A Preliminary Biological Survey of the North Cascades National Park and the Ross Lake and Lake Chelan National Recreation Areas

March 1, 1969

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A PRELIMINARY BIOLOGICAL SURVEY OF THE NORTH CASCADES NATIONAL PARK AND THE ROSS LAKE AND LAKE CHELAN NATIONAL RECREATION AREAS

Prepared for the National Park Service

by

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March 1, 1969

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INTRODUCTION

The North Cascades National Park and the Ross Lake and Lake Chelan National Recreation Areas were established on October 2, 1968. This North Cascades Complex comprises about 675,000 acres of majestic mountains in the North Cascades of Washington.

This rather inaccessible area has received very little scientific attention, with only the geology of the complex being well known. Pertinent publications in other fields of science are quite rare. Obtaining references which pertained to or were applicable to the North Cascades was a major endeavor, as was contacting people familiar with various aspects of the complex. However, the short ten-week period during which this survey was written did not allow all leads to be followed and some references may have been inadvertently omitted. The information from the various sources, as well as my own data, has been summarized and hopefully presents the most complete description of the present biological conditions within the complex.

I would like to thank Dr. David R. M. Scott for helpful suggestions during the writing of this survey and for reviewing the final manuscript. Appreciation is also due Dr. Tim M. Ballard, James G. Bockheim, Dr. Roger del Moral, Dr. Jerry F. Franklin and Dr. Gordon H. Orians for reviewing sections of the manuscript.

I am particularly grateful for the aid of Drs. C. Leo Hitchcock and Arthur R. Kruckeberg, who assisted in the determination of the more difficult plant genera. I am also indebted to Dr. Elva Lawton, who identified the mosses, and Dr. Grace E. Howard, who identified the lichens. Noel H. Holmgren of the New York Botanical Garden determined

the *Castilleja* species and Dr. F. J. Hermann of the U. S. National Herbarium identified the *Carex*, *Juncus* and some of the Graminae species.

Jim Duemel, Gary Koehler and Terry R. Wahl contributed many additional species and up-to-date information to the bird checklist. Dr. Gordon H. Orians aided in the habitat determinations of the avifauna.

PHYSIOGRAPHY

The most prominent feature of the North Cascades National Park and the Ross Lake and Lake Chelan National Recreation Areas is the high rugged mountains comprising most of the area (see figure 1). This North Cascades Complex is part of the northern Cascade Mountains which extend from near Snoqualmie Pass to the International Boundary.

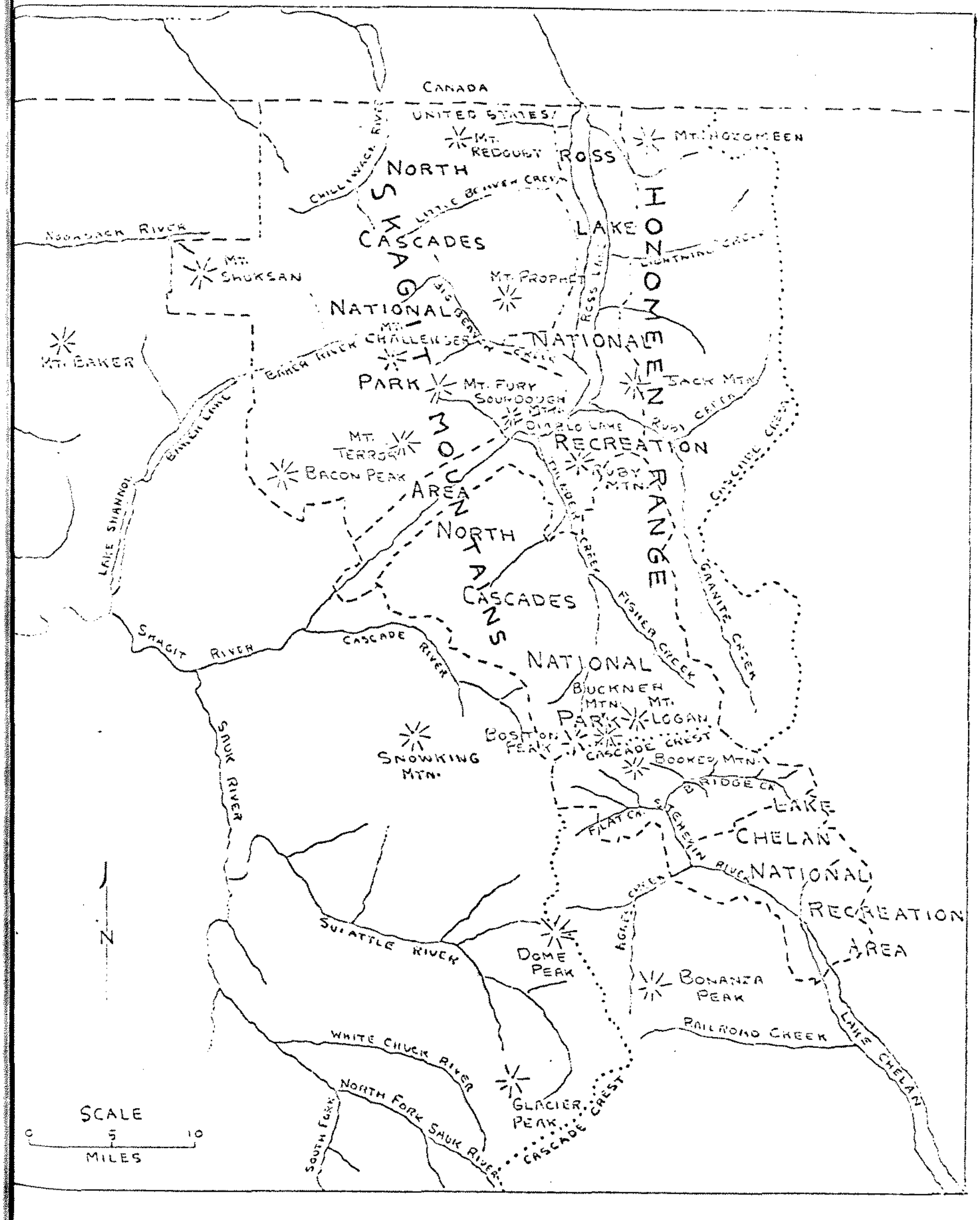
On a physiographic basis the mountains may be subdivided into three ranges, two of which occur within the complex (see figure 2). The most western of the subranges is known as the Skagit Mountains. These mountains, which include most of the North Cascades National Park, begin at the Cascade crest and veer northwest, continuing east of Mt. Baker and into Canada. The jagged peaks and ridges, frequently reaching elevations of 7000 to 9000 feet, have a maximum relief of about 8500 feet. Some of the higher mountains are Mt. Shuksan, Mt. Redoubt and Mt. Challenger.

