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Fire Frequency and the Vegetal Mosaic of the Utah State University Experimental Forest

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FIRE FREQUENCY AND THE VEGETAL MOSAIC
OF THE
UTAH STATE UNIVERSITY EXPERIMENTAL FOREST

by

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Linda L. Wadleigh-Anhold

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ABSTRACT

Fire Frequency and the Vegetal Mosaic

of the Utah State University Experimental Forest

by

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A fire history study conducted for the Utah State University (USU) Experimental Forest using three distinct periods of fire frequency, historic (1700-1855), settlement (1856-1909), and suppression (1910-present), showed a decreased mean fire interval (MFI) during the settlement period and a greatly increased MFI during the suppression era. The difference was attributed to the influx of ignition sources during the settlement of the nearby Cache Valley, located 40 kilometers to the west. The interaction of settlers with the resource during logging and livestock grazing activities encouraged the high MFI and created the vegetal mosaic now observed on the study area.

The elevation of the study area, 2377 m to 2651 m, places the site in the Engelmann spruce-subalpine fir zone (<u>Picea engelmannii</u>, Parry ex Engelm.-<u>Abies lasiocarpa</u> (Engelm. ex. Wats)). The suppression era and its corresponding increase in MFI has permitted the advancement of tolerant species in the understory of the intoleran lodgepole pine (Pinus contorta var. latifolia (Engelm. ex. Wats)) and aspen (Populus tremuloides Michx.). Continue suppression of disturbance from wildfire will allow the lodgepole pine cover type, which experienced the lowest MFI during the settlement period, to be further invaded by tolerant species, leading to a decrease in stand diversity and more intense fires when they do occur.

(61 pages)

REVIEW OF LITERATURE

INTRODUCTION

The absence of fire in wildland ecosystems, due in part to suppression policies initiated in the 1900s and the removal of fine fuels by domestic livestock grazing, has contributed to a marked decline in induced vegetation mosaics. Natural succession patterns have been altered by man's disruption of natural fire regimes in fire-dependent communities.

Fire-dependent ecosystems gained their structure and distribution from diverse frequencies and intensities of cyclic fires (Parsons 1981), but now natural diversities and long-term stabilities of fire-dependent plant communities are in jeopardy due to the removal of the random disturbance of fire (Heinselman 1973). Where once the influence of fire could be seen as a contributing factor to dynamic plant communities, now a decline in the diversity of vegetation distribution and structure is seen in the absence of fire.

According to a fire history study conducted by Heinselman (1973) in the Boundary Waters Canoe Area, regular fires helped keep diversity and production high, created a mosaic of plant communities and perpetuated those communities through regular disturbances. The continuous disturbances effectively stalled succession in seral plant stages and encouraged fire-climax species. Yet the suppression of fire for the past 80 years has led to unnatural changes in western forests. Longer intervals between fires causes fuel buildup in both aerial and surface fuels and changes in forest structure such as multilayered stands and more shade tolerant species. Lengthening the fire interval could lead to more intense surface fires when they do happen and to further changes in fire frequencies and mean fire intervals (Kilgore 1978).

The realization that fire is an important natural management tool coincides with the evolving awareness that not only is total suppression frequently cost prohibitive, but also that it is a possible detriment to the perpetuation of fire-dependent communities.

Fire's Role--Pre-European Man

European man was not the first to use fire on the North American continent. Before his arrival, Indians significantly augmented lightning ignitions in the more inhabited areas of prairies, valleys and lower montane forests (Gruell 1983). Interior subalpine forests, comprised of lodgepole pine(_Pinus contorta_, Dougl. ex Loud), subalpine fir (_Abies lasiocarpa_, (Hook.) Nutt.) and Engelmann spruce (_Picea engelmannii_, Parry ex Engelman.) produce sufficient fuel to exhibit a fire cycle of 50-300 years. Indian fires may have had a small effect on these forests if summer habitation zones were adjacent, travel routes took them through these upper elevation forests or fires spread upward from lower elevations (Gruell 1983), but lightning appears to be the main ignition source due to the remoteness of the type (Arno 1983).

The arrival of European man upon the North American frontier brought an end to aboriginal fire ignitions. The advent of an agricultural society with the first European settlers clashed with the hunting and gathering fire practices of the Indians (Dahl et al 1978). Indians were relocated to reservations, and fine fuel reductions from grazing of domestic livestock and efficient fire suppression caused an increase in fire return intervals (Gruell 1983). Less frequent fires allowed more fire intolerant shrubs and trees to develop, and with even longer intervals nonsprouting shrubs, such as big sagebrush (*Artemesia tridentata*, Nutt.) and most coniferous trees were able to establish (Arno 1983). Even though early settlers also utilized fire for land clearing and accidental ignitions occurred as a result of increasing populations, woody vegetation was still able to make unprecendented advances following settlement (Gruell 1983).

Fire Source Changes Hands

Indian ignitions significantly contributed to the number of natural ignitions, helping to shape the vegetation pattern as European man found it. However, with the migration of the Indian to reservations, the flood of pioneers provided a new source of ignition. Industrialization arrived in the United States with the whistle of a locomotive and the strike of the new friction match in 1837 (Dahl et al 1978). Ignition risks increased as the expanding population demanded fossil fuels and forest products.

Lying in the northern part of Utah, near the Idaho border, the Cache Valley serves as a microcosm for the effect of settlement on the surrounding natural resources. The Valley attracted Mormon settlers in the late 1850's. However, prior to settlement by the Mormon pioneers, the areas resources were used by the Shoshone Indians, a hunting and gathering culture, that found their subsistence mainly within the confines of the valley. Once introduced to the horse, they were able to diversify their habits and travel to the buffalo grounds of western Wyoming (Roberts 1968).

Even before the first Mormon pioneer settlers ventured into the valley in 1856, it was known for the surrounding timber resource, reported by Jim Bridger in 1925 (Bird 1964). Trappers frequented the valley between 1825-1855, using it as winter quarters and trapping its' bountiful resource of wildlife. The trappers were only transient however, and the Cache Valley grew rapidly after the first influx of settlers that stayed in the valley in

1859, due largely to its plentiful water and other natural resources (Ricks and Cooley 1956).

The arrival of the railroad in Cache Valley helped the logging industry to flourish, and most lumber went to railroad ties. The 1870 census report showed five operating sawmills, which doubled to ten mills on the 1880 census after the railroad boom (Bird 1964). Besides utilizing lumber for ties, the railroads provided an important transportation outlet for timber products of Cache Valley (Bird 1964). The railroad boom diminished when the majority of forested areas were cut over.

History of Grazing

Livestock use dates back to the earliest use of the Cache Valley, when early settlers brought in a herd of cattle in 1856. A harsh winter drove them out, and saw much of the livestock perish on the trek to lower grazing lands near what is now Brigham City (Ricks and Cooley 1956). Settlers did not venture into the valley again until 1859, when Maughn's Fort was established at what is now Wellsville (Ricks and Cooley 1956).

The small number of livestock owned by settlers in the valley until 1880 did not roam far, but found suitable forage in the lower foothill range of the surrounding mountains (Roberts 1968). Sheep and cattle numbers grew rapidly with the livestock industry as settlers traded for them with migrating pioneers and the Mormon church advocated raising livestock (Roberts 1968). The increase in livestock numbers was complicated by large herds of transient sheep that came into the valley and moved into the higher mountains for summer range (Roberts 1968).

Present-day Cache and Rich counties became popular grazing sites in the 1880's and '90's, as competition for grazing on the ranges became very intense. The sheep numbers swelled with sheep travelling in from what is now Weber and Box Elder counties (Roberts 1968). Both resident livestock and transient sheep used the range without restriction.

The unregulated use of the resources caused Cache Valley citizens to fear the destruction of important watershed and timber producing areas. They requested Congress protect the lands and President Theodore Roosevelt responded by creating the Bear River Forest Reserve in 1903 (Ricks and Cooley 1956). By 1905, permits were required for grazing and livestock numbers were on the decline. The number of sheep in the valley had risen from 10,000 in 1880, to approximately 300,000 in 1900. Federal grazing controls brought the number down to less than 75,000 in 1910 (Ricks and Cooley 1956).

Early Documented Fire History

The size and number of fires in the mountains surrounding Cache Valley coincided well with the heaviest use period (Bird 1964). The census of 1880 stated one to ten percent of the timbered area of Cache County burned, or 5,000 to 50,000 acres.

