Changes in Species Composition of a Ponderosa Pine Stand: the effects of a fire suppression policy

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Preface and Acknowledgments

This thesis is submitted in partial satisfaction of the requirements for the Bachelor of Arts degrees in Environmental Studies and Biology at the University of California at Santa Cruz.

I began researching the subject in the winter of 1974-75. The field work was done in the summer of 1975, and the thesis was completed in the spring of 1976.

The subject is the changes that have occurred in a stand of Ponderosa pine, (*Pinus ponderosa*), which are situated in the midst of a Douglas-fir, (*Psuedotsuga menziesii*), forest. The changes are mostly due to the changing frequency of natural fire in the ecosystem.

Because this thesis is fulfilling both Biology and Environmental Studies requirements I attempt not only to identify and explain the biological aspects of the problem, but also to account for the social conditions which created the problem, and to offer some suggestions and recommendations as to how the problem may be alleviated.

Many people helped me at various times with this study. I am grateful to Henry Hazen and all the people at the Steamboat Ranger Station who made their records available to me and gave of their time and also supplied me with an increment borer to use in my field work. Thanks also to Jason Greenlee who made his reference files available to me and advised me as I conceived of this study. I am also grateful to the Umpqua Wilderness Defenders for showing me Pine Bench for the first time in 1974, and for their great hospitality to me while I was in Oregon. Finally, I would like to thank my father, who not only lent me his car so that I could do the field work, but more importantly helped me to develop my great love and respect for the forests and the North Umpqua Valley as I grew up.

ABSTRACT

A 35 acre Ponderosa pine stand situated in the midst of a Douglas-fir forest is being invaded by Douglas-fir seedlings in the understory. Located in the Umpqua National Forest, Oregon, west of the crest of the Cascade Mountains, this region is subject to many lightning fires every year. Frequent ground fires, caused by lightning strikes, used to burn through the stand, returning to the soil the nutrients locked in the litter. These fires also kept the more fire-susceptible Douglas-fir at a minimum level in the pine stand. With fire suppression the more shade-tolerant Douglas-fir invade the understory of the pines and the young pines are reduced in number due to decreased levels of light. Other undetected effects, such as infestations of pine beetles, may become evident as suppression continues.

In order to restore the area to its natural state it is necessary that fire be returned to the system. A program of prescribed, controlled burns (perhaps in conjunction with manual thinning at first) would be necessary to reduce the high level of Douglas-fir in the understory and allow Ponderosa pines to regenerate themselves. Once natural conditions were attained it might be possible to allow lightning fires to burn harmlessly through the stand.

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Introduction

In the past fifty years a 35 acre area in the Umpqua National Forest, Oregon, has changed from a nearly pure stand of Ponderosa pine (Pinus ponderosa) with an open, grassy understory to a stand of Ponderosa pine with an understory of numerous Douglas-fir (Pseudotsuga menziesii) saplings. If this trend were to continue, fifty years from today there would be some large pines still living, many pines dead or dying, and almost no young pines taking their place. I will explain the cause of this invasion of Douglas-fir in this paper, but first I will summarize the history of fire in the west: its role in the ecosystem, and various peoples attitudes towards it.

Fire, as a natural part of the ecosystem, has been affecting plant communities long before humans existed. (Chapman 1952, Mutch 1970) In fact, lightning, a major cause of natural fires is of such frequency and magnitude that few, if any, ecosystems have been unaffected by recurring lightning fires. (Komarek 1964)

Native Americans, living in an area where natural fire was common, used fire frequently, but in a careful way. Joaquin Miller, an early explorer of the Sierras, wrote in 1887

> Every spring...the old squaws began to look about for the little dry spots of headland or sunny valley,

> and as fast as dry spots appeared, they would be burned. In this way fire was always the servant, never the master....By this means, the Indians always kept their forests open, pure and fruitful, and conflagrations were unknown. (in Biswell 1967)

Ahlgren and Ahlgren (1960) have suggested that Indians also used fire to control insects and to herd game.

In the early 1800's trappers, people in the lumber industry, cattle ranchers, and pioneers came into the area believing that fire was harmful. People viewed those who set fires intentionally as being more concerned about making a fast buck, than with caring about the environment (probably an accurate view).

In keeping with this attitude in the early 1900's, the Forest Service began the policy of suppressing fires--those caused by lightning as well as by humans. At first pack animals, shovels, and dirt trails were used in fighting fires. But these gave way to tank trucks and constantly improving roads, which in turn gave way to the smokejumpers, air tankers, and aerial surveillance of today. Complete fire control and suppression is still the policy of many National Forests. In a bulletin entitled "Protecting the Forests from Fires," prepared by the Forest Service in 1969, the attitude towards fire is that "while much has been achieved in eliminating fire as a destroyer of forests and wildlands nationwide, there is still much to be done...full and effective protection against fire is one of the important phases of this great forestry job."

But there is also another view re-emerging today. This is the idea that fire is a natural and necessary part of the environment. According to this view, the suppression of natural fires leads to abnormal conditions which are undesireable from a foresters point of view as well as from an ecologists. These abnormal conditions are: increasing fire hazards in the forests, prevention of successful reproduction among some forest trees, invasions of other species, and a general breakdown of natural processes which provide for such things as nutrient recycling and elimination of insects which attack the trees. (Chapman 1952)

Harold Weaver, a forester on the Colville Indian Reservation in southern Oregon, has studied the relationship of fire and Ponderosa pine. Though Weaver was taught to believe in the incompatibility of pine forestry and fire (Weaver 1967) he realized that fire was necessary for the survival of ponderosa pine in many cases. Today, Weaver's studies are famous in fire ecology literature.

Weaver began questioning the role of fire as he noticed that many forests of the west began developing thickets of seedlings, brush, or invasions of other tree species, rather than having wide open grassy space beneath the trees. Though Weaver was beginning to believe that fire was the agent which naturally controlled these problems, he was still unsure of the exact role of fire.

In particular, he was confused how ponderosa pine could reproduce under conditions of frequent fires. Upon researching the problem, he discovered how fire and the forest interacted to allow reproduction of the pines. In the process, he discovered why ponderosa pine so often grow in groups of small even-aged trees which combine to make an uneven-aged forest over all.

In a grassy pine stand with an understory free of much brush or litter, lightning fires would burn quickly through the small deposits of needles, twigs, cones, and exfoliated bark scales. Under a group of larger trees these accumulations would be thicker, and the fires would burn hotter there, killing any young seedlings which had germinated. As the fire moved to a group of old, dead or diseased and dying pines, it would burn these trees, release the nutrients into the soil, and create a bed of ashes upon which germination of seeds could occur. Furthermore, a clearing would be created in which the young pines would grow protected from falling cones, needles, and bark scales which could feed a fire hot enough to kill them. As this group of trees grew, surface fires might burn through the grass and thin out the stand, as well as kill some of the less fire tolerant species. When the stand was larger it would drop needles, twigs, cones, and bark scales. This fuel would cause a fire to burn hot enough to prevent the development of an understory which could compete with the old pines for water and nutrients. Finally, as these trees grew old and died of lightning strikes, windthrow, or insect infestations, they would be burned, and would provide for the establishment of a new even-aged group of young pines. (Weaver 1964)

Harold Weaver began practicing controlled burning to keep pine stands healthy; he would determine when a safe time for a fire would be, and start a fire allowing it to work in its natural way.

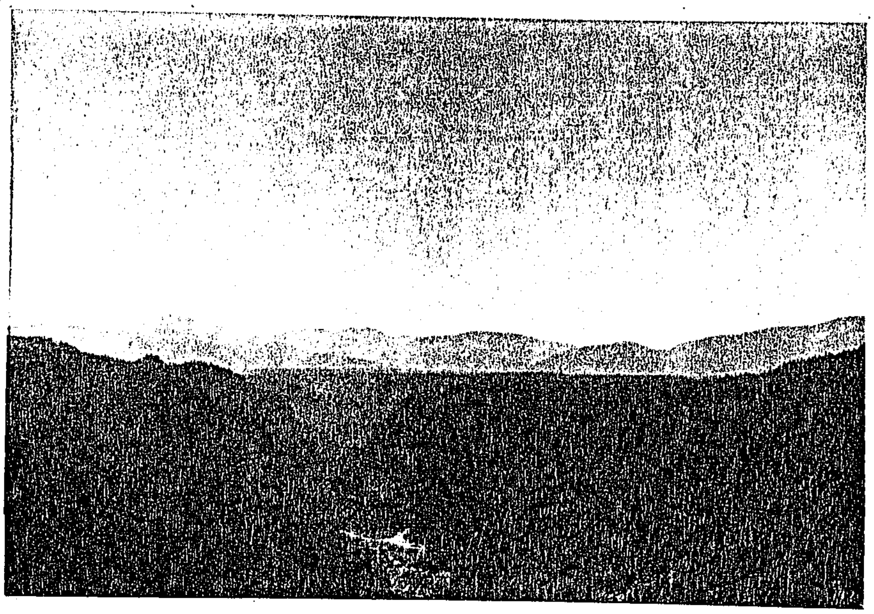
But, the awareness of the value of fire was not present everywhere. Many forests were still being protected from fire, and the forest litter accumulated. Along with the increase in levels of litter came further changes. Insect attacks on trees became more common and more severe. Less fire tolerant but more shade tolerant species began to invade some forests. In some Ponderosa pine forests, especially in the Northwest, Douglas-fir and white fir (Abies concolor) began to invade may stands. Some foresters were not upset with these changes because they believed it to be a process of natural selection. (Weaver 1964)

With increasing levels of litter, fires became hotter and began doing severe damage to some pine forests. Where this lead to increased fire protection the problem was only compounded.