The second range of mountains has been named the Hozomeen Range. This range forms the eastern boundaries of both the Ross Lake National Recreation Area and the south unit of the National Park, before cutting through the lower third of the southern unit. The range begins just north of the International Boundary, where many of the mountains, although high, are relatively gentle. It becomes equally as rugged as the Skagit Mountains as one proceeds south. The maximum relief is about 7000 feet, with some of the higher mountains (Mt. Logan, Boston Peak and Buckner Mtn.) reaching elevations of over 8800 feet.

The mountain massif is dissected by numerous tributaries of the several large streams emerging from the range. The Skagit River System,

Figure 1. View of the north unit of the North Cascades National Park. Picket Range in center. Photo by Max R. Jensen, August, 1968.

Figure 2. Map of the North Cascades Complex.



the largest drainage system of the North Cascades Complex, drains most of the National Park and the entire Ross Lake National Recreation Area. Some of the larger tributaries of the Skagit include the Cascade and Baker Rivers and Thunder, Ruby and Big Beaver Creeks. These tributaries originate in glacial cirques or at glacial termini and flow through wide steep-sided "U"-shaped valleys. Streams flowing east and draining the south unit of the National Park and the Lake Chelan National Recreation Area include Bridge Creek and Flat Creek, tributaries of the Stehekin River, which flows into Lake Chelan.

Many of the lakes of the Complex are situated at the headwaters of the tributaries. These numerous alpine lakes are usually cirque lakes occurring above 2500 feet. Lake Chelan, Ross Lake and Diablo Lake are found in the two National Recreation Areas. The latter two are manmade and fill canyons and valleys where the Skagit River once flowed.

Contributing even more to the modification of the North Cascades than the numerous tributaries was the glaciation caused by both continental and alpine glaciers. Many of the alpine glaciers are still retained by the high rugged mountains of the area. The glaciers include hundreds of hanging and small cirque glaciers and several extremely large cirque glaciers. These glaciers (north of Snoqualmie Pass and exclusive of Mt. Baker and Glacier Peak) encompass an area estimated at 125 square miles, or approximately 50% of the total glacierized area in the contiguous United States (Hubley, 1956).

GEOLOGY

Introduction to Bedrock Geology

The North Cascades are part of the North American Cordillera, which extends from northern Central America into Alaska. This 5000-mile-long mountain belt is bounded by the Pacific Ocean on the west and the interior of the continent on the east.

The history of the cordillera, from Paleozoic to late-Mesozoic time, follows the classic eugeosynclinal-miogeosynclinal pattern. During late-Mesozoic time it underwent several climactic orogenies. After this the history becomes more confused or obscured by numerous superimposed events and processes (King, 1966).

This summary will first review the work of geologists in the North Cascades. The geological description will be restricted to the area within the North Cascade Complex.

Early Workers

It is likely that the first geologists to visit the North Cascades were members of the first parties of the International Boundary Commission in 1859-1861. Gibbs (1874) described the physical geography along the boundary, while Baurman (1885) described the rock units encountered along a route that may have been further south over Whatcom Pass (Smith and Calkins, 1904, p. 16).

