Past Fire Incidence in Sierra Nevada Forests

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THAT FIRES recurred frequently over past centuries in the virgin forests of California has been generally accepted as an established fact by foresters. From a fire chronology for the mixed conifer forests of central and northern California originally reported by Boyce (*3*) and re-evaluated by Show and Kotok (*20*), the latter authors concluded that extensive fires had occurred at intervals of 3 to 11 years, or at a "general average periodicity of eight years . . . for all areas studied." Similar chronologies were later presented by Kotok (*14, 15*) and have recently been quoted by Biswell (*1*). In Kotok's second paper he refers to a study on the Stanislaus National Forest and states that 221 distinct fires swept the area between 1454 and 1912, or an average of about a fire every 2 years. Biswell refers to this 2-year average in support of his view that fires from lightning and the aborigines were very frequent in the Sierra Nevada.

The general applicability of the frequent-fire concept to the forested regions of California has recently been challenged by Burcham (*6*). He offered evidence from historic and anthropologic sources that fires could not have been as frequent in the state as the above chronologies had indicated. He pointed out that the incense-cedar decay studies by Boyce on which these chronologies had largely been based represented only a few limited areas in two parts of the west slope of the Sierra Nevada. Burcham also noted that Boyce (*2*) had pointed out a difference in frequency of fires in the two districts where the studies were made.

These differences in viewpoint raise a question as to the actual past fire frequence in the Sierra Nevada forests. As a contribution to this question it has seemed worthwhile to re-examine the available fire wound data from past decay studies and to present the results in sufficient detail to permit the reader to form his own judgments concerning them.

Basis for Chronologies

Neither Boyce, Show and Kotok, nor Kotok gives any specific information on the areas from which their conclusions were drawn. Boyce (*3*) states that his was derived from "some two thousand white firs and incense cedars in the mixed conifer forests of central and northern California." This indicates that the source must have been what were known as "dissection studies"[1] by the San Francisco Office of Forest Pathology, which were confined to these two species. Kotok (*14*), in a statement repeated by Biswell (*1*), reports that Boyce's incense-cedar study "extended from the Oregon line, through the Sierras, to the southernmost part of the California pine region."

Actually, although the dissection studies as a group took in areas from near the Oregon line to the central Sierra National Forest, only five of them (Table 1) afforded age counts on fire wounds, and of these only three were in incense-cedar. On the remainder, including an incense-cedar study area at Cow Creek on the Stanislaus National Forest, age counts on wounds were omitted. Moreover,

[1]Studies of cull from decay in incense cedar and white fir carried out under the general direction of the late E. P. Meinecke.

TABLE 1.—STUDY LOCATIONS FOR WHICH COUNTS OF FIRE WOUND AGES ARE AVAILABLE[1]

Location	Year	Tree species	Area	Trees examined: Total	Having fire wounds with countable ages	
			Acres	*Number*	*Number*	*Percent*
Sloat (Plumas N.F.)	1915	Incense-cedar	205	510	354	69[2]
Westville[3] (Tahoe N.F.)	1913	White fir	25(?)	56	20	36
Strawberry (Stanislaus N.F.)	1915	Incense-cedar	80	266	130	49
Crockers (Stanislaus N.F.)	1916	Incense-cedar	75	200	95	48
		White fir	11	50	14	28
Ellis Meadow (Sierra N.F.)	1917	White fir	51	276	117	42
Subtotals	--------	------	447	1,358	730	53
Madsens (Sierra N.F.)	1921	White fir	38	257	102	40
Pinecrest (Pickering study, Stanislaus N.F.)	1929	Ponderosa pine, sugar pine, white fir, incense-cedar	40	890	499	56
Totals	--------	--------	525	2,505	1,331	53

[1]The first five locations formed the basis for the Boyce, Show and Kotok, and Kotok fire chronologies.
[2]Differs from percent for trees with fire scars given by Boyce ([*2*], p. 39) because only trees with fire wounds of countable ages are included here.
[3]Fire record incomplete.

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at one of the five—the Westville location—the fire wound record was incomplete in that only the age of the oldest fire wound on a tree was counted, making the record of limited value in establishing a fire history for the area. Including Westville, 730 trees with countable fire wounds out of a total of 1,358 study trees on the five areas were available to Boyce, and subsequently to Show and Kotok, for establishing their fire chronologies.

Counts at two additional locations, Madsens on the Sierra National Forest and Pinecrest on the Stanislaus National Forest, later increased the total number of trees with counted fire wound dates from 730 to 1,331 (Table 1).

All of the study areas were located in mixed coniferous stands at elevations of 4,300 to 5,600 feet on the west slope of the Sierra Nevada Range from the Feather River on the north to the San Joaquin River on the south (Fig. 1). All were well back of the Mother Lode belt, in which the native vegetation was seriously disturbed by cutting and fire following the 1849-1850 Gold Rush. At no location was there anything to suggest that fire histories on them differed from those of the general surrounding districts. In fire history, therefore, they should be representative for much larger areas than the relatively limited acreages of ground actually covered by the studies would suggest.

Fire Record Value of Conifer Species

As pointed out by Lachmund (*16, 18*) and confirmed by Show and Kotok (*20*), the species components of the mixed-conifer forests in California differ in susceptibility to cambial injury by fire. They found that incense-cedar was the most susceptible and white fir the least susceptible of the four species compared. Sugar pine and ponderosa pine were intermediate.

