Forest fire history of Desolation Peak, Washington

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Forests in the vicinity of Desolation Peak, Washington, are of special ecological interest because of their transitional nature between coastal and interior forest types. The area is west of the Cascade Mountain crest but in the rainshadow of mountains farther to the west. Fire return intervals were hypothesized to be shorter than typical for coastal forest types, such as those dominated by western hemlock and Pacific silver fir, and longer than typical for interior forest types, such as ponderosa pine, owing to the close juxtaposition of these types at Desolation Peak. Seven forest community types were defined, and a 400-year fire history was developed for this 3500-ha area. The average natural fire rotation was 100 years; this varied by a factor of two by century and by topographic aspect. Forest types typical of coastal regions, such as Douglas-fir, – western hemlock and mountain hemlock – Pacific silver fir, had mean fire return intervals (108–137 years) much lower than in other western Washington areas. The most interior forest type, ponderosa pine – Douglas-fir, had a higher mean fire return interval (52 years) than reported for similar forest types east of the Cascades. Historically, fire has created structural and landscape diversity on Desolation Peak and may be an important process in the maintenance of such diversity into the future.

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Les forêts de la région de Desolation Peak, Washington, sont d'un intérêt écologique particulier de par leur nature de transition entre les types forestiers de la côte et ceux de l'intérieur. Ce territoire se situe à l'ouest de la crête des Cascades mais est une région sous le vent abritée de la pluie des montagnes plus à l'ouest. À cause de l'étroite juxtaposition des types forestiers à Desolation Peak, on a émis l'hypothèse que les cycles des incendies forestiers y sont plus courts que la normale pour les types forestiers typiques de la côte comme ceux dominés par la Pruche de l'ouest et le Sapin gracieux, et plus longs que la normale pour les types forestiers de l'intérieur tels les pinèdes à Pin ponderosa. Sept communautés forestières ont été identifiées et un historique des incendies forestiers des 400 dernières années a été dressé pour ce territoire de 3500 ha. La période moyenne de rotation des incendies forestiers naturels est de 100 ans, valeur variant d'un facteur de deux selon le siècle et l'exposition de la pente. Les types forestiers typiques de la côte, comme les associations Sapin de Douglas – Pruche de l'ouest et Pruche subalpine – Sapin gracieux, ont des cycles des incendies forestiers beaucoup plus courts (108–137 ans) que ceux des autres régions de l'ouest du Washington. Le type forestier le plus à l'intérieur, l'association Pin ponderosa – Sapin de Douglas a un cycle des incendies forestiers plus long (52 ans) que celui rapporté pour des types forestiers semblables à l'est des Cascades. Dans le passé, les incendies ont créé une diversité de la structure et du paysage forestiers de Desolation Peak. Ils pourraient constituer un élément important du maintien d'une telle diversité dans l'avenir.

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Introduction

The fire history of forests on the west side of the Cascade Mountains in Washington is usually characterized by infrequent (200- to 500-year interval) fires that kill all the trees in the stand (Morris 1934; Hemstrom and Franklin 1982). Fire has been an important disturbance process in this maritime climate area for millennia (Sugita and Tsukada 1982; Cwynar 1987). Tree regeneration after fire is often prompt, but may extend in some instances over decades (Franklin and Hemstrom 1981). At high elevation (>1500 m), the tree re-establishment process may take a century or more (Agee and Smith 1984). In the eastern Cascades of Washington, with an interior climatic influence, the subalpine fire regime is similar to that of west side forests, but the low-elevation (<1000 m) fire regime is one of more frequent (10- to 50-year interval) fires (Agee 1981), which may result in forests with multiple age-classes (Larson 1981).

The North Cascades in Washington (Fig. 1) include lowland forests on the moist west side of the Cascades, subalpine forests along the crest, and interior forests on the dry east side. A typical zonal forest-type sequence up the coastal west side of the Cascades is western hemlock (*Tsuga heterophylla* (Raf.) Sarg.), Pacific silver fir (*Abies amabilis* (Dougl.) Forbes), and mountain hemlock (*Tsuga mertensiana* (Bong.) Carr). A typical zonal forest-type sequence up the east side of the Cascades is ponderosa pine (*Pinus ponderosa* Dougl.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), often with grand fir (*Abies grandis* (Dougl.) Forbes) or lodgepole pine (*Pinus contorta* Dougl. var. *latifolia* Engelm.), and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) (Agee and Kertis 1987).