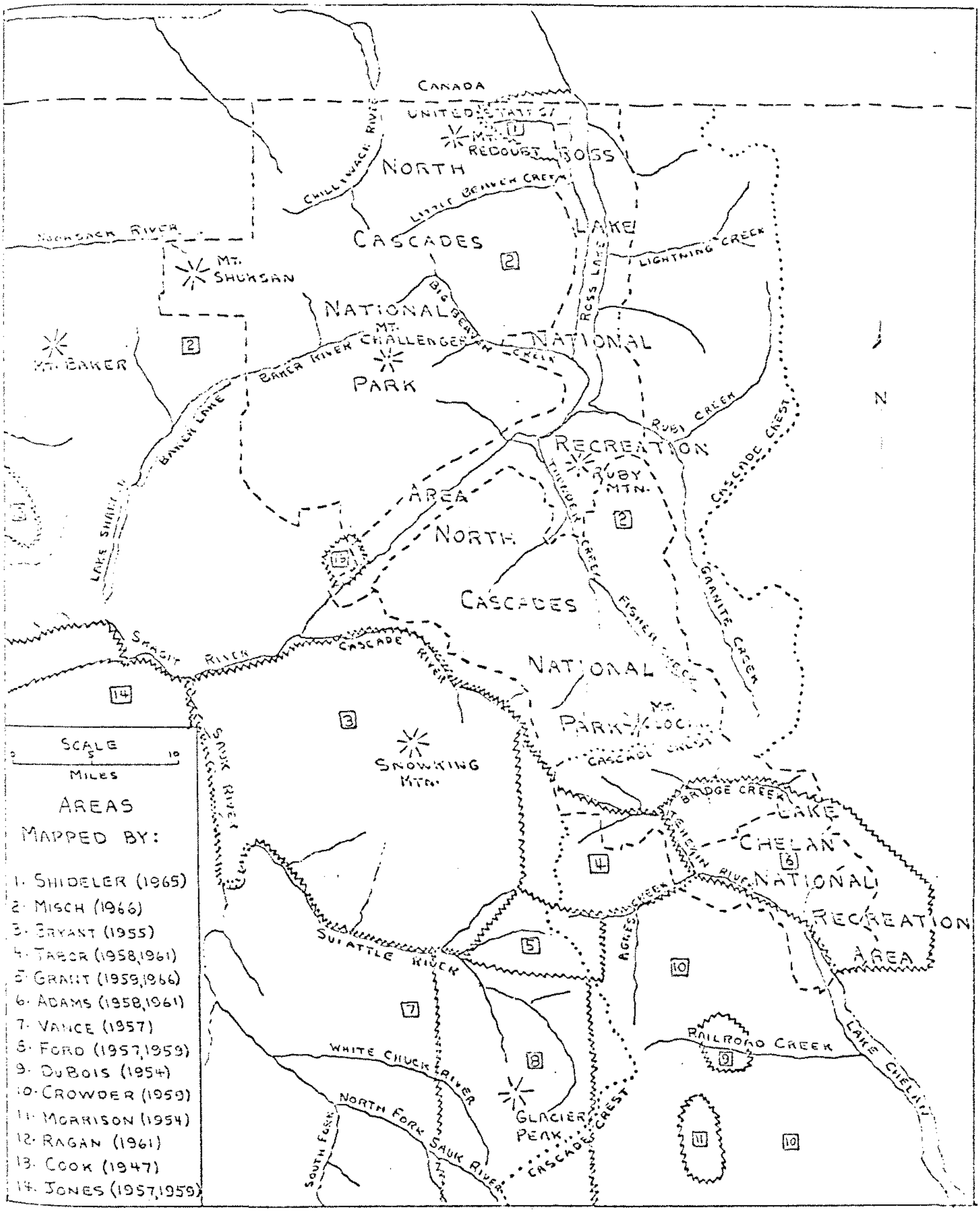
In 1898 I. C. Russell, during a reconnaissance trip, travelled up the Cascade River to Cascade Pass and back, up the Skagit River, then along Ruby Creek and up to Hart's Pass (Russell, 1890). The next men to visit and describe the area were G. O. Smith and F. C. Calkins (1904), who in 1901 made a traverse from Windy Pass on the Cascade crest to the Skagit River. R. A. Daly (1903, 1907, 1912) worked from 1901 to 1906 along both sides of the boundary through the North Cascades. In 1903 Bailey Willis (1903) travelled up the Stehekin River and Bridge Creek. He studied the glacial and physiographic history of the Stehekin valley. C. E. Cairnes (1924) travelled along the Skagit River, near Ross Lake, and up the Silver Creek drainage. Coombs (1939) studied the Mt. Baker volcano.

