PHYTOSOCIOLOGICAL RECONNAISSANCE OF WESTERN REDCEDAR STANDS IN FOUR VALLEYS OF THE NORTH CASCADES NATIONAL PARK COMPLEX

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DECEMBER, 1970

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PHYTOSOCIOLOGICAL RECONNAISSANCE OF WESTERN REDCEDAR STANDS IN FOUR VALLEYS OF THE NORTH CASCADES NATIONAL PARK COMPLEX

Introduction

The proposal by the City of Seattle to raise the height of Ross Dam in its Skagit River hydroelectric complex has brought much opposition from conservation organizations in the Pacific Northwest. The major effect within the state of Washington if the dam were raised by the proposed 122½ feet would be the flooding of the lower 5½ miles of Big Beaver Valley.

Numerous arguments have been advanced for the preservation of the Big Beaver Valley—its scenic qualities, its potential recreational value, its importance as a major trout spawning ground, its value as winter deer range etc. The argument by a prominent Northwest ecologist that the Big Beaver may possibly contain the best remaining example of western redcedar stands suitable for designation as a research natural area has proven particularly controversial. Although no ecological studies had as yet been conducted either of the Big Beaver drainage or of alternate sites within the North Cascades National Park complex, proponents of raising the dam insisted the western redcedar stands in the valley had no claim to uniqueness. They contended that stands of cedar equally suitable for selection as research natural areas were to be found in Big Beaver Valley above the level to be flooded by High Ross Dam as well as in several other drainages in the Park complex.

The writers had some degree of familiarity with Big Beaver Valley, having spent 15 days there in July-August, 1969, making preliminary studies aimed toward an ecosystem survey. At the request of Roger J. Contor, superintendent of North Cascades National Park, they undertook in the summer of 1970 a comparative reconnaissance in the four valleys known to contain sizeable stands of old-growth western redcedar—Big Beaver, Little Beaver, Baker, and Chilliwack.

Limits of Study

Of the four valleys, only Baker can be reached by road. The mouths of Big and Little Beaver can be reached by water transportation on Ross Lake. The lower Chilliwack can be reached either by poor road through Canada to Lake Chilliwack and thence by faint trail or by trail over Hannegan Pass. Because of Canadian fire closures, it was necessary to take the latter approach. The cedar stands in each valley are spread over considerable distances, requiring many trail miles to reach the study areas. Because of the logistical problems and the substantial physical effort involved, the resulting reconnaissance was of necessity somewhat limited. It was largely restricted to an examination of the vascular plant communities within the stands of western redcedar in the various valleys.

It is recognized that a truly rational decision as to which of these areas best meets research natural area criteria cannot be made solely on the basis of data developed in this survey. Comparative studies should also be conducted of the animal communities—micro and macro—within the cedar stands, the microclimatic conditions, the thallophytic and bryophytic plant communities, the soil types, and the aquatic communities in the associated streams, ponds, and bogs. A decision on the fate of Big Beaver Valley will undoubtedly be made before these desirable studies can be carried to completion. It is hoped that the data developed in the course of this survey can contribute in some measure to the soundness of that decision.

The writers were unable to find in the available literature any extensive phytosociological surveys of the western redcedar community.

Daubenmire (1952) listed major associates of Thuja plicata for the Northern Rocky Mountains and Jones (1936) did the same for the Olympic Peninsula. As the North Cascades appear intermediate in many respects between these two areas, the writers' tabulations of vascular plants associated with this rapidly disappearing lowland forest type may be of interest to other investigators.

Basis for Selection of Study Areas within the Four Valleys

The Society of American Foresters, Committee on Forest Types (1954) defines Type 228, Western Redcedar, as a moist site type in which western redcedar or its associate, Alaska-cedar, occurs as a pure stand or makes up at least 80% of the dominant canopy. It is further defined as a climax type occurring on moist slopes and valley bottoms, occupying sheltered sites and, in its coastal form, seldom growing above an elevation of 3,000 feet.

Valuable preliminary aids to the selection of study sites were the forest type maps of Whatcom County, Washington, prepared by the Pacific Northwest Forest and Range Experimental Station of the United States Forest Service. Although the species type designations on these maps refer only to plurality of basal area rather than to the 80% dominance specified in the research natural area definition, the writers found them most useful. With some exceptions, on the ground examination proved the "C4" designation (50% or more western redcedar 21" and larger d.b.h.) to be an accurate description of the stands.

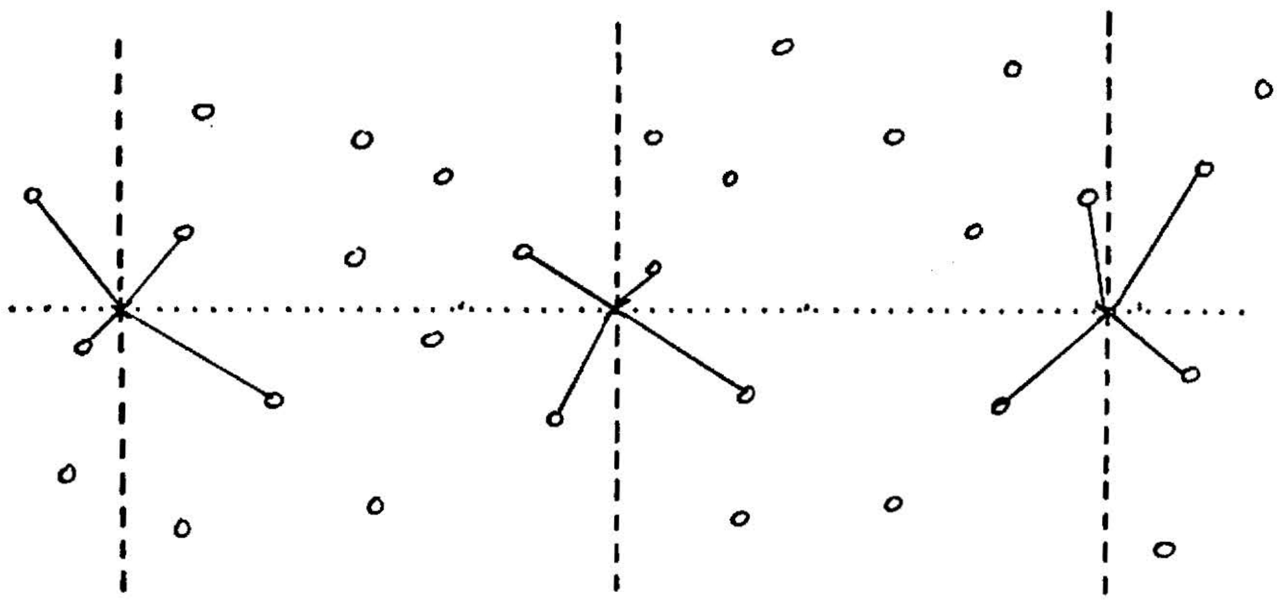
In none of the valleys does western redcedar constitute continuous stands. Rather this type is found in groves or islands, separated by bogs, bodies of water, willow bottoms, avalanche scars, and stands of other forest types—principally western hemlock. Consequently, in each valley visited, a careful visual examination was made of the forested areas in an attempt to pick the best representative examples of western redcedar type for the sites to be sampled. Because the sampling technique used required a stand of at least ¼ mile in cross-section, selection of study sites was sometimes difficult. Such a selection of only a few of the stands raises a question of subjective bias, but the writers made a studied effort to select sites containing the largest and most numerous cedars in each study area. For complete avoidance of subjective bias, it is, of course, desirable to introduce some randomization technique. However, because the cedar stands do occur in clumps, with open spaces or other types between, a completely random selection of the study sites would have resulted in distorted figures of density. The problem of aggregation or clumping in forest populations greatly increases the possibility of variable results. (Curtis & McIntosh, 1950.)

Method of Study

A review of the literature of phytosociological sampling led the writers to choose a spacing distance technique rather than a fixed-area plot method. The greatly dispersed areas to be studied demanded a technique that would be highly efficient in terms of results obtained per man-hour expended.

In sampling through the use of fixed-area plots, only a small portion of the total area is examined, by means of a number of separated subsamples. In each of these, density is computed directly by counting and then expanded to total density per acre or per stand by applying the ratio between sample size and stand size. Instead of beginning with this concept of the number of plants per unit area, it may be more useful to consider the amount of area per plant, the mean area (M) being reciprocal to the density. It becomes possible to use the distance between plants as a measure of abundance when that abundance is expressed as mean area. (Cottam & Curtis, 1956.)

Four standard distance measuring techniques have been used in plant community studies—the closest individual method, the nearest neighbor method, the random pairs method, and the point-centered quarter method. Cottam & Curtis (1956) showed the latter method to give the least variable results, to provide the most data on plant species per sampling point, and to be the least susceptible to subjective bias. The method is a very old one, being an adaptation of the practice used by the early Federal surveyors in establishing the witness trees at the section and quarter-section corners. (Cottam, 1949.)



