Fire History of a Western Larch/Douglas-Fir Forest Type in Northwestern Montana[1]

Kathleen M. Davis[2]

Abstract.--Mean frequencies were about 120 years for valleys and montane slopes and 150 years for subalpine slopes in this western larch/Douglas-fir forest from 1735 to 1976. Fires were small and moderately intense with occasional high intensity runs. Single burns thinned the overstory favoring mixed conifer regeneration. Multiple burns created homogeneous stands or shrubfields.

INTRODUCTION

In coniferous forests of North America fire is recognized as an ecological agent of change that, in some cases, is essential for continuation of certain biotic communities (Muir 1901, Intermountain Fire Research Council 1970, Kilgore 1973, Wright and Heinselman 1973). Acknowledging this as an integral factor of some environments, Mutch (1970) hypothesized that floral species in a fire-dependent community have flammable characteristics that promote fire. Features such as volatile oils, high resin content, serotinous cones, and fibrous bark perpetuate fire as a major ecological influence. However, in a community that is not fire dependent, species do not display flammable characteristics.

As an environmental factor, fire has direct and indirect effects on all resources; soil, water, air, animals, vegetation, etc. Provided with fire history information, land managers have an ecological basis on which to suppress fires, develop fire precriptions, and evaluate planning alternatives in order to maintain and restore natural resources. Knowledge of the pattern, behavior, and effects of historic fires gives facts to develop logical resource programs.

PURPOSE

This study was undertaken to refine sampling techniques and extend fire history investigations in western Montana into a more mesic forest type and climate than encountered by Arno (1976) in the Bitterroot Valley of the Bitterroot National Forest.[3] Coram provided a contiguous study unit with documented history of logging operations and fires since the 1920's. A fire history investigation would be a continuation of research in this Bioshpere Reserve. Specific objectives of the study were:

1.--Field test the fire methodology that was being prepared by Arno and Sneck and develop techniques for sampling logged areas and mesic forest types.

2.--Determine and describe fire history through scar analysis and stand age class structure.

3.--Interpret the role of fire using the study results and historical information from surrounding areas.

GENERAL DESCRIPTION

Coram Experimental Forest was established by the US Forest Service on June 21, 1933, for the purpose of studying the ecology and silviculture of western larch (Larix occidentalis) forests. In recent years, research projects have included other forest resources and ecological influences such as watershed, soils, pathogens, insects, and fire. The forest is located on the Hungry Horse Ranger District of the Flathead National Forest in northwestern Montana about 11 km (7 mi) south of Glacier National Park and 34 km (21 mi) northeast of Kalispell, Montana.

Coram encompasses 2984 ha (7460 ft) of the western slopes of Desert Mountain drained by Abbott Creek. The landform was created by glacial activity. Elevations rise from 1006 m (3300 ft) on Abbott Flats

[1]Paper presented at the Fire History Workshop. (University of Arizona, Tucson, October 20-24, 1980).

[2]Kathleen M. Davis is Plant/Fire Ecologist, Western Region, National Park Service, San Francisco, California.

[3]Fire history of Coram Experimental Forest was studied as partial fulfillment of a Master of Science degree in 1977. The study was supported with a cooperative agreement between the Research, Development, and Application Project, Northern Forest Fire Laboratory, US Forest Service, and School of Forestry, University of Montana, Missoula.

to 1911 m (6370 ft) on the mountain top. Slopes vary up to 80%. Soils are loamy-skeletal, and much of the area has a thin layer of volcanic ash just below the soil surface.

Coram has a mean temperature of 16°C (61°F) in summer and -7°C (19°F) in winter, and annual precipitation is about 760 mm (30 in). Seasons are distinct. Snow may fall in early October and last until May in the high elevations. Summers are short and cool with the most favorable fire weather occurring during the driest months, July and August. Summer thunderstorms approach in the late afternoon from the southwest and are usually weakened by the time they reach the forest since they have travelled over several mountain ranges. It has been noted that fewer lightning fires occur in forests of northern Idaho and Montana than in forests to the south (Barrows 1951).