Fires were largely untended until 1906, when the U.S. Forest Service arrived. An employee of the Forest Service stated in 1906 that three-fourth's of the Bear River Forest Reserve (later to become part of the Wasatch-Cache National Forest) had been burned over in the last 20 years. Blame was placed on careless sheepherders. Fires were recorded in Blacksmith Fork Canyon in 1878, as well as a "large fire" in Stump Hollow in Logan Canyon in 1881 (Bird 1964).

Public Seeks Regulations

The rapid settlement of North America by European man brought with it tools for agriculture and industrialization, but as the frontier was as yet untamed, so was Euro-man unrestrained in his use of the land. Unregulated firing practices in industrial logging and agriculture in the Lake States precipitated large conflagrations, such as the Peshtigo fire of 1870 and the Hinckley fire of 1894, which painfully awoke the public to what fire could do if indiscriminate use was allowed. These fires were actually the result of unregulated logging practices and agricultural land clearing in an area where settlement precluded land use laws. The public cried out for reforms when death tolls reached hundreds and damage was devastating. Public support for strong fire control programs arose as a result of the disastrous loss of life and property (Lotan 1977).

The Federal Government became active in fire suppression for the first time in 1886 in Yellowstone National Park. Army troops were called on to suppress 60 fires the first summer (Dahl et al 1978).

The Bureau of Forestry, established in 1905 to protect established forest reserves, was still in it's infancy when the Great Idaho blowup occurred in 1910. The Use Book, which directed Forest Service policy after 1905, listed three chief duties of forest officers: "To protect the reserves against fire, to assist the people in their use, and to see that they are properly used" (Pyne 1982, p. 194). Although other agencies, public and private alike, had sought to obtain some control over wildfires, the fledgling Forest Service took it upon itself as protector of the newly established Forest Reserves to also provide fire protection (Pyne 1982).

The Forest Service persisted in a single attitude where wildfire or man-caused ignitions were concerned. Several of the members of the new agency had survived the holocaustic fires of the first decade of the new century, and they saw fire only as an evil, to be controlled and stopped at all costs. Their attitudes flowed over into Forest Service policy, which ignored calls for controlled burning, or the fact fire might be necessary. Other disastrous fire years had occurred, but the 1910 fires were monumental in effecting policy because the conservation movement in America was at a peak, strong and vocal at the time (Dahl et al 1978). Proper management of forests was not to let them burn, and the foresters felt the holocaustic fires of 1910 gave them a public mandate of fire suppression (Pyne 1982).

The Forest Service stepped in as front runners in the race against wildfire to assume what they believed to be their duty. Chief Forester Henry Graves stated in 1910, "the first measure necessary for the successful practice of forestry is protection from forest fires" (Lotan 1977, p. 8).

Unfortunately all ignitions, natural or man-caused, were treated with the same suppression policies. In 1932, Roy Headley, Chief of the Forest Service's Division of Fire Control advocated a test of a let-burn program. The program suggested minimum protection in the areas of the 1910 fires. The plan was voted down, and partly as a result of a greatly increased labor force from the New Deal, the "10 A.M. policy" was born (Pyne 1982).

A string of bad fire years, including the Tillamook burn of 1933, brought a rapid request for stepped up fire control. The Forest Service replied with the "10 A.M. policy", born at a regional foresters meeting in 1935 (Pyne 1982). The policy was to "pursue an aggressive stance, dispatching sufficient forces to control a fire by

10 a.m. of the following day" (Lotan 1977, p. 11). The policy had critics from its initiation. Gisborne, reviewing fire control and research in 1942, objected because it specified the same measure of protection for all areas, regardless if fires were in a plantation, sagebrush steppe, or timber (Mutch 1977). Neither was there a distinction in policy between natural or man-caused ignitions.

Challenges to total fire suppression continued to arise--the southeastern United States allowed limited prescribed burning in 1943 as a result of a study of periodic burning, and in 1963 the Leopold Report on wildlife management in national parks, cited habitat changes due to suppression (Leopold et al 1963). The report suggested the National Park Service should endeavor to reimplement the natural role of fire. The policy was largely adopted in 1968. The United States Forest Service was more hesitant to react, but in 1972 they sanctioned exceptions to the 10 A.M. policy, such as wilderness areas, and in 1978, the policy was revised to integrate fire protection and use programs sensitive to management objectives (Parsons 1981).

The change in federal policy came upon a tide of realization of what fire exclusion had caused. In the publication entitled "Fire Management Considerations for Land Use Planning" (USDA Forest Service, 1974 in Mutch

1977) the Fire Management division stated:

> In our quest for total dominance over wildfires, we have set up conditions which greatly favor destructive conflagrations. We have paid too little attention to the benefits of fires. We have given little heed to the damage we cause fighting fires, compared with that of the fire itself. Finally we have isolated fire management so much from land management that some of our land use plans fail to recognize fire as a key force in the forest environment. (p. 5)

The denial of the natural role of fire in ecosystems brought about noticeable, often detrimental, changes.

During the 1960s, resource managers noticed diminishing returns on the amount of money invested in fire control (Mutch 1977). The term "cost-effective" was merely a prelude to fire management. Aside from ecological improvements, management could save money on suppression bills that frequently ran into embarrassing millions.

PRESCRIBED FIRE

Just as fire management meshes fire control methods with fire ecology, so has prescribed fire been an integral part of fire use. Fire is prescribed for wildlife habitat improvement, slash disposal and seedbed preparation, but only recently has it been viewed as a necessary ecological factor (Moore 1977). So while land managers have felt safe prescribing fire for such rudimentary improvements as reducing hazardous fuels, forage improvement, controlling undesirable understory, and access improvement (Mutch 1977), they still view fire as a very complicated tool, and when challenged with the idea of reintroducing natural fire, they tend to be cautious. They realize a need for research to determine the role of fire prior to man's intervention.

Today, fire management--"the blending of traditional fire control activities with fire ecology principles and land use planning requirements" (Mutch 1977,p. 9) is a common practice. However, the return to fire as a natural factor rather than just a tool has many requirements that have yet to be filled.

Wright and Heinselman (1973), presented fire as a natural ecosystem process that effected nutrient flow, succession, diversity and stability. Fire has been presented as an applied tool and a natural process. If fire were to be employed as a combination, would results improve? An initial step in finding the natural role of fire is to study the effects of fire before man's arrival, and the effects since.

FIRE HISTORY STUDIES

The need to predict the consequences of fire demands knowledge of the relation of natural fire to natural vegetative composition (Taylor 1974). Fire history studies, derive the historical response of an area to fire by revealing previous fire frequencies and intervals through the analysis of fire scars and age-classes of post-fire growth (Arno 1983). Fire effects may be predicted for an area by applying that information to the present vegetal composition along with the pre-burn conditions and type of fire (Lotan 1977).

The fire frequencies and effects of natural fire on stand composition and structure provided by fire history studies (Arno and Sneck 1977), may then be incorporated as a fire regime for the area into a management plan along with control activities.

Outcome of Analysis

Analysis of fire scars and age-class distributions develops the components of an ecosystem's fire regime, defined as a "particular pattern of fire frequency and intensity occurring within a particular ecosystem" (Kilgore 1978,p. 5). Once developed, the natural role of fire will have a clearer implication. The elements of a fire regime include the fire type and intensity, size of fires, and the frequency and return intervals of fire typical for the site (Heinselman 1978). Related to a site, these elements have been shown to directly affect stand dynamics.

FIRE IN THE SPRUCE-FIR TYPE

The frequency and intensity of fires is significant in determining which species will survive (Kilgore 1978), as well as affecting the complexity of the resulting vegetative mosaic. Such a mosaic is composed of varying age classes, successional stages and species. The degree of diversity may be a direct result of the fire regime, such as in the Engelmann spruce-subalpine fir type (Kilgore 1978), whose seral, climax and associate species exhibit a wide range of fire responses. In this type, lodgepole pine is a seral species as are quaking aspen (Populus tremuloides, Michx.) and Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) at lower elevations. Engelmann spruce and subalpine fir may occur as climax, depending on the particular habitat type.

Found at high elevations in northern Utah, the spruce-fir type is bounded on its upper limit by the alpine, and at the lower limit encounters the Douglas-fir climax forest. Forest litter accumulations, due to short growing seasons and generally cold, wet conditions, build up faster than they are able to decompose, providing ample fuel for natural ignitions (Lotan et al. 1978).

