Succession After Wildfire in the North Cascades National Park Complex

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INTRODUCTION

Biologists employed by or associated with the National Park Service have begun fire ecology studies in a number of the parks and monuments under the jurisdiction of the agency. Because of the Service's administrative policies allowing fire where it is appropriate (Hendrickson, 1972), it is important to gain a better understanding of the processes of succession following these natural disturbances.

The North Cascades National Park complex is one of the most recent additions to the nation's roster of parks and monuments, having been created by Act of Congress only in 1968. It is located athwart the Cascade Range of north-central Washington, extending from the U. S.–Canadian border to a point on Lake Chelan about 50 miles south. Much of the park complex is above the tree line and consists of extremely rugged mountains and glaciers, but the lowland valleys that penetrate the Cascade Range are covered with heavy stands of virgin timber. East of the Cascade Crest, these valleys are in the *Pseudotsuga menziesii* and *Abies grandis* Zones and west of the Crest they are in the *Tsuga heterophylla* Zone. The subalpine forests in the park complex are in the *Abies amabilis* and *Tsuga mertensiana* Zones (Franklin and Dyrness, 1973).

In July of 1970 a series of thunder storms crossed the North Cascades National Park complex following several weeks of warm

TABLE 1. Physical data of study sites.

	Thunder Creek No. 1	Thunder Creek No. 2	Silver Creek
Fire dates	July 17, 1970	July 17, 1970	July 16, 1970
Location	SE¼ of Sec. 1, T 36 N, R 13 E	SE½ of Sec. 1, NE½ of Sec. 12, NW¼ of Sec. 11, T 36 N, R 13 E	NW¼ of Sec. 15, NE¼ of Sec. 16, T 40 N, R 13 E
Acres Burned	55	410	290
Number of plots	25	23	31
Elevation of plots	1800'–1900'	1800'–2000'	1602.5'–2440'
Aspect of plots	7–N 12–S 6–0	10–E 13–S	15–E 2–SE 14–NE
Mean % of slope	23.96	38.86	49.8

and dry weather. Numerous lightning strikes touched off several wildfires within the park complex. Some were vigorously suppressed by park personnel and others were allowed to burn unimpeded. The resulting burns (Table 1), of varying sizes, afforded the Park Service administration an opportunity to undertake a Resources Studies Problem on Forest Fire Ecology in the North Cascades. The writers, who had previously conducted a number of other biological research projects for North Cascades National Park, were requested by the administration to begin these fire studies.

AREAS OF STUDY

Three of the largest burns, Thunder Creek No. 1, Thunder Creek No. 2, and Silver Creek, were selected as sites for plant succession studies. They were visited during the growing seasons of 1971, 1972 and 1974 for recording plant succession and in 1973 for marking the established study plots with permanent plastic boundary stakes.

Thunder Creek No. 1, a burn of 55 acres, lies on the east side of Thunder Creek, a major tributary of the Skagit River, 4 miles upstream from Diablo Reservoir. This fire crossed one of the most heavily-used recreation trails in the park complex, and was sup-

pressed by park personnel. Thunder Creek No. 2, a mile further upstream, is the largest of the 1970 burns, covering 410 acres. The major portion of the burn is west of the stream on extremely precipitous slopes. Because of the nature of the terrain, suppression activities were less vigorously carried out, the fire burning up the ridge to near the 4000 foot level before dying out. The forest on and around both burns is composed of the typical *Tsuga heterophylla-Pseudotsuga menziesii-Thuja plicata* mixture characteristic of the *Tsuga heterophylla* Zone. *Pseudotsuga* appeared to be dominant in most stands, with a scattered representation of *Pinus monticola*, *Abies amabilis* and *A. grandis.*

The Silver Creek burn is located on the west side of Ross Reservoir, 4 miles south of the U. S.–Canadian border and covers 290 acres. It resulted from a single lightning strike on a ridge more than 1000 feet above the reservoir, and the fire then burned down to the water and up the ridge to timberline. The fire was controlled on the north edge by a fire break and on the south edge by the use of relay pumps, but it was allowed to burn unimpeded up the ridge until extinguished by the winter rains. The forest on and around the burn contains the same mixture of tree species as on the Thunder Creek sites, with the addition of a very few *Pinus contorta.*

