THE FIRE HISTORY OF DESOLATION PEAK

A Portion of the
Ross Lake National Recreation Area

James K. Agee
Mark Finney
Roland de Gouvenain

Final Report
National Park Service
Cooperative Agreement
CA-9000-3-0004
Subagreement 5

National Park Service Cooperative Park Studies Unit
College of Forest Resources, University of Washington
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INTRODUCTION

> In 1919 a fire had raged in the upper Skagit and all the country around Desolation, my mountain, had burned for two months and filled the skies of northern Washington and British Columbia with smoke that blotted out the sun. The government had tried to fight it, sent a thousand men in with pack string supply lines that then took three weeks from Marblemount fire camp, but only the fall rains had stopped that blaze and the charred snags, I was told, were still standing on Desolation Peak and in some valleys. That was the reason for the name: Desolation.
>
> Quoted with permission from
> Jack Kerouac, The Dharma Bums

The 1919 fire was but one of many that have burned through the northern Skagit country, not only in this century but in previous centuries as well. Desolation Peak may have received its name in this century for its burned-over landscape but that landscape has dynamically evolved with fire for eons.

The objective of this study was to obtain fire history information about Desolation Peak as one of the more fire-prone areas within the North Cascades National Park Service Complex (Figure 1). This information will be useful in fire management planning for natural fires and in defining the need for prescribed burning in the area. The driest areas in the park complex are located along the eastern edge of the park in the Ross Lake and Lake Chelan National Recreation Areas. The study site was selected within the Ross Lake area because of the relatively scarce fire information compared to Lake Chelan.

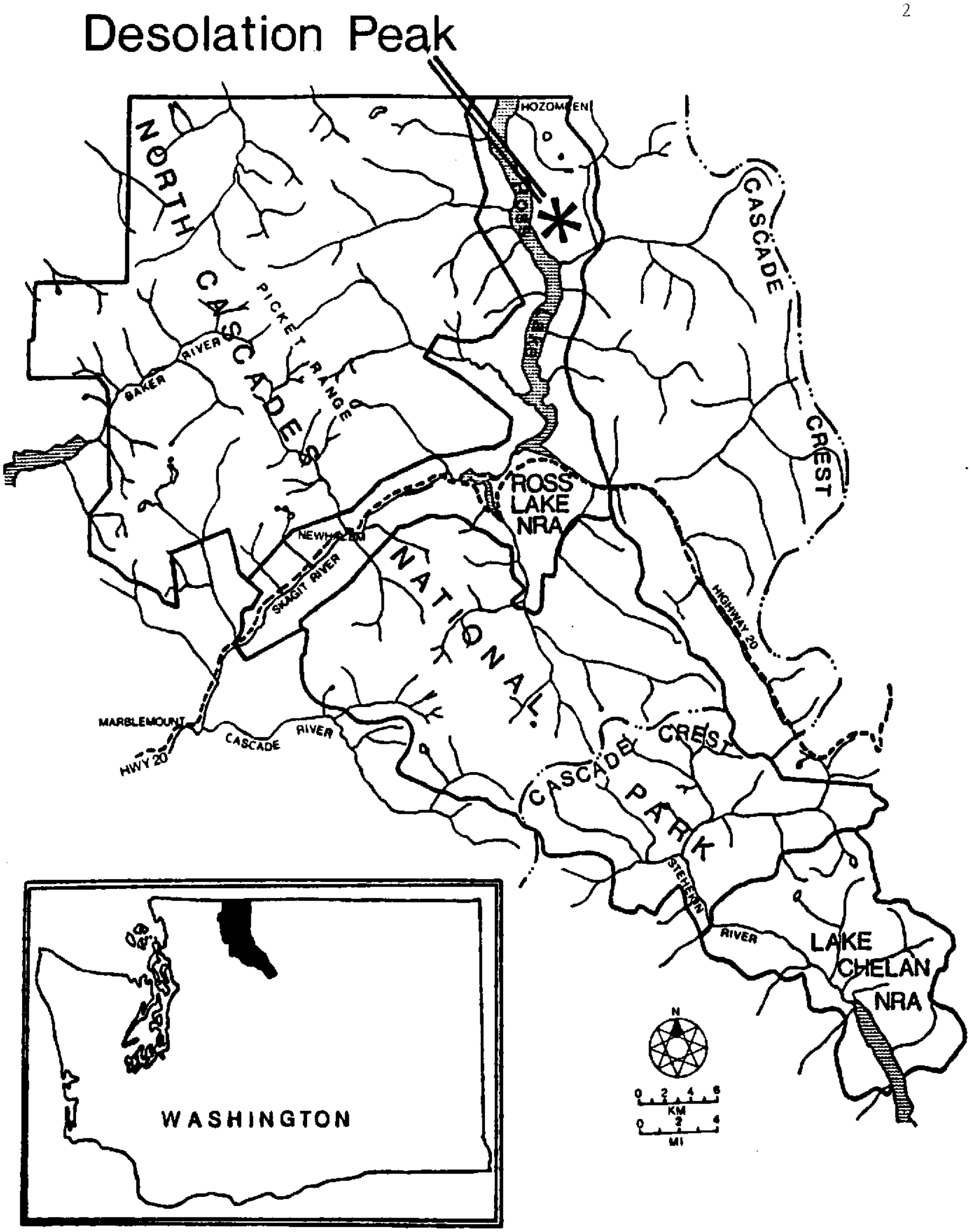


Figure 1. Desolation Peak is in the northeastern corner of the North Cascades National Park Service Complex in north-central Washington.

Historical influences of fire are extensive throughout this area. A multiple age and size class forest structure, as well as dead snags and charred stumps, are evidence of past fires. Unlike wildfires in the wetter forests to the west, fires in this area are not necessarily of stand destroying severity. Topographic features, such as rocky outcrops, rock slides, and avalanche chutes, provide natural fire breaks. Variable intensity fires can create variable fire severity levels across the landscape, forming multiple age classes and complex stand structures.

The study was originally designed to include a westside watershed for comparison, but financial constraints and priorities caused that portion of the study to be deleted. The Desolation Peak area within Ross Lake NRA was determined to best provide the topographic variations necessary for analysis of different fire frequencies and effects. Desolation Peak contains five distinct aspects and is itself a discernible unit, bounded by valleys on three sides and Ross Lake on the west. Ross Lake is a water power reservoir that flooded that upper Skagit River valley in the 1940's. The study included the collection of fire history data, vegetation sampling to characterize the forest communities, and the establishment of two permanent plots to aid fire history determinations and provide a remeasurable baseline for forest ecology purposes.

METHODS

Two types of plots were established in this study: a large number of reconnaissance-level plots (called recon plots) and two permanent plots of larger size, one at low elevation and one at high elevation.

Reconnaissance Plot Methods

Recon plot locations were subjectively selected to represent certain forest characters and/or fire incidence. Fire dates at each plot were obtained from increment cores (on larger trees or where only one fire was recorded) and wedge samples. Additional fire evidence was gathered during travel between plots. Although no uniform or predetermined sampling pattern was used, reconnaissance was very thorough. All areas of the mountain were at least visually examined for potential plot sites and forest characters which indicated disturbance.

Sampling began on the southwest facing aspect (by Lightning Creek) and proceeded north and subsequently in a clockwise fashion around the mountain. Essentially, each aspect was sampled as a unit. This allowed the crew to closely examine specific qualities and patterns peculiar to each aspect and identify more subtle variations. A total of 97 plots were established within the 3500 ha area, or roughly 1 per 36 ha (7 per sq. mile).

Fixed area plots best characterized these forest conditions. 10 X 10 meter plots were most commonly used; however, 15 X 15 and 20 X 20 meter plots were occasionally required to accurately "fit" certain structural characteristics in widely-spaced stands. Diameter at breast height, total tree height, and basal area by species were recorded for each tree in the plot. Aspect, slope, and elevation were also measured at each site. Coverage of subordinate vegetation was determined by cover class (1 = 0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 =76-95%, and 6 = 96-100%), for all species present. Increment cores were extracted from selected trees as close to the base as possible (for age counts). Height at which these cores were extracted were recorded for later corrections.

Recon Plot Vegetation Data Analysis. Vegetation data were analyzed using two multivariate methods: ordination and classification. These two procedures are described in detail by Gauch (1982); their main purposes are (1) to summarize community data, (2) to relate the community variation to environmental gradients, and (3) to help understand community structure.

The two computer programs that were used are DECORANA (Hill 1979a) for the ordination and TWINSPAN (Hill 1979b) for the classification. Both these programs were used in a previous study of the vegetation of the entire park complex (Agee and others 1985). Species importance values used as input to the programs were cover classes for shrubs and herbs and a weighted average of relative basal area and relative cover (expressed on the same 1-6 scale) for trees.

Fire History Analysis

Over 1000 increment cores and approximately 50 wedge samples were removed. Laboratory analysis established ages of sampled trees and fire dates. All increment cores were mounted, sanded, and counted under a binocular microscope. Total tree age was obtained from core ages corrected for both core height and where cores did not intersect the pith. Adjustments of tree age for core height are shown for Douglas-fir, grand fir, lodgepole pine, and mountain hemlock in Table 1.

Age corrections for Pacific silver fir and subalpine fir were made using both height and the number of rings per inner cm at core height (Figure 2). Disks cut from the base of 28 small fir of both species at known height provided the data. This technique improved the coefficient of determination from roughly 0.25 to 0.75.

Fire dates were recorded from cores and wedges. Many cores, not intentionally removed for their indication of disturbance, contained pitch rings and/or abnormal or abrupt fluctuations in ring widths. Dates of these occurrences were recorded and later correlated with more definitely known fire occurrences. Forest Service and Park Service fire records were also reviewed for ignitions and possible fires that were undiscovered in the field.

Table 1. Correction factors used to adjust tree ages from core height to ground level.

Height Above Ground (cm)	Douglas-fir/grand fir Dry Site*	Douglas-fir/grand fir Mesic-Dry Site**	lodgepole pine Low Elev.**	lodgepole pine High Elev.	mountain hemlock
	years				
0	0	0	0	0	0
10	3	1	1	2	6
20	4	2	2	3	8
30	5	3	3	4	11
40	6	4	3	5	14
50	7	4	4	6	16
60	6	5	4	6	19
70	8	-	4	7	22
80	9	-	5	-	-
90	9	-	5	-	-
100	10	-	5	-	-

*From Agee and Dunwiddie (1984)
**From Agee (1984)
Other data from this study.

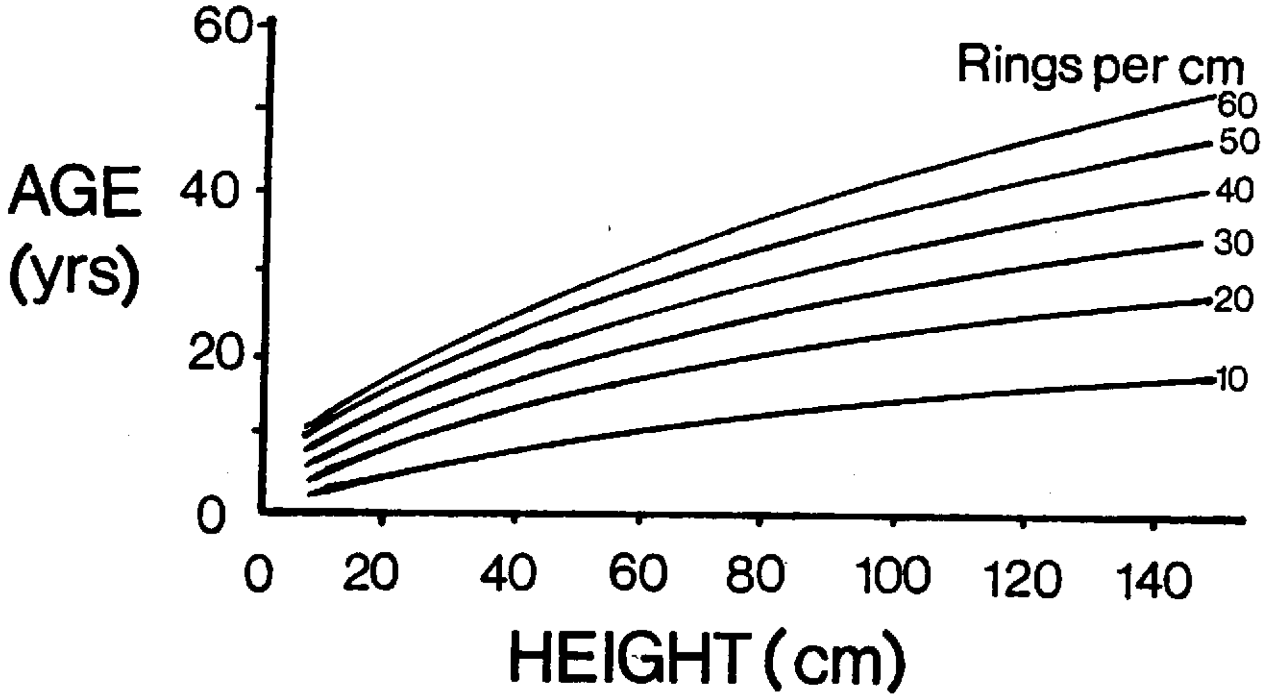


Figure 2. A predictive model for age of subalpine fir and Pacific silver fir based on height and number of annual rings in the inner centimeter at core height.

From all tree ages recorded, distinct age separations between groups of trees were generally distinguishable within each plot. Recruitment periods appeared short enough that age "groups" less than 30 years apart were detectable. These groups were subjectively determined from clusters of corrected tree age counts within each plot. Each age group within each plot was represented by the oldest tree in that group for plotting on the map of corresponding plot locations.

Once possible age groups were mapped on corresponding plot locations, age "classes" were designated according to the distribution and variation between similar age group indicators. Using aerial photographs and mapped age groups, age class coverage was delineated on acetate overlays. The area occupied by each age class was determined using a dot-count approach.

A similar technique was used for determining extent of historical fires. Guidelines for mapping individual fire coverages are similar to those used by Hemstrom and Franklin (1982). However, unless otherwise indicated, fires were assumed to have burned uphill until a topographic barrier and/or the approximate elevation where subalpine forests predominate. Evidence from this and other studies (e.g., Schmidt 1960) suggest a natural dampening of fire spread and intensity upon entering higher elevation fuels from below. Additionally, historical fires frequently left residual trees; therefore, assumptions of stand destroying severity and consequent regeneration patterns were not made.

Reconstruction of these fires was deliberately conservative where evidence was scarce. The existence and presence of a specific fire on a certain area was determined according to logical geographic association along with four sources of data: (1) The most reliable and accurate evidence was produced by wedge samples, although these were less abundant than indicators from cores. (2) Cores specifically extracted for determining a fire date (i.e., from a large tree with a fire scar) were considered more reliable than (3) cores merely exhibiting aberrant ring patterns. However, all three were used in determining the coverage of past fires. The latter was found to usually display disturbance one to three years after (or more recently) than the actual date. This is probably due to a delayed effect of fire on the tree's growth record. The final source was (4) the previously mapped age class distributions. These were especially valuable where severe fires removed all previous evidence.

Area of each fire was determined as for age classes. Additionally, for fire frequency analysis, the entire sampling area was subdivided into five aspects: north, east, south, southwest, and west. These divisions were geographically distinct, and boundaries followed ridgelines. Coverage of each fire was partitioned according to these aspect divisions.

Several methods were considered for calculating fire frequency. Point estimates, such as individual fire scars or cluster fire scars (e.g., Kilgore and Taylor 1979, Dieterich 1980) are most applicable in very frequent fire regimes where trees are regularly scarred and not usually killed. Area estimates that rely solely on age class distribution and several assumptions about randomness of ignition and frequency of regeneration, such as the Weibull and negative exponential distributions (Johnson and Van Wagner 1985) work well in boreal forests but not in variable fire regimes such as at Desolation Peak. The preferred method in this study was to calculate fire frequency using Natural Fire Rotation (Heinselman 1973). A selected time period divided by the proportion of the total area burned during that time period yields the NFR, which is the time required to burn an area the size of the study area. This technique can use a combined record derived from age classes and fire scars to produce fire frequencies for various time periods and for various geographical units, such as by aspect.