The above diagram depicts the point-quarter sampling method as adapted by the writers from Cottam & Curtis (1956.) The dotted line represents the paced compass line between points. The area around each point is divided into four 90° quarters (dashed lines,) and the distance measured from the point to the nearest tree in each quarter (solid lines.) As established empirically by Cottam <u>et al</u> (1953) and theoretically by Morisita (1954) the average of the four distances is equal to $\sqrt{M}$, the latter furnishing a direct indication of the spacing of the plants.

In each stand sampled, ten points separated by a compass line of 50 paces were used, thus resulting in a stand cross-section of approximately ¼ mile. Only trees of at least 12" d.b.h. were measured. The following results were obtained from the raw measurement data:

1. Relative frequency (F) by:

$$\frac{\text{Number of points of occurrence of the species}}{\text{Number of points of occurrence of all species}} \times 100$$

2. Relative density (D) by:

$$\frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

3. Relative dominance (DO) by:

$$\frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} \times 100$$

4. Importance value (F+D+DO)

5. Mean distance by adding all the distances in the sample and dividing this figure by the total number of distances.

6. Mean basal area per tree by dividing total basal area by the total number of trees.

7. Density per acre by squaring mean distance and dividing into 43560.

8. Total basal area per acre by multiplying number of trees per acre by the mean basal area per tree.

9. Absolute density per acre for any species by multiplying relative figures for density by total trees per acre.

10. Absolute dominance value per acre for any speciesby multiplying relative figures for dominance by total basal area per acre.

As part of the survey, the nearest shrub in each of the quarters was recorded as to species and its distance from the point measured. Only shrubs at least 12" in height were recorded and measured. Relative frequency and relative density were obtained from the raw measurement data in the same manner as described for the trees. Mean distance and density per acre were also obtained as described above. The presence of herbs in the various stands was determined by recording those species occurring in a meter square quadrat centered on each point.

Nomenclature follows that of Hitchcock et al (1955, 1959, 1961, 1964, 1969.)

Characteristics of Study Areas

The four river valleys surveyed are shown on the map in Figure 1. All are similar in that their streams drain a portion of the Picket Range and empty into lakes, Baker and Ross being artificial impoundments and Chilliwack a large natural lake in British Columbia. The upper Baker River and the Chilliwack River have cut through igneous rocks—Tertiary granite intrusives—while the lower Baker has penetrated Pre-Upper Jurassic metamorphics. Almost the full length of Big Beaver Creek cuts through Pre-Upper Jurassic gneiss, whereas Little Beaver Creek has a more complex structure, consisting of, from west to east: Tertiary granites, Pre-Upper Jurassic gneiss, Tertiary granites again, Pre-Upper Jurassic schists, and Carboniferous-Permian volcanics. (Huntting et al 1961).

All valleys have undergone extensive glaciation and are presently floored with varying amounts of alluvial materials. These materials, consisting of peats, silt, sand, gravel, and glacial deposits, are least extensive in the narrow valley of Little Beaver. A local granitic intrusion in the parent metamorphic rock at the present mouth of Big Beaver has proven resistant to the effects of glaciation and stream action alike. As a result, Big Beaver Creek, before the present Ross Lake was filled, occupied a hanging valley, debouching 300 feet up on the walls of the Skagit Valley.

Baker and Big and Little Beaver drain active glaciers in the Picket Range, and their waters in the summer months contain considerable amounts of rock flour. The Chilliwack, on the other hand, drains a large area of static snow fields, and its waters are completely clear. The Baker is a large, braided stream subject to recurring floods that have prevented the growth of mature forest on most of its valley floor. The lower Big Beaver and the Chilliwack flow through wide, flat valleys, with mature forest occurring to the water's edge. The valleys of the upper Big Beaver and Little Beaver are narrower, with the stream frequently flowing in a slot and the forest occurring on river terraces.

Throughout its range the western redcedar has frequently been intimately associated with the beaver, Castor canadensis. The dam-building habits of this mammal with the subsequent hydrarch succession have oftimes encouraged the growth of western redcedar on otherwise inhospitable sites. All the valleys studied have varying amounts of beaver habitat and evidence of currently occupied as well as abandoned beaver ponds. Lower Big Beaver contains the only evidence of natural ponds not constructed by beaver. These ponds, the largest of which is 15 acres in area (Wolcott, 1961,) appear to be the remnants of a larger lake which formed behind the granite sill at the valley's mouth following the retreat of the valley glacier.

Table 1. specifically locates the study sites by legal description down to quarter-section and furnishes other data regarding elevation, stream gradients, and moisture characteristics of the various habitats. The sites varied from 900 to 2200 feet, all well within the optimum range of western redcedar.

