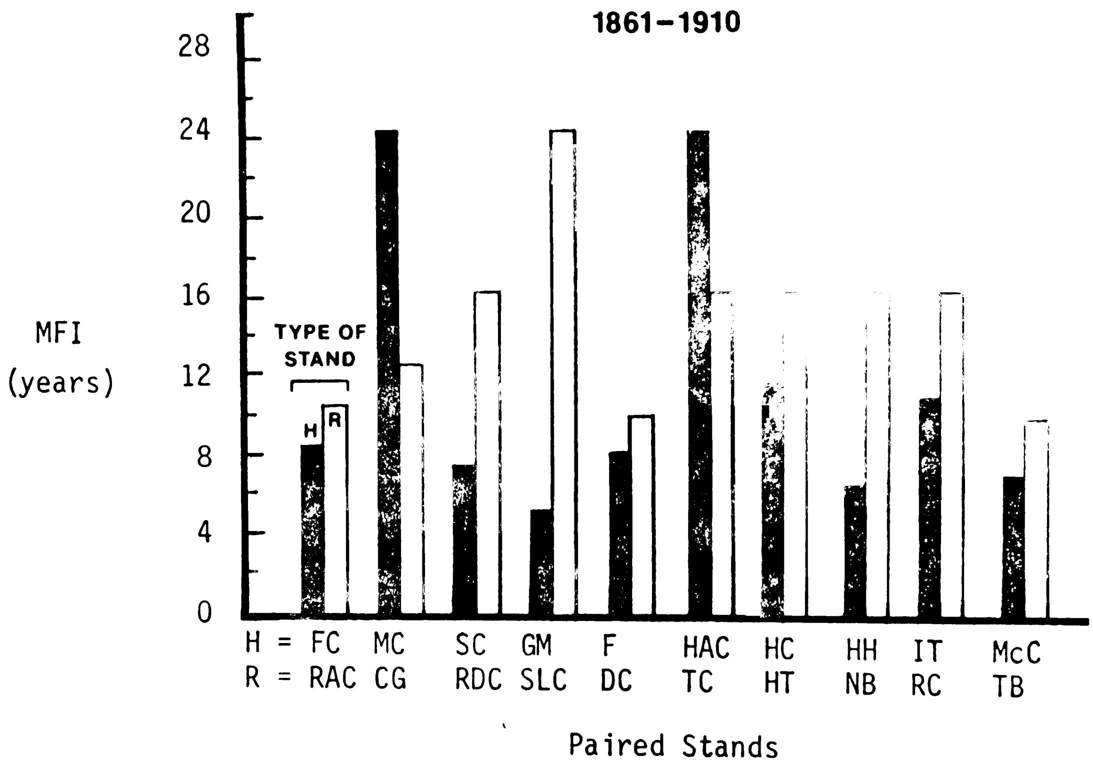


Figure 9. Mean Fire Interval (MFI) comparisons for 20 paired stands during the Settlement Period.

longer MFIs and 2 remote stands had much shorter MFIs than in the previous period.

Individual fire intervals in the heavy-use stands were similar to those of the previous period except that longer intervals (15-20 years) became more common. Individual intervals in remote stands were similar to those of the previous period except that 5-10-year intervals became more common. In 2 cases, I interpreted the shortest interval to be 1 year and the longest intervals usually did not exceed 25 years.

Several explanations are possible for the variability in fire occurrence in the 20 stands. First, the shortness of the 50-year period can be conducive to variable means. Fire intervals of from 1 to 25 years, or longer, commonly occurred in this forest type before fire suppression; long intervals usually were interspersed with many short intervals which, over a longer time span, tend to balance out an MFI. However, the chance occurrence of a majority of either long or short intervals in a 50-year period would give an unrepresentative mean. A second possibility for the variability is that stands bordering open valleys apparently still were subjected to man-caused and unobstructed lightning fires. However, forest fires came into disfavor by settlers during the period (Lieberg 1899); thus, some frequency reduction might be expected in the heavy-use stands. Also, examination of individual fire-year intervals in heavy-use stands shows that the previous relatively uniform pattern of fires did not continue through this period. This might be an indication that repeated burning by Indians had ceased. The apparently slight increase in fire occurrence in remote stands could be due to chance. However, a strong possibility is that may have been set by prospectors, hunters, and other forest travelers in the back-country areas where remote stands are located.

The Fire-Suppression Period (1911-1980) Fire History

The impetus for complete fire exclusion in the Northwest came after numerous severe lightning fires burned throughout much of northern Idaho and western Montana in 1910. Organized suppression efforts began after that time and were quite effective by the 1930s (Arno 1976). Therefore, 1911-1980 marks a logical time period for examining fire-scar data.

The data show a marked decrease in fire occurrence in most stands during this period (Tables 6 and 7, Fig. 10). Twelve of the 20 stands had MFIs of 35 years or more. Four stands did not have a fire during the period and 2 stands had only 1 fire. The MFIs in the 12 stands for this period now equal or exceed the longest *individual* fire-year intervals documented in most stands for the pre-1910 periods. These results are similar to those of other fire history studies done in the region (Arno 1980). However, several of my sample stands still show relatively short MFIs for the period.

In general, heavy-use stands still appeared to burn slightly more often than remote stands during this period, perhaps reflecting modern man-caused fires; shorter MFIs caused by unobstructed lightning fires no longer is a plausible explanation because of efficient fire suppression. Mean differences were not significant at the .05 level for the 3 pairs of stands for which t-testing was possible (7 pairs had only 1 interval, or a partial interval, for the 70 years, thus making it impossible to do

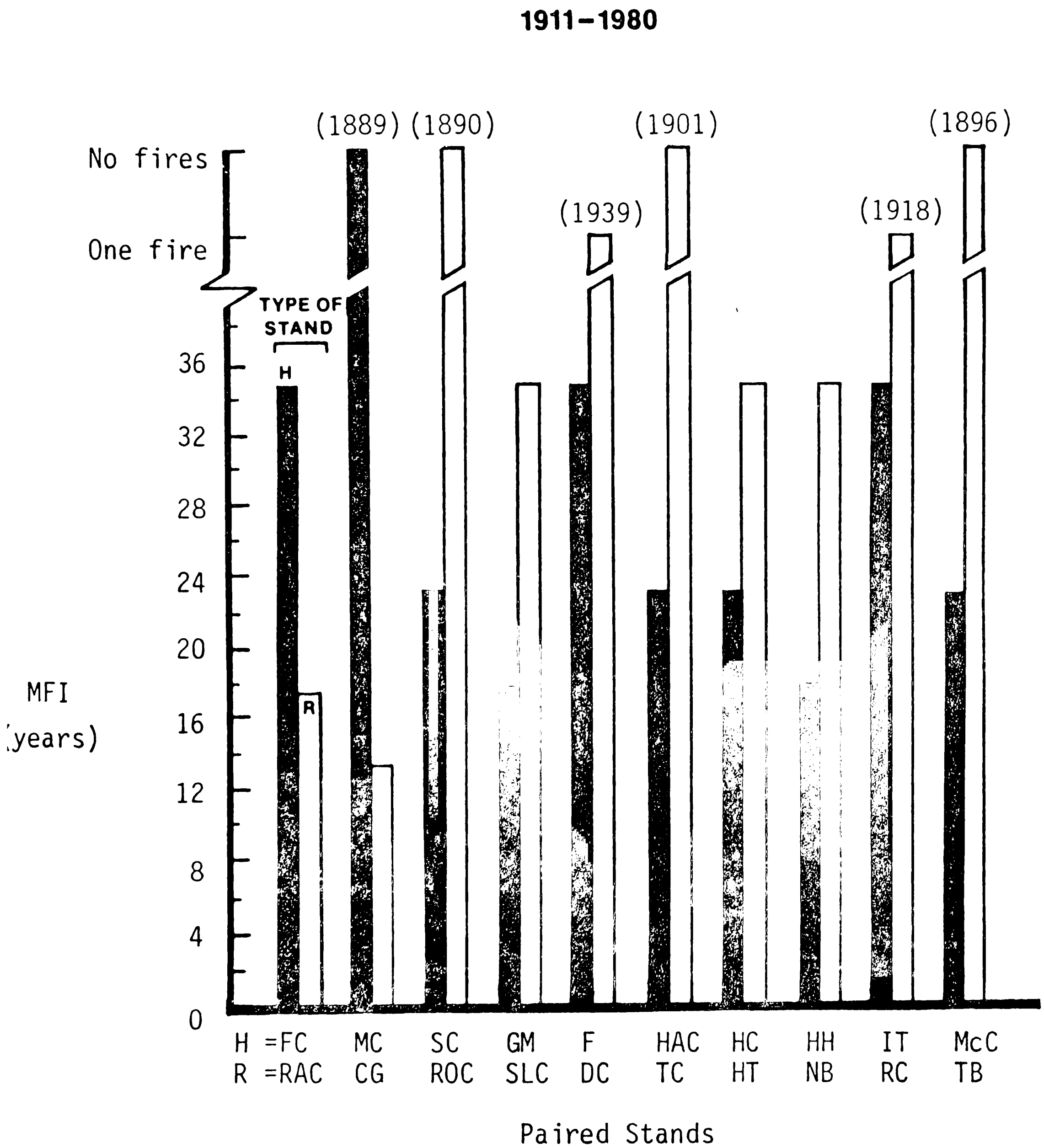


Figure 10. Mean Fire Interval (MFI) comparisons for 20 paired stands during the Fire Suppression Period. Dates in parentheses indicate year of last fire.

a t-test). The 10-stand heavy-use MFI of 25.5 years was not significantly shorter than the 10-stand remote MFI of 34.5 years.

The general reduction in fire frequency is illustrated most dramatically by the McCalla Creek heavy-use stand. Fires occurred on an average of every 8.3 years in this stand from 1697 to 1860, but sample trees did not record a fire during the 91 years from 1889 to 1980.

CHAPTER V

COMPARING FIRE OCCURRENCE BETWEEN TIME PERIODS

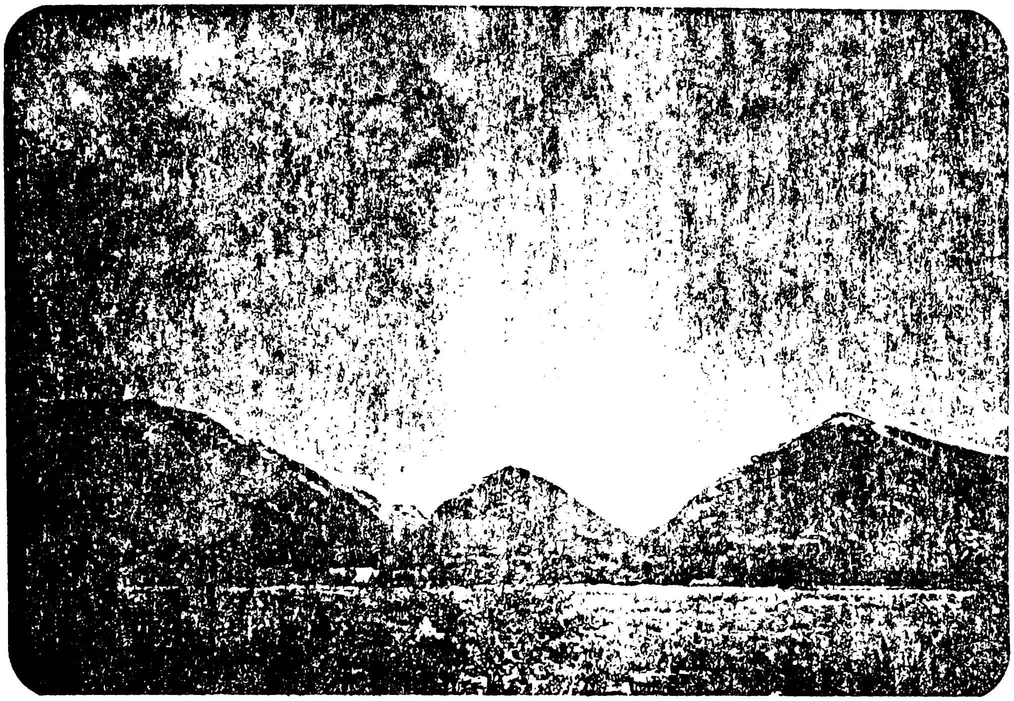
Goat Mountain and Onehorse Ridge Period Comparisons

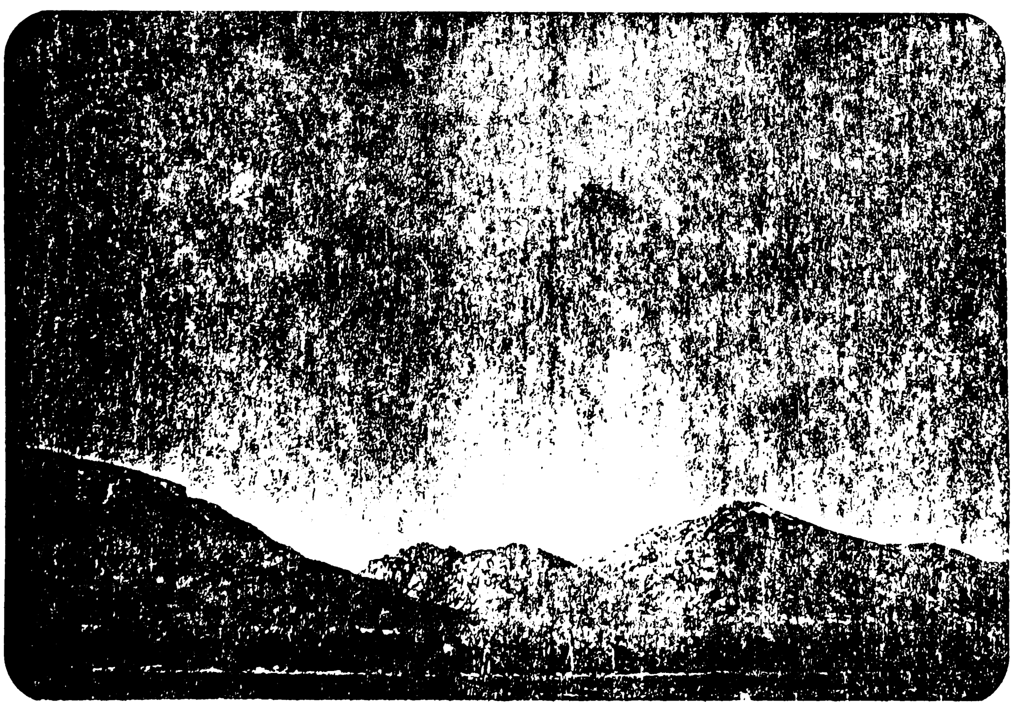
Methods

I used another fire history approach to quantify the extent of Indian influence in the historic fire regime. Two heavy-use stands on the eastern front of the Bitterroot Range were selected for intensive fire history sampling (the adjacent Bitterroot Valley to the east was the ancestral territory of Salish Indians as early as 6,000 years ago [Malouf 1974]. The objective was to compare the MFIs of two time periods in a stand to see if the MFIs are similar. I assumed lightning fire occurrence to be relatively similar during both periods, which were: (1) the pre-1860 period, when lightning and Indians were the ignition sources, and (2) 1931-1980, when lightning was the major ignition factor and detailed records of all fire causes are available.

It was desirable to select two stands from among the many triangular ridge-faces that slope downward into the Bitterroot Valley. The stands, Goat Mountain (7 miles [4 km] southwest of Hamilton) and Arno's (1976) Onehorse Ridge (5 miles [3 km] northwest of Florence), are topographically isolated by wide, cliffy, glacial canyons which are characteristic of the front range (Fig. 11). These fire barriers markedly reduced the possibility of laterally spreading fires from adjacent

Figure 11. Front and side views of the Goat Mountain stand (located in center of photographs). The wide, cliffy glacial canyons present formidable barriers to laterally spreading fires.





stands, during the pre-1860 period. It was important to avoid this possibility because fires that were not site-specific could be recorded on sample trees. This would tend to shorten pre-1860 MFIs, thus invalidating the time-period comparisons (1931-1980 MFIs are calculated on the basis of lightning ignitions on-site only).