While these obvious changes were taking place above ground in the forests, some less obvious changes were occurring in the soils.

In 1937, Isaac and Hopkins studied the effects of fire on the soils in the Douglas-fir region. They reported that "the field capacity of the duff and top three tenths inches of the soil was decreased, but no changes were noted below that." Vlamis et. al. (1955) reported increases in levels of phosphorous in Ponderosa pine regions in California following fires.

As the type of fire varied, so did its effect upon the soils. In general, fires where more litter had accumulated were hotter, larger, and more destructive. Frequent smaller fires kept the litter at a low level and the nutrients were returned to the soil. (Lewis 1974)



The North Umpqua river gorge cutting through the benches formed in the Miocene. Looking east from Pine Bench, the Cascade Crest is visible on the horizon.

<u>Study Area</u>

The study area is located in the Cascade Mountains of southwest central Oregon in the Umpqua National Forest. On a bench at an elevation of 2700 feet, there is a 35 acre stand of ponderosa pine, known locally as Pine Bench. The bench is flanked on two sides by precipitous slopes dropping 1100 feet into Boulder Creek and the North Umpqua River. On these slopes and to the northeast the bench is surrounded by a forest composed primarily of Douglas-fir, but also including white fir (<u>Abies concolor</u>), sugar pine (<u>Pinus lambertiana</u>), and incense-cedar (<u>Calocedrus decurrens</u>.)

Ponderosa pine is rare this far north and west of the Cascade Crest, but several small stands are found nearby on similar benches overlooking the river.

The origin of these benches stems from volcanic activity in the Miocene when a thick layer of highly erodable pyroclastics was capped by an andesitic flow of lava. As the river and creeks wore through the protective layer of andesite, the underlying pyroclastics were readily attacked, creating the deep gorges flanking these benches today. (Geldon in Daly, Caruso, Counts, Taylor, and Leuthold, 1973)

The soil found on the study area is moderately well drained, permeable, reddish brown, and plastic, ranging in thickness from seven to twelve feet. (Algis, 1965)

Located west of the crest of the Cascades, precipitation is quite heavy in the winter, and summer thunder storms are common, making the area quite wet in relation to the usual habitat of ponderosa pine.

The first people known to have inhabited the area were a band of Athapaskan peoples known as the Umpquas. These people were decimated by the diseases of the white people and the tribe, once numbering several hundred, was reduced to less than 75 people by 1840. In 1854-56 the remaining Umpquas, except for Chief Nezic and 20 of his family group, were removed to a reservation at Grande Ronde. (Bakken, 1974) Evidence of their use of Pine Bench and areas nearby remains in their tools, and paintings in some hunting caves.

In approximately 1875 Bill Bradley came to the Boulder Creek area as a trapper and homesteader. Perry Wright came to the area near the turn of the century and used Pine Bench as a resting place for some of his cattle as he moved them from winter to summer pasture, but the cattle were few and were not on the bench long, so the effects of their grazing upon the vegetation were small. (Wright, personal communication)

By 1920 the USFS had established a fire lookout on Illahee Rock, four miles from Pine Bench, and the policy of fire suppression was begun. Fires were fought at first by pack trains, but today the Forest Service is engaged in fire suppression to a high degree using aerial surveilance and suppression.

The most convenient surface access to the bench is a foot trail from the North Umpqua Highway. Pine Bench is used by hikers and backpackers exploring the Boulder Creek area which is the last completely unlogged drainage in the Umpqua National Forest; many people would like to see this area designated as a wilderness area by the Forest Service.

Walking through Pine Bench, one can notice that the area is in a state of change. Many of the big old pines are dying and coming up in their places are not young ponderosa pines, but Douglas-firs--in some places in such thickets that one can hardly walk through them. (figure 1.) Young pines do exist, but not in such abundance as the Douglas-firs. The rest of this paper will explain the cause of this invasion, and offer some possibilities for checking and reversing it.

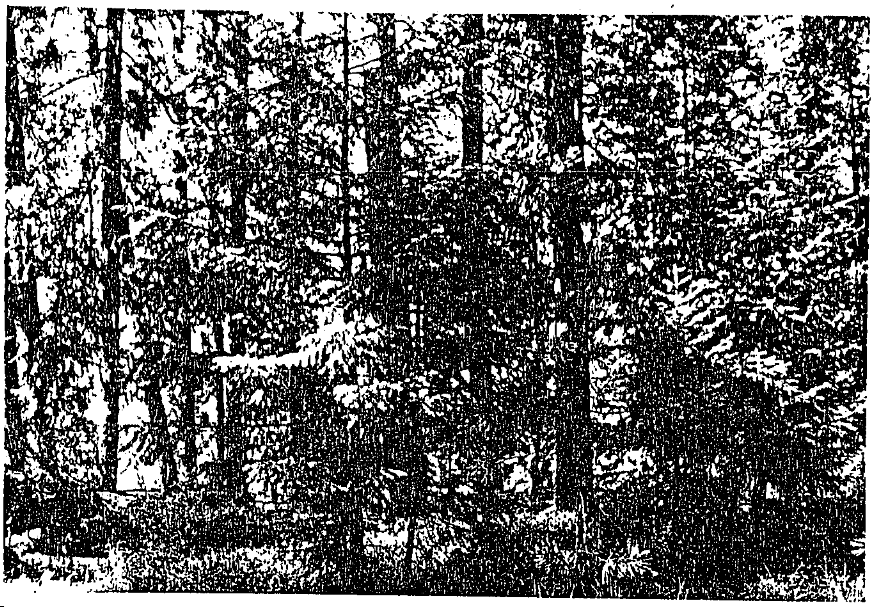


Figure 1. Thicket of young Douglas-firs. The large trunked trees in the photo are ponderosa pine.

Study Methods

In order to study the changes occurring on Pine Bench I wanted to find out as much as I could about what had happened on the bench. The USFS has kept records of fires since 1939, including how large the fires were, how they were started, and each fire's location. I used this information to explain the geographical distribution and frequency of fires in the area. The Forest Service also made soil and timber type maps available to me. According to the Forest Service, the only use to which the bench had been put since white settlement was the grazing by Perry Wright's cattle in the early 1900's. I was able to visit with Jessie Wright, his wife, to get information on how much grazing was done.

With this information obtained, I began my field work which was divided into two parts. The first dealt with determining the changing species composition of the trees on the bench, and the second part with determining the structure of the pine stand. I wanted to know if the pines grew in even-aged or uneven-aged stands, at what intervals they reproduced, and whether this was changing.

To collect data on species compostion I wanted to sample from the entire 35 acre stand. Since two of the three sides of the study area were steep slopes, and the third was a well marked change into a Douglas-fir timber type, I used these as boundaries for my study area.

My plots were 100 feet by 100 feet laid out on a gridwork over the study area with 330 feet between each plot. (figure 2) In each plot I recorded each tree by species, measured its circumference at breast height, (cbh) and used an increment borer to determine the age of those trees over eight inches cbh. Most trees over 120 inches cbh were too large to accurately age with an 18 inch increment borer.

In order to determine the structure of the stand, I wanted to examine how the different ages and sizes of pines grew in relation to one another. To do this, I marked off a two and one quarter acre area in the center of the study area. This was broken into nine square plots 104.35 feet on each side. Within each plot all ponderosa pines were recorded and located on a plot map. Each tree's circumference was measured at one foot above the ground level and recorded. All trees over eight