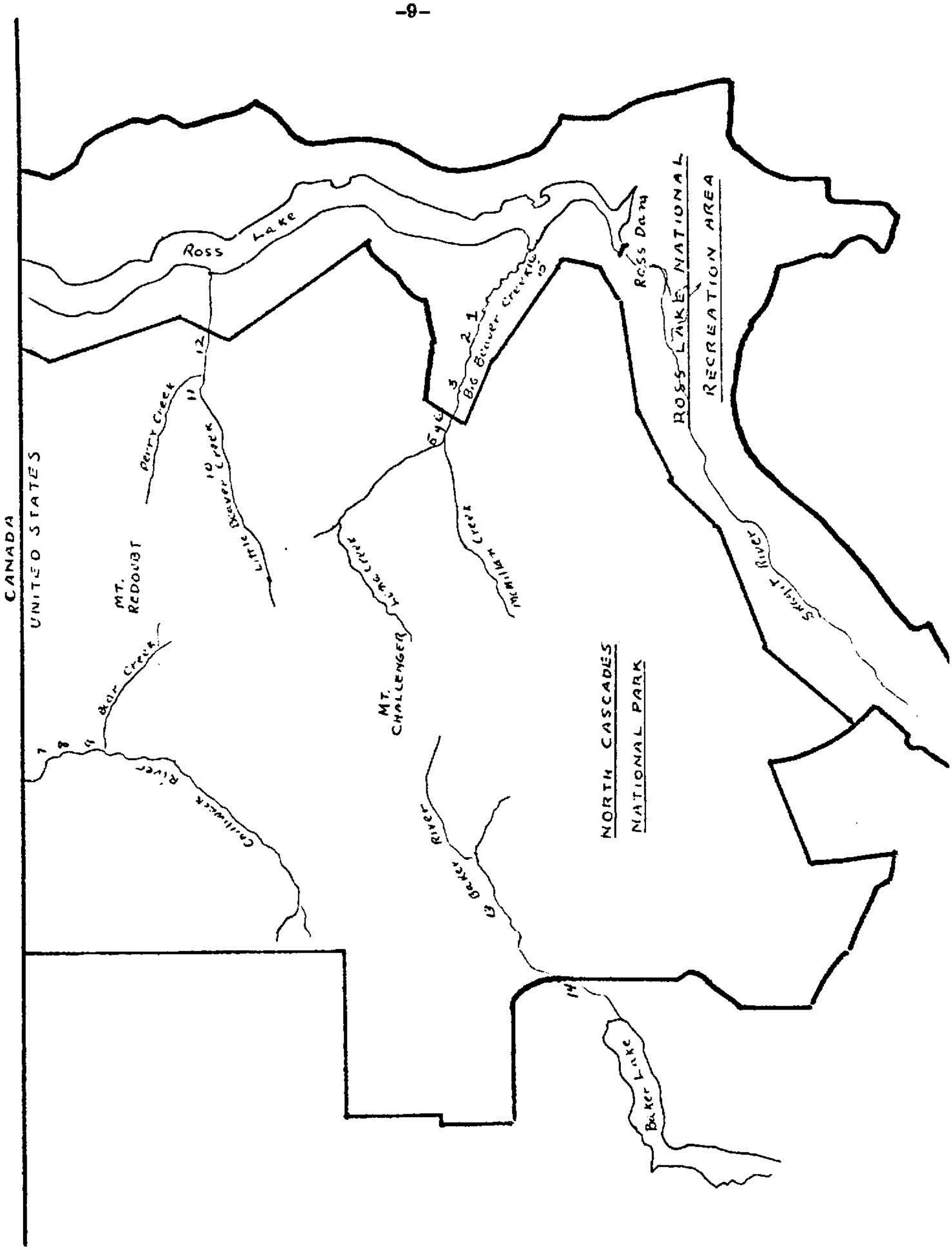


Figure 1. Location of Stations

Table 1. General Data of Stations

GENERAL DATA OF STATIONS

No.	Valley	Location	Elevation	Av. Drop in River	Site Characteristics
1	Lower Big Beaver	SW¼ S4, R13E, T38N	1650	25'/mi.	Valley bottom mesic site
2	"	SW¼ S4, R13E, T38N	1675	"	Valley bottom mesic site
3	"	SW¼ S5, R13E, T38N	1700	"	Valley bottom wet-mesic
4	Upper Big Beaver	NW¼ S6, R13E, T38N	1960	150'/mi.	River terrace mesic to wet-mesic
5	"	NE¼ S1, R12E, T38N	2000	"	River terrace mesic site
6	"	NW¼ S6, R13E, T38N	1850	"	River terrace mesic site
7	Chilliwack	NE¼ S5, R11E, T40N	2140	13'/mi.	Valley bottom mesic to wet-mesic
8	"	NE¼ S5, R11E, T40N NW¼ S4, R11E, T40N	2150	"	Valley bottom mesic site
9	"	SW¼ S4, R11E, T40N NW¼ S9, R11E, T40N	2175	"	River terrace mesic site
10	Little Beaver	NW¼ S36, R12E,T40N	2200	100'/mi.	River terrace mesic site
11	"	SW¼ S29, R13E,T40N	2100	"	Valley bottom wet-mesic
12	"	SW¼ S28, R13E,T40N	2100	"	River terrace mesic site
13	Baker	NE¼ S16, R10E,T38N	1125	40'/mi.	Valley bottom mesic site
14	"	SE¼ S19, R10E,T38N	900	"	Valley terrace mesic to wet-mesic
15	Big Beaver at lake	SW¼S14, R13E, T38N	1650	25'/mi.	River terrace Dry mesic to mesic
16	"	SW¼S14, R13E, T38N	1625	"	"

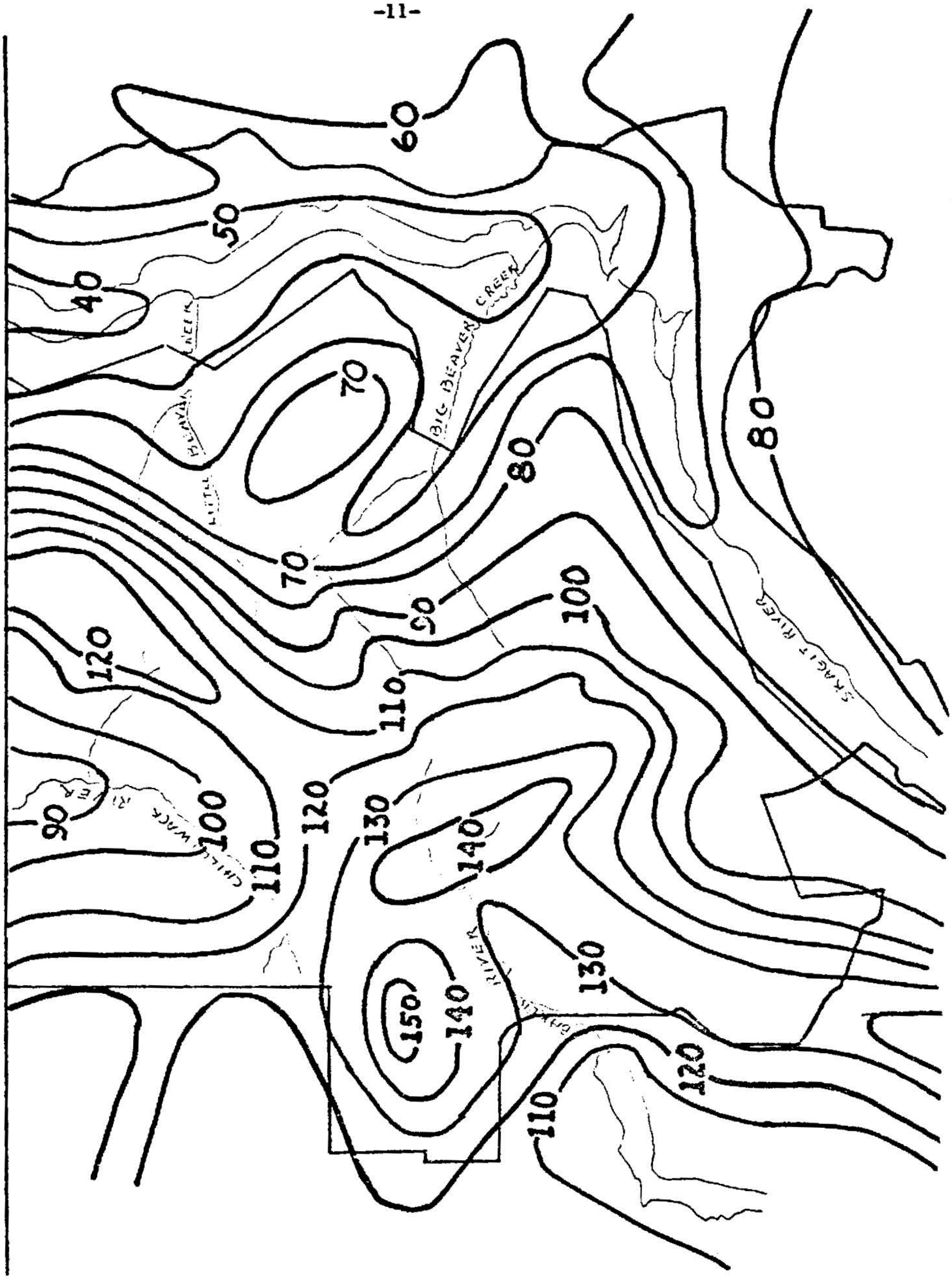


Figure 2. Mean Annual Precipitation

Analysis of Quantitative Data

Tables 2 through 7 depict the composition of the western redcedar forest in the North Cascades west of the crest. These figures tend to indicate that the stands in the Big Beaver Valley below the 1725 foot level are more uniformly composed of redcedar than those in the other study areas. In all other areas western hemlock plays a larger role in the forest community, markedly so in the Chilliwack, where it exceeds redcedar both in frequency and density. The Baker River Valley contains western redcedar trees of the largest average size, but the stands there also contain other major components, particularly hardwoods. Density per acre is fairly uniform in all the stands examined except for the young cedar forest in Big Beaver Valley near Ross Lake, where it is almost double that of any other area.

The phytographs in Figure 3 represent graphically certain important features of the quantitative data as they relate to the dominant tree species—western redcedar and western hemlock. These phytographs are adapted from Oosting (1956) with the substitution of the percentage of trees over 3'd.b.h. in Radius 3 as being more meaningful than percentage of total size classes represented. They demonstrate that the western redcedar stands in the Lower Big Beaver are markedly superior in every measureable aspect to those in any of the other study sites. The phytographs for western hemlock demonstrate the relative importance of this species in the Chilliwack.

As indicated above, the writers measured and recorded only trees of at least 12"d.b.h. This arbitrary cut-off point was chosen to eliminate saplings and young trees, the inclusion of which would tend to distort the picture of a mature forest. Unfortunately, failure to count saplings also makes it difficult to establish that regeneration of major species is occurring. The table below gives the percentage of size classes for western redcedar for all areas examined. Considering the extremely long life span of the western redcedar, it would appear that the lower size classes are sufficiently numerous, even without counting saplings, to indicate that the cedars are maintaining their populations and are not seral.

Percentage of Size Classes of Western Redcedar

	1'through 1' 11"	2'through 2' 11"	3'through 3' 11"	4'through 4' 11"	5' and over
Lower Big Beaver	7.8%	5.8%	9.8%	25.4%	50.9%
Upper Big Beaver	10.0%	11.8%	26.5%	22.0%	29.1%
Chilliwack	6.0%	16.2%	10.2%	18.3%	48.9%
Little Beaver	9.6%	23.3%	26.0%	19.1%	21.9%
Baker	3.3%	6.7%	20.0%	10.0%	60.0%
Big Beaver near Ross Lake	23.5%	53.7%	19.6%	3.9%	0.0%

Tables 8 through 13 depict the shrub component of all areas examined. These show the Chilliwack to possess the densest understory of any of the areas. The young cedar stands in Big Beaver Valley near Ross Lake are characterized by a depauperate understory, perhaps caused less by the drier site than by the much greater density of the trees here than in the other areas.

The presence table in Table 14 lists all vascular plants recorded at 160 points during the reconnaissance. Only the following were recorded as occurring, without exception, in all 16 stands: Thuja plicata, Tsuga *heterophylla*, *Acer circinatum*, *Oplopanax horridum*, *Tiarella unifoliata*, *Athyrium filix-femina*, and *Galium triflorum*. One tree species, western white pine, *Pinus monticola*, was noted as occurring sporadically in all study areas except the Baker River Valley. Because of the randomness of the sampling technique, it was not recorded at any one of the 160 points. Engelmann spruce, *Picea engelmannii*, was noted in only two of the study areas--Little Beaver and Chilliwack. Although a few large specimens were seen in the latter valley, they did not occur as closest trees in any of the point-quarters. The species appears to be at the lowest elevation of its range in the Cascades at these two locations where it was noted (Alexander, 1958).