Fire frequency was also analyzed for different vegetation types in two ways. The first method analyzed fire frequency by forest community type. The map of community types (Figure 7) was overlayed onto the fire history maps (Figure 9). Coverage of each fire by community type was recorded. Natural fire rotations by community type were calculated by dividing the time period (411 yrs) by the average number of fires per plot in a community type over that period (the total number of fires on all plots in a community type divided by the number of plots in that type).

A second method to assess fire frequency differences by vegetation analyzed fire frequency by dominant species of trees. Primary dominant and secondary dominant tree species for each plot were determined by density and height measurements. Within each plot, the height class which represented the dominant tree stratum was divided according to the two species which accounted for the greatest and second greatest density in that stratum. Thus, the "dominant" stratum was not necessarily composed of the tallest trees in the plot. The percent cover of each fire by primary and secondary species was then converted to natural fire rotations for each species as primary and secondary dominants with the same technique used for forest community types.

Permanent Plot Methods

Permanent plots were established in one low elevation and one high elevation area. Each plot was 40m by 40m in size. Percent cover of shrub and herb species was visually estimated within the plot and recorded. All living trees with a dbh (diameter at breast height) of more than 5.5 cm and all dead trees with a dbh of more than 5.5 cm and a height of more than 3 m were numbered and tagged within the plot. All tagged trees were measured for dbh and height, and their species name recorded (for dead trees, only height and dbh were recorded). An increment core was taken from each living tagged tree and the diameter of the tree at core height was recorded. A map was made of the plot indicating tagged tree locations and downed logs of more than 7.5 cm diameter. A log decay class (Cline et al. 1980) was assigned to downed material, from a value of 1 for undecayed logs to a value of 5 for highly decayed logs. The two end diameters of all downed material of more than 3 meters length were recorded.

All cores were measured in the lab to estimate age of the trees. A correction factor to estimate the age of each tree at the height of the core was calculated from sapling disc cross-sections at various heights above the ground; the estimated age at core height was then added to the ring count from the core to obtain total tree age.

Four regeneration subplots were located in each corner of the large plot to measure the density of tree seedlings and saplings. Both 2m and 4m radius subplots were used, the smaller for trees shorter than 1 m in height and the larger for trees above 1 m in height but less than 5.5 cm dbh. Ages of seedlings of less than 0.1 m height were estimated visually by counting the number of nodes. Six additional regeneration sampling plots were randomly located in the subalpine plot and data were pooled with the four original regeneration plots.

Subalpine plot location. The 40 by 40 m plot was semi-randomly located on the southwest side of the southern reach of Desolation Peak at 1455 m elevation (Figure 3). It is located on the Hozomeen Mountain quadrangle at UTM 54.1730N and 6.4600E. To reach the plot, ascend the Desolation Lookout trail until a saddle is reached at about 1575 m. A highly visible strip of mature subalpine fir is located due south/southeast along the southwestern flank of the saddle, running from the ridgetop down to about 1300 m elevation. Leave the main trail (which proceeds steeply to the lookout) and hike cross-country for slightly less than a mile in a south-southeast direction, towards the top of the subalpine forest strip, along the ridge crest. The plot is located in the upper portion of this forest; it is marked with red flagging and red markers at each corner. The following azimuths were taken from a small rocky outcrop located a few feet uphill from the plot: Desolation Lookout (348), Cat Island (250), Jack Mountain (170).

Montane Plot Location. The 40 by 40 m plot was located just above Ross Lake within a mature/old growth stand dominated by Douglas-fir, at 540 m elevation (Figure 3). To reach the plot from the junction of the East Bank trail with the Desolation Lookout trail, hike up the Desolation Lookout trail for about 500 ft and leave the trail just before the first switchback; then hike slightly downslope towards the lake at an azimuth of 290. The plot is located just downslope of a rocky outcrop and is marked by flagging and

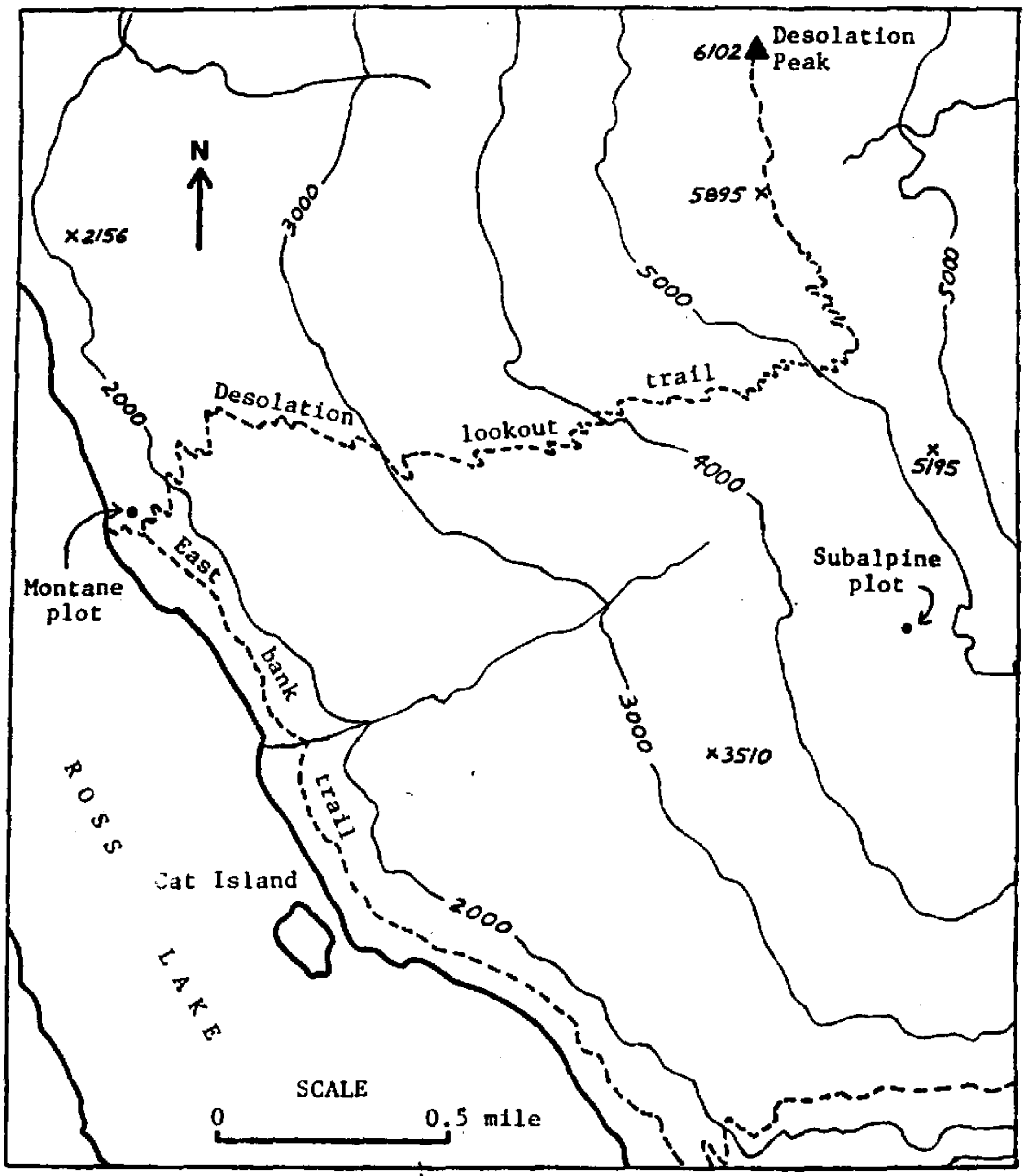


Figure 3. Location of the subalpine and montane plots.

markers at each corner. Location on the Hozomeen Mountain USGS quadrangle is UTM 54.1770N and 6.4340E.

RESULTS AND DISCUSSION

Environmental Gradients Affecting Forest Communities

Forest communities on Desolation Peak, as elsewhere, are arranged along environmental gradients. These gradients were analyzed and identified through an ordination of the recon plot data. The species ordination (Figure 4) has major tree species labelled and appears fairly straightforward. High elevation species such as *Tsuga mertensiana* (mountain hemlock) and *Abies lasiocarpa* (subalpine fir) are located on the right side of the ordination while low elevation species such as *Pinus ponderosa* (ponderosa pine) and *Acer macrophyllum* (bigleaf maple) are on the left side.

The interpretation of axis 1 as an elevational or temperature gradient is supported by a high positive linear correlation between elevations of the plots and their corresponding axis 1 scores (R-squared = .43, n = 97). The elevation gradient is most likely a temperature gradient, with low elevation, warm sites to the left and high elevation, cold sites to the right.

Axis 2 is more difficult to interpret, although species usually associated with dry environments (such as subalpine fir) are located on the high end while species usually associated with more mesic environments are located on the low end. This axis is most likely representing a moisture gradient. A multiple regression using axis 2 sample scores

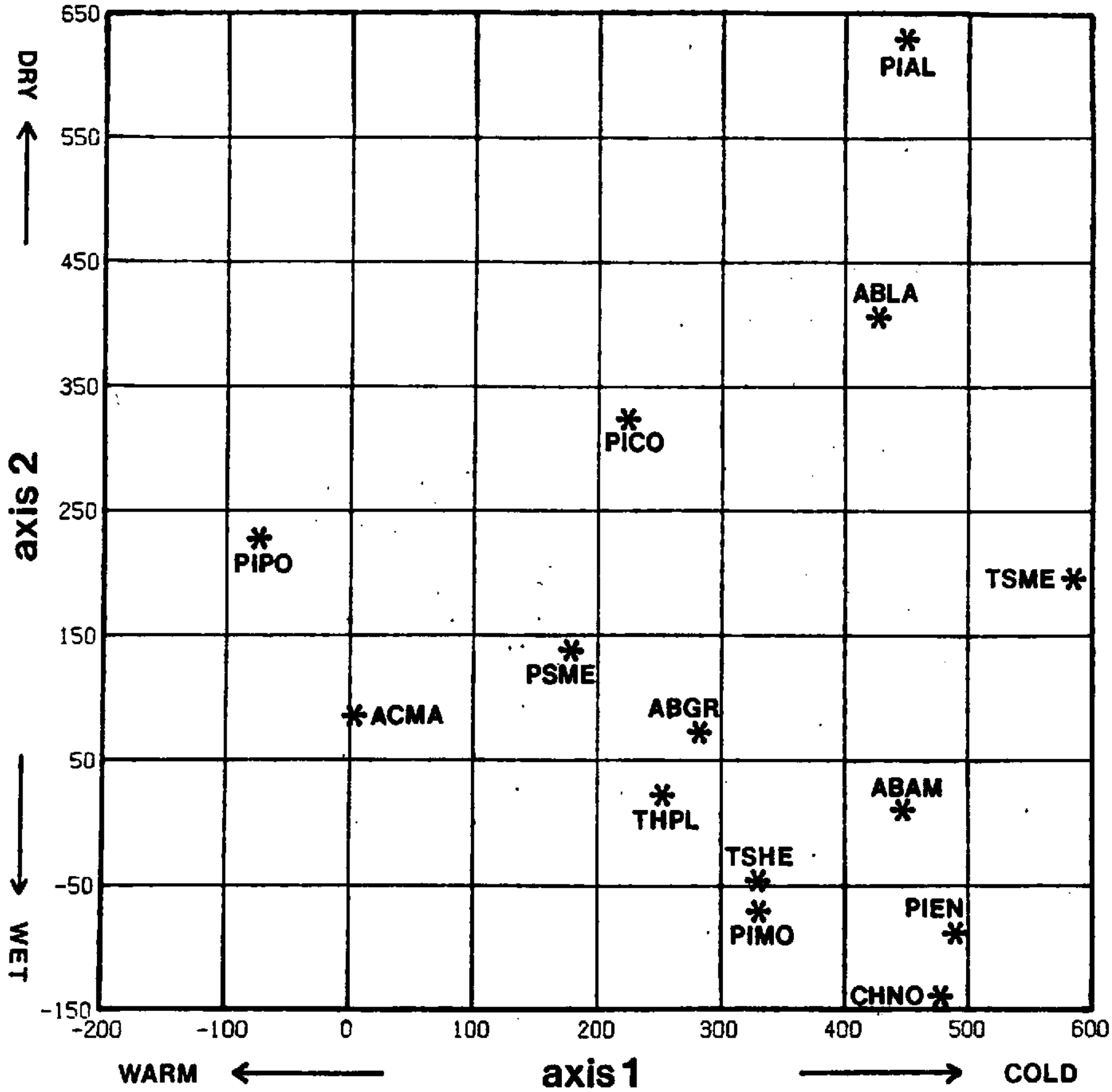


Figure 4. Ordination space of major tree species on Desolation Peak. ABAM = Pacific silver fir; ABGR = grand fir; ABLA = subalpine fir; ACMA = bigleaf maple; CHNO = Alaska yellow-cedar; PIAL = whitebark pine; PICO = lodgepole pine; PIEN = Engelmann spruce; PIMO = western white pine; PIPO = ponderosa pine; PSME = Douglas-fir; THPL = western redcedar; TSHE = western hemlock; TSME = mountain hemlock.

with aspect, azimuth, and slope data to represent moisture availability (a low slope, north aspect should be more moist than a steep, south aspect) using the technique of Stage (1976) yielded a coefficient of determination (R-squared) of 0.23. This would generally be interpreted as a low association but for this type of data it is very significant. When sample plot elevation data were added to the regression equation as an additional predictor, the coefficient of determination increased to 0.37. Thus, axis 2 can be best interpreted as a complex gradient combining moisture availability (affected by aspect and slope) and temperature (affected by elevation). Since the coefficients are positive for elevation but negative for moisture availability, high axis 2 values represent both cold and dry environments while low axis 2 values represent warm and moist conditions.

Vegetation community types were identified through the use of classification analysis by clustering various vegetation samples on the basis of their floristic similarity (Figure 5). The classification produces a large number of groups that are to some degree similar; community types were defined that often combined several of these groups together (each marked by a star in Figure 5).

Forest Community Types of Desolation Peak

Seven forest community types were identified (numbered 1-7 on Figure 5) and are outlined on the sample ordination

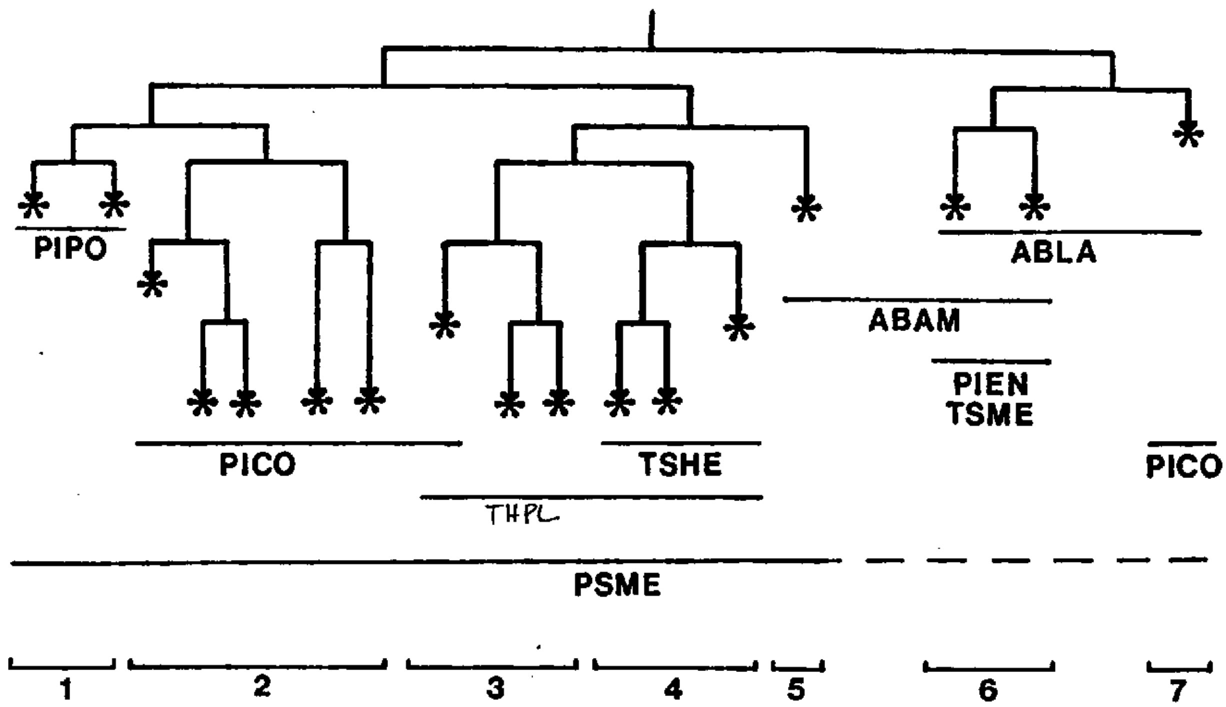


Figure 5. Classification of vegetation recon plots. Presence of tree species (see caption Figure 4 for species codes) is shown by horizontal lines. Forest community types 1-7 are: 1 = Douglas-fir/ponderosa pine; 2 = Douglas-fir/lodgepole pine; 3 = Douglas-fir/western redcedar; 4 = Douglas-fir/western hemlock; 5 = Douglas-fir/Pacific silver fir; 6 = Subalpine fir/Douglas-fir; 7 = Pacific silver fir/subalpine fir.