I first determined pre-1860 MFIs for each stand by intensive fire-scar sampling (12 or more samples per stand). This was done according to the methods described by Arno and Sneck (1977). Next, I estimated expected lightning-fire MFIs from 1931-1980 for each stand. Fire suppression records on the Bitterroot National Forest are complete back to 1939, allowing identification and location of all lightning ignitions of appreciable size in each stand. The records presumably are very complete and accurate because both sites are fully visible from Forest Service ranger stations and from the densely populated valley bottom. Thus, it is highly unlikely that lightning fires since 1931 would have gone undetected in these stands. The records also allow elimination of man-caused fires from the calculations (both sites are undeveloped and have little human use). I next subjectively determined which lightning ignitions might have developed into spreading fires had there been no suppression. I did this by examining Forest Service *Individual Fire Reports* (Form 5100 series), using date of ignition, fuel types and amounts, slope, aspect, elevation, position on slope, fire weather data, and nature and duration of each ignition as decision criteria. I also examined National Weather Service daily temperature and precipitation data for one week before and one week after each ignition, to judge if it could have resulted in a spreading fire (weather stations are located within ten miles of each sample stand). For example, after examining the following data from an actual ignition on Goat Mountain in July 1970, I concluded that the ignition had spreading-fire potential (these data are very typical of those found in the fire reports):

Ignition Date	:	7/17/70
Discovery Date	:	(same)
Date Extinguished	:	(same)
Size Class	:	"B" (¼ - 10 acres [.1 - 4 ha])
Elevation	:	5500 feet (1,804 m)
Position on Slope	:	Upper 1/3
Slope	:	60 percent
Aspect	:	South
Cover Type	:	Ponderosa pine, brush
Fuel Loading	:	(not given)
Wind	:	Gusty, 4 mph (2.5 km per hour), (no direction given)
Fireman's Comments	:	Fire near top of ridge, burned 1/3 acre (.1 ha) before extinguished
Precipitation		
previous week	:	.9 inches (2.25 cm)
two weeks after	:	.8 inches (.2 cm)

Conversely, I might have concluded that the same ignition did not have spreading-fire potential if the ignition was confined to a snag, and was accompanied by one inch (2.5 cm) of rain on the day of ignition. Finally, after estimating the total number of potential fire years from

1931-1980, I calculated an expected MFI for each stand by dividing the number of possible fire intervals into 50 years. I then compared these results with the pre-1860 MFIs for the same stands. Statistical testing was not considered feasible for this approach because of the amount of subjectivity involved, and because of such uncontrollable variables as the possibility of pre-1860 fires spreading into the stands from other locations.

Results and Discussion

Six lightning ignitions occurred on Goa Mountain from 1931 to 1980 (Appendix F). After examining *Individual Fire Reports* and weather data, I concluded that three or four ignitions had potential to develop into spreading fires for an expected MFI of 12.5 to 16.6 years. The MFI for the same stand from 1700 to 1860 was 5.7 years.

Seven lightning ignitions occurred in the Onehorse Ridge stand from 1931 to 1980 (Appendix G). I concluded that as many as five ignitions had potential to develop into spreading fires. However, two of the ignitions judged to have spreading potential occurred during the same year; therefore, these constitute one fire year. This results in an expected MFI of 12.5 years. Arno's (1976) data for the same stand show an MFI of 5.2 years from 1631 to 1860.

There are several uncontrollable variables in this approach that make it unfeasible to statistically test the two periods' mean differences. First, an "error" in judgment of just one or two potential fires would result in large discrepancies in expected MFIs because the 50-year period is relatively short. Errors are possible because of the inherent uncertainty in predicting which ignitions might develop into spreading fires. Second, there is no way of knowing with certainty that pre-1860 MFIs reflect only site-specific fires. Shorter MFIs would result if fires had spread laterally into the stands from adjacent forests along the Bitterroot front.

There may be a mitigating effect on this last variable, in that my estimates of potential spreading fires in both stands from 1931 to 1980 probably are overestimates. If this is true, then the modern expected MFIs might likewise be shorter than would be characteristic from lightning fires. It is generally recognized that less than 50 percent of lightning ignitions develop into spreading fires (personal communication with J. Puckett, Division of Aviation and Fire Management, USDA Forest Service, Missoula, Montana). However, I estimated spreading-fire potential for 50-60 percent of the ignitions on Goat Mountain and Onehorse Ridge. I examined Forest Service data for 48 lightning ignitions which were allowed to burn under prescription in primarily wilderness fire management zones in Region 1, from 1973 to 1980. Only 5 of 18 ignitions, or 28 percent, which occurred below 5,500 feet (1,804 m) developed into fires larger than Class A (0-$\frac{1}{4}$ acre [0-.08 ha]), which I defined to be spreading fires.

Few explanations seem plausible for the apparently large mean differences between the two time periods. It is possible that the number of lightning ignitions in both stands during the past 50 years were uncharacteristically low, compared with the past few centuries. However, there is no reason to suspect that this is true. It also is possible that past lightning fires spread into the stands from the valley bottom, thus causing the short MFIs before 1860. However, lightning ignitions apparently are not frequent in the lower elevations. Barrows (1951) recorded lightning-ignition occurrence from 1936-1944 by per-million-acre units (.4 million ha) by elevation zone. His data began in the 2,000-3,000 feet category (656-984 m) for the Bitterroot National Forest; 73 percent of ignitions occurred about 4,000 feet (1,312 m) (this is the general elevational limit of the valley edge below both Goat Mountain and Onehorse Ridge). Barrows et al. (1977) examined percent of lightning ignitions by elevation zone. For the Southwestern Zone National Forests (this zone includes the Bitterroot National Forest), 89 percent of the ignitions occurred above 4,000 feet. Therefore, the large mean differences probably were not caused by valley-bottom lightning fires. Overall, my data suggest that Indian-caused fires contributed to the short MFIs in both stands before 1860.

Comparison of Pre- and Post-1730 Fire Frequencies

Methods

I speculated that Indian burning probably increased after the acquisition of horses about 1730. To test this, I examined the 20 Master Fire Chronologies and selected fire chronologies from individual trees, or from a combination of several trees in a stand. These chronologies had to have fire-scar sequences which began at least 50 years before 1730 (1680). These chronologies were used as indicators of relative fire frequency for a small site, rather than an entire stand, for the pre- and post-1730 periods. It is not feasible to use a stand's

Master Fire Chronology for comparing the periods because the Master Chronology is based on a composite of fire scars from five or six trees, some of which do not have scar sequences pre-dating the 1700s. The result is that the composite favors a more complete fire record after 1730; MFIs would thus be inherently shorter for the post-1730 period than for the pre-1730 period, which would bias statistical testing. Individual tree or multi-tree chronologies from very old sample trees are more equal indicators of relative fire frequency during both periods. Such trees can record fires relatively evenly before and after 1730. However, even with this approach some fire record can be lost with time because the oldest fire scars often have been obliterated by subsequent fires and by weathering. Therefore, somewhat shorter MFIs after 1730 might still result even if the actual MFIs had been identical.

I calculated MFIs for the pre-1730 and 1731-1860 periods. The beginning date of the pre-1730 chronology is the point at which the sample trees began recording fires, without an obvious gap in the record. I formulated the hypothesis that there was no difference between the frequency of fires during the two periods and tested for significance ($\alpha = .05$), using the t-test for unpaired plots (Snedecor and Cochran 1967).

Results and Discussion

Nineteen trees from eight heavy-use stands and one remote stand had sufficiently long chronologies for testing (Table 8)--eight of the nine small sites had scar chronologies beginning about 100 years or more before 1730. Post-1730 MFIs were shorter than pre-1730 MFIs on six of

TABLE 8

MEAN FIRE INTERVALS (MFIs) FOR EIGHT HEAVY-USE SITES AND ONE REMOTE SITE FOR (X) - 1730 AND 1730-1860

Site	Type of Site	Number of Trees	Chronology Beginng Date	(X)-1730[a/] MFI (Years)	1730-1860[b/] MFI (Years)
McCalla Creek	(H)	3	1475	15.9	10.0
Lick Creek[c/] (Gruell et al. [in press])	(H)	1	1545	14.3	8.1
Fairview	(H)	1	1554	13.8	10.8
Hughes Creek	(H)	2	1608	24.4	14.4
Hay Creek	(H)	2	1615	12.7	13.0
Onehorse Ridge (Arno 1976)	(H)	6	1631	6.0	5.9
McCartney Creek	(H)	1	1637	13.8	21.6
Goat Mountain	(H)	2	1641	12.7	8.8
Railroad Creek	(R)	2	1678	26.5	21.5
TOTAL		19	(Mean) (all stands)	15.6 ±6	12.7 ±6

a/ General date of Indian acquisition of horses in western Montana.
b/ General date of beginning of white settlement in western Montana.
c/ Mean difference is significantly shorter during the post-1730 period (α -.05).
(H) Heavy-use sites.
(R) Remote sites.

the nine sites, by from three to ten years. One site had an eight-year-shorter MFI before 1730 and two sites had MFIs that were about equal during both periods. After statistical testing, one tree's chronology from a heavy-use site had a significantly shorter MFI after 1730, and the remaining mean differences were not significant at the .05 level. The results do not support the hypothesis of increased burning after 1730. This suggests that burning probably was common in the region before 1730 for reasons other than horse-grazing, such as for hunting and native food plant production. If the acquisition of horses did not markedly affect the frequency of burning, burning probably at least became more widespread because of the expansion of tribal ranges that was possible with the increase in mobility.

These data are useful in another way. The approach may shed light on the question of long-term duration of Indian burning. This method provides an earlier indication of relative past fire frequencies than was possible in previous fire history analysis. When I compared Master Fire Chronologies between heavy-use and remote stands, about 1700 was the earliest comparison date between paired-stand chronologies. However, the above approach allows examination of relative amounts of fire back to at least the early 1600s, and three sites had relatively uniform scar sequences back to 1475, 1545, and 1554. Of course, the individual-tree or multi-tree MFIs are inherently longer than stand MFIs which are calculated from the combined records of five or six trees. However, with the statistical tests I was able to examine the relative frequencies of fire that occurred, primarily in the heavy-use stands. Fire occurrence seems to have been as frequent from at least

1600 to 1730 in most of the nine stands, as it was from 1730 to 1860. Unfortunately, it was not possible to compare relative frequencies between heavy-use and remote stands for the earlier dates, because only one remote stand had a tree that fit the criterion for the approach. Still, it appears that Indian burning may have been occurring during this earlier period, possibly as far back as the 1400s.

CHAPTER VI

IDENTIFYING SEASONS OF FIRE OCCURRENCE

Methods

Another fire history approach was to closely examine all fire scars with a binocular microscope to see if the seasons of fire occurrence could be determined. The objective was to see if most of the fires occurred during mid- to late-summer, as is typical of lightning fires in the region.

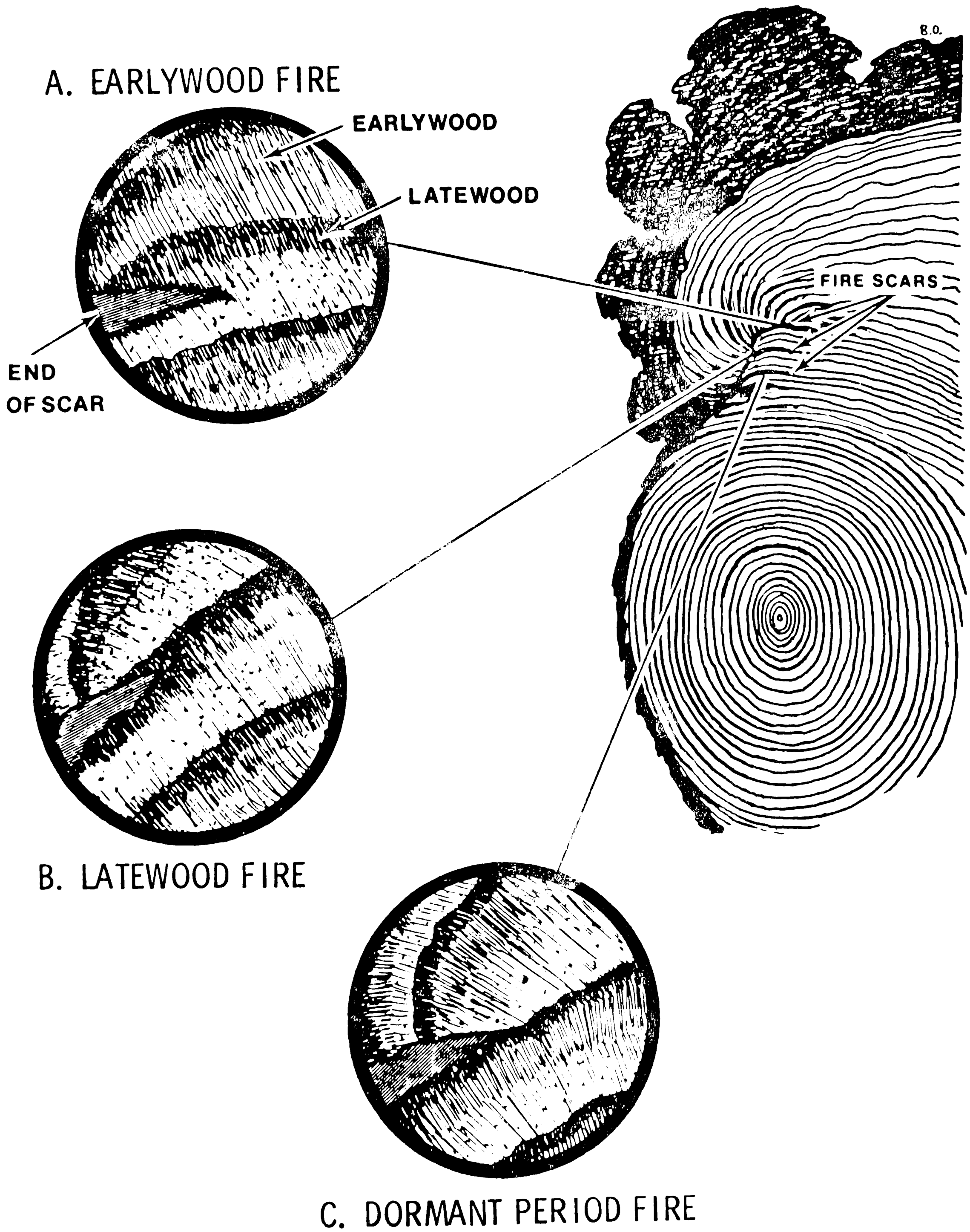
I examined the position of clearly-initiated scars relative to annual ring formation to see if fires occurred during either earlywood formation (approximately May 1 to July 1), latewood formation (July 1 to September 15), or during the dormant period (September 15 to May 1) (dates obtained in personal communication with E. Burke, Wood Technologist, University of Montana, Missoula). No technical dendrochronological or statistical techniques can be used to positively verify seasons of fire occurrence from scars. However, a subjective evaluation can be made after examining very clear ring and scar formations (Fig. 12) (personal communications with E. Burke; M. Stokes, Dendrochronologist, Laboratory of Tree-Ring Research, University of Arizona, Tucson; M. Parker, Dendrochronologist, Western Forest Products Laboratory, Vancouver, British Columbia). Evaluations were made by first marking an "E" for an earlywood scar, an "L" for a latewood scar, a "D" for a dormant-period scar, or an "I" for a scar whose season of occurrence was

Figure 12. Hypothetical fire-scarred ponderosa pine. Enlargements illustrate seasons of scar formation.

A. Portion of earlywood formed before fire occurrence; scar appears to bisect earlywood band.

B. Portion of latewood formed before fire occurrence; scar appears to bisect latewood band.

C. Earlywood and latewood completely formed; scar appears to bisect interface of latewood and following year's earlywood.


A. EARLYWOOD FIRE
EARLYWOOD
LATEWOOD
END OF SCAR
FIRE SCARS
B. LATEWOOD FIRE
C. DORMANT PERIOD FIRE
B.O.

indeterminable. I next correlated scars among a stand's samples to see if several scars from the same fire indicated the same season of occurrence. For example, if two or more scars apparently occurred during the same year and appeared to have been formed during the earlywood season, then I interpreted that these scars were formed by the same early-season fire. If several scars did not all indicate the same season of occurrence, I had to interpret subjectively. For example, if three scars had earlywood, earlywood, and indeterminable readings, respectively, then I interpreted these to indicate a probably early-season fire. If the scars had three different readings, then I concluded that the season of fire occurrence was indeterminable. With this situation, it is possible that three separate fires occurred in a stand during the same year, thus, the three different readings. However, with current fire history methods, it is not possible to positively conclude that three different fires occurred during one year.