The absence of fire allows for the influx of tolerant subalpine fir at the expense of the spruce, Douglas-fir and lodgepole pine (Lotan et al. 1978).

Each of the species present has an exclusive response to fire due to genetic characteristics of seed production, seedbed requirements, ability to establish after a disturbance and level of shade tolerance.

A species' successional status may be related to its degree of shade tolerance. For example, lodgepole pine and aspen exhibit a high degree of shade intolerance, and as a result will not usually occur as climax species in the spruce-fir type. However, spruce and fir both have a high measure of shade tolerance, defined as the ability to survive under low light intensities and high root competition (Daniel et al. 1979).

Among the seral species appearing in the spruce-fir type is Douglas-fir, a thick barked, relatively intolerant species. As Douglas-fir occurs on the warmer end of the spruce-fir type (Barrett 1980), fire may be more frequent, favoring Douglas-fir over the more tolerant spruce-fir.

Aspen is a frequent seral associate of spruce-fir and may replace the type after a fire (Barrett 1980). Vegetative sprouting allows aspen a head start on its competition after fire, plus fire also cleanses aspen of some diseases, and destroys the competing conifer understory (Loope 1971).

The intolerance of lodgepole pine dictates its aggressive seral nature just as its' ability to establish readily on disturbed sites makes it an energetic pioneer. Fire may contribute to the establishment of lodgepole pine by preparing a bare mineral soil seedbed. Once established, lodgepole pine may play several successional roles, depending on fire frequency and intensity. Fire frequencies in lodgepole pine have been shown to vary from a maximum of 500 years to a minimum of below 100 years, with regional variations accounting for the climatic stage present (Brown 1975). As a minor seral associate, in an area of infrequent fires, young even-aged stands may be replaced by shade tolerant species in 50-200 years (Lotan et al. 1984). The short-term effects of fire control have demonstrated this to be accurate to date in lodgepole pine forests (Brown 1975).

As fire frequencies increase, so may the longevity of lodgepole pine as a seral stage. It becomes a more dominant cover type with more frequent fires, but a vigorous understory of shade tolerants may still replace the stand in 100-200 years. As fire frequency increases, lodgepole pine may become a persistant dominant, as the seed source of the less fire-resistant tolerants may have been eliminated. And finally, lodgepole pine may be a climax species, not always due to fire, but because its' wide ecological amplitude may allow it to reproduce on a site where conditions such as soil moisture are too extreme for other species to survive (Lotan et al. 1984).

Without periodic fires, lodgepole pine may easily be replaced due to its intolerant nature. A disturbance dependent forest type such as lodgepole pine can come to rely on fire as natural selection has favored the development of characteristics that let it burn more easily. Lodgepole pine exhibits a reproductive strategy of serotinous cones, and fuels created are from recurrent fire, bark beetles, dwarf mistletoe and suppression mortality (Brown 1975).

The presence of fire augments lodgepole's reproductive strategy of serotinous cones. P. contorta, var. latifolia, features hard, heavy serotinous cones (Lotan et al. 1978) which require heat to break the resin-sealed scales so the seed may be released (Taylor 1974). Frequently, soil surface heating by solar insolation is sufficient to open the cones, but a fire largely contributes to the successful release of the seeds by blackening the soil surface so more heat is absorbed, and placing the cones closer to the ground, so they receive more intense heat. Once the seeds are released, establishment may be considered a variable of fire intensity. High intensity fires create good seedbeds, release more seed in crown fires, and easily remove competing understory. A heavily stocked stand will usually result (Lotan et al. 1984).

Effects of a fire with lesser intensity will vary according to duff moisture. Dry duff will burn cleaner, exposing more soil, while wet duff exposes less bare mineral soil, and the stocking level decreases. A low-intensity fire will also result in sporadic mortality of lodgepole pine and its associates, and its survival will be with respect to the amount of seeds released and fire resistance of associates present.

The remnants of the replaced stand may also affect establishment and subsequent stand composition. The downed fuels from a stand-replacing fire create a hazard, contributing to further ignitions. Two critical periods of fire hazard exist in a new stand, according to Lotan et al. (1984), immediately after establishment when crowns of the regeneration are adjacent to downed fuels, and later in the life of the stand when the lodgepole pine begins to deteriorate, spruce-fir is evident in the understory, and able to create a fuel ladder that will carry fire into the crowns of lodgepole pine.

In the absence of fire, lodgepole pine will begin to slow in growth rate at approximately 80 years of age, and eventually the more shade tolerant species of spruce and fir will begin to dominate the stand (Lotan et al 1984). Insects, disease and fire all serve to interrupt the string of events leading to lodgepole pine's replacement (Gara et al. 1985).

Lodgepole pine may occur in extensive pure stands in flat areas due to the lack of fire breaks allowing fire to encompass vast areas. The monoculture that results makes lodgepole pine particularly susceptible to attacking pests and pathogens due to its sheer abundance (Loope 1971). A well-known pest, in terms of damage to lodgepole pine, is the mountain pine beetle (Dendroctonous ponderosae, Hopkins). The beetle promotes fire by contributing to hazardous fuel buildup. Continuous fire suppression in lodgepole pine has eliminated a natural control of pine beetle and it will continue to intensify as a result.

Fire and Climax Species in the Spruce-fir Type

The rate of successional changes in the spruce-fir type may rely heavily on the presence or absence of fire. In most naturally occurring spruce-fir sites, Houston (1973) found spruce-fir to be abundant on mesic north slopes and in riparian zones. The dampness of the site contributes to the low frequency of fires, but during droughts, the fuel ladders created by the shade tolerants lack of self-pruning and low-laying branches contribute greatly to crown fires (Kilgore 1978). As stated, periodic low intensity burns can aid the staying power of lodgepole pine on spruce-fir sites as spruce-fir crowns high flammability, non-serotinous cones and thin bark force their eventual absence from the site (Kilgore 1978).

In the absence of a lodgepole pine seed source, spruce-fir may take over immediately after a fire. Boundary trees or survivors provide a viable seed source (Loope 1971). The more tolerant subalpine fir eventually replaces Engelmann spruce in the absence of fire, as spruce seedlings have difficulty establishing in low light and increasing organic matter buildup (Loope and Gruell 1973).

FIRE SUPPRESSION AND
THE SPRUCE-FIR TYPE

The successional patterns presented in the spruce-fir type illustrate what fire suppression, or the lack of produces. The longer intervals between fires caused by suppression favors the more tolerant climax species of spruce and fir, while natural fire cycles in the type with seral lodgepole pine present, tend to favor lodgepole's perpetuation.

Fire suppression, according to Kilgore (1978), also leads to an increase in crown and surface fuels (when not periodically removed), changes in stand structure (a mosaic to monotypes), a denser forest (no periodic thinnings), a multi-layered vertical stand structure (understory present is usually tolerant competitor), an increase in ladder fuels (hence an increase in fire hazard) and an increase in the presence of more fire intolerant species. These factors lead to more intense fires when they do occur, and an increased fire occurrence probability (Kilgore 1978).

FIRE FREQUENCY AND THE VEGETAL MOSAIC OF THE UTAH STATE UNIVERSITY EXPERIMENTAL FOREST

INTRODUCTION

The absence of natural fire in wildland ecosystems, due to removal of fine fuels by livestock, lack of Indian ignitions and a suppression policy instituted in the early 1900s, has led to extensive alterations in natural vegetal succession patterns. Man's disruption of natural fire regimes in fire-dependent communities has limited natural diversity and altered the long-term stability of fire adapted plant species by removing the random disturbance of fire (Heinselman 1973). Prior to man's intervention in fire-maintained ecosystems, diverse fire frequencies and intensities materially influenced the structure and distribution of plants and animals as natural ecosystems had evolved to depend on cyclic fires for their existence and perpetuation (Parsons 1981). The absence of fire, however, has contributed to a marked alteration of natural vegetation mosaics.

Fire history studies provide land managers with fire frequencies and the effects of natural fire on stand composition and structure (Arno and Sneck 1977). Such studies help to determine the return interval of fires on a site, intensity and size of fire, effects of past fire on stand dynamics and the effects of an era of modern suppression. Once an area's natural fire cycle or regime is developed, planners may incorporate it into a fire management plan along with control activities.