The bar graphs in Tables 15 through 21 depict more graphically than the tabulations of quantitative data the relative importance of the dominant trees and shrubs. Particularly noteworthy was the importance of *Acer circinatum*, a shrub not previously regarded as a major associate of the western redcedar. The significance of this species is further explored below in the discussion of plant associations. The bar graphs contain data on presence of herbs not contained elsewhere in the report. The figures on percent of presence refer to the number of times each species was noted in the quadrats centered on each point. These figures have also been used to construct the dominant flora discussed below.

Table 2. Quantitative Data, Trees, Big Beaver Valley, below 1725' level

Big Beaver Valley, Old-Growth Western Redcedar Stands 1, 2, 3, Below 1725' Level

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)
Western Redcedar	30	102	2242.33	68.2%	85.0%	96.7%	249.9
Western Hemlock	10	14	56.98	22.7%	11.7%	2.4%	36.8
Douglas-Fir	1	1	10.38	2.3%	0.8%	0.4%	3.5
Grand Fir	1	1	5.12	2.3%	0.8%	0.2%	3.3
Pacific Silver Fir	2	2	4.70	4.5%	1.7%	0.2%	6.4
Totals	44	120	2319.51	100.0%	100.0%	99.9%	299.9

Total Distance = 3171.61 Ft. Trees per Acre = 63.27 Mean Basal Area per Tree = 19.33 Sq. Ft

Mean Distance = 26.43 Ft. Total Basal Area = 2319.51 Sq. Ft. Basal Area per Acre=1221.65 Sq.

For Western Redcedar Mean Basal Area per Tree = 21.98 Sq. Ft.

Absolute Density per Acre = 53.79

Absolute Dominance Value per Acre = 1181.33 Sq. Ft.

271.19 m^2/ha

Big Beaver Valley, Old-Growth Western Redcedar Stands 4, 5, 6, Above 1725' Level

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)	
Western Redcedar	29	68	1263.76	46.8%	56.7%	87.2%	190.7	
Western Hemlock	20	35	82.67	32.3%	29.2%	5.7%	67.2	
Douglas-Fir	6	7	83.32	9.7%	5.8%	5.8%	21.3	
Pacific Silver Fir	7	10	19.78	11.3%	8.3%	1.4%	21.0	
Totals	62	120	1449.53	100.1%	100.0%	100.1%	300.2	

Total Distance = 3110.90 Ft. Trees per Acre = 64.69 Mean Basal Area per Tree = 12.08 Sq. Ft.

Mean Distance = 25.95 Ft. Total Basal Area=1449.53 Sq. Ft. Basal Area per Acre=781.42 Sq. Ft.

For Western Redcedar: Mean Basal Area per Tree = 18.58 Sq. Ft.
Absolute Density per Acre = 37.05
Absolute Dominance Value per Acre = 681.40 Sq. Ft.

Table 3. Quantitative Data, Trees, Big Beaver Valley, above 1725' Level

Table 4. Quantitative Data. Trees, Chilliwack Valley

Chilliwack Valley, Old-Growth Western Redcedar Stands 7, 8, 9

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)
Western Redcedar	25	49	1103.73	39.1%	40.8%	71.9%	151.8
Western Hemlock	27	58	328.70	42.2%	48.3%	21.4%	111.9
Douglas-Fir	1	1	38.20	1.6%	.8%	2.5%	4.9
Pacific Silver Fir	11	12	64.92	17.2%	10.0%	4.2%	31.4
Totals	64	120	1535.55	100.1%	99.9%	100.0%	300.0

Total Distance = 3240.24 Ft. Trees per Acre = 59.75 Mean Basal Area per Tree=12.80 Sq. Ft.
Mean Distance = 27.00 Ft. Total Basal Area=1535.55 Sq. Ft. Basal Area per Acre=764.57 Sq. Ft.

For Western Redcedar: Mean Basal Area per Tree = 22.53 Sq. Ft.
Absolute Density per Acre = 24.38
Absolute Dominance Value per Acre = 549.73 Sq. Ft.

Little Beaver Valley, Old-Growth Western Redcedar Stands 10, 11, 12

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)
Western Redcedar	29	73	984.12	46.0%	60.8%	86.5%	193.3
Western Hemlock	22	32	95.79	34.9%	26.7%	8.4%	70.
Douglas-Fir	4	5	16.58	6.3%	4.2%	1.5%	12.0
Pacific Silver Fir	5	6	14.29	7.9%	5.0%	1.3%	14.2
Engelmann Spruce	3	4	26.53	4.8%	3.3%	2.3%	10.4
Totals	63	120	1137.31	99.9%	100.0%	100.0%	299.9

Total Distance = 2973.66 Ft. Trees per Acre = 70.94 Mean Basal Area per Tree = 9.48 Sq. Ft.
Mean Distance = 24.78 Ft. Total Basal Area=1137.31 Sq. Ft. Basal Area per Acre=672.34 Sq. Ft.

For Western Redcedar: Mean Basal Area per Tree = 13.48 Sq. Ft.
Absolute Density per Acre = 43.13
Absolute Dominance Value per Acre = 581.57 Sq. Ft.

Table 5. Quantitative Data, Trees, Little Beaver Valley

Table 6. Quantitative Dat
Trees, Baker
River Valley

Baker River Valley, Old-Growth Western Redcedar Stands 13, 14

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)
Western Redcedar	17	30	885.87	30.4%	37.5%	84.8%	152.7
Western Hemlock	11	12	53.50	19.6%	15.0%	5.1%	39.7
Douglas-Fir	1	1	3.63	1.8%	1.3%	0.4%	3.5
Pacific Silver Fir	6	6	18.38	10.7%	7.5%	1.8%	20.0
Big Leaf Maple	14	22	52.89	25.0%	27.5%	5.1%	57.6
Red Alder	5	7	16.38	8.9%	8.8%	1.6%	19.3
Black Cottonwood	2	2	14.50	3.6%	2.5%	1.4%	7.5
Totals	56	80	1045.15	100.0%	100.1%	100.2%	300.3

Total Distance = 2444.84 Ft. Trees per Acre = 46.64 Mean Basal Area per Tree= 13.06 Sq. Ft.
Mean Distance = 30.56 Ft. Total Basal Area=1045.15 Sq. Ft. Basal Area per Acre=609.32 Sq. Ft.

For Western Redcedar: Mean Basal Area per Tree = 29.53 Sq. Ft.
Absolute Density per Acre = 17.49
Absolute Dominance Value per Acre = 516.70 Sq. Ft.

Table 7. Quantitative Data, Big Beaver Valley at Lake, Trees

Big Beaver Valley, Young Western Redcedar Stands 15, 16, Near Ross Lake

Species	No. Pts. of Occurrence	No. of Trees	Total Basal Area	Relative Frequency (F)	Relative Density (D)	Relative Dominance (DO)	Importance Value (F+D+DO)
Western Redcedar	17	51	260.72	48.6%	63.8%	57.9%	170.3
Western Hemlock	9	15	71.03	25.7%	18.8%	15.8%	60.3
Douglas-Fir	9	14	118.90	25.7%	17.5%	26.4%	69.6
Totals	35	80	450.65	100.0%	100.1%	100.1%	300.2

Total Distance = 1477.50 Ft. Trees per Acre = 127.69 Mean Basal Area per Tree=5.63 Sq. Ft.
Mean Distance = 18.47 Ft. Total Basal Area=450.65 Sq. Ft. Basal Area per Acre= 719.29 Sq. Ft.

For Western Redcedar: Mean Basal Area per Tree = 5.11 Sq. Ft.
Absolute Density per Acre = 81.92
Absolute Dominance Value per Acre = 416.47 Sq. Ft.