(Figure 6). The sample plot locations on Desolation Peak are shown in Figure 7.

Community Type 1: Douglas-fir/Ponderosa pine. This type is restricted to low elevation, southwesterly aspects above Ross Lake and Lightning Creek. Elevation ranges from 485 m (1600 ft) to 1030 m (3400 ft). Slopes range from 20 to 75 percent. The dominant tree species is Douglas-fir, with an average cover of 25%; this relatively low cover value is indicative of the fairly open stand structure. Shallow soils and rocky outcrops are common.

The major codominant species is ponderosa pine, with an average cover of 5%. These pines often grow to large size and acquire the yellow-bark characteristic of old growth ponderosa pine. Lodgepole pine is a secondary dominant in this type, and its presence is often associated with past fire. The understory is usually abundant, dominated by shrub species; in the most rocky sites, these shrubs are replaced by herbs that are better adapted to the very dry environments. The major shrub and herb species in the Douglas-fir/Ponderosa pine type are listed in Table 2; tree species are summarized in Table 3.

Community Type 2: Douglas-fir/Lodgepole pine. This community type occurs mostly on southwesterly exposed and fairly steep slopes (15-85%) from low to mid elevation (485-1300 m; 1600-4300 ft). It is also found - but to a lesser degree - on some very steep south-facing slopes above Lightning Creek.

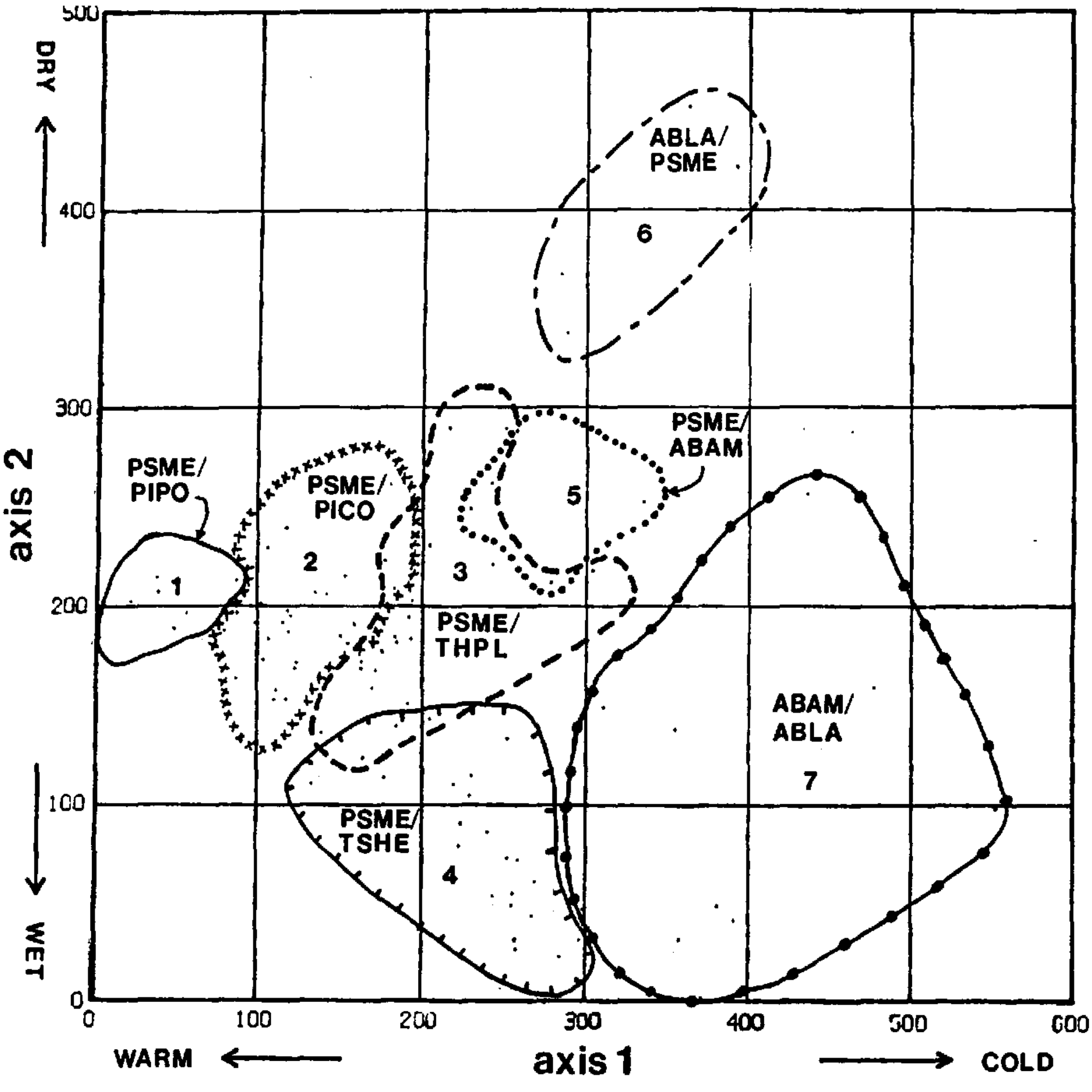


Figure 6. Sample plot ordination showing ordination space of forest community types.

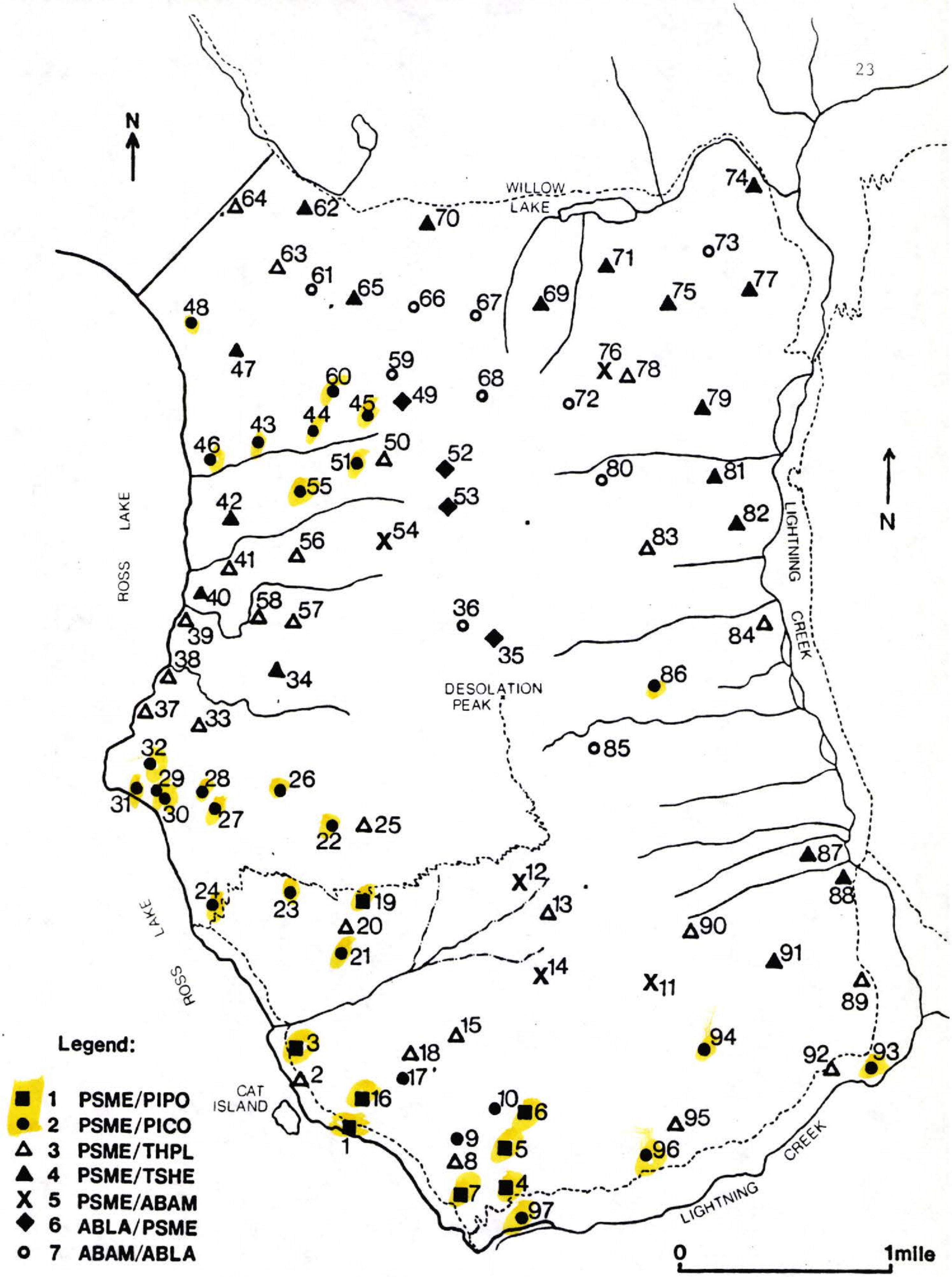


Figure 7. Sample plot locations with forest community types shown.

Table 2. Relative constancy of major shrubs and herbs in Desolation Peak community types.

Scientific Name	Comm. Type 1 Psme Pipo	Comm. Type 2 Psme Pico	Comm. Type 3 Psme Thpl	Comm. Type 4 Psme Tshe	Comm. Type 5 Psme Abam	Comm. Type 6 Abla Psme	Comm. Type 7 Abam Abla
	percent						
Shrub Layer							
Acer circinatum		41	56				
Amelanchier alnifolia	70	41			80		
Arctostaphylos uva-ursi	60	22					
Berberis nervosa	90	59	76	80	40		
Ceanothus velutinus	100						
Corylus cornuta			24				
Holodiscus discolor	60	52					
Lonicera hispidula		26					
Pachistima myrsinites		52	88	40	100	50	20
Rhododendron albiflorum							50
Rosa gymnocarpa		96	72	15			
Rubus parviflorus			24		60	25	
Salix spp.			24		40	50	20
Spiraea betulifolia		78	36				
Vaccinium spp.			48	30	60	100	100
Herb Layer							
Achillea millefolium	50						
Arenaria sp.							20
Arnica sp.						25	
Calamagrostis rubescens	50	33					
Chimaphila umbellata		25	52	20			
Fragaria virginiana	90	41		20			
Hieracium albiflorum	25						
Linnaea borealis			36	30			30
Lupinus sp.					40	75	30
moss		25	16	60			30
Pedicularis sp.						25	
Polystichum munitum			16				
Pyrola sp.				15			20
Trientalis latifolia		44	52	20			
Valeriana sitchensis					40		
Viola sp.					40	25	

Relative constancy is the percentage of plots within a community type that contain the species.

Table 3. Characteristics of tree species in community type 1: Douglas-fir/ponderosa pine.

Species	Density by Height Class			Basal Area Mean	Basal Area Max	Average Cover	Relative Constancy
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Pinus contorta	0	0	29	0	0	T	14
Pinus ponderosa	0	160	57	4	15	5	70
Pseudotsuga menziesii	130	200	280	14	40	25	100

Table 4. Characteristics of tree species in community type 2: Douglas-fir/lodgepole pine.

Species	Density by Height Class			Basal Area Mean	Basal Area Max	Average Cover	Relative Constancy
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Pinus contorta	0	54	260	4	35	5	26
Pinus ponderosa	0	0	8	1	30	T	7
Pseudotsuga menziesii	140	230	450	27	65	35	96

Table 5. Characteristics of tree species in community type 3: Douglas-fir/western redcedar.

Species	Density by Height Class			Basal Area Mean	Basal Area Max	Average Cover	Relative Constancy
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Abies grandis	72	48	8	0.6	10	T	12
Pinus contorta	4	4	120	2.8	20	T	40
Pseudotsuga menziesii	340	230	500	31	65	50	100
Thuja plicata	48	20	16	0.6	10	T	40
Tsuga heterophylla	8	28	4	0.2	5	T	16

Stands have higher cover here than in the Douglas-fir/Ponderosa pine community type, and have fewer rock outcrops. The dominant species is Douglas-fir, and it is often represented by mature trees, while lodgepole pine, the codominant species, is represented by younger age classes following forest fires. At high elevation, subalpine fir is a minor component of this community type while ponderosa pine is a minor component at low elevation. Characteristics of plants in this type are listed in Tables 2 and 4.

Community Type 3. Douglas-fir/western redcedar. The Douglas-fir/western redcedar community type occupies the same elevation range as the Douglas-fir/lodgepole pine community type, but is found more often on mesic, west- to northwest-facing slopes of 15-85% steepness. It is also found scattered throughout most other aspects except for north aspects. Because this type is more mesic, it contains a wider variety of tree species: Douglas-fir remains the dominant species, but western redcedar, lodgepole pine, grand fir, and western hemlock are codominants in specific areas. Subalpine fir is a minor codominant at the high end of the elevation range.

Stands associated with both recent and older fires are found in this type, and in both cases old residual Douglas-fir trees dominate the stands (Table 5). The understory vegetation varies from essentially depauperate forest floors to thick tree regeneration and tall shrubs on better sites (Table 2).

Community Type 4. Douglas-fir/western hemlock. This type occupies mostly northwest, north and northeast aspects with slopes of 20-50% at elevations ranging from 600-1060 m (2000-3500 ft). Douglas-fir is again the dominant species, and is almost always represented by mature and old growth trees. The codominant tree is western hemlock, which is often found as a dense, suppressed understory to Douglas-fir. Occasionally, Pacific silver fir is mixed with the western hemlock. These understory trees can exceed 100 yrs of age.

Most stands in this community type are two-aged stands: the Douglas-fir is a post-fire residual cohort and the understory is a post-fire regeneration cohort with a wide age range. Some stands have almost no understory at all. The major shrub and herb species in this community type are shown in Table 2; tree data are summarized in Table 6.

Community Type 5. Douglas-fir/Pacific silver fir. This type is found scattered at fairly high elevations (1270-1575 m, 4200-5200 ft) on southwest, south, and southeast aspects on slopes up to 75%. It is dominated by two tree species, Douglas-fir and Pacific silver fir. Douglas-fir is usually a dominant canopy member while Pacific silver fir is a younger and more numerous component of the forest.

Plots in this type appear to have all burned within the last 60 yrs, which may explain the dominance of the more fire tolerant Douglas-fir. Characteristics of species in

Table 6. Characteristics of tree species in community type 4: Douglas-fir/western hemlock.