A fire history study was conducted on the Utah State University(USU) Experimental Forest to examine the role wildfire has played in shaping the current vegetal mosaic. The objective of the study was to determine whether fire frequency has been reduced in the last century and if the resultant vegetal mosaic reflects that change.

A variety of techniques were used to evaluate fire history, including vegetational mapping, the correlation of fire dates from fire-scarred trees to establish a fire chronology, determination of age-class distributions using increment cores to establish the extent of fires (Tande 1979) and fuels inventory.

METHODS

Study Area

The study area encompassed the USU Experimental Forest. Located approximately 40 kilometers east of Logan, UT, the site is 1036 hectares in size and ranges in elevation from 2377m to 2651m.

Winters are cold and wet and summers warm and dry. The average monthly temperature for January is -11 degrees Celsius and 17 degrees Celsius for August. Precipitation averages 104 cm per year with only 8.3 cm occurring in the summer months. Snow packs reached maximum depths of 1.2 to 2.4 meters and may remain on site until late June

(Hart and Lomas 1979).

The major vegetation component is the Engelmann spruce-subalpine fir (*Picea engelmannii*, Parry ex Engelm.-*Abies lasiocarpa* (Hook.) Nutt.) type in late successional stages, with seral lodgepole pine (*Pinus contorta* var. *latifolia*(Engelm. ex. Wats)) and aspen (*Populus tremuloides* Michx.) stands, and small meadows distributed throughout. A young conifer understory may often be observed in the aspen stands.

The predominant habitat type over the Experimental Forest is *Abies lasiocarpa*/*Pedicularis racemosa*, (ABLA/PERA) (Schimpf et al. 1980). Seral and associate species in this habitat type correspond to the species present in the spruce-fir type. Douglas-fir is found in the lower elevations on warmer exposed sites, while lodgepole pine occurs on similar sites on higher elevations. Aspen is a common associate and Engelmann spruce is found on cooler sites (Mauk and Henderson 1984). All four species may appear on a site after a major disturbance such as fire.

Sampling

Sampling transects were established along 61m contour intervals in the elevational range from 2377m to 2651m. The 61m interval sought to provide ample coverage and facilitate location of fire-scarred trees. In flat areas where 61m spacing was insufficient, an additional transect was inserted. A continuous log of forest cover type, the predominant vegetal type, was kept along each transect. Each time the cover type changed, the boundaries, or ecotones between types were indicated on the map.

As the contour intervals were traversed, trees with fire scars were identified and recorded. Fire scars result when the cambium is killed and radial growth ceases in that area of the bole (Loope 1971). The number of fire scars were recorded for each 'catface'--an open scar resulting from fire damage. Trees with the largest number of sound scars were marked to allow for relocation.

Trees having the most visible, individual fire scars were sampled by taking a cross-section from the pith to one side of the catface (Arno and Sneck 1977). The wedges were sanded and rings were counted, using the Bannister ring counter and increment measuring software, recording the number of years back to each fire, and the number between fires. Pockets of obscured rings or rot may cause inaccurate counts, so tree records were combined into a master fire chronology (Arno and Sneck 1977).

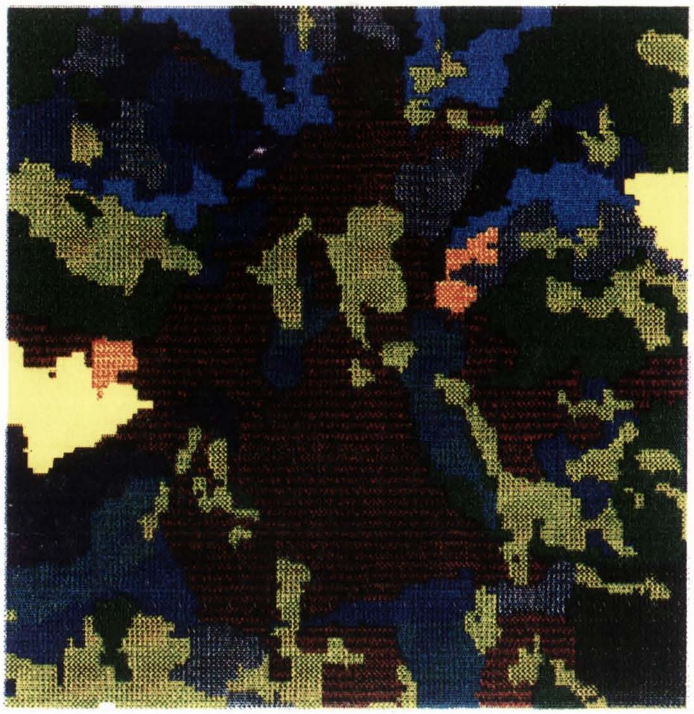
Individual tree ring counts were arranged horizontally on paper, geographically ordered so that neighboring trees were adjacent. Ten year increments were placed on the left vertical axis, beginning with the sample year at the top, and the oldest ring year recorded at the bottom. The number of trees scarred in a year was compared to the number of trees susceptible to scarring. If a tree was consistently out of order, a number of years were added or subtracted to bring it into alignment. The maximum number of years added or subtracted equaled three and sixteen trees were adjusted.

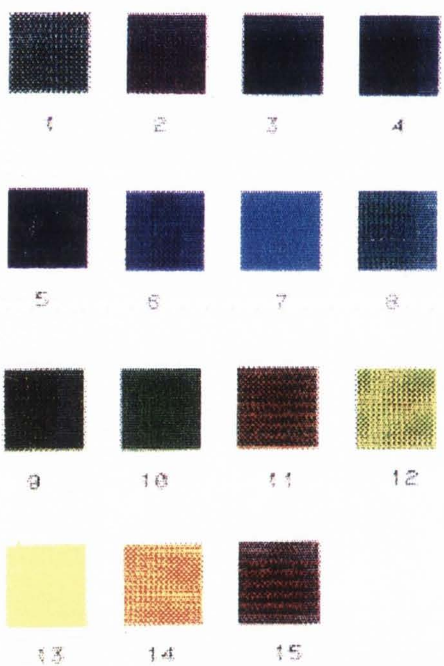
Variable cruise plots were laid out on the contour intervals at a spacing of approximately 200 meters apart. Species present were used to determine cover type and a site tree, a dominant or codominant tree on the plot, was aged for each species. Regeneration was recorded to aid in determining successional patterns. A fuel load transect (Brown 1974) was also conducted at each plot.

Stands were delineated on the study map to aid in fire frequency analysis for each cover type (Figure 1). The cover types were mapped in correlation with sample trees. Analysis of vegetal composition aided in defining fire type, size, intensity and frequency.

Increment cores taken at each plot were counted, using the Bannister core counter. After determination of stand-plot correspondence, fire years for the stand were compared to age-class. If age-class data did not correspond to fire years, other damaging agents were considered responsible for establishment of the regeneration.

A fuel load transect was measured at each plot along the contour intervals using Brown's (1974) planar intersect technique to calculate fuel loads. The





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2	AF	19.620
3	DF/ES	1.350
4	ES	25.650
5	DF/PF	8.260
6	AF/AS	62.350
7	LP/AF/AS	59.130
8	AS/ES/AF	64.980
9	LP	68.400
10	AS	162.810
11	LP/AF/ES	54.000
12	CL	188.280
13	DF/ES/AF	31.770
14	DF/AF	9.810
15	ES/AF	226.440
TOTALS:		1078.920

SCALE = 1:30000

Figure 1. Stand type map of Utah State University Experimental Forest. Stand type abbreviations--As=aspen, AF=subalpine fir, DF=Douglas-fir ES=Engelmann spruce, LP=Lodgepole pine, and PF=Limber pine

calculations determined weight for each cover type in kg/ha and volume and depth of downed woody material and duff.

Fire Frequency Calculations

Fire frequency, "the number of fires per unit" (Romme 1980), on an area basis was calculated using the stands and cover types previously determined. Three fire frequency periods were established to portray the effects of settlement, logging, grazing and modern fire suppression on the fire regime, and mean fire intervals, "an arithmetic average of all fire intervals determined in a designated area" (Romme 1980), were calculated for each period. The periods were "suppression" (1910 to the present), "settlement-era" (1859-1910) and "historic fire" (pre-settlement). The "historic fire" period had as a lower limit the year just prior to the age of the oldest tree sampled--1700. The history is limited by the longevity of the trees on the site, and the durability of the wood exposed when scarred(Heinselman 1973).