The data in Table 1 bear out these conclusions. At Crockers, 48 percent of the incense-cedars bore countable fire wounds as compared with only 28 percent of the white firs. At both Ellis Meadow and Madsens, where only white firs were cut, the percentages of trees with fire wounds were lower than at Sloat and Strawberry, where only incense-cedar was studied.

The difference is attributable chiefly to differences in bark characteristics. The outer bark in incense-cedar is rather dry and stringy and tends to be deeply furrowed; thinly covered crevices alternate with thick bark ridges which protect the inner bark and cambium from heat injury. Killing of the cambium under the crevices does not require very prolonged or intense heat. Accordingly, narrow wounds from fire are common in the species in locations subject to past fires. Many of these heal over and close within 5 to 10 years. However, Lachmund found that once a fire wound in incense-cedar has been extended by a second fire it is likely to remain open for a long time, and extensions from subsequent fires are more pronounced than in associated species. White fir bark, in comparison, is more corky in texture, much more uniform in depth, and resists fire damage to the cambium much better than incense-cedar bark.

Another advantage of incense-cedar in studying fire history is the character of the principal heartwood decay. The chief heart rot in incense-cedar is a pocket dry rot, with practically sound wood between the pockets (*2*). By following these sound septa it is usually possible to obtain age counts on almost any cross section, even though heavily damaged by pocket dry rot. Thus the ages of few fire wounds in the species are uncountable except where the evidence of older wounds has been burned out.

In white fir, conversely, not only is the heartwood less resistant to

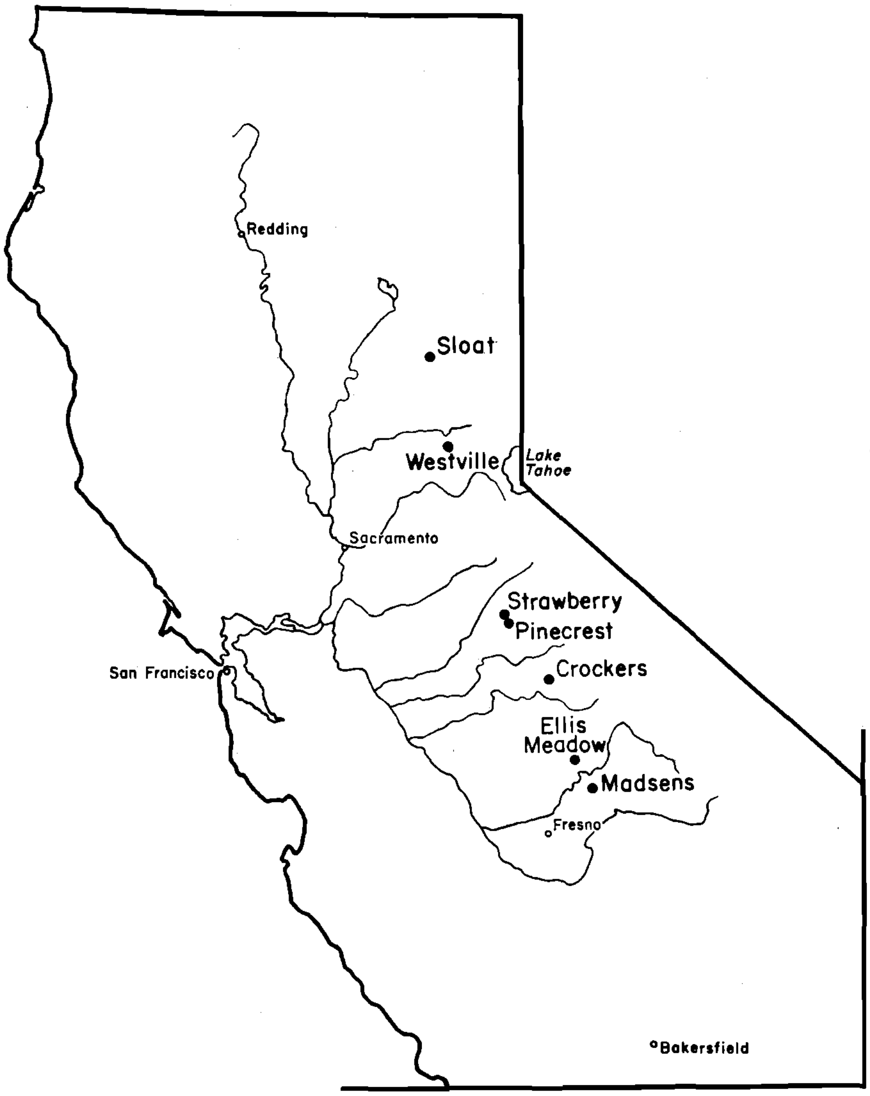

FIG. 1.—Locations of decay studies in which dates of fire wounds were determined from ring counts.

decay than in incense-cedar, but the chief fungi causing basal decay in the species attack the wood quite uniformly, making the annual rings uncountable when the decay has reached an advanced stage.

On open old fire wounds in both species the calluses marking the locations of the oldest wounds often burn out, destroying the record of their occurrence. For this reason the record of old fires in a stand is much more fragmentary than for more recent fires, even though many trees may be still present that were there when the older fires occurred.