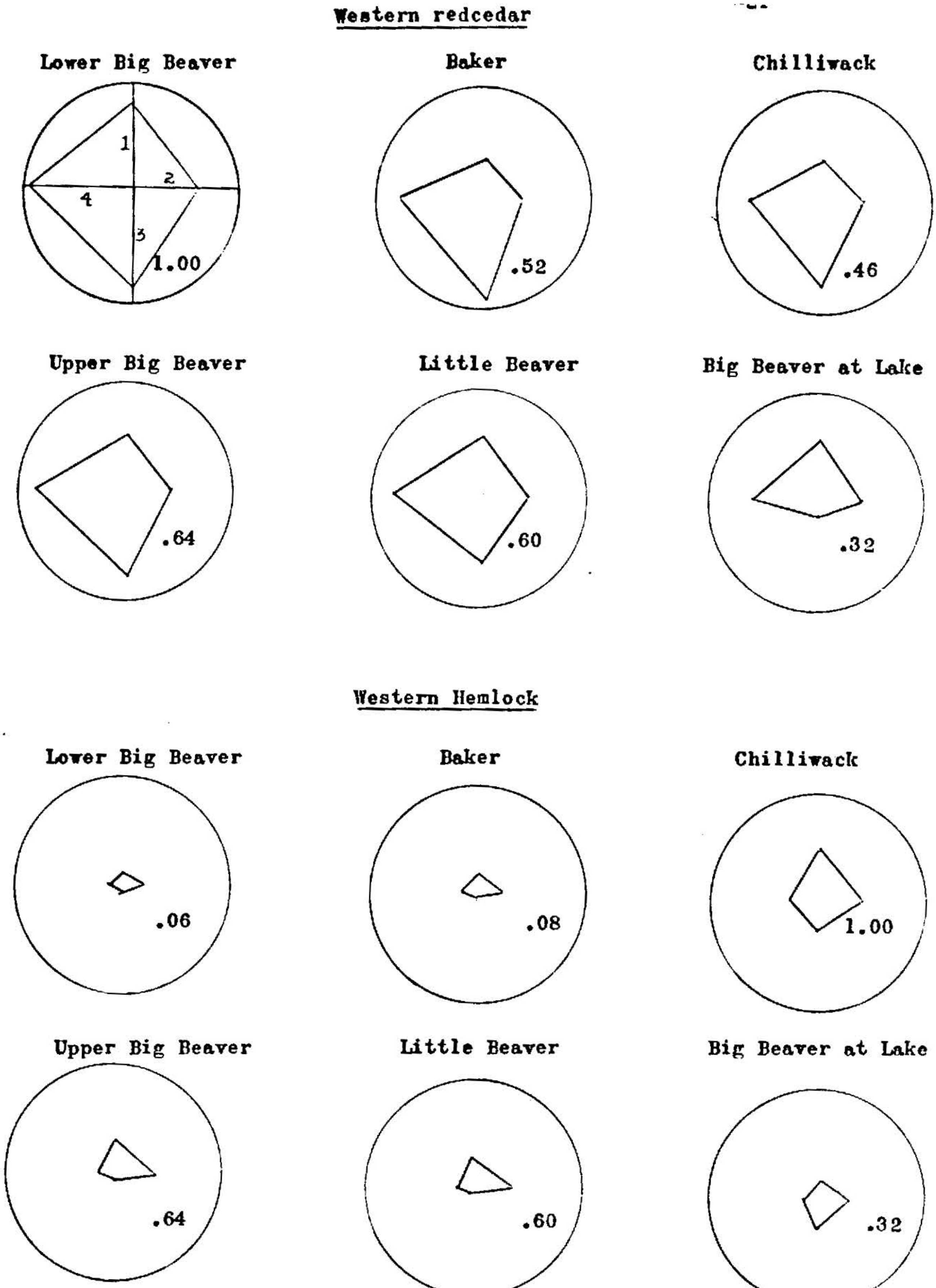


Figure 3. Phytographs of dominant tree species. Radius 1, relative density; Radius 2, relative frequency; Radius 3, percentage of size class (over 3'd.b.h.); Radius 4, relative dominance. Each radius scaled from 0 at center to 100% at circumference. Figures within circles represent relationship of area of phytograph to the largest (value of 1.00.)

Big Beaver Valley, Stands 1, 2, 3, Below 1725' Level

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
<u>Ribes lacustre</u>	5	7	7.8%	5.8%	13.6	31.84
<u>Rubus parviflorus</u>	7	9	10.9%	7.5%	18.4	41.18
<u>Rubus spectabilis</u>	1	1	1.6%	.8%	2.4	4.39
<u>Sorbus sitchensis</u>	1	1	1.6%	.8%	2.4	4.39
<u>Acer circinatum</u>	26	62	40.6%	51.7%	92.3	283.83
<u>Rhamnus purshiana</u>	1	1	1.6%	.8%	2.4	4.39
<u>Oplopanax horridum</u>	19	34	29.7%	28.3%	58.0	155.37
<u>Cornus stolonifera</u>	1	1	1.6%	.8%	2.4	4.39
<u>Menziesia ferruginea</u>	1	1	1.6%	.8%	2.4	4.39
<u>Sambucus racemosa</u>	2	3	3.1%	2.5%	5.6	13.73
Totals	64	120	99.9%	99.8%	199.7	549

Total distance = 1071 Ft. Mean Distance = 8.9 Ft. Shrubs per acre = 549

Table 8. Quantitative Data, Shrubs, Big Beaver Valley below 1725' Level

Big Beaver Valley, Stands 4, 5, 6, above 1725 ' Level

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
Ribes lacustre	1	1	1.6%	.8%	2.4	5.45
Aruncus sylvester	1	2	1.6%	1.7%	3.3	11.58
Rosa gymnocarpa	2	3	3.2%	2.5%	5.7	17.03
Rubus parviflorus	7	19	11.1%	15.8%	26.9	107.60
Rubus spectabilis	1	1	1.6%	.8%	2.4	5.45
Sorbus sitchensis	2	2	3.2%	1.7%	4.9	11.58
Pachystima myrsinites	1	2	1.6%	1.7%	3.3	11.58
Acer circinatum	23	47	37.1%	39.2%	76.3	265.95
Oplopanax horridum	9	18	14.5%	15.0%	29.5	102.15
Vaccinium ovalifolium	11	20	17.7%	16.7%	34.4	113.73
Vaccinium parvifolium	3	4	4.8%	3.3%	8.1	22.47
Sambucus racemosa	1	1	1.6%	.8%	2.4	5.45
Totals	62	120	99.6%	100.0%	199.6	681

Total Distance = 963 Ft. Mean Distance = 8.0Ft. Shrubs per Acre = 681

Table 9. Quantitative Data, Shrubs, Big Beaver Valley above 1725' Level

Table 10. Quantitative Data, Shrubs, Chilliwack Valley

Chilliwack Valley, Stands 7, 8, 9

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
Ribes lacustre	4	5	5.7%	4.2%	9.9	40.74
Rubus parviflorus	4	8	5.7%	6.7%	12.4	64.99
Rubus spectabilis	16	19	22.8%	15.8%	38.6	153.26
Acer circinatum	13	21	18.6%	17.5%	36.1	169.75
Oplopanax horridum	16	36	22.9%	30.0%	52.9	291.00
Cornus stolonifera	1	1	1.4%	.8%	2.2	7.76
Vaccinium membranaceum	2	4	2.9%	3.3%	6.2	32.01
Vaccinium ovalifolium	8	17	11.4%	14.2%	25.6	137.84
Sambucus racemosa	5	8	7.1%	6.6%	13.7	64.02
Viburnum edule	1	1	1.4%	.8%	2.2	7.76
Totals	70	120	99.9%	99.9%	199.8	970

Total Distance 808 Ft. Mean Distance= 6.7 Ft. Shrubs per Acre = 970

Little Beaver Valley, Stands 10, 11, 12

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
Taxus brevifolia	3	5	4.4%	4.2%	8.6	32.09
Corylus cornuta	2	3	2.9%	2.5%	5.4	19.10
Ribes lacustre	3	4	4.4%	3.3%	7.7	25.21
Rubus parviflorus	11	24	16.2%	20.0%	36.2	152.80
Rubus spectabilis	3	3	4.4%	2.5%	6.9	19.10
Sorbus sitchensis	1	1	1.5%	.8%	2.3	6.11
Pachystima myrsinites	8	9	11.8%	7.5%	19.3	57.30
Acer circinatum	20	38	29.4%	31.7%	61.1	242.19
Oplopanax horridum	13	27	19.1%	22.5%	41.6	171.90
Cornus stolonifera	1	1	1.5%	.8%	2.3	6.11
Vaccinium parvifolium	2	4	2.9%	3.3%	6.2	25.21
Sambucus racemosa	1	1	1.5%	.8%	2.3	6.11
Totals	68	120	100.0%	100.1%	200.1	764

Total Distance = 899 Ft. Mean Distance = 7.5 Ft. Shrubs per Acre = 764

Table 11. Quantitat Data, Shrubs, Littl Beaver Valley

Table 12. Quantitative Data
Shrubs, Baker River Valley

Baker River Valley, Stands 13, 14

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
Ribes bracteosum	4	7	8.5%	8.7%	17.2	69.18
Ribes lacustre	1	1	2.1%	1.3%	3.4	10.34
Rubus parviflorus	3	6	6.4%	7.5%	13.9	59.73
Rubus spectabilis	13	24	27.7%	30.0%	57.7	238.50
Acer circinatum	7	10	14.9%	12.5%	27.4	96.38
Oplopanax horridum	6	13	12.8%	16.3%	29.1	129.59
Cornus stolonifera	2	2	4.3%	2.5%	6.8	19.88
Vaccinium ovalifolium	2	3	4.3%	3.8%	8.1	30.21
Sambucus racemosa	9	14	19.1%	17.5%	36.6	139.23
Totals	47	80	100.1%	100.0%	200.1	795