Results and Discussion

Of the 469 fires that were identified from 946 scars, 314 occurred in heavy-use stands and 155 occurred in remote stands. It was not possible to identify the season of occurrence in 55 percent of the fires (256) because of one or more of the following factors: (1) the scar formations were partially obscured by pitch pockets, insect galleries, wood decay, or subsequent fires; (2) the fires were not of sufficient intensity to create large, clearly formed scars, or scars were located in portions of the sample that had extremely suppressed ring growth; (3) lack of fire-year correlation--in 16 cases, scars which were judged to have occurred during the same year indicated different seasons of occurrence (either because of mistakes in year designation or possibly because of separate fires which occurred in a stand during the same year).

Of the 213 fires for which season of occurrence apparently was identifiable, 39 percent indicated earlywood fires, 58 percent indicated latewood fires, and only 3 percent indicated fires which occurred during the dormant period. These totals represent all 20 sample stands, irrespective of type of stand or the three time periods examined in the study.

Results for three periods (pre-1860s, 1861-1910, 1911-1980) are shown in Table 9. Pre-1860 scars in heavy-use stands indicate that about one-third of the fires were earlywood or dormant-period fires, and about two-thirds were latewood fires. Results for remote stands show a large percentage of earlywood fires compared with those occurring in the latewood or dormant periods--more than half of the fires occurred before July. However, remote stand percentages are based on only 36 fires, versus 103 fires in the heavy-use stands. Thus, the small number of fires could be responsible for disproportionate percentages.

Seasons of fire occurrence in the heavy-use stands during the 1861-1910 period essentially did not change, compared with those of the pre-1860 period. Results for remote stands again indicate an unusually high percentage of earlywood fires; 68 percent of the fires occurred before July. However, remote-stand percentages are based on only 13 fires, versus 41 fires in the heavy-use stands, during the short 50-year

TABLE 9

APPARENT SEASONS OF FIRE OCCURRENCE BY PERCENT AND NUMBER OF FIRES ACCORDING TO THREE TIME PERIODS

Type of Stand	pre-1860				1861-1910				1911-1980				Total
	E (percent)	L	D	Number of Fires	E (percent)	L	D	Number of Fires	E (percent)	L	M	Number of Fires	Number of Fires
Heavy-use	29	67	4	103	29	68	3	41	54	46	0	11	155
Remote	55	42	3	36	69	33	0	13	78	11	11	9	58
Total (number of fires)				139				54				20	213

period.

Results for the 1911-1980 period may not be meaningful because of infrequent fires (11 fires occurred in heavy-use stands and 9 fires occurred in remote stands). The percentage of earlywood fires versus those occurring in other seasons rose markedly in the heavy-use stands compared with previous periods; more than half of the fires were in the earlywood period. Results for remote stands show that the percentage of earlywood fires is even higher than in the previous periods.

Since a relatively large number of the fires occurred before 1860 in the heavy-use stands (103 of 213 fires), examination of a considerable amount of data is possible for the Indian occupation period. One-third of the fires occurred during the earlywood period and dormant period--the times when Indians are alleged to have set purposeful fires. Two-thirds of the fires occurred during the latewood season. Barrows' (1951) comprehensive examination of regional fire records from 1931 to 1945 shows that approximately 80 percent of lightning fires occurred during the latewood period (Table 10). Barrows et al.'s (1977) continuation of the same study from 1946 to 1973 shows that, again, about 80 percent of lightning fires occurred during the latewood period.

Several possible variables must be examined to determine the validity of comparing Barrows' results with mine. First, these studies listed seasons of fire occurrence for a wide array of vegetative types and elevations. The studies did not list per-month figures by vegetation categories; however, the vast majority of fires occurred between 4,000 and 6,000 feet (1,312-1,935 m). Thus, the seasons of occurrence likely

TABLE 10

COMPARISON OF SEASONS OF FIRE OCCURRENCE
WITH BARROWS (1951) AND BARROWS ET AL. (1977)

E = earlywood fires (approx. May 1 - July 1)
L = latewood fires (approx. July 1 - September 15)
D = dormant-period fires (approx. September 15 - May 1)

Source of Data	Time Period	Season E (percent)	Season L (percent)	Season D (percent)	Number of Fires
Barrows (1951)	1931-45	20	77	3	21,744
Barrows et al. (1977)	1946-73	11	82	7	26,847
Barrows (1951) and Barrows et al. (1971) (combined)	1931-73	15	80	5	48,591
Heavy-use stands	1500s-1860	29	67	4	103
Heavy-use and remote stands	1500s-1980	39	58	3	213

are accurate for Douglas-fir series forests. Second, the 42-year period covered by the Barrows studies could represent a different climatic pattern than that of my pre-1860 period. However, there is no evidence to suggest that this is true. Third, my data for the pre-1860 period are based upon a time span of more than two centuries; thus, any short-term climatic aberrations should not affect my results. Therefore, the comparison with Barrows' statistics seems valid.

If my figures represent the actual seasons of occurrence, then about 13 percent of the fires which occurred in the off-season are unaccounted for. Indian-caused fires might be responsible for this discrepancy. However, this aspect of the study is inconclusive due to several factors that make the results questionnable. First, there is some subjectivity involved in the approach, both in identifying seasons of occurrence from scars, and in stating that several scars were caused by the same fire (the accuracy of assigning fire years to un-crossdated samples can be questioned). Second, the small number of fires which occurred in all stands after 1860 make comparisons with the "non-Indian" periods and zones somewhat unfeasible. Still, if results for heavy-use stands in the pre-1860s are compared with those during 1861-1910, note that percentages did not change. Third, the 13 percent discrepancy between Barrows' figures and mine is not large, considering the uncontrollable variables. Fourth, the discrepancy probably is not meaningful because the percentage of latewood fires could change if I had more data. My data base is very small compared with Barrows' (103 fires versus 48,591 fires, respectively) and my percentages might not present an adequate view of actual seasons of occurrence.

The above variables do not seem to warrant rejecting the approach outright and the discrepancy between Barrows' and my data could be another indication of Indian influence in the lightning fire regime. However, I do not consider this to be a very reliable means of quantifying seasons of fire occurrence.

CHAPTER VII

EFFECTS OF PAST FIRES ON STAND STRUCTURE

Presettlement-Stand Reconstruction

Methods

Reconnaissance sampling was conducted in the 20 sample stands so that each stand's tree structure in 1980 could be compared with that of the presettlement era. The objective was to relate past fire occurrence to stand dynamics over time. For this approach, I chose the year 1880 to indicate presettlement conditions because stand structure could be reasonably documented back about 100 years. Thus, the term "presettlement" is not precise, although most trees in the 1880 stands existed in the actual presettlement era (pre-1860s).

Field Sampling. Three circular half-acre (.2 ha) plots were located in representative portions of each sample stand after a visual inspection of the area. Each of the three plots then were subdivided into a 1/50th- and a 1/10th-acre (.01 and .04 ha) circular subplot, the two subplots having the same center point. Tree seedlings were recorded by species within the 1/50th-acre subplots, trees greater than 4.5 feet (1.5 m) tall and less than 100 years old were recorded by species and size class within the 1/10th-acre subplots, and trees dating back to presettlement times (more than 100 years old) were recorded by species and size class within the ½-acre plots. Standing trees, downed trees, and stumps were tallied in these ½-acre plots to aid the reconstruction of presettlement-stand structure.

Standard plot-sampling techniques were used to record the following information:

a. Stand and plot locations (legal location and general location)
b. Position on slope
c. Source of location (records, visual)
d. Elevation, slope (percent), aspect (azimuth)
e. Tree species by 2-inch (5 cm) size classes
f. Tree condition (live, snag, downed, stump)
g. Tree ages (several increment cores from major size classes)
h. General canopy height
i. Logging history (if any)

Modeling the Presettlement Stands. I had to develop a general approach to modeling the presettlement stands so that successional patterns could be examined for the 1980 and 1880 periods. The literature did not provide information for this approach.

The first step was to estimate which trees in the sample plots existed before 1880. I examined the relationship of age to diameter at breast height (d.b.h.) by estimating a linear regression from scatter diagrams of increment-cored trees and datable fire-scar samples. I constructed these graphs, one each, for 132 ponderosa pines and 67 Douglas-firs (I did not graph western larch because it was only a minor component in four stands and I obtained only a few cores from this species). These graphs did not include data from four stands which are located in northwestern Montana. These relatively moist stands could have different age/size relationships than those in the remaining 16 stands in the generally semi-arid southern half of the study area. Thus my age/size model probably will be conservative for moist stands (not enough data were obtained from the four stands for development of a separate model).

To get an indication of the validity of my age/size estimates, I compared my curves with Meyer's (1961) age/size curve for even-aged ponderosa pine stands at site index 51. Meyer's curve generally is applicable to most ponderosa pine/Douglas-fir stands in the southern half of the study area, although his model is somewhat idealized (Meyer's growth projections are based upon even-aged trees, converse to the generally uneven-aged old growth Douglas-fir series forests in the study area).

After estimating a general age/size relationship, I constructed 20 stand tables (Appendix H) which showed each species' average number of trees per unit area by d.b.h. size class. I bar-graphed these values and smoothed the resultant curves to obtain a visual comparison of species composition and successional patterns in the 1880 and 1980 stands.

Results and Discussion

The resultant regression curves from my increment-core data indicated that, on the average, the 12-inch (31 cm) size class is attained by both ponderosa pine and Douglas-fir at about 100 years. Both of my curves matched Meyer's very closely; thus, my model assumes that trees over the 12-inch increment existed in the 1880 stands (Fig. 13). Very slow-growing trees will not fit the model; however, the approach dictates that averages be used.

The d.b.h.'s measured in 1980 would have been variably smaller in 1880. I examined my age/size curves and those of Meyer to get an indication of d.b.h. regression from 1980 to 1880. Both sets of curves indicate that 1800 d.b.h.'s were from about 10 inches (25 cm) to only about 2 inches (5 cm) smaller than the present measurements. As examples: (1) 12-inch trees in the 1980 stands would represent seedlings to the 2-inch size class in 1880; (2) 14-inch (36 cm) trees in 1980 would represent the 1880 4-inch (10 cm) size class; (3) 26-inch (66 cm) trees in 1980 would represent the 1880 20-inch (51 cm) size class; and (4) trees that are larger than 34 inches (86 cm) d.b.h. in 1980 would represent age classes that were only about 2 or 3 inches (5 or 7.5 cm) smaller in 1880. These general relationships are presented only to assist the reader's mental reconstruction of such stands as they existed 100 years ago; precise characterization of the tree's specific sizes in 1880 is not possible. Specific sizes are not as important as the relative sizes and stocking densities of each species in 1880, compared with those in 1980.

This approach has uncontrollable variables which make the model useful only as a general indicator of successional patterns. These variables are: (1) the stand-table graphs reflect only those trees that are still alive or that were not obliterated by decomposition or fires in the past 100 years; thus, trees that were small in 1880 are underrepresented; (2) all identifiable dead trees larger than 12 inches (31 cm)

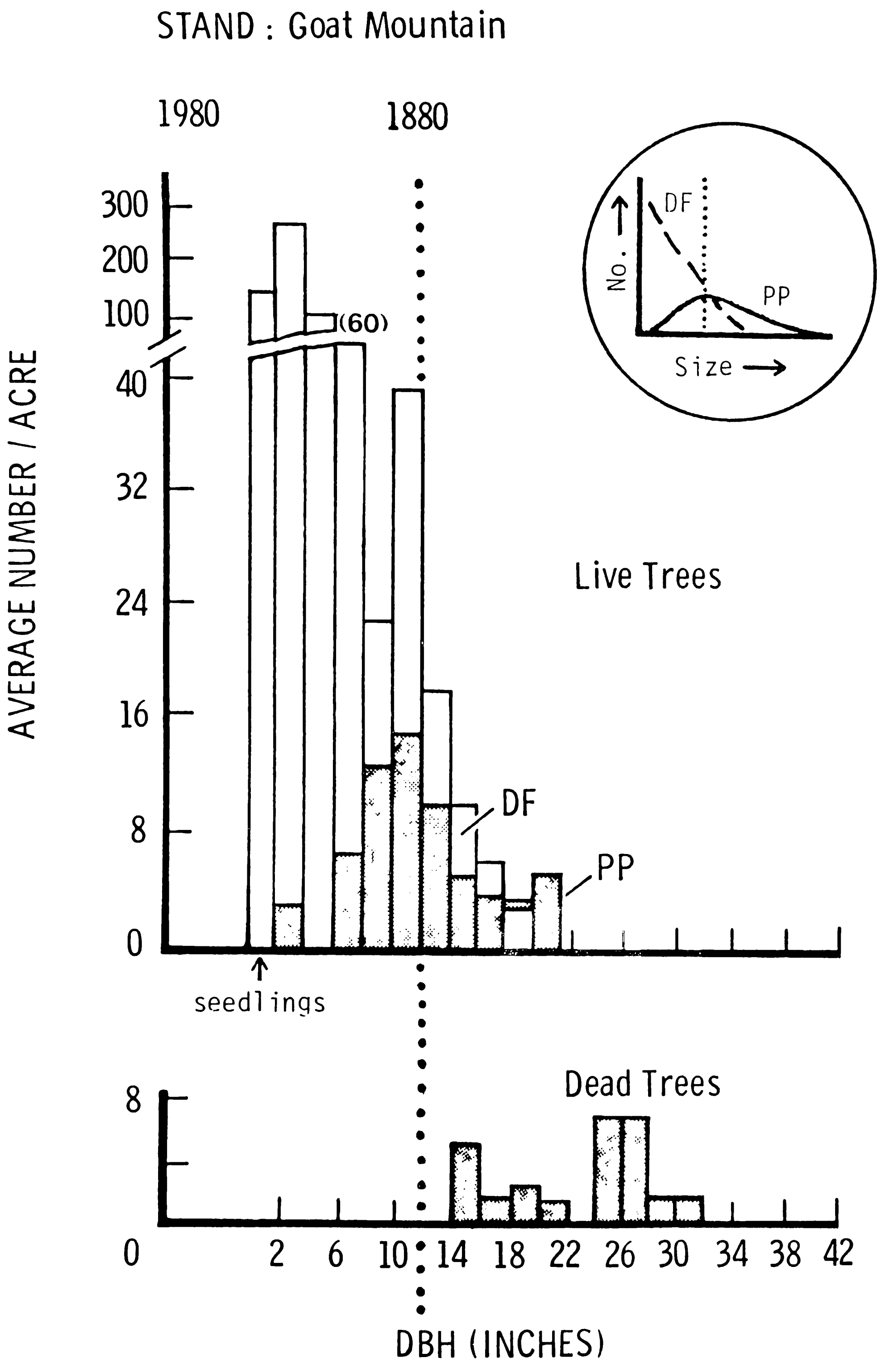


Figure 13. Graphed results for ponderosa pine and Douglas-fir from the Goat Mountain stand table (Appendix H). Inset at upper right illustrates resultant curves for each species.

d.b.h. are represented on the graphs, and there is no reliable way to estimate the year of death. These trees were plotted on the graphs under the size class that they attained at death; therefore, the graphs reflect conservative estimates of the 1880 size classes; (3) during field sampling I only tallied dead trees which were in the pre-1880 stands (when the study was designed, it was thought necessary to tally just the old, dead trees to facilitate presettlement stand reconstruction); as a result, dead trees are not reflected on the 1880-1980 portions of the graphs, so these portions reflect conservative estimates of stand composition during the last 100 years.