Sugar pine is of especial value in ring counting because of its well-maintained diameter growth to an advanced age on good sites and the relative durabilitiy of its heartwood. In the Pinecrest (Pickering) study, the most reliable counts on fire wound ages, particularly for the older past fires on the area, were obtained from this species. Unfortunately, no counts on sugar pine were available from the other locations.

Methods and Accuracy

Counting procedures.—Age counts of fire and other wounds and of trees were ordinarily made on stump tops about 1.5 feet above ground level measured midway on the slope. If wounds were evident closer to the ground but did not extend to stump height, a supplementary saw cut was usually made into the stump in the side where the fire wound or scar was located, and this part of the stump was split off, baring the wound calluses in cross section.

Counts were made radially from the last outside full ring toward the center with the aid of a wide-field hand lens of medium power. Before a count was started, the top of the stump was examined for the most favorable counting radius. Then a radial strip across the stump surface was shaved with a sharp knife blade, chisel, or timber scribe to bring out the rings clearly. In case not all of a chosen radius was favorable for counting, a new radius might be chosen for the rest of the count, a connection from old to the new being established by following a prominent ring from one to the other and resuming the count there. Each tenth ring was marked to permit rechecking in case of interruption or of doubtful sequences.

Accuracy of counts.—Counting was done as carefully as possible but usually by men without previous ring counting experience. At the start they were given on-the-ground instruction in counting by an experienced project leader. Proficiency normally increased as the season progressed. No planned attempt was made to cross-date, by which ring age is confirmed through the identification, from tree to tree, of prominent rings or ring sequences for which accurate years of occurrence have been established. However, as counting progressed on an area the person making the counts naturally became conversant with the dates for certain of the more prominent fire wounds, such as 1890 for the fire of that year on the Pinecrest area, and these dates came to play a role as partial controls for counts.

Since the days of Douglass (*8*), who was the first to demonstrate the value of the method, specialists in tree ring chronologies have been agreed that cross-dating is a necessary step in establishing the accuracy of the dating of rings for individual trees (*9*). Douglass found an average error of 4 percent in Arizona pines when the dates were not verified by cross-dating, even though he was dealing with virtually wound-free trees and the counting was done in a laboratory. Keen states, in connection with a determination of fire history in the pine region of central Oregon,[2] "Accurate dating of fire scars rarely can be done in the field with the naked eye or even with a powerful hand lens, but sections must be examined under a microscope and the ring pattern cross-identified with a well established master pattern."

Keen probably did not mean that an accurate individual count could rarely be obtained under field conditions. Instead he probably meant that only rarely could all fire dates for an area be accurately established from field counts. The statement is not of universal applicability in any case, because the opportunity for accuracy in field counts is influenced by the general growth rate on the area concerned and by the tree species on which the counts are made. Keen was working with ponderosa pine in an area of low site quality not far removed from the desert fringe, where the diameter growth inside bark of many trees averaged under 10 mm. per decade. On better sites and with favorable species the opportunities for accuracy in field counting would be much better.

Sources of error in counts.—Difficulty in obtaining accurate counts may arise from what Keen (*11*) terms "disturbing influences" such as fire and defoliation, or it may arise from sources other than aberrations in ring growth. The chief sources of disturbance in annual growth layers are:

(1) Fire. As reported by Craighead (*7*), fires may seriously affect the normal pattern of ring growth in coniferous forests if they result in a heavy scorching of foliage. However, his conclusions were drawn from a rather extreme case, a very early season (June) fire for the Sierra Nevada of California in 1924, the driest year so far recorded in this century. Under these conditions the impact on growth could be expected to be near maximum. In south central Oregon Keen (*11*) found that the more severe fires had a marked effect on growth rings, whereas others had little or no effect, the difference apparently depending on the proportion of crown lost. He reported that "false rings were extremely rare but missing rings were not uncommon, especially following abrupt stoppages of growth." Later Keen[3] reported that in central Oregon many trees showed a sudden stoppage of diameter growth after a severe fire in 1829, and in many cases several years of missing rings, indicating severe defoliation.

[2]Keen, F. P. The South Ice Cave fire. A study of effects of fire in ponderosa pine forests. Contribution to a cooperating study. Forest Insect Laboratory, Portland, Ore. Blueline. 15 pp. July 30, 1943.

[3]Keen. 1943. *Op. cit.*

It is evident that fires can be a major factor in the disturbance of normal ring development, often making age counts uncertain without careful cross-dating.

(2) Defoliation. In parts of the West, attacks by defoliating insects may reduce growth markedly or eventually result in heavy mortality among conifers (*11, 13*). Fortunately for our purposes, the middle-elevation forests on the west slope of the Sierra Nevada are reasonably free of serious damage by defoliators. No important defoliator is reported for incense-cedar, and no serious attacks have been recorded on ponderosa or sugar pines. Two defoliators, the Douglas-fir tussock moth and the white fir sawfly, have been reported as causing a severe loss of foliage and some mortality in white fir over rather localized areas in recent years (*21, 22*), but the white fir sawfly confines its attacks chiefly to rather dense second growth (*21*). It seems unlikely that either of these insects so disrupted the growth of white firs included in the studies as to contribue to errors in ring counts.