Forests in the vicinity of the upper Skagit River, Ross Lake area, are of a special botanical interest because of their transitional nature between moist coastal and dry interior forests (Franklin and Dyrness 1973). The area is west of the Cascade crest but is in the rainshadow of mountains farther to the west, including Mount Baker, Mount Shuksan, and the Picket Range. The uniqueness of the area lies in the close juxtaposition of coastal and interior forest communities rather than the presence of unique community types (Agee

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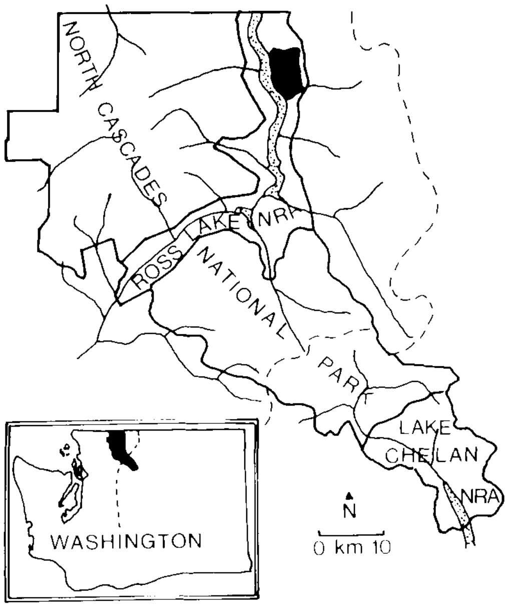

FIG. 1. Location of Desolation Peak study area (shown in black) within Ross Lake National Recreation Area (NRA) in the North Cascades of Washington. Broken line is the crest of the Cascade Mountains.

and Kertis 1987). Commonly, the west side zonal forest sequence occurs on mesic north and east aspects, whereas the east side zonal forest sequence is found on drier south and west slopes.

The objective of this study was to define the forest fire history in the vicinity of Desolation Peak just east of Ross Lake. It was hypothesized that the fire frequencies for east side and west side forest communities would reflect the close proximity of these quite different fire regimes: on the low end of the range for forest types common on the west side, and on the high end of the range for types common to the east side of the Cascades. To achieve this objective it was necessary to define the forest community types on Desolation Peak and reconstruct the disturbance history over the study area. For the purposes of this study, a low severity fire is defined as one that kills primarily understory trees. A moderate severity fire kills most understory trees and leaves at least a patchy overstory, with residual trees often scarred. A high severity fire kills most trees in the stand.

Methods

The Desolation Peak study area is defined by Ross Lake on the west, Lightning Creek on the south and east, and a valley and low saddle to the north. Ross Lake is a reservoir created in the 1940s in the Skagit River valley; many fires before then burned in areas now inundated. A total of 97 plots were subjectively established over the 3500-ha area, representing the different forest types and apparent stand ages based on the size classes represented in the stand. Fixed 100-m^2 plots were most commonly used, because in most cases plots of this size encompassed the range of tree sizes present in the stand. In widely spaced stands 225- or 400-m^2 plots were occasionally employed. Aspect, slope, and elevation were measured by compass, clinometer, and altimeter, respectively. Diameter at breast height, total tree height, and basal area by species were recorded for each tree in the plot. 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%). Roughly 10 trees per plot were increment cored for determination of age; selection was based on adequate representation of species and size cohorts in each stand. Wedge samples were cut and removed from 50 trees in all locations where single or multiple fire scars were present (Arno and Sneck 1977), except along trails. Multiple samples were taken in the same area only when there was an obvious difference in the number of scars on adjacent samples.

Vegetation community analysis

Two-way species indicator analysis (TWINSPAN) was used to classify the vegetation data (Hill 1979; Gauch 1982). Species importance values used as inputs to the programs were cover classes for shrubs and herbs and an average of relative basal area and relative cover (expressed on the same 1–6 scale) for trees (Agee and Kertis 1987).