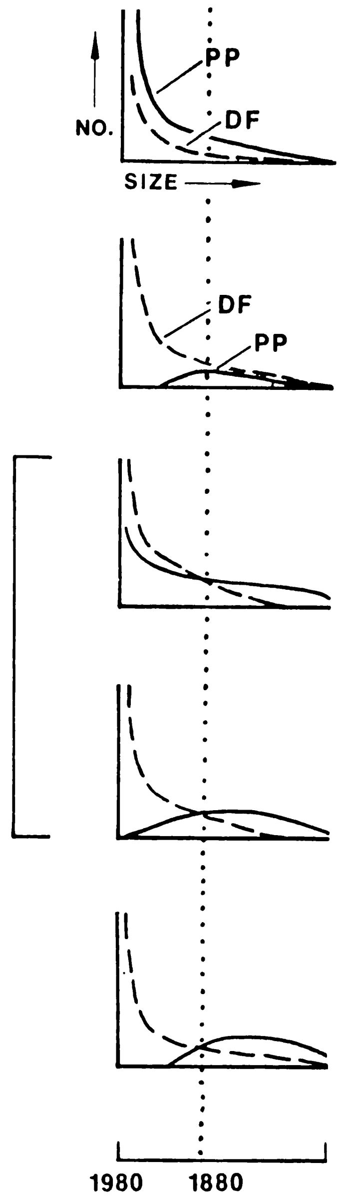
A mitigating effect on this inaccuracy may be that the 1880 portion also is imprecise because some of the small, old trees have decomposed or were consumed by fires. There likely is just a small amount of data missing from the smaller size classes of both portions, so the model still should be useful for examining relative amounts of trees during the two periods.

After examining the stand-table curves for the 20 stands, I found that the curves conformed to five general patterns. Successional patterns can be viewed in Figure 14 by using the dotted line as a focal point. This line indicates the 12-inch (31 cm) size class. Trees to the right of this line represent some of the understory and most of the overstory of the 1880 stands. Trees to the left of the dotted line represent successful regeneration in the past 100 years.

Graph A indicates that there has been no major change from ponderosa pine dominance in 1880. Seven stands' curves generally conformed to this pattern. However, apparently only four of the stands

Figure 14. Successional trends in 20 sample stands from presettlement times to the present.

	Stand	Dominant Trees (most-abundant listed first) pre-1880 ⟶ 1980	Generalized shapes of curves [1]
A.	Mc Cartney Cr.[2] Indian Trees Fairview[3,4] N. Bassoo Cr.[3] Cutoff Gulch Mc Calla Cr. Sleeping Child Cr.	PP/DF ⟶ (no change)	A.
B.	Fivemile Cr.	DF/ PP or DF- PP ⟶ DF/ PP	B.
C.	Sixmile Cr. Rainy Cr.[4] Rock Cr. Hog Heaven[3] Hog Trough Cr. Hughes Cr. Goat Mtn. Two Bear Cr.	PP/ DF ⟶ DF/ PP	C.
D.	Thompson Cr. Hay Cr. Railroad Cr. Doak Cr.[4]	PP/ DF or PP- DF ⟶ DF / (PP)	D.



[1]See Appendix H for specific stand tables.

[2]Very dry site: *Pinus ponderosa/Festuca scabrella* habitat type.

[3]Regeneration probably influenced by selective cutting in past 15 years.

[4]Western larch present in stand as minor component.

reflect natural succession, or are capable of supporting equal numbers of ponderosa pine and Douglas-fir. One stand is located on a very dry, south-facing slope that likely will not support substantial numbers of Douglas-fir (the stand keyed to *Pinus ponderosa/Festuca scabrella* habitat type; Pfister et al. 1977). Stand structure and dynamics on such sites appear to be controlled more by harsh environmental conditions than by fires (Tesch 1981). Two stands were partially selective-cut and burned within the past 15 years. This may be one of the main factors responsible for maintaining successful regeneration of ponderosa pines in the understories because ponderosa pine regeneration often is perpetuated by such stand treatments (Arno 1979b, Gruell et al. in press). . . .

Graph B indicates a change from the 1880 stand which was slightly Douglas-fir dominated, or dominated by Douglas-fir and ponderosa pine, to strong Douglas-fir dominance of the understory in 1980. One stand's curves conformed to this pattern. Fires were very frequent in this Fivemile Creek stand during the presettlement and settlement periods; MFIs were less than ten years for each period (Table 6). However, in spite of frequent thinning-fires, Douglas-fir regeneration apparently has been quite successful throughout at least the last 300 years. Ponderosa pine also successfully regenerated until about 30 years ago. Fires may have been important factors which helped control this stand's structure. For example, only two fires (sizes unknown) occurred in the stand from 1911 to 1980 and the last fire was in 1953. The three sample plots that I placed in representative parts of the stand contained no ponderosa pines in the size classes below 6 inches (15 cm) d.b.h.. Lack of disturbance by fire could be partly responsible for this lack of ponderosa pine regeneration in the past 27 years.

Graphs C and D indicate varying degrees of changes in dominance. The two sets of curves in category C indicate an apparent crossover from ponderosa pine dominance in 1880 to Douglas-fir dominance in the 1980 understory (the two graphs' only difference is in the present average amounts of ponderosa pine regeneration per unit area). Eight stands' curves generally conformed to these patterns. The large average amounts of Douglas-fir regeneration in one stand may have been influenced by rather heavy selective-cutting in the past 15 years; there was no evidence of slash-burning in the stand. This type of treatment favors the regeneration of Douglas-fir because of the lack of site preparation (Arno 1979b).

Graph D shows an apparent crossover from ponderosa pine dominance (or perhaps nearly equal dominance by the two species) in 1880, to strong Douglas-fir dominance of the understory in 1980 (ponderosa pine regeneration is absent or nearly absent from the 1980 side of the curve). Four stands' curves generally conformed to this pattern.

If the very dry stand and the selective-cut stands are removed from consideration, then 12 of 16 stands have shifted by varying degrees to Douglas-fir dominance over the past 100 years. The lack of fires in most stands for the past 50 to 70 years probably is a major factor in allowing these changes in stand structure. First, with the possible exception of very moist sites, the large number of Douglas-fir in the smaller size classes in most stands today could not have been present in the presettlement era. Frequent thinning-fires would have precluded dense understory structure (Weaver 1945). Second, the present 20-stand means of average Douglas-fir and ponderosa pine seedlings per unit area are 600 and 126, respectively; the proportion of Douglas-fir seedlings to ponderosa pine seedlings would have been much smaller in the presettlement stands because of the former species' greater susceptibility to fire in its immature stages (Arno 1979b). Third, ponderosa pine seedlings can regenerate very successfully under a regime of frequent surface fires (Weaver 1945), indicating that past numbers probably would have been higher for this species. Fourth, the presently large numbers of Douglas-fir in the understories of many stands probably will not be drastically reduced in the future by mechanisms other than fire; therefore, the future overstories probably could not eventually resemble those of the 1880 stands.

The general successional trends observed in the 12 stands agree with Arno's (1979b) models of natural succession with continued fire exclusion (Figs. 15 and 16). These models hypothesize that, in the absence of fire, Douglas-fir eventually will assume dominance in stands that were previously dominated largely by ponderosa pine, or by ponderosa pine and western larch.

Other observations from my plot sampling generally are consistent with those of other studies in ponderosa pine/Douglas-fir forests: (1) Weaver (1945) stated that ground fires are major thinning-agents in understories and that this leads to uneven-aged stands; increment cores from my stands verify that several age classes existed in all of the presettlement stands; (2) each age class consisted predominantly of widely spaced ponderosa pines; early-day photographs (Gruell et al. in press) verify the past openess of many ponderosa pine stands; (3) few large, old Douglas-firs were observed in my stands, further indicating the extent of past dominance by ponderosa pine, (4) portions of a number of stands were heavily infested with dwarf mistletoe (*Aceuthobium douglasii*), indicating possible trends toward stand decadence in the absence of fire (Arno 1976).

Interpretations

Early accounts (Cooper 1853, Lieberg 1899, Ayres 1899) and interpretations from modern fire ecology studies (Buck 1973, Arno 1976, Dorey 1979, Gruell et al. in press) have provided detailed documentation of past fires' effects on regional ponderosa pine/Douglas-fir forests. This evidence and my data indicate that most fires in the pre-1900 era were low- to moderate-intensity surface fires. The evidence shows that: (1) frequent fires maintained early herb/shrub successional stages in the understories of many stands--light fuel loadings and small fuel diameters were characteristic of such understories (Davis et al. 1980); (2) the recurrence of fires at least every 5 to 20 years precluded long-term buildups of horizontal and vertical fuels; (3) "ladder" fuels usually could not develop with such a fire regime (Arno 1976); crown fires were not characteristic of these frequently burned forests because low-intensity fires could not bridge the gap from the forest floor to the lower canopy; and (4) plot sampling shows that past stands were uneven-aged, indicating that stand-replacing fires were not characteristic.

Fire behavior apparently was variable in many stands (Arno 1980), especially in the mesic types which can have a relatively wide array of fuel types, sizes, and spatial arrangements. Fires spread through

stands with varying rates and intensities in finger-like or locally uniform patterns; variable behavior was dictated by such factors as weather changes, local topographic changes, and different patterns and types of horizontal and vertical fuels. Historical accounts (Mullan 1861, Jacquette 1888) and modern observations of management fires in wilderness areas (Mutch 1974) indicate that a fire can burn in this manner for weeks, even months, before being extinguished by autumn rains or snow.

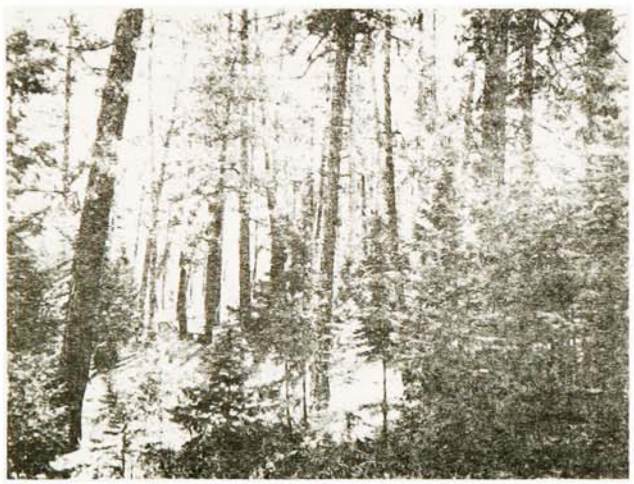
These frequent surface fires had pronounced effects on stand structure. Grasses, forbs, shrubs, and the majority of invading tree seedlings were regularly recycled. Historical accounts (Lieberg 1899, Ayres 1899 and 1900) indicated that many understories were much more open than they are at present. Photographic research by Gruell et al. (in press) indicated that such understories often were composed almost entirely of grasses so that many ponderosa pine stands had an open park-like appearance (Fig. 17).

Tree seedlings were killed differentially in space and time and a few escaped mortality to mature to fire-resistant stages. Seedlings and saplings of ponderosa pine and western larch have superior fire-resisting qualities because the species have wide and open branching habits and develop corky bark at a relatively early age (Davis et al. 1980). These species have a competitive advantage over those of the more fire-susceptible Douglas-fir which has a lower-growing, more compact crown. As a result, ponderosa pine usually was the dominant species on dry sites, with a few scattered Douglas-fir as minor components (Fig. 15). Moist sites were dominated by ponderosa pine,

Figure 17. Thirty-nine years of successional change in the Lick Creek stand, Bitterroot Valley, during the Fire Suppression Period (from: Gruell et al. in press). Light selective cutting occurred in the stand before 1909; however, that photograph appears to largely reflect pre-settlement stand conditions. Later successional patterns reflect the influence of fire-exclusion, and possibly cutting.

1909.
View is south-southeast through an open ponderosa pine stand selectively cut in 1907 or 1908 (PSME/SYAL h.t.). Luxuriant grass/forb cover reflects prelogging conditions. Note fire-scarred ponderosa pine and lone Douglas-fir seedling immediately to the left of W.W. White. A low-growing bitterbrush plant can also be seen between White and stump. (USDA FS Photo 86480)

1927, 18 YEARS LATER.
Douglas-fir regeneration has resulted in marked change in understory. Grass/forb ground cover persists, but now bitterbrush and snowberry are more evident in foreground. Pine stand is somewhat less dense because of cutting or windfall (USDA FS Photo 221282)



1938, 29 YEARS LATER.
Douglas-fir understory continues to increase in size and density. Some overstory trees continue to die. (USDA FS Photo 361703)

1948, 39 YEARS LATER.
Original view is now screened out by growth of young Douglas-fir Ground cover in foreground now has considerable numbers of low shrubs Snowberry appears to predominate (USDA FS Photo 452640)

western larch, and Douglas-fir, often in that order of abundance (Fig. 16).

My data and those of studies cited previously indicate that there has been a sharp decline in spreading fires in most ponderosa pine/ Douglas-fir forests since the early part of this century. This phenomenon presumably is the result of efficient fire suppression. Longer fire intervals are allowing stands to develop toward climax conditions, and the ecological implications are most marked in the moist stands. Larger amounts of fuels per unit area now are characteristic of most stands than in the pre-fire suppression era. Relatively slow decomposition probably will not completely replace fire as a rapid recycling agent, thus setting the stage for more intense fires than before. Considerable portions of many stands are becoming densely overstocked primarily with shade-tolerant Douglas-fir, because frequent thinning-fires have been largely eliminated. These low-crowned, densely needled trees now provide fuel ladders for fire-spread into portions of the canopy (Davis et al. 1980). Also, many stand canopies presently are, or have potential to be, more dense and continuous than before as previous gaps become filled by the numerous younger trees. Subsequent fires in such stands have potential to be hotter and can spread closer to or into crowns, resulting in crown-scorch or combustion. Even old-growth trees that previously were rarely harmed by fires may now be susceptible to mortality in such stands (Arno 1976).

CHAPTER VIII

CONCLUSIONS

Interpretation of Study Findings

I have shown that each of the five research approaches involved subjectivity and uncontrollable variables. As a result, it is difficult to derive firm conclusions about the role of Indian fires from any one approach. However, when combined, the findings of the five methods indicated that Indian fires were an important ecological process in many ponderosa pine/Douglas-fir forests of habitation zones. The study did not produce any evidence to the contrary. My overall findings generally are consistent with those of most other studies which documented Indian burning in this forest type in western America (Fig. 18). However, only a few of these studies were able to use ecological research to support their conclusions, for example, Reynolds (1959) and Kilgore and Taylor (1979).

Fire-scar data showed that most of the heavy-use sample stands consistently lacked the long fire intervals which are necessary to permit large fuel buildups; Indian-caused fires apparently precluded the infrequent long intervals which might occur under a strictly lightning-fire regime. My data indicate that remote stands have more variable, and often longer, fire intervals probably because of the absence of humans as ignition sources. As a result, long intervals

FIGURE 18

Key

A. Study area, western Montana

B. Columbia Plateau, northeastern Washington (Ross 1981)

C. Mid-Willamette Valley, northwestern Oregon (Habeck 1961)

D. Blue Mountains, northeastern Oregon (Shinn 1980)

E. Sierra Nevada Mountains, northeastern/east-central California (Reynolds 1959, Lewis 1973, Kilgore and Taylor 1979)

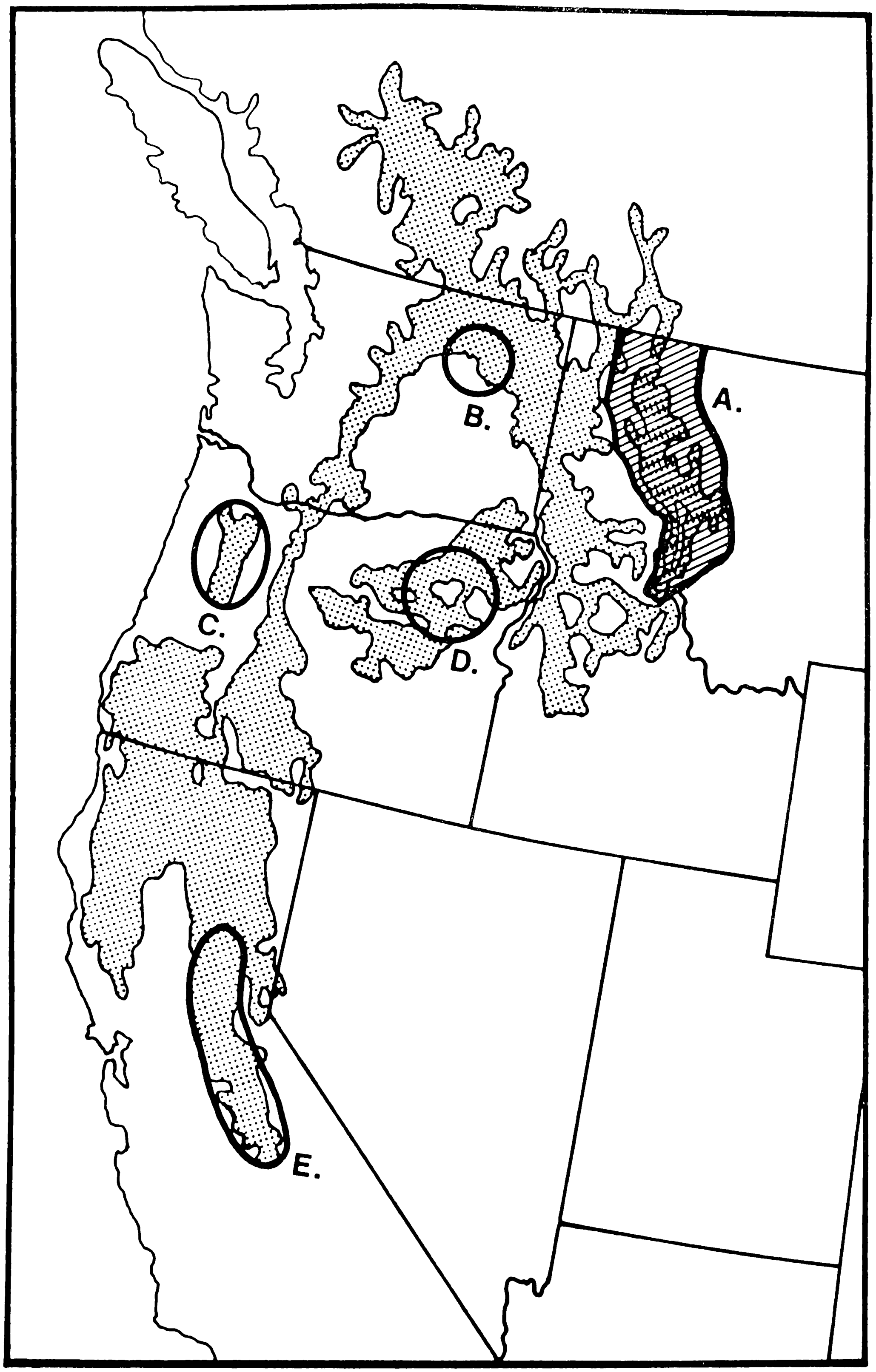


Figure 18. General distribution of ponderosa pine in western North America (after: Little 1971) (map slightly under-represents moist forest types which are similar to western Montana's Douglas-fir series). Letter areas indicate regions where Indian burning has been documented as having been an important ecological factor.