Total number of years in each period was then divided by the number of fires in each division, and mean fire interval was obtained. Documented evidence of historical fires was used to verify dates in the "settlement-era" and "fire suppression" periods.

Data were analyzed to determine fire frequencies and mean fire intervals of the area by cover type. Mean fire intervals may be overestimated from fire scars as fires must be of moderate to severe intensity to scar a tree, whereas surface fires of light intensity may be overlooked if they do not produce visible scars (Arno and Petersen 1983). Fires dated from scars were associated with the age of increment cores taken in the same stands as the fire scars to estimate age of the stand.

RESULTS

Forest Cover and Stand Types

Three forest cover types consisting of fifteen stand types were identified(Table 1 and Figure 1). Four species are represented in pure stands, lodgepole pine, Engelmann spruce, subalpine fir and aspen, but in relatively small percentages compared to their appearance in mixed stands.

Of the fourteen delineated stand types, subalpine fir, the climax species in the habitat type present (Mauk and Henderson 1984) was a major secondary stand component in nine types, and the principle component in two (Figure 1). Regeneration surveys conducted at each plot showed subalpine fir in the majority as regeneration in thirteen of the types. It secedes only to aspen regeneration in the aspen stand type.

Recorded site tree ages at each plot were used to age stand types. Ages among major stand components ranged from 63 to 284 in lodgepole pine, up to 106 in aspen, 188 in subalpine fir and 193 in Engelmann spruce. Ages for

spruce on the Experimental Forest have been recorded over 300 years of age in previous research (Daniel 1988).

Fuel load dry weights calculated ranged from 932.9 kg/ha in the clearings to 10052.66 kg/ha in the lodgepole pine/subalpine fir stand type (Table 2). The values are averages representing the total area of the stand type. Among pure stand types, Engelmann spruce had the highest fuel load followed by fir, lodgepole pine and aspen.

Calculated fuel loads for those lodgepole pine stand types experiencing fires during the last two major fire years of 1902 and 1903 are represented in Table 3. Pure lodgepole pine stands which burned in 1903 had the lowest fuel loading of 1079.83 kg/ha while lodgepole pine/subalpine fir stands which burned in 1902 had the highest with 15224.06 kg/ha.

Fire boundaries were mapped according to recorded ages of vegetation present that originated due to the disturbance, dated scars, present stand boundaries, and topography that may have encouraged the spread of the fire or served as a barrier (Figures 2, 3, 4 and 5).

Sixty-two scars were collected, 22 on Engelmann spruce trees, one on a subalpine fir and 39 on lodgepole pines. All scar and pith dates were used in the master fire chronology (Arno and Sneck 1977), but only six of the spruce scars were used to indicate fire years, while 37

Table 2. Fuel load totals within stand types in kg/ha. Numbers in parentheses are values in Tons/Acre. Stand type abbreviations--AF=subalpine fir, AS=aspen, DF=Douglas-fir, ES=Engelmann spruce, LP=lodgepole pine and PF=limber pine.

Table 3. Fuel loads in Kg/Ha in stands experiencing most recent fires. Numbers in parentheses are values in Tons/Acre.

Stand Type	Fire Year 1902	Fire Year 1903
LP		1079.83 (2.94)
LP/AF/AS	3276.2 (8.92)	1964.99 (5.35)
AF/LP/ES	3922.63 (10.68)	
LP/AF	15224.06 (41.45)	11503.44 (31.32)

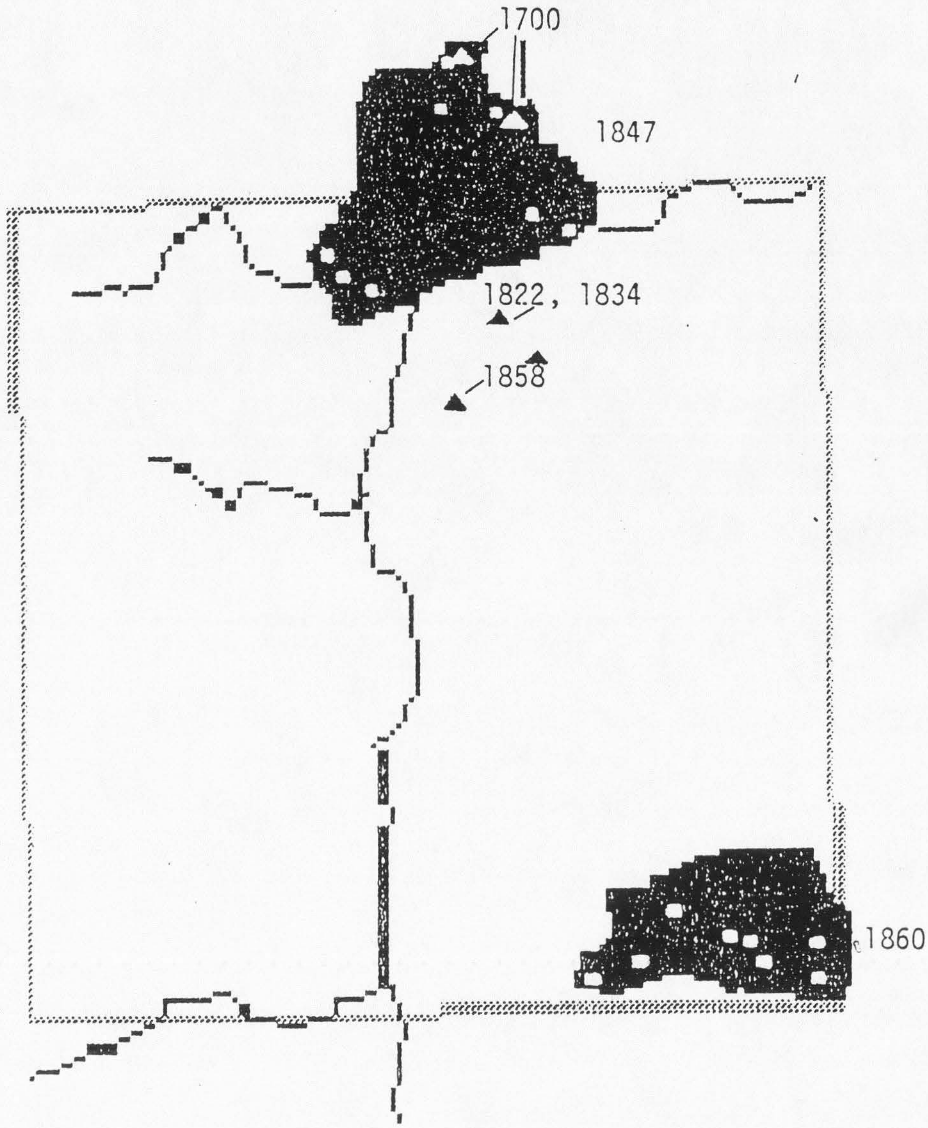

Figure 2. Fires occurring between 1700-1860 on the USU Experimental Forest. ▭ represent regeneration that occurred after the fire date. △ represent scars that recorded the particular fire date.