Total Distance = 594 Ft. Mean Distance = 7.4 Ft. Shrubs per Acre = 795

Big Beaver Valley, Stands 15, 16, Near Ross Lake

Shrub Species	No. Pts. of Occurrence	No. of Shrubs	Relative Frequency (F)	Relative Density (D)	Importance Sum (F+D)	Absolute Density per Acre
Taxus brevifolia	12	23	26.1%	28.8%	54.9	48.38
Rosa gymnocarpa	1	1	2.2%	1.3%	3.5	2.18
Acer circinatum	14	30	30.4%	37.5%	67.9	63.00
Oplopanax horridum	6	7	13.0%	8.7%	21.7	14.62
Menziesia ferruginea	3	3	6.5%	3.7%	10.2	6.22
Vaccinium ovalifolium	3	5	6.5%	6.3%	12.8	10.58
Vaccinium parvifolium	7	11	15.2%	13.7%	28.9	23.02
Totals	46	80	99.9%	100.0%	199.9	168

Total Distance = 1288 Ft. Mean Distance = 16.1 Ft. Shrubs per Acre = 168

Table 13. Quantitative Data, Shrubs, Big Beaver Valley at Ross Lake

Presence Table from 16 Western Redcedar Stands

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Trees																
Thuja plicata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tsuga heterophylla	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Abies amabilis	X		X	X	X	X	X	X	X		X		X	X		
Pseudotsuga menziesii		X		X	X	X		X		X		X	X		X	X
Acer macrophyllum													X	X		
Alnus rubra													X	X		
Picea engelmannii										X						
Abies grandis	X															
Shrubs																
Acer circinatum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Oplopanax horridum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rubus parviflorus	X	X	X		X	X	X			X	X	X	X	X		
Rubus spectabilis			X			X	X	X	X		X		X	X		
Vaccinium ovalifolium				X	X	X		X	X				X		X	X
Sambucus racemosa	X	X			X			X	X	X			X	X		
Ribes lacustre	X	X	X	X				X	X	X		X	X			
Sorbus sitchensis		X		X	X					X						
Cornus stolonifera	X						X			X			X			
Vaccinium parvifolium					X							X			X	X
Taxus brevifolia												X			X	X
Pachystima myrsinites							X			X		X				
Menziesia ferruginea			X												X	X
Rosa gymnocarpa					X											X
Corylus cornuta												X				
Ribes bracteosum														X		
Aruncus sylvester					X											
Rhamnus purshiana			X													
Vaccinium membranaceum							X									
Viburnum edule								X								

Table 14. Presence Table

Presence Table from 16 Western Redcedar Stands (Continued)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Herbs																
Tiarella unifoliata	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Athyrium filix-femina	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Galium triflorum	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Clintonia uniflora	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Smilacina stellata	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Osmorhiza chilensis	X	X	X		X	X		X	X	X	X	X	X	X	X	X
Gymnocarpium dryopteris	X	X	X	X		X	X	X	X	X	X			X	X	X
Disporum smithii	X	X	X		X	X	X		X	X		X	X		X	X
Circaea alpina	X	X	X	X	X		X	X	X	X			X	X		X
Asarum caudatum	X	X	X	X		X			X	X	X			X	X	X
Cornus canadensis	X	X			X	X	X	X	X		X	X	X		X	X
Trillium ovatum	X	X	X				X		X	X		X	X		X	X
Geum macrophyllum	X		X		X		X	X		X			X	X		
Viola spp.	X	X	X		X	X				X	X					X
Streptopus roseus	X	X	X		X	X					X	X				
Actaea rubra		X			X			X	X	X	X	X				
Polystichum munitum			X		X				X			X	X		X	X
Linnaea borealis				X	X			X		X		X			X	X
Adiantum pedatum	X		X	X				X						X		
Adenocaulon bicolor	X	X			X	X							X	X		
Dicentra formosa		X	X	X	X				X				X			
Goodyera oblongifolia			X			X						X			X	X
Streptopus amplexicaulis			X	X		X	X									
Montia sibirica			X		X			X					X	X		X
Smilacina racemosa			X		X					X	X	X				
Chimaphila umbellata						X						X			X	X
Pyrola secunda								X	X			X				X
Rubus pedatus	X						X	X	X		X		X			
Tiarella trifoliata		X														
Prunella vulgaris		X												X		
Hieracium albiflorum		X					X									

Table 14. (Continued) Presence Table

Presence Table from 16 Western Redcedar Stands (Continued)

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Herbs, continued																
Arenaria macrophyllum		X														
Fragaria virginiana			X										X			
Thalictrum occidentale			X								X					
Botrychium lanceolatum					X	X										
Chimaphila menziesii						X										
Epilobium watsonii							X							X		
Epilobium angustifolium							X									
Lycopodium clavatum								X								
Streptopus streptopoides								X					X			
Tolmiea menziesii									X				X	X		
Polystichum lonchitis													X			
Ranunculus uncinatus														X		
Stachys cooleyae														X		
Montia parvifolia														X		
Equisetum arvense										X						
Phacelia heteromorpha												X				
Anaphalis margaritacea												X				
Berberis nervosa												X			X	X
Pyrola asarifolia												X				X
Pteridium aquilinum															X	
Arctostaphyllos uva-ursi															X	
Corallorhiza maculata															X	
Trientalis latifolia															X	X

Table 14. (Concluded) Presence Table

Lower Big Beaver Valley, Stands 1, 2, 3 below 1725' Level

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	249.9
Western Hemlock	36.8
Pacific Silver Fir	6.4
Douglas Fir	3.5
Grand Fir	3.3

Shrubs	Importance Sum (F+D) (0–200)
Acer circinatum	92.3
Oplopanax horridum	58.0
Rubus parviflorus	18.4
Ribes lacustre	13.6

Herbs	Percent of Presence (0–100)
Tiarella unifoliata	90.0
Athyrium filix-femina	66.7
Smilacina stellata	66.7
Osmorhiza chilensis	43.3
Galium triflorum	40.0
Asarum caudatum	33.3
Circaea alpina	33.3
Clintonia uniflora	30.0
Trillium ovatum	30.0
Gymnocarpium dryopteris	26.7
Disporum smithii	26.7
Streptopus roseus	23.3

Criteria used in constructing bar graphs:

Trees: all species listed in decreasing order of importance value.

Shrubs: those species listed with an importance sum greater than 10.

Herbs: those species listed with percent of presence greater than 20(higher than Class 1.)

Table 15. Bar Graphs of Principal Species, Stands 1, 2, 3

Upper Big Beaver Valley, Stands 4, 5, 6 above 1725' Level

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	190.7
Western Hemlock	67.2
Douglas Fir	21.3
Pacific Silver Fir	21.0
Shrubs	**Importance Sum (F+D) (0–200)**
Acer circinatum	76.3
Vaccinium ovalifolium	34.4
Oplopanax horridum	29.5
Rubus parviflorus	26.9
Herbs	**Percent of Presence (0–100)**
Tiarella unifoliata	53.3
Clintonia uniflora	53.3
Smilacina stellata	43.3
Galium triflorum	33.3
Gymnocarpium dryopteris	30.0
Cornus canadensis	30.0
Linnaea borealis	30.0
Athyrium filix-femina	26.7
Osmorhiza chilensis	26.7
Circaea alpina	23.3

Table 16. Bar Graphs of Principal Species, Stands 4, 5, 6

Chilliwack Valley, Stands 7, 8, 9

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	151.8
Western Hemlock	111.9
Pacific Silver Fir	31.4
Douglas Fir	4.9
Shrubs	**Importance Sum (F+D) (0–200)**
Oplopanax horridum	52.9
Rubus spectabilis	38.6
Acer circinatum	36.1
Vaccinium ovalifolium	25.6
Sambucus racemosa	13.7
Rubus parviflorus	12.4
Herbs	**Percent of Presence (0–100)**
Tiarella unifoliata	90.0
Gymnocarpium dryopteris	80.0
Athyrium filix-femina	63.3
Circaea alpina	53.3
Smilacina stellata	43.3
Rubus pedatus	33.3
Cornus canadensis	26.7