might have led to more-variable fire behavior than was characteristic in many heavy-use stands. However, there probably were no major differences in fire behavior and effects between the heavy-use stands and remote stands. Lightning fires apparently still occurred frequently enough to maintain early successional stages in remote stands. Results of plot sampling and reconstruction of past stand characteristics did not indicate any pattern of differences between heavy-use stands and remote stands. For this reason, it may no longer be meaningful to differentiate between the two types of zones, except to say that heavy-use stands were under a semblance of early management. Just as in earlier times, it is today undesirable to simply wait for randomly occurring lightning fires to achieve man's objectives, except in special fire management zones such as wilderness.

The policy of excluding fire from "fire-dependent" forests (Mutch 1970), in effect from about 1910 to quite recently, has resulted in ecological changes (Habeck 1970, Habeck 1972, Habeck and Mutch 1973) that often are incompatible with forest management objectives. For example: (1) fire exclusion appears to be strongly related to the silvicultural problems of overstocking and subsequent reduction in tree vigor and productivity (Weaver 1945, Arno 1976, Gruell et al. in press); (2) problems of increased insect and disease susceptibility may develop (Fellin 1979); (3) resulting decadent stands are more susceptible to stand-destroying fires (Arno 1976); and (4) the end result is a more difficult and expensive fire suppression effort.

Management Implications

Ponderosa pine/Douglas-fir forests evolved with frequent fire-disturbances, often initiated by man. However, successional trends in many forests today suggest that this balance is being upset by fire exclusion. The results of this study generally support the management implications produced by other fire ecology analysis in the region (Habeck 1972, Habeck and Mutch 1973, Arno 1976, Dorey 1979). These studies indicate that, for certain management objectives, more emphasis should be put on restoring or simulating some of the presettlement forest conditions. Below are some management considerations that are directly related to such a recommendation.

Fire Management/Wildlife Hazard-Reduction

Managers may need to reduce the risk of destructive fires in stands that have been subjected to relatively large fuel buildups (Arno 1976). Prescribed underburning in the fall often is desirable not only for initial fuel reduction or for logging-slash disposal, but also on a periodic basis thereafter to keep stands in a managed, vigorous condition. Historic fire interval ranges probably are the best guides for burning periodicity; a general range of 5 to 20 years has been indicated by most fire history studies in this forest type.

Silviculture

Logging began in western Montana in the late 1800s (Lieberg 1899), and ponderosa pine dominated stands were highly desirable from a commercial timber standpoint. Today, large-growth ponderosa pine still is a highly favored timber species. Weaver (1943) stated that optimum growth and stocking of ponderosa pine can be maintained by frequent underburning in such forests. Arno (1979b) suggested that a silvicultural prescription of selective cutting and periodic underburning will simulate presettlement stands by perpetuating uneven-aged ponderosa pine stands.

Insects/Diseases

Frequent fire can maintain vigorous ponderosa pine stands which generally are resistant to insect and disease problems (Weaver 1945). In over-stocked stands where Douglas-fir is a major component, infestations of dwarf mistletoe are common; problems with this parasite possibly can be avoided or reduced by prescribed burning (Alexander and Hawksworth 1975). However, in stands where the objective is timber management, managers may wish to consider the alternative of favoring ponderosa pine with appropriate silvicultural prescriptions. Also, Arno (1976) and Fellin (1979) suggested that proper application of prescribed fire might maintain vigorous, well-thinned stands which resist attacks of mountain pine beetle (*Dendroctonous ponderosae*) and western spruce budworm (*Choristoneura occidentalis*).

Management of Wildlife Habitat and Livestock-Grazing

In the presettlement era, the most frequently burned stands probably favored those species that have minimal cover requirements and that prefer primarily grasses for food; habitat diversity may have increased in stands that were subject to more variable rates of fire occurrence. Both situations might present implications for managing the habitats of wildlife and domestic livestock. In intensively managed stands where a selective cut/frequent-underburning prescription is used, livestock and wildlife with low cover requirements might be favored. The frequency of stand disturbance and vegetation removal often determines whether the habitat requirements of big game and other wildlife will be met (Lyon 1966). In stands where entries are less frequent, later successional species such as canopy-feeding birds or cavity-nesting birds might be favored (McClelland et al. 1979, Gruell et al. in press) because of the increased mosaic structure of the understory and increased canopy closure.

Wilderness/Natural Areas

Most Federal agencies that manage wilderness and national parks in the western United States now have policies that call for restoring lightning fires to a semblance of their previous role. Also, national park managers have been directed to restore or recreate ecosystems so as to perpetuate their existence in a state similar to that first seen by European man (Leopold et al. 1967). This directive has been used as a justification for manipulating some park ecosystems with prescribed fire. For example, Glacier and Yosemite National Parks have conducted underburning in some stands. The implication of this policy is that once park ecosystems are restored to supposedly pristine conditions, then burning will cease and only lightning fires will be allowed to operate in ecosystems. However, many national park ecosystems are known to have been important to aboriginal economies (Lewis 1973) and these ecosystems were manipulated with fire (Reynolds 1959, Lewis 1973, Kilgore and Taylor 1979), possibly for thousands of years. Therefore, man was an important ecosystem component before European settlement. The implication here is that preservation is not necessarily incompatible with ecosystem influence by man.

Recreation/Aesthetics

Most forest-users seem to prefer ponderosa pine/Douglas-fir stands that are open and park-like (Davis et al. 1980, Gruell et al. in press) and such conditions generally existed in many stands before the fire suppression era. Recreation activities such as hiking, picnicking, and bird-watching often are enhanced in such stands because of the ease of travel and open views. In intensively managed areas, these activities can be compatible with the silvicultural and prescribed burning prescriptions that were described below.

CHAPTER IX

SUMMARY

The objectives of this study were to determine (1) if fires were set by Salish and Kootenai Indians in western Montana forests, (2) if so, to determine what role these fires played in ecosytem functioning, and (3) to interpret findings in relation to current forest management concerns.

Five research methods were used to achieve the objectives. The first method was to reconstruct the ethnohistory of Indian-caused fires in the region by interviewing knowledgeable informants and by researching historic journals. Results revealed 13 reasons for subsistence burning, in addition to the occurrence of inadvertent ignitions. Indians apparently set fall and spring underburns primarily for hunting purposes, food plant growth-stimulation, and, after about 1730, to increase the growth of forage for horses. Arbitrary and unsystematic burning seems to have been characteristic, because the tribes' nomadic ways and large subsistence land base probably precluded the necessity for planned burning. Annual burning apparently often occurred somewhere in broad locales, but probably not in single stands.

The second research method was to compare fire history between ten pairs of ecologically similar ponderosa pine/Douglas-fir stands. The objective was to see if presettlement (pre-1860) fire occurrence was similar between stands located in Indian habitation zones and remote zones. Comparison of Master Fire Chronologies revealed shorter mean fire intervals MFIs for nine of ten heavy-use stands than their remote mates, often by as much as half of the MFI lengths. Three of these shorter MFIs were significantly different (α = .05). Fires occurred in the 20 stands usually on the average of every 7 to 20 years, and intervals between individual fires ranged from possibly one year to a usual maximum of 35 years. The occurrence of rather uniform individual fire intervals in the heavy-use stands strongly implicates Indians as having been responsible for the shorter MFIs; remote stand intervals appeared to be more variable in length, which may be characteristic of random lightning fire occurrence. Ecological phenomena other than Indians probably cannot account for these differences.

There were more-variable MFI differences between heavy-use and remote stands during the Settlement Period (1861-1910). Eight of ten heavy-use stands had shorter MFIs than remote mates; however, differences generally were smaller than in the Presettlement Period. In general, lightning fires and man-caused fires still were frequent in the region, with MFIs averaging 6 to 25 years. In addition to occurring in heavy-use zones, man-caused fires apparently also occurred in remote zones, probably due mostly to prospectors, hunters, and travelers.

The MFIs were markedly longer during the Fire Suppression Period (1911-1980), presumably because of efficient fire exclusion. The MFIs in 12 stands now equal or exceed the longest individual fire intervals recorded in most stands before 1911. Six stands had only one fire or no fires in the 70-year period.

The third research method was to compare the MFIs of two time periods in a single stand to see if the MFIs were similar. I assumed that lightning fire potential was relatively similar for the two periods, which were the pre-1860s and 1931-1980. This method was used for two stands that border the Bitterroot Valley, which was a major heavy-use zone of Salish Indians. In both stands, the pre-1860 MFIs appeared to be about half the length as those estimated for lightning fires from 1931-1980. These results suggest that Indians were responsible for contributing to apparently shorter MFIs.

The fourth research method was to examine 946 fire scars under a microscope to see if the seasons of fire occurrence could be determined. The objective was to see if most fires occurred during mid-summer, as is expected of lightning fires in this region. Informants indicated that Indian burning occurred primarily in fall and spring. Results for the pre-1860 period seemed to indicate an unusually large percentage of fires which occurred during fall, spring, or the dormant period. Modern statistics suggest that 80 percent of lightning fires occur from mid-July to late August, whereas my data indicated only 67 percent. However, these results are inconclusive because there was a considerable amount of subjectivity involved in the approach, and my data base was relatively small.

The fifth research method was to reconstruct presettlement stand structure for the 20 stands by developing a model based on plot sampling data. The objective was to compare 1880 stand structure with successional patterns in 1980. Results indicated that stand composition and structure has changed, by varying degrees, from previous ponderosa pine dominance toward Douglas-fir climax in 12 of 16 stands. Douglas-fir dominance in the stands presumably is largely due to the absence of fire disturbance since the early 1900s. Presently overstocked stands eventually could become decadent, with a resultant increase in destructive fires.

Overall, the results of the five methods suggested that Indian fires were very influential in modifying grasslands and lower-elevation forests in habitation zones. These zones comprised a large part of western Montana. Lightning and Indians created a pattern of frequent, usually low-intensity ground fires, and this pattern was in effect for at least 400 years before the 1880s, perhaps as far back as 2,000 years or more.

The implication for modern management is to restore fire to a semblance of its previous role in ponderosa pine/Douglas-fir forests, wherever practicable. Managers may wish to conduct initial fuel reduction, followed by periodic underburning, to favor the development of stands which resemble presettlement conditions. This strategy might facilitate fire management, silviculture, management of wildlife habitat and livestock habitat, and recreation management.

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Appendix A

Informant Interview Outline

The following information was sought from informants:

I. Background Information

A. Name
B. Address
C. Race
D. Brief family history in western Montana
E. Informant's general familiarity with the area's history

II. Topical Information

A. Did informant recall hearing of Indians using fire?
B. If so, from whom?
C. What general date is referred to?
D. Any particular locations?
E. What tribes?
F. Particular details of burning:

1. Type of vegetation affected
2. Reasons for burning
3. Seasons of burning (and any related weather details)
4. Burning periodicities
5. Were fires systematically ignited? controlled? extinguished?
6. Areal extent of burning in one location
7. Who was involved in carrying out burning?
8. Any religious/ceremonial significance?
9. Long-term duration of fire-use
10. Characterize the nature of fire-use (Was burning significant in ecosystems? What effects? Other details?)
11. Do you know of carelessly caused or accidental fires?

G. Any other types of burning in the region? (e.g., by white settlers settlers or others)

III. Interview Results

A. Length of interview
B. Date
C. How informant was located (historical societies, tribal committees,,,,,, by word-of-mouth)
D. Comments (e.g., general impression of informant and interview)

Appendix B

List of Informants

Informants Who Verified Fire-Use

Doug Allard (Salish) (St. Ignatius)
Lucylle Bass (White) (Stevensville)
Louise Combs (Salish) (Arlee)
William and Clara Fewkes (White) (Rexford)
Correy Gerard (White) (Victor)
Henry Grant (White) (Grantsdale)
Inez Herrig (White) (Libby)
Lawrence Humble (White) (Hamilton, now deceased)
Charles Husec (White) (Fivemile Creek, northeast of Libby)
Dan Longpre (White) (Missoula, now deceased)
Adelaide Matt (Salish) (Arlee)
Charles McDonald (Salish) (St. Ignatius)
Harry Mittower (White) (Victor)
Larry Parker (Salish) (Ronan)
Clarence Popham (White) (Corvallis)
Eneas Pierre (Salish) (Arlee)
Irwin Puphal (White) (Thompson Falls)
Ken Rohan (Salish/White) (Victor)
Mrs. Frank Rummel (White) (Corvallis)
Pete Stasso (Kootenai) (Elmo)
Fred Wetzsteon (White) (Corvallis)
Harold Whitley (White) (Hamilton)
Burt Wilke (White) (Fortine)

Other Informants

Louise Abraham (Kootenai) (Elmo)
Mary Andrews (Kootenai) (Elmo)
Joe Antiste (Kootenai) (Elmo)
Bud Barnaby (Salish) (Arlee)
Gilbert Chaffin (White) (Corvallis)
Helen Charlo (Kootenai) (Elmo)
Abel Combs (Salish) (Arlee)
Vic Cordiere (Salish) (St. Ignatius)
Madeline Couture (Kootenai) (Elmo)
Moddess Eneas (Kootenai) (Elmo)
Harry Felix (Salish) (Arlee)
(Mrs.) Felsman (Salish) (St. Ignatius)
Helen Geisey (White) (Corvallis)
Mary Louise Glover (Kootenai) (Elmo)
Stan Greenup (White) (Hamilton)
Ben Hackett (White) (Victor)
Agnes Kenmille (Kootenai) (Elmo)
Eneas Kenmille (Kootenai) (Elmo)
Kootenai Culture Committee (Elmo)
Gilbert Lord (White) (Sula)
Dewey Matt (Salish) (St. Ignatius)
John McClintick (White) (Sula)
Hugh McKillop (White) (Woodside)
Bessie K. Monroe (White) (Hamilton)
Pete Pierre (Salish) (Arlee)
Frank Rummel (White) (Corvallis)
Salish Culture Committee (St. Ignatius)
Sarah Saloway (Cree) (Elmo)
Mitch Small Salmon (Salish) (Perma)
Phyllis Twogood (White) (Hamilton)
Agnes Vanderburg (Salish) (Arlee)
George Vogt (White) (Hamilton)
George Weisal (White) (Missoula)
Thain White (White) (Dayton)
Christine Woodcock (Salish) (St. Ignatius)