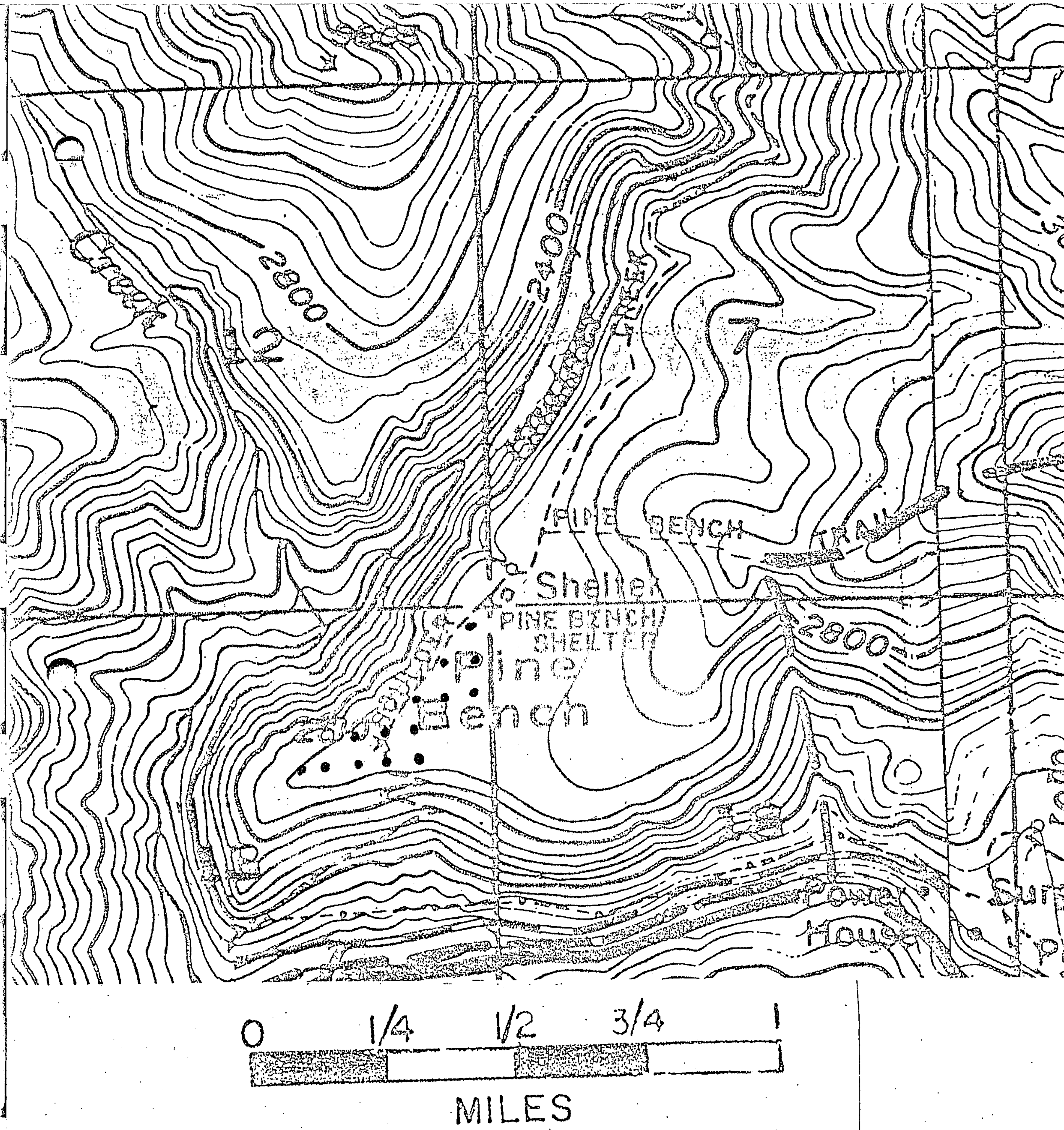


Figure 2. Topographic map of Pine Bench showing location of study plots. Contour interval=80 feet.

inches in circumference were cored at one foot above the ground to determine their age.

Results and Discussion

-COMPOSITIONAL DATA-

The age-class diagram, figure 3., clearly reveals a change in the species composition of Pine Bench in the last century. Since tree boring and circumference measurements for compositional data were made at breast height on the trees, in order to determine how old trees are from the data in any age-class it was necessary first to determine how many years it takes a tree to grow to breast height. This was calculated by running a linear regression on Douglas-fir and ponderosa pine separately which tested the correlation between circumference and age of each tree. For ponderosa pine I obtained a correlation coefficient of .89 for this relationship; meaning that age and circumference are very closely related. The equation I obtained linking age and circumference for ponderosa pine is as follows.

Age = 13 years + 1.3 x Circumference (in inches)

In other words a tree with a circumference of 10 inches would be 13 + 1.3 x 10 which is equal to 26 years. A tree with a circumference of zero inches at breast height would be 13 years old. Therefore it takes 13 years for a ponderosa pine to grow to breast height. Although this will vary somewhat from tree to tree, a correlation coefficient of .89

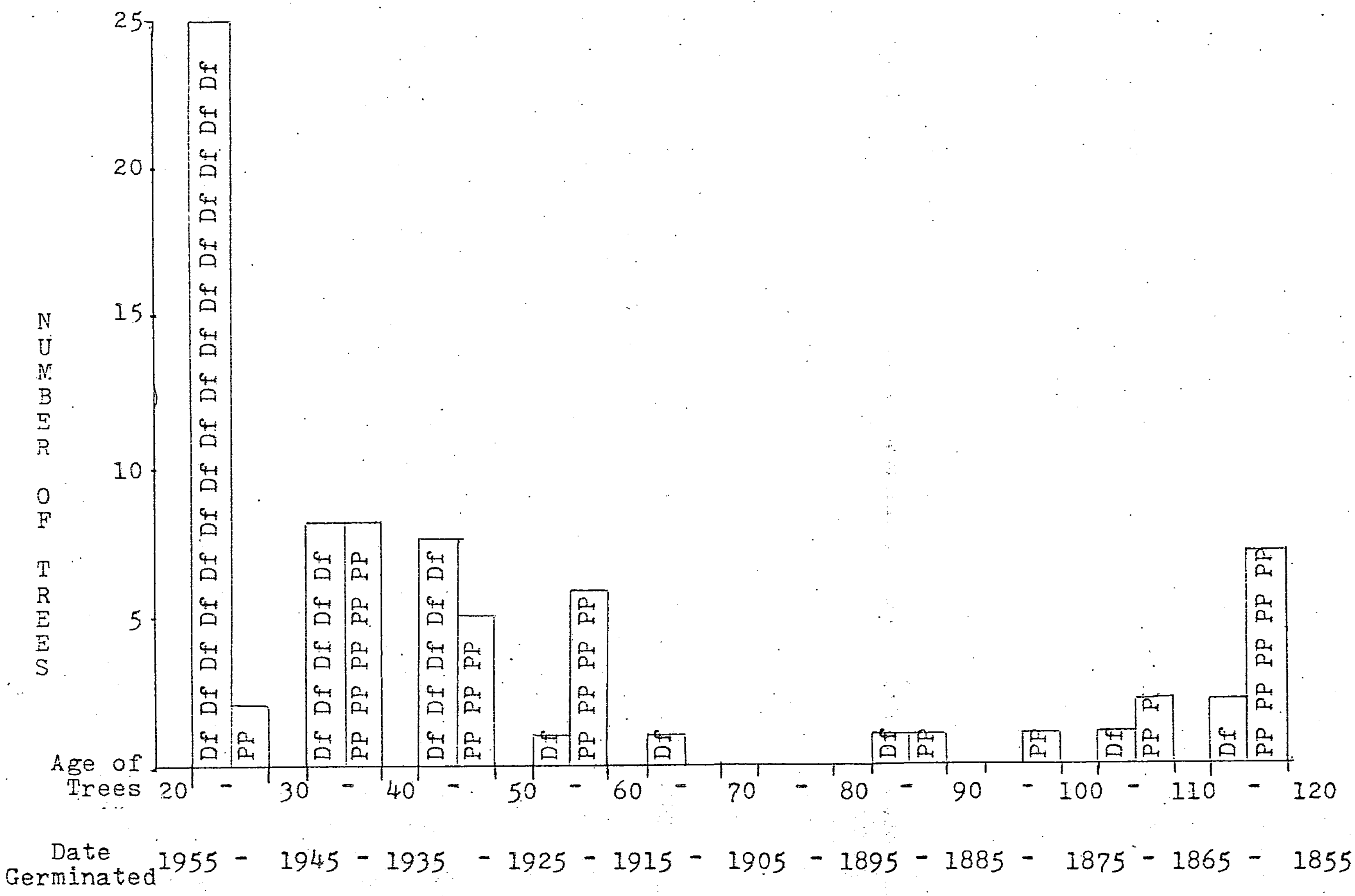


Figure 3. Age-class distribution of Douglas-fir (Df) and Ponderosa Pine (PP) on Pine Bench.

leaves only 21% of the variance to be accounted for by other than the age-circumference relationship.

Since Douglas-fir grow at a different rate than do ponderosa pine, I had to also calculate the number of years required for a Douglas-fir to reach breast height. I obtained the following equation.

$$Age = 6.1 + 1.0 \times Circumference$$

The correlation coefficient for this equation is .90. Therefore, it takes six years for a Douglas-fir to reach breast height, and 19% of the variance is left to be accounted for by other than the age-circumference relationship.

Using these results the age-class diagram is obtained and the time axis can be calibrated in terms of the year in which a tree was a seedling. At a cbh of eight inches, a ponderosa pine would be 23 years old, while a Douglas-fir would be 14 years old. As I only bored trees larger than eight inches cbh, the age-class of 0-10 would be deficient in both ponderosa pine and Douglas-fir, and the 10-20 year age-class would be deficient in ponderosa pine. Therefore I began the age-class distribution with the 20-30 age-class. Another limit to the age-class distribution is that those trees over approximately 120 inches cbh were not included since I couldn't accurately age them. The size-class diagram, figure 4, gets around both of these inadequacies nicely because I could measure the circumference of all trees; those under eight inches were included simply as less than eight inches. The disadvantage of the size-class distribution is