Fire history analysis

Increment cores were mounted on boards, sanded, and counted under a binocular microscope. Total tree age on a sample was determined by adding to the age of each core an estimated age for core height. Correction factors were based on unpublished data from similar sites throughout the region (J.K. Agee, unpublished data). At 30 cm height, for example, the correction factor was as follows: Douglas-fir and grand fir, 3 years (mesic site) to 5 years (dry site); lodgepole pine, 3 years (low elevation) to 5 years (high elevation). Pacific silver fir and subalpine fir correction factors were based on height and the spacing of the innermost rings on the sample: at 30 cm height, 10 rings/cm, the correction factor was 5 years, while at 30 cm height, 50 rings/cm, the correction factor was 20 years.

Fire dates were recorded from cores (Barrett and Arno 1988) and wedges. USDA Forest Service and the United States Department of the Interior National Park Service records were reviewed for additional 20th century fire occurrences. Age-class information was also used to determine disturbance dates. Distinct age-class separations between groups of trees on a plot were determined from clusters of tree ages from each plot. Each defined age-class was represented by the oldest tree age in the cluster for plotting on the site map. Recruitment periods after disturbance in multiaged stands were usually less than 30 years. Age-class coverage across the study area was mapped using 1 : 12 000 aerial photography and the mapped age groups in the plots.

Although fires were dated to specific years (e.g., ca. 1648), there was a lack of correspondence between dates among wedge samples owing to unusual annual ring patterns in the vicinity of scars (Arno and Sneck 1977); oldest trees in cohorts of age-class data were also used to establish dates of events. Accuracy of the pre-1800 dates includes an approximate 5-year range, while 1800–1900 dates have about a 2-year range and >1900 dates are accurate to the year. In ecosystems with fire return intervals >20–30 years, dendrochronological techniques are less critical than in ecosystems with high fire frequency, where individual fire events are more easily confused (Madany et al. 1982). In areas with longer mean fire return intervals, where fires may often be of high severity, frequent fires may be uncommon, but if they do occur, their presence is likely to be missed if dendrochronological techniques are not employed. Furthermore, fire event dates determined without dendrochronology, while suitable for calculating fire frequencies in medium to long fire return interval regimes, cannot be used to associate fire with climate or other characteristics of specific years.

Historical fire boundaries were mapped using the age-class map and fire ages from wedge and core information. Criteria for mapping were similar to those of Hemstrom and Franklin (1982):

(1) *Uniformity*. The nature of vegetation responses to fire has not changed during the period of study.
(2) *Age continuity*. Trees in stands with similar age cohorts, separated by younger stands but not significant vegetation or topographic barriers, probably originated after the same fire episode.

TABLE 1. Average basal area (BA; $m^2\ ha^{-1}$), cover (CV; %), and constancy (CON; %) of tree species in Desolation Peak forest community types

	Pipo–Psme			Pico–Psme			Psme–Abgr			Psme–Tshe			Psme–Abam			Tsme–Abam			Pico–Abla		
	BA	CV	CON	BA	CV	CON	BA	CV	CON	BA	CV	CON	BA	CV	CON	BA	CV	CON	BA	CV	CON
Abam										tr	tr	11	5	1	40	20	20	100			
Abgr							1	tr	12	tr	tr	11									
Abla																3	tr	40	18	15	75
Chno																tr	tr	10			
Pien																3	tr	50			
Pial																			tr	tr	25
Pico	tr	tr	14	4	5	26	3	tr	40										6	2	50
Pipo	4	5	70	1	tr	7															
Psme	14	25	100	27	35	96	31	50	100	29	35	100	15	15	80	6	2	60	4	tr	25
Thpl							1	tr	40	3	5	55									
Tshe							tr	tr	16	13	10	83				7	2	50			
Tsme																6	11	50			

NOTE: Abam, Pacific silver fir; Abgr, grand fir; Alba, subalpine fir; Chno, Alaska yellow-cedar; Pien, Engelmann spruce; Pial, whitebark pine; Pico, lodgepole pine; Pipo, ponderosa pine; Psme, Douglas-fir; Thpl, western red cedar; Tshe, western hemlock; Tsme, mountain hemlock. Also present in the area but not sufficiently represented for analysis were Acma, bigleaf maple and Pimo, western white pine.

(3) *Topographic consistency*. Disturbances other than fire, such as avalanches, characteristically operate on steep gullied slopes, whereas mudflows and floods affect stands at valley bottoms. Typically, these disturbances do not have surficial charcoal and can be distinguished from fires.
(4) *Conservative limits*. Reconstructed burns are often minimum areas burned and represent conservative reconstructions of past fire events.