GEOLOGY AND SOILS

The bedrock of the Thunder Creek sites is a pre-Upper Jurassic gneiss (Huntting, et al. 1961), formerly called the Skagit Gneiss (Misch, 1952, 1966) but now named the Custer Gneiss (McTaggart and Thompson, 1967). This unit is principally made up of biotite and hornblende gneisses. The Silver Creek sites are underlain with the Hozomeen Group of Cairnes (1944). This sequence, of Cretaceous age, is composed of slightly metamorphosed mafic lavas (greenstones) with subordinate chert, phyllite, argillite and mafic intrusives (Staatz, et al. 1972). Both the Thunder Creek and Skagit River Valleys were occupied by local glaciers during the major periods of Pleistocene glaciation (Mackin and Cary, 1965).

The soils of the North Cascades have not been adequately described, but the steeper slopes of both Thunder Creek No. 2 and

Silver Creek sites appear to be principally composed of Lithosols and Rocklands (Taber, 1971). Deeper soils on river terraces appear to be Podsols and Brown Podsols. Soil pits were dug in 1971 in burned and unburned areas of all three study sites, and profiles were measured, described and sampled. Samples were turned over to the Park Service's Regional Chief Scientist for analysis, but results have not been received.

CLIMATE

The climate of the Skagit Valley and its tributaries may be described as wet, mild and maritime. Summers are generally warm and dry and winters moderately cold with much rain and heavy snowfall. The nearest weather stations to the study sites are a Canadian weather station 7 miles north of the Silver Creek burn and the Ross Dam station 6 miles north of the Thunder Creek burns. Weather observations are also maintained during summer months only at the Hozomeen Ranger Station 4 miles north of the Silver Creek burn.

TABLE 2. Climatic data of study sites and nearest weather stations.

	Ross Dam Weather Station	Thunder Creek (estimated)	Silver Creek (estimated)	Hozomeen Ranger Station and Canadian Skagit Weather Station
Mean annual Precipitation	56.8 in.	80	40	42.5
June, July, Aug. precipitation (10 year mean)	3.84	5.4	4.5	4.87
1970 June, July, Aug. precipitation	1.28	1.8	.45	.46
Temperature, (10 year mean)	48.5°F	45°	47°	46.32°
Temperature, June, July, Aug. mean	63.5°	61.5°	64°	64.41°
Temperature, 1970 June, July, August mean	65.4°	63.5°	68°	68.48°

Climatic data on the chart in Table 2 were derived from a synthesis of reports from these stations and other hydrographic data from the U. S. Geological Survey.

METHODS OF STUDY

The methods of vegetative sampling were as suggested by Garrett A. Smathers, formerly Regional Chief Scientist, Region 10, National Park Service, and are based on his fire ecology studies in Hawaii Volcanoes National Park (Smathers, 1968, 1969). Several belt transects of permanent contiguous 10 m x 10 m plots were laid out on compass bearings from established landmarks. These belt transects varied in length from 100 m to 280 m. A total of 103 10 m^2 plots was marked and sampled, and two 25 m^2 plots were also marked and sampled on the Silver Creek burn. Data from only 79 of the more thoroughly burned 10 m^2 plots have been used in the preparation of this paper.

In each plot all living trees, shrubs and herbs were recorded by species. Mosses, liverworts and fungi were recorded but not identified by species. Plants were classified according to their Raunkiaer life forms as revised by Ellenburg and Mueller-Dombois (1965-66). The Raunkiaer classification of the various species is according to Jones (1936). Nomenclature of vascular plant species follows Hitchcock, et al. (1955, 1959, 1961, 1964, 1969). The abundance of each species was recorded according to the Braun-Blanquet (1932) index of coverage, and where possible, the mode of survival was also recorded for the plants in each plot.