(3) Climate. Where rainy seasons are divided or where precipitation is highly erratic in time of occurrence, double rings may be formed in a single season (*10*). In these areas the cross-dating of rings is useful but does not guarantee accuracy. In California, however, climatic characteristics are such that Glock doubts if more than one growth layer per year will be produced on the west slope of the Sierra—"except perhaps," he adds, "in cases of partial defoliation." Those conversant with the work of coniferous defoliators in the Sierra Nevada will recognize that the qualification appended by Glock is unnecessary. Accordingly, double rings can be dismissed as a source of error in ring counts there.

Minor sources of ring disturbance include lightning, which may sometimes produce ring abnormalities, as has been reported in both incense-cedar and white fir (*4*).

Other sources of possible error lie in the misidentification of causes of wounds and in nonuniformity in allowance for the ring of the season in which the counts are made.

Old fire wounds resulting from several fires are not likely to be mistaken owing to the readily recognizable discoloration and charring of the face of the wound. However, wounds arising as a result of only a single fire usually show no charring of the wood face but develop as a result of the heat killing of the cambium, as Lachmund has described (*16, 17*). Many of these wounds heal over before additional killing occurs from a second fire, but even so their appearance and location identify most of them as fire wounds. Occasionally, however, a lesion may be attributed to fire when it is actually from some other cause. Such wounds will have no relation to the fire incidence in the area and will tend to obscure the fire chronology record if included in fire wound tallies.

Another chance for error arises from the gradual development during the season of the ring for the current year. During the early part of the season there is no difficulty in beginning the count with the first full ring, that of the preceding year, but if the study proceeds into the late summer or early fall there is a chance for confusion, particularly if the field work is interrupted for a time or if there is a change in the personnel making the counts.

On some of the study areas included in the present review, such as the Pickering area at Pinecrest, there would have been practically no opportunity for confusion because all counting was completed within a few weeks and relatively early in the season. Others continued later, but in this re-tally of the field notes no specific indication of changes in the counting base were noted. If present, they should have been manifested by a consistent displacement of fire wound dates over parts of the cutting area.

Review procedure.—In this reappraisal all fire dates were retallied from the original field notes and tree diagrams, thus insuring that all were placed on the same basis. A number of fire wound dates were followed by a question mark, indicating that difficulties were encountered in the ring count, and that although the date shown was the best the field worker could obtain, its accuracy could be questioned. Rather than omit these I chose to tally them according to the possible dates shown. Occasionally wounds were designated as caused by "fire?" indicating that to the note taker the most probable cause seemed to be fire but that he could not be certain of it. These I tallied as fire wounds.

Also, the review turned up some apparent discrepancies in assigned dates, such as differences of a year in the dates assigned to wounds that apparently occurred from the same fire in trees situated in the same general group. I decided to tally these just as shown in the notes, without attempting corrections to make the dates conform to what appeared to be the true ones.

The Fire Record

The tallied results are graphed by individual study areas (Fig. 2). Records from the upper five localities were available to Boyce and to Show and Kotok in establishing their fire chronologies. Those from Madsens and Pinecrest did not become available until later. Because the vertical scale in Figure 2 represents numbers of trees with wounds originating in a given year rather than wounds alone, the figure, when read from left to right also provides some indication of the increasing basis of trees with fire wounds with the progress of time.

From the patterns of distribution by years of the graphed trees with wound age records, a definite peaking of numbers around certain years is evident. Assuming that all dates were determined with equal accuracy, this increase in incidence to a peak year, followed by a progressively lessening incidence, could not be expected from what we know of fire in the forest. It would mean that mild burns, which leave only a few scars but reduce the volume of flammable material on the ground, pave the way for increasingly severe burns up to a peak year after which burns decrease in severity over several succeeding years. Such a progression would violate all experience with fire behavior.