Appendix C

Stand Descriptions for Ten Pairs of Stands in Western Montana

Paired Stand Descriptions

Paired Stands	Type Heavy-Use (H) Remote (R)	Legal Location	Aspect	Elevation Ft.	Elevation (m)	Habitat Type (Pfister et al. 1977)
Fairview	(H)	SWNE22 30N 27W	270° (W)	3100-3300	(1017-1083)	Psme/Sval (Caru phase
Doak Cr.	(R)	SWNE18 31N 30W	260-270°(W-WSW)	3500-3700	(1148-1214)	Psme/Phma (Caru phase
Fivemile Cr.	(H)	SWNE17 32N 28W	208-218°(SSW-SW)	2800-3400	(919-1115)	Psme/Caru (Aruv phase)
Rainy Cr.	(R)	NESE 4 31N 30W	190-200°(SSW)	3800-4000	(1247-1312)	Psme/Syal (Caru phase)
Hog Heaven	(H)	SWSW 9 24N 22W	160-208°(SSE-SSW)	4800-5300	(1575-1739)	Psme/Caru (Agsp phase)
North Bassoo Cr.	(R)	NWNW 6 24N 24W	230° (WSW)	4300-4600	(1411-1509)	Psme/Caru (Aruv phase)
Hay Cr.	(H)	NENE 9 14N 24W	250° (WSW)	4400-4800	(1444-1575)	Psme/Phma (Caru phase)
Thompson Cr.	(R)	NENE14 14N 24W	190-210° (SSW)	4300-4800	(1411-1575)	Psme/Phma (Caru phase)
Sixmile Cr.	(H)	SESW35 16N 22W	200-240°(SSW-WSW)	4800-5200	(1575-1706)	Psme/Phma (Caru phase)
Rock Cr.	(R)	NESE25 14N 22W	180-220° (S-SW)	4200-4500	(1378-1476)	Psme/Fesc
McCalla Cr.	(H)	SESW 6 9N 21W	125-155°(SE-SSE)	5200-5700	(1706-1870)	Psme/Caru (Agsp phase)
Cutoff Gulch	(R)	NENW 5 7N 18W	120-130°(SE)	5200-5800	(1706-1903)	Psme/Phma (Caru phase)
Goat Mt.	(H)	S 9 5N 21W	130-160°(SE-ESE)	5000-5500	(1641-1804)	Psme/Syal (Agsp phase)
Sleeping Child Cr.	(R)	NESE13 4N 19W	90-140°(E-ESE)	5600-5800	(1837-1903)	Psme/Phma (Caru phase)
Hughes Cr.	(H)	NE 34 2S 22W	210-250°(SW-WSW)	5200-5400	(1706-1772)	Psme/Syal (Agsp phase)
Hog Trough Cr.	(R)	SWNW33 5N 18W	170-178°(SSE-S)	5200-5800	(1706-1903)	Psme/Syal (Agsp phase)
Indian Trees	(H)	SWSW 9 1S 19W	178-185°(S)	5300-5600	(1739-1837)	Psme/Syal (Agsp phase)
Railroad Cr.	(R)	SWSE29 5N 19W	170-178°(S)	5200-5400	(1706-1772)	Psme/Phma (Caru phase)
McCartney Cr.	(H)	SWSE22 5N 19W	190-220°(S-SW)	5100-5300	(1673-1739)	Pipo/Fesc (Fesc phase)
Two Bear Cr.	(R)	NESE 5 4N 19W	230-260°(SW-WSW)	5800-6400	(1903-2100)	Psme/Syal (Agsp phase)

Appendix D

Fire Chronologies for 10 Heavy-Use Stands

(Master Fire Chronologies begin when at least two trees, together, begin recording a relatively regular pattern of fires.)

Stand: Fairview

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	F1 PP 1980	F2 PP 1980	F3 PP 1980	F4 L 1980	F5 L 1980	F6 L 1980
1948					X		
1918		X	X				
1903						X	
1891		X		X			
1887			X		X		X
1883						X	
1871		X			X		
1866						X	X
1854		X			X		
1848			X				X
1840				X		X	
1829				X	X	X	
1824		X	X				X
1821			X	X			X
1814		X				X	
1810			X			X	X
1804		X	X	X	X		
1797			X	X		X	
1792		X			X	X	X
1785		X					X
1780			X	X		X	
1776					X	X	X
1768		X	X	X			X
1766			X			X	
1759		X	X		X	X	X
1753					X	X	
1749				X		X	X
1746		X	X	X	X	X	
1740		X		X		X	X
1731					X	X	X
1724					X		
1720					X	X	X
1717							X
1712					X		
1700 *					X		X
1688							X
1647							X
1623							X
1619							X
1590							X
1585							X
1574							X
1557							X
1554							X
	pith:	>1682	>1721	>1711	>1699	1691	>1553

*Beginning date of Master Fire Chronology

Stand: Fivemile Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	FC1 PP 1980	FC2 PP 1980	FC3 DF 1980	FC4 PP 1980	FC5 PP 1980
1953			X			
1946		X	X			
1907				X		
1901		X	X	X	X	X
1886				X		
1883			X		X	X
1876			X	X		
1870			X	X	X	
1856			X	X		
1853		X		X	X	X
1844				X		
1831		X			X	X
1824				X	X	X
1816		X				
1803		X				X
1801				X		X
1794						X
1790						X
1780						X
1764 *				X		X
1754						X
1745						X
	pith:	>1780	1844	1789	1813	1735

*Beginning date of Master Fire Chronology

Stand: Hog Heaven

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	HH1 PP 1968 (stump)	HH2 PP 1980	HH3 PP 1963 (stump)	HH4 DF 1968 (stump)	HH5 PP 1980	HH6 PP 1980
1953		X					
1946					X		
1937		X					
1926		X					
1909		X	X	X	X	X	X
1895		X	X	X	X	X	X
1888				X			X
1886				X	X		
1880		X	X	X	X		X
1869		X		X	X		
1864				X			
1860			X	X	X		X
1857		X					
1852			X				X
1850		X		X			
1840		X				X	X
1837		X		X			
1827							X
1823		X					
1815		X					
1811						X	X
1804							X
1799						X	X
1792							X
1780		X					
1748		X					
1739		X				X	
1731		X					
1725		X				X	
1717 *		X					
1691						X	
	pith:	1616	>1837	>1651	>1850	1537	>1649

*Beginning date of Master Fire Chronology

Stand: Hay Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	HAC1 PP 1980	HAC2 PP 1980	HAC3 PP 1980	HAC4 PP 1980	HAC5 PP 1980
1960		X				
1945		X				
1912		X	X		X	
1898				X	X	X
1863				X	X	
1851		X	X	X	X	X
1829		X		X	X	X
1826			X			
1818		X				
1803				X	X	X
1797					X	
1791			X		X	X
1787			X			
1772		X				X
1760		X		X	X	X
1756		X	X		X	
1752					X	
1747		X			X	X
1738					X	X
1734			X			
1727		X				X
1723					X	X
1713		X		X		X
1699		X				X
1683		X				X
1663			X	X		X
1653		X				
1637 *		X	X	X		
1615		X				
	pith:	1499	1475	1553	1556	1621

*Beginning date of Master Fire Chronology

Stand: Sixmile Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	SC1 PP 1980	SC2 PP 1957 (stump)	SC3 PP 1957 (stump)	SC4 PP 1980	SC5 PP 1980
1954						X
1936				X		X
1917		X			X	X
1907				X	X	
1899			X		X	X
1890		X			X	
1887					X	X
1869			X	X		X
1861		X				X
1858				X	X	X
1849		X		X		X
1841		X		X	X	
1829				X	X	X
1819		X			X	
1809		X	X	X	X	X
1804		X				
1793		X			X	X
1787		X	X	X	X	
1784				X		
1780			X	X		
1777				X		
1767		X	X	X		X
1762				X		X
1749		X	X	X	X	
1743			X	X		
1735		X	X			
1727			X	X		
1720			X		X	
1712				X	X	
1704 *			X	X		
1621			X			
	pith:	1623	1605	1612	1638	1678

*Beginning date of Master Fire Chronology

Stand: McCalla Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	MC1 L 1967 (stump)	MC2 PP 1967 (stump)	MC3 PP 1980	MC4 PP 1980	MC5 PP 1980
1889				X		X
1877			X		X	X
1857		X	X	X		X
1851		X				
1844				X		
1836		X	X	X		
1828		X	X			X
1824				X	X	
1818		X				X
1815		X	X			
1809			X			
1804		X	X	X	X	X
1795		X	X			
1785		X		X		X
1773		X		X	X	X
1762		X		X		
1749				X		X
1743		X			X	
1738		X		X		
1719		X		X		X
1712		X		X		
1699		X			X	X
1692		X				
1684				X		
1682				X		
1666				X	X	
1632					X	X
1628			X			
1618 *						X
1602						X
1588						X
1557						X
1530						X
1520						X
1514						X
1475						X
	pith:	1589	1616	1602	1594	1359

*Beginning date of Master Fire Chronology

Stand: Goat Mountain

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	GM1 PP 1980	GM2 PP 1980	GM3 PP 1980	GM4 PP 1980	GM5 PP 1980	GM6 PP 1980	GM7 PP 1980	GM8 DF 1980	GM9 PP 1980	GM10 PP 1980	GM11 PP 1980	GM12 PP 1980
1942												X	
1937												X	
1928										X			
1916			X										
1910								X	X			X	
1905		X		X		X							
1903						X			X				X
1888				X				X					X
1883									X				X
1880			X		X	X							
1877							X	X					
1871		X								X	X		
1870			X	X	X	X							X
1860		X		X		X	X	X			X		X
1856									X	X			
1846				X			X				X		X
1840						X		X	X	X			
1836			X			X							X
1831						X	X						X
1823				X		X			X				
1816					X	X	X	X		X			X
1812			X	X					X				
1807			X			X				X			X
1802		X		X	X			X					

(cont.)

Stand: Goat Mountain (cont.)

X = Fire Scar

Estimated Fire Year / sample: species: cambium:	GM1 PP 1980	GM2 PP 1980	GM3 PP 1980	GM4 PP 1980	GM5 PP 1980	GM6 PP 1980	GM7 PP 1980	GM8 DF 1980	GM9 PP 1980	GM10 PP 1980	GM11 PP 1980	GM12 PP 1980
1791					X							X
1786		X	X			X	X					
1783		X		X	X				X			X
1778		X										X
1769			X	X								
1765		X	X				X					
1754		X							X		X	
1749				X	X							
1740				X	X	X						
1735		X		X		X				X	X	
1723	X	X										
1709		X		X		X						
1701		X							X			
1686		X		X		X						
1678	X								X			
1666						X						X
1659		X								X		
1651	X			X								
1641	X	X										
1600				X								
1545 *		X		X						X		
1535										X		
1512										X		
1510										X		
1505										X		
pith:	>1616	1445	1753	1460	>1738	1631	1690	1730	1673	1375	1723	1638

*Beginning date of Master Fire Chronology

Stand: Hughes Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	HC1 DF 1967 (stump)	HC2 PP 1980	HC3 PP 1980	HC4 PP 1980
1954			X		
1931			X		
1927			X		
1905		X			
1886		X			
1870				X	
1865					X
1860		X			
1852				X	
1837		X	X	X	
1832					X
1825		X			
1820			X		
1810		X	X	X	
1800		X			
1791				X	X
1781		X	X	X	
1766			X		
1753		X	X	X	
1742				X	
1723		X			
1715				X	
1706			X		
1675 *			X	X	
1643			X		
1608			X		
	pith:	1697	1526	1540	>1597

*Beginning date of Master Fire Chronology

Stand: Indian Trees

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	IT1 DF 1980	IT2 PP 1980	IT3 PP 1980	IT4 PP 1980
1942		X			
1934		X			
1902		X			
1896		X			
1888		X			
1872		X		X	
1853					X
1850				X	X
1839		X			X
1834		X			
1825		X	X		
1819				X	X
1809		X		X	X
1787		X	X	X	X
1752		X	X	X	
1732			X		
1724			X		
1719			X		
1705			X		
1695 *		X	X		
1565			X		
	pith:	1720	1478	1666	1676

*Beginning date of Master Fire Chronology

Stand: McCartney Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	McC1 PP 1980	McC2 PP 1980	McC3 PP 1980	McC4 PP 1980	McC5 PP 1980	McC6 PP 1980
1932					X		
1923					X		
1914		X					
1902		X					
1897							X
1892			X	X	X	X	X
1877					X		
1874					X		X
1869			X		X		
1861			X	X		X	
1839			X			X	X
1834						X	
1825					X		X
1815							X
1805			X	X	X	X	X
1795							X
1784				X		X	
1758					X		X
1745				X	X		X
1721						X	X
1703					X	X	
1694					X		
1671						X	
1653						X	
1648						X	
1637 *						X	
	pith:	1718	1771	1691	1610	1625	1699

*Beginning date of Master Fire Chronology

Appendix E

Fire Chronologies for 10 Remote Stands

(Master Fire Chronologies begin when 2 trees, together, begin recording a relatively regular pattern of fires.)

Stand: Doak Creek

X = Fire Scar

Estimated Fire Year	sample :	DC1	DC2	DC3	DC4	DC5	DC6	DC7
	species:	DF	DF	PP	PP	PP	DF	PP
	cambium:	1980	1980	1980	1980	1980	1980	1980
1939				X	X		X	X
1907						X		
1891		X	X	X				
1888							X	X
1867				X			X	X
1861		X						
1840		X						
1832						X		
1823					X			
1801						X		
1797 *				X	X			
	pith:	1828	1723	>1783	>1765	1785	1833	>1802

* Beginning date of Master Fire Chronology

Stand: Rainy Creek

X = Fire Scar

Estimated Fire Year		RAC1	RAC2	RAC3	RAC4	RAC5	RAC6	RAC7
	sample :	RAC1	RAC2	RAC3	RAC4	RAC5	RAC6	RAC7
	species:	L	DF	PP	DF	L	LPP	PP
	cambium:	1980	1980	1980	1980	1980	1980	1980
1947		X						
1937		X						
1928		X						
1907			X				X	
1900		X				X		
1889			X	X	X			X
1880		X						
1869								X
1855		X	X					
1796				X	X			
1776 *		X		X				
	pith:	1761	1807	1751	1782	>1895	1897	1665

* Beginning of date Master Fire Chronology

Stand: North Bassoo

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	NB1 PP 1980	NB2 PP 1961 (stump)	NB3 PP 1961 (stump)	NB4 PP 1967 (stump)
1931		X	X	X	X
1916			X	X	
1903		X	X	X	X
1888		X	X		
1872		X	X	X	X
1856		X			
1848				X	
1843		X			X
1836		X	X		
1825		X	X		
1819			X		
1800		X			
1777		X		X	
1756		X			
1750				X	
1727				X	
1710 *				X	
	pith:	>1656	>1789	>1688	>1833

*Beginning date of Master Fire Chronology

Stand: Thompson Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	TC1 PP 1980	TC2 PP 1980	TC3 PP 1980	TC4 PP 1980	TC5 PP 1980	TC6 PP 1980	TC7 DF 1980	TC8 DF 1980
1901			X					X	
1889		X		X	X	X			X
1864			X						
1857								X	
1853				X	X		X		
1833						X		X	
1823		X		X	X		X		
1820									X
1758								X	
1752				X					
1731								X	
1727						X			
1721		X				X			
1700 *		X				X			
1651		X							
1609		X							
	pith:	1596	>1767	1742	1729	>1676	1681	1715	1767

*Beginning date of Master Fire Chronology

Stand: Rock Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	ROC1 PP 1980	ROC2 PP 1980	ROC3 PP 1980	ROC4 PP 1980	ROC5 PP 1980	ROC6 PP 1980
1889		X	X		X		X
1880							X
1872			X				
1848		X					
1842			X	X	X		X
1832					X		X
1826			X	X			
1819							X
1803			X				X
1786				X		X	
1776		X					
1768			X				
1695				X	X		
1680 *				X	X		
1666					X		
1562					X		
1518						X	
1443						X	
	pith:	1752	1588	1589	1550	1353	1724

