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Notes on the vegetation zones of western Canada, with special reference to the forests of Wells Gray Park, British Columbia

LEENA HÄMET-AHTI

Department of Botany, University of Helsinki

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I. Introduction

The forest communities recognized in this paper represent *forest site types* in the sense of Cajander (e.g. 1926, 1949) and Kalela (e.g. 1954, 1960), as well as Kujala (1945), who, however, also treated some seral stands as independent types. The forest site type system, originally presented by Cajander (op.cit., etc.) and developed by Finnish botanists and foresters, seems to be frequently misunderstood by foreign workers because some of the theoretical points concern the local use of the system rather than its more universal application. In practice, however, this system *is not* such a purely floristic or phytocoenotic classification as is generally believed (e.g. Krajina 1960, p. 51), but has a very strong *ecological background*. In Finland, the ecological requirements of the common forest (and peatland) species are well known – unfortunately most of the relevant publications are in Finnish – and the classification is actually based on these requirements, and not so much on the presence or abundance of the species. Recently Kalela (1960, etc.) has improved this classification with regard to the zonal distribution of forest site types. So in principle this system is close to what Krajina (1960) in his excellent account regarded as ideal. But it is not ready for universal use; for instance, we do not know the best way to name these types. Moreover, their grouping into higher units has not been performed adequately, and, although we do not need such a complicated hierarchy as the Zürich – Montpellier school uses, a certain degree of additional classification is necessary. In the French-Swiss system the Finnish forest site types are usually known either as *subassociations* or climatic *variants*. However, the seral, subclimax and climax stages

of same forest type may even be referred to different associations and the other higher units. I have avoided giving any Latinized or otherwise more exact names to these forest types, because my experience of the sociological value of the component species outside my study area is not sufficient. In general, such names cannot be of more than provisional significance until properly collected sample plot material is available from large areas in northwestern North America.

The results are chiefly based on a sample plot method. In the description of the tree layer, sample plots 1000 sq. m in area (radius 17.9 m) were used. They were chosen in large homogeneous forests, at least one square kilometre in area. In each plot the tree species and their percentages of the total number of stems, their crown canopy (as percentages), age and (ocularly estimated) height were recorded. The other layers of the vegetation were sampled in plots 100 sq. m in size. The covers of the bush, field and ground layers are also indicated as percentages. In addition, the epiphytic macrolichens (above the basal parts of the stems) were identified, and the altitude (with a barometer), slope and exposure of each sample plot were determined. In many cases, measurements or observations were also made on the thickness of the humus and of the leached horizon of the underlying soil.

The relevees in Table 3 have been arranged according to the following criteria:

1. Their zonal distribution: from the lower oroboreal up to the orohemiarctic zone.

2. The age of the tree layer: first climax and subclimax forests and then seral stands. In this paper, the term subclimax is applied to all forests having more or less the same species in field and ground layers as climax forests, though the climax trees are not dominant. So in the study area only *Pinus contorta* var. *latifolia*, *Populus tremuloides* and *Salix scouleriana* form real seral stands.

3. The ecological characters indicated by the species and their abundance: from moist to dry and from eutrophic (rich in nutrients) to oligotrophic (poor in nutrients).

The differences between the zones distinguished are most easily found by comparing this kind of material. However, a much larger body of data than mine will be necessary before more definite conclusions are warranted, even in the Wells Gray Park area.

In addition to the Wells Gray Park area, I was able to make observations during travels from Vancouver to Wells Gray Park, on Vancouver Island and in Oregon and Washington.

II. General description of the Wells Gray Park area

Situation. Wells Gray Provincial Park is situated in the Cariboo Mountains, in east-central British Columbia, the southern portion being at approximately lat. 52° N, and long. 120° W. The lowest elevation in the area is about 600 m and the timber-line is at about 2 000 m.

Bedrock. There is no detailed map of the bedrock, but from the outcrops it may be concluded that it consists largely of schistose rocks. In the Hemp Creek valley the soil is clearly calcareous. In the areas covered by forests the bedrock mostly lies under thick, fine or coarse sandy till or sometimes under gravel.

Climate. Climatically, Wells Gray Park belongs to the so-called Interior Wet Belt. Very little detailed information is available concerning the climate. At Hemp Creek, meteorological observations have been made since the year 1952, and the stations of Blue River and Vavenby are also situated near the park (cf. MACKIE 1963, HÄMET-AHTI 1965). In most parts of the park the precipitation is probably similar to that at Blue River; the valley of Hemp Creek is in the driest portion of the park. Further, the temperature in the other parts of the park is obviously lower than at Hemp Creek, which is near the boundary between the Interior Wet Belt and the Dry Belt. This feature is also revealed by the distribution of many vascular plants (HÄMET-AHTI 1965).

Age of forests. Several forests in Wells Gray Park are very old, but in many places there are signs of lightning fires and young second-growth forests are also fairly common. The largest recent forest fire occurred in 1926, when about 200 sq. miles of forested land was denuded in the southern portion of the park (EDWARDS 1954). In general, the forests near the timber-line are better preserved than those in the valleys. There are no extensively cut areas within the park.

III. Bioclimatic or life zones distinguished in western North American mountain areas

In studies on the zonation of the vegetation in the western North American mountain areas there are two main types of division. One unites altitudinal zonation with latitudinal, the other keeps them separated.

The first comprehensive studies of the life zones in North America were made by MERRIAM (1894, 1898, 1899, etc.). His well-known division from north to south and from east to west is of the following kind:

Region	Zone	Area
Boreal	Arctic and alpine Hudsonian Canadian	
Austral	Transition	Alleghenian Arid transition Humid transition
	Upper Austral	Carolinian Upper Sonoran
	Lower Austral	Austroriparian Lower Sonoran
Tropical		Humid Arid

These latitudinal zones are also used in mountain areas. MERRIAM (1899) himself applied his system thoroughly in the Mt. Shasta area of California.

In western North America this system of Merriam's has been used by several botanists, especially those studying the distribution of plants. PIPER (1906) applied it to Washington, SMILEY (1915) to the Lake Tahoe region, California, STANDLEY (1921) to the Glacier National Park, Montana, ST. JOHN (1937) to southeastern Washington and Idaho, TAYLOR (1922) and BROCKMAN (1938) to the Mt. Rainier National Park, Washington, ABRAMS (1923 and later) to California, MCAVOY (1931) to the Bella Coola region, British Columbia, BAILEY (1936) to Oregon, JONES (1936) to Olympic Peninsula, Washington, NELSON (1953) to the Rocky Mountain National Park, Colorado, SCOTT (1962 a) to Washington and Oregon, etc. SLIPP and SNELL (1944) have used this system in taxonomic and ecological studies of mushrooms in northern Idaho and adjacent Washington.

There are some differences in the delimitation of MERRIAM's units as practised by different authors, especially as regards the Hudsonian and Canadian zones. Some authors consider the Hudsonian zone to be only the ecotone between the real forests and the forestless alpine zone (e.g. STANDLEY 1921, BAILEY 1936, ST. JOHN 1937, BROCKMAN 1938), whilst others have united with it the upper parts of the continuous forests as well. In eastern Washington and Oregon the Canadian zone has been split by SCOTT (1962 a) into two subzones, a lower and an upper (cf. p. 295), but it is generally undivided.

In papers concerning the western mountain areas most other North American authors, especially in recent years, have kept the altitudinal zones apart from the latitudinal ones and given different names to the mountain forest zones. WEAVER and CLEMENTS (1938) put the western mountain forests under the names subalpine and montane forests, while the central and eastern Canadian lowland forests are included in the boreal forest. HALLIDAY (1937) and ROWE (1959) also separated their Columbian, montane and subalpine forest »regions» from the boreal forest »region». HARE (1954) divided the whole climatic zone of the boreal forests into three subzones, but, likewise, did not include the real mountain forests in these, separating them as subalpine forests. Moreover, SJÖRS (1963), who compared the zonation of vegetation in Europe and North America, distinguished the coniferous forests of the Rocky Mountains and other ranges from the boreal zone, though regarding them as related. Recently, in a Soviet atlas, the taiga and other vegetation zones commonly distinguished in the U.S.S.R. (e.g. LAVRENKO and SOCHAVA 1954) were also presented for North America, in more detail than probably ever before. Unfortunately, however, not all the taiga zones mapped by LUKICHEVA (1964) for northern Russia seem to correspond directly to those mapped by SEMENOVA-TYAN-SHANSKAYA (1964) for North America, there having been some confusion in interpreting the southern and middle taigas (see Table 1).

Many botanists have classified the vegetation in the western mountains of North America without any reference to latitudinal zonation at all. For the Rocky Mountains RYDBERG (1916, 1917) distinguished alpine, subalpine, montane and submontane zones. DAUBENMIRE (1942, 1943, 1952) applied the names *Picea engelman-*

Table 1. The vegetation zones (or subzones) distinguished by AHTI (1964) in Ontario, Canada, by HARE (1959) in eastern Canada, by SEMENOVA-TYAN-SHANSKAYA (1964) in Canada and by LUKICHEVA (1964) in Northern Russia and their true correspondence according to the present author.

Ontario (AHTI 1964)	Eastern Canada (HARE 1959)	Canada (SEMENOVA-TYAN-SHANSKAYA 1964)	Northern Russia (LUKICHEVA 1964)
– – southern arctic tundra	tundra	arctic desert grass tundra heath tundra	tundra
hemiarctic	forest tundra	forest tundra and northern taiga	forest tundra
northern boreal	woodland		northern taiga
middle boreal		middle taiga	
southern boreal	forest (subzone)	southern taiga	middle taiga
hemiboreal			southern taiga

nii – *Abies lasiocarpa* zone, *Thuja plicata* – *Tsuga heterophylla* zone, *Pseudotsuga taxifolia* var. *glauca* zone and *Pinus ponderosa* zone. SPILSBURY and TISDALE (1944) divided the interior parts of British Columbia into upper subalpine, subalpine, montane, and upper, middle and lower grassland zones. KUJALA (1945, pp. 393 – 402) also very tentatively placed the localities visited by him in British Columbia in climatic regions corresponding to some areas in Europe. In F.C.T.N.A. (1954) western North America has been divided into the regions »northern Interior, high elevations in the mountains, middle elevations in the Interior, north Pacific, low elevations in the Interior, and south Pacific except for high mountains». In British Columbia KRA-

Table 2. KRAJINA's (1964) biogeoclimatic divisions for British Columbia.

Region	Zone	Subzones
I. Pacific coastal mesothermal forest region	1. Coastal western hemlock zone	Douglas fir – western hemlock (drier subzone)
		Pacific silver fir – western hemlock (wetter subzone)
	2. Coastal Douglas fir zone	Garry oak – Douglas fir (drier subzone)
		Madrono – Douglas fir (wetter subzone)
II. Pacific coastal subalpine forest region	3. Mountain hemlock zone	Subalpine forest (lower subzone)
		Subalpine parkland (upper subzone)
III. Canadian Cordilleran forest region	4. Interior western hemlock zone	Western larch (drier subzone)
		Western hemlock (wetter subzone)
	5. Interior Douglas fir zone	Pinegrass (drier subzone)
		False boxwood (wetter subzone)
	6. Cariboo aspen – lodgepole pine Douglas fir parkland zone	–
IV. Cordilleran cold steppe and savanna forest region	7. Ponderosa pine – bunchgrass zone	Bunchgrass (drier subzone)
		Ponderosa pine (wetter subzone)
V. Canadian Cordilleran subalpine forest region	8. Engelmann spruce – subalpine fir zone	–
VI. Canadian boreal forest region	9. Subboreal spruce zone	–
	10. Boreal white and black spruce zone	–
	11. Peace River aspen – white spruce zone	–
VII. Alpine tundra region	12. Alpine zone	Coastal alpine subzone
		Interior alpine subzone

JINA (1959, 1964) distinguished seven 'biogeoclimatic regions' and 12 zones, each of which has climatic plant associations of its own (Table 2).

The correspondence of some of the systems suggested by different authors in western North America has been studied by DAUBENMIRE (1946) and HÄMET-AHTI (1965). It is not a very easy task, because often no accurate descriptions of the vegetation are available, and in some papers the plant lists presented can only give a very rough idea of the author's meaning.

IV. The »zone-section system» and its application to the forest vegetation of Wells Gray Park

It is quite apparent and also frequently stated that the vegetation zonation in several mountain areas is very similar to the zonation in the lowlands of the same or adjacent latitudes. Therefore a zonal system and nomenclature that would combine the corresponding altitudinal and latitudinal units under the same heading are both warranted and necessary. However, great floristic dissimilarities, even in the dominant plants, caused by historical vicissitudes, often prevent direct recognition of the correspondence between regions. When all the plant communities and species, particularly bryophytes, lichens and mushrooms, besides climatic and life-form criteria, are taken into account, the situation becomes less complicated.

Such a division has recently been provisionally outlined in Finland (AHTI et al. 1964, JALAS 1965) and is based on many papers published by authors from various parts of Europe, including the Soviet Union. In that attempt a number of latitudinal vegetation zones are distinguished. The same zones are also recognized in mountains as altitudinal zones (belts), but then they may be provided with the affix *oro-* (in Greek *oros* = mountain), if desirable. So we have from north to south and from peak to valley the following arctic and boreal zones:

arctic zones	oroarctic zones
hemiarctic zone	orohemiarctic zone
northern boreal zone	upper oroboreal zone
middle boreal zone	middle oroboreal zone
southern boreal zone	lower oroboreal zone
hemiboreal zone	orohemiboreal zone
(boreomeridional zones	oroboreomeridional zones)

Many investigators have divided the arctic zone group into three (e.g. POLUNIN 1951) or four (e.g. LAVRENKO and SOCHAVA 1954) zones – and this has also been done in some oroarctic (»alpine») areas (e.g. DU RIETZ 1930 pp. 355–358; REISIGL and PITSCHMANN 1958). The same is true of the boreomeridional (temperate) zones; there are at least three of them. But we are not concerned with these zones in the present paper.