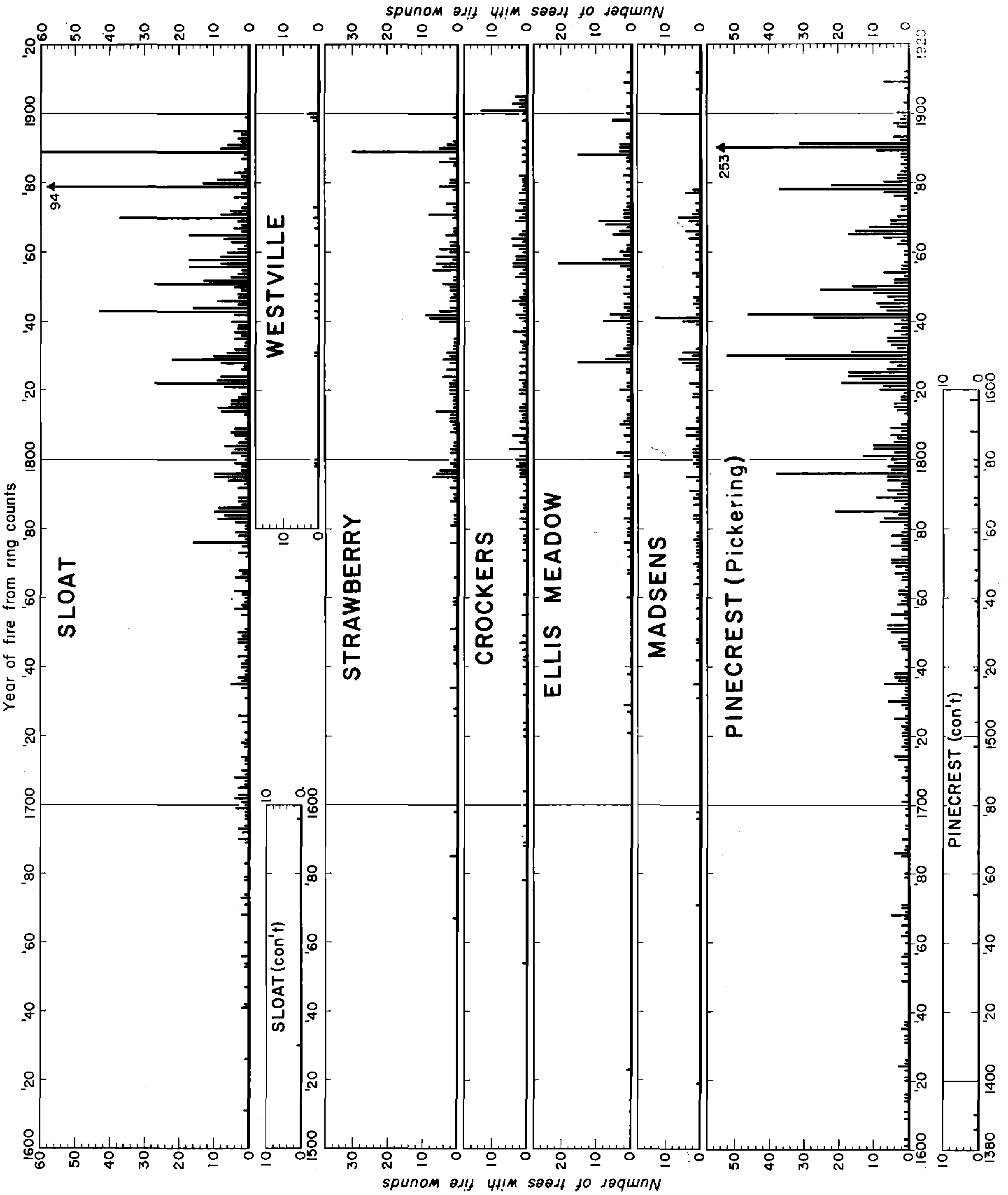

Fig. 2.—Tally by individual study locations of trees with fire wounds of given years of origin as determined by field counts of annual growth rings. The Madsens and Pinecrest records were not available to Boyce or to Show and Kotok in establishing their fire chronologies. As explained in the text, part of the years of origin as determined in the field were inaccurate.

If these patterns of incidence were actual, they should show a relation to weather conditions. Precipitation records are available for Sacramento (Fig. 3) and San Francisco from the 1849-1850 season onward, and temperature records since the early seventies. They offer no consistent support for the form of incidence patterns in Figure 2. For example, on the Pinecrest area, incidence of fire wounds in the graph rises from 1875 to a peak in 1878, then declines to 1884. However, rainfall for the 1877-1878 season was 34 percent above the mean at Sacramento and 60 percent above at San Francisco; spring rains continued into May, there was no prolonged summer heat, and September was cooler than in the preceding and following years. These are not conditions under which one would expect maximum fire intensity. Rather, one would expect it in a year such as 1877, after a seasonal rainfall of only 50 percent of the mean and with temperatures for July, August, and September above the mean for those months.

From still another standpoint, the fire frequency indicated by the individual year records on the graph seems highly improbable. All of the stands in which the decay studies were conducted were uneven-aged, with all age classes represented. If fires had been as frequent as the figure suggests if taken literally, there would have been no opportunity for seedlings to become established and no forest would have been present, let alone an uneven-aged one.

A much more logical explanation is that not all of the age determinations made in the field counts were accurate, for reasons already outlined and as often indicated in a comparison of the field notes themselves. I participated in the counts on three of the areas and can attest to the difficulties sometimes encountered in attempting to obtain accuracy. However, for most of the more recent fires, enough counts were accurate to establish the actual years of occurrence, with the erroneous counts grouped around them. On the Pinecrest area many of the major fire years back through 1796 were confirmed by the counts on tree number 372, a fire-scarred sugar pine which the field man noted as having exceptionally wide, clear, and readily counted growth rings. This tree showed 1890, 1878, 1842, 1830, 1822, 1801, and 1796 as dates for major fires. Although not leaving a record on this particular sugar pine, evidence in Figure 2 indicates that fires occurred on the area in 1849 and 1865 also.

Applying this reasoning to the Pinecrest graph in Figure 2, there were probably not over three fires between 1860 and 1884, two major ones and a possible minor one, although the graph shows fires in all but three of these years. Rings missing as a result of fire damage to the crown reduce the age count and in the graphed results shift the apparent dates to the right. This effect is particularly noticeable following the 1879 and 1889 fires on the Sloat area and the 1890 fire at Pinecrest.

Because counting proceeded from the outside in, and each major fire probably caused heavy foliage kill and strong growth disturbance on some of the trees that survived, it follows that the chances for errors in dating increase as the count is carried back into past centuries, while at the same time the number of trees with fire wounds decreases. These chances are further heightened by the handicaps to counting interposed by discoloration or decay of the wood likely to be associated with old fire wounds. Accordingly, the specific dates shown for old wounds, such as those formed in the 16th and 17th centuries, are to be regarded as approximate only. They indicate that a fire occurred at about that time but not exactly what year it occurred.