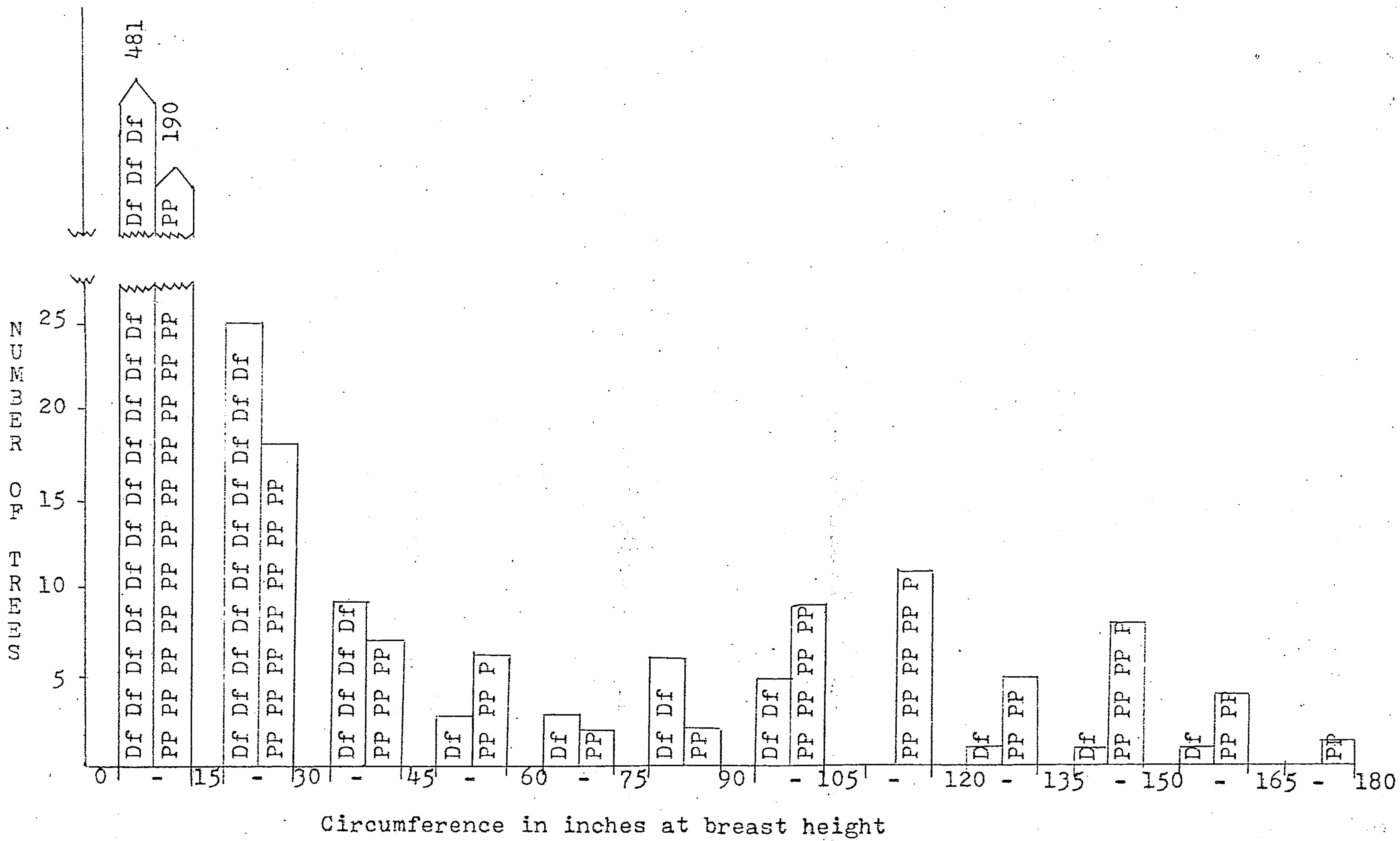


Figure 4. Size-class distribution of Douglas-fir (Df) and Ponderosa Pine (PP) on Pine Bench.

that it is not as accurate in identifying how old a tree is. However, for the very young trees at the beginning of the distribution, this discrepancy is reduced, therefore the size-class distribution gives a good general idea of the relative numbers of young ponderosa pine and Douglas-fir.

Though I have stated that I can be less sure of the correlation between circumference and age of trees as these two factors increase, the size-class distribution is still extremely useful in indicating the relative numbers of older ponderosa pine and Douglas-fir. Because Douglas-fir grow faster than ponderosa pine, corrections to make the size-class distribution correspond more closely to an age-class distribution would have the effect of shifting the Douglas-fir to a smaller size-class in the size-class distribution. That is, at the same circumference, Douglas-fir are actually younger than ponderosa pine so that if one wanted to be more accurrate about determining the age-class distribution from the size-class distribution, the Douglas-fir would be shifted to the left in the size-class distribution (fig. 4). This would only accentuate the already evident implication that the number of old ponderosa pines greatly exceeds the number of old Douglas-firs. This, and the observation that the number of young Douglas-firs greatly exceeds the number of young ponderosa pines fits well with what one would guess from just looking at the bench, figure 5.

What could be the cause of this change in species composition on the bench? A possible explanation could be

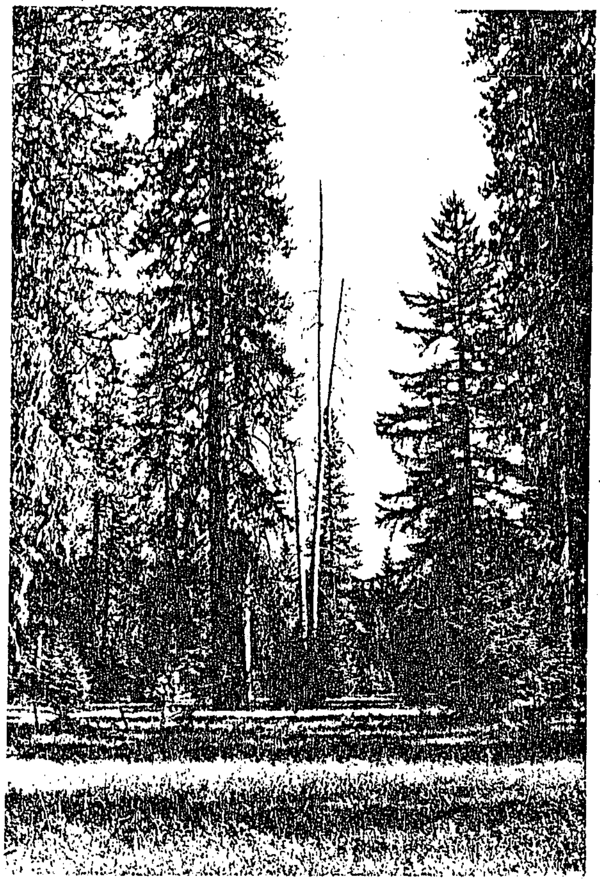


Figure 5.
The large trees in the foreground are ponderosa pines. The small trees are Douglas-firs. Notice the dead pine in the background.

that a change in climate, soils, or some other natural phenomenon is causing this invasion. It is well known that some plant associations give way to others in what is termed vegetational succession. If the change were that kind of phenomenon, however, one would expect it to be a reasonably continuous and gradual. The age-class distribution, which is most accurate in the region where this change is occurring, shows just the opposite, however. In the past 50 years, since 1925, the number of Douglas-fir in each age-class had been greater than or equal to the number of ponderosa pine. Before that time, the number of ponderosa pine had been greater than or equal to the number of Douglas-fir, except in the 60-70 year age-class where only one Douglas-fir is present.

The large gap in the 60-80 year age-classes in the age-class distribution is probably due to some long term environmental factor which kept trees from establishing for twenty years, or a short term event which killed those trees 20 years of age or less.

Cattle grazing in the early 1900's could have trampled young seedlings, accounting for the gap in the distribution. However, Jessie Wright told me that the cattle were few and on the bench only a short time; one might be suspicious of this as the only cause of the small number of trees in these age classes.

Another plausible cause would be a surface fire or fires burning in the area between 1905 and 1925. This could have killed almost all of the young trees and some of the somewhat larger trees. This would account for the reduced numbers of trees in the 80-90 and 90-100 year age-classes, as well. According to Jessie Wright (personal communication) lightning storms in 1917 ignited 32 fires in the area, some of these went out or were put out, and some of the fires burned "until the snow flew."

Whether the gap in the age-class distribution is the result of grazing, fire, or a combination of the two, it is still possible to determine the period when Douglas-fir began to invade the ponderosa pine in large numbers. Up until 1925, the number of Douglas-fir germinating and surviving is relatively small and stable. After 1925, the number of Douglas-fir steadily increases in each age-class up to the present.

The suggestion that the lack of Indian burning is responsible for the invasion seems to be incorrect when the age-class distribution is consulted. As we have seen, by 1840 the number of Indians in the North Umpqua valley was very few, and by 1865 only 20 were left in the valley at all. Yet, the change in dominance doesn't occur until 1925-1935.

Grazing occurred at approximately the right period to come under scrutiny as a cause. But if one postulated that the ceasing of grazing was responsible for the invasion, one would have to explain why there was no large number of Douglas-firs in the 1800's before cattle were present.

The most likely cause of the invasion, considering the age-class distribuiton and the literature cited in the introduction, would be the suppression of natural lightning fires on the bench. A lookout was established by 1920 on Illahee Rock, only four miles away from Pine Bench. But it wasn't until the 1940's that fire control could become highly effective; air-tankers and smoke-jumpers were introduced and used during this period. (Starkey, personal communication) Douglas-firs germinating from 1925 to 1935 would have escaped destruction in the summer fires of the 1910-1920's. They would be protected from fires in the 1940's which would have otherwise killed them. Thus, we see the Douglas-firs surviving in ever greater abundance from the 1925-35 year age-class through the 1945-55 year age-class where the graph ends. This trend is seen carried out in the size-class distribution (fig. 4) which accounts for all trees up to the present where there were 481 Douglas-fir seedlings under 15" cbh and only 190 ponderosa pine seedlings of this size.

The evidence indicates that fire suppression and the invasion of ponderosa pine by Douglas-fir are correlated. But should we expect that fire somehow favors the existence of ponderosa pine? And if so, why? There is surprisingly little information in the literature on this matter, however, what there is supports the theory that frequent ground fires favor the existence of ponderosa pine over Douglas-fir.

Working in eastern Oregon, Munger (1914), examined the damage to several tree species by light surface fire. He found that 4.38% of the Douglas -fir were burned to death as compared to 3.13% of the ponderosa pine. Though he broke down the damage to ponderosa pine into different diameter classes, unfortunately this wasn't done with the Douglas-fir. As I am concerned with the difference in mortality to tree seedlings, not mature trees, these figures may not be very relevant to my study. Also in 1914, Mitchell did a study which indicated that the heat resistance of terminal buds is apparently the factor in determining fire damage. He found that with ponderosa pine, in general, "where any part of the crown remains green, the tree will survive, and the portion of the crown not actually charred will recover.