In boreal and arctic areas both the latitudinal and altitudinal zones are essentially determined by the amount of heat during the growing seasons. The degree of continentality is not the same in different parts of each zone. For this reason the zones have been divided into *sections*, characterized by climatic variants or parallel forest site types of their own. The same idea is to be found in MERRIAM's system. He divided his transition zone, for instance, into three »areas». LIVINGSTONE and SHREVE's (1921) »two-dimensional climatic provinces», HALLIDAY's (1937) and ROWE's (1959) forest sections, KRAJINA's (1959, 1964) »biogeoclimatic regions and zones» of British Columbia, etc., are based on essentially the same principle. In the Soviet Union similar methods have been used on a large scale (e.g. SHENNIKOV 1940, LAVRENKO 1947, SOCHAVA 1952).

In ecological comparisons of different areas, in classification of vegetation, in presenting distribution of vegetation and plant species, etc., this procedure is obviously better, for instance, than distinguishing forest cover types according to the dominant tree species (F.C.T.N.A. 1954) or the French-Swiss vegetation classification, which emphasizes the importance of floristic similarity and which often unites ecologically dissimilar vegetation on account of its range. For example, the alliance Gaultherio-Piceetalia (cf. BRAUN–BLANQUET et al. 1939), which belongs to the class Vaccinio-Piceetea, has a very different composition according to its latitudinal (altitudinal) distribution. Ecologically it has hardly any meaning at all. The areas where this class occurs in Europe, Asia and North America, are not necessarily comparable as regards their different features (climate, etc.).

Likewise, in F.C.T.N.A. (1954) the »Aspen type», for example, occurs over very heterogeneous areas from the Arctic Circle in Alaska to Mexico.

The 'zone-section system' that I am using has been applied to Northwestern Europe (Ahti et al. 1964, Jalas 1965) and to arctic and boreal Ontario (Ahti 1964). These papers contain more detailed, though still preliminary, accounts of it, along with some comparisons with other systems.

In Wells Gray Provincial Park there occur the lower oroboreal, middle oroboreal, upper oroboreal, orohemiarctic and (lower) oroarctic zones. The zonal vegetation consists of coniferous forests, except in the orohemiarctic zone, which is partly grassland, and the oroarctic zone, which is naturally treeless.

Very little information has been available concerning the forest vegetation of the Wells Gray Park area: Hartman (1957) briefly described some forests for purposes of game management and Kujala (1945) published some relevees along the railway on the east side of the park. In my earlier paper on the flora of the park (Hämet-Ahti 1965), the abundance and zonal distribution of the vascular plants are indicated. Ahti (1962) also briefly discussed the vegetation zones and habitat classification in the park and especially the epiphytic macrolichens.

1. Lower oroboreal zone

This altitudinal counterpart of the southern boreal zone was studied in Wells Gray Park in the valleys of Hemp Creek, Murtle River, Clearwater Lake, Clearwater River, Azure Lake and outside the park at Blue River, up to about 900 m (3 000 feet). The bottom of the Clearwater Canyon may belong to the hemiboreal zone, but I have no observations from there.

This zone has two sections in the study area: one is relatively dry and is only found in the valley of Hemp Creek; the other is more humid and consists of all the remaining parts of this zone. The forest vegetation of these two sections is rather dissimilar, because in the Hemp Creek valley the soil is apparently more calcareous, accentuating the differences.

A. Dry section

a. Climax and subclimax forests

Mesic and mesotrophic sites (sample plots 1 – 5). *Thuja plicata* is dominant, sometimes with *Picea engelmannii* (partly *Picea glauca* and *P. glauca* × *P. engelmannii*). Common but sparse additional species are *Pseudotsuga menziesii* var. *glauca*, *Tsuga heterophylla*, *Betula papyrifera* var. *commutata*, and *Acer glabrum* var. *douglasii*.

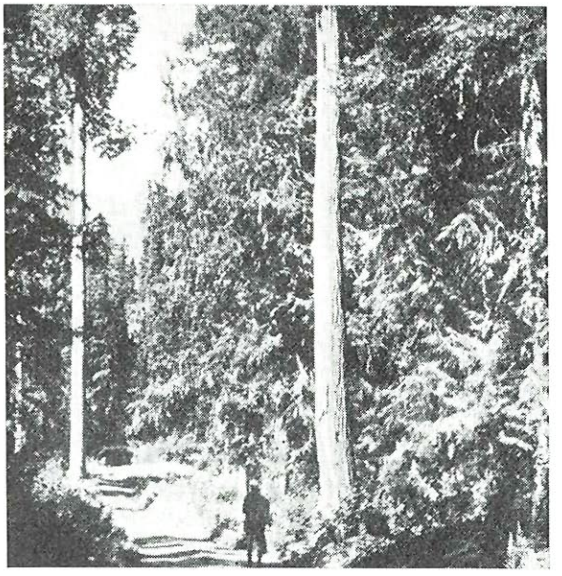

Fig. 1. Lower oroboreal forest on mesic and mesotrophic site on the Clearwater Lake Road, c. 2 mi. NW of Hemp Creek. *Thuja plicata* is dominant. The large trees on the roadside are *Populus trichocarpa*.

The bush layer is always well developed: *Thuja plicata* and *Acer glabrum* var. *douglasii* are abundant, *Ribes lacustre*, *Rubus parviflorus*, *Sorbus sitchensis*, *Spiraea betulifolia* var. *lucida*, and *Rosa gymnocarpa* frequent.

In the field layer *Aralia nudicaulis*, *Clintonia uniflora*, *Cornus canadensis*, *Pachystima myrsinites*, and *Tiarella unifoliata* are constant. Often *Goodyera oblongifolia*, *Linnaea borealis* ssp. *americana*, *Orthilia secunda*, and *Smilacina amplexicaulis* are also found.

In the ground layer *Rhytidiadelphus triquetrus* is common and abundant; *Ptilium crista-castrensis* and *Mnium drummondii* are common but often sparse.

The soil is fine-sand till. The leached horizon is thin but very clear, the humus layer 5 – 20 cm thick.

The related vegetation has been described by Ilvessalo (1929) under the name »*Pachystima – Coptis* Type» from northern Idaho, by Larsen (1930) under the name »mesophytic transition forest» from eastern Washington and Idaho, by Kujala (1945) under the name »*Tiarella – Pachystima* Typ» from Blue River and Barriere,

Table 3. Vegetation analyses from the Wells Gray Park area.

	Lower oroboreal																				
	Dry section													Humid section							
Sample plot no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
» » field no.	*1*	*35*	*36*	*37*	*38*	*34*	*33*	*4*	*2*	*3*	*51*	*52*	*53*	*30*	*39*	*40*	*31*	*32*	*28*	*7*	*19*	*20*
Altitude m	610 – 790													670 – 790								
Slope	3°	3°	2°	–	3°	–	2°	–	10°	10°	15°	3°	5°	2°	–	5°	–	–	3°	3°	7°	12°
Exposure	E	SE	E	–	N	–	E	–	W	E	E	N	N	S	–	N	–	–	N	NW	E	S
Humus	5	20	20	17	18	5	5	3	+	1	–	–	–	5	30	>10	2	1	?	5	20	8
Height of dominant trees m	30	24	26	25	30	18	15	20	8	8	12	12	10	16	14	12	12	16	26	28	30	28
Age	150	130	250	300	?	140	60	60	30	30	30	30	30	320	230	250	160	60	?	150	250	150
Cover of all the trees	80	70	60	70	70	70	50	40	30	30	30	90	90	60	50	50	70	50	30	40	80	50
Abies lasiocarpa	+	–	10	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	10	50	5	10
Picea engelmannii	–	20	20	20	20	10	–	–	–	–	–	–	–	–	–	–	–	–	60	50	15	10
Picea engelmannii × *glauca*	60	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pinus contorta	–	–	–	–	–	1	100	70	–	–	–	–	–	–	–	–	–	100	–	–	–	–
P. monticola	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	10	–	–	–	–	–
Pseudotsuga menziesii v. *glauca*	–	2	2	10	–	50	–	20	–	+	+	+	40	–	+	–	10	–	–	–	–	–
Thuja plicata	40	70	60	70	70	20	–	–	–	–	–	10	+	–	+	–	–	–	30	1	80	80
Tsuga heterophylla	+	1	5	–	–	5	–	–	–	–	–	–	–	100	100	100	80	–	–	–	–	–
Acer glabrum v. *douglasii*	–	1	1	–	+	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–
Alnus crispa ssp. *sinuata*	–	–	–	+	–	–	–	–	–	–	–	–	10	–	–	–	–	–	–	–	–	–
A. tenuifolia	–	–	–	–	–	–	–	–	–	–	–	30	–	–	–	–	–	–	–	–	–	–
Betula papyrifera v. *commutata*	+	2	1	–	+	10	+	+	10	40	10	10	40	–	–	–	+	–	–	–	+	–
Populus tremuloides	–	–	–	–	–	–	+	5	90	20	60	–	–	–	–	–	–	–	–	–	–	–
P. trichocarpa	–	1	–	–	10	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–
Salix scouleriana	–	–	–	–	–	–	–	–	–	40	30	50	10	–	–	–	–	–	–	–	–	–
Abies lasiocarpa	–	–	1	½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	1
Acer glabrum v. *douglasii*	+	¼	–	2	2	¼	+	+	–	½	3	+	1	–	–	–	–	–	–	–	–	–
Alnus crispa ssp. *sinuata*	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Amelanchier alnifolia coll.	2	–	–	–	–	–	–	½	–	3	5	–	–	–	–	–	–	½	–	–	–	–
Betula papyrifera v. *commutata*	–	–	–	–	–	–	–	+	–	–	½	–	–	–	–	–	–	–	–	–	+	–
Cornus stolonifera s. lat.	–	1	–	+	1	–	–	–	–	+	+	3	–	–	–	–	–	–	–	–	–	–
Corylus cf. *cornuta*	20	–	–	3	½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lonicera involucrata	–	2	1	+	–	–	–	1	¼	+	+	10	–	–	–	–	–	–	–	1	–	–
Menziesia ferruginea v. *ferruginea*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	10	2	1
M. f. v. *glabella*	1	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–
Oplopanax horridum	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–	–	90	30	10	3
Picea engelmannii	–	–	–	½	–	+	–	–	–	–	–	–	1	–	–	–	–	+	–	–	–	¼
P. glauca (+ × *engelmannii*)	–	–	–	–	–	–	–	1	+	–	–	–	–	–	–	–	–	–	–	–	–	–
Pinus contorta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20	–	–	–	–
Populus tremuloides	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
P. trichocarpa	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Prunus pensylvanica	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–
Pseudotsuga menziesii v. *glauca*	+	–	–	–	–	1	–	+	–	–	1	–	2	–	–	–	–	–	–	–	–	–
Rhododendron albiflorum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	5	–	½
Ribes lacustre	+	7	+	+	1	–	–	–	–	–	–	–	–	–	–	–	–	–	½	1	½	½
R. oxyacanthoides	–	–	–	–	–	–	–	–	–	+	+	½	–	–	–	–	–	–	–	–	–	–
Rosa gymnocarpa	–	+	–	½	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R. nutkana s. lat.	–	–	–	–	–	–	+	+	–	1	2	–	–	–	–	–	–	–	–	–	–	–
Rubus idaeus ssp. *sachalinensis*	+	–	–	–	–	–	–	–	+	+	–	¼	–	–	–	–	–	–	–	+	–	–
R. parviflorus	15	1	–	2	20	–	¼	–	50	30	30	5	10	–	–	–	–	–	5	1	–	–
Salix scouleriana	–	–	–	–	–	–	–	–	–	+	–	–	3	–	–	–	–	–	–	–	–	–
Shepherdia canadensis	–	–	–	–	–	–	15	15	10	20	20	–	10	–	–	–	–	–	–	–	–	–
Sorbus sitchensis	¼	+	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	1	–	–
Spiraea betulifolia v. *lucida*	1	¼	1	+	2	+	3	½	–	¼	1	30	–	–	–	–	1	–	–	–	–	–
Thuja plicata	10	½	1	1	–	3	7	–	–	–	–	10	20	15	3	2	2	–	+	¼	3	30
Tsuga heterophylla	2	–	–	1	–	–	–	–	–	–	–	–	–	5	1	1	1	–	–	–	1	–
Viburnum trilobum	–	3	¼	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Gaultheria hispidula	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–
Linnaea borealis ssp. *americana*	20	7	30	¼	–	20	1	30	–	–	½	5	15	1	½	1	–	+	–	–	–	–
Lycopodium annotinum	2	1	–	½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Mahonia aquifolium	+	+	–	¼	–	+	1	+	¼	1	2	½	–	–	–	–	–	–	–	–	–	–
Pachystima myrsinites	25	5	2	25	5	10	50	70	5	10	5	2	25	+	–	–	–	–	–	–	–	–
Phyllodoce empetriformis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vaccinium caespitosum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–
V. membranaceum	½	–	–	–	–	+	2	3	–	–	–	–	–	20	1	5	+	–	10	3	3	½
V. myrtilloides	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	–	–	7	30	–	–	–	–
V. ovalifolium	–	–	–	–	–	–	–	–	–	–	–	–	–	+	25	7	–	–	2	15	¼	3
Actaea arguta	–	¼	–	+	1	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
Anemone occidentalis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Antennaria howellii	–	–	–	–	–	–	–	–	2	1	½	–	–	–	–	–	–	–	–	–	–	–
Aralia nudicaulis	5	20	2	2	5	–	¼	5	1	10	10	5	–	–	–	–	–	–	–	–	–	–
Arnica latifolia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Aster ciliolatus	–	–	–	–	–	–	–	–	20	10	¼	–	–	–	–	–	–	–	–	–	–	–
A. conspicuus	–	–	–	+	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–
Athyrium filix-femina v. *sitchense*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1	–
Botrychium virginianum v. *europaeum*	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Calamagrostis canadensis	–	–	–	–	–	–	–	–	–	–	½	–	–	–	–	–	–	–	–	+	–	–
Carex spectabilis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Chimaphila umbellata ssp. *occidentalis*	–	1	–	–	+	15	3	5	–	–	¼	+	½	7	7	3	–	+	–	–	–	–
Clintonia uniflora	7	¼	10	5	+	–	–	–	–	–	–	3	+	+	2	–	–	–	+	–	7	10
Cornus canadensis	10	–	10	3	10	–	2	30	1	½	7	30	–	20	10	5	–	2	+	15	5	5