Statements accompanying the fire chronologies offered by Boyce (*3*), Show and Kotok (*20*), and Kotok (*14, 15*) suggested that the fires in all of the years listed were general and covered large acreages. However, a check on the locations within a study area of the trees bearing fire wounds of a given year or year group indicates that fires did not always burn over all of a study area. As an example, the 1870 fire at the Sloat location left no wounds on one side of Rattlesnake Creek, although the study extended to both sides of the stream.

For fire years sufficiently well represented in the wound record to provide a reasonable index on this point, six fires at Sloat, four at Strawberry, one at Crockers, five at Ellis Meadow, two at Madsens and one at Pinecrest appeared not to have covered the entire study area, or, if they did so, passed over part of it without creating any fire wounds as a record. Lightning fires starting under conditions not favorable for general spread are particularly likely to be of this type. Other cases of limited spread undoubtedly occurred, but in years represented by too few fire-wounded trees to judge fire extent on the study areas.

The single trees with wounds dated 1903 and 1907 respectively on the Pinecrest area are examples

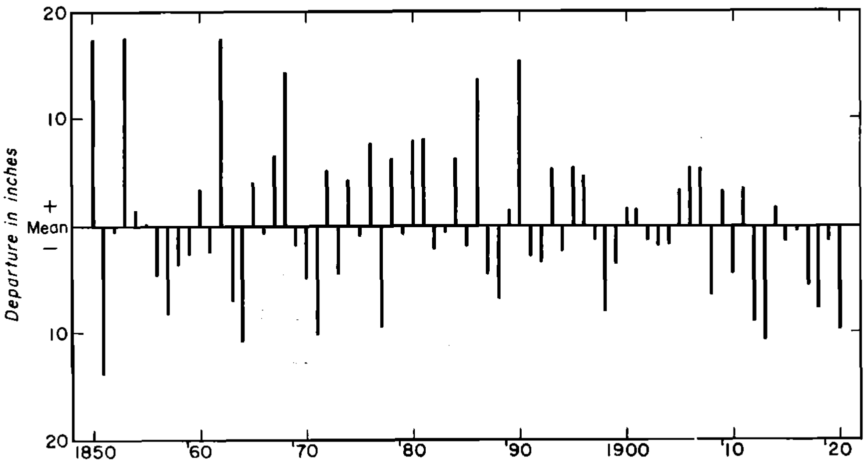

FIG. 3.—Departures in inches from mean seasonal precipitation, July 1 to June 30, at Sacramento, Calif. from 1849-1850 to 1919-1920. Mean = 18.50 inches.

TABLE 2.—FIRE CHRONOLOGIES IN THE SIERRA NEVADA AS LISTED BY BOYCE *(3)* AND SHOW AND KOTOK *(20)* AND PROBABLE FIRE YEARS BY INDIVIDUAL STUDY AREAS FROM FIGURE 2. DATES OF APPARENT MAJOR FIRES ARE ITALICIZED. WESTVILLE HAS BEEN OMITTED BECAUSE OF ITS LIMITED RECORD

Years of severe or extensive fires		Probable fire years by localities (from Fig. 2)					
Boyce	Show & Kotok	Sloat	Strawberry	Pinecrest	Crockers	Ellis Meadow	Madsens
				1588			
				1668			
	1685						
				1686			
	1690	1690					
	1699	1699					
1702	1702	1702					
1708	1708	1708					
				1714			
	1719						
1720							
				1725			
1726	1726	1726					
				1730			
1735	1735	1735		1735			
	1743	1743					
1746							
	1747						
1750	1750	1750					
				1751			
				1755			
1757	1757	1757					
		1762					
	1766	1766					
1767				1767			
				1770			
				1775			
1776		*1776*					
				1778			
				1782			
		1783					
1784							
	1785			*1785*			
1786							
				1789			
							1791
1795		1795	*1795*				1795
	1796			*1796*			
					1798		
				1801			
						1802	
				1803	1803		
1804	1804	1804					
					1807		1807
	1809						1809
						1810	
1814			1814				
	1815	1815		1815			
				1820		1820	
1822	1822	*1822*		1822			
			1824	1824			
						1828	
1829	1829		1829				1829
				1830			
							1831
				1834			
1837	1837				1837		
		1840				*1840*	
							1841
1842			*1842*	*1842*	1842	1842	
	1843	*1843*					
				1845			
					1846		
				1849			
1851	1851	*1851*	1851				
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				1854			
			1855				
1856	1856	1856			1856		
			1857			*1857*	
		1858					
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			1861				
					1862		
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1865	1865	1865	1865	1865		1865	
							1866
					1869	*1869*	
		1870					1870
1871			1871				
					1872		
							1877
				1878			
1879	1879	*1879*	1879				
1886			1886				
						1888	
1889	1889	*1889*	*1889*				
				1890			
		1895					
				1897			
						1898	
1899							
					1901		
					1903		
				1909			

in which wounds have been attributed to fire but were probably from other causes. Scattered cases of this must occur elsewhere in the graphed record for all areas. Adjacent to common routes of travel, wounds could have been from actual fires but not wildfires, for detailed accounts of early travelers through the Sierra Nevada, such as those of Bruff (*5*), show that overnight campfires were often built against or near the bases of trees flattened by old fire wounds. Local cambium injury from the heat of these fires could have resulted even though the fires did not escape. However, part of the areas, including the one near Pinecrest, were not on established routes of travel, and this type of individual wounding is not to be expected on them. Practically all of the older dates, such as those before 1760, are thought to represent actual wildfires.