Species	Density by Height Class			Basal Area		Average Cover	Relative Constancy
				Mean	Max		
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Abies amabilis	33	0	11	0	0	T	11
Abies grandis	0	6	11	0.3	5	T	11
Pseudotsuga menziesii	11	94	383	29	60	35	100
Thuja plicata	390	117	44	3.3	35	5	55
Tsuga heterophylla	230	180	230	12.5	50	10	83

Table 7. Characteristics of tree species in community type 5: Douglas-fir/Pacific silver fir

Species	Density by Height Class			Basal Area		Average Cover	Relative Constancy
				Mean	Max		
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Abies amabilis	940	200	30	5	15	1	40
Pseudotsuga menziesii	620	300	200	15	25	15	80

the Douglas-fir/Pacific silver fir type are summarized in Tables 2 and 7.

Community Type 6. Subalpine fir/Douglas-fir. This type is restricted to fairly dry habitats above 1500 m (5000 ft) elevation, and are typical of the west-facing uppermost reaches of Desolation Peak. Slopes are steep (40-65%) and soils are generally shallow.

Subalpine fir is the dominant species and is represented by several age classes. Douglas-fir and lodgepole pine are codominants, the latter often being found as a fairly young component of the stand following major fires. The major species in this community type are summarized in Tables 2 and 8.

Community Type 7. Pacific silver fir/subalpine fir. Typical habitat for this community type is a high elevation (>1200 m, or 3600 ft), moist, north aspect with slopes from 20-80%. These conditions are found on the upper, northern flank of Desolation Peak facing Hozomeen Mountain. This type is also found to a lesser extent on the north-facing slopes of small drainages running east and west from the top of Desolation Peak.

This community type appears to have been burned the least of all the forest types on Desolation Peak. Older age classes are well-represented for most tree species, and the understory vegetation is often sparse beneath a typically closed canopy forest (Table 2).

Table 8. Characteristics of tree species in community type 6: Subalpine fir/Douglas-fir.

Species	Density by Height Class			Basal Area		Average Cover	Relative Constancy
				Mean	Max		
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Abies lasiocarpa	300	275	275	18	35	15	75
Pinus albicaulis	25	0	0	0	0	T	25
Pinus contorta	0	175	100	6.3	20	2	50
Pseudotsuga menziesii	0	0	75	4	15	T	25

Table 9. Characteristics of tree species in community type 7: Pacific silver fir/subalpine fir.

Species	Density by Height Class			Basal Area		Average Cover	Relative Constancy
				Mean	Max		
	0-3m	3-10m	>10m	sq. meters per ha		percent	percent
	number per ha						
Abies amabilis	280	60	320	20	45	20	100
Abies lasiocarpa	60	50	60	3	15	T	40
Picea engelmannii	0	10	60	3	10	T	50
Pseudotsuga menziesii	0	0	100	5.5	25	2	60
Tsuga heterophylla	10	20	60	6.5	50	2	50

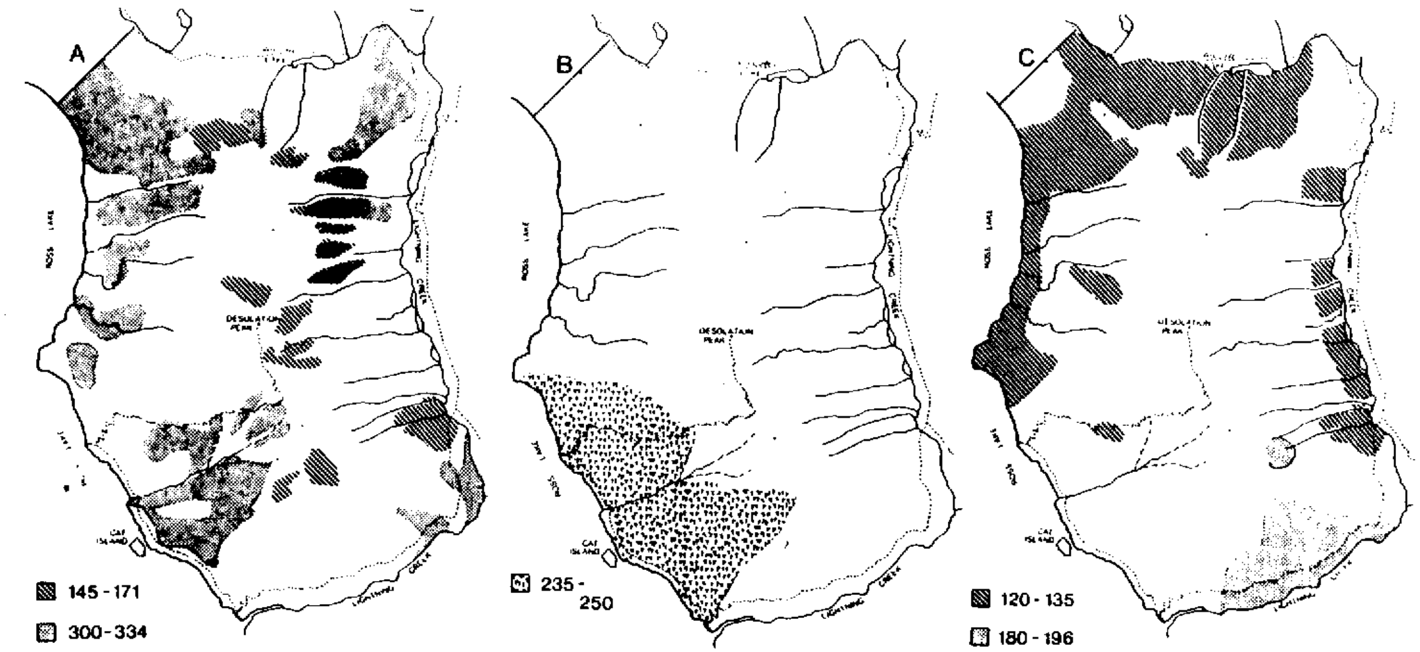
Pacific silver fir is actively regenerating within this community type, along with a lesser amount of subalpine fir. Among the codominant species are Douglas-fir, western hemlock, Engelmann spruce, mountain hemlock, western redcedar, and Alaska yellow-cedar (Table 9).

The Fire History Data Base

Four primary sources of information were used to build the data base necessary to infer the extent of past fires and fire frequency. The first three were derived from field sampling: fire dates recorded from wedges removed from trees, increment cores extracted specifically to determine a fire date or which showed unusual growth patterns which might be related to a fire, and age class patterns across the landscape. The fire dates established from wedge samples are listed in Table 10; possible fire dates from increment cores are listed in Table 11; and forest age class distribution on Desolation Peak is shown in Figure 8. Note that several age classes may occupy the same area due to variable severity of past fires. Additional fire information was gathered from USDA Forest Service and USDI National Park Service records; a summary of these fires is in Table 12.

The Fire History of Desolation Peak

The presence of fires could be detected over about a 400 yr period on Desolation Peak. While the record



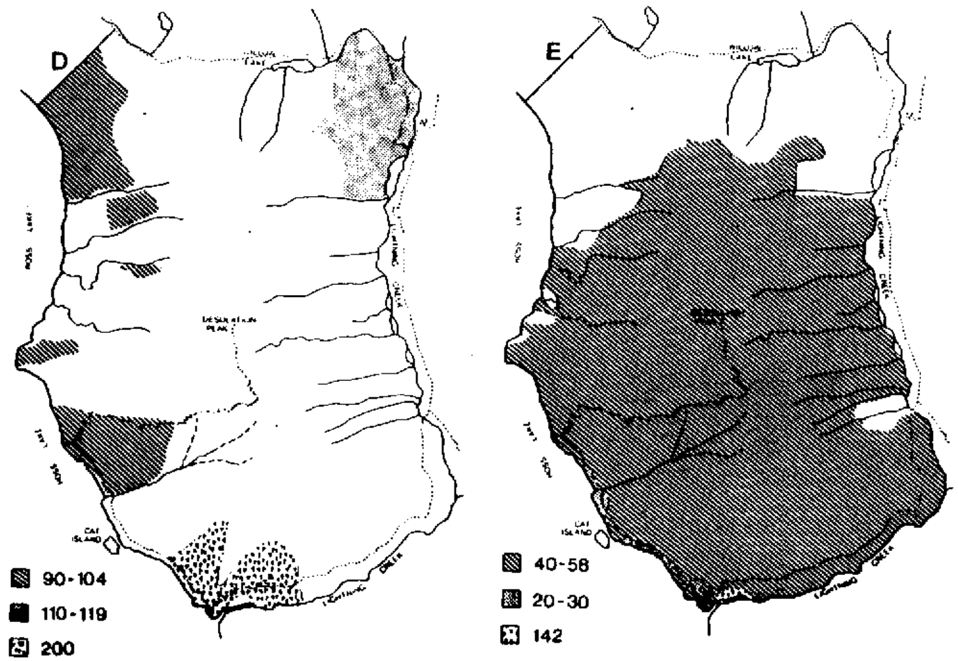


Figure 8 A-E. Forest age classes on Desolation Peak.

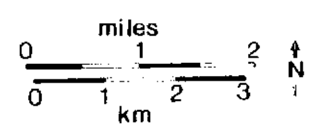


Table 10. Ages of past fires on recon plots established from wedges.

Plot No.	Wedge No.	Ages of Scars (yrs)	Plot No	Wedge No.	Ages of Scars (yrs)
2	1	32	64	1	85,100
4	1	58, 102	66	1	151
6	1	58, 106	67	1	112
7	1	58, 75, 98, 104, 178, 202	68	1	58
11	1	45	72	1	58
16	1	58, 78, 134, 178, 200	74	1	58, 110
19	1	58, 103, 118, 133, 155	76	1	58
20	1	34	76	2	57
27	1	58, 90, 175, 251, 336, 411	76	3	58
31	1	58	77	1	117, 134
31	2	119, 163 (stump counts)	80	1	58
31	3	120, 186, 308, 410	85	1	56+, 106
32	1	58	87	1	58, 133
35	1	66	89	1	57
35	2	58	91	1	58
35	3	67	91	2	58, 67
37	1	59	93	1	58
38	1	59			
41	1	[illegible]			
52	1	58			
63	1	70-71			

Table 11. Estimated ages of fires from increment cores.

Plot No.	Ages From Cores (yrs)	Plot No.	Ages From Cores (yrs)
9	202	72	58, 64, 188
13	58	73	294
14	58	74	98, 105
15	58	76	58
16	58	77	114, 115, 131, 133, 128, 132
17	58	78	55, 58
21	58	79	133
22	58	80	58, 60, 111, 290
23	58	82	58
30	176	83	58
31	85	84	58
35	58	85	58
37	58	86	56, 108, 109, 119, 168, 169
46	133+	87	58, 131
47	156, 170	88	58
48	88+	89	58, 112, 162, 197, 233
56	58	91	58, 66, 198
60	58, 148, 166, 167, 172, 330	92	58
63	93-98, 96-101	94	58, 88-91
64	100	96	58, 88
66	58, 85+, 143	97	39, 116, 119

Table 12. Fire dates from Forest Service and Park Service records.

Date	Description of Record
1922	Small fire just west of Desolation Peak - Class A
1931-40	One small fire just southeast of Desolation Peak, Class A. One at Deerlick Cabin on Lightning Creek- Class A
1940-49	Three fires south of Desolation Peak - Class A
1950-59	One small fire west of Desolation Peak - Class A One large fire in valley burned from Lightning Creek north - Class D-E.
1966	One small fire at Willow Lake - Class A
1970	One small human-caused fire at Lightning Creek - Class A One small lightning fire at Jackass saddle - Class C (5 ac)
1977	One small human-caused fire at Lightning Creek - Class A
1978	Three small lighting fires north of Desolation Peak - All Class A
1980	One human-caused fire at Lightning Creek - Class C (5 ac)

diminishes as one moves back in time, major fires, which have the largest ecological and geographical impact and the greatest effect on fire history, are discernible throughout the entire period. Most information lost is from small fires of fairly localized extent, which are more difficult to find on the landscape. Even some of the recent small fires, for which records were not searched until field work was complete, were not located in the field reconnaissance. A total of 26 fires prior to 1945 were capable of being mapped from the data base (Figure 9 A-L). Three small fires since then are mapped on Figure 9M.

<u>The Pre-1700 Record</u>

The oldest fire in 1573 (Figure 9A) was established from fire wedge information and its extent appeared to cover an area on the southwest aspect over which fires seem to consistently burn. These fires were probably prevented from moving north by discontinuous vegetation and rocky outcrops. Changes in aspect and consequent influences on burning conditions and fuels could also have contained fires on the southwest aspect. There were additional fires which were found to have been basically contained within this area: ca. 1733, 1782, 1806, and 1808. The V-shaped area excluded from these fires was probably spared because of the drainages marking the edges of the "V". Several other larger fires also somewhat followed this "heart-shaped" pattern.

The oldest age class was defined to be 300 to 334 years old. Trees from the 300-334 age class were found mainly in