RESULTS

These observations were originally designed to create a base-line for a long-range succession study, and it has been the hope of the writers to find a younger and more agile ecologist to inherit the project. However, readings of the plots during the lst, 2nd and 4th growing seasons following the fires have provided sufficient data to disclose some interesting short-term trends. The charts and graphs accompanying this paper illustrate these successional changes.

The total species of vascular plants recorded on all plots during the study was 90. (Table 3). The greatest number of species was found on Thunder Creek No. 1, with 74 percent of the total. This burn also had the greatest number of surviving species of trees, shrubs and herbs, with exceptionally large numbers of herb species the first growing season—over three times as many as on Thunder Creek No. 2 and over eight times as many as on Silver Creek. The same area, however, was the only one with no seedling shrubs in 1971. The largest number of species of seedling trees was found on Silver Creek, an area also leading in numbers of seedling trees and shrubs for all years.

On all sites 10 species of shrubs seeded in during the first growing season, and by 1974, 36 species had seeded in. Surviving species of shrubs remained about the same all years on all sites.

Table 4 shows, as would be expected, that *Epilobium angustifolium* has attained more percentage of cover than any other plant. On the Silver Creek burn, however, its population appears to have peaked between 1972 and 1974, and *Salix lasiandra* had almost

TABLE 3. Variations between study sites in numbers of different species of vascular plants recorded on plots (Sr=residuals, survivors; D=disseminules, seedlings).

	Thunder Creek No. 1		Thunder Creek No. 2		Silver Creek	
	Sr	D	Sr	D	Sr	D
TREES						
1971	6	2	5	2	3	4
1972	5	3	4	3	2	5
1974	3	3	4	5	2	9
SHRUBS						
1971	11	–	10	3	8	7
1972	10	5	9	8	9	14
1974	10	10	9	10	7	17
HERBS						
1971	26	11	7	7	3	8
1972	17	17	6	12	8	11
1974	14	16	5	16	7	21
TOTAL SPECIES						
1974	67		46		49	
TOTAL SPECIES, ALL SITES, ALL YEARS—90						

TABLE 4. Frequency and average cover values for principal plant species* recorded on permanent 10m² plots during growing seasons of 1971, 1972 and 1974.

*cover value>.5%

PLANT SPECIES	1971 Freq.	1971 Cover	1972 Freq.	1972 Cover	1974 Freq.	1974 Cover
			Percent			
THUNDER CREEK NO. 1						
TREES (Residuals)						
Pseudotsuga menziesii	36	2.4	24	1.5	20	1.2
Thuja plicata	32	1.8	20	1.4	20	1.4
Tsuga heterophylla	24	.8	4	.2	4	.1
TREES (Seedlings)						
Pseudotsuga menziesii	24	a	68	a	80	1.1
Thuja plicata	0	0	4	a	68	1.9
Tsuga heterophylla	36	.8	36	.6	40	.5
SHRUBS AND HERBS (Residuals)						
Acer circinatum	12	.8	12	.8	12	.8
Arctostaphyllos uva-ursi	32	.2	32	.1	28	.9
Berberis nervosa	44	a	40	.1	32	.6
Gaultheria shallon	24	.1	16	a	16	.7
Linnaea borealis	32	.1	28	a	28	.6
Spiraea betulifolia	28	.1	28	a	24	.9
SHRUBS AND HERBS (Seedlings)						
Collomia heterophylla	28	a	36	a	24	.5
Epilobium angustifolium	80	.7	100	18.5	100	31.8
E. minutum	20	a	40	.4	32	.6
Gramineae	0	0	36	.2	28	.9
Salix lasiandra	0	0	44	a	92	2.8
NON-VASCULAR GROUND COVERS						
Liverwort	88	.8	80	.5	16	.2
Moss	72	.5	88	7.3	100	45.8
THUNDER CREEK NO. 2						
TREES (Residuals)						
Pseudotsuga menziesii	17.4	3	13	2.3	4.3	.7
Thuja plicata	21.7	.4	8.7	.2	8.7	a
Tsuga heterophylla	65.2	14	21.7	2.1	13	1.4
TREES (Seedlings)						
Pseudotsuga menziesii	30.4	.1	73.9	.3	91.3	.8
Thuja plicata	0	0	17.3	a	56.5	.3
Tsuga heterophylla	73.9	3.3	69.6	2.9	82.6	6
SHRUBS AND HERBS (Residuals)						
Berberis nervosa	82.6	1.6	82.6	2.3	82.6	3.4