Middle oroboreal																					Upper oro-boreal		Orohemiarctic							
23 *16*	24 *13*	25 *18*	26 *25*	27 *26*	28 *27*	29 *5*	30 *6*	31 *23*	32 *22*	33 *21*	34 *15*	35 *12*	36 *29*	37 *10*	38 *11*	39 *14*	40 *17*	41 *24*	42 *8*	43 *9*	44 *50*	45 *47*	46 *48*	47 *49*	48 *45*	49 *46*	50 *42*	51 *43*	52 *44*	53 *41*
1050 – 1140																					1440 – 1580		1730 – 1760 m							
7°	5°	–	1°	1°	–	–	3°	–	–	15°	3°	5°	3°	5°	3°	5°	–	3°	–	12°	7°	2°	4°	7°	3°	4°	3°	3°	–	3°
SW	S	–	SW	SW	–	–	S	–	–	E	?	SW	S	SE	S	?	–	N	–	S	S	NW	W	W	E	S	S	E	–	E
5	5	7	16	8	5	3	1	7	6	25	4	3	11	5	2	12	2	5	1	2	5	5	4	4	2	4	3	5	2	2
26	25	25	30	30	24	24	24	24	20	18	18	25	?	24	26	22	12	12	14	14	20	24	23	19	13	13	16	15	12	16
120	100	200	150	150	250	100	100	100	100	80	60	100	200	100	120	60	60	80	60	60	250	280	250	210	160	200	140	140	130	240
70	60	30	50	70	30	50	40	40	30	95	70	60	50	70	40	80	60	90	60	70	40	50	30	30	40	40	50	40	50	20
40	40	10	30	30	50	7	50	50	60	10	+	40	40	20	20	30	+	80	–	+	90	60	80	90	90	100	95	90	100	90
40	15	90	30	50	50	90	50	50	40	5	–	15	50	50	50	–	100	5	10	5	10	40	20	10	10	1	5	10	1	10
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–	+	–	–	–	–	–	–	+	–	–	–	+	10	10	10	–	–	+	90	95	–	–	–	–	–	–	–	–	–	–
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20	30	–	40	20	–	3	+	–	–	15	20	30	+	–	5	5	–	15	–	–	–	–	–	–	–	–	–	–	–	–
+	+	–	–	+	–	–	–	–	+	70	80	+	–	+	10	60	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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–	1	–	–	–	20	15	2	7	2	–	–	1	2	2	1	–	5	–	30	1	½	–	–	–	–	–	–	–	–	–
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–	+	–	–	–	–	+	+	–	3	–	–	–	–	½	1	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–
5	10	–	10	5	–	2	–	1	–	–	5	40	–	–	–	+	10	1	–	–	–	–	–	–	–	–	–	–	–	–
3	1	–	–	–	–	–	–	–	–	–	10	½	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	½	10	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–
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7	3	–	2	3	–	5	5	–	15	–	3	20	7	1	10	–	–	1	2	1	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	¼	–	–	–	–	–	–	–	–	1	–	½	1	–	–	–	–	–	–	–	–	–	–
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+	¼	–	–	–	–	–	3	7	1	–	–	4	–	10	10	¼	–	–	–	50	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	½	5
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	–	–	–	¼
5	1	1	¼	¼	10	5	15	20	30	–	+	2	3	2	30	+	–	–	¼	5	1	30	3	–	¼	–	2	–	1	10
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–	–	2	3	2	15	1	1	1	–	2	–	–	–	–	–	–	+	–	–	–	–	1	–	–	–	–	–	–	–	–
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15	20	–	7	1	¼	5	1	10	7	1	10	3	15	–	1	½	–	10	–	–	1	–	–	–	–	–	–	–	–	–
30	10	2	5	3	7	20	10	7	20	3	7	20	15	10	30	½	5	7	1	30	–	–	–	–	–	–	–	–	–	–

Sample plot no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Disporum hookeri v. *oreganum*	1	2	3	4	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	+
Dryopteris »dilatata»	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	10	15	¼
Epilobium angustifolium	–	–	–	–	–	–	–	½	1	1	1	–	1	–	–	–	–	–	–	–	–	–
Galium triflorum	+	¼	+	–	+	–	–	–	+	+	+	½	–	–	–	–	–	–	+	–	–	–
Goodyera oblongifolia	4	+	¼	+	+	3	½	+	–	–	–	+	1	–	+	–	–	–	–	–	–	–
Gymnocarpium dryopteris	1	–	+	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	20	40	60	40
Habenaria unalascensis	–	–	–	–	–	–	–	–	–	+	+	–	–	–	+	–	–	–	–	–	–	–
Lathyrus ochroleucus	–	–	¼	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Lilium columbianum	+	–	–	–	–	–	+	+	½	+	½	–	–	–	–	–	–	+	–	–	–	–
Listera cordata v. *cordata*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
L. c. v. *nephrophylla*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Luzula parviflora	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Melampyrum lineare	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	½	–	–	–	–
Mitella breweri	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. nuda	5	1	–	1	+	–	–	–	–	–	–	¼	–	–	–	–	–	–	–	–	–	–
Moneses uniflora	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Orthilia secunda	+	+	¼	+	½	¼	–	3	–	–	¼	1	–	–	+	–	–	–	–	–	–	¼
Oryzopsis asperifolia	+	–	–	–	–	–	–	2	+	2	1	–	–	–	–	–	–	–	–	–	–	–
O. pungens	–	–	–	–	–	+	¼	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–
Osmorhiza chilensis	–	+	1	+	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–
Pedicularis bracteosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Poa palustris	–	–	–	–	–	–	–	–	½	+	+	–	–	–	–	–	–	–	–	–	–	–
P. pratensis coll.	–	–	–	–	–	–	–	–	+	½	+	–	–	–	–	–	–	–	–	–	–	–
Pyrola chlorantha	–	–	–	–	–	+	+	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rubus pedatus	–	–	–	–	–	–	–	–	–	–	–	–	–	2	5	–	–	–	3	5	3	3
R. pubescens	–	1	–	½	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Smilacina amplexicaulis	3	+	¼	1	¼	–	+	–	–	–	+	2	+	–	–	–	–	–	–	–	–	–
S. stellata	–	–	–	–	¼	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	–	–	–
Streptopus amplexifolius	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	¼	1
S. roseus	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	10	3	1
Taraxacum ssp.	–	–	–	–	–	–	–	–	+	+	+	+	–	–	–	–	–	–	–	–	–	–
Tiarella unifoliata	½	½	5	+	+	–	–	–	–	–	–	–	–	–	1	–	–	–	10	10	15	7
Trifolium pratense	–	–	–	–	–	–	–	–	¼	+	–	–	–	–	–	–	–	–	–	–	–	–
T. repens	–	–	–	–	–	–	–	–	+	+	¼	–	–	–	–	–	–	–	–	–	–	–
Vahlodea atropurpurea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Valeriana sitchensis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–
Veratrum viride	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	2	–	–
Viola renifolia v. *brainerdii*	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
V. r. v. *renifolia*	+	–	–	¼	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–
Barbilophozia lycopodioides	–	–	–	–	–	+	–	–	–	–	–	–	–	+	–	3	–	–	–	1	–	–
Brachythecium campestre	+	–	–	+	–	¼	+	3	–	–	2	1	5	–	–	–	–	–	–	–	–	–
B. curtum	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B. erythrorhizon	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–
B. hylotapetum	+	–	–	+	–	+	+	–	–	–	–	1	–	–	–	–	–	–	10	–	1	10
B. salebrosum	–	3	–	–	–	–	–	–	30	+	–	1	–	–	–	–	–	–	–	–	–	–
Bryum caespiticium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
B. sandbergii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ceratodon purpureus	–	–	–	–	–	–	–	–	½	+	+	–	–	–	–	–	–	–	–	–	–	–
Dicranum fuscescens	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
D. scoparium	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	+	–	–	–	–
D. undulatum	+	–	–	–	–	20	20	4	–	–	+	–	–	–	–	–	10	1	–	–	–	–
Eurhychium strigosum	+	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Hylocomium splendens	¼	–	10	1	–	10	–	–	–	–	–	–	–	40	30	50	–	–	–	+	–	+
Lophozia ventricosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mnium drummondii	5	10	–	5	¼	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. medium	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	–	+	20
M. nudum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	5	10	1
M. spinulosum	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Obtusifolium obtusum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–
Orthocaulis floerkei	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pleurozium schreberi	20	4	20	40	–	25	50	20	–	–	–	–	+	15	25	–	60	5	–	–	–	1
Pogonatum alpinum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pohlia nutans	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	+	–	–	–	–
Polytrichum juniperinum	–	–	–	–	–	–	–	–	+	¼	10	–	3	–	–	–	–	7	–	–	–	–
P. piliferum	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–	–
Pseudoleskea radicosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Ptilium crista-castrensis	5	1	–	+	–	3	3	2	–	–	+	–	+	10	–	–	–	–	–	+	–	3
Rhytidiadelphus calvescens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–
R. triquetrus	20	30	15	2	¼	5	¼	1	–	–	–	–	–	–	5	–	–	–	–	–	–	–
Rhytidiopsis robusta	–	–	–	–	–	1	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+
Cladonia acuminata v. *norrlinii*	–	–	–	–	–	–	–	–	+	–	+	–	–	–	–	–	–	–	–	–	–	–
C. arbuscula ssp. beringiana	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	25	–	–	–	–
C. chlorophaea s. lat.	–	–	–	–	–	–	–	–	+	¼	7	–	–	–	–	–	–	+	–	–	–	–
C. degenerans	–	–	–	–	–	–	–	+	–	–	¼	–	–	–	–	–	–	¼	–	–	–	–
C. gracilis v. *dilatata*	–	–	–	–	–	–	–	–	–	+	1	–	+	–	–	–	–	+	–	–	–	–
C. mitis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	30	–	–	–	–
C. multiformis	–	–	–	–	–	–	–	–	+	–	¼	–	½	–	–	–	–	–	–	–	–	–
C. pleurota	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–	–
C. pyxidata	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–
C. rangiferina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10	–	–	–	–
C. symphycarpia	–	–	–	–	–	–	–	–	10	5	½	–	–	–	–	–	–	–	–	–	–	–
Cetraria crispa	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	¼	–	–	–	–
C. subalpina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
+	—	1	—	—	—	+	+	—	—	—	—	+	+	—	—	—	—	—	—	½	—	—	—	—	—	—	—	—	—	—
—	—	2	—	¼	¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—
60	70	25	40	15	40	20	10	10	5	½	4	¼	—	—	—	—	—	—	—	—	—	7	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	+	—	¼	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
—	+	+	¼	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	¼	7	¼	½	1	1
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	3	2	10	15	+	10	7	¼
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	+	¼	1	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	+	—	—	—	—	—	+	+	—	1	+	3	—	—	—	3	1	1	+	¼	—	—	—	—	—	—	2	—	1	¼
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	¼	—	—	+	¼	—	+
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	+	—	—	—	—	—	—	—	—	—	—	½	—	—	+	—	—	—	—	¼	—	—	—	—	—	—	—	—	—	—
10	15	1	5	20	20	30	10	15	20	15	10	½	10	+	5	2	1	3	—	—	15	20	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	10	1	—	¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
+	—	—	1	½	½	—	—	+	—	—	—	—	—	—	¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
¼	1	+	½	+	1	7	15	10	40	¼	¼	+	25	—	—	+	—	—	+	—	20	10	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	3	7	10	7	1	10	1	1	5	—	—	¼	—	—	—	—	—	—	—	—	20	3	20	15	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	½	7	10	15	5	¼	7	3	5
—	—	+	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	20	—	40	40	10	25	7	30	+	7
—	—	—	—	—	—	—	—	—	½	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	3	20	—	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—	+
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	1	—	3	5	2	¼	+	10	15	—	1	¼	5	—	—	—	+	1	—	—	20	7	3	10	—	1	7	5	1	½
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	+	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3	1	10	7	3	—	1	—	5	10	—	—	3	—	—	—	—	—	1	—	3	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	+	—	¼	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	40	—	40	30	20	20	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	½	½	—	—	2	10
—	—	—	—	—	—	—	—	—	—	5	¼	2	+	—	—	1	5	—	20	1	—	1	1	3	10	3	10	—	30	40
—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	20	—	3	—	—	—	—	—	—	30	60	+	—	—	40	—	—	—	10	+	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	—	—	+
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20	—	10	20	10	+	—	—	—	1	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	7	1	10	3	7	2	+	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	¼	—	—	—	—	—
—	¼	—	—	+	—	—	—	1	—	—	—	1	—	—	—	+	—	10	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	3	—	¼	+	1
5	15	—	—	—	30	30	40	20	30	1	2	15	20	20	15	15	50	30	40	50	5	70	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	1	½	1	1	½
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	1	3
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	10	—	15	10	1	10	1	20	2	½
20	15	+	20	15	10	10	30	10	15	—	5	15	30	10	10	15	10	15	—	1	—	10	—	—	—	—	—	—	—	—
—	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	¼	—	—	—	—	—
10	—	—	1	5	—	—	—	—	—	5	—	3	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	+	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
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—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	¼