...Douglas-fir is, ...apparently quite subject to injury and has little power of recovery."

A more substantial study was undertaken by Bates in 1924 in determining the "Relative Resistance of Tree Seedlings to Excessive Heat". Though he was concerned with heat damage as opposed to fire damage, his findings may be of importance. Figure 6 shows his results in which Douglas-fir is shown to be much more susceptible to heat damage than is ponderosa pine.

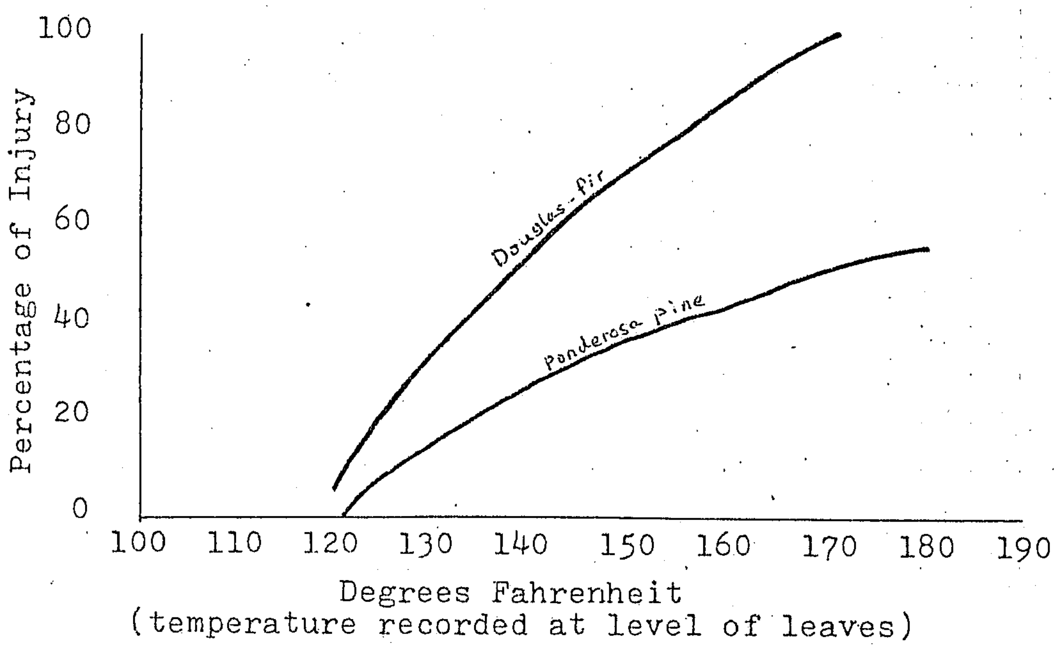


Figure 6. Relative Resistance of Tree Seedlings to Heat (Bates 1924)

Results and Discussion

-STRUCTURAL DATA-

The purpose in studying the structure of the pine stand is to determine how the pines grow. In other words, while the previous section dealing with the composition of the bench was concerned with the relationship between ponderosa pine and Douglas-fir, this section is concerned with interrelationships among the individual pines. In this section I was interested in accurately determining the relative ages of the pines rather than their absolute age, that is, I wanted to know if trees were older or younger than one another, and by how much. Therefore, I cored all the pines in the two and one quarter acre area at one foot above the ground instead of at breast height. This minimized any discrepancy in age due to differences in the number of years taken to reach breast height. To obtain the actual age of the tree, one would again have to add the number of years needed for the seedling to grow to one foot, however, I simply used the age at one foot above the ground to obtain an age-class distribution for the trees, figure 7.

I also measured the circumference of all pines at one foot above the ground, and calculated a size-class distribution, figure 8. In addition I kept a plot map on which I recorded the geographical position of each tree.

The age-class distribution reveals one age-class which has significantly more trees than the rest of the age classes. From the 110-134 year age-class and up I am unable to make any

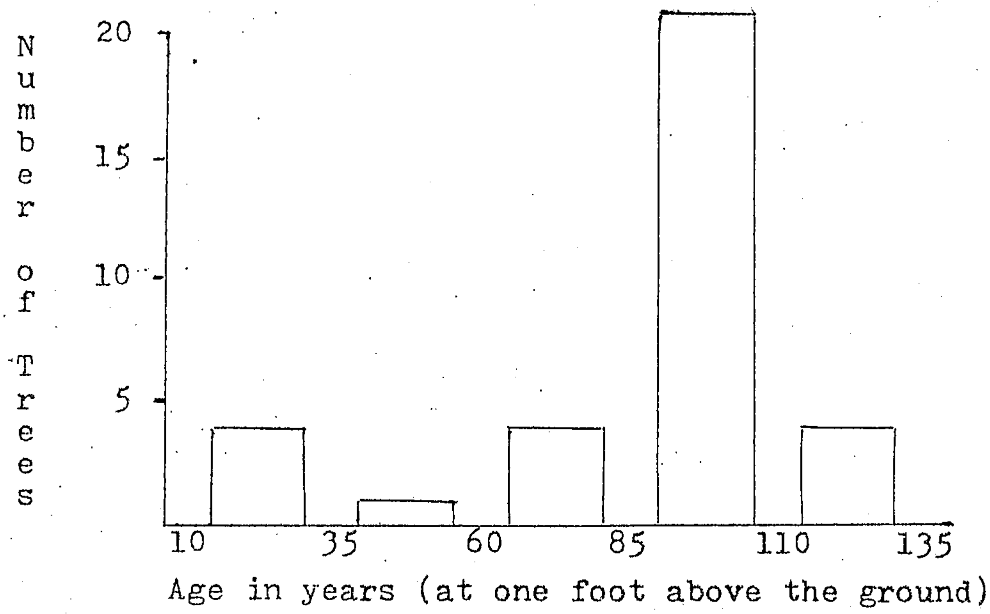


Figure 7. Age-class distribution of ponderosa pine in two and one quarter acre area.

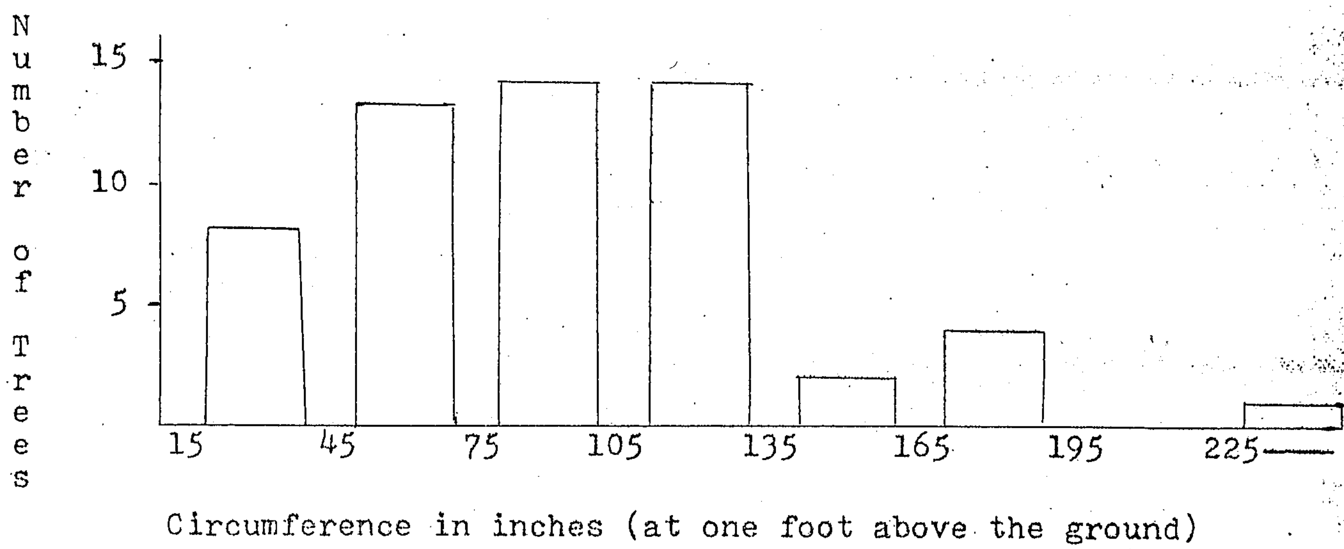


Figure 8. Size-class distribution of ponderosa pine in two and one quarter acre area.

definite statements about the relative sizes of the age-classes since some trees which were too large to accurately age were in these age-classes. In figure 9 I plotted trees from only two age-classes; those from the large class from 85-109 years old, and the youngest age-class, 10-34 years. It is evident that the younger trees were unable to become established under trees that were from 85-109 years old; there was no overlap in the distribution of these two age classes. The two intermediate age-classes 35-59, and 60-84 had few trees in them, and I could detect no pattern in their geographical distribution..

The size-class distribution gives me the same general pattern as the age-class distribution. If the classes are grouped into two groups, with trees less than 135 inches cbh in one group, and those over 135 inches cbh in another, one can see that the older trees tend to be in one area, while the younger trees tend to be in another, figure 10. Within these two groups I could detect no significant spatial grouping of the trees.