Table 4. *(Continued)*

Chimaphila umbellata	65.3	.1	52.1	a	52.1	.8
Gaultheria shallon	43.5	.9	43.5	.4	21.7	1
Linnaea borealis	56.5	.3	65.2	.4	65.2	9
SHRUBS AND HERBS (Seedlings)						
Anaphalis margaritacea	0	0	13	a	47.8	.5
Carex spp.	8.7	.2	13	.8	8.7	.7
Epilobium angustifolium	82.6	.5	100	8.5	100	14.9
Berberis nervosa	21.7	a	26.1	.3	30.4	1
Gramineae	4.3	.1	13	1.3	17.4	3.5
Collomia heterophylla	17.4	2.4	17.4	.4	17.4	.3
Rubus ursinus	4.3	a	13	.7	13	3.5
Salix lasiandra	0	0	34.8	.4	86.9	5.1
Vaccinium parvifolium	0	0	13	a	34.8	.9
NON-VASCULAR GROUND COVERS						
Liverwort	69.5	.4	65.2	.5	8.7	a
Moss	65.2	.1	78.3	3.2	91.3	30
	SILVER CREEK					
TREES (Residuals)						
Pseudotsuga menziesii	22.5	1.5	22.5	1.5	22.5	1.9
Thuja plicata	3.2	a	3.2	a	3.2	.1
Tsuga heterophylla	6.4	.5	0	0	0	0
TREES (Seedlings)						
Pinus contorta	0	0	0	0	41.9	.7
Pseudotsuga menziesii	100	1.6	100	1.8	100	2.2
Thuja plicata	0	0	42	.4	74.2	.4
Tsuga heterophylla	100	2.2	96.8	3.2	100	5.2
SHRUBS AND HERBS (Residuals)						
Berberis nervosa	90.3	.16	83.9	2.2	83.9	4.9
Rosa gymnocarpa	58.1	.9	45.2	1.1	45.2	2.4
Trientalis latifolia	32.3	.1	32.3	.1	32.3	.7
SHRUBS AND HERBS (Seedlings)						
Betula papyrifera	16.1	.1	38.6	.4	67.8	1.3
Epilobium angustifolium	93.5	3.6	100	24.5	100	17.6
E. minutum	47.3	1	35.4	.3	6.4	.2
Gramineae	6.4	.2	9.7	.2	16.1	.7
Holodiscus discolor	3.2	a	3.2	a	16.1	1.1
Pachystima myrsinites	32.3	.1	61.3	a	77.4	.6
Ribes sanguineus	29	.3	48.4	.6	67.7	1.2
Salix lasiandra	0	0	97	8.9	97	16.2
Trientalis latifolia	16.1	a	35.5	.2	97	1.5
NON-VASCULAR GROUND COVERS						
Liverwort	38.6	.6	45.1	1.2	9.7	.6
Moss	41.9	.6	48.4	1.5	96.8	15.8

a Value$<$.05

equalled it in coverage at the most recent sampling. Of interest is the remarkable increase in coverage of *Linnaea borealis* on the Thunder Creek No. 2, from .3 percent in 1971 to 9 percent in 1974.

Percentages of increase of vascular plant cover from 1971 to 1974 were 462 percent on Thunder Creek No. 1, 101 percent on Thunder Creek No. 2 and 327 percent on Silver Creek. The only site showing a decrease in cover was Thunder Creek No. 2 between 1971 and 1972 when many of the large trees injured by the fire finally died.

Silver Creek had the largest percentage of vascular plant cover in 1974 (62.3%), but its percentage of increase over 1972 (33.4%) was the smallest (Fig. 1). It can perhaps be predicted that Silver Creek will continue to show a slower rate of increase of cover owing to lesser annual precipitation and its higher mean percent of slope.