Sample plot no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Peltigera aphthosa	–	–	–	–	–	1	–	–	–	–	–	–	–	¼	+	7	¼	–	–	–	–	–
P. leucophlebia	+	–	–	–	–	–	+	+	–	–	1	–	¼	–	–	–	–	–	–	–	–	–
P. polydactyla	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	¼	–	–	–	–	–
P. rufescens	–	–	–	–	–	–	–	–	2	2	5	–	–	–	–	–	–	–	–	–	–	–
P. spuria	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–
Stereocaulon paschale	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–
S. tomentosum	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	–	–	–	–	–	–	–
S. sp.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–
Other species	1	2	3	4	5	6	–	7	8	9	10	11	12	–	13	14	–	15	–	16	17	–
Litter	20	20	30	40	90	25	20	50	50	80	50	90	60	5	10	10	10	20	30	50	60	50
Logs and stumps	30	30	25	10	10	10	5	20	2	10	7	10	20	30	30	10	30	–	50	10	30	15
Stones	–	–	–	–	–	–	–	–	+	–	½	–	1	–	–	–	–	–	–	–	–	–
Epiphytic lichens[1]																						
Alectoria glabra	2	–	–			–	–	3						–	–					1	–	
A. fremontii	–	3	1			3	2	3						–	1					–	1	
A. oregana	–	–	–			–	–	–						–	–					–	–	
A. sarmentosa	1	3	3			1	1	1						3	3					3	3	
A. tenerrima[2]	1	1	1			2	3	–						1	2					–	2	
Cetraria canadensis	–	–	–			–	1	1						–	–					–	–	
C. ciliaris	–	–	–			–	1	–						–	–					–	–	
C. glauca	–	3	–			3	2	1						3	3					3	3	
C. merrillii	–	–	–			–	–	–						–	–					–	–	
C. pinastri	–	–	–			–	–	1						1	–					1	–	
C. platyphylla	–	–	–			–	–	–						–	–					–	–	
C. scutata	–	–	1			1	1	2						1	1					1	–	
C. sepincola	–	–	–			–	–	–						–	–					–	–	
Letharia vulpina	–	–	–			–	–	1						–	–					–	–	
Lobaria pulmonaria	3	2	2			–	–	–						2	2					2	2	
Nephroma bellum	–	–	–			–	–	–						–	–					–	–	
N. helveticum v. sipeanum	–	–	–			–	–	–						1	1					1	–	
N. parile	–	1	–			–	–	–						–	–					–	1	
N. resupinatum	–	–	–			1	–	–						–	–					–	–	
Parmelia austerodes	–	–	–			–	–	–						–	–					–	–	
P. enteromorpha s. lat.	2	2	2			3	3	3						2	3					2	–	
P. physodes	2	2	2			3	3	3						2	1					1	1	
P. saxatilis v. *divaricata*	–	2	1			–	–	–						–	–					2	1	
P. sulcata	1	–	1			1	1	1						1	–					1	–	
P. tubulosa	1	–	–			1	–	–						–	–					–	–	
Parmeliopsis ambigua	–	–	1			2	2	2						1	1					1	–	
P. hyperopta	–	–	–			1	2	–						1	1					1	–	
Ramalina thrausta	3	1	1			–	–	1						–	–					1	1	
Sticta fuliginosa	–	–	–			–	–	–						1	–					–	–	
Usnea glabrata	–	–	–			–	–	1						–	–					–	–	

[1] *1* = scanty, *2* = fairly abundant, *3* = abundant
[2] including perhaps *A. canadensis*, cf. MOTYKA 1964, pp. 32, 36.

Other species: [1] *Goodyera repens* var. *repens* +. – [2] *Pyrola asarifolia* var. *asarifolia* ¼, *Hypnum subimponens* +, *Lepidozia reptans* +, *Mnium affine* +, *Plagiochila asplenioides* +. – [3] *Goodyera repens* var. *ophioides* ¼. – [4] *Symphoricarpos albus* +, *Adenocaulon bicolor* ¼, *Asarum caudatum* +, *Circaea alpina var. pacifica* +, *Goodyera repens* var. *ophioides* +, *Habenaria orbiculata* +, *Petasites palmatus* 1. – [5] *Symphoricarpos albus* +, *Circaea alpina var. pacifica* +. – [6] *Pyrola asarifolia* var. *asarifolia* ¼, *Peltigera canina* +. – [7] *Corallorhiza maculata* var. *punicea* +. – [8] *Anaphalis margaritacea* +, *Apocynum androsaemifolium* 1, *Cerastium fontanum* ssp. *triviale* +, *Carex peckii* +, *Festuca occidentalis* +, *Hieracium albiflorum* +, *Drepanocladus uncinatus* +, *Cladonia pocillum* +, – [9] *Symphoricarpos albus* ½, *Agropyron trachycaulum* +, *Antennaria rosea* +, *Elymus glaucus* ½. – [10] *Agropyron trachycaulum* ¼, *Anaphalis margaritacea* +, *Antennaria rosea* ¼, *Carex peckii* +, *Cerastium fontanum* ssp. *triviale* +, *Cirsium arvense* var. *maritimum* +, *Elymus glaucus* +, *Epilobium paniculatum* +, *Erigeron philadelphicus* +, *Hieracium albiflorum* +, *Prunella vulgaris* +, *Cladonia cariosa* +, *C. coccifera* +, *C. cornuta* +, *C. deformis* +, *C. subulata* +. – [11] *Equisetum scirpoides* +, *Petasites palmatus* ¼. – [12] *Juniperus communis* var. *depressa* +. – [13] *Habenaria orbiculata* +. – [14] *Nephroma arcticum* 2. – [15] *Hieracium albiflorum* +, *Maianthemum canadense* 3, *Rhacomitrium canescens* +. – [16] *Carex disperma* +. – [17] *Goodyera repens* var. *repens* +. – [18] *Equisetum arvense* 1. – [19] *Spiraea douglasii* var. *menziesii* 1, *Equisetum silvaticum* +. – [20] *Timmia austriaca* 1. – [21] *Equisetum arvense* ¼. – [22] *Ranunculus eschscholtzii* ¼, *Epilobium anagallidifolium* +. – [23] *Hieracium gracile* ¼, *Campyllium stellatum* +. – [24] *Hieracium gracile* ¼. – [25] *Epilobium anagallidifolium* ¼, *Erigeron peregrinus* ssp. *callianthemus* var. *callianthemus* 1, *Juncus drummondii* +, *Ranunculus eschscholtzii* 1, *Senecio triangularis* ½, *Trollius laxus* 10. – [26] *Hieracium gracile* +, – [27] *Antennaria »lanata»* +, *Cladonia carneola* +, *C. ecmocyna* var. *intermedia* ½, *Lecidea uliginosa* ½.

The sample plots

Lower oroboreal zone

1. Hemp Creek, on Clearwater Lake Road, c. 1.3 mi. W of Hemp Creek Ranger Sta., on Green Mtn. Trail. Alt. 700 m.

2 – 7. Hemp Creek, on Clearwater Lake Road, c. 1 – 2 mi. N and NW of Hemp Creek Ranger Sta. Alt. 650 – 790 m.

8. Murtle River, c. 5 mi. ENE of Mahood Lake, on Helmcken Falls Trail. Alt. 780 m.

9 – 11. Hemp Creek, outside the park boundary at the south entrance, the neighborhood of Hemp Creek Ranger Sta. Alt. 610 – 620 m.

12 – 13. Hemp Creek, on Clearwater Lake Road, c. 1.5 mi. W of Hemp Creek Ranger Sta., on Green Mtn. Trail. Alt. 650 – 670 m.

23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	1	—	—	—	—	3	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	¼	—	—	½	—	—	—	—	¼	¼	1	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—
—	—	18	—	—	19	—	—	—	—	—	—	—	—	—	—	—	20	—	21	—	—	—	22	—	23	24	—	25	26	27
15	10	50	15	25	10	40	20	50	10	20	20	20	20	30	10	40	15	25	15	25	20	10	20	20	40	30	70	70	20	30
20	30	25	20	20	40	20	10	25	20	20	20	40	25	40	20	30	25	30	5	20	10	5	10	25	10	20	5	5	40	10
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	1	—	1	—	7	+	1	3
—		1	—		—	—	1	—	—	—	—	2		2	3	1		—	2	2	2	2	2	2	2	2	2	3	2	2
1		1	1		1	—	1	—	—	—	—	2		3	2	—		—	3	3	2	1	2	2	2	2	2	2	2	2
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	—	—	2	2	2	2	3	3	3	3	3
3		3	3		3	3	3	3	3	3	3	2		2	3	3		3	2	2	3	1	2	2	2	1	2	1	1	1
1		2	2		2	2	1	2	1	2	2	3		2	—	2		2	—	2	2	3	3	3	2	2	2	2	2	2
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	1	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	—	—	—	—	—	—	1	—	—	—	—
3		3	3		3	3	3	3	3	3	3	3		3	3	3		3	3	2	3	—	1	—	—	—	—	1	1	1
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	1	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	1	—	—	—	—	—	1		—	—	—		—	—	1	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	1	—	—	—	—	1	1	1	—	1	1
1		1	—		1	1	1	—	—	1	1	2		2	—	1		—	2	2	2	2	1	—	1	1	—	1	1	1
—		—	—		—	—	—	—	—	—	—	1		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	1	—	—	—	1	—	—	—	1	1	1	1
2		2	2		—	2	—	2	—	2	2	—		—	1	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	1		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	1		1	1	—	—	—	—	—	—		—	1	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	—		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		1	—	—	—	—	—	—	—		—	1	—		—	—	1	—	—	2	—	2	2	2	2	2	1
2		2	2		1	2	2	1	—	1	2	2		2	2	2		2	2	3	2	3	3	3	3	3	3	3	3	3
1		2	2		1	2	2	1	—	1	1	2		2	2	2		1	2	3	2	2	1	2	2	1	3	2	2	3
1		—	1		—	—	—	—	—	1	—	1		—	—	1		1	—	—	—	—	—	—	—	—	—	—	—	—
—		1	1		1	3	2	1	—	—	1	—		1	1	1		—	1	1	1	—	—	—	—	—	1	1	1	1
—		—	—		—	—	1	—	—	—	—	—		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	1
1		1	1		1	1	1	1	1	1	1	1		1	1	1		1	1	1	3	3	3	3	3	3	3	3	3	3
1		1	1		1	—	1	1	1	1	1	1		1	1	1		1	1	1	2	2	2	3	2	3	2	2	2	2
1		2	2		2	1	1	2	1	—	—	—		—	—	1		2	—	1	—	—	—	—	—	—	—	—	—	—
—		—	—		—	1	—	—	—	—	—	—		—	1	—		—	—	—	—	—	—	—	—	—	—	—	—	—
—		—	—		—	—	—	—	—	—	—	1		—	—	—		—	—	—	—	—	—	—	—	—	—	—	—	1

14. C. 3 mi. SW of Blue River Station. Alt. 760 m.
15 – 16. Azure Lake, southern shore of the lake, c. 3 – 4 mi. E of the western end. Alt. 760 – 790 m.
17. C. 2 mi. SW of Blue River Station. Alt. 700 m.
18. Near the Blue River Station. Alt. 670 m.

Middle oroboreal zone

19 – 21. Murtle Lake, SW end, east side of Diamond Lake. Alt. 1050 – 1060 m.
22. Murtle Lake, W shore of the northern arm, the mouth of Vachon Creek. Alt. 1050 m.
23 – 24. Murtle Lake, S shore of the western arm, the neighborhood of the patrolman's cabin. Alt. 1070 – 1090 m.
25. Murtle Lake, N end, c. 1 mi. up Murtle River. Alt. 1060 m.
26. Murtle Lake, N shore of the western arm, foot of Ramsay Mtn. Alt. 1050 m.
27 – 32. Murtle Lake, SW end, 0.5 – 1 mi. N, NE and E of Diamond Lake. Alt. 1050 – 1070 m.
33. Murtle Lake, S shore of the northern arm, c. 6.5 mi. S of the mouth of Vachon Creek. Alt. 1030 m.
34 – 35 = 23 – 24. Alt. 1070 – 1140 m.
36· Murtle Lake, W end, c. 0.5 mi. N of the mouth of File Creek. Alt. 1050 m.
37 – 38. Murtle Lake, SE end, the mouth of Snookwa Creek and the end of Blue River Trail. Alt. 1070 m.
39 = 23 – 24. Alt. 1100 m.
40. Murtle Lake, N end. Alt. 1050 m.
41. Murtle Lake, SW end, 1.5 mi. NW of Diamond Lake. Alt 1050 m.
42 – 43. = 27 – 32. Alt. 1050 – 1060 m.

Upper oroboreal zone

44. Battle Mtn., S slope, c. 3 mi. SW of Fight Lake. Alt. 1580 m.
45. Stevens Lakes, N end of the southernmost Stevens Lake. Alt. 1440 m.

Orohemiarctic zone

46 – 47. Battle Mtn., S slope, the neighborhood of Fight Lake. Alt. 1740 – 1750 m.
48. Battle Mtn., S slope, the neighborhood of Caribou Meadows. Alt. 1750 m.
49 – 53. = 46 – 47. Alt. 1730 – 1760 m.