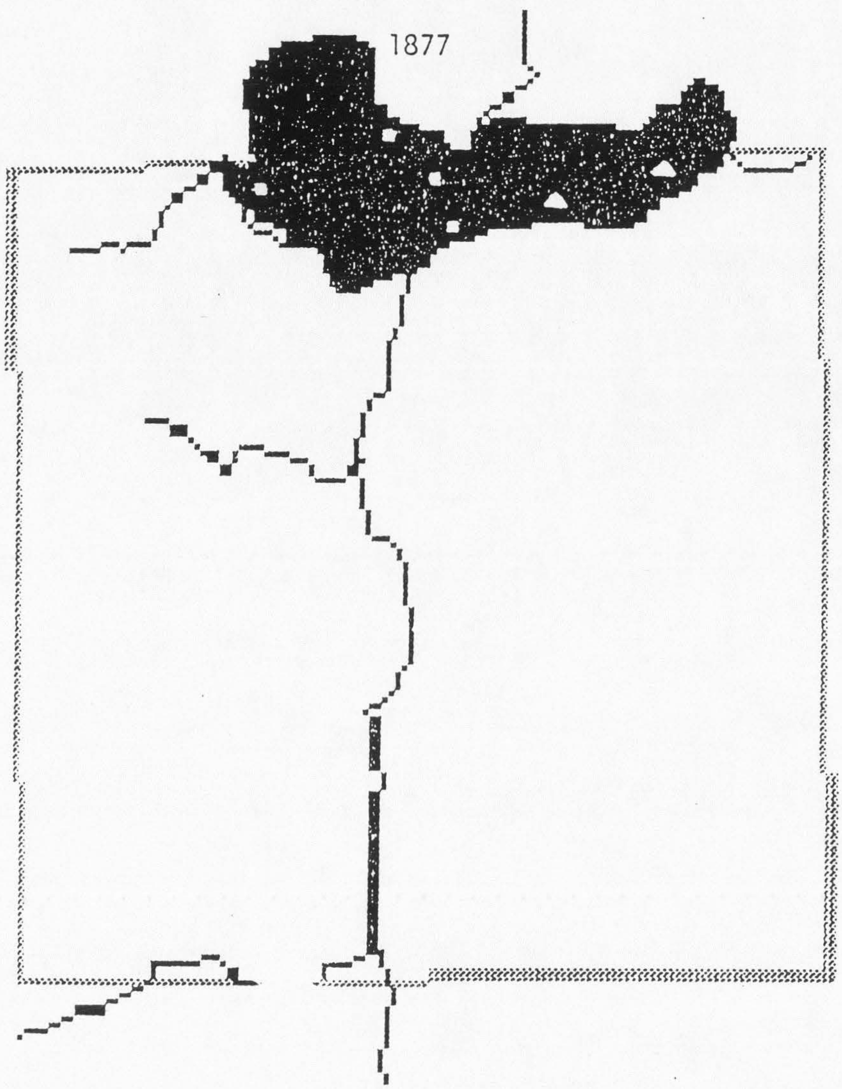

Figure 3. Fires occurring between 1861-1882 on the USU Experimental Forest. ▭ represent regeneration that occurred after the fire date. △ represent scars that recorded the particular fire date.

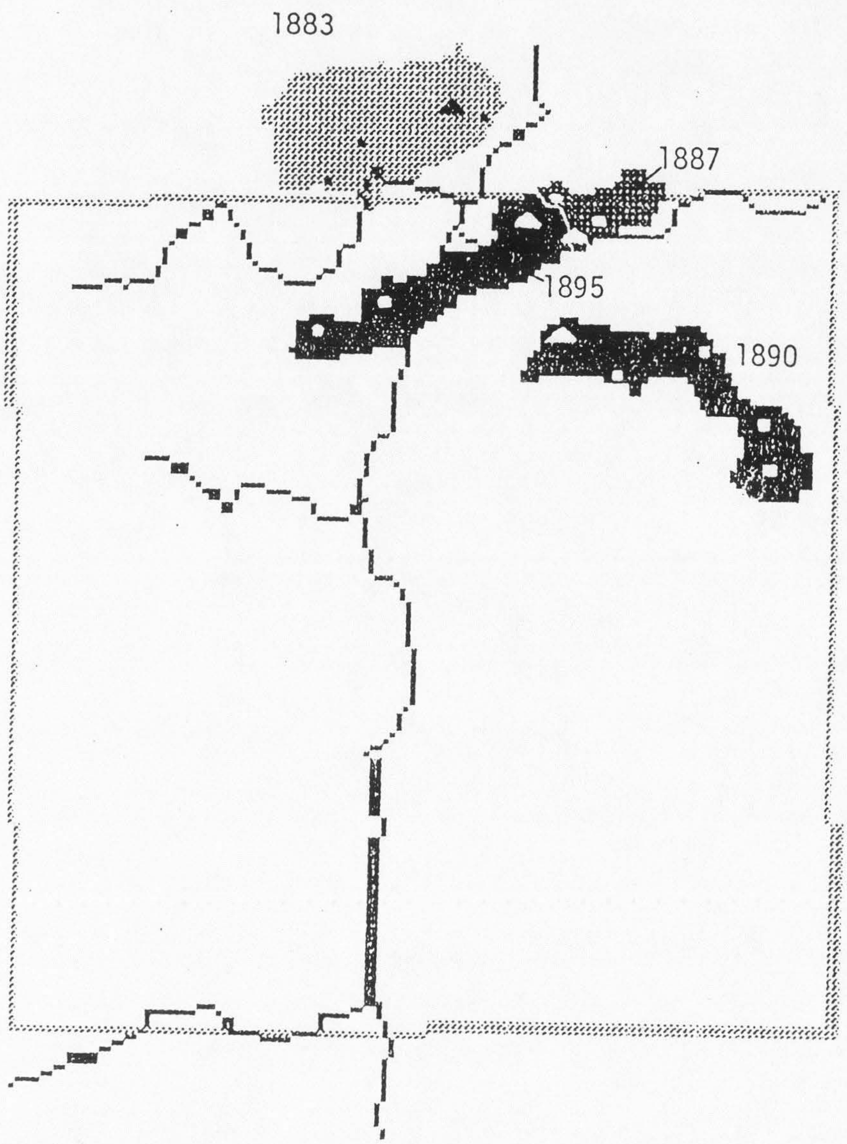

Figure 4. Fires occurring between 1883-1898 on the USU Experimental Forest. ▭ represent regeneration that occurred after the fire date. △ represent scars that recorded the particular fire date.

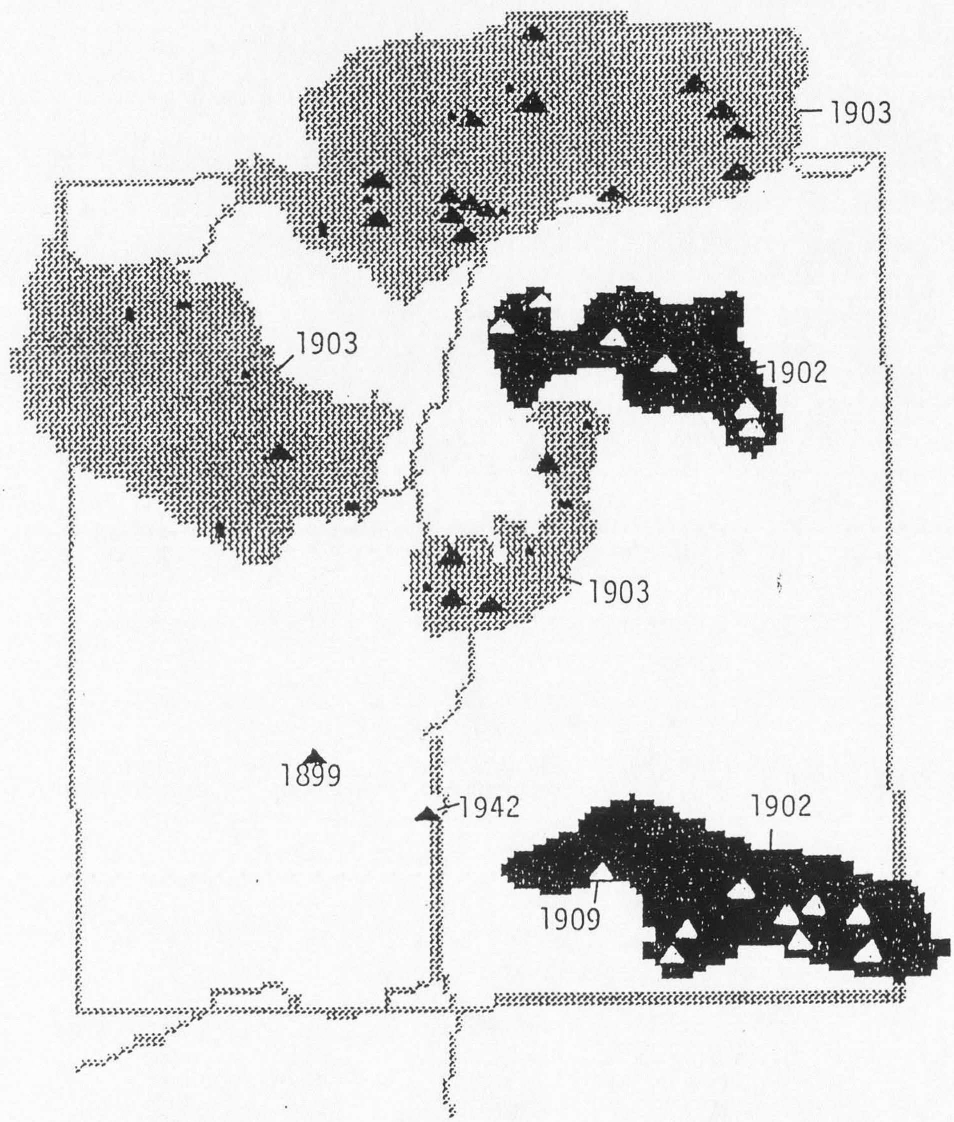

Figure 5. Fires occurring between 1899-1988 on the USU Experimental Forest. ▭ represent regeneration that occurred after the fire date. △ represent scars that recorded the particular fire date.

lodgepole scars were utilized. The remaining scars were not used due to obscured rings from decay.