Two other assumptions by Hemstrom and Franklin (1982) were modified for this study:
(5) The regeneration span assumption with early seral tree cohorts spanning 75 years or more was not used in this study, even though regeneration can be very slow at elevations >1500 m on Desolation Peak. Regeneration has been more rapid in most locations because of the presence of moderate severity fires evidenced by substantial survival of residuals after many fires.
(6) Unless specific fire evidence was apparent, fires were assumed to burn uphill only until they reach a topographic barrier or subalpine forest, since other studies (Schmidt 1960; J.K. Agee, unpublished data) suggest a dampening of fire spread and intensity when fires burn upslope into more moist fuels at higher elevation.

Fire events, defined as either single fires or a series of simultaneous or closely spaced fires, were reconstructed using aerial photo and topographic data along with, in priority order, (*i*) fire scars from wedge samples, (*ii*) cores specifically extracted to date a fire scar, (*iii*) cores exhibiting aberrant ring patterns, generally associated with dates determined from *i* or *ii*, and (*iv*) age-class data, particularly where severe fires had removed previous evidence. Boundaries of past fires were estimated by drawing lines equidistant between points where fire scars or age-class data indicated a discontinuity in past disturbance. This technique underestimates area coverage of fires because low severity fires may leave little or no trace that is recognizable decades or centuries later. Area coverage of each fire was calculated using a dot-grid overlay on 1 : 24 000 scale maps, with 15.5 dots/cm.

Natural fire rotations (NFR) (Heinselman 1973) were calculated using the mapped fire areas for various time periods and geographical units. A selected time interval divided by the proportion of total area that is burned within that interval yields the NFR. Point estimates of fire frequency, using individual or clustered fire scar samples, are more applicable in very frequent fire regimes where trees are often scarred but rarely killed (Kilgore and Taylor 1979; Dieterich 1980). Fire return interval methods that rely solely on age-class distribution and assumptions about randomness of ignition (Johnson and Van Wagner 1985) work best in areas of uniform terrain and stand-replacing fires. A major disadvantage of the NFR method is the need to reconstruct past fire events, which can result in conservative fire return intervals (Van Wagner 1978).

Mean fire return intervals were calculated for community types defined by TWINSPAN by dividing the average number of fires per plot for a community type into the time period covered. A second method of analyzing fire return intervals for vegetation was used to compare stand species composition and structure with mean fire return intervals (MFRIs). On each plot, the two species representing the highest (primary dominant) and second highest (secondary dominant) tree density in the combined dominant and codominant tree strata were identified. The MFRI for a primary dominant species was calculated by pooling all plots where that species was a primary dominant and dividing the mean number of fires per plot into the time period covered. The same technique was used for secondary dominant species.

Results

Forest communities

Vegetation community types were identified through TWINSPAN on the basis of floristic similarity. Seven forest community types were identified; vegetation characteristics of the sites are summarized in Tables 1 and 2 and Fig. 2. Communities were named for two common conifer species; the second conifer in the name is the likely potential overstory dominant in the long-term absence of disturbance (plant series sensu Daubenmire 1968), whereas the first named conifer is an associated seral dominant.

Forest fire events

Fires were detected over a 400-year period on Desolation Peak. Major fires are discernible over the entire period, but the chance of reconstructing small fire events diminishes as those events become older. A total of 29 fire events were mapped (Figs. 3A–3L). The oldest fire (ca. 1573) was determined from fire wedge information and covered a southwest aspect that has burned repeatedly since that time. The ca. 1648 fire was identified from widely scattered age-classes over the entire study area and probably burned a significant area adjacent to Desolation Peak. The ca. 1733 and ca. 1782 fires burned much of the same area covered by the ca. 1573 fire. The ca. 1787 fire burned south to southeast aspects; a portion of the ca. 1782 fire was reburned. A fire that probably started in an area that is now under Ross Lake

TABLE 2. Relative constancy (%) of major shrubs in Desolation Peak forest community types

	Community type						
	Pipo–Psme	Pico–Psme	Psme–Abgr	Psme–Tshe	Psme–Abam	Tsme–Abam	Pico–Abla
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	20	50
Rhododendron albiflorum						50	
Rosa gymnocarpa		96	72	15			
Rubus parviflorus			24		60		25
Salix spp.			24		40	20	50
Spiraea betulifolia		78	36				
Vaccinium spp.			48	30	60	100	100

NOTE: Relative constancy is the percentage of plots within a community type that contains the species. See Table 1 for an explanation of species abbreviations.