The conclusion that younger trees are not able to become established under older trees is consistent with previous studies of ponderosa pine. (Weaver 1943, Cooper 1960) These studies have also reported the existence of several, distinct age classes within a stand of trees. The large number of trees in the 85-109 year age-class is the only distinct age-class I could identify in my data. This may be due to one or a combination of three reasons.

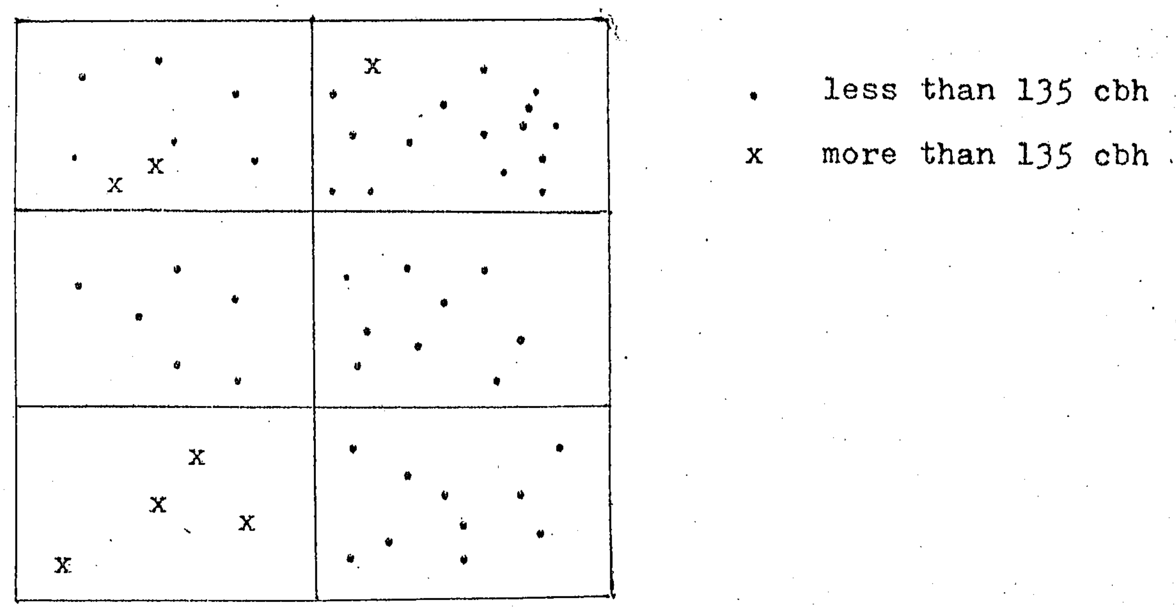


Figure 10. Geographical distribution of two size-classes in two and one quarter acre area.

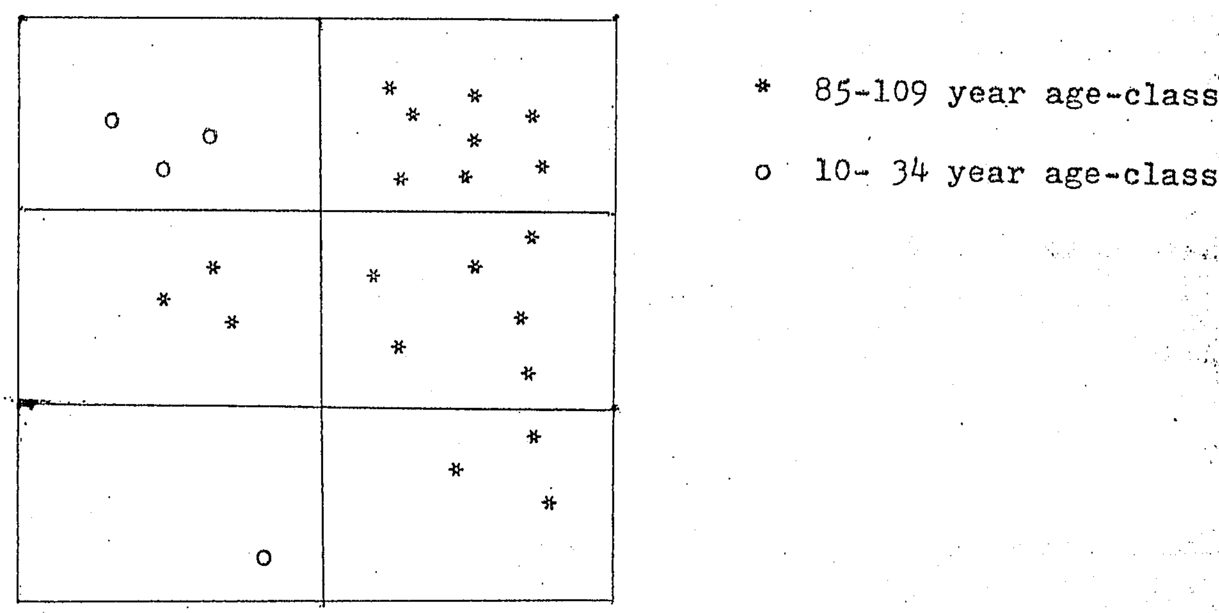


Figure 9. Geographical distribution of two age-classes in two and one quarter acre area.

First, I was unable to accurately age trees over 110 years of age, and there may exist distinct age-classes among the older trees that I was unable to identify. The size-class data could easily obscure this age-class since the trees, once they are that old, could vary in size even if they were the same age.

A second reason may be that in this area which is wetter than most ponderosa pine areas, there are more years when favorable moisture conditions are present. In other words, out of a possible number of years when trees could get established under larger trees, there may be a larger percentage here in which the environmental conditions are favorable for germination and establishment.

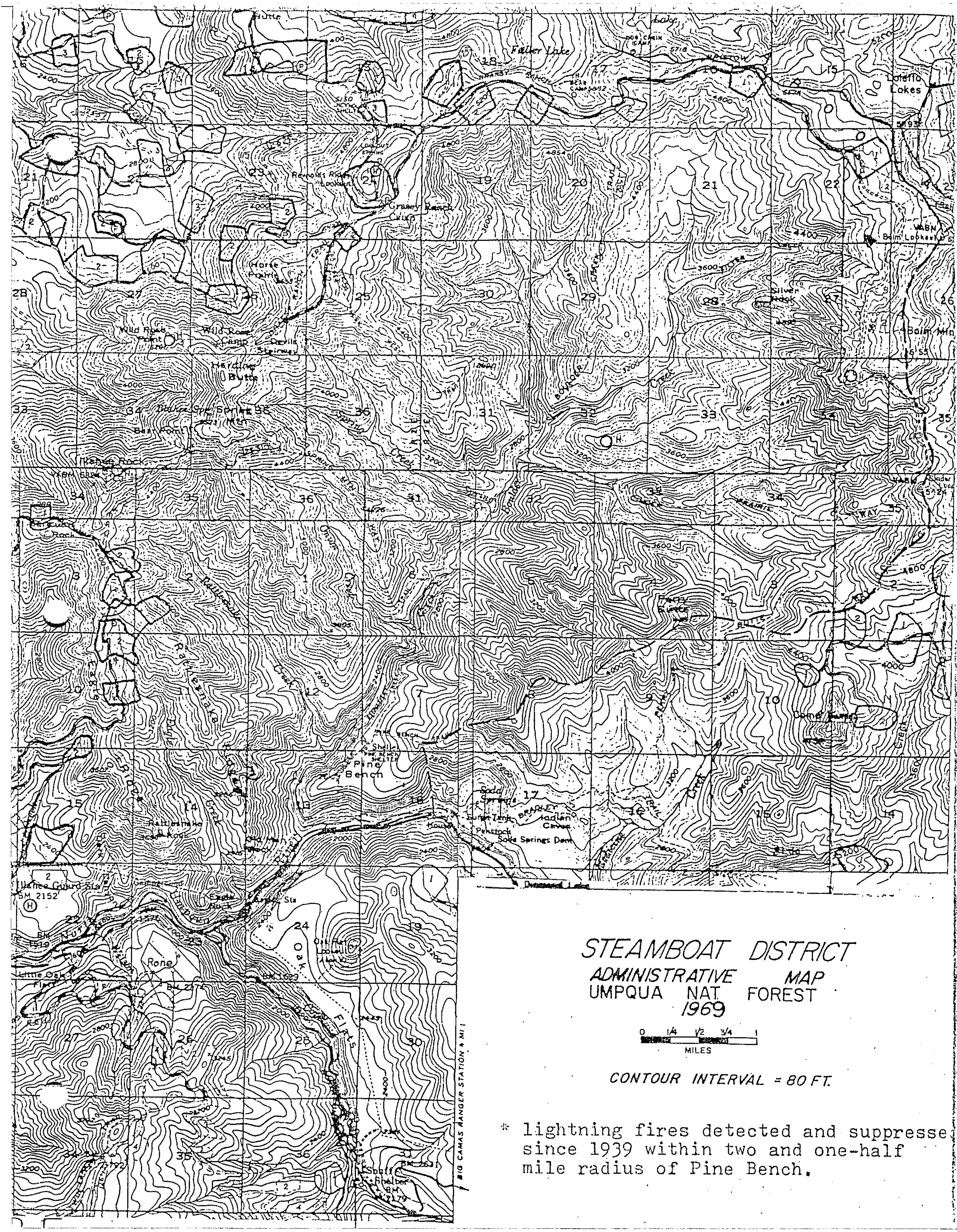
The third possibility for the absence of distinct age-classes has to do with the small size of the pine stand. Cooper (1960) reports that frequent ground fires, occurring under the larger trees where more litter had accumulated were responsible for retaining the integrity of the age-classes by keeping the younger pines from becoming established in these areas. In a large pine stand, it is more likely that a fire would occurr in some area within that stand in any given period of time, and then spread over the whole stand. In this small stand on Pine Bench, it could be that fires are frequent enough to stop the invasion of Douglas-fir and frequent enough to keep young trees from establishing under old trees, but still infrequent enough to allow a group of trees to develop into an age-class which encompasses more years than age-classes in other areas.