*Beginning date of Master Fire Chronology

Stand: Cutoff Gulch

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	CG1 PP 1980	CG2 PP 1980	CG3 PP 1980	CG4 PP 1980	CG5 PP 1980
1962				X	X	
1957					X	
1951				X	X	
1949					X	
1934						X
1920		X				
1908		X	X			
1894						X
1878		X				
1865			X			
1854						X
1838		X		X		
1824			X			
1818				X		
1780		X	X	X		
1754		X		X		X
1727		X		X		X
1697 *						X
1652			X			
1622			X			
	pith:	1648	1540	1619	1945	1620

*Beginning date of Master Fire Chronology

Stand: Sleeping Child Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	SLC1 PP 1980	SLC2 PP 1980	SLC3 DF 1980	SLC4 PP 1980	SLC5 PP 1980	SLC6 PP 1980
1963				X			
1912				X			
1901			X			X	
1889		X			X		X
1857			X		X		
1846			X		X	X	X
1824			X		X		
1804			X			X	X
1799			X		X		
1780			X			X	X
1765					X		
1747							X
1737 *			X		X		
1635					X		
	pith:	>1815	1817	>1738	1595	>1620	>1625

*Beginning date of Master Fire Chronology

Stand: Hog Trough Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	HT1 LPP 1980	HT2 DF 1980	HT3 PP 1980	HT4 PP 1980	HT5 PP 1980	HT6 PP 1980	HT7 PP 1980	HT8 PP 1980
1949		X							
1916			X						X
1912						X	X	X	X
1904		X		X	X				
1873							X		
1868			X					X	
1859			X	X					X
1854						X			
1811					X				
1787							X		X
1779						X			
1743					X		X		
1735						X			
1722 *					X		X		
	pith:	1867	>1840	1807	1634	1633	1680	1810	>1624

*Beginning date of Master Fire Chronology

Stand: Railroad Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	RC1 PP 1980	RC2 PP 1980	RC3 PP 1980	RC4 LPP 1980	RC5 LPP 1980
1918					X	
1910		X				X
1904		X	X	X		X
1874				X		
1858		X	X			
1852		X				
1845		X				
1812		X				
1800			X			
1783		X	X			
1761			X			
1740		X	X			
1723			X			
1717		X	X			
1678		X	X			
1668 *			X			
	pith:	1621	>1661	>1858	1882	1869

*Beginning date of Master Fire Chronology

Stand: Two Bear Creek

X = Fire Scar

Estimated Fire Year	sample : species: cambium:	TB1 DF 1964 (stump)	TB2 PP 1980	TB3 PP 1980	TB4 PP 1980	TB5 PP 1980	TB6 PP 1980
1896		X	X		X		
1889				X		X	X
1872		X	X				
1867		X			X	X	
1861				X		X	X
1835			X				
1828		X		X			
1816			X				
1809		X					
1804				X			
1791		X					
1786				X		X	
1776				X	X		
1764		X			X		
1758						X	
1746					X		X
1740							X
1729 *		X					X
	pith:	1692	1794	>1722	>1649	1603	1683

*Beginning date of Master Fire Chronology

Appendix F

Synthesis of Individual Fire Report Data and Climatological Data for 6 Lightning Ignitions which Occurred in the Goat Mountain Stand between 1931 and 1980.

(Climatological Data from Environmental Sciences Administration, Env. Data Service, U.S. Department of Commerce)

Fire Name	:	Goat Mountain
Location	:	SWNE8 5N 21W
Ignition Date	:	8/20/72
Discovery Date	:	(Same)
Date Extinguished	:	(Same)
Size Class	:	A (0-1/4 acre)
Elevation	:	5,800 feet
Position on Slope	:	Upper 1/3
Slope	:	50 percent
Aspect	:	Southwest
Cover Type	:	Ponderosa pine, rocks
Fuel Loading	:	Light to medium
Wind	:	gusty, 10mph (no direction given)
Fireman's comments	:	Fire creeping in duff

Maximum
Temperature (°F)

Date:	8/13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	9/1	02	03
1 week before	83	79	80	77	80	82	81	83														
2 weeks after									86	77	65	77	81	85	88	89	91	79	74	73	77	79

Daily
Precipitation(in.)

Date:	8/13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	9/1	02	03
1 week before	.02	-	.01	-	-	-	T	T														
2 weeks after									.05	.23	-	-	-	-	-	-	-	-	-	-	-	-

ignition date

Decision: Possible spreading fire due to fuels and wind.

Fire Name : Goat Mountain
Location : SWNE8 5N 21W
Ignition Date : 7/17/70
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : B (1/4-10 acres)
Elevation : 5,500 feet
Position on Slope : Upper 1/3
Slope : 60 percent
Aspect : South
Cover Type : Ponderosa pine, brush
Fuel Loading : (not given)
Wind : gusty, 4mph (no direction given)
Fireman's comments : Fire near top of ridge; burned 1/3 acre when out

Date:	7/10	11	12	13	14	15	16	17 (ignition date)
Maximum Temperature (°F)								
1 week before	90	87	37	84	76	90	92	90
Daily Precipitation (in.)								
1 week before	.08	-	-	.76	-	-	-	.07

Date:	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Maximum Temperature (°F)														
2 weeks after	85	90	98	96	73	77	86	83	84	78	77	75	75	80
Daily Precipitation (in.)														
2 weeks after	-	-	-	.01	.04	-	-	-	-	T	.42	.40	-	-

Decision: Definite spreading fire potential (burned 1/3 acre before being extinguished).

Fire Name	:	Goat Mountain
Location	:	SWNE8 5N 21W
Ignition Date	:	7/30/64
Discovery Date	:	(Same)
Date Extinguished	:	(Same)
Size Class	:	A (0-1/4 acre)
Elevation	:	5,600 feet
Position on Slope	:	Middle
Slope	:	10 percent
Aspect	:	East
Cover Type	:	Ponderosa pine, grass
Fuel Loading	:	Light to medium
Wind	:	0-15mph (no direction given)
Fireman's comments	:	[Fire apparently confined to one snag; interpreted from description.]*

Maximum
Temperature (°F)

Date:	7/23	24	25	26	27	28	29	30 (ignition date)	31	8/1	02	03	04	05	06	07	08	09	10	11	12	13
1 week before	79	80	87	93	91	79	85	78														
2 weeks after									70	70	78	83	88	78	81	80	90	90	79	84	81	75

Daily
Precipitation(in.)

Date:	7/23	24	25	26	27	28	29	30 (ignition date)	31	8/1	02	03	04	05	06	07	08	09	10	11	12	13
1 week before	-	-	-	-	-	-	-	.33														
2 weeks after									.26	.26	T	-	-	-	-	-	-	-	-	-	.01	-

Decision: Possible spreading of fire but <u>questionable</u> due to single snag, relatively low temperatures, and .85 inches rain <u>within 2 days of ignition</u>.

Fire Name	:	Goat Mountain
Location	:	NESE8 5N 21W
Ignition Date	:	7/21/61
Discovery Date	:	(Same)
Date Extinguished	:	(Same)
Size Class	:	B (1/4-10 acres)
Elevation	:	5,200 feet
Position on Slope	:	Middle
Slope	:	100 percent
Aspect	:	South
Cover Type	:	Ponderosa pine, grass, and brush
Fuel Loading	:	Medium
Wind	:	5mph (no direction given)
Fireman's comments	:	Fire creeping in grass and duff; burned 1/2 acre before out.

Maximum
Temperature (°F)

Date:	7/14	15	16	17	18	19	20	21 (ignition date)	22	23	24	25	26	27	28	29	30	31	8/1	02	03	04
1 week before	92	95	94	87	84	86	85	89														
2 weeks after									96	91	89	88	84	93	92	90	89	93	95	98	101	101

Daily
Precipitation(in.)

Date:	7/14	15	16	17	18	19	20	21 (ignition date)	22	23	24	25	26	27	28	29	30	31	8/1	02	03	04
1 week before	-	-	.03	-	-	-	-	-														
2 weeks after									-	-	-	-	-	.07	-	-	-	-	-	-	-	-

Decision: Definite spreading fire potential: burned 1/2 acre before extinguished, hot temperatures, lack of precipitation.

Fire Name	:	Sawtooth Ridge
Location	:	SESE7 5N 21W
Ignition Date	:	8/11/45
Discovery Date	:	(Same)
Date Extinguished	:	(Same)
Size Class	:	A (0-1/4 acre)
Elevation	:	6,700 feet
Position on Slope	:	Upper 1/3
Slope	:	90 percent
Aspect	:	South
Cover Type	:	Ponderosa pine, lodgepole pine, grass, rocks
Fuel Loading	:	(not given)
Wind	:	5mph (no direction given)
Fireman's comments	:	Fire creeping [in grass and duff]; burned 1/10 acre when out.

Maximum
Temperature (°F)

Date:	8/4	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1 week before	85	86	89		82	88	86	84														
2 weeks after									83	78	81	85	93	89	91	85	85	87	87	92	96	95

Daily
Precipitation(in.)

Date:	8/4	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1 week before	-	-	-	-	T	-	-	.03														
2 weeks after									T	.16	.05	-	-	-	-	-	-	-	-	.02	-	-

(11 = ignition date)

Decision: Possible spreading fire but not probable due to cliffy terrain, near ridgetop, and slightly beyond study area (fire probably would have spread uphill and away from study

Fire Name : Roaring Lion #1
Location : NWNE18 5N 21W
Ignition Date : 7/9/39
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : B (1/4-10 acres)
Elevation : 4,500 feet
Position on Slope : Lower 1/3 (near creek bottom)
Slope : 70 percent
Aspect : Southwest
Cover Type : Ponderosa pine, lodgepole pine, spruce, duff, and grass.
Fuel Loading : (not given)
Wind : Light (no mph or direction given)
Fireman's comments : Fire creeping, burned 2 acres when out.

Date:	7/2	03	04	05	06	07	08	09 (ignition date)
Maximum Temperature (°F)								
1 week before	85	78	72	71	77	89	91	95
2 weeks after								
Daily Precipitation (in.)								
1 week before	-	T	T	.04	-	-	-	-
2 weeks after								

Date:	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Maximum Temperature (°F)														
1 week before														
2 weeks after	96	86	87	83	91	91	86	80	91	91	84	78	88	90
Daily Precipitation (in.)														
1 week before														
2 weeks after	.03	.26	-	.03	-	.05	-	-	-	-	.11	-	-	-

Decision: Definite spreading fire potential: burned 2 acres before extinguished.

Appendix G

Synthesis of *Individual Fire Report* Data and

Climatological Data for Seven Lightning Ignitions Which

Occurred in the Onehorse Ridge Stand Between 1931 and 1980

(Climatological data from Environmental Services Administration, Env. Data Service, U.S. Dept. of Commerce)

Fire Name : Tie Chute
Location : NWNW4 10N 20W
Ignition Date : 7/20/76
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : A (0-1/4 acre)
Elevation : 5,300 feet
Position on Slope : Lower 1/3
Slope : 40 percent
Aspect : Southeast
Cover Type : Ponderosa pine/Douglas-fir; large amount of regeneration
Fuel Loading : (Not given)
Wind : 0-5mph (no direction given)
Fireman's comments : Spot fire in one snag

Maximum
Temperature (°F)

Date:	7/13	14	15	16	17	18	19	20 (ignition date)	21	22	23	24	25	26	27	28	29	30	31	8/1	02	03
1 week before	82	83	86	89	89	76	82	84														
2 weeks after									82	84	89	90	84	90	90	84	89	85	90	88	82	85

Daily
Precipitation(in.)

Date:	7/13	14	15	16	17	18	19	20 (ignition date)	21	22	23	24	25	26	27	28	29	30	31	8/1	02	03
1 week before	-	-	-	-	-	.01	-	.15														
2 weeks after									.06	-	T	.16	.03	-	-	-	-	-	-	-	-	-

Decision: Possible spreading fire, but questionable due to single snag and some rain.

Fire Name : Tie Chute #1
Location : SESW5 10N 20W
Ignition Date : 7/12/75
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : A (0-1/4 acre)
Elevation : 5,800 feet
Position on Slope : Middle
Slope : 28 percent
Aspect : Southeast
Cover Type : Douglas-fir/snowberry
Fuel Loading : (Not given)
Wind : NE 6mph
Fireman's comments : Fire burning in snag; no ground fire

Date:	7/05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Maximum Temperature (°F)																						
1 week before	90	89	86	88	91	92	91	89														
2 weeks after									84	89	86	79	76	77	84	84	86	85	84	89	91	89
Daily Precipitation(in.)																						
1 week before	-	-	-	-	-	-	-	--														
2 weeks after									-	-	-	-	-	-	-	-	-	-	-	-	-	-

(Column 12 boxed: ignition date)

Decision: Possible spreading fire, but questionable due to single snag and no ground fire.

Fire Name : Tie Chute #2
Location : NWSW5 10N 20W
Ignition Date : 7/12/75 (ignited on same day as Tie Chute #1)
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : A (0-1/4 acre)
Elevation : 5,900 feet
Position on Slope : Middle
Slope : 25 percent
Aspect : East
Cover Type : Ponderosa pine/Douglas-fir/beargrass
Fuel Loading : (Not given)
Wind : NE 6mph
Fireman's comments : Some creeping ground fire in spots

Maximum
Temperature (°F)

Date:	7/05	06	07	08	09	10	11	12 (ignition date)	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1 week before	90	89	86	88	91	92	91	89														
2 weeks after									84	89	86	79	76	77	84	84	85	85	84	89	91	89

Daily
Precipitation(in.)

	7/05	06	07	08	09	10	11	12 (ignition date)	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1 week before	-	-	-	-	-	-	-	--														
2 weeks after									-	-	-	-	-	-	-	-	-	-	-	-	-	-

Decision: Possible spreading fire because of ground fire, fuels, and no rain.

Fire Name : Tie Chute
Location : Center of Sec. 7 10N 20W
Ignition Date : 7/11/68
Discovery Date : (Same)
Date Extinguished : (Same)
Size Class : A (0-1/4 acre)
Elevation : 6,300 feet
Position on Slope : Upper 1/3
Slope : 40-50 percent
Aspect : Northeast
Cover Type : western larch/Douglas-fir/"brush" and downfalls
Fuel Loading : Medium to heavy
Wind : (Not given)
Fireman's comments : Some ground fire smoldering and creeping in downed logs

Date:	7/04	05	06	07	08	09	10	11 (ignition date)	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Maximum Temperature (°F)																						
1 week before	76	86	90	90	93	95	98	93														
2 weeks after									95	91	94	89	78	74	78	78	78	87	92	82	84	84
Daily Precipitation (in.)																						
1 week before	-	-	-	-	-	.02	-	--														
2 weeks after									.02	.03	-	-	-	.10	-	-	-	-	-	-	-	-

Decision: Possible spreading fire because of ground fire, fuels, temperatures, little rain.

Fire Name	:	Onehorse
Location	:	NWNW5 10N 20W
Ignition Date	:	8/25/39
Discovery Date	:	(Same)
Date Extinguished	:	(Same)
Size Class	:	A (0-1/4 acre)
Elevation	:	6,000 feet
Position on Slope	:	Upper 1/3
Slope	:	45 percent
Aspect	:	Northeast
Cover Type	:	Douglas-fir/grass, needles, and duff
Fuel Loading	:	(Not given)
Wind	:	light (no mph given)
Fireman's comments	:	Creeping; burned 400 square feet when out

Maximum Temperature (°F)

Date:	8/18	19	20	21	22	23	24	25	26	27	28	29	30	31	9/1	02	03	04	05	06	07	08
1 week before	90	85	91	87	88	91	90	88														
2 weeks after									86	95	85	84	80	84	77	75	79	87	81	66	68	82

Daily Precipitation (in.)

	8/18–24	25	26	27	28	29	30	31	9/1	02	03	04	05	06	07	08
1 week before	(35 days since last rain)	.08														
2 weeks after			T	.09	.09	T	-	-	-	-	-	-	T	.14	-	.02

(Boxed column 25: ignition date)

Decision: Possible spreading fire because of ground fire, fuels, temperatures, little rain.