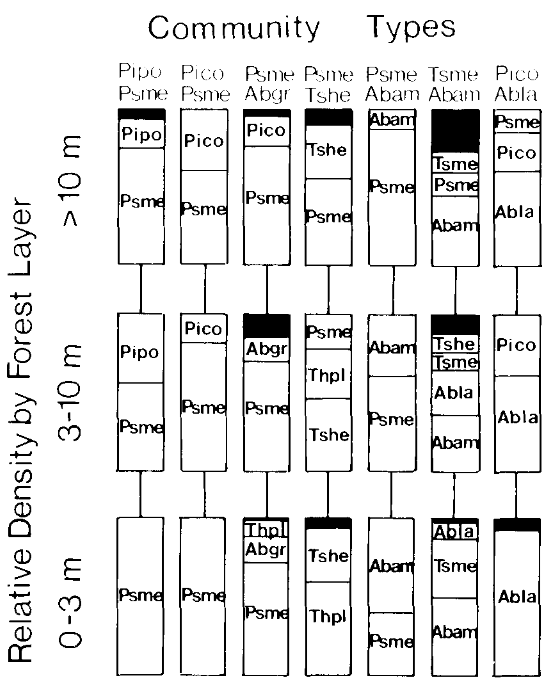

FIG. 2. Percent density of tree species within each community type by forest layer: 0–3 m height, 3–10 m height, and >10 m height. Species constituting less than 10% of relative density are lumped in a miscellaneous category (shaded black).

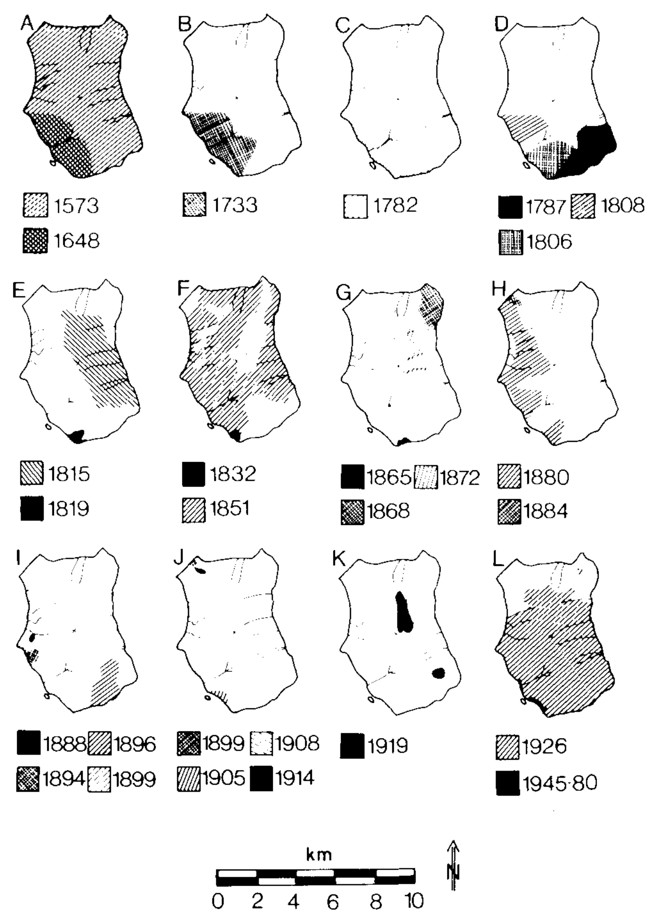

FIG. 3. Individual fire events since ca. 1573 at Desolation Peak. Multiple fire years on a single map are denoted by different shading.

burned up two sides of a major west-facing drainage in ca. 1806. An area on the east side of Desolation Peak, which had not been burned by a major fire for 165 years, burned in ca. 1815. In ca. 1819 and ca. 1832, small fires burned lower portions of the southwest-facing slopes.