To determine which, if any, of these factors is responsible for accounting for the trends I have identified would take further study, probably with a better method of aging those trees over 120 inches cbh.

Lightning

Since I indicated that the suppression of natural lightning fires is responsible for the compositional changes seen on Pine Bench, I wanted to explore the occurrence and nature of lightning fires in this area. I obtained records of reported lightning-caused fires in a two and one-half mile radius area on Pine Bench and plotted them on the map in figure 11. In the past 36 years there have been 23 lightning fires reported in this area. Most of these fires were one-quarter acre or less in size since they were suppressed as soon as possible. If they had not been suppressed some of them would have undoubtedly been larger.

Henry Hazen, Steamboat District Ranger for the USFS told me some stories that he has been told of fires in the area before 1939. One story is of a man who spent two or three weeks alone in the Boulder Creek area fighting multiple lightning fires. One of the fires covered 40 acres before being controlled. He also said that some of the fires must have been very large, 1000 acres or more. Jessie Wright,



STEAMBOAT DISTRICT

ADMINISTRATIVE MAP
UMPQUA NAT FOREST
1969

0 1/4 1/2 3/4 1
MILES

CONTOUR INTERVAL = 80 FT.

* lightning fires detected and suppressed since 1939 within two and one-half mile radius of Pine Bench.

who homesteaded in the area with her husband Perry near the turn of the century remembers how fires burned all summer long from 1910 through the 1920's.

The distribution of these lightning fires may be a clue to the way in which these lightning fires function in this area. I calculated the position of each fire relative to the top of a ridge by counting the contour lines on a topographic map from the nearest ridge or bench top to the nearest lowest stream or bench. I then calculated the fire's position from the top of each ridge as a per cent of this number. For example, if there were ten contour lines from a ridge top to a stream and the fire was on the second contour line down, then it was 20% downslope from the top of the ridge. The distribution of the fires is shown in the graph in figure 12. It is seen that most of the fires are located near the tops of the ridges with progressively fewer fires towards the bottom. In order to make certain that this pattern was not simply a result of there being more area near the tops of the ridges than in the bottom of canyons, I plotted 23 random points in the same area as the fire map. I then calculated the position of each of these points as I had with the fires and found that they were evenly distributed over the ridges. (figure 13) The unsurprising implication of these calculations is that fires tend to be concentrated near the tops of ridges or benches, rather than in the canyon bottoms. Since Pine Bench is such an area one would expect it to receive many lightning strikes, and it has, in fact, had two reported lightning fires in the past 36 years.

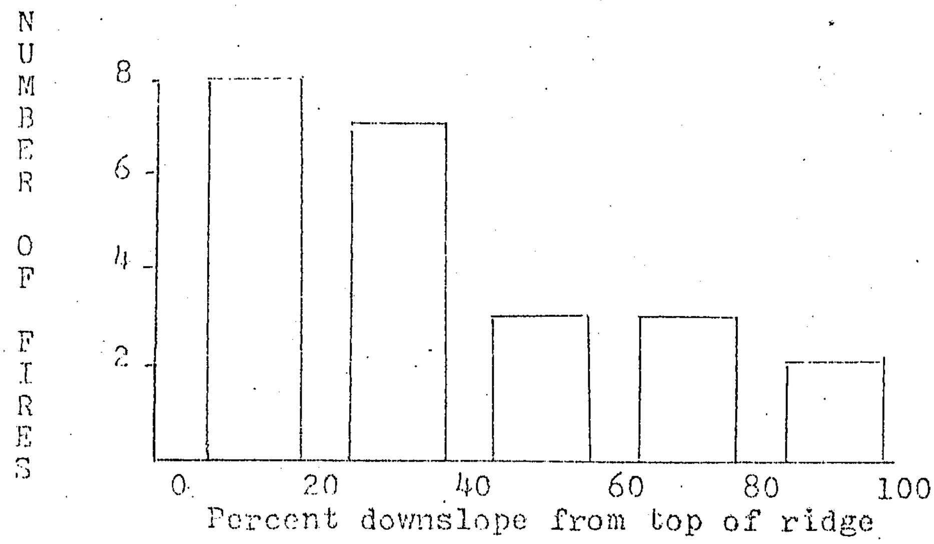


Figure 12. Distribution of Lightning Fires.

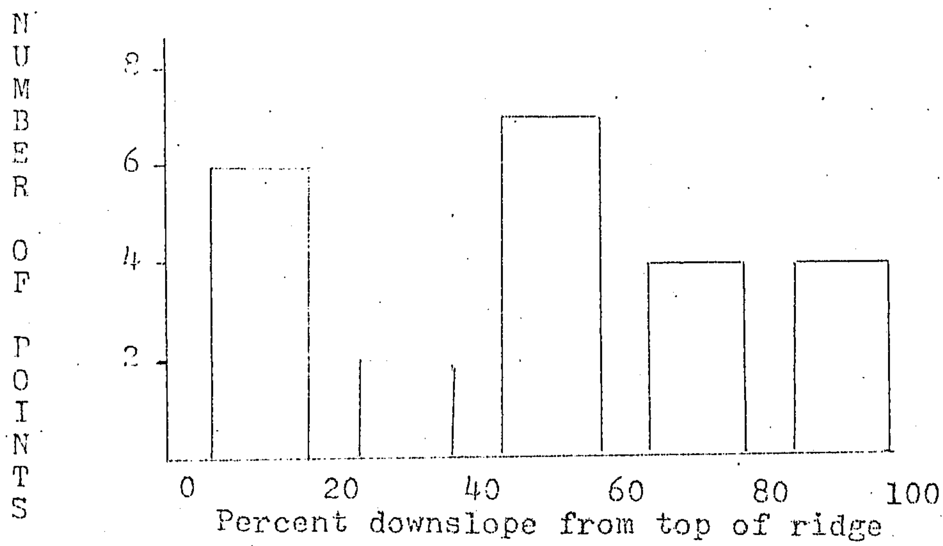


Figure 13. Distribution of 23 Random Points

Dynamics

I will now attempt to integrate the information I have obtained into a theory of the role of fire on Pine Bench. Figure 14 is a diagram which summarizes the following theory.

I have shown that lightning fires, common to the area are particularly frequent on Pine Bench because of the steep canyon walls dropping off into the North Umpqua River and Boulder Creek. I believe that the existence of these pines and others on similar benches, whether or not they are relicts of a once larger stand, is tied to the occurrence of these frequent fires. Indians using these benches may have also burned the area in order to control insects, decrease the brush, or reduce fire hazard, but in the absence of Indian burning, lightning fires would still occur. The well studied processes of pines and fires interacting to produce an environment which is susceptible to fire, yet not destroyed by it, accounts for the groups of more or less even-aged trees in an overall uneven-aged forest.

The lack of several distinct age-classes in the structural data may have several causes. It may be these age-classes exist, but were not evident to me due to my inablility to accurately age larger trees. It may be that this area is far enough north and west that moisture is not a limiting factor, therby enabling many years of successful reproduction in a small clearing as long as light is sufficient. Or it may be a result of the small size of the stand, making the interval between fires longer than usual for ponderosa pine