Fire incidence.—Differences in views on earlier fire history in Sierra Nevada forests center chiefly around two points, (1), the frequency with which fires occurred, and (2) their origins. This review can contribute little to the second point, but it should provide more specific evidence on the first than has been available in published accounts to date.

In Table 2 the most probable fire dates on the different study areas are listed, as judged from the graphed data in Figure 2. Dates of what appear to have been major fires are italicized. For comparison the Boyce and the Show and Kotok chronologies are also given.

Even though included as probable, some of the dates listed are open to considerable question. For example, the four fires in the Strawberry list between 1855 and 1861 may not all have been separate fires, although they came at a time when white men were frequenting the mountains on exploratory trips and fires could well have resulted as often as every other year.

It will be noted that both the Boyce and the Show and Kotok chronologies depend heavily on the Sloat and Strawberry records, although neither includes the fire of 1870 on the Sloat area. Comparing the records for the six separate locations and assuming that the dates chosen are the correct ones for the fires that they represent, 19 cases are found in which fires occurred on two areas in the same year, one case (1795) of fires on three areas, and two (1842 and 1865) when four areas were burned over in a single year. The remaining 69 occurrences listed were confined to a single one of the six locations.

Table 2 does not include fires, particularly in the earlier years of record, which produced wounds for which the actual year of occurrence is questionable. To cover these as well as the fires listed in Table 2, I tallied, by inspection from the graphs in Figure 2, all fires that I considered to be probable after a chosen date when fire wound representation seemed to be reasonably complete. The results (Table 3), showing average intervals between fires of 7 to 9 years for the various localities, are open to question because of the interpretative judgment involved. If anything, the tallies are thought to be on the generous side, that is, actual fire incidence may have been a little less frequent. Moreover, the tallies do not take into account the indications that not all fires burned over an entire study area.

TABLE 3.—FIRE FREQUENCY BY LOCALITIES AS JUDGED FROM GRAPHS OF OCCURRENCE (FIG. 2) BASED ON FIRE WOUND AGE COUNTS

Locality[1]	Tally of probable fires: Starting year	Closing year	Span	Total fires	Average interval between fires
			Years		*Years*
Sloat	1640	1910	270	38	7
Strawberry	1720	1910	190	25	8
Pinecrest	1540	1910	370	51	7
Crockers	1680	1910	230	29	8
Ellis Meadow	1760	1910	150	20	7
Madsens	1730	1910	180	21	9

[1]Westville omitted because of inadequate record.

Allowing for these considerations, the average intervals between fires for individual trees were probably as long as 8 or 10 years.

For the Pinecrest area (Pickering study plots) much shorter average intervals of from 1.1 years[4] to 2 years (*15*) between burnings have been reported. These reports trace to a preliminary chart which I prepared in the late 1930's to accompany a talk before a local gathering of foresters on fire history on the Pickering plots. The chart was similar to that prepared from the same original field notes for Figure 2 of the present paper, where it is designated as the Pinecrest area. The original talk pointed out that not all age counts of fire wounds undertaken in the field could be made with equal accuracy and that because of this difficulty only the more obvious peaks in numbers on the chart represented actual fires. In later interpretations of the chart by others, this explanation was overlooked and each date shown was accepted at full face value, with resulting regrettable misunderstandings of the probable past fire incidence on the plots.

For foresters and ecologists the ranges in length of periods between damaging fires are likely to be of greater interest than the average fire periodicity in interpreting the character of the resulting forests.

On the Sloat and Pinecrest areas, where the basis in fire-wounded trees is greater than at the other locations, tallies of probable intervals between damaging fires back to 1815 at Sloat and to 1785 at Pinecrest show minimum intervals of 2 years at both locations. The maximum interval was 14 years at Sloat and 21 years at Pinecrest. These are long enough to permit seedlings to become established and to develop some degree of fire resistance before the next general fire on the area.

Other Western Fire Chronologies

In the pine region of south central Oregon, Keen (*11*) found

[4]Reynolds, R. D. Effect of natural fires and aboriginal burning upon the forests of the central Sierra Nevada. M. A. thesis. Univ. of Calif. Dept. of Geography. 262 pp. Illus. 1959.

that, on the Watkins Butte sample area northeast of Fort Rock, fires during the 19th century had swept through in 1824, 1838, 1843, 1863, 1883, and 1888. He found similar frequencies in earlier centuries. The fires in 1863 and 1883 were evidently not severe and had no noticeable effect on ring growth. Keen (*12*) also reported that a ponderosa pine in Klamath County, Oregon, showed 25 fires at approximately 18-year intervals from 1481 to 1936, when the tree was cut.

Near the South Ice Cave in the same general part of Oregon, fires were found to have occurred in 1829, 1845, 1855, 1869, 1883, and 1905, with a following major fire in 1915. Of these, judging by the ring response, only the 1829 and 1915 fires were very severe.[5]

In these instances the years of fire occurrence were accurately determined by means of the cross-dating technique. They show longer intervals between fires than at the Sierra Nevada locations but this is to be anticipated because of the climatic and site differences between the two regions. The Oregon stands were on relatively marginal sites, with a sparse ground cover, low average annual precipitation, but with a less pronounced dry season than in the Sierra Nevada.