Table 17. Bar Graphs of Principal Species, Stands 7, 8, 9

Little Beaver Valley, Stand 10, 11, 12

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	193.3
Western Hemlock	70.0
Pacific Silver Fir	14.2
Douglas Fir	12.0
Engelmann Spruce	10.4
Shrubs	**Importance Sum (F+D) (0–200)**
Acer circinatum	61.1
Oplopanax horridum	41.6
Rubus parviflorus	36.2
Pachystima myrsinites	19.3
Herbs	**Percent of Presence (0–100)**
Tiarella unifoliata	76.6
Clintonia uniflora	63.3
Smilacina stellata	46.6
Galium triflorum	36.6
Osmorhiza chilensis	30.0

Table 18. Bar Graphs of Principal Species, Stands 10, 11, 12

Baker River Valley, Stands 13, 14

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	152.7
Big-leaf Maple	57.6
Western Hemlock	39.7
Pacific Silver Fir	20.0
Red Alder	19.3
Black Cottonwood	7.5
Douglas Fir	3.5

Shrubs	Importance Sum (F+D) (0–200)
Rubus spectabilis	57.7
Sambucus racemosa	36.6
Oplopanax horridum	29.1
Acer circinatum	27.4
Ribes bracteosum	17.2

Herbs	Percent of Presence (0–100)
Athyrium filix-femina	65.0
Galium triflorum	60.0
Tolmiea menziesii	50.0
Tiarella unifoliata	45.0
Circaea alpina	45.0
Streptopus streptopoides	35.0
Clintonia uniflora	30.0

Table 19. Bar Graphs of Principal Species, Stands 13, 14

Big Beaver Valley at Ross Lake, Stands 15, 16

Trees	Importance Value (F+D+DO) (0–300)
Western Redcedar	170.3
Douglas Fir	69.6
Western Hemlock	60.3

Shrubs	Importance Sum (F+D) (0–200)
Acer circinatum	67.9
Taxus brevifolia	54.9
Vaccinium parvifolium	28.9
Oplopanax horridum	21.7
Vaccinium ovalifolium	12.8
Menziesia ferruginea	10.2

Herbs	Percent of Presence (0–100)
Tiarella unifoliata	70.0
Clintonia uniflora	65.0
Linnaea borealis	45.0
Athyrium filix-femina	40.0
Disporum smithii	35.0
Trillium ovatum	30.0
Cornus canadensis	25.0
Berberis nervosa	25.0

Table 20. Bar Graphs of Principal Species, Stands 15, 16

Western Redcedar	Importance Value (F+D+DO) (0–300)
Lower Big Beaver	249.9
Upper Big Beaver	190.7
Chilliwack	151.8
Little Beaver	193.3
Baker	152.7
Big Beaver at Ross Lake	170.3
Western Hemlock	
Lower Big Beaver	36.8
Upper Big Beaver	67.2
Chilliwack	111.9
Little Beaver	70.0
Baker	39.7
Big Beaver at Ross Lake	60.3
Pacific Silver Fir	
Lower Big Beaver	6.4
Upper Big Beaver	21.0
Chilliwack	31.4
Little Beaver	14.2
Baker	20.0
Big Beaver at Ross Lake	0
Douglas Fir	
Lower Big Beaver	3.5
Upper Big Beaver	21.3
Chilliwack	4.9
Little Beaver	12.0
Baker	3.5
Big Beaver at Ross Lake	69.6

Table 21. Bar Graphs of Principal Tree Species, All Areas

Vegetative Associations

With the exception of the young redcedar stands in stations 15 and 16, in all sites examined western redcedar represents an edaphic climax. Barring fire or other catastrophe, in these young stands, also, western redcedar will eventually replace the older and less tolerant douglas-fir and achieve a climax shared with the subordinate western hemlock. All areas examined lie in what has been termed the western hemlock-western redcedar type group by Scott (1962) or the western hemlock vegetative zone by Franklin (1966). These two authors have differed somewhat on the successional relationship of western redcedar. Scott has considered the species, because of its shade tolerance, to be climax wherever it occurs. Franklin found western redcedar to be seral on most sites and only climax on sites with ample soil moisture during the summer months. By either definition, the cedar stands described in Tables 2 through 6 appear to represent a climax, whether climatic or edaphic.

Daubenmire (1952) in his vegetative studies of the Northern Rocky Mountains of Idaho described three associations or climax communities in which western redcedar played a major role. He termed these the Thuja-Tsuga/Oplopanax, the Thuja/Pachystima, and the Thuja-Tsuga/Pachystima associations. In the North Cascades Pachystima myrsinites occurs generally on more xeric sites than those under consideration in this paper. It is a common associate of the lodgepole pine (Pinus contorta) stands around the shores of Ross Lake, but it constituted only 11 of the 640 shrubs tabulated in the survey of the cedar stands. It appears that cedar associations in which Pachystima is a dominant are not characteristic of at least that portion of the North Cascades lying west of the crest.

Daubenmire's Thuja-Tsuga/Oplopanax association had as its most outstanding characteristic a union dominated by Oplopanax horridum with the second most conspicuous member of the union Athyrium filix-femina. Other herb members of this union with a high degree of constancy were Galium triflorum, Smilacina stellata, Gymnocarpium dryopteris, Adenocaulon bicolor, Tiarella unifoliata, and Viola glabella.

Franklin and Dyrness (1969) describe a wet-mesic to hydric community typified by Thuja-Tsuga/Oplopanax with dominant herbs including Athyrium filix-femina, Blechnum spicant, Vaccinium spp., Gymnocarpium dryopteris, Dryopteris austriaca, Trautvetteria caroliniensis, Anemone deltoidea, Viola glabella, Streptopus spp., Smilacina spp., Tiarella trifoliata, and Achlys triphylla.

The sites draining to Ross Lake have a mean annual precipitation of 45-60 inches as compared with 90 inches in the Chilliwack and 120-130 inches in the Baker River Valley. While the moisture gradients in Big and Little Beaver Valleys are at least the equivalent of those in Daubenmire's Northern Idaho study sites and in many lowland valleys of Western Washington, the vegetative tabulations made by the present writers indicate a drier community than the two described above. The most significant of the dominant shrubs occurring in these sites in Big and Little Beaver Valleys is Acer circinatum, a species found by Franklin and Dyrness (1969) to constitute, along with Berberis nervosa, a character species for mesic sites. It is probable that the superior drainage afforded by the glacial deposits in these valleys rather than any moisture deficiency accounts for the dominance of Acer circinatum.

On the basis of the consistency shown in the vegetative tabulations for the Big and Little Beaver Valleys, the writers would hypothesize a Thuja/Acer association. This association has a characteristic union dominated by Acer circinatum with Tiarella unifoliata being the next most conspicuous member. Oplopanax horridum is a common shrub, although secondary to the Acer, and Rubus parviflorus also has a high degree of constancy. The other dominant herbs are Clintonia uniflora, Smilacina stellata, Athyrium filix-femina, Galium triflorum, Osmorhiza chilensis, Gymnocarpium dryopteris and Disporum smithii.

The areas examined in the Chilliwack appear significantly similar to Daubenmire's Thuja-Tsuga/Oplopanax association, although Tiarella unifoliata and Gymnocarpium dryopteris are somewhat more conspicuous than Athyrium filix-femina. The small cedar stands examined in the Baker River Valley are somewhat atypical in that they include substantial numbers of hardwoods and had as their commonest shrub component Rubus spectabilis. Further study would be required to determine whether these differences are attributable to the much greater precipitation or to soil depths and composition. Of all the valleys examined, only the Baker had the superficial appearance of "rain forest."

Statistical Correlation

It was felt desirable to make a statistical comparison of the vegetative communities in the Thuja/Acer association described above in order to determine the differences and similarities of the various sites. The Index of Similarity of Mountford (1962) was used where:

$$I\,(A:B) = \frac{j}{2(a)(b)-(a+b)j}$$

j = number of species found in both sites

a = number found at site A

b = number found at site B

Sites with identical species lists would result in an index of 1.0. Sites with no common species would provide an index of .0. Only dominant species occurring in the various sites were included in the calculations, excluding randomly occurring or accidental species. The following indices of similarity appeared:

Lower Big Beaver to Upper Big Beaver	= .118
Lower Big Beaver to Little Beaver	= .108
Lower Big Beaver to Big Beaver near Ross Lake	= .048
Upper Big Beaver to Little Beaver	= .200
Upper Big Beaver to Big Beaver near Ross Lake	= .097

Another approach was taken by comparing the herb communities in more detail for differences and similarities. The eight herbs listed above as dominants for the *Thuja/Acer* association were compared for each of the sites containing this association. The following formula for Rank Correlation Coefficient was used:

$$R = 1 - \frac{6\Sigma D^2}{N(N^2 - 1)}$$

ΣD^2 = the sum of the squares of the differences in ranks

N = the number of species ranked

A positive figure represents a higher degree of correlation than a negative figure. Absolute correlation would be + 1. The following Rank Correlation Coefficients were found:

Lower Big Beaver	= +.26
Upper Big Beaver	= −.93
Little Beaver	= −.25
Big Beaver near Ross Lake	= −5.48

The radically negative correlation of the stands in Big Beaver near Ross Lake is caused by the extreme scarcity of three species--*Smilacina stellata*, *Galium triflorum*, and *Gymnocarpium dryopteris*--in this younger and denser forest.