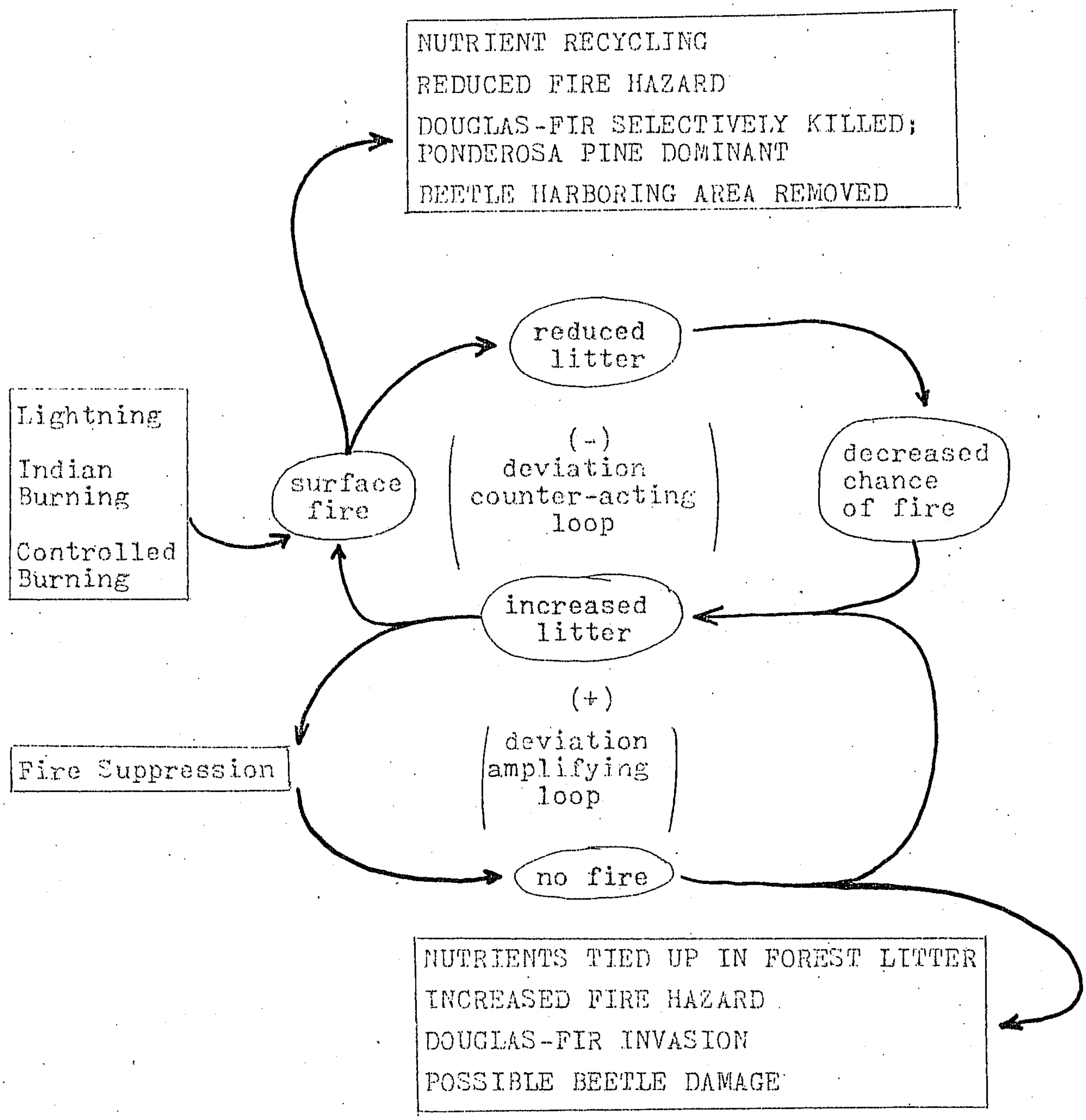


Figure 14. System diagram summary of the role of fire on Pine Bench.

stands. My feeling is that it is a combination of these three factors.

Douglas-fir are able to invade the understory of the pines as the Douglas-fir are more shade tolerant than the ponderosa pine. (Sudworth 1908, in Kozlowski and Ahlgren 1974) Figures 15 and 16 show the changing understory on the Bench.

Since the ponderosa pine are more resistant to fire damage than are the Douglas-fir, frequent surface fires will kill more Douglas-fir than ponderosa pine leaving only a low level of Douglas-fir to survive, while allowing the ponderosa pine to be the dominant species on the bench. Frequent fires also reduce the amount of litter on the ground and the amount of brush and young trees in the understory, thus reducing the hazard that a fire will change from a ground fire into a crown fire and actually kill even the mature ponderosa pine. Fire may also serve to keep the areas which harbor the pine beetles at a minimum.

In such an area, fire suppression acts to allow the Douglas-fir to invade and survive, and with continued suppression the Douglas-fir would become the dominant species on the Bench, replacing the ponderosa pine.

Figure 15, at left, shows three trees in the center foreground. One is a ponderosa pine, the other two are Douglas-firs. The pine shows signs of being shaded out.

Figure 16, below, shows a common more-or-less even-aged group of pines in the background. Notice the clearing and the young Douglas-firs in the foreground.

Reccommendations

If fire is essential in continuing the natural dominance of pines on Pine Bench as I have asserted, then the question arises of how to return fire to its place in the ecosystem.

Controlled, prescribed burning is a technique gaining use and acceptance in regions where fire has been shown to be a necessary component of the ecosystem. Although the technique varies with differing areas, the underlying theory is to establish the role of fire in an area by means of ecological studies, and then to set fire to the area when conditions are such that the fire will burn only the amount of fuel desired, and could be contained if necessary. Parameters such as wind, temperature, fuel moisture, and amount of fuel are studied to determine when the best time to burn would be. The first time an area which has been subjected to fire suppression is burned, it may sometimes be necessary to do some mechanical thinning of the accumulated understory vegetation so that the fire isn't able to carry through this into the overstory. After this thinning, prescribed burns can be set to reduce fuel levels. Once natural conditions are restored, in many cases the area can then be left to burn naturally should lightning fires occur.

This technique has been used in Sequoia-Kings Canyon National Park where the giant sequoia was being invaded by white fir because of fire suppression. At low elevations fir thickets were so dense that manual thinning was required before an area was burned. Since this process is expensive it is crucial to develop less expensive and more natural means of using prescribed fire to simulate natural fire results. At higher elevations, there have been "let them burn" zones established where natural fires are allowed to run their courses. (Kilgore, 1970)

Controlled burning has also been used extensively among ponderosa pine in areas where younger age-classes are too dense. Surface fire can selectively thin out the smaller trees leaving a more healthy stand of trees. (Biswell 1967; Morris and Mowatt 1958; Schultz and Biswell 1959; Weaver 1952, 1957, 1959, 1965, 1967)

To begin a program of controlled prescribed burning certain management policy guides would have to be developed. The National Park Service has already made some steps in this direction.

> Of the various methods of manipulating vegetation, the prescribed use of fire is the most 'natural' and much more inexpensive to apply. Once the fuel is reduced, periodic burning would be a relatively simple operation, with a high degree of safety and at low expense. (Murphy, 1967)

The policy statements for fire and fire control by the Park Service are as follows:

1. The presence or absence of natural fire within a given habitat is recognized as one of the ecological factors contributing to the perpetuation of plants and animals native to that habitat.

2. Fires, in vegetation, resulting from natural causes are recognized as natural phenomena and may be allowed to run their courses when such burning can be contained within predetermined fire management units and when such burning will contribute to the

accomplishment of approved vegetation and/or wildlife management objectives.

3. Prescribed burning to achieve approved vegetation and/or wildlife management objectives may be employed as a substitute for natural fire.

4. Any fire threatening cultural resources or physical facilities of a natural area or any fire burning within a natural area and posing a threat to any resources or physical facilities outside that area will be controlled and extinguished.

5. The (Park) Service will cooperate in programs to control or extinguish any fire originating on lands adjacent to a natural area and posing a threat to natural or cultural resources or physical facilities of that area.

6. Any fire in a natural area other than one employed in the management of vegetation and/or wildlife of that area will be controlled and extinguished. (Murphy, 1967)

I believe that the use of controlled fire on Pine Bench would be the cheapest, most effective, and most natural way of stopping the invasion of Douglas-fir into the understory and assuring the continued dominance of ponderosa pine.

Some may ask why it is important at all to attempt to stop the invasion of Douglas-fir and assure the continued dominance of ponderosa pine. First, the bench is used by hikers and backpackers and is of significant local interest since pure stands of ponderosa pines are rare in this area. Second, because it is unusual it is of considerable ecological interest and could be used for further scientific studies. Third, the fire danger in an open, grassy pine stand, would be less than in a stand with tall pines and intermediate sized Douglas-firs. Fourth, if Harold Weaver's premise about pines being more subject to beetle attack when in competition from the understory is correct (Weaver 1964), then these pines would be more susceptible to beetle attack and could possibly endanger other nearby pines. A final point is that by interfering with the natural processes operating in the forest, further unexpected and possibly harmful effects may well result. A dynamic, homeostatic system can maintain some stability, but with enough external inputs it may change its mode to a deviation amplifying system wherein change breeds further change until a subsequent equilibrium is reached--one which may or may not be viewed as desirable.

If controlled burning were to be planned for Pine Bench, a number of issues would have to be investigated. There is the problem of Pine Bench being in the midst of a Douglas-fir forest. While the role of natural fire in ponderosa pine has been well studied and shown to exist naturally as a ground fire, this may not be true for Douglas-fir. In fact it has been suggested that in a Douglas-fir region, fires may naturally be infrequent crown fires. (Kozlowski and Ahlgren, 1974) The Douglas-fir on the slope between the North Umpqua River and the Bench appear to be an even-aged stand suggesting that this stand could be the result of an old crown fire. If fires do burn as crown fires in the Douglas-fir, then this would have to be an expected consequence of prescribed burning <u>or</u> steps would have to be taken to keep the fires out of the Douglas-firs. On the south and west slopes this would be relatively easy since they both drop off at 54 degrees away from the bench making it highly unlikely that a fire could get started burning down this slope. In fact, I suspect this is what kept the lightning fires from burning down into the Douglas-fir before the Forest Service suppressed them. On the north and east side the pine type changes into a Douglas-fir type with no abrupt change in slope. It would be theoretically possible to have a crew of firefighters on hand to keep the fire from going into this area, however simpler ways may also be available. For instance, fires could be started along this side with a slight wind from the northeast behind them and allowed to burn only to the southwest. What kept the lightning fires out of this area originally is not clear to me. Perhaps the dense cover in the Douglas-fir forest keeps the understory cool and wet enough that fires do not spread there. In any case this issue deserves more study.

A study which attempted to answer the questions of the interactions of fire, pines, and fir, might also investigate the question of why the pines exist in this area at all. Their distribution seems to be limited to these benches near the gorge cut by the river, but whether or not these are relict stands from a previously larger distribution is not clear. This would be useful information to have in trying to establish the role of fire in the Umpqua National Forest as a whole.

It is my personal opinion that controlled burning should be planned for Pine Bench; the earlier that it is done the more effective it will be in returning the area to its natural state, and the cheaper it will be to do so. If controlled burning is not undertaken, I feel certain that the pines will not continue to exist on the benches as they have, considering the increasing fire hazard and the poor establishment of the ponderosa pine.

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