A master fire chronology was developed for each stand experiencing fire in the study area as indicated by scars and the presence of even-aged regeneration (Table 4 and 5), (Arno and Sneck 1977). Sixteen fire years were represented in scar and/or regeneration data. Where scars were not present, but even-aged vegetation occurred, such as in stands L20, F24, L18 and L17 (Table 4 and 5), a fire year was assigned as one year older than the regeneration. Two of the sixteen fire years, 1700 and 1860, were represented solely by age-classes on the site. Two fire years during the settlement period, 1890 and 1895 were documented by Bird (1964). While the fires were not recorded as occurring on the study area, the occurrence of other fires implies conditions were right for wildfires.

Those stands where the major component was lodgepole pine exhibited 13 fire years, four in the historic fire period from 1700 to 1855, nine fires in the settlement period from 1856 to 1909, and no fires were indicated or recorded for the suppression period from 1910 to the present. Ten of the 13 fires were represented by fire scars and age-class analysis of the present stands (Table 4).

Stands in the spruce/fir cover type comprised of predominantly spruce/fir and secondary components of lodgepole pine, aspen, Douglas-fir and limber pine

Table 4. Fire frequency in the lodgepole cover type by stand and fire year. Stands consist of a predominant lodgepole component or mixed species with the primary overstory component of lodgepole.

Fire Year	Stands L2	L3	L4	L5	L6	L7	L22	L11	L10	L12	L15	L20	L18	L17	L9	L 13
1942	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1903	3r	2r	1r	4r	2	1	1	-r	-	-	-	-	-	-	-	-
1902	-	-	-	-	-	-	-	1r	1	1r	2	1r	1	5r	-	-
1899	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1895	-r	-	-	-	-	1	-	-	-	-	-	-	-	-	-r	-
1890	-	-	-	-	-	-	-	-	1	-r	-r	-	-	-	-	-r
1887	-	-	-	-r	-	-	-	-	-	-	-	-	-	-	-	-
1883	-r	-	-	1r	-	-	-	-	-	-	-	-	-	-	-	-
1877	-r	-	-	-r	-	1	-	-	-	-	-	-	-	-	-	-
1860	-	-	-	-	-	-	-	-	-	-	-	-r	-r	-r	-	-
1858	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
1847	-r	-r	-	2r	-	-	-	-	-	-	-	-	-	-	-	-
1834	-	-	-	-	-	-	-	-	1r	-	-	-	-	-	-	-
1822	-	-	-	-	-	-	-	-	1r	-	-	-	-	-	-	-
1700	-	-	-	r	-	-	-	-	-	-	-	-	-	-	-	-

(Adapted from Arno and Sneck 1977)

Stand Description: Lodgepole=L3, L5, L6, L22, L12, L17, L9, L13; LP/AF/AS=L2, L7, L15; LP/AF=L4, L11, L20; LP/AF/ES=L10, L18. LP=lodgepole pine, AF=subalpine fir, AS=aspen, ES=Engelmann spruce.

Digit(1,2, etc...)=number of trees in stand with fire scar date; r=regeneration in stand, determined from increment cores, that corresponds to fire date.

Table 5. Fire frequencies in the Engelmann spruce/subalpine fir and aspen cover types.

Fire Year	Engelmann spruce/subalpine fir Stands											Aspen Stands	
	E2	F3	D2	F5	E4	E5	F9	F21	F24	F7	F23	A3	A8
1942	1	-	-	-	-	-	-	-	-	-	-	-	-
1909	-	-	-	-	-	-	-	-	-	-	1	-	-
1903	1r	r?	r?	r?	1r	2r	-r	-	-	-	-	1	1r
1902	1	-	-	-	-	-	-	-r	1	-	-	-	-
1899	1	-	-	-	-	-	-	-	-	-	-	-	-
1895	-	-	-	-	-	-	-	-	-	-	-	-	-
1890	-	-	-	-	-	-	-	-	-	-r	-	-	-
1887	-	-	-	-	-	-	-	-	-	-	-	1r	-
1883	-	-	-	-	-	-	-	-	-	-	-	-	-
1877	-	-	-	-	-	-	-	-	-	-	-	1	-
1860	-	-	-	-	-	-	-	-	-r	-	-	-	-
1858	-	-	-	-	-	-	-	-	-	-	-	-	-
1847	-	-	-	-	-	-	-	-	-	-	-	-r	-
1834	-	-	-	-	-	-	-	-	-	-	-	-	-
1822	-	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-	-

(Adapted from Arno and Sneck 1977)

Stand Description: ES/AF=E2, E5; AF/AS=F3, F23; DF/ES=D2; AF/LP=F5, F7; ES/AF/AS=E4, F24; AF/ES=F9; AF/LP/ES=F21; AS=A3, A8. AS=aspen, AF=subalpine fir, DF=Douglas-fir, ES=Engelmann spruce and LP=lodgepole pine.

Digit(1,2)=number of trees in stand with fire scar date; r=regeneration in stand determined from increment cores that correspond to fire date; ?=regeneration that may have resulted from fire date but is questionable.

recorded seven fire years. There were no fires indicated in the historic fire period, six in the settlement period and one in the suppression period. Five of the seven fires were recorded by scars and validated by the age of the present stand (Table 5).

The aspen cover type exhibited four fire years, three of which were expressed by both fire scars and age-class analysis. One fire occurred in the historic fire period, four in the settlement period and no fires were recorded for the suppression period (Table 5).

Only one fire year, 1903, was common to all three types. Four fire years, 1860, 1890, 1902 and 1903 were shared between the spruce/fir and lodgepole pine cover types.

Other possible fire years are indicated by ages of the present vegetation on the study site. However, the occurrence of the regeneration was of a widespread, spotty nature and could not be attributed to a single disturbance.

Mean fire intervals were estimated for the entire study area, for each cover type and for each fire frequency period considered (Table 6). The period of deliberation for mean fire interval's ranged from 1700 to the present, 1700 being the year just prior to the establishment of the oldest tree sampled. The mean fire interval for the entire study area was 18.1 years. The

Table 6. Mean fire interval by cover type and fire frequency period. Mean fire interval is an arithmetic average in years of the number of years in a period divided by the number of fires occurring in that period. A double hyphen denotes no evidence of fire occurring in that period was found.

	Historic 1700-1855	Settlement 1856-1909	Suppression 1910-1988	Total 289 years
Study Area	39	4.9	79	18.1
Cover Types				
ES/AF	--	9	79	41.3
LP	39	6	--	22.2
AS	156	18	--	72.3

value implies a fire occurred on the average every 18.1 years somewhere within the unit.

Lodgepole pine accounted for the lowest mean fire interval among the cover types, while aspen had the highest. When the time period is divided into fire frequency periods, the lodgepole pine cover type exhibits the lowest mean fire interval for the historic and settlement periods. All three cover types display high mean fire intervals for the suppression period as in spruce/fir, or no fires at all, as in lodgepole pine and aspen (Table 6).

DISCUSSION

Stand Age and Regeneration

The widespread occurrence of subalpine fir in the types found in the study area suggests the stage of succession for the stands. The stands experiencing the most recent extensive fires, 1902 and 1903, have less of a subalpine fir component than those not experiencing recent fires. However, subalpine fir is apparent as a component of regeneration following those fires and now as a tolerant understory. When a subalpine fir climax is reached, overtopping intolerant seral species, it is not easily replaced due to its tolerant reproduction, unless a disturbance interferes, such as fire, insects, disease or logging (Eyre 1980).

Fire frequencies have shown a marked decline in the last century on the Experimental Forest. This has lead to the development of less fire resistant Engelmann spruce and subalpine fir stands. Aspen stands also have a component of subalpine fir present (Figure 1) and will require a disturbance if they are not to be replaced by the tolerant subalpine fir climax (Mauk and Henderson 1984).