Recent Workers

The first extensive geologic mapping project in the North Cascades was initiated by Peter Misch of the University of Washington in 1949 (Misch, 1966). Misch (1951, 1952a, 1952b, 1956, 1959, 1960, 1961, 1962, 1963) mapped and described most of the Cascades north of the Cascade River and the upper Stehekin River (see figure 3). Papers by Miller and Misch (1963) and Misch and Mallory (1956) describe the bedrock geology of the area.

It was not, however, until 1964 that a complete summary was made of the entire North Cascade Range (Misch, 1966). During the period of Misch's work, his students mapped most of the remainder of the North Cascades while completing their theses (see figure 3). Shideler, Jr. (1965) mapped the area around Silver Creek near the north end of Ross Lake. Further to the west, Ragan (1961) mapped the dunite formation of the Twin Sisters Range. Just south of the Twin Sisters Range, Jones (1957, 1959) mapped the Higgins Mountain area and the nearby Finney Peak area. Bryant (1955) mapped the Snowking Mountain area. The Cascade Pass area to the east of this was mapped by Tabor (1958,

Figure 3. Index Map of the North Cascades.



1961), while Grant (1959, 1966) mapped the Dome Peak area. Adams (1958, 1961) mapped the area east of the Stehekin River. Morrison (1954) mapped the Phelps Ridge area and Du Bois (1954) mapped the area of the Holden Mine. These last two are both in the Holden quadrangle just east of Glacier Peak. The Glacier Peak quadrangle was mapped by Ford (1957, 1959). Vance (1957) mapped the Sauk River to the west of Glacier Peak.

Several others have also worked in the North Cascades. Cook (1947) worked on the lower Bacon Creek area. Maps of adjacent areas on the Canadian side of the International Boundary have been published by the Geological Survey of Canada (Rice, 1959) and the British Columbia Department of Mines (1960). The Holden quadrangle was completed in 1956 (Misch, 1966). A Washington state geologic map by Hunting, et al (1961) includes all work up to 1960 in the North Cascades.

Bedrock Geology

The complex geologic history of the North Cascades ranges from Tertiary to pre-Middle Devonian times. The following geologic description is derived, for the most part, from the work of Misch and his students. A map (see figure 4) taken from Misch (1966, Plate 7-1) shows the rock units of the North Cascades Complex and nearby areas. These units, along with the major tectonic events, will be described in order of decreasing age.

The pre-Middle Devonian basement rocks of the area indicated an involved history of numerous metamorphic, igneous and migmatic events (Misch, 1966). These basement rocks were first recognized and named the Yellow Aster Complex in 1958 (Misch, 1960, 1962, 1963; Miller and Misch, 1963).

Figure 4. Geologic Map of the North Cascades Complex
(Legend on following page)