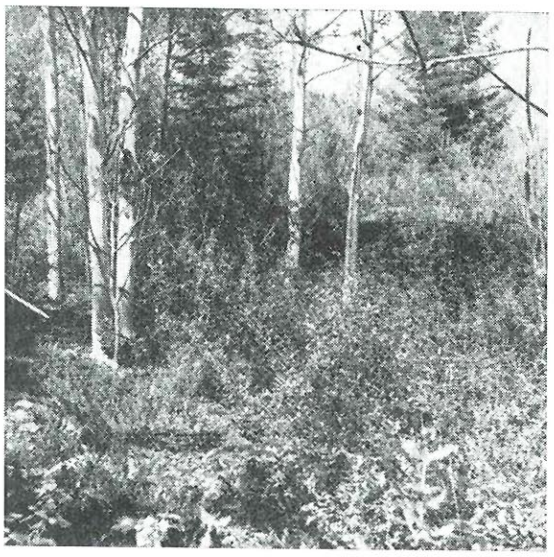

Fig. 2. Lower oroboreal seral forest at Hemp Creek. The trees are *Populus tremuloides*, *Betula papyrifera* var. *commutata* and *Picea glauca*. The bush layer is rich in *Shepherdia canadensis* and *Pachystima myrsinites*.

British Columbia, and by DAUBENMIRE (1952) under the name »*Thuja plicata* – *Tsuga*/*Pachystima myrsinites* Association» from northern Idaho and adjacent Washington. The »*Tsuga heterophylla* – *Cornus canadensis* – *Dryopteris linnaeana* – *Aralia nudicaulis* association» in F.H.B.C. (1959) is also very similar.

Fairly dry and mesotrophic sites (sample plot 6). *Pseudotsuga menziesii* var. *glauca* is dominant, and among it occur *Thuja plicata*, *Tsuga heterophylla*, *Betula papyrifera* var. *commutata*, and *Picea engelmannii*.

The bush layer is poorer than in mesic sites, consisting of *Acer glabrum* var. *douglasii* and of small individuals of the tree species.

The field layer is without several species that prefer mesic sites (e.g. *Aralis nudicaulis*, *Disporum hookeri* var. *oreganum*, *Tiarella unifoliata*), but it has some others characteristic of dry sites, such as *Chimaphila umbellata* ssp. *occidentalis*, *Oryzopsis pungens* and *Pyrola chlorantha*.

In the ground layer *Dicranum undulatum* (which is here almost lacking in mesic sites!), *Pleurozium schreberi* and *Hylocomium splendens* are common. *Rhytidiadelphus triquetrus* and *Ptilium crista-castrensis* are sparser.

The soil is gravel. The leached horizon is 2 cm, the humus layer 5 cm thick.

KUJALA (1945) described similar communities under the name »*Pachystima*-Typ» from Blue River, Dorreen, Barriere, and Smithers, British Columbia. ILLINGWORTH and ARLIDGE (1960) distinguished a »*Pachystima* site type» in the Kamloops Forest District, which resembles the Hemp Creek forest.

b. Seral forests (sample plots 7 – 13)

In this section the seral forests seem to be formed by *Populus tremuloides*, *Salix scouleriana* and *Betula papyrifera* var. *commutata*, which occur in both dry and mesic sites. A sparser component is *Pinus contorta* var. *latifolia*, which has been found only in dry sites. All these stands are young (30 – 60 years) and therefore the other coniferous trees are of little importance.

In the bush, field and ground layers there are many plants wanting in climax and subclimax forests (*Anaphalis margaritacea*, *Antennaria howellii*, *A. rosea*, *Carex peckii*, *Hieracium albiflorum*, *Shepherdia canadensis*, *Ribes oxyacanthoides*, *Rosa nutkana*, *Epilobium angustifolium*, *Aster ciliolatus*, *Lilium columbianum*, *Melampyrum lineare*, *Poa palustris*, *Brachythecium campestre*, *Ceratodon purpureus*, *Polytrichum juniperinum*, *Cladonia symphycarpia*, *C. cariosa*, *Peltigera rufescens*, *Stereocaulon tomentosum*). Others are found only near the road and pastures of Hemp Creek village, where they also grow

Fig. 3. Lower oroboreal seral forests near Mushbowl Falls. The dominant tree is *Pinus contorta* var. *latifolia; Populus tremuloides*, *Betula papyrifera* var. *commutata* and *Picea engelmannii* are scattered. *Pachystima myrsinites*, *Aralia nudicaulis*, *Lonicera involucrata* and *Mahonia aquifolium* are abundant.

as weeds (e.g. *Taraxacum* spp., *Trifolium pratense*, *Poa pratensis* coll.). *Trifolium repens* also occurs very far from the village (e.g. near Stillwater).

Many of the species are the same as in the climax forests: the only differences are in frequency (*Rubus parviflorus*, *Acer glabrum* var. *douglasii*, *Lonicera involucrata*, *Linnaea borealis* ssp. *americana*, *Mahonia aquifolium*, *Pachystima myrsinites*, *Aralis nudicaulis*, *Cornus canadensis*, *Galium triflorum*, etc.)

I am not able to determine the kind of climax forests into which these stands will develop; nos. 12 and 13 are obviously in mesic sites and will develop into the same as nos. 1 – 5; the others are situated on drier sites and they may perhaps become like no. 6 or like some other dry, mesotrophic forest type not seen by me.

The »*Aralia-Lathyrus* – Siedlung »of the »*Vaccinium caespitosum*-Typ» described by KUJALA (1945) from Prince George, Hazelton and Vanderhoof, British Columbia, resembles these stands in part. ILLINGWORTH and ARLIDGE's (1960) »*Pachystima* site type» would also cover the present stands.

B. Humid section

a. Climax and subclimax forests (sample plots 14 – 17)

Mesic and oligotrophic sites (sample plots 14 – 16). The tree layer consists of *Tsuga heterophylla*.

The bush layer is poor; only small *Tsuga heterophylla* and *Thuja plicata* individuals are constant.

The field layer is not very well developed, either. Its most important members are *Cornus canadensis*, *Chimaphila umbellata* ssp. *occidentalis*, *Vaccinium membranaceum*, *V. ovalifolium*, *Linnaea borealis* ssp. *americana*, and *Rubus pedatus*.

In the ground layer *Hylocomium splendens*, *Pleurozium schreberi* and *Peltigera aphthosa* are common.

The soil is sandy till or sand. The leached horizon is distinct; the humus layer is 5 – 30 cm thick.

Under the name »*Vaccinium membranaceum*-Typ» KUJALA (1945) described communities from Valemount, Smithers and Prince George, British Columbia, which resemble these *Tsuga* forests. KUJALA's stands were young and their distribution seems to have been close to the middle oroboreal.

Fig. 4. Lower oroboreal forest on the mesic and oligotrophic site c. 3 mi. SW of Blue River Station. *Tsuga heterophylla* is dominant, intermingled with some *Pinus monticola*.

Dry and oligotrophic sites (sample plot 17). The tree layer is dominated by *Tsuga heterophylla*, among which there occur *Pseudotsuga menziesii* and *Pinus monticola*.

The bush layer consists only of small individuals of *Tsuga heterophylla* and *Thuja plicata*.

The field layer is characterized by *Gaultheria hispidula*, *Vaccinium myrtilloides* and *V. membranaceum*.

The ground layer is covered by *Pleurozium schreberi*, and *Dicranum undulatum*.

The soil is sand; the humus layer is 2 cm thick.

b. Seral forests (sample plot 18)

In this section I recorded only one seral stand, at Blue River. Its age is 60 years, the dominant tree being *Pinus contorta* var. *latifolia*.

In the field layer *Vaccinium caespitosum* and *V. myrtilloides* are abundant, and *Clintonia uniflora*, *Cornus canadensis*, *Melampyrum lineare*, and *Oryzopsis asperifolia* sparse. Large patches of lichens (*Cladonia arbuscula*, *C. rangiferina*) are common in the ground layer, which is otherwise covered with mosses (*Dicranum undulatum*, *Pleurozium schreberi*, *Polytrichum juniperinum* and *P. piliferum*).

This stand will probably develop into the same kind of forest as in sample plots 14 – 16. KUJALA (1945) from Vanderhoof and Endako and ILLINGWORTH and ARLIDGE (1960) from the Kamloops Forest District described forest types rich in lichens, but they are different.

2. Middle oroboreal zone

This altitudinal counterpart of the middle boreal zone has been studied at Murtle Lake, and it seems to occur in the park from 900 m to 1200 m (3000 – 4000 feet). All the middle oroboreal forests belong to the same, humid section.

A. Comparison of the lower and middle oroboreal zones

Comparison of the lower and middle oroboreal zones in Wells Gray Park is difficult because the former occurs partly in the area which has calcareous soil and a much lower precipitation than elsewhere.

The same tree species dominate in the two zones, but *Abies lasiocarpa* and *Picea engelmannii* are more abundant in the middle oroboreal zone, where *Tsuga heterophylla* also seems to be scanty in old forests. This difference may be more edaphic than zonal, since at Murtle Lake dry oligotrophic soil is rare, but KUJALA (1945) also mentions some young *Tsuga* stands from the middle oroboreal zone of central British Columbia. He included them in the »*Vaccinium membranaceum*-Typ». The seral stands in the two zones are very different: at Murtle Lake only coniferous trees form seral forests, whereas in the lower oroboreal zone these stands are often dominated by *Populus tremuloides*, *Salix scouleriana* and *Betula papyrifera* var. *commutata*, which in the middle and upper oroboreal zones never form pure stands, though they sometimes occur scattered among other trees.

In the bush layer there are many differences. In the middle oroboreal zone a number of species are lacking (or very rare) e.g. *Ribes oxyacanthoides*, *Rosa nutkana* and *R. gymnocarpa*. The reason for the absence of *Shepherdia canadensis* is probably that the soil is not particularly calcareous. Some species occur at Murtle Lake only on lake shores (*Amelanchier alnifolia* s. lat., *Cornus stolonifera* s. lat.). More common in the middle oroboreal than in the lower oroboreal zone are *Menziesia ferruginea* (obviously var. *ferruginea*, at Hemp Creek var. *glabella*) and *Oplopanax horridus*, which both indicate the higher precipitation of Murtle Lake. The presence of *Rhododendron albiflorum* is obviously a clear sign of the lower limit of the middle oroboreal zone.

In the field layer many differences are also caused by climatic moisture conditions (e.g. the great frequency of *Rubus pedatus* and *Vaccinium ovalifolium* at Murtle Lake) or by the quality of the soil (e.g. the abundance of *Gymnocarpium dryopteris*, which avoids highly calcareous soil, at Murtle Lake), but in addition there are many truly zonal differences. In the middle oroboreal zone *Mahonia aquifolium*, *Lathyrus ochroleucus*, *Lilium columbianum*, *Oryzopsis asperifolia*, *O. pungens* and *Rubus pubescens* are obviously lacking and *Aralia nudicaulis* is very rare. *Pachystima myrsinites* is more abundant in seral stands; in the climax forests it is rare, obviously because of their shadiness. On the other hand, in this zone there are *Streptopus roseus*, *Athyrium filix-femina* var. *sitchensis*, *Veratrum eschscholtzii*, etc., which are typical middle and upper oroboreal species.

In the ground layer, *Brachythecium campestre*, *Eurhynchium strigosum* and *Mnium drummondii* seem to be lower oroboreal in the study area, *Mnium medium*, *M. nudum* and *M. spinulosum* being more abundant in the middle oroboreal zone.

As regards epiphytic lichens there seem to be only insignificant differences between these zones. The middle oroboreal zone is richer in lichens than the lower oroboreal zone, but the species are almost the same.

All the differences described are features of the forest vegetation. But in the other plant communities the same limit can also be discerned. For instance, the peatlands at Hemp Creek are mainly ombrotrophic, but at Murtle Lake they are dominantly minerotrophic, though small extrazonal ombrotrophic bogs occur close to the lake shore. The boundary between these two types of peatland is generally situated at the limit of the southern and middle boreal zones, as was clearly demonstrated by RUUHIJÄRVI (1960) and EUROLA (1962) in northern Europe. Thus the same limit also occurs in the mountains of western North America.

B. Middle oroboreal forests

All the middle oroboreal forests studied in Wells Gray Park belong to the same humid section.

a. Climax and subclimax forests

Moist and mesotrophic sites (sample plots 19 – 25). *Thuja plicata*, *Picea engelmannii* and *Abies lasiocarpa* may all be dominant together or one

Fig. 5. Middle oroboreal moist *Thuja plicata* forest at Murtle Lake. *Oplopanax horridus* is abundant; *Dryppteris dilatata* s. lat., *Gymnocarpium dryopteris*, *Streptopus amplexifolius* and *Clintonia uniflora* are common.

of them may dominate alone. *Tsuga heterophylla* and *Pseudotsuga menziesii* var. *glauca* are rarer and sparser.

The bush layer is very well-developed, often making these forests difficult to penetrate. Common and often abundant species are *Oplopanax horridus*, *Rhododendron albiflorum*, *Menziesia ferruginea* var. *ferruginea*, *Thuja plicata*, and *Ribes lacustre*.

The field layer is rich in *Gymnocarpium dryopteris*, *Rubus pedatus*, *Vaccinium membranaceum*, *Streptopus roseus*, and *Tiarella unifoliata*. Other common species include *Streptopus amplexifolius*, *Dryopteris dilatata* s. lat., *Clintonia uniflora*, *Disporum hookeri* var. *oreganum*, *Vaccinium ovalifolium*, and *Athyrium filix-femina* var. *sitchense*.

In the ground layer *Mnium nudum* is constant and *Brachythecium hylotapetum*, *Mnium medium* and *Ptilium crista-castrensis* are common.

The soil is fine-sand till. The leached horizon is obscure and the humus layer 5 – 20 cm thick and dark brown.