This is a western larch/Douglas-fir forest type (SAF 212). Habitat types according to Pfister et al. (1977) are _Abies lasiocarpa/Clintonia uniflora_ h.t. (subalpine fir/queen cup beadlily); _Abies lasiocarpa/Menziesia ferruginea_ h.t. (subalpine fir/menziesia); _Abies lasiocarpa/Linnaea borealis_ h.t. (subalpine fir/twinflower); _Abies lasiocarpa/Xerophyllum tenax_ h.t. (subalpine fir/beargrass); _Pseudotsuga menziesii/Physocarpus malvaceus_ h.t. (Douglas-fir/ninebark); _Tsuga heterophylla/Clintonia uniflora_ h.t. (western hemlock/queen cup beadlily); and _Abies lasiocarpa/Oplopanax horridum_ h.t. (subalpine fir/devil's club).

The forest canopy becomes open at high elevations and there are very few trees on the top of Desert Mountain. Here where local climate is cold, soils are poorly developed, and snow lingers, vegetation cover is hardy perennial herbs. On lower slopes the forest is dense and continuous. Mixed conifer stands are common but small pockets of larch, lodgepole pine (_Pinus contorta_), Douglas-fir, subalpine fir, and hemlock do occur. Spruce (_Picea glauca_ x _Picea engelmannii_) is found in mixed stands mainly with Douglas-fir and subalpine fir. Ponderosa pine (_Pinus ponderosa_), western white pine (_Pinus monticola_), and whitebark pine (_Pinus albicaulis_) are scarce.

Light to medium fuel loadings prevail throughout. Undergrowth, litter, and debris less than 8 cm (3 in) diameter constitite the bulk of the ground fuels. Heavy accumulations occur as downfall where intense fires have burned or Douglas-fir bark beetle have occurred. Fuel model H is appropriate and depicts a situation where fires are typically slow spreading becoming intense only in scattered areas where the downed woody material is concentrated (Deeming et al. 1978).

METHODS

The methodology used to investigate fire history in forested and logged areas is described by Arno and Sneck (1977). The techniques were a simple process of aging and correlating dates of scars and identifying age classes of fire-initiated regeneration.

Transects were laid out in a network to cover all elevations and aspects. They were subjectively placed to maximize sampling obvious burns and other areas likely to have scarred trees and regeneration, such as ridges. Trees that were sampled were located on or adjacent to the route. When a transect crossed a logged unit, the area was intensively and systematically examined in a zigzag pattern that covered the cut.

The method suggested by Arno and Sneck is a reconnaissance walk of the network to identify and locate the best scarred trees then a second walk to collect samples. However, since trees with external scars were scarce and since most trees had only one scar, the plan was changed to sample from scarred trees and stumps on the first walk.

Sampling procedures entailed:

1.--Describing habitat types and existing vegetation.

2.--Cutting cross sections with a chainsaw from scarred trees and stumps (or making field counts on stumps when unable to get a sound cut).

3.--Coring fire-initiated regeneration to age stands.

4.--Describing in detail all trees, stumps, and regeneration sampled.

Adjacent logged areas of the Flathead National Forest were selectively studied when it became obvious that Coram's history was different from the extensive, stand-replacing fires reported for surrounding forests. The purpose of examining outlying areas was to look for evidence of past fires in order to better understand the history of the region and draw a comparison for Coram.

Attempts were made to document each fire year with a combination of cross sections, stump ring counts, or stand age classes. For some years this was not possible because of limited evidence. Cross sections were cut from lower tree trunks at a position to obtain the best scar and pith record. Annual rings on unsound stumps were counted enough times to obtain a good estimate of fire scar and pith dates. Cores to age regeneration were mainly taken from seral trees, usually larch, lodgepole, and Douglas-fir. In a few cases the climax species were used to age stands when it was obvious they represented the immediate post fire sere. All sampling was done at approximately 0.3 m (1 ft) height to obtain more accurate dates and standardize the information.

Total age for each sample was determined by adding to the pith count the estimated number of years for each species to reach 0.3 m. Throughout the study area, several seedlings of all species about 0.3 m tall were aged. This resulted in a growth factor by species for the period between germination and attaining 0.3m in height. Factor for larch, lodgepole, ponderosa, and white pine was four years, for Douglas-fir five years, and subalpine fir, whitebark pine, and spruce was six years. A ten year span was allowed as the maximum time for establishment after fire because of the many factors influencing seed germination and development.