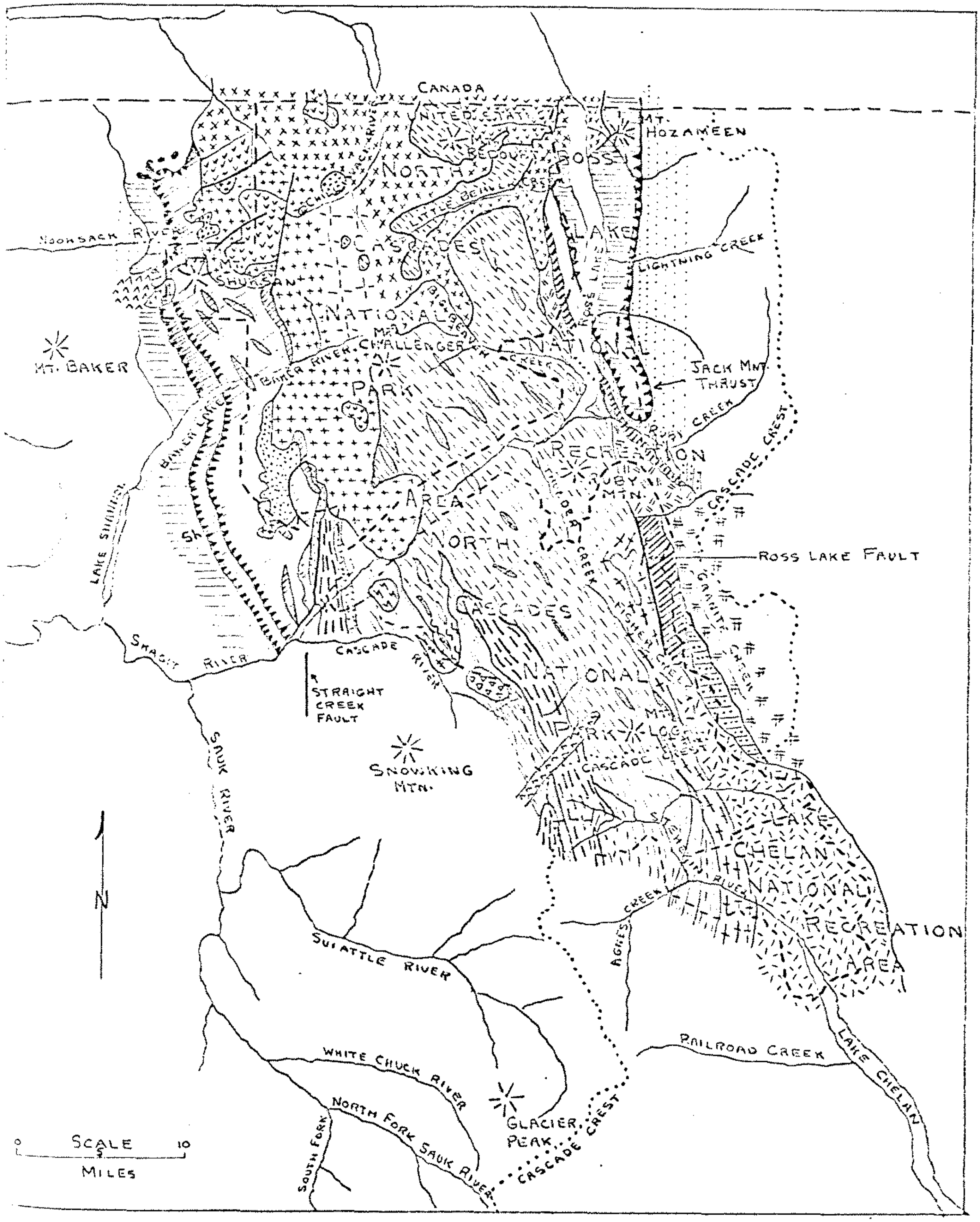


Figure 4. - Legend

CRYSTALLINE BASEMENT COMPLEX

Allochthonous slices associated with the Shuksan Thrust

Autochthonous belts associated with the Skagit Metamorphic Suite ← W. belt; Marblemount Meta Quartz Diorite / E. belt; Eldorado Orthogneiss → Yellow Aster Complex

SHUKSAN METAMORPHIC SUITE

Shuksan Greenschist

Darrington Phyllite

SKAGIT METAMORPHIC SUITE

Skagit Gneiss

± isochemical remnants in Skagit Gneiss

Low-grade

Medium-grade

→ Cascade River Schist

GRANITIC INTRUSIVES ASSOCIATED WITH SKAGIT METAMORPHIC SUITE

Alma Creek Leucotrondhjemite, latest-metamorphic intrusive

Haystack Creek Leucotrondhjemitic Gneiss, late-metamorphic intrusive

Marble Creek Orthogneiss, pre-metamorphic intrusive

Gabriel Peak Orthogneiss, post-Skagit Suite?

SURFACE ACCUMULATED ROCKS

Mt. Baker Volcanics, Pleistocene

Hannegan = Skagit Volcanics, Oligocene

Swauk Formation, latest Cretaceous and Paleocene

W. side: Nooksack Group, Late Jur. & Early Cret.
E. side: Early Cretaceous → W. side: phyllitic Nooksack Group
E. side: Jack Mtn. Phyllite

North Creek Volcanics, Late Paleozoic or pre-late Jurassic Mesozoic → Elijah Ridge Schist and presumed equiv.

W. side: Chilliwack Group, Mid.Devonian - Mid. Permian
E. side: Hozomeen Group, (?) Penn. - Permian

LATE CRETACEOUS AND TERTIARY GRANITIC INTRUSIVES

Cascade Pass Quartz Diorite, Miocene

Hidden Lake Stock, Late Cretaceous or early Tertiary

Ultramafics

Sh Shuksan Thrust

Overthrusts

High-angle faults

Faults covered

Chilliwack Composite Batholith

Late (Perry Creek) Phase

mostly, Main Phase later Eocene

Early Phase, diorite and minor gabbro

Undifferentiated

Eastern Intr. Belt

Perry Creek intrusive, Late Oligocene

Golden Horn Batholith Late Eocene-Early Oli.

Black Peak Batholith Late Cretaceous

Ruby Creek Heterogeneous Plutonic Belt

Dioritic stocks

Basement rocks are found in two structural settings. The first is the autochthonus belts within the Cascade Metamorphic Suite. The second setting, basement rocks which occur as allochthonous slices, appears on the western edge of the range (Misch, 1966). The major outcrops of these rock units in the North Cascades are found as a northwest-northeast band running from just south of Mt. Shuksan to just east of Lake Chelan (see figure 4).

The crystalline basement rocks are pre-Middle Devonian and may be as old as Precambrian (Misch, 1966). They predate the oldest known strata in the North Cascades, which consist of sedimentary and volcanic rocks, including fossiliferous limestone. These have been dated as Middle Devonian (Danner, 1960b, 1964, 1965).