The »*Tiarella-Falsia*-Typ» described by Kujala (1945) from Prince George, Blue River, Smithers and Dorreen, British Columbia, resembles these forests at Murtle Lake, and Daubenmire's (1952) »*Thuja plicata – Tsuga/Oplopanax horridus* association» from northern Idaho is also closely related. Illingworth and Arlidge's (1960) »*Oplopanax* site type» from the vicinity of Prince George and the »*Thuja plicata – Oplopanax horridus – Dryopteris linnaeana* association» mentioned in F.H.B.C. (1959, p. 601 – 606) are very similar, but they clearly consist of both lower and middle boreal forests. The association rich in *Oplopanax horridus* is very well-defined and seems to occur in the southern (lower oro-) to middle (oro-)boreal zones in the humid parts of British Columbia, Washington and Idaho. Of course, a few climatic variants of it may be distinguished.

Mesic and mesotrophic sites (sample plots 26 – 35). *Abies lasiocarpa* and *Picea engelmannii* are dominant, but among them there may be *Thuja plicata* and *Tsuga heterophylla*.

The bush layer is not so well developed as on moist sites. Frequent species are *Lonicera involucrata*, *Menziesia ferruginea*, var. *ferruginea*, *Rubus parviflorus*, *Ribes lacustre*, and small trees.

In the field layer *Streptopus roseus*, *Rubus pedatus*, *Gymnocarpium dryopteris*, and *Clintonia uniflora* are constant, whilst *Vaccinium membranaceum*, *V. ovalifolium*, *Cornus canadensis*, and *Tiarella unifoliata* are fairly frequent.

In the ground layer there is no fully constant species; *Mnium medium*, *M. nudum*, *Ptilium crista-castrensis*, *Pleurozium schreberi*, and *Brachythecium hylotapetum* are fairly frequent.

The soil is fine-sand till. The leached horizon is distinct and 2 – 5 cm thick, the humus up to 25 cm thick.

Kujala's (1945) »*Tiarella – Rubus pedatus*-Untertyp» from Prince George very much resembles these forests.

Fairly dry and mesotrophic sites (sample plots 36 – 41). Many of these stands are young and so essentially seral, being occupied not by *Pinus contorta* but by *Picea engelmannii*, *Abies lasiocarpa* and sometimes *Tsuga heterophylla*. *Thuja plicata* and *Pseudotsuga menziesii* var. *glauca* are sparse.

The bush layer is poorly developed. *Menziesia ferruginea* var. *ferruginea*, *Spiraea betulifolia* var. *lucida* and small individuals of the tree species are scattered.

In the field layer the only constant species is *Rubus pedatus*, whilst *Vaccinium membranaceum*, *Cornus canadensis*, *Clintonia borealis*, *Pachystima myrsinites*, and *Linnaea borealis* ssp. *americana* are fairly frequent. *Goodyera oblongifolia*, *Orthilia secunda* and *Streptopus amplexifolius* are less constant and sparse.

The ground layer has only *Pleurozium schreberi* and *Ptilium crista-castrensis* as constants. *Dicranum undulatum*, *D. scoparium* and *Barbilophozia lycopodioides* are scattered.

The soil is gravel or stony till. The leached horizon is distinct, the humus layer up to 12 cm thick.

The heterogeneity of these fairly dry, mesotrophic forests is partly caused by their unequal age. Some species (e.g. *Pachystima myrsinites*) occur only in young forests. Some moss species (e.g. *Dicranum scoparium*) cannot grow among the heavy litter of the old forest, either, where only the litter mosses (*Brachythecium* and *Mnium* species, etc.) are abundant.

The »*Rubus pedatus* – *Vaccinium membranaceum*-Untertyp» described by KUJALA (1945) from Valemount, Blue River and Canoe River, British Columbia, is similar.

b. Seral forests (sample plots 42 – 43)

In these stands the dominant tree is *Pinus contorta*. The sample plots are situated near the lake shore on very dry fine sand. I was not able to determine the kind of forest into which they will develop. The differences between these and the preceding forests are not great.

3. Upper oroboreal zone

This altitudinal counterpart of the northern boreal zone has been seen at Stevens Lakes, on Fish Lake Hill and on Battle Mountain. It seems to occur in the southernmost portion of the park from 1200 m to 1600 m (4000 – 5500 feet).

A. Comparison of the middle and upper oroboreal zones

The upper oroboreal zone is the uppermost continuously forested zone. The only climax tree species are *Picea engelmannii* and *Abies lasiocarpa*. A common seral species is *Pinus contorta*. *Tsuga heterophylla*, *Thuja plicata*, *Pseudotsuga menziesii* var. *glauca*, *Acer glabrum* var. *douglasii*, *Populus tremuloides* and *Betula papyrifera* var. *commutata* were not seen in this zone in the park.

The bush layer is well-developed, consisting chiefly of *Menziesia ferruginea* var. *ferruginea* and especially *Rhododendron albiflorum*, which forms very dense thickets at the upper limit of this zone.

Many species of the bush and field layers that

Fig. 6. The upper oroboreal zone around the Stevens Lakes; the forests consist of *Picea engelmannii* and *Abies lasiocarpa*. The Monashee Mts. in the background.

are common in the middle oroboreal forests are rare (e.g. *Lonicera involucrata*, *Ribes lacustre*, *Rubus parviflorus*, *Clintonia uniflora*, *Cornus canadensis*, *Streptopus amplexifolius*) or totally lacking in the upper oroboreal (e.g. *Cornus stolonifera* s. lat., *Osmorhiza chilensis*, *Aralia nudicaulis*, *Chimaphila umbellata*, *Goodyera oblongifolia*. *Disporum hookeri* var. *oreganum*, *Lycopodium annotinum* var. *annotinum*, *Cinna latifolia*).

Common species in this zone are *Mitella breweri*, *Arnica latifolia*, *Hieracium gracile*, *Osmorhiza purpurea*, and *Lycopodium annotinum* var. *alpestre*. Some species occurring only on wet sites in the middle oroboreal zone are here common on mesic sites also, – for instance, *Veratrum eschscholtzii* and *Valeriana sitchensis*.

Among the bryophytes there are also several differences; e.g. *Mnium nudum* and *M. medium* are not found in this zone, while *Barbilophozia lycopodioides* seems to be very abundant.

Among the epiphytic lichens *Alectoria jubata*, *Parmeliopsis ambigua* and *P. hyperopta* are more abundant in this zone than in the middle oroboreal zone. *Lobaria pulmonaria*, *Nephroma helveticum* and *Ramalina thrausta* are rare or absent. *Alectoria oregana*, very rare in the middle oroboreal zone, is here scattered.

The peatlands are minerotrophic, but their flora is somewhat different from the middle oroboreal peatlands. For example, at Murtle Lake *Kalmia polifolia* var. *polifolia* occurs on hummocks but at Stevens Lakes it is replaced by *K. polifolia* var. *microphylla; Ledum groenlandicum* is lacking in the upper oroboreal zone, etc.

Fig. 7. Upper oroboreal burned area at Stevens Lakes. The trees are *Pinus contorta* var. *latifolia*. Among other plants *Epilobium angustifolium* and *Agrostis scabra* were dominant.

B. Upper oroboreal forests

a. Climax and subclimax forests (sample plots 44 – 45).

The table contains data of only two sample plots from this zone. They are typical mesic, mesotrophic sites. No. 44 is situated near the lower limit of the zone on the precipitous southern slope of Battle Mtn. and it has some middle oroboreal features.

These forests in Wells Gray Park and the vicinity are very similar to the photographs published by Smith (1955) of the »*Vaccinium membranaceum – Rubus pedatus*» and »*Vaccinium ovalifolium-Dryopteris linnaeana*» associations from Bolean Lake, British Columbia.

b. Seral forests

Pinus contorta is a common seral tree species in dry sites, whilst in mesic sites *Abies lasiocarpa* and *Picea engelmannii* occur. The regeneration of forests after fires seems to be fairly good.

4. Orohemiarctic zone

This zone is the altitudinal counterpart of the hemiarctic zone, which is often called forest-tundra. It refers to the zone with scattered trees and tree groups above the continuous forest intermingled with open meadows. In the study area (Battle Mtn.) it occurs at 1600 m to 2000 m (5400 – 6600 feet).

A. Comparison of the upper oroboreal and orohemiarctic zones

Abies lasiocarpa is the dominant tree in the orohemiarctic stands, but *Picea engelmannii* is also constant.

Apart from small individuals of *Abies lasiocarpa*, *Rhododendron albiflorum* is the only bush species in the forests, and even it is very rare in the upper parts. Regeneration of *Picea* is not common.

Almost all the species of the orohemiarctic meadows are absent or rare in the preceding zones. Some of the meadow species (e.g. *Luzula parviflora*, *Pedicularis bracteosa*, *Carex spectabilis*, *Anemone occidentalis*, *Phyllodoce empetriformis*, *Viola renifolia* var. *brainerdii*) are also common in the timber-line forests. In the meadows many of them are usually confined to the peripheral parts.

Species common to this and the upper oroboreal zone include *Mitella breweri*, *Osmorhiza purpurea*, *Arnica latifolia*, *Vahlodea atropurpurea*, *Valeriana sitchensis*, *Veratrum eschscholtzii*. Most of the widespread oroboreal species, like *Rubus pedatus*, *Vaccinium ovalifolium*, *Streptopus roseus*, etc, are lacking or very rare in this zone.

The ground layer also differs strikingly from that of the foregoing zone. *Dicranum fuscescens* is very common and abundant, and likewise *Pseudoleskea radicosa*, *Polytrichadelphus lyallii*, *Bryum sandbergii*, and *B. caespiticium*. Hepatics are abundant (*Barbilophozia lycopodioides*, *Orthocaulis floerkei*, etc.)

The trees are very rich in epiphytic lichens: *Alectoria lenerrima*, *A. glabra*, *A. fremontii*,

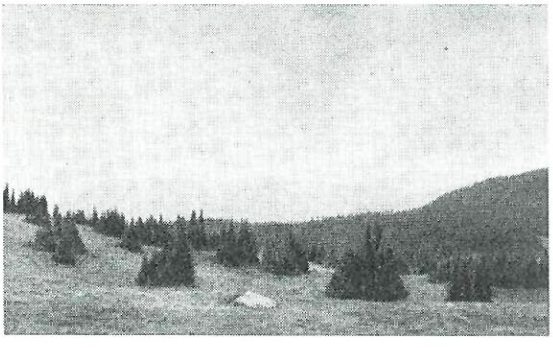

Fig. 8. The orohemiarctic zone on Battle Mtn. The characteristic pattern of alternating tree stands and meadows has not been affected by grazing or recent burns.

A. oregana, *Parmelia enteromorpha*, *P. physodes*, *Parmeliopsis ambigua*, and *P. hyperopta* are very abundant. *Parmelia austerodes* is also constant. *Alectoria sarmentosa* and *Cetraria glauca* are scantier than in the preceding zones.

B. Orohemiarctic stands

a. Climax and subclimax stands

Mesic and mesotrophic stands (sample plots 46 – 52). The tree layer is formed by *Abies lasiocarpa* and *Picea engelmannii*. The forests are richer in *Picea* in the lower part of the zone (sample plots 46 and 47) than in the upper part. The density is variable but more open than in the preceding zone.

The bush layer consists of only a few small individuals of *Abies lasiocarpa*.

The composition of the field layer varies according to the density of the tree stand. It is fairly rich in *Arnica latifolia*, *Luzula parviflora*, *Vahlodea atropurpurea*, and *Valeriana sitchensis*. *Vaccinium membranaceum*, *Carex spectabilis* and *Pedicularis bracteosa* are also frequent. *Tiarella unifoliata* occurs in sample plots 46 – 47, situated in the lower part of the zone.

The ground layer consists of *Pseudoleskea radicosa*, *Polytrichadelphus lyallii*, *Bryum sandbergii*, and *B. caespiticium*.

The soil is fine-sand till. The leached horizon is distinct, 3 – 4 cm, the humus up to 5 cm thick.

Fig. 9. A mesic orohemiarctic stand on Battle Mtn. The tree is *Abies lasiocarpa*. The field layer is very rich in herbs (*Valeriana sitchensis*, *Pedicularis bracteosa*, *Lupinus latifolius* var. *subalpinus*, *Mitella breweri*, *Arnica latifolia*).

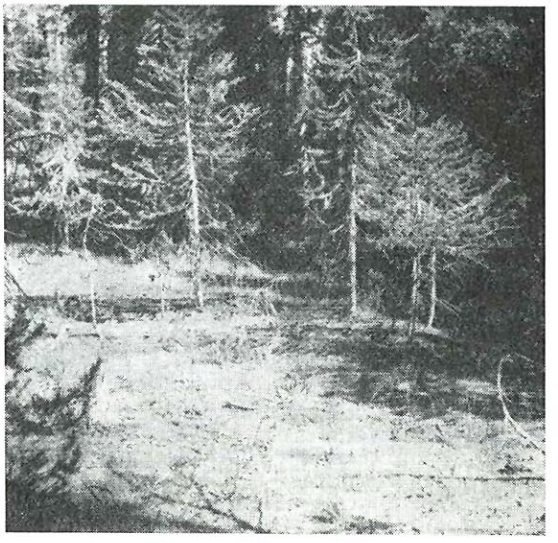

Fig. 10. A fairly dry orohemiarctic stand near Fight Lake on Battle Mtn. The tree layer consists of *Abies lasiocarpa* and *Picea engelmannii*, the bush layer of *Abies lasiocarpa*. In the field layer *Vahlodea atropurpurea* and *Carex spectabilis* are common; the ground layer is covered with a solid mat of *Dicranum fuscescens*.

Fairly dry mesotrophic sites (sample plot 53). The tree layer is similar to the preceding stands, only not so dense.

In the field layer *Vaccinium caespitosum* and *Phyllodoce empetriformis* are dominant and *Vaccinium membranaceum* is abundant. The other species also occur in mesic sites.