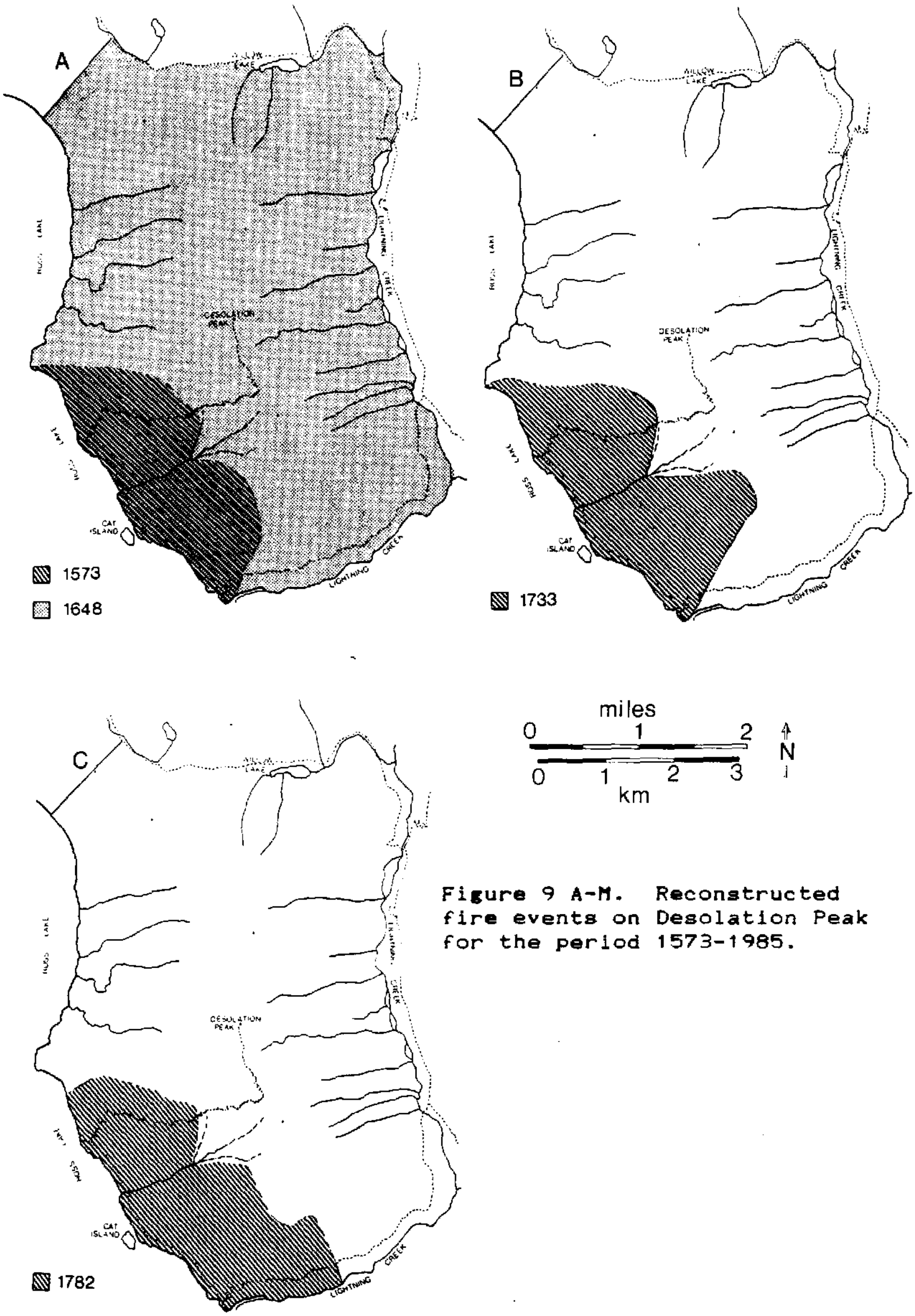
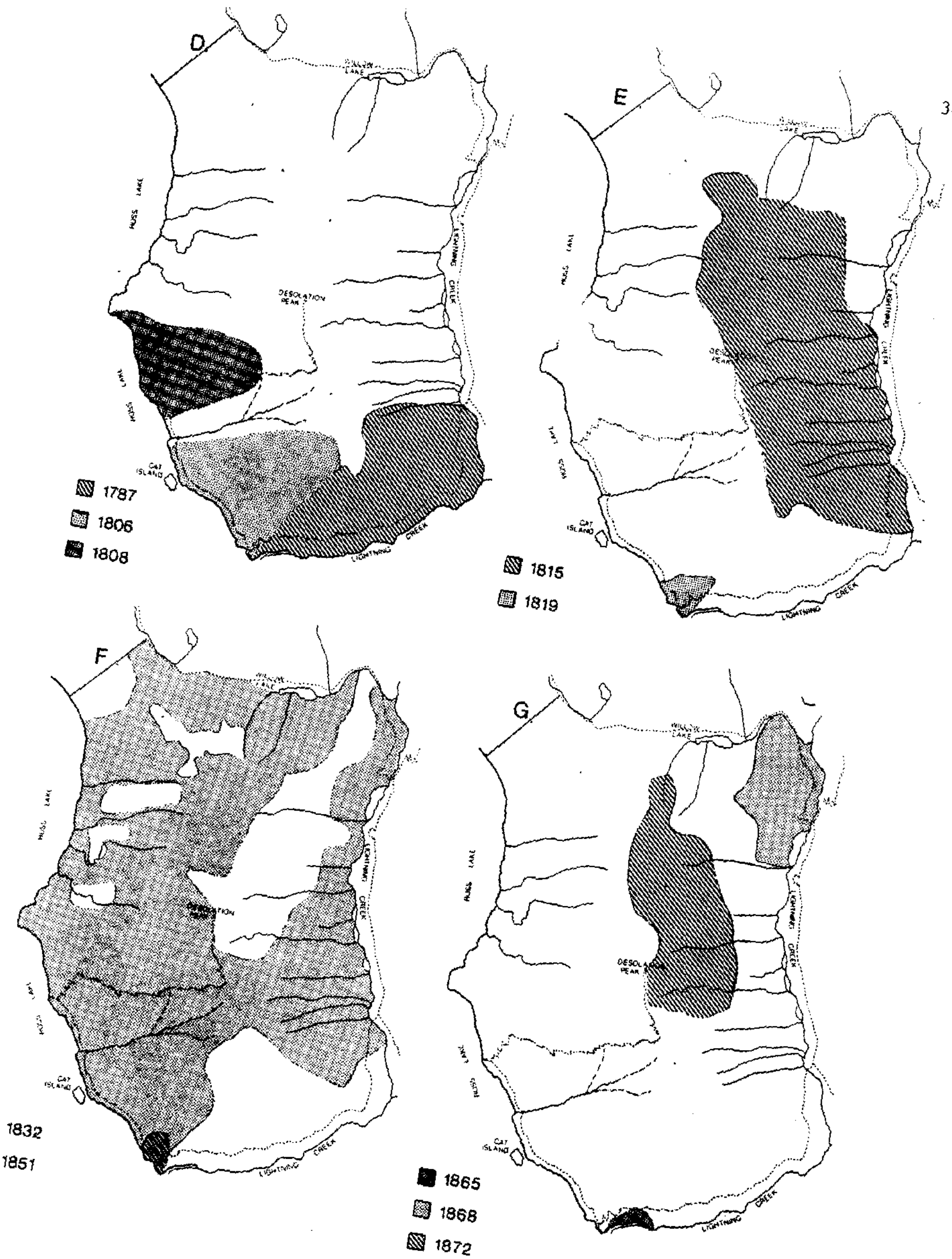
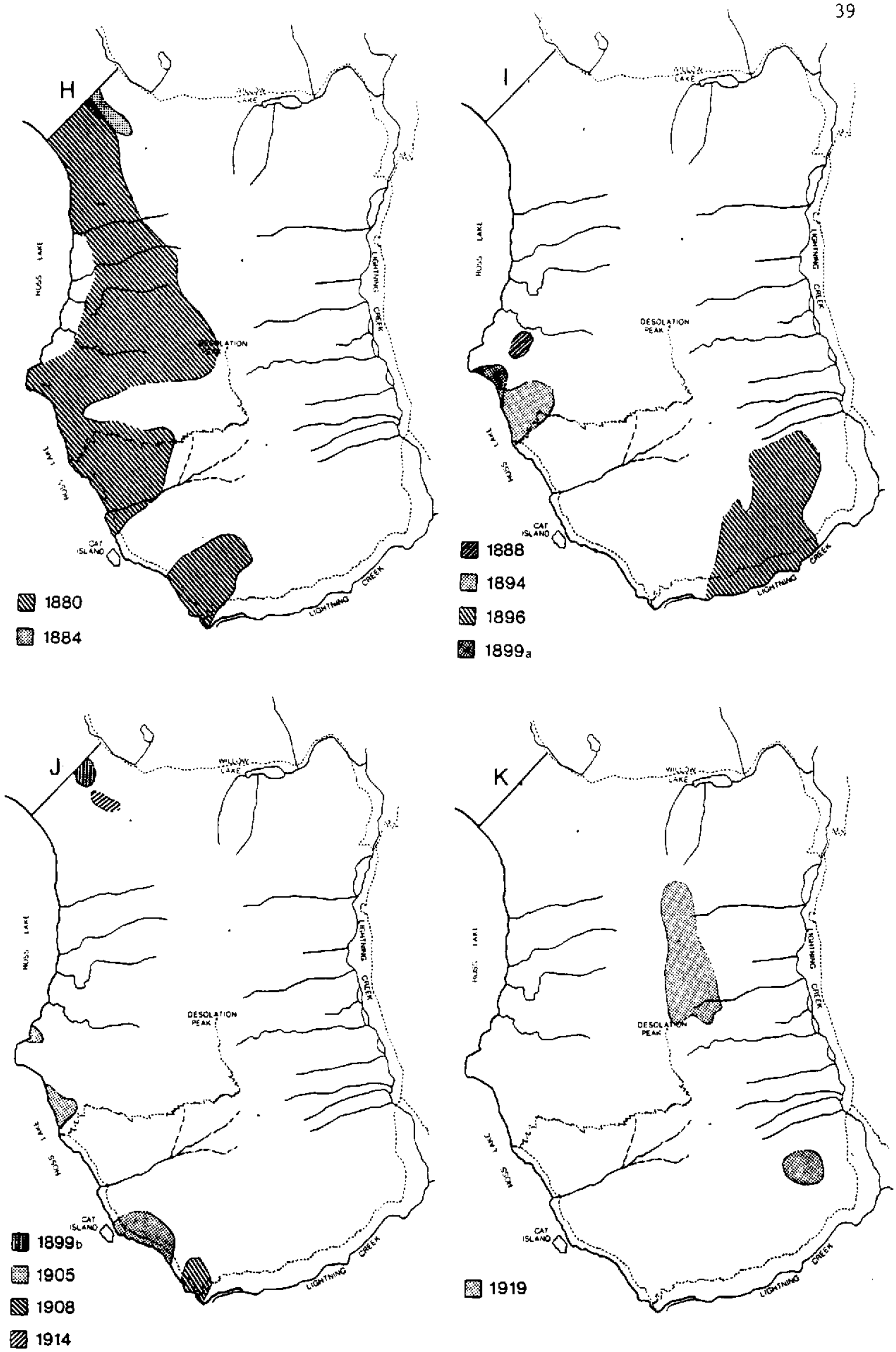
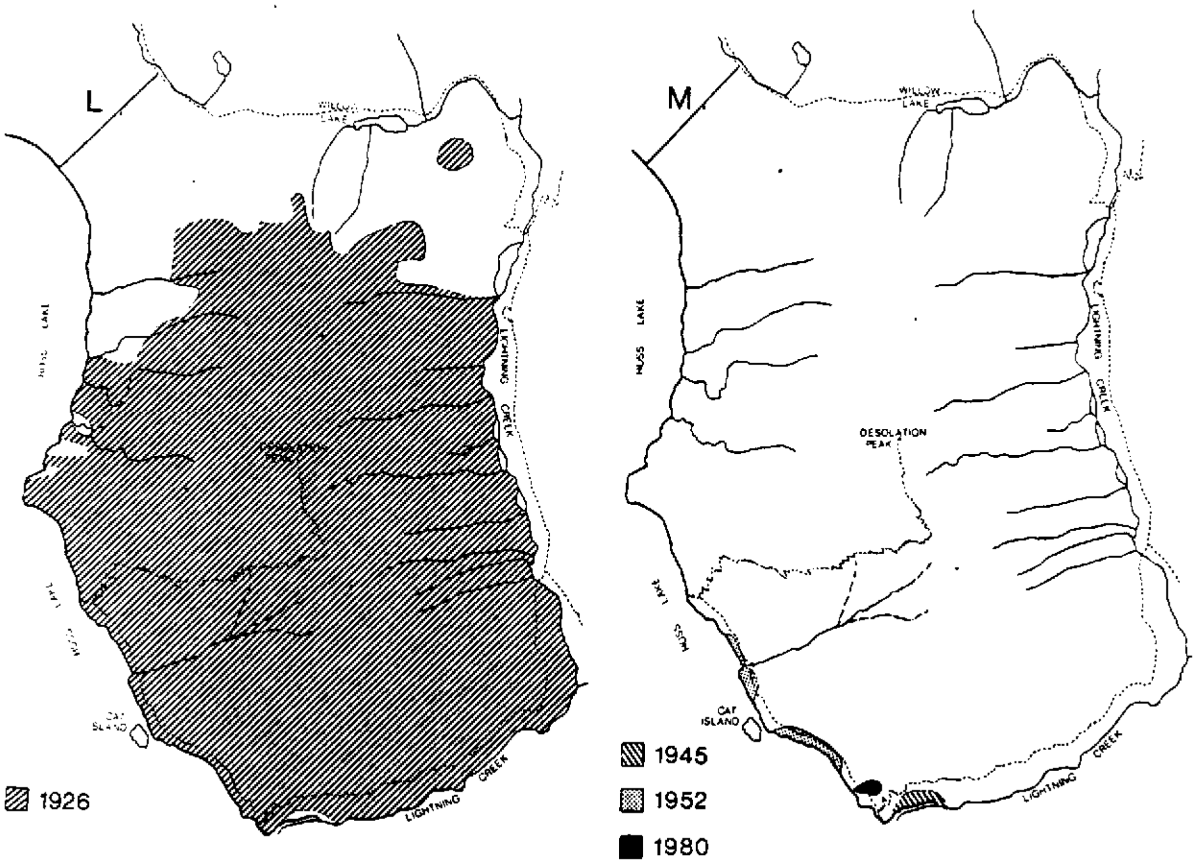


Figure 9 A-M. Reconstructed fire events on Desolation Peak for the period 1573-1985.


D
DESOLATION PEAK
CAT ISLAND
LIGHTNING CREEK
1787
1806
1808
E
CAT ISLAND
LIGHTNING CREEK
1815
1819
F
CAT ISLAND
LIGHTNING CREEK
1832
1851
G
DESOLATION PEAK
CAT ISLAND
LIGHTNING CREEK
1865
1868
1872


H
WILLOW LAKE
ROSS LAKE
DESOLATION PEAK
CAT ISLAND
LIGHTNING CREEK
1880
1884
I
WILLOW LAKE
ROSS LAKE
LIGHTNING CREEK
DESOLATION PEAK
CAT ISLAND
1888
1894
1896
1899a
J
WILLOW LAKE
ROSS LAKE
LIGHTNING CREEK
DESOLATION PEAK
CAT ISLAND
1899b
1905
1908
1914
K
WILLOW LAKE
ROSS LAKE
LIGHTNING CREEK
DESOLATION PEAK
CAT ISLAND
1919


L
M
WILLOW LAKE
HUSS LAKE
LIGHTNING CREEK
DESOLATION PEAK
CAT ISLAND
1926
1945
1952
1980

small isolated patches as indicated on Figure 8A. Many of these areas have been underburned by several fires. The survival of these trees has been aided by being situated in drainages and low spots along benches, between closely spaced avalanche chutes, or on protected saddles (especially along the north facing aspect). Douglas-fir is the most common species in these residual stands, probably because of its thick bark. Other minor stand components include western redcedar and western hemlock.

The 1700-1800 Record

The 235 to 250 year old age class (Figure 8B) is composed of very widely scattered individuals on the south west facing aspect, which are distributed between patches of other age classes. The physical character of these trees is not obviously different from those in the next oldest age class. This ca. 1733 fire (Figure 9B) covered much of the same area as the ca. 1573 and ca. 1782 fires.

The 200 year old age class (Figure 8D) is very localized despite the substantial coverage of the corresponding fire (ca. 1782). A few individuals are present on only the southwest facing slope.

The 180 to 195 year old age class (Figure 8C) is found exclusively on the southern aspect. Fire evidence suggests that ca. 1787 was the date this area burned (Figure 9D). The south aspect contains no forest vegetation at the very top of the slope due to a cliff. The entire area was found to have underburned in 1896. At present, no distinct age class originating after the 1896 burn remains. The 1926 fire which also covered most of this area may have eliminated some regeneration after the 1896 fire (now 88 years old).

The 1800-1900 Record

Fires in ca. 1806 and 1808 (Figure 9D) covered the typical burn pattern on the southwest aspect. Evidence repeatedly showed a two year separation between the more southern 1806 and the 1808 fires.

Almost the entire population of residual subalpine species are represented by the 145 to 175 year old age class (Figure 8A). This age cohort originated from the ca. 1815 fire which covered most of the subalpine area on Desolation Peak (Figure 9E). The 1926 fire eliminated much evidence of this fire. Although some trees seem to be of greater age than the fire, the inaccuracy of estimating age of true firs from increment cores is probably responsible.

Two apparently small fires at Lightning Creek in 1819 and 1832 were detected from fire scars. No trees dating to these events were found.

A 142 year old age class is isolated along the very bottom of the south facing slope next to Lightning Creek (Figure 8E). The exact origin of this pure Douglas-fir stand is not known, but probably resulted from a fire which burned the bottom of the valley (before the lake was filled). This small stand was not burned in 1926, but witnessed one fire in 1865 and a more recent under-burn in 1945. No regeneration is present from those fires.

The major fire of 1851 (Figure 9F) contributed to the formation of a very widespread 120-135 yr age class (Figure 8C). This age class covers the entire north slope of Desolation Peak as well as numerous patches extending south along Ross Lake. Despite the many fires since 1851, individuals from this age class are widespread on all but the south aspect. A small stand above Deer Lick Cabin contains two distinct age classes; the dominants belong to the 145-170 year old class and the subordinates to this 120-135 yr age class.

The 110 to 119 year old age class (Figure 8D) is found exclusively in the northeast corner of the study area. The present density of residuals (trees belonging to both the 330-334, and 120-133 year old age classes) in some areas suggests that the fire created patches of various severity; thus some areas are dominated by the 110-119 yr age class trees while in other areas this age class is represented only by subdominant trees. It is difficult to distingish between the appearance of trees in this age class and those in the 120 to 135 year class. The fire occurred ca. 1868 (Figure 9G), although age corrections may have resulted in some tree ages seemingly older than the disturbance.

A moderately sized subalpine fire occurred in 1872 primarily north of Desolation Peak. Although the probable age class resulting from the fire was removed by the 1926 fire, some scar evidence exists among older stands bordering this fire. Due to lack of evidence this age class is not mapped.