The latest basement rocks are preserved within the autochthonous belts of the Cascade Metamorphic Suite (see figure 4). One of these, the Marblemount Meta Quartz Diorite, was originally identified by Misch (1952) and later assigned to the basement (Misch, 1963) because of the stratiographic relationships to the nearby Cascade River Schist. Another belt is that of the Eldorado Orthogneiss (Misch, 1963), which was derived during Cascade Metamorphism from previously non-metamorphic igneous quartz diorite similar to the parent material of the Marblemount Meta Quartz Diorite.

The crystalline core of the North Cascades is formed by the Cascade Metamorphic Suite as well as by younger intrusives. The Cascade Suite, although continuous in outcrops, is subdivided by two major faults. The Straight Creek Fault (see figure 4) was named by Vance (1957) and dated in the Darrington area as probably Early Eocene. This fault was found to run north of the Skagit River (Misch, 1966) and south of Darrington (Yeats, 1958), a total length of about 70 miles. The second fault, occurring further east, is the Ross Lake Fault (see figure 4). The fault can be dated as Middle to Late Cretaceous (Misch, 1966).

One of the three subdivisions of the Cascade Suite is the Shuksan Metamorphic Suite, which is on the east side of the Straight Creek Fault. The western edge of the Shuksan Suite is formed by the mid-Cretaceous Shuksan Thrust. The Shuksan Suite displays blueschist metamorphic facies (Misch, 1959) that are probably no less than late-Permian. The suite consists of metaclastic beneath metabasaltic rocks. The lower rocks (Darrington Phyllite) are composed mainly of pelitic and semipelitic, commonly quartz-rich phyllites (Misch, 1966). Above this is Shuksan Greenschist, comprised of actinolitic greenschists and subordinate crossite and glaucophane schists (Misch, 1966).

A second subdivision, the Skagit Metamorphic Suite, is on the east side of the Straight Creek Fault. The eastern boundary of this suite is formed by the Ross Lake Fault. The main part of this suite consists of Skagit Gneiss (Misch, 1952a). The derivation of this unit from supercrustal rocks is equivalent to that of the Cascade River Schist to the south (Misch, 1966).

Unlike the Shuksan Suite, the Skagit Suite contains various granitic intrusives. Within the medium grade Cascade River Schist (see figure 4) occurs the Marble Creek Orthogneiss (trondhjematic orthogneiss), the Haystack Creek Gneiss (leucotrondhjemite gneiss) and the Alma Creek Leucotrondhjemite (semi-concordant leucotrondhjemite) (Misch, 1966). Further east, bordering the Skagit Gneiss, is a band of quartz-dioritic orthogneiss (Gabrial Peak Orthogneiss). This body is probably derived from a post-Skagit Suite intrusive (Misch, 1966).

The metamorphic facies of the Skagit Suite consist of greenschist as displayed by the Cascade River Schist and the associated Marblemount Meta Quartz Diorite. It is not known if the ages of the Shuksan Suite and the Skagit Suite are the same, since a major fault separates them, and the two facies were not found to intergrade (Misch, 1966).

The third subdivision of the Cascade Suite is the eastern metamorphic belt which lies east of the Ross Lake Fault. According to Misch (1966), Lower Cretaceous strata grade into the Middle or early-Late Cretaceous Jack Mountain Phyllite east of Ross Lake. This unit is related to the phyllitic Nooksack Group rocks just outside the western flank of the Complex. The pre-Late Jurassic, Late Paleozoic or Mesozoic, andesitic North Creek Volcanics and associated sedimentary rocks, all further to the south, grade into amphibolites and schists (Elijah Ridge Schist). The metamorphism of this schist seems to be of the same age as that of the Jack Mountain Phyllite (Misch, 1966).

During the later Paleozoic, eugeosynclinal deposition produced a deep mafic volcanic and clastic sedimentary sequence. The Chilliwack Group occurs on the western boundary of the North Cascades. Daly (1912), who worked along and north of the International Boundary, described this Upper Carboniferous Group of sedimentary and volcanic rocks, which also included fossiliferous limestone. More recently, Misch (1952a) established the southern extension of this unit at the Skagit River. He also reported probable Pennsylvanian fossils from limestone lenses at several locations throughout the unit. Other fossil discoveries in limestone made by Danner (1957, 1960a, 1960b, 1964, 1965) and

McGugan, Roessingh and Danner (1964) were proven to include Middle and upper Devonian, Lower Pennsylvanian, and Lower and Middle Permian. Many of the time intervals not covered by fossiliferous limestone may by represented by the unfossiliferous rocks which make up the bulk of the limestones (Misch, 1966). Clastics include mainly graywackes, shales, slates and phyllites. Volcanic rocks include basalts and andesites. Limestone units are minor except near and north of the border where a more continuous unit is found. From this unit Monger (1964, 1966) has obtained Permian fossils.

The Hozomeen Group of unfossiliferous phyllites, cherts and greenstones is found from Mt. Hozomeen south to Jack Mountain. This unit was first described by Daly (1912), who assigned it to the Carboniferous, which Misch (1966) feels is questionable.