On two of the sites, Thunder Creek No. 2 and Silver Creek, the percentage of cover of the principal coniferous seedlings does not give the classic picture of even-aged Douglas-fir representing the first stage of post-fire secondary succession (Spurr, 1973). Figure 2 shows *Tsuga heterophylla* as having substantially larger percentages of cover in all years than *Pseudotsuga menziesii*. It is, however, fair to point out that *Pseudotsuga* appears to be making more rapid growth than the more tolerant and less drought-resistant *Tsuga* (Table 5).

According to Jones (1936), Raunkaier's life form spectrum is valuable in expressing differences and similarities between communities. Unlike the mature mesophytic evergreen forest (Table 6), the burn sites have considerably more Chamaephytes and fewer Hemicryptophytes and Therophytes. The decreasing number of Phanerophytes on all sites results from the dying of fire-injured trees.

Thunder Creek No. 1 showed in 1971 a higher percentage of Hemicryptophytes than other sites. This is perhaps due to the pattern of the burn—the existence of more small unburned patches of vegetation. This site also has the smallest mean percent of slope which might provide more moisture for perennial survival. Silver Creek had the lowest percentage of Hemicryptophytes in 1971, perhaps reflecting the intensity of the fire on that site. The outstandingly large percentage of Chamaephytes on all sites compared to a normal spectrum is probably accounted for by the sprouting and seedling stages predominating since the fire.

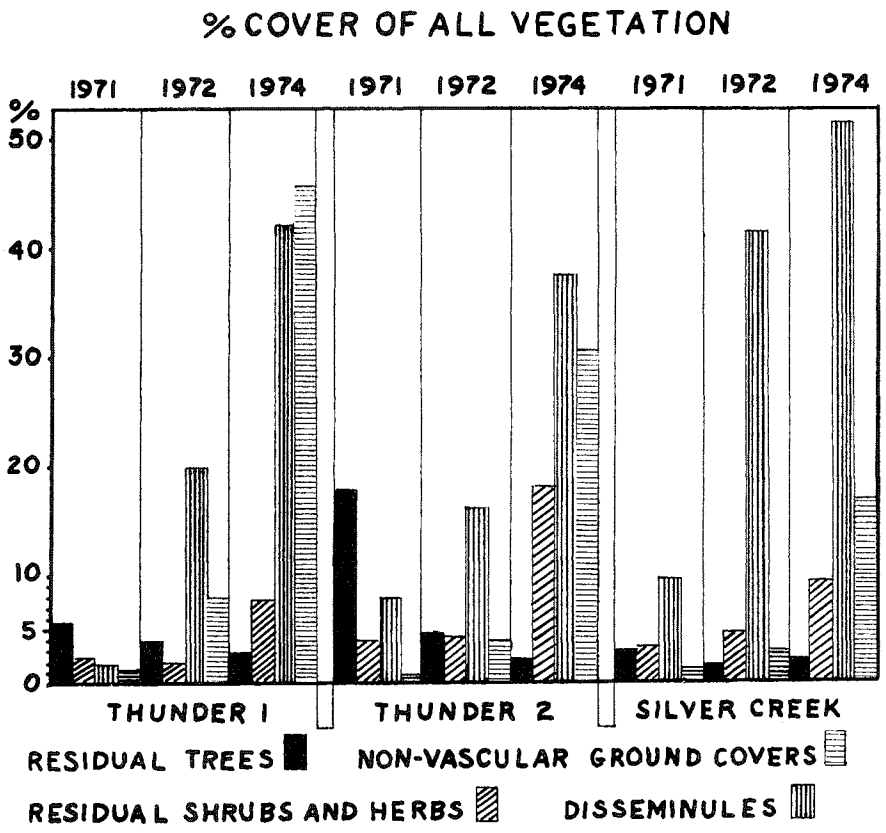

Fig. 1. Percent cover of all vegetation.