In the laboratory, cross sections and increment cores were air dried, sanded or shaved, and examined with a binocular microscope. Ring counting proceeded from the cambium to the pith and was taken on at least three separate occasions to verify the dates. When the pith was not included, the number of additional rings to the pith was estimated by projecting the curvature and thickness of the innermost rings.

To aid analysis of fire frequencies, tree and stump data were arranged into stands based on habitat type, geographic locale, species, fire chronology, and regeneration information. Fire history was determined from individual chronologies of each stand member. The largest amount of evidence for a certain date, particularly from samples with clear ring formations, indicated the probable fire year. Dates were synchronized by moving scattered dates ahead in time (false rings) or back (missing rings) towards the fire year. Minor ring errors do not allow for precise detection of fire years so it was hypothesized that two separate scarring intensity fires did not occur within three to four years of each other in one stand. This span was selected since the scattering of dates around a year was usually within this range. Chronologies for all stands were compiled to develop a master chronology.

RESULTS AND DISCUSSION

Techniques to sample logged units and an area of infrequent fires were added to the methodology developed by Arno in a drier forest type. The successful application of the basic methodology with slight variations indicated it is generally applicable to inland coniferous forests of western North America in locations where ring counts furnish reliable data.

Vast areas of seral forest communities, mosaic vegetation patterns, fire-scarred trees, and charcoal verify the prevalence and ecological importance of fire in forests of the northern Rocky Mountains. Coram Experimental Forest is no exception. Historical evidence showed that fire has been a regular and widely occurring ecological factor.

A total of 136 scars were examined on 130 trees and stumps. Only one-fifth of the data was obtained from live trees because open scars (catfaces) were uncommon. They were generally found on thin-barked lodgepole pine, subalpine fir, spruce, and whitebark pine. Fire resistant, thick-barked western larch and Douglas-fir usually had healed scars (buried). These were undetectable on the trunk but readily could be identified on cut stumps. Consequently, information found in logged areas was essential to determining fire occurrence.

Thirty-five fire years were documented from 1602 to 1976. Fire years from 1602 to 1718 should be considered as approximate because sample sizes were small and accuracy diminishes with time. From 1718 to 1976 they are probably within a year of the actual date because more evidence was available. When dates are based solely on stand age classes they were felt to be within three to five years of the actual date. It is difficult to pinpoint fire years by age classes because of factors which can delay seedling establishment and development.

The master fire chronology undoubtly does not include all fires occurring during the record period since some small area burns would have been missed by the transect network. Moreover, it is extremely difficult if not impossible to record low intensity fires which do not leave long-termed evidence, such as scars, regeneration, or vegetation moasics. This was confirmed by the difficulity of relocating suppressed lightning fires that had been mapped.

The term "fire frequency" as used here denotes the number of years between fires or the fire-free interval. To calculate frequency, logical time periods were established. Prior to 1735 the chronological information became too sparse and frequency could not be accurately determined. From 1735 to 1910 was designated the "historical fire" period when lightning was the principal cause. The period from 1911 to 1976 was the "fire suppression" period when concerted efforts were made to contain fires since extensive control forces were organized after the notorious fires of 1910.

Average frequency was calculated for the historical fire period (1735-1910) in order to determine the occurrence of lightning fires. This was done for topographic units by computing frequency for each stand then obtaining the average of the stands in each habitat type (table 1). Thus, mean fire-free interval represents the average reoccurrence of fire on a particular site. Since fire may kill trees in a stand or, conversely, leave little evidence, frequency is referred to the site. Minimum and maximum fire-free intervals are the range of actual frequencies.

Mean fire-free intervals displayed in the table may seem long, but most stands had just one fire recorded for the historical fire period. The exceptions were three stands that had up to six fires. Long intervals are also substantiated by the fact that most trees had only one scar, because once a tree is scarred it is more susceptible to injury due to exposed, dry wood and resin accumulations around the wound. Although differences were not large, there was a trend of decreasing mean frequency with increasing elevation. On north aspects, fires were least frequent and most intense. As would be expected, multiple burns occurred primarily on south facing slopes.