Suitability of Study Areas as Research Natural Areas

An admittedly arbitrary figure of 500 acres has been suggested by Franklin and Trappe (1968) as the minimum size for research natural areas of the major western coniferous forest types. However, these investigators point out that larger areas of 1000—5000 or more acres can include more age classes, stand types, habitats, and transitions between major types. Of the four valleys examined, only the Baker fails to disclose sufficiently large stands of western redcedar to permit the establishment of a contiguous natural area of from 1000—5000 acres including at least 500 acres of cedar type. While this valley contains many magnificent single trees and isolated small groves of western redcedar, the largest stand found did not exceed 80 acres in extent. The only substantial areas of western redcedar type in the Baker River drainage are downstream from the upper end of Baker Lake and have already been disturbed by roads and timber harvest.

All valleys investigated meet the additional criterion of reasonable accessibility. The writers would consider a day's travel time from the Puget Sound metropolitan centers by car, boat, and foot to be a reasonable measure of accessibility for research scientists. All areas qualify on this basis. Each of the four valleys is also traversed by an excellent trail suitable for use by pack stock should it be necessary to transport heavy or bulky equipment needed in research activities.

Concern has been expressed by one of the investigators employed by Seattle City Light that the potential recreational impact on Big Beaver Valley will render it unsuitable as a research natural area (Dowdle, 1970). An unnecessarily purist view of the nature and purpose of research natural areas would, of course, rule out the establishment of any western redcedar research areas in the North Cascades National Park complex.

As indicated above, all substantial stands of western redcedar occur in valleys that are traversed by trails and all will receive inevitably increasing amounts of visitation by foot travelers in the years to come.

It is precisely because most of the western redcedar type in the Pacific Northwest has already been disturbed by timber cutting and roadbuilding that the search has narrowed down to the North Cascades National Park complex where these activities have not taken place. A representative of the Forest Service Research Natural Area Committee has advised the writers that what is acceptable for a cedar natural area may depend more on what is available than on what might be desirable, provided species composition is correct, disturbance by man is not excessive, and size of the area is reasonable (David Tackle, personal communication).

Almost no recreational visitors to Big Beaver Valley leave the trail. Big Beaver Creek is closed to fishing, and the Park Service, through the use of fire permits, has been able to localize camping at the site of the Tenmile Shelter. The nature of the understory (Acer circinatum-Oplopanax horridum community) and the abundant biting insect life do not encourage off-trail travel. Even a many-fold increase in visitor use of the Big Beaver Valley, together with the essential establishment of an interpretive nature trail would not, in the opinion of the writers, render the Valley unsuitable as a research natural area. Recreational impact on the western redcedar stands north of the stream would be minimal and on those very substantial stands south of the stream it would be non-existent.

Both Big and Little Beaver Valleys appear to meet the final criterion of proper species composition for a western redcedar natural area. The Chilliwack, however, appears transitional between western hemlock and western redcedar. The sampling conducted by the writers would tend to indicate that this valley contains primarily Type 227, Western Hemlock-Western Redcedar rather than Type 228, Western Redcedar. This essentially climax type is defined as forest composed of western redcedar and western hemlock in which either species may predominatebut neither may make up over 80 percent of the dominant canopy.

As previously indicated, the configuration of Little Beaver Valley is such that the stands of western redcedar occur in narrow stringers along river terraces and steep valley slopes. The Forest Type Map for this area shows these narrow stands to be contiguous, but the writers' work in the valley disclosed the stands to be discontinuous and separated by other forest types, principally western hemlock. In other aspects, as well, the Little Beaver Valley lacks some of the attributes of an ideal western redcedar natural area. Thuja plicata, throughout its range, occurs on a wide variety of soils. The principal edaphic factor governing its optimum development is an abundance of soil moisture (Boyd, 1959). An understanding of the development of this species under competitive stress would not be possible unless it were to be studied in an area containing a mosaic of habitats including bogs, ponds, and hydric Carex-Salix zones. Because of its narrow valley floor and the rapid fall of its stream, Little Beaver Valley does not contain the abundance of aquatic communities essential to a western redcedar natural area.

The Big Beaver Valley, of the four valleys examined, appears ideally suited for the variety of studies that might be carried on in a western redcedar natural area. It is necessary to examine the contention by proponents of raising the reservoir level that this action would leave sufficient western redcedar type above the 1725 foot contour line for the establishment of an adequate cedar natural area. Different figures have been advanced as to the amount of western redcedar type that would be lost to flooding. These vary from 65 to 80% of the cedar in Big Beaver Valley and from 12 to 19% of the cedar type in the entire North Cascades National Park complex. These estimates appear to have been derived largely from an examination of the Forest Type Maps and aerial photographs. While the present writers have made no attempt to compute the area of cedar type to be lost, they would point out that the area of young western redcedar, mixed with douglas fir and western hemlock, in their study sites 15 and 16 would also be flooded. This substantial area of approximately 200 acres has not been included in the above estimates, since it is classified on the Forest Type Map as predominately an area of old-growth douglas fir.

It appears obvious, also, that isolated pockets of redcedar type left above the reservoir level on the north and south valley walls would be useless for inclusion in a natural area. While they would not have to be logged, the fact that they would be immediately adjacent to the fluctuating reservoir would surely compromise any studies that might be carried out in their confines.

Much has been made by proponents of High Ross Dam of the fact that larger individual trees were found above the 1725 foot level than below. It is doubtful that all cedar trees in the valley have yet been measured, and in any event, a redcedar natural area cannot be hypothesized around a few individual trees. On the basis of individual tree size and average basal area alone, the writers found the cedars in the Baker River Valley to exceed those in all other areas examined. The Baker River Valley is nevertheless unsuitable for a redcedar natural area because the remaining stands of this type cover too small an area and are too isolated from each other.

Western redcedar type continues for approximately one mile up the Big Beaver Valley from the 1725 foot level to the confluence of McMillan Creek. The Forest Type Map indicates the existence of a small patch of western redcedar up McMillan Creek, but this grove is too inaccessible for inclusion in a research area and was not considered by the writers. The cedar type in the upper Big Beaver Valley covers approximately 300 acres and primarily occupies river terraces or valley side-walls. This portion of the valley is narrower than that part downstream, the stream has a rapid rate of fall (150 foot/mile,) and for most of its course flows in a narrow slot. The plant communities of this area have a closer index of similarity to those in Little Beaver than to those downstream. It would seem reasonable to predict that the existence of a fluctuating reservoir adjoining these cedar stands would alter the microclimate sufficiently to render the area no longer "natural." The construction of boat docks and campgrounds on "Big Beaver Arm" together with the resulting increased human impact would undoubtedly alter the area significantly. The fine redcedar stands above the 1725 foot level differ materially from those downstream and would complement the latter in a cedar natural area. They are not extensive enough to comprise a viable natural area by themselves should the lower valley be flooded.

Summary

The reconnaisance was carried out in the summer of 1970. The areas examined were the principal western redcedar stands in the four valleys of the North Cascades National Park complex where this species has its optimum development. The purpose of the study was two-fold: to compare the remaining western redcedar stands to determine which area was most suitable for designation as a research natural area, and to examine the vascular

plant communities associated with this forest type.

The sampling technique used for the trees and shrubs was the point-centered quarter method of Cottam and Curtis. The presence of herbs was tabulated through the use of meter-square quadrats centered on the sampling points.

Of the 16 sites examined, 14 had substantial populations of large old-growth western redcedar. The remaining sites were characterized by a dense young western redcedar forest with subordinate numbers of western hemlock and large relict douglas-fir. Material differences were found to exist between the western redcedar stands in the two valleys with higher precipitation, the Baker and the Chilliwack, and the two valleys draining to Ross Lake, Big and Little Beaver. The latter sites were found to contain a characteristic association of western redcedar and vine maple (Acer circinatum) with Tiarella unifoliata being the most constant herb.

The sites in the Big Beaver Valley below the 1725 foot level were found to contain the most extensive stands of western redcedar, and the species was found to have the highest relative frequency, density, and dominance in these sites. This area was also found to have the highest incidence of similarity to the typical herb flora of the Thuja/Acer association.

In applying the criteria for research natural areas, the stands in the Big Beaver Valley below 1725 feet were found to be best suited for protection and designation as a western redcedar research natural area.

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Figure 1. Location of study areas and mean annual precipitation

Map by Noel McGary, Department of Oceanography, University of Washington