TABLE 5. Maximum heights in cm. for selected seedling species by years.

	Sites	1971	1972	1973(SC)	1974
Pseudotsuga menziesii	all	2	16-18	25	40-50
Tsuga heterophylla	all	1.5	7	15-25	25-35
Pinus contorta	SC			15-25	30
Salix lasiandra	all		30-45	125	150-200
Eiplobium angustifolium	all	3	25-100	200	240
Betula papyrifera	SC	5	20		100

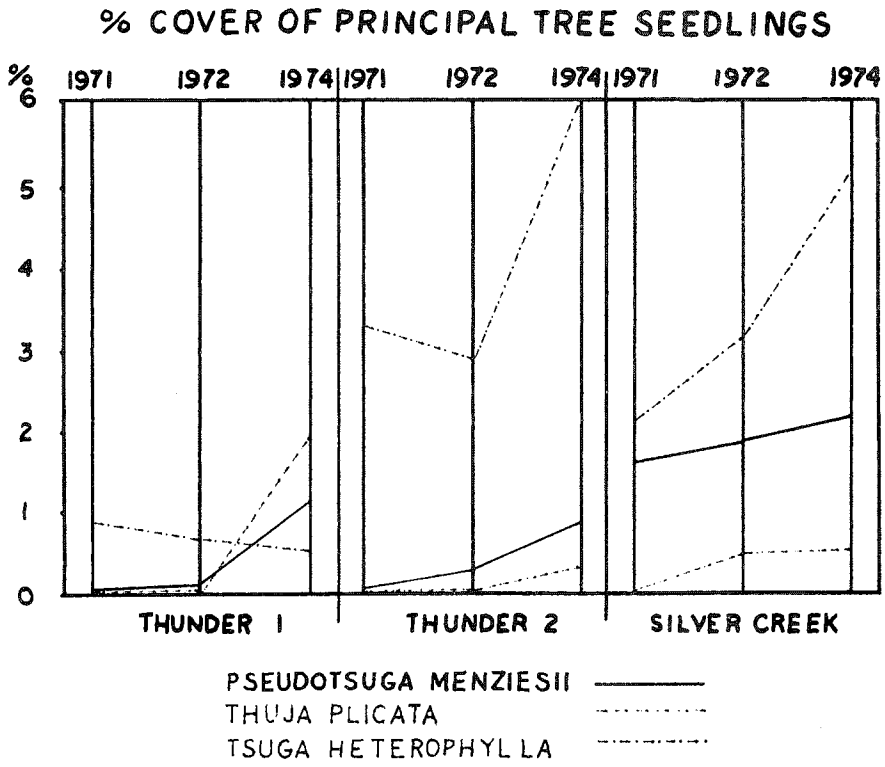

Fig. 2. Percent cover of principal tree seedlings.

Those herb species characteristic of nearby unburned areas but missing from all burn sites since the fires are *Clintonia uniflora, Coralhoriza mertensiana, Goodyera oblongifolia, Listera caurina, L. cordata, Lycopodium spp.,* and *Rubus pedatus.* No shrub species was found to be missing on all three sites. One tree species, *Abies grandis,* is missing from all sites.

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TABLE 6. Life form spectra (Per cent of Total Species).

	1971			1974		
	Th. No. 1	Th. No. 2	S. C.	Th. No. 1	Th. No. 2	S. C.
Phanerophytes	18	22.6	21.4	12.5	12.5	10.2
Chamaephytes	28	45.2	53.6	37.5	52.1	51
Hemicryptophytes	36	25.8	14.3	30.4	25	30.7
Geophytes	12	3.2	7.1	12.5	4.2	6.1
Therophytes	6	3.2	3.6	7.1	6.2	2

	Raunkiaer's normal world spectrum (Daubenmire, 1968)	Representative spectrum for temperate mesophytic forest, evergreen—Olympic Mountains, Washington (Daubenmire, 1968)
Phanerophytes	41	15
Chamaephytes	9	3
Hemicryptophytes	26	43
Geophytes	4	25
Therophytes	13	14

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