The fire of ca. 1851 covered most of the mountain. Some areas shown as unburned islands were not mapped as burned owing to lack of evidence for reconstruction of the fire, although it is possible they did burn. A similar area was mapped by Ayres (1899) as an old burn that had not restocked. In ca. 1865, another small fire burned on the lower elevation south slopes. In ca. 1868 and ca. 1872, the northeastern portion of the mountain was burned. The ca. 1872 fire, which showed an age-class slightly younger than the lower elevation ca. 1868 fire, might have been interpreted as a single event, but fire scar data indicated a separa-

TABLE 3. Natural fire rotations for Desolation Peak

Time period	Natural fire rotation (years)
1600–1699	100
1700–1799	208
1800–1899	60
1900–1985	103
1573–1985	100

TABLE 4. Natural fire rotation by aspect over the 1573–1985 period

	Natural fire rotation (years)
North	182
East	107
South	97
Southwest	65
West	120

tion of 4 years. In ca. 1880, much of the west slope of the mountain burned, and over the next 4 decades small fires occurred in scattered locations around the mountain. Other small fires may have occurred earlier in the record, but could not be identified on the landscape.

The area of the 1919 fire was reburned by the larger fire of 1926. The 1919 fire was romanticized in Jack Kerouac's (1958, 1960) novels *The Dharma Bums* and *Desolation Angels*, although he assumed the burned area was a single large fire in 1919. The first fire apparently burned primarily in subalpine forests (Fig. 3K), whereas the second was part of the 20 000-ha Big Beaver fire that started near what is today the south end of Ross Lake, jumped the Skagit River, and ended north of Desolation Peak (Fig. 3L). Since the big 1926 fire, only scattered areas have burned in a period when a fire suppression policy has been in effect.

Patterns of fire frequency

Natural fire rotations were calculated for the entire area over the time period 1573–1985 and for each century (Table 3). The NFRs were also calculated by aspect (Table 4). The average NFR for the area was 100 years, interpreted to mean that in the course of a century an area equal in size to the study area would burn; some areas would burn twice and others not at all. Wide temporal and spatial variations are evident during the time period covered by the study. The post-1900 period has a NFR equal to the average over the whole study period, whereas the period 1800–1899 has a low NFR. The 1700–1799 period has a high NFR, whereas the large fire in ca. 1648 results in an average NFR (100 years) for the 1600–1699 period. Infrequent fire events of wide extent markedly affect the calculations, and the probable occurrence of additional but unidentified fires in the 1600–1700 period may make this NFR conservative. Southwest aspects burned most frequently whereas north aspects burned least frequently.

Mean fire return intervals for community types (Table 5) showed a range of 52–137 years. The ponderosa pine – Douglas-fir type has the shortest MFRI; it is most common

TABLE 5. Mean fire return intervals for forest community types on Desolation Peak

	Mean fire return interval (years)
Ponderosa pine – Douglas-fir	52
Lodgeple pine – Douglas-fir	76
Douglas-fir – grand fir	93
Douglas-fir – western hemlock	137
Douglas-fir – Pacific silver fir	108
Mountain hemlock – Pacific silver fir	137
Lodgepole pine – subalpine fir	109

TABLE 6. Mean fire return intervals for major species where they are either primary or secondary dominants

	Mean fire return interval (years)	
	Primary dominant	Secondary dominant
Ponderosa pine	44	56
Lodgepole pine	69	82
Douglas-fir	94	84
Western red cedar	>411	204
Western hemlock	169	126
Pacific silver fir	192	108
Subalpine fir	154	89
Mountain hemlock	137	123

on the southwest aspects that have burned repeatedly with low severity fires. The lodgepole pine – Douglas-fir community, with the next lowest MFRI, is found on most other aspects at low elevation. The Douglas-fir – grand fir community is found in protected low-elevation draws, which occasionally have not burned, so its MFRI is higher. The Douglas-fir – western hemlock community has burned the least of the low-elevation communities. It is found primarily on north aspects that are floristically and climatically similar to moist lowland forests farther to the west. The remaining community types tend to be subalpine forest types and have more similar MFRIs than the montane forests. This is due to the widespread nature of past high-elevation fires and limited geographic separation between the subalpine types.

Fire frequency variation was also assessed for species where they were primary or secondary dominants (Table 6). Ponderosa pine and lodgepole pine were the only species to have shorter MFRIs where they were primary dominants. These are the only two major species at Desolation Peak that are restricted to early seral status; all of the other species are late successional or potential vegetation dominants (sensu Daubenmire 1968) in some locations. As their dominance depends on seral community maintenance through disturbance, the early seral species should be more dominant where disturbance is more frequent and the MFRI is lower. Species that are later successional or relatively fire sensitive, including subalpine fir, mountain hemlock, and Pacific silver fir, have longer MFRIs where they are primary dominants and tend to be secondary dominants where disturbance by fire is more frequent. Douglas-fir is both a major seral species in middle- to high-elevation communities and a major potential vegetation dominant in the drier lowland communities. Over the study area, it has roughly equal MFRIs whether it is a primary or secondary dominant.