In the ground layer *Dicranum fuscescens* is often dominant, and *D. scoparium* and *Pohlia nutans* are common. Scattered individuals of *Polytrichadelphus lyallii*, *Lescuraea radicosa*, *Barbilophozia lycopodioides*, and *Orthocaulis floerkei* occur.

The soil is stony sandy till. The leached horizon is 4 cm and the humus 2 cm thick, containing some charcoal.

»*Luetkea pectinata forests*». On the north slope of Battle Mtn. and also on Fish Lake Hill outside the park boundary there are extensive forests in which the field layer is dominated by *Luetkea pectinata* and sporadically by *Phyllodoce empetriformis*. Drink (1959) described similar forests in Garibaldi Park, British Columbia, considering them to be characteristic of places of late snow-lie. This is apparently also true in the Wells Gray area.

b. Seral stands

The regeneration of the forests is often very poor and meadows take their place for a long time after a fire. *Abies lasiocarpa* is the first tree species to invade these sites. Otherwise, luxuriant herb and grass vegetation (e.g. *Veratrum eschscholtzii*, *Carex spectabilis*) develops. In young burns *Anaphalis margaritacea* and *Epilobium angustifolium* may become abundant.

5. The distribution of the forests similar to Wells Gray Park in western North America

Forests similar to the lower and middle oroboreal types occurring in Wells Gray Park are found along the western slopes of the mountains southward to northern Idaho and Montana (cf. KIRKWOOD 1922, LARSEN 1930, ILVESSALO 1929, DAUBENMIRE 1952) and northward at least to Prince George (KUJALA 1945, ILLINGWORTH and ARLIDGE 1960). On some eastern slopes of Hazelton Mountains (near Smithers, Hazelton, etc.) in the Coast Range, similar or almost similar forests have also been described by KUJALA (1945). Obviously, all these areas are connected by identical or closely related bioclimatic sections of the lower and middle oroboreal zones and also by a similar floral history.

On the other hand, the upper oroboreal forest types of Wells Gray Park and their variants are confined to the eastern interior of British Columbia (cf. SMITH 1955, F.H.B.C. 1959). The descriptions of the upper oroboreal forests from Idaho and elsewhere are very different (cf. DAUBENMIRE 1952, etc.). The only comparable orohemiarctic stands known to me were reported by DRINK (1959) from Garibaldi Park, southwestern British Columbia. However, the very scanty information available on the upper boreal and orohemiarctic forests does not allow definite conclusions to be drawn regarding their distribution outside the study area.

V. A preliminary outline of the vegetation zones and sections of British Columbia

My map of the vegetation zones and sections of British Columbia. (Fig. 11) is *only provisional.* The zonal limits on the map are based on several papers concerning British Columbia and the adjacent areas mentioned in the text. The concepts »dry» or »arid» and »humid» are used only schematically. The very *rough limits* between the dry and humid sections are outlined partly according to the moisture region maps of Canada (SANDERSON 1948 b, 1950, KENDREW and KERR 1955) and partly according to different phytogeographical and floristic papers. More detailed section boundaries would have required more field experience than I have. It is particularly difficult to decide, without thorough studies, whether certain limits are zonal or sectional. Earlier this difficulty has been largely avoided by the use of a special, local nomenclature (e.g. ROWE 1959, KRAJINA 1964) which is not directly linked with the great circumpolar and transcontinental divisions.

1. Boreomeridional zones

This zone exists in British Columbia at least around the Strait Gulf and in the Okanagan Valley near the Washington boundary.

The *arid section* occurring in the Okanagan valley is called »Osoyoos Arid» by COWAN and GUIGUET (1960), and according to KÜCHLER (1964) this area joins the *Festuca - Agropyron* grassland of Washington.

The *summer-dry section* occupies the southeast side of Vancouver Island and the rocky islands in Georgia Strait. According to SANDERSON (1948 b), this area is moist subhumid. It is called by MUNRO and COWAN (1944) and, following their usage, by LYONS (1959) »Gulf Islands zone», by COWAN and GUIGUET (1960) »Gulf Islands biotic area» and by ROWE (1959) the »Strait of Georgia section» of the »coast forest region». KRAJINA (1964) named this section the »Garry oak – Douglas-fir subzone» of the »coastal Douglas-fir zone». SPILSBURY and SMITH (1947) published an excellent description of the forest types and HARDY (1957) presented notes on the flora of this section.

The *humid section* (or section group) ranges from the lowermost Fraser Valley to the southernmost part of Vancouver Island. KRAJINA (1964) called this section by the name »Madrono – Douglas-fir subzone» of the »coastal Douglas-fir zone». COWAN and GUIGUET (1960) distinguished the delta of the Fraser River as a »Puget Sound

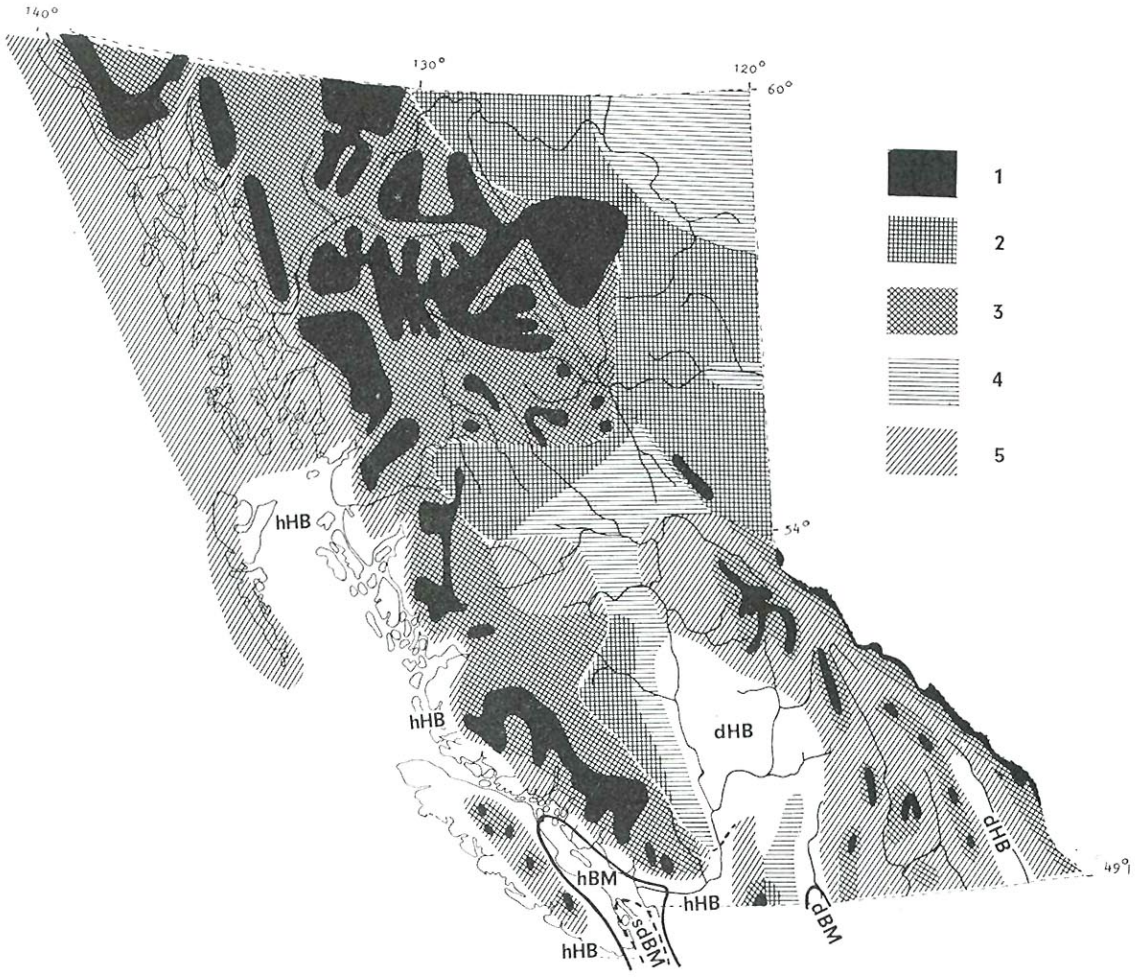

Fig. 11. The vegetation zones of British Columbia. 1 = oroarctic and orohemiarctic. 2 = dry upper oroboreal and dry middle oroboreal. 3 = humid upper oroboreal and humid middle oroboreal. 4 = dry southern boreal (lower oroboreal). 5 = humid southern boreal (lower oroboreal). dHB = dry hemiboreal. hHB = humid hemiboreal. dBM = dry boreomeridional. sdBM = summer-dry boreomeridional hBM = humid boreomeridional.

Lowlands biotic area». The »Douglas fir – red cedar type» (Whitford and Craig 1918) in the coastal area of B.C., the »*Tsuga – Thuja*» and the »*Picea – Tsuga* climax» (Jones 1936) on the Olympic Peninsula, Washington, the »cedar – hemlock forests» (Weaver and Clements 1938) and the »*Picea – Thuja – Tsuga*» and the »*Thuja – Tsuga – Pseudotsuga* forests» (Küchler 1964) in the western United States are obviously chiefly referable to this section group but also include some hemiboreal vegetation. Hansen (1947) published an excellent description of the boreomeridional forests in northwestern U.S.A. Eis (1962) described four boreomeridional forest associations (»Salal, Mahonia, Moss, and *Polystichum*») from the vicinity of Vancouver. Becking (1956) reported 10 boreomeridional associations of the Douglas fir forests of Washington and Oregon (Polysticheto-Pseudotsugetum asaretosum caudatae, Polysticheto-Pseudotsugetum tiarelletosum laciniatae, Polysticheto-Pseudotsugetum trillietosum chloropetalae, Gaultherieto-Pseudotsugetum chimaphiletosum, Gaultherieto-Pseudotsugetum arbutetosum menziesii, Gaultherieto-Pseudotsugetum cladinetosum, Gaultherieto-Pseudotsugetum quercetosum garryanae, and

Gaultherieto-Pseudotsugetum sitchensetosum). KUJALA's (1945, p. 402) southern maritime area is boreomeridional.

2. Hemiboreal zone

The hemiboreal zone occurs in the Kootenay Plains, in the valleys of the Okanagan, Similkameen and Lower Fraser Rivers, and along the coast up to the Alaskan boundary.

The *driest sections*, which are found in the Okanagan, Similkameen and Columbia valleys, are covered by savannah-like stands (forest steppe) of *Pinus ponderosa* and (or) *Pseudotsuga menziesii* var. *glauca*. SPILSBURY and TISDALE (1944) divided them into the »lower, middle and upper grasslands» and gave 960 m (3200 feet) as their upper limit. TISDALE (1950) referred them to the »grasslands» and the »Ponderosa pine zone», which, according to him, did not reach north of latitude 51. DAUBENMIRE (1942, 1952) used the name »*Pinus ponderosa* zone» in northern Idaho. MCLEAN and HOLLAND (1958) called them the »Douglas fir groveland subzone» in the upper Columbia Valley. ROWE (1959) distinguished a »lower parkland of open ponderosa pine» from the »ponderosa pine and Douglas fir section of the montane forest region». KRAJINA (1959, 1964) described a »Ponderosa pine – bunchgrass zone». Likewise the »sagebrush type», the »grass and semiopen forest types» and the »yellow pine type» mentioned by WHITFORD and CRAIG (1918) are obviously very dry hemiboreal.

The *dry sections* occur in the Interior Dry Belt above and to the north of the driest sections between the altitudes 960 and 1200 m (3200 – 4000 feet) near Kamloops, according to SPILSBURY and TISDALE (1944), who called them »Montane zone». TISDALE (1950) and TISDALE and MCLEAN (1957) referred the same areas to the »Douglas fir zone» ranging approximately to latitude 53. MCLEAN and HOLLAND (1958) reported it under the name »Douglas fir forest subzone», reaching 1050 m (3500 feet) in the upper Columbia Valley. According to KRAJINA (1959, 1964), they appear in the southeast of B.C. at 300 – 700 m (1000 – 2500 feet), in the southwest at 600 – 1200 m (2000 – 4000 feet) and in the north at 450 – 900 m (1500 – 3000 feet). He used the name »interior Douglas-fir zone», in which he obviously also included some dry lower oroboreal (southern boreal) areas. ROWE (1959) placed them under the name »central Douglas fir section of montane forest region». Similarly, the »interior Douglas fir type» of WHITFORD and CRAIG (1918) and of F.C.T.N.A. (1954) and »dry forest» of COWAN and GUIGUET (1960) belong chiefly to these sections. ILLINGWORTH and ARLIDGE (1960) described some lodgepole pine forest site types from the interior of B.C.; their *Calamagrostis*, *Calamagrostis – Vaccinium scoparium* and *Calamagrostis – Arctostaphylos* site types are obviously hemiboreal. In Washington and Oregon, east of the crest of the Cascades. SCOTT (1962 a) referred the »interior Douglas fir forests» to the Canadian zone, as its lower subzone.

I am uncertain as to the correct interpretation of these Douglas fir forests but obviously they belong partly to the hemiboreal and partly to the southern boreal (lower oroboreal) zone and more detailed studies are needed before the limit between these two zones in the interior of B.C. can be drawn.

A list of vascular plants from a typical dry hemiboreal area, Lac la Hache, has been published by CARL and HARDY (1942).

The *humid sections* occur along the coast at lower elevations from the Fraser Valley (cf. MCMINN 1951) northward to *about* the Alaskan boundary, on Vancouver Island and in the eastern portions of the Queen Charlotte Islands. They are found only at lower altitudes, in the southernmost part above the boreomeridional zone (orohemiboreal), and in the northernmost portion also at the sea-level.