Fire in 1880 produced the 90 to 104 year old age class (Figure 8D). The character of this age class, however, is not uniform. Distinct patches of lodgepole pine and Douglas-fir are present throughout the west and northern southwest aspects. All areas where the age class is dominant were underburned in 1926. Areas toward the northern part of the west aspect were found to support a scattered suppressed cohort belonging to this age class. Fire intensities apparently did not induce sufficient mortality for better development of regeneration. A fire in 1894 also produced a small pocket of 90 year old lodgepole pine and Douglas-fir which are included in this age class. There were many small fires which had minor ecological impact: 1884, 1888, and 1899 (2) (Figure 9I).

<u>The 1900-1985 Record</u>

Two small fires, each covering less than 20 ha., burned in 1908 and 1914 (Figure 9J). The fire which occurred in 1905 was probably confined to the valley bottom. Only those areas which burned above the present high-pool lake level are visible. This would explain the apparent disconnected coverage of the fire.

Another moderately-sized subalpine fire is thought to have burned in 1919 on the north side of Desolation Peak. Evidence of this fire was very sparse because of the overlapping 1926 burn. This fire was the one described in Jack Kerouac's 1958 book The Dharma Bums, but the scene at the time Kerouac served as a fire lookout on Desolation Peak (early 1950's) was largely the result of the 1926 fire that followed.

The most obvious age class is between 40 and 57 years old (Figure 8E). This age class was initiated following the fire in 1926. The rate of development is somewhat variable, however. In some subalpine areas trees have only recently begun to dominate the brush. Lower elevations usually support well developed closed stands depending on site quality. All of the tree species on the mountain are present in this age class due to its vast coverage. There are many areas where pure lodgepole pine and Douglas-fir patches form a mosaic according to localized soil and slope conditions.

The 1926 fire is described as starting in the area of Big Beaver Creek and moving north and east towards Desolation Peak, where it stopped (Thompson 1970). The fire burned from July 4 until late in October, with several periods of rapid spread. In the area of Desolation Peak, it was reported to have moved five miles in 15 minutes, which would be a spread rate of 20 mph. This spread rate is too high to be believable; the fire did chase crews from the vicinity, however, and probably was spotting up Desolation Peak as it burned upslope. Roughly 2650 ha (6535 ac) of the 17400 ha Big Beaver fire burned on Desolation Peak.

The youngest age class is between 20 and 30 years old and is confined to the very lowest portions of the southwest and west facing slopes (Figure 8E). This resulted from a fire ca. 1952 (Figure 9M). Forest Service fire records show the occurrence of a class D-E fire along the bottom of the valley (below current lake level) between 1950 and 1959. The age class is very limited and composed primarily of Douglas-fir, lodgepole pine, and ponderosa pine.

Overall, most aspects are dominated by trees younger than 60 years old. The north facing aspect however, was almost entirely spared by the 1926 fire. Only two fires have probably burned this area in the past 411 years (1648 and 1851). This suggests that slopes facing north are least likely to burn, even during major conflagrations on adjacent areas. The absence of any trees belonging to the 330 to 334 year old age class indicates the complete replacement by regeneration following the 1851 fire (120 to 133 year age class).

Fires on south aspects appear to typically burn the entire area, yet allow trees to survive. For example, fires in 1896 and 1926 both were found to have left many residuals. The steep and comparatively less productive slopes of this area may prevent sufficient fuel build-up for more intense fires. This slope is also divided by fuel-free areas such as rock slides and rocky outcrops which would also help to "check" fire behavior. Presently this slope is dominated by trees in the 180 to 197 year old age class, but also has trees between 40 and 57 years old.

The remaining aspects are much more diverse in terms of age class structure. The southwest aspect probably has the greatest representation of all possible age classes due to its history of more frequent and lower severity disturbance. The lower east and west slopes both have strips of residual 120 to 134 year old trees along the creek bottom and lake shore elevations, respectively. This suggests less conducive burning conditions than on mid-slope areas at the time of fires. Topographic maps of this area reveal only a small proportion of the west facing slope to now be below lake-level; thus, forests along the present lower slope shoreline were also lower slope forests prior to creation of Ross Lake. All of these aspects have patches of 300 to 334 year old trees, protected by certain topographic features, and surrounded by the post-1926 cohort.

Fire Frequency on Desolation Peak

Natural fire rotations were calculated for the entire area over the time period 1573-1985 and for each century (Table 13). The frequency was also examined per aspect (Table 14). The total average natural fire rotation for this area was almost exactly one hundred years (99.49 years). Thus, over the course of 100 years (based on the average for the last 411 years) an area equal in size to Desolation Peak would be burned; some areas would probably

Table 13. Natural fire rotations for Desolation Peak.

Time Period years	Natural Fire Rotation years
1600-1699	100
1700-1799	208
1800-1899	60
1900-1985	103
1573-1985	100

Table 14. Natural fire rotation by aspect over the 1573-1985 period.

Aspect	Natural Fire Rotation years
North	182
East	107
South	97
Southwest	65
West	120

5 | 571

≈ 114

burn twice while others would not burn at all. However, wide temporal and spatial variations in this frequency occurred during this period. The last 85 years since 1900 show a 102 year fire rotation, which is very similar to the total average. Between 1800 and 1899, the fire rotation was drastically lower - 59 yrs. An equally dramatic deviation from the mean occurred in the next preceding century (1700-1799) with an NFR of 208 yrs. Although information is scarce, one large fire in 1648 appeared to cover the entire area; thus a 100 year rotation is calculated between 1600 and 1699. Calculations prior to that century are probably too inaccurate for comparison due to limited data.

Increases in fire activity in the 19th century fire record are often assumed to be the result of settler activity. While the nineteenth century fire record at Desolation Peak does show more fire activity than other centuries, settler influence on the record is not clear. Accurate records of settlement in the upper Skagit Valley are not available. Europeans were certainly well established by the 1870's with gold strikes on Ruby Creek 15 km (9.5 mi) to the south, and as early as 1814 Alexander Ross had crossed the Cascades in the vicinity of the Skagit River. The largest fire of the century occurred ca. 1851, with roughly equal areas burning between 1800-1850 (mostly pre-settlement in upper Skagit Valley) and 1852-1900 (mostly post-settlement). A forest type map of 1900 (Ayres 1899) indicates that much of the Ruby Creek area to the south had burned over in the recent past, probably as a result of mining fires. Desolation Peak is also shown as burned and not restocked, probably from the ca. 1851 fire. The early forest type crews often mapped areas as burned even after 50 years if snags remained or if areas were not restocked; this is clearly evident on maps of the Oregon Coast completed at the same time (Gannett 1902). The mapped burn area Ayres shows is close to the reconstructed ca.1851 fire map. In any event, area burned by fire appears to be well-distributed across the 19th century, suggesting that late nineteenth century settler impact on fire frequency is not obvious. Whether the 1851 fire, which comprises about 40 percent of the area burned in that century, was settler-caused is not known.

There is no information available on the influence of Indian burning in the Skagit Valley or on Desolation Peak. Indians are known to have burned forests in the Pacific Northwest for a variety of reasons, and fire frequencies are often higher in the vicinity of Indian villages (Barrett and Arno 1982). Indians did live in the vicinity of Desolation Peak/Lightning Creek along the SKAGIT river. source? A preliminary count of fire scars on stumps now underwater most of the year about 5 km north of the study area at Hozomeen suggested a 10-15 yr fire frequency in the valley bottom (Taylor 1977). Such closely-spaced fires are infrequent in the above-water record at Desolation Peak. Such frequent fires in the vicinity of known Indian villages suggest localized burning by such tribes as the most likely explanation. Some of these fires may have burned south into the Desolation Peak area.

Fires early in the record appear to be considerably larger than fires closer to the present. Only the more severe and widespread fires are still detectable. The scar evidence for these fires was present only on the south and southwest aspects where lower fire severities permitted residuals and survivable evidence.

There are obvious variations in fire rotation lengths when fire frequency was examined by aspect (Table 14). Fire frequencies are greater on the southwest aspect than on south facing slopes. The east side of Desolation Peak exhibits a slightly shorter rotation than the west side, and north facing slopes have the least frequent fire. Two sizable subalpine fires have affected the natural fire rotation of the east aspect more than either north or west facing aspects.

A decline in accuracy for the natural fire rotation occurs before 1700. Better precision would probably result in more fires recorded in the seventeenth century in addition to the ca.1648 fire, and would decrease the natural fire rotation below 100 years. Obviously, the widespread and severe fire ca. 1648 removed evidence of fires prior to that event. On some areas, the repeated occurrence of fires on the same ground separated by less than three decades suggests that some fire may have been closely followed the ca. 1648 fire. Undoubtedly, the fire evidence prior to 1700 overestimates the natural fire rotations, and therefore underestimates fire frequency.

From the available data, the effects of an enforced fire suppression policy are not detectable around Desolation Peak. The fire record of the 20th century is within the variation experienced in previous centuries.

Vegetation Differences in Fire Frequency

Natural fire rotations were calculated for each community type and resulted in fire frequencies ranging from 52 yrs to 137 yrs (Table 15). The shortest rotation was in the Douglas-fir/ponderosa pine community, which is largely found on low elevation, southwest aspects (Figure 7) that have burned repeatedly with low severity fires (Figure 9). The Douglas-fir/lodgepole pine community has the next lowest natural fire rotation (76 yrs). It is the most common low elevation forest type on other aspects. The Douglas-fir/western redcedar community has an intermediate natural fire rotation (93 yrs). This community is found in protected draws surrounded by the two more frequently burned communities described above. The Douglas-fir/western hemlock community has the highest natural fire rotation of the low elevation forests. This type is common on north-facing aspects and is similar floristically and climatically to the wetter, typical "westside" low elevation forests.

Table 15. Natural fire rotations for forest community types on Desolation Peak.

Community Type	Natural Fire Rotation (years)
Douglas-fir/ponderosa pine	52
Douglas-fir/lodgepole pine	76
Douglas-fir/western redcedar	93
Douglas-fir/western hemlock	137
Douglas-fir/Pacific silver fir	108
Subalpine fir/Douglas-fir	109
Pacific silver fir/subalpine fir	137

Table 16. Natural fire rotations for major species where they are either primary or secondary dominants.

Species	Natural Fire Rotation (yrs)	
	Primary Dominant	Secondary Dominant
Ponderosa pine	44	56
Lodgepole pine	69	82
Douglas-fir	94	84
Western redcedar	>411	204
Western hemlock	169	126
Pacific silver fir	192	108
Subalpine fir	154	89
Mountain hemlock	137	123

The subalpine forests have natural fire rotations more similar to one another than do the montane forests, ranging from 108 to 137 yrs. The similarity is due to the widespread, ubiquitous nature of past subalpine fires and the limited geographic separation between the various subalpine forest coomunities. The Douglas-fir/subalpine fir community and Douglas-fir/Pacific silver fir community have essentially the same natural fire rotation; the Pacific silver fir/subalpine fir community, on north and east aspects, had the highest natural fire rotation at 137 yrs.

A second way of assessing fire frequency variation within plant communities was to calculate a natural fire rotation by tree species. Natural fire rotations were calculated for areas dominated by each species over the entire 411 year time period (Table 16).

Where each species occupied the primary dominant position, the fire rotation was longer, except for ponderosa pine and lodgepole pine. These are the only two major tree species on Desolation Peak that are restricted to seral status; all the other species in Table 16 are potential vegetation dominants (sensu Daubenmire 1966) somewhere on the study area.

Species which characteristically avoid fire should be rated primary dominants where low fire frequencies (high natural fire rotations) would favor their presence. All higher elevation species on Desolation Peak (subalpine fir, mountain hemlock, and Pacific silver fir) follow this pattern. Likewise, species benefitting from more frequent disturbance (of whatever severity) tend to occupy sites as primary dominants where higher fire frequency (lower natural fire rotations) have historically been present. Lodgepole pine and ponderosa pine both exhibit this trend. Douglas-fir at Desolation Peak is both a major "climax" dominant at low elevation and a major seral dominant at middle to higher elevations; there should be approximately equal natural fire rotations for Douglas-fir as a primary and secondary dominant. Of all species examined, Douglas-fir has the most similar natural fire rotations for the two dominance ratings.

Fire rotations for secondary dominant Pacific silver fir, western hemlock, subalpine fir, and mountain hemlock, were all shorter than where these species were rated as primary dominants. The higher elevation species border an extensive montane forest below; species of both forest types mix along a diffusely defined ecotone. When burned, such sites often revert to Douglas-fir, which is slowly replaced by the later successional shade-tolerant species listed above. The higher fire frequency of these lower elevation sites compared to higher elevation sites causes the shade tolerant species to show shorter natural fire rotations when they are secondary dominants to other species after fire. Douglas-fir displays a similar pattern because it is a late-successional species in areas with ponderosa pine and lodgepole pine.

The natural fire rotations calculated by either forest community type or dominant tree species are quite similar, suggesting that tree species are a good index to general floristic similarity as defined by community types.

Desolation Peak is an unusual area west of the Cascade crest in terms of its fire history. Most forests west of the crest are more moist and burn less frequently (Agee 1981), although forests of the San Juan Islands, in the rainshadow of the Olympic Mountains, may have natural fire rotations of less than 100 yrs (Agee and Dunwiddie 1984). The Ross Lake area has been identified as a botanically interesting area due its transitional nature between moist coastal and dry interior forests (Franklin and Dyrness 1973). Recent data suggest that this uniqueness is due to the close juxtaposition of coastal and interior communties rather than the presence of a series of unique community types (Agee and Kertis, in prep.). The close juxtaposition of these communities appears to result in longer fire rotations for interior species such as ponderosa pine and shorter fire rotations for coastal species such as Pacific silver fir.

Stand Description of the Subalpine Plot

The plot is on a slope of about 45%; it was located so as to sample both: (a) a fairly even-aged mature stand of *Abies lasiocarpa*, (b) and extensive area of *Abies lasiocarpa* regeneration adjoining the mature stand, mostly to the north of it. Therefore the plot was treated as two major subplots for most of the sampling and stand description; these two subplots are referred to as 'mature area' and 'regeneration area'. About 15% of the plot is occupied by steep rocky outcrops devoid of trees while the rest is well stocked with either mature or regeneration-size Abies lasiocarpa with few Abies amabilis in clusters, and very few Picea engelmannii; no Pinus albicaulis were found within or immediately around the plot (Table 17).

Stand characteristics for both mature and regeneration areas of the subalpine plot are given in Table 17, and distribution diagrams for dbh, height, and age of trees are shown in Figures 10 and 11.

Forest age classes within the mature area of the plot represent a multi-age distribution resulting from past forest fires. The earliest fire to pass through the area was the ca. 1648 fire; the plot was along the edge of the ca. 1733 and 1806 fires, as well as the 1926 burn. Only one tree dates back to the 1733 fire; a large regeneration pulse follows the 1806 fire; and another pulse has followed the 1926 fire on the mature side of the plot. Some of the 1926 pulse may be occurring at places that did not burn but benefitted from increased light due to the large stand opening created by fire immediately to the north. The location of the plot along the margin of repeated burns has undoubtedly been responsible for some subalpine fir surviving the last two fires in the area. Very few charred

Table 17. Stand data for the subalpine and montane permanent plots.

Plot	Average dbh(cm)	Average height(m)	Average age(yrs)	Number trees/ha
Subalpine (mature)	16.9	9.12	116	488
Subalpine (regen.)	9.4	4.97	48	644
Montane	38.3	17.60	90	225

	Percent Cover By Species					
	ABLA	ABAM	PIEN	PSME	PICO	SALX
Subalpine (total)	90	8	2	-	-	-
Montane	-	-	-	85	2.5	12.5

ABLA = *Abies lasiocarpa*; ABAM = *Abies amabilis*; PIEN = *Picea engelmannii*; PSME = *Pseudotsuga menziesii*; PICO = *Pinus contorta*; SALX = *Salix* spp.