Between 1602 and 1976, fire occurred somewhere in Coram on an average of every 11 years, and for the historical period it was every 12 years. During the suppression years (1910 to 1976) frequency averaged 7 years, but most burns occurred between 1910 and 1930. This may be due in part to extended

Table 1.-- Fire frequency between 1735 and 1910 by habitat type for Coram Experimental Forest, Flathead National Forest. Frequencies are based on all fire years identified within stands.

Topographic description	Habitat type groups[1]	General elevation range (meters)	Dominant trees with continued fire exclusion (most abundant species first)	Dominant trees before 1910 (most abundant species first)	No. of stands (no. of trees)	Mean fire-free interval (min-max interval[2])
Valleys	ABLA/CLUN h.t., ARNU phase ABLA/CLUN h.t., VACA phase	1000-1140	Douglas-fir western larch	western larch Douglas-fir	2 (15)	>117 years[3] (21-175)
Montane slopes	PSME/PHMA h.t., CARU phase PSME/PHMA h.t., PHMA phase ABLA/CLUN h.t., ARNU phase ABLA/CLUN h.t., VACA phase ABLA/CLUN h.t., XETE phase ABLA/CLUN h.t., PHMA phase[4] ABLA/CLUN h.t., CLUN phase ABLA/LIBO h.t., VACA phase	1200-1650	Douglas-fir western larch	Douglas-fir western larch lodgepole pine	11 (88)	121 years (6-173)
Lower subalpine slopes	ABLA/CLUN h.t., XETE phase ABLA/XETE h.t.	1575-1800	subalpine fir Douglas-fir	subalpine fir Douglas-fir lodgepole pine	3 (15)	146 years (47-132)
Upper subalpine slopes	ABLA/XETE h.t.	1800-1910	subalpine fir Douglas-fir	subalpine fir lodgepole pine whitebark pine	3 (8)	>146 years (47-175)

[1]Habitat types according to Pfister et al. 1977.

[2]The maximum interval was the longest fire-free interval within the period 1735 to 1910. For example, 175 means no fire between 1735 and 1910. The minimum interval was the shortest interval between fires during the period. The mean interval is the average frequency.

[3]The "greater than" sign denotes some stands had no fires between 1735 and 1910, so frequency was stated as 175 years for computation.

[4]ABLA/CLUN h.t., PHMA phase was a locally occurring variation of ABLA/CLUN h.t. only found in a small area of Coram Experimental Forest dentified by Pfister (1976 personal communication).

drought conditions between 1916 and 1940 (Wellner 1970) and increased settlement. It is interesting to note that 20 lightning fires have been suppressed since 1920. Thirteen of these were extinguished between 1920 and 1940.

Fires were small and usually stopped along ridges, ravines, and creeks which suggested that fuel availability and local weather influences controlled spread and intensity. Cloudy, rainy days that typically follow thunderstorms would contribute to moderate behavior. The three largest fires that occurred in 1832, 1854, and 1892 each covered only 100 to 190 ha (250 to 475 ac). No evidence of extensive, stand-replacing fires anywhere indicated that such fires are not typical of Coram. Fragments of charcoal in the soil, however, showed that past fires occurred widely throughout the forest.

Low to moderate intensity fires were common on montane slopes, but intensity increased at ridgetops or on steep slopes with heavy fuels. Fire functioned primarily as an agent of change that thinned stands, reduced fuels, rejuvenated undergrowth, and prepared seedbeds. Seral species, particularly western larch, Douglas-fir, and lodgepole pine, were promoted. In the high elevations, lodgepole pine and subalpine fir were the post fire sere under their own canopies. In the absence of fire, shade tolerant species became dominant.

The effects on vegetation varied with fire frequency, behavior, and intensity. Infrequent, moderately intense burns were most prevalent. They resulted in regeneration of mixed conifer stands commonly with small pockets dominated by a seral species. Severe burning created a more definite even-aged structure. Intense, multiple burns within a short time (<50 years) reduced the original stand and modified the species composition, generally favoring lodgepole pine or shrubfields.