The North Creek Volcanics are found on the eastern edge of the south unit of the National Park. This unit is considered by Misch (1966) to be Late Paleozoic or pre-Late Jurassic, and is made up of altered, mainly andesitic volcanics with commonly arkosic sedimentary beds. On the northwest, this unit grades into Elijah Ridge Schist.

Major orogeny occurred in the North Cascades during Middle to early-Late Cretaceous time. Four large cretaceous thrusts occur in the North Cascades. Of the two on the western flank (Church Mountain Thrust and Shuksan Thrust), only the Shuksan Thrust (see figure 4) is found within the North Cascades Complex. A thrust relationship between the Shuksan belt and the Chilliwack Group was first recognized by Vance (1957) near Darrington, where he demonstrated a minimum displacement of nine miles. A similar relationship was later recognized from the Skagit

River to the International Boundary (Misch, 1966). The fault is well exposed on Shuksan Arm, northwest of Mt. Shuksan proper, and between Mt. Shuksan and the Skagit River where erosion has cut back to or near the steep root of the thrust (Misch, 1966).

East of the crystalline core of the range, the Ross Lake Fault Zone and Jack Mountain Thrust are found (see figure 4). Within the North Cascades Complex much of the Ross Lake Fault Zone has been obliterated by Late Cretaceous-Tertiary intrusions. A five-mile segment of the fault is exposed on the north face of Gabrial Peak just south of Ross Lake. Another segment is exposed on the east shore of Ross Lake, just opposite Big Beaver Creek.

The eastward-directed Jack Mountain Thrust near Ross Lake was shown by Misch (1951, 1952a) to have risen from the Ross Lake Fault, bringing Upper Paleozoic over Lower Cretaceous rocks (see figure 4). The actual root has been faulted out and a narrow band of Jack Mountain Phyllite separates it from the gneisses west of the Ross Lake Fault. Near Mt. Hozomeen the thrust becomes an eastern branch of the Ross Lake Fault.

The Swauk Formation, first described by Russell (1893, 1900) and given an Eocene age by Smith (1906), is now considered late-Upper Cretaceous and Paleocene (Foster, 1960). It has been estimated to be from 15,000 to 20,000 feet thick (Willis, 1953). This formation occurs several miles east of Baker Lake and approximately parallels it.

Post-Eocene Tertiary deposits are represented by scattered Oligocene volcanics. Misch (1952) described them as the mid-Tertiary Hannegan Volcanics, and they were later jound to be identical with Daly's (1912) Skagit Volcanics further east (Shideler, Jr., 1965).

Many Late Cretaceous and Tertiary granitic intrusives occur as belts along the Ross Lake Fault Zone on the east and in the western part of the metamorphic core of the North Cascades (see figure 4). These two belts merge in the northern part of the North Cascade Complex where the Skagit Gneiss overlies the younger intrusives.

On the southern end of Ross Lake the Ruby Creek Heterogeneous Plutonic Belt is found along the Ross Lake Fault Zone. It is composed of gabbro, diorite, quartz diorite, and granodiorite, and includes substantial amounts of Elijah Ridge Hornsfelsic Schist and related hornsfelses. The unit predates the Golden Horn Batholith and may have occurred at the same time as the Black Peak Batholith (Misch, 1966).

Misch (1952) described the Black Peak Batholith, which roughly follows the Ross Lake Fault Zone, as consisting of Quartz-diorite and granodiorite rocks. The southern half of this unit was studied by Adams (1961, 1964). The unit predates the Golden Horn Batholith and is younger than intra-Cretaceous orogeny (Misch, 1966).

The Golden Horn Batholith, just north of and intruding the Black Peak Batholith, was first recognized by Misch (1952a). This unit is post-Cretaceous.

The northernmost section of the Perry Creek Intrusive was studied by Shideler, Jr. (1965), who found that it had intruded the Oligocene volcanics. The main rocks of the unit are quartz-diorite and granodiorite. This unit is continuous with the Perry Creek phase further to the west (Misch, 1966).

On the west, along the International Boundary, the main intrusive was first named the Chilliwack Batholith by Daly (1912). Misch (1952a) traced this unit to the Skagit River, and finding that it included at least four phases, renamed it the Chilliwack Composite Batholith. The earliest phase (see figure 4), consisting of diorite and subordinate gabbro, predates all quartz-bearing phases (Misch, 1966). The main phase, making up the southern portion of the batholith, is younger than the Late Cretaceous-Paleocene Swauk Formation which it intrudes, and predates the Oligocene volcanics above this phase in the Hannegan Pass area. The late phase (Perry Creek), consisting of mainly quartz diorites and granodiorites, makes up the northeastern section of the batholith.

Of the two small plutons southwest of the Chilliwack Batholith, the Hidden Lake Stock has been found to have moved aside the Cascade River Schist (Misch, 1952a). Tabor (1961, 1963) traced the second pluton, which follows a fracture system of Tertiary age, near the Cascade Pass area.