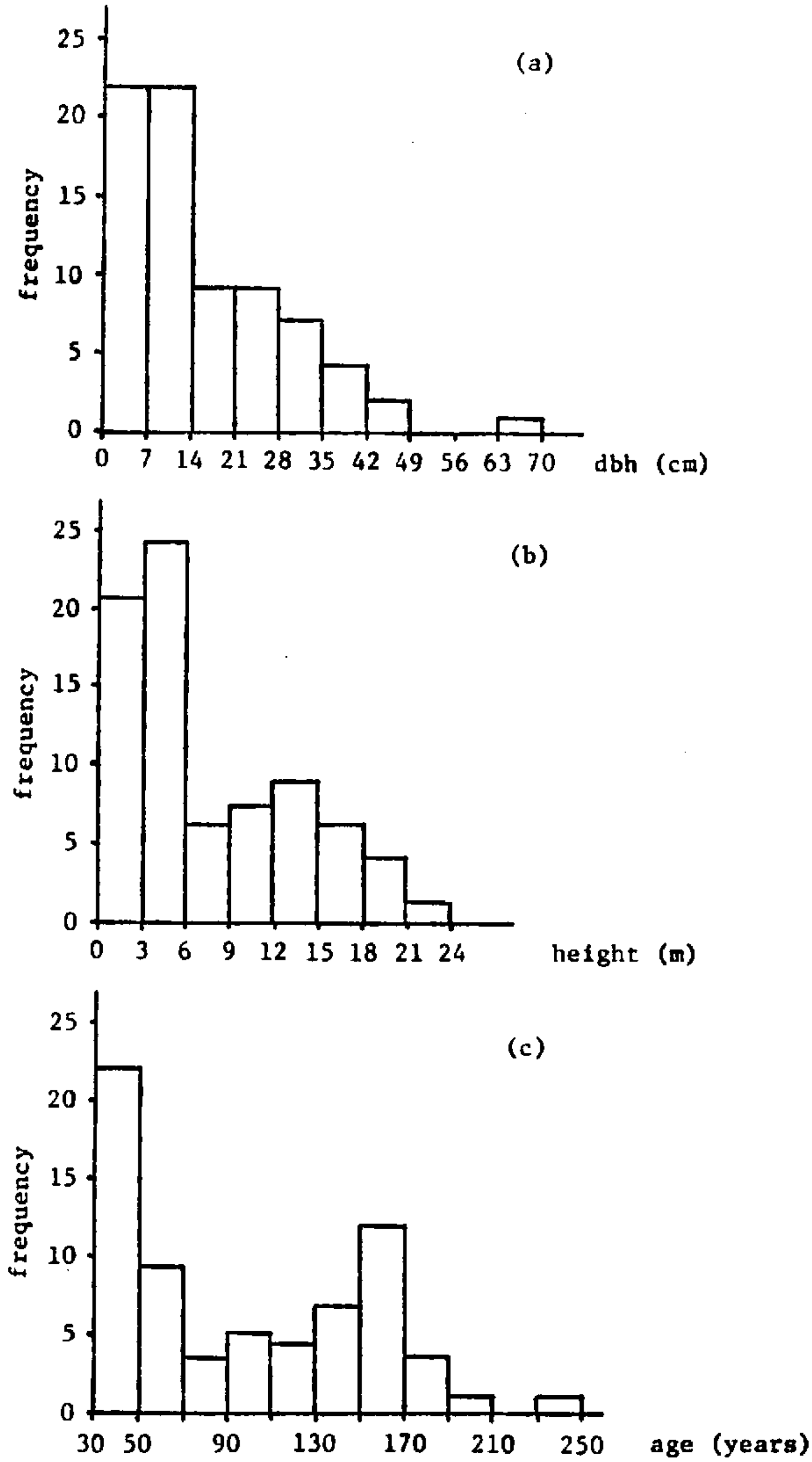


Figure 10. Diameter, height, and ages of trees on the mature area of the subalpine permanent plot.

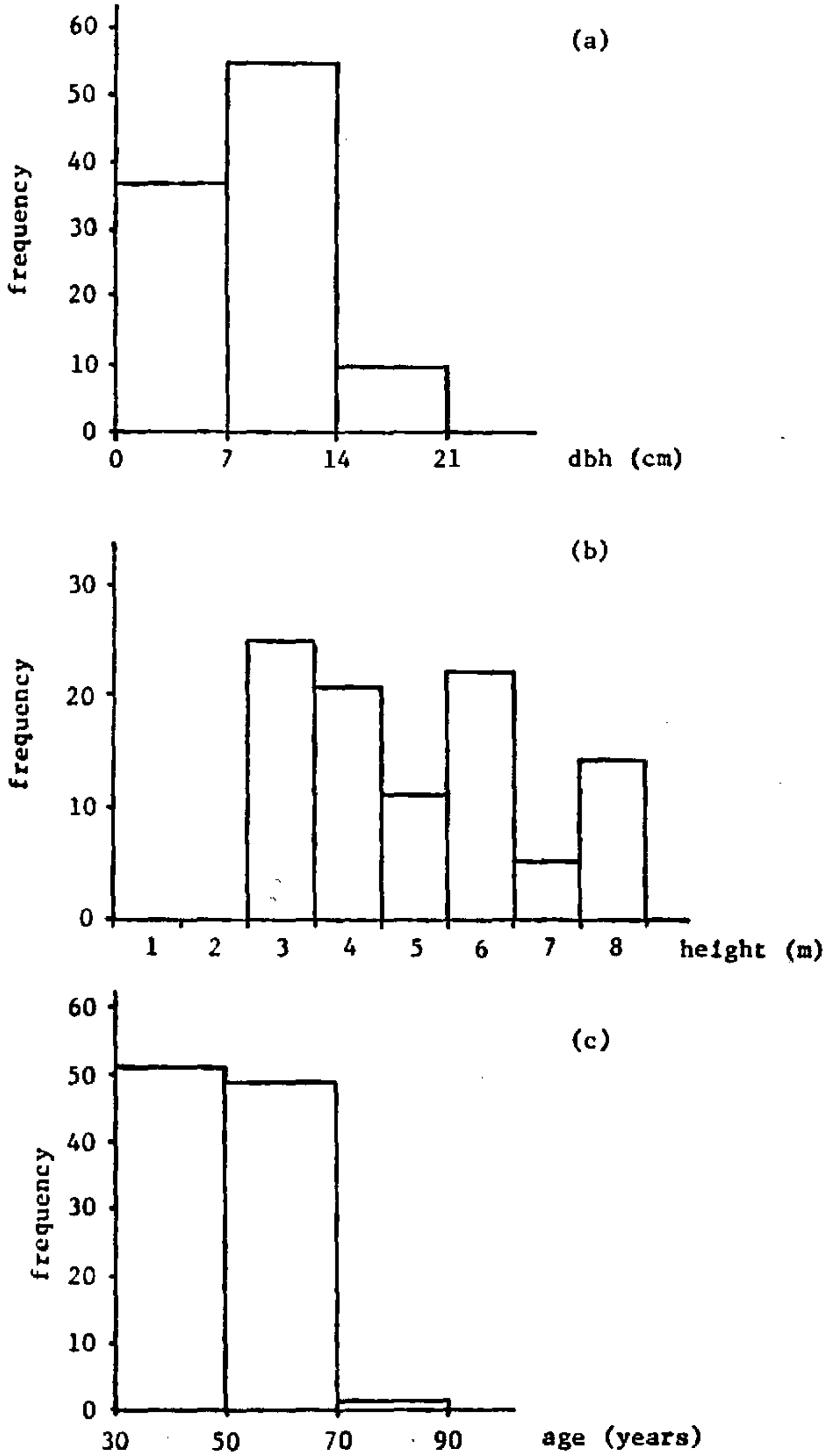


Figure 11. Diameter, height, and ages of trees on the regeneration area of the subalpine permanent plot.

Table 18. Cover classes for shrubs and herbs on subalpine permanent plot.

Species	Mature Area	Regeneration Area
Achillea millefolium	1	T
Amelanchier alnifolia	-	2
Castilleia spp.	-	T
Cryptogramma crispa	-	T
Fragaria spp.	2	1
Grass spp.	1	2
Lomatium brandegei	T	1
Lupinus spp.	1	2
Moss spp.	2	1
Pachistima myrsinites	2	2
Pedicularis spp.	1	2
Pedicularis bracteosa	-	1
Penstemon procerus	-	1
Phlox diffusa	T	1
Rhododendron albiflorum	-	2
Ribes spp.	1	2
Salix spp.	-	2
Sorbus sitchensis	2	2
Spiraea spp.	1	-
Valeriana sitchensis	1	2
Viola spp.	2	1
Vaccinium myrtillus	3	4

Cover classes: T= less than 1%; 1=1-5%; 2=6-25%; 3=26-50%; 4=51-75%.

Table 19. Tree regeneration density (per hectare) for the montane and subalpine permanent plots.

Species	Age (years)			Size Class (m)			
	1	2	3/4	.1-.3m	.3-1m	1-3m	>3m
Subalpine plot (Regeneration area)							
ABLA	-	1590	8000	4000	7000	13200	-
ABAM	-	-	-	-	-	200	-
Subalpine plot (Mature area)							
ABLA	-	-	-	800	3200	2200	200
ABAM	-	-	-	-	1600	600	-
Montane plot							
PSME	800	1590	19000	11950	4000	1600	1200
THPL	-	-	-	-	-	600	-
SASC	-	-	-	-	-	-	1000

PSME = *Pseudotsuga menziesii*
THPL = *Thuja plicata*
SASC = *Salix scouleriana*
ABLA = *Abies lasiocarpa*
ABAM = *Abies amabilis*

logs or snags were found and no appreciable amount of charcoal was visible on the ground surface. Few fire scars were found within the mature stand, and most scars observed appeared to have been caused by mechanical damage from rolling logs. Dead trees were either standing or uprooted (no stump of less than 3 meters height were found). There was no evidence of any past logging or of any substantial windthrow.

The regeneration side of the plot has one tree that survived the 1926 fire; all of the other trees are post-1926 in origin. This stand replacement effect of fire is more typical of subalpine forests dominated by true fir.

The stand map for the plot (Figure 12) shows the top half of the plot (the regeneration area) to have a much higher tree density than the lower, mature half of the plot.

The understory was found to be very dense in the regeneration area, with a depth averaging 80 cm, while it was much sparser in the mature stand, with an average depth of 20 cm. In both cases, it was dominated by perennial herbs and shrubs, but species composition was slightly different (Table 18). Deer browsing was observed to be light.

Density of very young Abies lasiocarpa seedlings and saplings is higher in the regeneration area of the plot, but regeneration of Abies amabilis is greater in the mature area (Table 19).

Stand Description of the Montane Plot

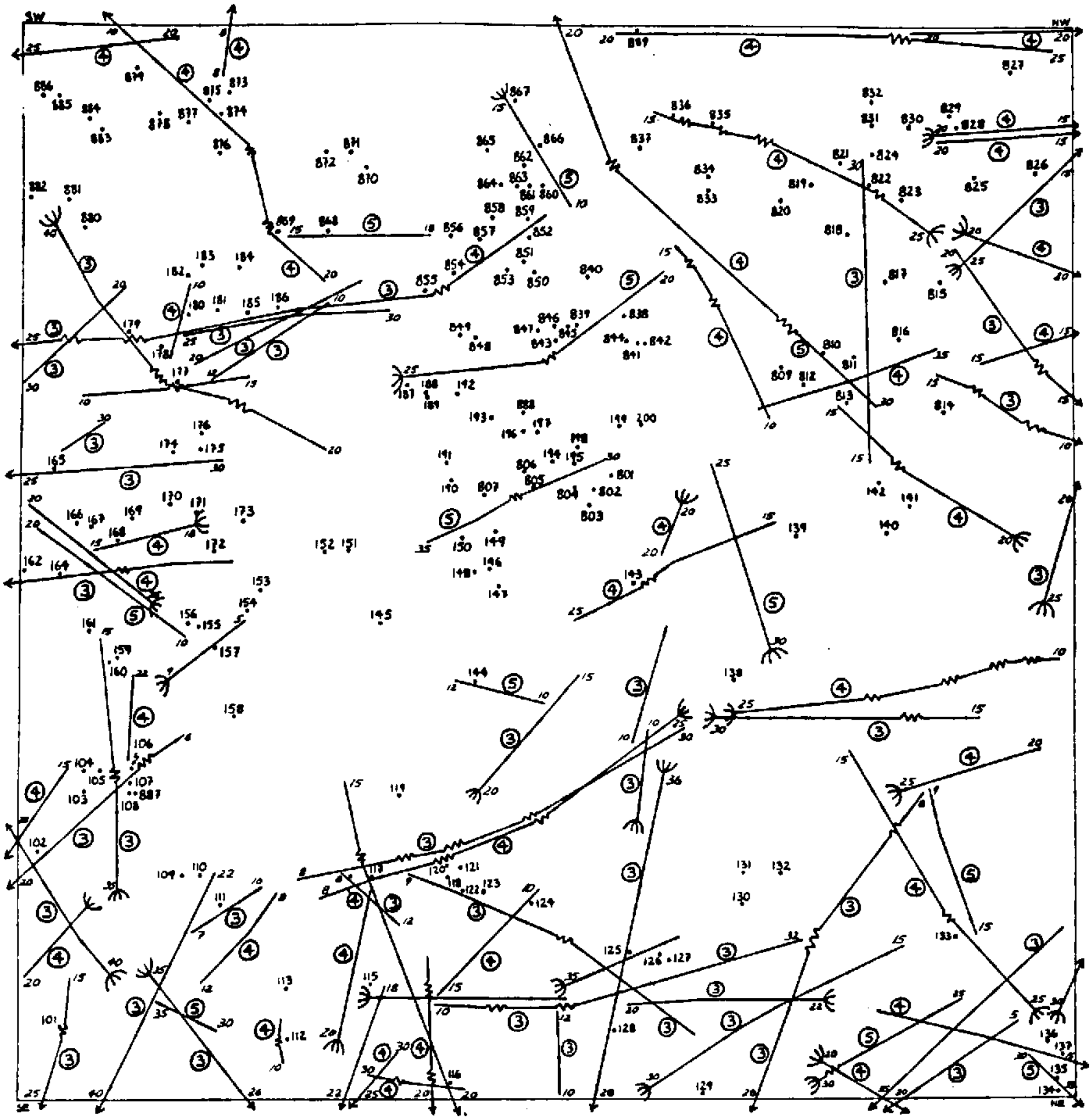


Figure 12. Stem and log map of the subalpine permanent plot. Plot dimensions are 40 meters by 40 meters. Dots with numbers are trees. Lines are dead and down logs; numbers at end of each line are log end diameters; and circled numbers are decay classes of logs.

About 5% of the plot is occupied by rocky outcrops. Tree density is much lower than at the subalpine plot but dbh and height are higher on the average per tree (Table 17, Figure 13). Distribution diagrams for dbh, height, and age of trees are shown in Figure 14. *Pseudotsuga menziesii* made up the bulk of the tree cover but *Salix* species and *Pinus contorta* were also found (Table 17).

The montane permanent plot is estimated to have burned in the following years: 1573, 1648, 1733, 1782, 1808, 1851, 1880, 1894, 1905, and 1926. The presence of several fires per century has probably encouraged wave after wave of regeneration to become established on the plot, only to be removed by the next fire. There are likely representatives of once-larger age classes from each of the fires between 1648 and 1808, but no representatives from the nineteeth century fires. Those fires could have been of such low severity that no growing space was opened, or the trees that became established could have been removed by the 1926 fire, after which the highest density age class on the plot became established. Fire has encouraged an essentially all-aged stand to be maintained on the plot.