Appendix H

Stand Tables for 20 Sample Stands

(average number of trees per acre and hectare by

d.b.h. size class)

Stand: Fairview

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species		Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	[illegible]
Douglas-fir		117 (293)	43 (108)	13 (33)	23 (58)	7 (18)	2 (5)	3 (8)	1 (3)		2 (5)	1 (3)												
	Dead Trees																							
Ponderosa pine		617 (1543)	93 (233)	37 (93)	13 (33)					1 (3)	2 (5)	6 (15)	7 (18)	11 (28)	1 (3)			2 (5)		1 (3)		1 (3)		
	Dead Trees							1 (3)	1 (3)	5 (13)	4 (10)	5 (13)	7 (18)	5 (13)	1 (3)	1 (3)				1 (3)				
Western larch			17 (43)	10 (25)	7 (18)	10 (25)			2 (5)			1 (3)	1 (3)			1 (3)								
	Dead Trees							1 (3)				3 (8)	1 (3)	1 (3)										

a/ Values rounded off to nearest whole number.

Stand: Doak Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	2083 (5208)	123 (308)	7 (18)	17 (43)	3 (8)	7 (18)	9 (23)	3 (8)	3 (8)	1 (3)	4 (10)	5 (13)	2 (5)										
						Dead Trees	2 (5)	1 (3)	1 (3)		1 (3)	2 (5)	1 (3)										
Ponderosa pine								3 (8)	5 (13)	3 (8)	11 (28)	10 (25)	14 (35)	1 (3)									
						Dead Trees	1 (3)	2 (5)			3 (8)	2 (5)	1 (3)										
:ern :h				7 (18)					1 (3)		1 (3)			1 (3)									
						Dead Trees																	

a/ Values rounded off to nearest whole number.

Stand: Fivemile Cr.

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	133 (333)	87 (218)	43 (108)	20 (50)		15 (38)	9 (23)	6 (15)	5 (13)	3 (8)	5 (13)	3 (8)											
						Dead Trees	3 (8)	3 (8)	3 (8)	2 (5)	4 (10)	1 (3)	1 (3)										
Ponderosa pine				10 (25)	3 (8)	7 (18)	4 (10)	7 (18)	3 (8)	4 (10)	3 (8)	5 (13)	3 (8)		1 (3)	1 (3)			1 (3)				
						Dead Trees	1 (3)	1 (3)	1 (3)	1 (3)	3 (8)		5 (13)	1 (3)									

a/ Values rounded off to nearest whole number.

Stand: Rainy Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	150 (375)	357 (893)	33 (83)	20 (50)	37 (93)	25 (63)	14 (35)	13 (33)	1 (3)	4 (10)	1 (3)	1 (3)											
						Dead Trees	7 (18)	7 (18)	1 (3)	2 (10)	1 (3)												
Ponderosa pine						6 (15)	1 (3)	5 (13)	7 (18)	1 (3)	5 (13)	3 (8)	2 (5)										
						Dead Trees	1 (3)	3 (8)	1 (3)														
ern h								2 (5)	1 (3)		2 (5)												
						Dead Trees	1 (3)		1 (3)	1 (3)													

a/ Values rounded off to nearest whole number.

Stand: Hog Heaven

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	400 (1000)	490 (1225)	67 (168)	27 (68)	10 (25)	3 (8)	3 (8)	2 (5)	2 (5)	1 (3)	1 (3)	5 (13)											
						Dead Trees			1 (3)	2 (5)	3 (8)	2 (5)	1 (3)	1 (3)					1 (3)				
Ponderosa pine	33 (83)	13 (33)	3 (8)	3 (8)	3 (8)	6 (15)	2 (5)	3 (8)	1 (3)	1 (3)	1 (3)	1 (3)	2 (5)	1 (3)	1 (3)	1 (3)							
						Dead Trees			1 (3)		1 (3)	2 (5)	1 (3)	1 (3)	2 (5)		1 (3)	1 (3)	2 (5)	1 (3)	1 (3)		

a/ Values rounded off to nearest whole number.

Stand: North Bassoo Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	67 (168)	40 (100)	17 (43)		10 (25)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)													
						Dead Trees			1 (3)	1 (3)	1 (3)	1 (3)											
Ponderosa pine	67 (168)	103 (258)	50 (125)	17 (43)	13 (33)	23 (58)		5 (13)	2 (5)	1 (3)		3 (8)	7 (18)	1 (3)		1 (3)		1 (3)	1 (3)				
						Dead Trees	2 (5)	2 (5)	2 (5)	2 (5)	5 (13)	7 (1[illegible])	5 (13)	7 (18)	2 (5)	2 (5)	1 (3)		1 (3)				
:ern :h		7 (18)	3 (8)	7 (18)	3 (8)		1 (3)							1 (3)									
						Dead Trees																	

a/ Values rounded off to nearest whole number.

Stand: Hay Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	50 (125)	577 (1443)	190 (475)	73 (183)	23 (58)	20 (50)	3 (8)	1 (3)	3 (8)	1 (3)	1 (3)		1 (3)	1 (3)									
Dead Trees							2 (5)		1 (3)				3 (8)	1 (3)	1 (3)		1 (3)		1 (3)		1 (3)		
Ponderosa pine			3 (8)			1 (3)	1 (3)	1 (3)	1 (3)		1 (3)	2 (5)	4 (10)	1 (3)	1 (3)		1 (3)		1 (3)		2 (5)	1 (3)	
Dead Trees												2 (5)	2 (5)	1 (3)					2 (5)		1 (3)		

a/ Values rounded off to nearest whole number.

Stand: Thompson Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	167 (418)	210 (525)	87 (218)	20 (50)	37 (93)	20 (50)	10 (25)	8 (20)	8 (20)	7 (18)	7 (18)	1 (3)	1 (3)		1 (3)								
						Dead Trees	7 (18)	4 (10)	4 (10)	1 (3)	1 (3)	3 (8)	1 (3)										
[illegible]derosa [illegible]e			3 (8)						3 (8)	2 (5)	4 (10)	3 (8)	3 (8)		1 (3)	1 (3)							
						Dead Trees	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	2 (5)				1 (3)		1 (3)					

a/ Values rounded off to nearest whole number.

Stand: Goat Mountain

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	150 (375)	263 (658)	97 (243)	60 (150)	23 (58)	30 (75)	10 (25)	9 (23)	4 (10)	2 (5)													
						Dead Trees	8 (20)	1 (3)	2 (5)	1 (3)													
Ponderosa pine		3 (8)		7 (18)	13 (33)	13 (33)	10 (25)	5 (13)	4 (10)	3 (8)	6 (15)	4 (10)	1 (3)										
						Dead Trees	5 (13)	5 (13)	1 (3)	2 (5)		1 (3)	7 (18)	7 (18)	1 (3)	1 (3)							

a/ Values rounded off to nearest whole number.

Stand: Sleeping Child Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	450 (1125)	43 (108)	17 (43)	37 (93)	40 (100)	11 (28)	11 (28)	5 (13)			1 (3)												
						Dead Trees	5 (13)	10 (25)	3 (8)	1 (3)	1 (3)	2 (5)	1 (3)										
ıerosa ı	67 (168)	7 (18)				1 (3)		2 (5)			3 (8)	1 (3)		1 (3)			1 (3)		1 (3)				
						Dead Trees	1 (3)	1 (3)			1 (3)	1 (3)		1 (3)		1 (3)							

a/ Values rounded off to nearest whole number.

Stand: Sixmile Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species		Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir		267 (668)	273 (683)	27 (68)	17 (43)	10 (25)	3 (8)	1 (3)	1 (3)	1 (3)	2 (5)	2 (5)	1 (3)											
	Dead Trees								1 (3)	3 (8)	1 (3)	1 (3)	1 (3)	1 (3)										
Ponderosa pine		100 (250)	37 (93)	3 (8)			1 (3)	3 (8)		1 (3)	3 (8)	1 (3)	1 (3)	3 (8)	2 (5)		1 (3)			1 (3)		1 (3)		
	Dead Trees							2 (5)	1 (3)	5 (13)	6 (15)	1 (3)	5 (13)	1 (3)			3 (8)	1 (3)				2 (5)		

a/ Values rounded off to nearest whole number.

Stand: Rock Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	267 (918)	63 (158)	40 (100)	40 (100)	20 (50)	10 (25)	4 (10)	2 (5)	1 (3)	3 (8)	3 (8)	1 (3)											
						Dead Trees	3 (8)	3 (8)	2 (5)	3 (8)	3 (8)	1 (3)		1 (3)									
ıderosa ıe	33 (83)	17 (43)		3 (8)	3 (8)	10 (25)	6 (15)	6 (15)	5 (13)	3 (8)	3 (8)		2 (5)										
						Dead Trees	3 (8)	2 (5)		1 (3)	1 (3)			1 (3)	1 (3)	1 (3)	1 (3)						

a/ Values rounded off to nearest whole number.

Stand: McCalla Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	100 (250)	220 (550)	33 (83)	10 (25)		3 (8)	3 (8)	1 (3)	1 (3)	1 (3)	1 (3)						1 (3)						
						Dead Trees	1 (3)	1 (3)	1 (3)	1 (3)			1 (3)										
Ponderosa pine	133 (333)	193 (483)	65 (163)	23 (58)		3 (8)	7 (18)	6 (15)	3 (8)	5 (13)	1 (3)	4 (10)	2 (5)	2 (5)	2 (5)	1 (3)	1 (3)	1 (3)	1 (3)				
						Dead Trees		3 (8)	4 (10)	1 (3)	6 (15)		1 (3)	1 (3)		1 (3)	1 (3)						

a/ Values rounded off to nearest whole number.

Stand: Cutoff Gulch

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	850 (2125)	163 (408)	20 (50)			1 (3)	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)						1 (3)						
						Dead Trees	1 (3)	1 (3)	1 (3)	1 (3)	1 (3)		1 (3)										
derosa e	1100 (2750)	80 (200)		3 (8)	3 (8)	3 (8)	9 (23)	7 (18)	4 (10)	7 (18)	3 (8)	1 (3)	4 (10)	1 (3)		1 (3)							
						Dead Trees	1 (3)	3 (8)	3 (8)	3 (8)	1 (3)	2 (5)	3 (8)										

a/ Values rounded off to nearest whole number.

Stand: Hughes Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	167 (418)	100 (250)	20 (50)	27 (68)	13 (33)	3 (8)	3 (8)	1 (3)	1 (3)				1 (3)										
						Dead Trees																	
Ponderosa pine		10 (25)	13 (33)	10 (25)	30 (75)	20 (50)	7 (18)	11 (28)	7 (18)	4 (10)	3 (8)	3 (8)	4 (10)		1 (3)				1 (3)				
						Dead Trees	3 (8)		2 (5)	2 (5)	3 (8)	1 (3)	1 (3)			1 (3)		1 (3)					

a/ Values rounded off to nearest whole number.

Stand: Hog Trough Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	183 (458)	70 (175)	17 (43)		23 (58)	23 (58)	11 (28)	12 (30)	3 (8)				1 (3)										
Dead Trees							1 (3)	1 (3)	1 (3)														
onderosa ine	17 (43)	3 (8)			7 (18)	3 (8)	5 (13)	7 (18)	6 (15)	1 (3)	5 (13)												
Dead Trees								3 (8)	1 (3)	1 (3)	1 (3)	1 (3)											

a/ Values rounded off to nearest whole number.

Stand: Indian Trees

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	80 (200)	7 (18)	7 (18)	27 (68)	7 (18)	4 (10)	3 (8)	5 (13)	1 (3)	1 (3)	1 (3)												
						Dead Trees		1 (3)		1 (3)													
Ponderosa pine	50 (125)	33 (83)	23 (58)	33 (83)	53 (133)	12 (30)	9 (23)	7 (18)	3 (8)	2 (5)	1 (3)				1 (3)	1 (3)	1 (3)	1 (3)	1 (3)		2 (5)	1 (3)	
						Dead Trees	2 (5)	1 (3)	3 (8)	3 (8)			1 (3)			1 (3)					1 (3)	1 (3)	

a/ Values rounded off to nearest whole number.

Stand: Railroad Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir	17 (43)			1 (3)	1 (3)	5 (13)	5 (13)		4 (10)		2 (5)	3 (8)	4 (10)										
Dead Trees									1 (3)		1 (3)	1 (3)	3 (8)			1 (3)			1 (3)		1 (3)		
nderosa ne						1 (3)										1 (3)		1 (3)			1 (3)		
Dead Trees									1 (3)			1 (3)	1 (3)						1 (3)				

a/ Values rounded off to nearest whole number.

Stand: Two Bear Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species		Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir		217 (543)	367 (918)	153 (383)	50 (125)	17 (43)	29 (73)	10 (25)	3 (8)															
	Dead Trees							16 (40)	20 (50)	5 (13)	4 (10)	3 (8)	2 (5)	1 (3)										
Ponderosa pine					3 (8)	3 (8)	3 (8)	3 (8)	4 (10)	1 (3)	1 (3)	1 (3)	2 (5)	3 (8)	1 (3)			1 (3)		1 (3)		2 (5)		
	Dead Trees							1 (3)	2 (5)	3 (8)	1 (3)	3 (8)	3 (8)	3 (8)	1 (3)		1 (3)					1 (3)		

a/ Values rounded off to nearest whole number.

Stand: McCartney Creek

Average Number of Trees per acre (hectare) by size class a/

d.b.h. Inches (cm.) a/

Species	Seedlings	(5) 2	(10) 4	(15) 6	(20) 8	(25) 10	(31) 12	(36) 14	(41) 16	(46) 18	(51) 20	(56) 22	(61) 24	(66) 26	(71) 28	(76) 30	(81) 32	(86) 34	(91) 36	(96) 38	(101) 40	(107) 42	(112) 44
Douglas-fir					3 (8)																		
Dead Trees																							
lerosa	300 (750)	7 (18)	3 (8)	3 (8)	13 (33)	5 (13)	3 (8)	2 (5)	3 (8)	1 (3)	6 (15)	4 (10)	7 (18)	1 (3)		1 (3)	1 (3)						
Dead Trees								1 (3)	1 (3)		4 (10)			1 (3)		1 (3)			1 (3)				

a/ Values rounded off to nearest whole number.

Appendix I

Average Basal Area per Acre and Hectare

by Species for 20 Sample Stands

Average Basal Area Per Acre and Hectare by Species a/

Stand	Douglas-fir		Ponderosa Pine		Western Larch		Totals	
	Ft^2/acre	(m^2/hectare)	Ft^2/acre	(m^2/hectare)	Ft^2/acre	(m^2/hectare)	Ft^2/acre	(m^2/hectare)
Fairview b/	19.3	(4.4)	103.9	(23.9)	17.4	(4.0)	140.6	(32.3)
Doak Cr.	55.9	(12.9)	113.6	(26.1)	8.7	(2.0)	178.3	(41.0)
Fivemile Cr.	62.5	(14.4)	74.2	(17.1)	------	------	136.7	(31.5)
Rainy Cr.	79.1	(18.3)	49.1	(11.3)	7.9	(1.8)	136.1	(31.4)
Hog Heaven b/	54.9	(12.6)	37.4	(8.6)	------	------	92.3	(21.2)
North Bassoo Cr. b/	11.4	(2.6)	88.9	(20.4)	7.3	(1.7)	107.6	(24.7)
Hay Cr.	80.7	(18.6)	71.8	(16.5)	------	------	152.2	(35.1)
Thompson Cr.	105.4	(24.2)	49.3	(11.3)	------	------	154.7	(35.5)
Sixmile Cr. b/	30.2	(6.9)	53.0	(12.2)	------	------	83.2	(19.1)
Rock Cr.	46.6	(10.7)	43.8	(10.1)	------	------	90.4	(20.8)
McCalla Cr.	25.4	(5.8)	103.2	(23.7)	------	------	128.6	(29.5)
Cutoff Gulch	12.8	(2.9)	67.8	(15.6)	------	------	80.6	(18.5)
Goat Mt.	76.5	(17.6)	65.6	(15.1)	------	------	142.1	(32.7)
Sleeping Child Cr.	48.8	(11.2)	23.2	(5.3)	------	------	72.0	(16.5)
Hughes Cr.	23.4	(5.4)	92.4	(21.3)	------	------	115.8	(26.7)
Hog Trough Cr.	52.5	(12.1)	36.8	(8.5)	------	------	89.3	(20.6)
Indian Trees	25.1	(5.8)	123.8	(28.5)	------	------	148.9	(34.3)
Railroad Cr.	37.7	(8.7)	20.5	(4.7)	------	------	58.2	(13.4)
Two Bear Cr. b/	63.4	(14.6)	63.4	(14.6)	------	------	126.8	(29.2)
McCartney Cr.	1.1	(0.3)	78.6	(18.1)	------	------	79.7	(18.4)

a/ measurements taken at breast height.
b/ stand has been selectively logged within the past 15 years.