Most of the perennial undergrowth species are capable of sprouting as long as the regenerative tissue is not killed by high temperatures. Moderately intense fires rejuvenated plants by burning decadent parts and stimulating new growth. Multiple and intense fires that reduced the overstory and halted succession also created conditions which favored shrubs and grasses. Herbaceous plants preferring shaded, cool microclimates decreased in abundance at least immediately after fire.

In logged units around Hungry Horse Reservoir, 24 stumps provided information for 18 fire years. Sampling confirmed fire years, areal spread, and multiple burns that were mapped by the Forest Service. It also gave evidence of older and less obvious burns. Frequency was slightly greater than for Coram, which is in accordance with other fire history studies.

Other investigators documented the character and effects of past fires in the region (Ayres 1900a, 1900b, Gabriel 1976, Antos 1977). All emphasized the severe, extensive fires and cited changes in vegetation composition, especially replacement by dense stands of lodgepole pine. Shrubfields created by multiple burns were also common. Furthermore, each mentioned the occurrence of low to moderate burns that thinned stands, primarily changing the structure more than composition. These burns typically occurred in small drainages on the side of larger valleys or in mesic valley bottoms.

In 1929 the intense Half Moon Fire almost entered Coram when it burned just to the south on Lion Hill and the present-day site of Hungry Horse Dam. A few days after the headfire went up the drainage of the Flathead River, the eastern flank became active and burned towards Coram resulting in an explosive fire on the steep north facing slopes of Belton Point on Desert Mountain (Gisborne 1931). Strong, cold drafts pulled in by the convection of the blow up subdued the flames along the ridges running south and west from the point. If winds had not stopped the flaming front, the fire would have burned into Coram.

In summary, information obtained from the experimental forest was compiled with data from the extended study area, literature, and records to gain an understanding of fire regimes for and around Coram. Coram's fire history is not representative of most of the surrounding forested lands that experienced extensive, stand-replacing fires. However, it is not atypical of the region. Several accounts and vegetative evidence of moderately intense fires proved these are widespread occurrences, especially in moist valley bottoms, topographically isolated drainages, and high elevations. Coram is a small, mesic valley that has little lightning activity except on top of Desert Mountain. The valley is topographically isolated, being protected by high ridges of Desert MOuntain. Low to moderate fires are the history of Coram, but judging from the surrounding areas, it is conceiveable that intense fires could occur in the future.

MANAGEMENT IMPLICATIONS

In this western larch/Douglas-fir forest type, fire is the primary ecological agent of disturbance that creates mosaics of vegetation composition and structure and, in turn, affects interrelated biotic and abiotic components. Mean frequencies range from 120 to 150 years within different topographic locations in an area where suppression has been carried out for roughly 50 years. The effect control has had depends when exclusion started in the fire cycle. The fact that 20 lightning fires have been suppressed since 1920 is reason to believe changes that would has occurred were prevented.

The management implications are straightforward. An important ecological factor is being successfully excluded, at least until now. If variety and stability of heterogeneous forest communities are desired, then fire ought to be restored. This can be done by incorporating prescribed burning into existing programs for wildlife, silviculture, natural fuel reduction, insects, diseases, watershed, etc. It can also be accomplished by establishing fire management zones wherein fire (natural, prescribed, or accidental) is allowed to burn during predetermined conditions.

When suppression is necessay, managers would do well to examine areal spread, regeneration, frequency, and other signs of past fire behavior to tailor control tactics when possible. In a location like Coram, the best method may be indirect attack to catch fires at topographic or vegetative breaks where most historically stopped. In areas where large, extensive fires are obvious, it would be wise to have strong control forces available or to get out of the way of the headfire. By using knowledge gained from past fires, managers can evaluate effective suppression methods beforehand and be aware of safety hazards for firefighters.

Fire history studies are planning tools. They are essential information for developing logical fire management plans. Even if the plan is total suppression it is important to know potential fire behavior and fuel situations as well as ecological consequences of fire exclusion. In addition, historical studies provide pertinent data for a variety of planning; such as wildlife management, watershed management, forest-wide planning, resources management, recreation planning, and forest pest control. Where fire is an integral factor, it must be acknowledged and incorporated into planning efforts.

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