Past selective logging was evident both inside and nearby the plot, probably associated with the construction of Ross Dam and the flooding of the Skagit River Valley. Some tree stumps were discovered at the time the plot was established, but were thought to be totally outside of the plot. Later, scattered stumps were found inside the plot,

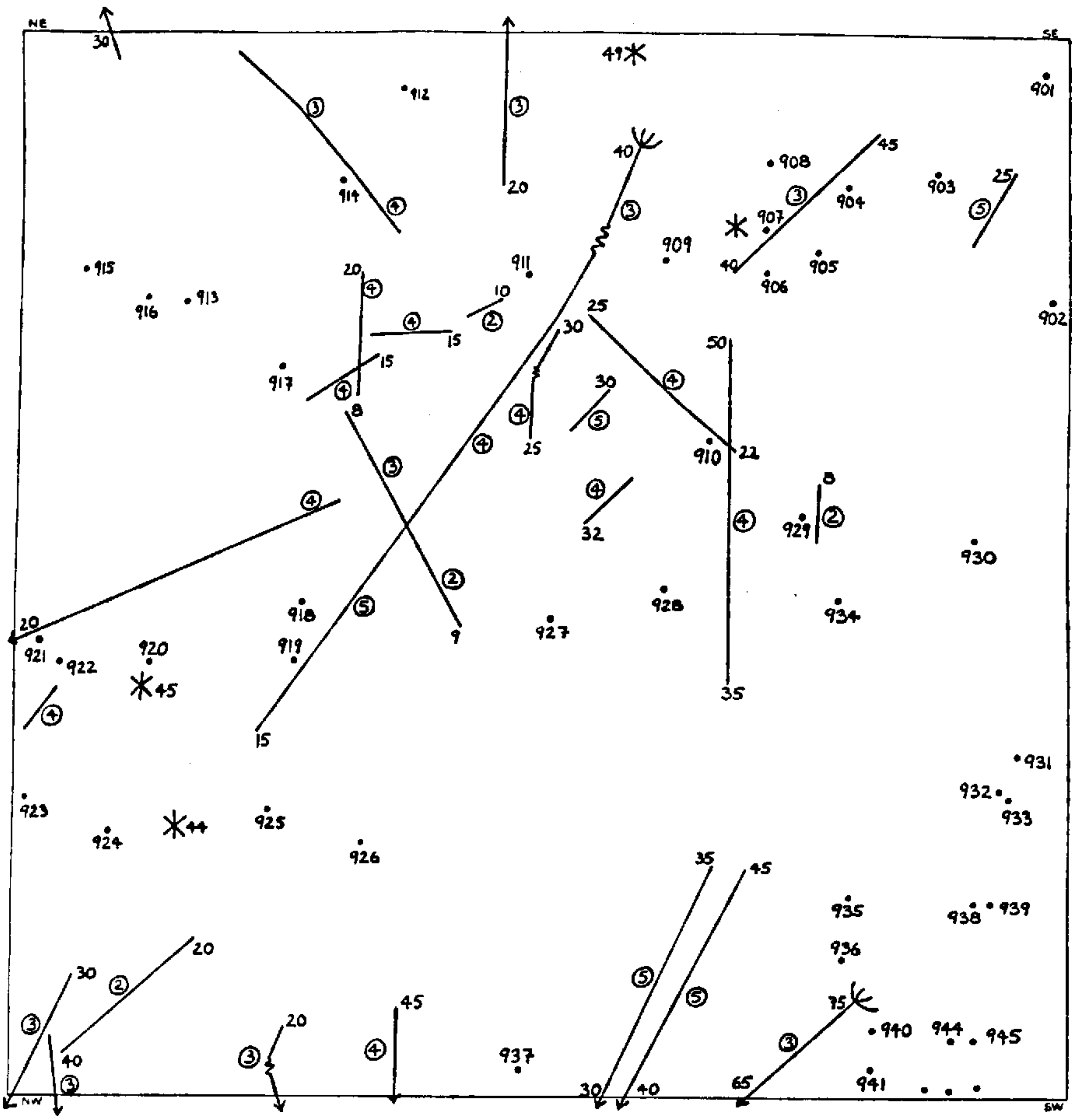


Figure 13. Stem and log map of the montane permanent plot. Plot dimensions are 40 meters by 40 meters. Dots with numbers are trees. Lines are dead and down logs; numbers at end of each line are log end diameters; and circled numbers are decay classes of logs.

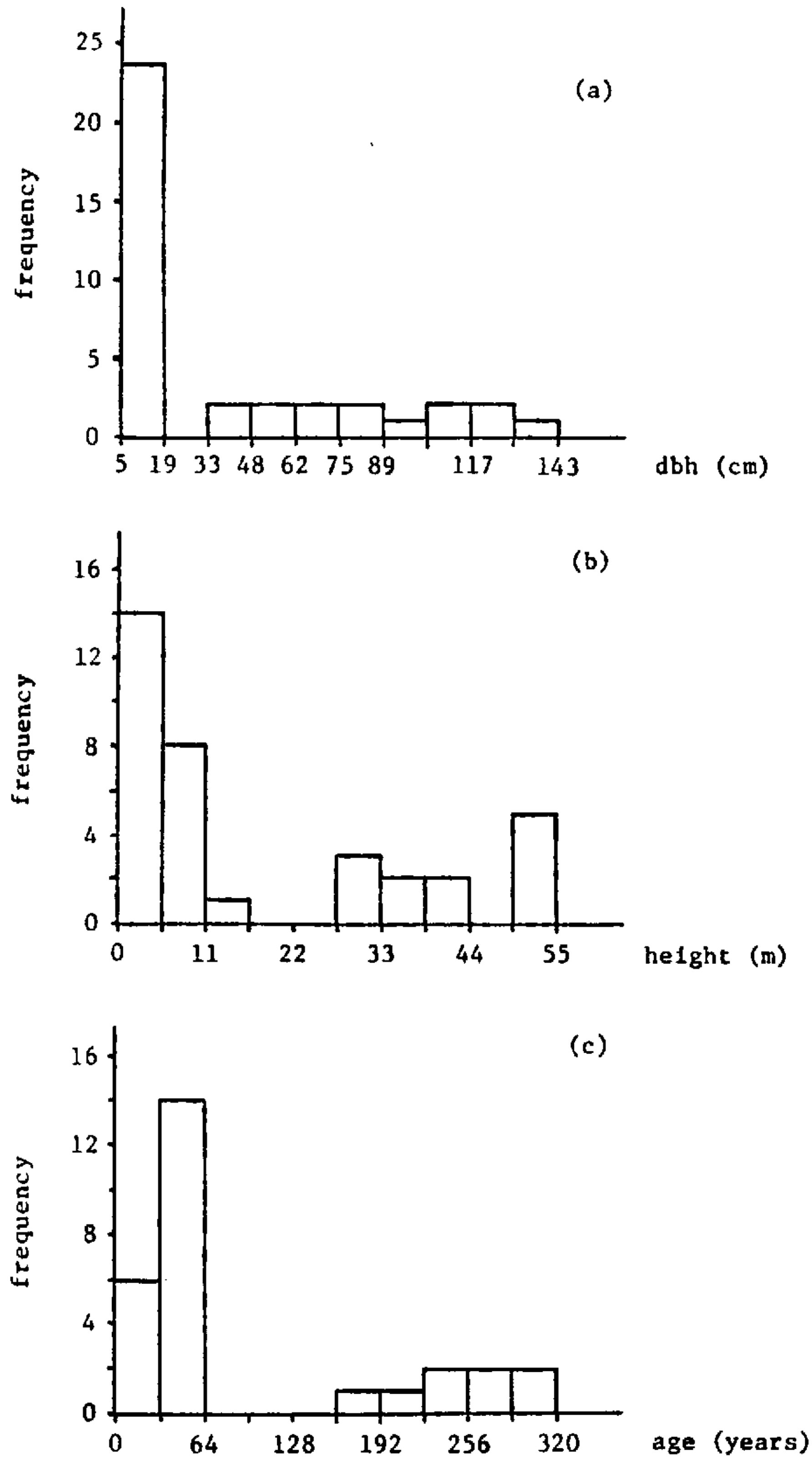


Figure 14. Diameter, height, and ages of trees on the montane permanent plot.

indicating that cutting, while not intensive, has occurred. Evidence of past fires were found in the fire scars observed on some of the larger Douglas-firs. There was no evidence of substantial windthrow.

The understory cover was low throughout most of the plot, with an average depth of only 15 cm; this may be due to browsing. Table 20 lists the major herbs and shrubs found at the site. The bulk of the regeneration was found to be made of *Pseudotsuga menziesii* seedlings of all ages, with limited regeneration of *Thuja plicata* occurring as well (Table 19). This suggests that Douglas-fir is a very dominant and stable component of the forest in that area of Desolation Peak.

Table 20. Shrubs and herbs of the montane permanent plot.

Species	Cover Class
Acer circinatum	3
Amelanchier alnifolia	2
Apocynum androsaemifolium	1
Arenaria spp.	1
Arnica cordifolia	1
Athyrium filix-femina	1
Berberis nervosa	2
Calamagrostis rubescens	3
Ceanothus velutinus	2
Chimaphila umbellata	3
Corylus cornuta	2
Cryptogramma crispa	1
Festuca idahoensis	1
Festuca spp.	1
Fragaria virginiana	2
Grass spp.	1
Hieracium albiflorum	1
Holodiscus discolor	2
Lichen spp.	2
Linnaea borealis	2
Lonicera ciliosa	1
Moss spp.	5
Pachistima myrsinites	2
Polygonum spp.	1
Polystichum munitum	1
Prunus emarginata	1
Pyrola secunda	1
Ribes sanguineum	1
Rosa spp.	3
Rubus parviflorus	2
Shepherdia canadensis	1
Salix scouleriana	2
Smilacina racemosa	2
Spiraea betulifolia	3
Symphoricarpos laevigatus	1
Trientalis latifolia	2
Vaccinium membranaceum	T

Cover classes: T= less than 1%; 1=1-5%; 2=6-25%; 3=26-50%; 4=51-75%; 5=76-95%.

MANAGEMENT IMPLICATIONS

Management implications of research depend on interpreting information in the context of management objectives. The legislation that established the North Cascades National Park Service Complex included several paragraphs or phrases of note:

> Section 201. In order to provide for the public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge Lakes, together with the surrounding lands, and for the conservation of the scenic, scientific, historic, and other values contributing to public enjoyment of such lands and waters, there is hereby established, subject to valid existing rights, the Ross Lake National Recreation Area.

> Section 402. (a). The Secretary shall administer the recreation areas in a manner which in his judgment will best provide for (1) public outdoor recreation benefits; (2) conservation of scenic, scientific, historic, and other values contributing to public enjoyment; and (3) such management, utilization, and disposal of renewable natural resources and the continuation of such existing uses and developments as will promote or are compatible with, or do not significantly impair, public recreation and conservation of the scenic, scientific, historic, or other values contributing to public enjoyment. In administering the recreation areas, the Secretary may utilize such statutory authorities pertaining to the administration of the national park system, and such statutory authorities otherwise available to him for the conservation and management of natural resources as he deems appropriate for recreation and preservation purposes and for resources development compatible therewith.

The legislation allows a broad spectrum of resource management activities within the Ross Lake National Recreation Area. Lands surrounding the lakes could conceivably be managed for wilderness-type values or managed for timber production or for featured wildlife species, such as a harvestable population of deer. As far as is known, no land management objectives for the Ross Lake National Recreation Area have been formulated.

The 1981 Fire Management Plan for the park complex identified the fire management objective: "to provide for the continued development of a natural ecological system in which fire plays a role, and to protect those values identified under 'Management Constraints'". The constraints included human safety, physical facilities, private property, adjacent land, endangered species, and air quality standards. Implicit within this definition is a land management objective to maintain a wilderness-like system for the park and recreation areas within the constraints listed. This is the objective that will be assumed in the management implications discussed below. Future changes in the fire management plan might be associated with different implications of this research.

In an area managed for natural values, one of the first challenges is to define past deviations from "naturalness" due to modern man so that, if possible, these can be mitigated. In the Desolation Peak area, changes in fire frequency due to the "settlement era" and "fire suppression era" are not clearly evident. There does appear to have been considerable burning associated with mining activity in the Ruby Creek/Canyon Creek area southeast of the study area. The "settlement era" did not increase fire frequency, although this has occurred elsewhere (e.g., Hemstrom and Franklin 1982). The "fire suppression" era consisted of largely ineffective efforts in this rough terrain until recent decades; the fire rotation of this century is well within the variation of the past few centuries. There is no direct evidence for Indian burning in the area, although it may have been important in now-inundated areas of the valley. The major management implication here is that no well-defined deviations from natural fire frequencies have been identified for the Desolation Peak area. Therefore, no restorative techniques such as prescribed burning for the purpose of reducing fuel loads to natural levels are recommended. This recommendation parallels that of Allen (1983).

North aspects appear to have acted as natural fuelbreaks in the past and under "average" fire behavior conditions many fires will stop on north aspects. Southwest aspects, at least on Desolation Peak, have burned the most frequently, and have left more residual trees than fires on other aspects. The lower severity is probably a fuel-limited effect on fire intensity and duration due to rocky slopes. The fire history on the southwest aspect suggests a fairly self-contained pattern of fire spread.

Natural fires have been common in the past and fairly frequent if fire presence within this study area is a criterion. Roughly every 14 years a fire has occurred on Desolation Peak for the last four hundred years. Many of these have been large fires that burned areas much larger than Desolation Peak. The Big Beaver fire of 1926 was more typical than atypical of fires of the past; it did, however, spread from the west side of what is now Ross Lake, a pattern that will not likely be repeated in the future. The 1851 fire, as mapped by Ayres (1899) burned an area from Desolation Peak north into British Columbia. The direction of spread was not identified but if it followed the pattern of the Big Beaver fire it burned to the north, indicating large fires can still occur on the east bank of the Skagit drainage. Both the east and west banks of Ross Lake have many tributary drainages aligned in generally an east-west direction; the north-facing slopes will generally burn less easily than other aspects, and they will act as containment boundaries for many fires.

Three implications of this history are: (1) a refined fire protection plan is needed for Hozomeen and the Canadian border, including potential fuelbreaks or prescribed burning for hazard reduction around the developed areas; (2) interagency cooperation should continue with the Forest Service, which manages the Pasayten Wilderness immediately adjacent to the east of Ross Lake National Recreation Area; and (3) active management of natural fire will be necessary to maintain the diversity and extent of present forest communities on Desolation Peak. The extent of both lodgepole pine and ponderosa pine communities will decrease over time with fire suppression. Neither lodgepole pine nor ponderosa pine would disappear with complete fire exclusion, as each would remain persistent on some drier, rockier sites. However, forest communities dominated by these species are unusual west of the Cascade Crest and their presence maintains a unique landscape diversity in the area. Continued management of natural fires will maintain this diversity.

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Reviewer RU

Date MAY 27, 1987

HABITAT AND VEGETATION
DOCUMENT, PHOTO, MAP AND INTERVIEW
SUMMARY

Formal Citation (or Interviewee's Name, Address, Telephone).
Agee, James K., M. Finney, R. de Gouvenain. 1986. THE FIRE HISTORY OF DESOLATION PEAK. Nat. Park Serv. Cooperative Park Studies Unit. College of For. Res., Univ of WA, SEATTLE, WA.

o Document location and call No. SCL/EAD

Purpose Of Document (or Interviewee's association with the project area). To obtain & interpret fire history information about Desolation Peak; to describe existing forest ~~and~~ plant communities on Desolation Peak

Study Area

o Location (as specific as possible for where data covers). Desolation Peak, all aspects. Desolation Peak is on the E. side of Ross Lake, N. of Lightning Creek.

o Time period when data or observations were made.
unreported probably 1985-86.

Methods used to obtain data or observations.

o Sample design. 97 reconnaissance plots (10m x 10m) w/in the 3500 hectare study area (≈ 7/sq. mile)
2 permanent plots (40m x 40m) - one at 540 m., one at 1445 m. elevation

o Survey procedures. Plots on all aspects, at all elevations from Ross Lake to the peak

o Variables measured. DBH, total height, basal area by tree species. Aspect, slope, elevation, Shrub & herb cover by Daubenmire class. Age determined by increment cores

Applicability Does the information pertain directly to:

Yes	No	
☒	☐	Plant community composition or distribution in the project area?
☒	☐	Occurrence or distribution of unusual plant species or communities in the project area? describing a Douglas Fir - Ponderosa Pine community type
☒	☐	Habitat features in the project area? Fire Frequency

Summary Of Results/Discussion/Conclusions Cite page numbers for information sources and use direct quotes when applicable.

o Describe what is illustrated.

o Are additional sources suggested? OVER

RESULTS & DISCUSSION:

Identifies 7 forest communities:

1. Douglas-fir / Ponderosa Pine - restricted to low elevation SW aspects. D. fir dominant w/ 25% cover (avg). Shallow soil & rock outcrops common. Lodgepole pine usually present. Understory ~~x~~ abundant, dominated by shrubs

2.