KRAJINA (1959, 1964) referred these hemiboreal sections to his »coastal western hemlock zone», which he subdivided into a »Douglas-fir – western hemlock» and a »Pacific silverfir – western hemlock subzone», both of which are obviously good sections in my system. ROWE (1959) included these sections in the »Southern Pacific coast», the »Northern Pacific coast» and the »Queen Charlotte Islands» sections of his coastal forests. According to DAY (1957), the lower altitudes in the northern part of the Queen Charlotte Islands are obviously very similar to the area around Terrace on the continent and thus it is not necessary to distinguish these islands entirely from the continent in biotic treatments, as many authors have done (e.g. COWAN and GUIGUET 1960).

The »red cedar – hemlock type» described by WHITFORD and CRAIG (1918) for the coast is obviously chiefly hemiboreal, like KÜCHLER's (1964) *Pseudotsuga* forests in Washington. MACNAB's (1958) paper contains some notes on similar forests in northwestern Oregon. EIS (1962) de-

scribed five hemiboreal forest associations (*Vaccinium – Gaultheria, Vaccinium* – Moss, *Blechnum, Vaccinium – Lysichitum* and *Ribes – Oplopanax*) from the vicinity of Vancouver. SCHMIDT (1957) also discussed these forests. STANEK and KRAJINA (1964) described several associations from Long Beach, Vancouver Island, which seem to be hemiboreal, CARL, GUIGUET and HARDY (1950) published floristic notes from the Scott Island group, which, at least in its lower parts, belongs to this zone, as does also Goose Island (GUIGUET 1953). Forest associations on the east and west coasts of Vancouver Island and in the southern montane forest region in B.C. mentioned in F.H.B.C. (1959, p. 582 – 594) are chiefly hemiboreal. BECKING's (1956) »Polysticheto-Pseudotsugetum montanum» and »Gaultherieto-Pseudotsugetum montanum» are obviously hemiboreal. KUJALA's (1945, p. 398 – 401) »arid, subarid and subhumid Central European region», »South European region» and »submaritime and northern maritime area» are chiefly hemiboreal.

3. Southern boreal zone

The southern boreal zone occupies most of the northeastern corner of British Columbia and the lower course of the Peace River, and reaches some northwestern valleys on the coast of the Alaska Panhandle. Its altitudinal counterpart, the lower oroboreal zone, occurs widely in the southern and central parts of the province.

The *dry southern boreal* (partly *lower oroboreal*) sections occur in the Peace River Lowland, which is in parts semiarid (cf. SANDERSON 1948 a) and therefore not always covered with continuous forests but forest steppe (cf. WHITFORD and CRAIG 1918, RAUP 1934, Moss 1952, etc.), and in the northeasternmost corner of British Columbia, which is dry subhumid (SANDERSON op. cit.). These areas are climatically part of the cultivated tract of Northwestern Alberta (cf. CURRIE 1948, etc.). They are called by several names in B.C. and Alberta: »Parkland prairie» and »Boreal Cordilleran Transition region» (Moss 1955),»Peace River aspen – white spruce parkland» (KRAJINA 1959, 1964), »Peace River parkland» (LYONS 1959, COWAN and GUIGUET 1960), »Aspen grove section» and »mixed wood section of boreal forest region» (ROWE 1959). The vegetation of these areas, chiefly in Alberta, has been fairly well studied by Moss (1952, 1953, 1955) and others (LEWIS et al. 1928; Moss and PEGG 1963). JEFFREY's (1964) »mixed coniferous forests, low elevation» along the Liard River in Mackenzie District, Northwest Territories, are apparently southern boreal, and obviously strips of this zone extend along the river valleys up to southern Yukon and Alaska (cf. RAUP 1934, 1945, 1947, PORSILD 1951, DAUBENMIRE 1953, JEFFREY 1961, etc.).

The *dry lower oroboreal sections* of the interior of B.C. include narrow strips above the hemiboreal zone in the south, especially on the east slopes, and a vast area in the north. These sections have often been included in the subalpine forest (COWAN and GUIGUET 1960, LYONS 1959), on account of the dominant tree species, *Abies lasiocarpa* and *Picea engelmannii*. However, the zonal range of such forests is from the lower boreal up to the orohemiarctic (cf. GARMAN 1957, FRASER and ALEXANDER 1949) WHITFORD and CRAIG's (1918) »white spruce – alpine fir type» and »Engelmann spruce – alpine fir type, or lodgepole pine type» occur in both these and the middle oroboreal sections. DAUBENMIRE (1953) described the »*Picea glauca* forb-rich forest» occupying the lower slopes of the mountains from Prince George to Whitehorse, Yukon. It seems to be chiefly southern boreal to lower oroboreal or perhaps, partly middle (oro)boreal. GLEW (1963) has also discussed these forests. KRAJINA's (1959, 1964) »Cariboo aspen – lodgepole pine – Douglas – fir parkland» is apparently part of this zone, as well as ROWE's (1959) »northern aspen section» and »montane transition section» of his montane forest region and COWAN and GUIGUET's (1960) »Cariboo Parklands». ILLINGWORTH and ARLIDGE's (1960) *Cornus* – Moss and *Arctostaphylos* – Lichen site type from the interior of B.C. quite obviously belong to these sections.

The *humid lower oroboreal* sections occupy the heavily forested *lower altitudes* of the Interior Wet Belt, which are referred to the »Columbia forest» region by ROWE (1959) and COWAN and GUIGUET (1960), to the »Interior western hemlock zone» by KRAJINA (1959, 1964), to the »Cedar-hemlock zone» and the »spruce – fir zone» by MCLEAN and HOLLAND (1958), to the »Interior Wet Belt» by LYONS (1959), and to the »Cedar types of the Interior Wet Belt» by WHITFORD and CRAIG (1918). ILLINGWORTH and ARLIDGE (1960) published excellent descriptions of the forest types of this section from the vicinity of Prince George. The lowermost portions of these

may be partly hemiboreal, but this point needs further study. According to my observations in Wells Gray Park, this zone is represented below 900 m (3000 feet).

On Vancouver Island and elsewhere on the coast this zone has *very humid sections* above the hemiboreal zone up to the Alaskan border and from there along the coast (cf. GODMAN 1952) up to the Kenai Peninsula (cf. COOPER 1942, SCOTT 1962 b, etc.) and obviously also to the valleys of White Pass, the Taku, Stikine and Iskut Rivers, and the Portland Canal. DAUBENMIRE (1953), for instance, has given an excellent description of a southern boreal forest at Haines, B.C. Obviously the west side of the Queen Charlotte Islands largely falls into this zone. There, and also in Alaska, the most maritime parts of this zone may be treeless *Empetrum* heaths or grasslands (cf. COOPER 1942). Ecologists have not generally distinguished this section group but included it in the »coastal forests» (LYONS 1959, ROWE 1959, COWAN and GUIGUET 1960) or the »coastal western hemlock zone» (KRAJINA 1959, 1964), which thus in its upper parts belongs to the lower oroboreal zone (and perhaps partly even to the middle oroboreal zone). WHITFORD and CRAIG's (1918) »western hemlock – Sitka spruce type» and »western hemlock – balsam fir type» are obviously chiefly southern boreal, possibly including middle boreal forests like KÜCHLER's (1964) »*Abies – Pseudotsuga*», »*Thuja – Tsuga – Pinus*» and »*Picea – Abies*» forests in Washington and Oregon and LARSEN's (1930) »mesophytic transition forests» in Idaho and eastern Washington. KUJALA's (1945, p. 395 – 400) »Central-Southern Finnish region» consists of both lower and middle oroboreal forests; his »humid Central European area» is obviously lower oroboreal.

4. Middle (oro)boreal zone

This zone obviously covers very extensive areas in the north of the province, where the climate is relatively dry, particularly in the northernmost and eastern portions. Those regions are referred to the »northern foothills, upper foothills, upper Mackenzie, upper Liard and Stikine Plateau sections of the boreal forest region» by ROWE (1959), to the »Boreal forests» by LYONS (1959) and by COWAN and GUIGUET (1960), and to the »boreal white and black spruce zone» by KRAJINA (1959, 1964). In F.C.T.N.A. (1954) the »white spruce type» and »white spruce – birch type» are obviously middle oroboreal (middle boreal). Illustrative data of these forests are also to be found in RAUP's (1954, 1947), PORSILD's (1951) and DUFFY's (1964) papers.

The middle oroboreal zone also exists as relatively narrow strips above the lower oroboreal zone in the more southern mountains. In the Interior Dry Belt they seem generally to be included in the »Petran subalpine forests» (WEAVER and CLEMENTS 1938), in the »Engelmann spruce – subalpine fir type» (F.C.T.N.A. 1954), or in the »subalpine forests» (LYONS 1959, ROWE 1959, KRAJINA 1959, 1964, COWAN and GUIGUET 1960), or partly in the »cedar – hemlock» and »spruce – fir» zones (MCLEAN and HOLLAND 1958). In the humid interior of B.C. they are referred to the »Columbian forests» (ROWE 1959, COWAN and GUIGUET 1960), to the »Interior Wet Belt» (LYONS 1959) or to the »Interior western hemlock zone» (KRAJINA 1959, 1964). In Wells Gray Park this zone occurs between 900 – 1200 m (3000 – 4000 feet).

On the coast and Vancouver Island the middle oroboreal zone has partly – perhaps – been included in the »Sierran subalpine forests» (WEAVER and CLEMENTS 1938), in the »mountain hemlock – subalpine fir type» (F.C.T.N.A. 1954), in the »coastal subalpine section» (ROWE 1959), and in the »subalpine mountain hemlock zone» (KRAJINA 1959, 1964). PETERSON (1964) and KRAJINA (1964) have divided the subalpine mountain hemlock zone in southern British Columbia into two subzones, the lower of which is obviously middle oroboreal. Probably WHITFORD and CRAIG's (1918) »hemlock – amabilis fir type» is middle oroboreal (their »Engelmann spruce – alpine fir type or lodgepole pine type» and »white spruce – alpine fir type» are also partly middle boreal, cf. p. 00). KUJALA's (1945, p. 395 – 398) Central-Southern Finnish region» also consists of some middle oroboreal forests. DAUBENMIRE (1953, p. 136) has published a description of a middle oroboreal forest in Alaska in the area 75 km north of Haines, British Columbia, at an elevation of 460 m (1510 feet).

At sea level this zone seems to appear to the west of the Kenai Peninsula, Alaska, where, for instance, *Tsuga mertensiana* comes down to the sea (F.C.T.N.A. 1954), and where it also occurs as *Empetrum* heaths and maritime grasslands, which are for the most part completely treeless (cf. HULTÉN 1937, GRIGGS 1934, 1936, HOPKINS 1959, etc.).

5. Upper oroboreal zone

The upper oroboreal zone is the uppermost *continuously* forested zone in the greater part of British Columbia. Only in maritime areas (at sea level) is this zone sometimes unwooded, as on the Aleutian Islands (cf. HULTÉN 1960, TATEWAKI 1958) and in Iceland and Scotland, but I have not been able to find any records concerning this phenomenon in British Columbia. The *Alnus* thickets and heaths dominated by *Empetrum* mentioned by DAUBENMIRE (1953) and others from southeastern Alaska may be upper oroboreal (or hemiarctic).

Usually this zone has been included in the subalpine forests in the central and southern parts of the province (LYONS 1959, COWAN and GUIGUET 1960). There it is almost always more or less humid. Only on the eastern slope of the Coast Range (cf. CARL et al. 1952) are quite dry sections to be found. Indeed, some authors have distinguished between the inland and coastal subalpine forests (WEAVER and CLEMENTS 1938, ROWE 1959, KRAJINA 1959, 1964). In northern B.C. the upper oroboreal zone has been included in the »boreal forests» (ROWE 1959, LYONS 1959, COWAN and GUIGUET 1960). KUJALA's (1945, p. 394) »northern Finnish region» is middle and upper oroboreal.

In Wells Gray Park this zone is situated between 1200 – 1600 m (4000 – 5500 feet). SHAW (1916) mentioned 1400 – 1900 m (4600 – 6300 feet) for what seems to have been the same zone in the Selkirk area, but in which the orohemiarctic zone was apparently included, partly at least.

PETERSON's (1964) and KRAJINA's (1964) upper subzone of the mountain hemlock zone is upper oroboreal. WHITFORD and CRAIG's (1918) »subalpine forest types» are obviously upper, and partly – perhaps – middle oroboreal. SMITH (1955) published photographs of the *Vaccinium membranaceum – Rubus pedatus* and *Vaccinium ovalifolium – Dryopteris linnaeana* associations from Bolean Lake (east of Kamloops) at the altitude 1500 m (5000 feet), which seem to be upper oroboreal like the subalpine forest associations mentioned in F.H.B.C. (1959, pp. 606 – 609).

6. Orohemiarctic zone

This zone is a narrow, poorly known strip below the oroarctic zones. In more or less continental mountains it consists of forest stands or solitary trees and meadows. Near the coast the forest stands are often intermingled with heaths and grasslands, and it is even possible that it may appear fully treeless there.

I hope to deal with the distribution of this zone in connection with the timber-line meadows and heaths in a forthcoming paper.

VI. Summary

In Wells Gray Provincial Park, east-central British Columbia, forest site types and their zonal distribution have been studied. A preliminary outline of the vegetation zones and sections below the oroarctic (alpine) zones in the whole of British Columbia has also been presented. The present system, in which both horizontal and vertical zonations are combined under the same units, has been used before by the author in northwestern Europe. In British Columbia six zones occur, one of which (boreomeridional) is only horizontal, two (hemiboreal – orohemiboreal and southern boreal – lower oroboreal) being both horizontal and vertical, and the others (middle oroboreal, upper oroboreal, orohemiarctic) apparently only vertical. In all these zones many subdivisions, called sections, may be distinguished according to their humidity.

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