Lodgepole pine overstory crown classes were dated as just following the last major fire years of 1902, 1903 or prior to that, suggesting no major disturbance since that which encouraged regeneration.

Lodgepole pine/subalpine fir stands demonstrated the highest fuel load (Table 2). Especially in this cool, moist upper subalpine zone where fuels accumulate faster than they decompose (Heinselman 1983) one should see a large amount of fuel build-up where fires have not occurred recently. Both subalpine fir and Engelmann spruce stands show a large component of their fuel load in the 3-inch and over rotten category, suggesting the fuels have been accumulating for some time, without removal by fire.

Those stands showing a greater component of fuel load in the 7.6cm plus sound category include lodgepole pine/subalpine fir and subalpine fir/Douglas-fir, suggesting these stands are younger, and have started to deteriorate only recently.

Stands experiencing the most recent fires recorded exhibit a wide range of fuel loads according to stand type (Table 3). Lodgepole pine stands with a strong subalpine fir component have much higher fuel loading, as subalpine fir is more susceptible to disease and death from injury to its thin bark than lodgepole pine (Lotan et al 1978).

Fire Frequencies

All three major cover types demonstrated few if any fires in the historic fire period. Shoshone Indians inhabited the valley prior to settlement by European man. They were a hunting and gathering culture and found sufficient food in the valley. Their ability to search for food was enhanced with the introduction of the horse (Roberts 1968)

The first trappers to come to the valley worked for the Rocky Mountain Fur Company and made the area their winter quarters in 1824. They were followed by the Hudson Bay Company trappers in 1825. The period of 1824 to 1855 probably did not see a year when the area was not visited by trappers and explorers. Migrating settlers, headed for parts further west travelled mostly through the north end of the valley (Ricks and Cooley 1956).

Although trappers and explorers visited the valley frequently, they appear to have had little more effect on ignition sources than the resident Indians. If fire did occur such as in aspen, the damage to the cover has since been lost to natural mortality and decay. Also fires may not have been severe enough to leave any indication of fire such as scarring. This also applies in the lodgepole pine and spruce/fir cover types. Additional fires may have occurred but were not recorded due to lack of substantial evidence.

All three cover types then show a large increase in fire frequency in the Settlment period (Table 4 and 5). This coincides with the increased amount of ignition sources with the arrival of settlers who utilized the resource for logging and grazing, both activities which have inherent hazards--burning slash for entry and forage. Mormon settlers entered the valley for the first time in 1856, but were driven out by a harsh winter. They returned in 1859 and established the first permanent settlement of Wellsville (Ricks and Cooley 1956). The valley was already known for the surrounding timber resource, reported in 1825 by Jim Bridger (Bird 1964), and the valley grew rapidly after the first influx of settlers, due largely to the plentiful water and other natural resources.

The arrival of the railroad in Cache Valley brought a boom to the logging industry. The 1870 census report showed five operating sawmills in Cache Valley. After the railroad boom, ten mills were reported in the 1880 census. The railroad's effect on the timber industry diminished when the majority of the forested areas were cut over

(Bird 1964).

The small number of livestock owned by the early valley settlers did not roam far but found suitable forage in the lower foothill range of the surrounding mountains (Roberts 1968). The sheep and cattle industry experienced growth as the settlers traded with migrating pioneers for livestock and the Mormon church advocated the raising of domestic livestock (Roberts 1968). Transient sheep herds from neighboring counties inflated the number of livestock already present in the 1880's as they moved into the higher mountains for summer range.

Use of the range was unrestricted in the 1890's and Valley citizens began to fear the destruction of important watershed and timber producing areas. Responding to a request to Congress to protect the lands, President Theodore Roosevelt created the Logan Forest Reserve in 1903 (Ricks and Cooley 1956). By 1905, permits were required for grazing and livestock numbers were on the decline.

The size and number of fires in the mountains surrounding Cache Valley coincided well with the heaviest use period (Bird 1964). The census of 1880 stated one to ten percent of the timbered area of Cache County burned, or 5,000 to 50,000 acres. Heavy grazing of the period undoubtedly reduced fine fuel loads, but the inordinate amount of entries into the area created an inflated ignition hazard.

Fires were largely untended until 1906, when the U.S. Forest Service arrived. An employee of the Forest Service in 1906 stated that three-fourth's of the Bear River Forest Reserve (later to become part of the Wasatch-Cache National Forest) had been burned over in the last 20 years. He blamed it on careless sheepherders. Fires were recorded in Blacksmith Fork Canyon in 1878, as well as a "large fire" in Stump Hollow in Logan Canyon in 1881 (Bird 1964).

The suppression period saw a marked decrease in fire frequency, with no evidence of fire found in the lodgepole pine and aspen types. With the advent of Forest Service suppression techniques, fire size and occurrence dropped drastically. The Logan Ranger district of the Wasatch-Cache National Forest administers the area, and although a summary of fire activity was not available, current employees of the Forest Service note the lack of fire occurrence in the area or small "single-tree" fires being immediately suppressed (Brunner and Miller 1988).

The lack of evidence of fire since 1910 cannot be credited to deterioration of the evidence as in the historic period. A fire occurrence severe enough to scar standing trees should be recorded in the present stands. The fire frequency may in actuality be higher than recorded, but fires that did occur were simply not severe enough to scar trees or were suppressed before they became extensive.

Weather variables of precipitation and temperature, recorded respectively since 1892 and 1896, did not exhibit trends conducive to decreasing or increasing fire frequency (Ashcroft 1988).

Mean Fire Intervals

Mean fire intervals for all cover types under consideration show a significant trend with a decrease in the settlement period to a large increase or no fires at all during suppression (Table 6).

The lodgepole pine cover type exhibits an expected mean fire interval for the upper subalpine zone, where if it is to exist it is perpetuated by disturbance (Mauk and Henderson 1984). Lodgepole pine types are not as abundant in the Engelmann spruce/subalpine fir areas which display a higher mean fire interval (Figure 1).

There are two periods of high fire hazard in a lodgepole pine stand that has experienced wildfire, one immediately following a fire when the regeneration shares the site with standing snags and increased ground fuels from the previous fire, and later in stand age development when crowns of the intolerant understory reach into crowns of mature lodgepole pine creating ladder fuels (Brown 1975). Consequently, lodgepole pine is able to reburn several times within a short period, such as the nine fires it experienced within 54 years on the Experimental

Forest. All the areas did not reburn nine times, however one stand had evidence of burning four times within those 54 years and several areas burned more than once (Table 4).

Aspen, also a disturbance species (Mauk and Henderson 1984), had no evidence of fire in the suppression period. The susceptibility of aspen to rot once it is damaged (Barrett 1980), allows evidence of a damaging fire to quickly disappear, which would unjustly inflate the mean fire interval for the cover type.

CONCLUSIONS

The lack of disturbance by fire on the USU Experimental Forest in the last 80 years has allowed succession to proceed towards a climax of subalpine fir. Fire frequency has been reduced following the settlement period, but the high frequencies of that time cannot be attributed to natural causes. The sharp increase in use of the natural resources in the area during settlement, and the concomitant increase in ignition sources caused the high fire frequencies. Climatic change does not appear to have caused the change in fire frequency from the historic to settlement to suppression periods; although, climate may have contributed to the size of fires during the settlement period.

The unrestricted grazing that took place during the settlment period reduced fine fuels, yet fires still occurred. Sheepherders contributed to the fire hazard as well as deflating the danger. The presence of sheepherder's campfires in the high country added to wildfire ignition sources. In addition the practice of burning slash areas to allow for entry by herds and enhance forage increased potential ignitions (Roberts 1968). Logging was not recorded as taking place on the Experimental Forest; however, documented logging areas were in close proximity (Bird 1964), and slash fires could have easily traveled upward into the area. Consequently, the resource use activities of logging and grazing unduly inflated fire frequencies during the settlement period from increased ignition sources.

Frequent disturbance by fires during the settlement period gave us the mature vegetal mosaic we now observe. Evidence indicates that these earlier fires favored lodgepole pine. However, the less frequent fires of the suppression period are favoring the more tolerant species as demonstrated by the abundance of subalpine fir regeneration in all types. The continued lack of disturbance will allow the more tolerant species of subalpine fir and Engelmann spruce to overtop the intolerant lodgepole pine and aspen. Eventually the area will lose its varietal appearance and exhibit a cover type similar to what now appears in the areas with a less frequent record of fire disturbance.

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