In the ponderosa pine forests of eastern Washington an interval comparable to that in the Sierra Nevada was found by Harold Weaver, Bureau of Indian Affairs, on the Colville Indian Reservation. Fire wounds on a ponderosa pine there indicated an average interval between fires of 7.2 years from 1739 to 1905. The longest period without a wound was 13 years (*19*).

Discussion and Conclusions

History, whether of populations of humans or of trees, is significant chiefly for the understanding that it may provide of the conditions and environments under which those populations existed over a past span of time and for the wisdom that this understanding may yield in the guidance of future actions or policies. Forest fire history presents a number of intriguing aspects, such as the origins of fires, their character and intensities, the relation to weather, and the ecological influence of fire on the forest. However, the present reappraisal from decay-study records has been confined to the question of fire frequency for the periods covered within the study areas and the subsidiary one of whether the frequency pattern underwent any marked change after the coming in large numbers of the white man to California at the time of the Gold Rush.

Some of the statements made in connection with earlier chronologies were undoubtedly too broad and inclusive, but the evidence indicates that the conclusion by Show and Kotok (*20*) of a general average fire periodicity of 8 years at all areas studied was substantially correct and needs only minor adjustment to bring it into line with the probabilities of an average 8 to 10 year incidence, as developed here. For the Pinecrest area this frequence holds to before the middle of the 16th century; for two other areas back to the 17th. Intervals between fires on these areas were as short as 2 years or as long as 21 years.

On the subsidiary question of change in frequency pattern after the coming of the white man, an inspection of the graphs in Figure 2 suggests that no major change occurred until after 1900, corresponding roughly with the establishment of the national forests. On one or two areas, such as at Strawberry, the rate of incidence appears to have increased temporarily about 1855, but only for a few years. The average periodicity of 8 to 10 years between fires of any consequence corresponds fairly well with the 7.2 year average interval cited for the Colville Indian Reservation in Washington. From the fact that there was no marked change in incidence pattern with the advent of the white man, one may infer that most fires in the middle elevation stands represented by the study areas were from natural sources, such as lightning. None of the locations appear to offer a parallel to special situations, such as that in Yosemite Valley, where the evidence for control of the vegetation by fire on the part of the Indians seems strong,[6] whether for protection from ambush or to favor the oaks, the acorns of which constituted an important food staple for the natives. Fires there may have occurred at more frequent intervals than the 8 to 10 year average for middle elevations in the Sierra Nevada as a whole, as developed from the study records reported here.

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[5]Keen 1943. *Op cit.*

[6]Reynolds. 1959. *Op. cit.*

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Opportunities in Forest Products Marketing in the Far West[1]

Richard W. Bruce

THE FOCAL POINT of much rather controversial interest was Senate Bill 840, first introduced in the Senate on January 25, 1957, by Senator Humphrey. This bill called for the Secretary of Agriculture to "... provide farmers and other owners of small forest properties with current information on markets and prices ..." (*4*). The result was a small avalanche of material both pro and con, from which the following observations might be made:

1. Lumber price reporting is already adequate.
2. Reliable stumpage price reporting may not be possible.
3. There appears to be little discussion concerning price reporting for sawlogs.
4. Local rather than federal aid should do the job of price reporting if it is to be done for forest products.
5. Some feel price reporting may lead to federal controls and unfavorable tax adjustments.
6. Price reporting may be desirable in spite of the possible implications and limitations.

The controversy raises questions concerning both desirability and feasibility of market reporting.

Findings in Washington State indicate that *sawlog* price reporting, at least, is desired by both forest landowners and operators in the forest industry (*1*). This paper, then, will deal with sawlog market reporting; specifically, sawlogs from private forests. An assumption will be made that such reporting is desirable in order that we may proceed to discuss the actual job of collecting and disseminating market information. Feasibility will be examined in conjunction with problems encountered.

Programs in the Far West

Numerous local market reports are being compiled by county agents and farm foresters. Many cooperative state and federal agencies are also doing some rather extensive market reporting. The purpose has always been to inform private landowners of market conditions and prices, often with the secondary aim of encouraging forest management. Regularly published reports are now available in Oregon, Washington, Idaho, Montana, and California. These reports vary in extent of geographic coverage and frequency and they all tend to emphasize prices for sawlogs and pulpwood, as well as minor forest products. The limited information available indicates that these reports have been very favorably received. Acceptance and encouragement has come from landowners, loggers, and sawmill operators.

With that brief background, and armed with four years of monthly data from Washington State, I will explore the following questions:

1. What information has been gained from these reports?
2. What problems have been encountered?
3. Where do the opportunities lie for future development?

Information Gained From Market Reporting Experience

Method of collecting data.—Two common methods of obtaining price and market information are mail questionnaires and personal contact. Our experience indicates that the decision to use one or the other, or a combination, is closely related to the extent of market development in the area. If an open market exists in which there are numerous buyers and sellers with frequent sales being transacted, it is likely that a fairly uniform market price will prevail throughout the area. But if there are only a few buyers and sellers with infrequent sales, prices may be quite varied from mill to mill or town to town.

We have good examples of both of these situations in Washington. Eastern Washington has a well established open market for private sawlogs. Central Washington has

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[1]Scientific paper 2064, Washington Agric. Expt. Sta. Work was conducted under project 1481.