Discussion

The spatial arrangement of the forest communities on Desolation Peak is influenced by temperature and moisture gradients, which were also found to be important in other Pacific Northwest forests (Zobel *et al.* 1976; del Moral and Watson 1978) and in the North Cascades (Agee and Kertis 1987).

Variable fire environments on Desolation Peak are illustrated by the spectrum of fire return intervals in the forest community types. The communities in drier, warmer environments have the shortest MFRIs, whereas the communities in cooler, wetter environments have the longest MFRIs. These fire frequencies also reflect the landscape heterogeneity within which they occur.

At Desolation Peak, the interspersion of west side and east side types has a significant influence on fire frequency within a forest community. The ponderosa pine - Douglas-fir community has an MFRI of 52 years, far higher than fire intervals for the type elsewhere in the Pacific Northwest where environmental gradients are more gradual and a homogeneous contiguous forest is present (Wischnofske and Anderson 1983; Finch 1984; J.K. Agee, unpublished data). The lodgepole pine - Douglas-fir community has an average MFRI higher than typically found in similar forest types of western Montana (Arno 1980). The Douglas-fir - western hemlock community fire intervals are below those calculated for either Douglas-fir (230 years) or western hemlock (598 years) for western Washington (Fahnestock and Agee 1983), but are close to those of 100 years from Means (1982) and Morrison and Swanson (1990) for dry Douglas-fir forests of the Oregon Cascades. The Douglas-fir - grand fir community has an MFRI within the wide range of Arno (1980) from the northern Rocky Mountains and Wischnofske and Anderson (1983) from the Wenatchee Valley of Washington. The most cool and moist forest community, the mountain hemlock - Pacific silver fir community, has an MFRI far below the 434 years for similar forest types at Mount Rainier (Hemstrom and Franklin 1982). The fire return intervals of Desolation Peak forest communities appear to reflect the juxtaposition of forest types not commonly found together, lengthening fire return intervals for communities with typically frequent fire regimes and shortening them for communities with typically infequent fire regimes.

Although forest environment and interspersion of forest types are important influences on fire return intervals, patterns of lightning and aboriginal ignitions are also important. Indians inhabited the Skagit River valley in the vicinity of Desolation Peak, and a preliminary analysis of fire scars on stumps now underwater most of the year about 5 km north of the study area suggests a 10- to 15-year fire return interval on the valley floor (Taylor 1977). Such closely placed fires are generally absent from the record on Desolation Peak, suggesting more frequent burning in the vicinity of the Indian village (e.g., Barrett and Arno 1982). Although mining era fires were common in the Cascades (Mack 1988) during the last half of the 19th century, the settler influence found elsewhere in the North Cascades (Ayres 1899; Hemstrom and Franklin 1982) is not locally apparent at Desolation Peak.

The short NFR for the 17th century and the long NFR for the 18th century would not be notable if Desolation Peak were the only area in the Pacific Northwest to show such a record. However, a similar pattern is reported for the forests at Mount Rainier (Hemstrom and Franklin 1982), the southern Olympic Mountains (Henderson and Peter 1981), and the west-central Cascades of Oregon (Morrison and Swanson 1990). This apparent regional pattern is not explained by any of the separate studies, but may reflect climatic changes such as the Little Ice Age (Henderson and Brubaker 1986) and associated changes in biomass flammability, dry summer winds, or lightning storm frequency.

The forests of Desolation Peak have been significantly influenced by fire over the past half millennia and no doubt for millennia before. The preservation of the structural and landscape diversity of these natural ecosystems will require maintenance of these disturbance patterns into the future. Over the last 4 centuries a fire has burned on Desolation Peak about every 15 years. Although it is unlikely the major seral dominants ponderosa pine and lodgepole pine would disappear with complete fire exclusion, the spatial extent of these communities would shrink over time. Forest communities dominated by these species are unusual west of the Cascade crest, and future active management of disturbance by fire will help maintain this unique landscape diversity.

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