Surficial Geology

Glaciation

The last ice age proper (Pleistocene Epoch) and subsequent time (Holocene or Recent Epoch) are known as the Quaternary Period. The Quaternary, unlike previous time periods, has a relatively excellent stratigraphic record (Wright and Frey, 1965).

During the Quaternary, the major occurrence in most of the world was a climatic change. This not only resulted in glaciation, but also caused changes in the composition and distribution of plant and animal communities. In the Pacific Northwest the Pleistocene phytogeography has been developed from palynological reconstructions (Hanson, 1938a, b, 1947; Heusser, 1964, 1965).

Evidence of past glaciation may be seen throughout the North Cascades. The rounded tops of the lower mountains, the steep-sided valleys, the outwash terraces and moraines all bear witness to previous glaciation.

Many alpine glaciers still exist in the Cascades today. The more heavily glacierized areas, most of which are within the North Cascades Complex, have received very little scientific attention. Tuttle (1941) studied the glacial features just east of Cascade Pass. Meier (1964) worked on the South Cascade Glacier and Miller (1967) studied that glacier and three others nearby. These glaciers are just west of the boundary of the south unit of the North Cascades National Park. Just west of the National Park's north unit, Bengston (1956) studied the Coleman Glacier on Mt. Baker for almost a decade.

Glacial studies have been more numerous in other areas of Washington and may provide a basis for comparison with glaciers in the North Cascades. Mt. Rainier has been the subject of many reports and studies (Emmons, 1877; Russell, 1898; Le Conte, 1906; Meany, 1916; Brockman, 1938; Harrison, 1951, 1956; Johnson, 1954; Bender and Haines, 1955; Sigafoos and Hendricks, 1961; Crandell, 1963a, 1965a; La Chapelle, 1963; Meier, 1963; Post, 1963; Crandell and Miller, 1964). In the Olympic Mountains the glaciers were described by Danner (1955) and Hubley (1956). Heusser (1957) studied the Blue, Hoh and White Glaciers. Other work in the Cascade Range between Mt. Rainier and the North Cascades Complex has been done by Mackin (1941), Long (1951a,b) and Hopkins (1966). In the Coast Range of British Columbia several glacial studies have been undertaken by Mathews (1951), Armstrong (1956, 1957) and Barendsen, Deevy and Gralenski (1957).

During the Salmon Springs Glaciation (Late Pleistocene), the Cordilleran ice sheet advanced and receded twice. The alpine glaciers of the Cascade Range also advanced and receded at this time (Crandell, 1965b). The broad, steep-sided valleys of the North Cascades Complex appear to have been occupied by ice during these advances.

The Fraser Glaciation, beginning with the Evans Creek Stade about 25,000 years ago, lasted for about 15,000 years (Crandell, 1965b). The Evans Creek Stade resulted in alpine glaciers advancing down the valleys. These glaciers were from 15 to 40 miles long in the valleys heading on Mt. Rainier (Crandell and Miller, 1964). Other alpine glaciers probably advanced similarly (Crandell, 1965b; Hopkins, 1966; Miller, 1967). As the alpine glaciers began to retreat the Cordilleran ice advanced. By the time this ice had reached its maximum extent in western Washington between 15,000 and 13,000 years ago, alpine glaciers in the Cascade Range had greatly decreased or disappeared completely (Cary and Carlston, 1937; Mackin, 1941; Crandell, 1963b). At this time the ice lobe blocked the valleys of the Cascade Range, forming large glacial lakes (Crandell, 1965). Evidence of this should be found in the Skagit River Valley upon investigation. Erratics carried by this ice have been found at an elevation of about 5200 feet in the Twin Sisters Range, just west of the North Cascades Complex (Esterbrook, 1963). Toward the end of the Fraser Glaciation, during the Sumas Stade and after the recession of the Cordilleran ice, a colder climate occurred once again. The Cordilleran ice advanced and receded once more and the alpine glaciers were reborn (Crandell, 1965b).

The mild Hypsithermal interval followed the Fraser Glaciation, and during this time most glaciers decreased in size or disappeared altogether

(Miller, 1967). Subsequently mudflow and fluvial aggradation ensued in the Cascades (Crandell, 1965b). Evidence of this on Mt. Rainier was found by Crandell (1963a,b).

The last period of glaciation (Neoglaciation) had its maximum advances in the North American Cordillera at varying times for different glaciers (Porter and Denton, 1967). On Mt. Rainier the maximum advance for the Winthrop Glacier was 3500 to 2000 years ago, while the maximum advance for the Carbon Glacier was during the thirteenth century (Crandell and Miller, 1964). From the middle of the nineteenth to the middle of the twentieth centuries, the glaciers on Mt. Rainier were retreating (Harrison, 1956; Meier, 1963; Post, 1963). Around 1950, probably in response to lower temperatures and increased precipitation, most of the glaciers of Mt. Rainier and other Pacific Northwest mountains began to advance (Bengston, 1956; Hubley, 1956; La Chapelle, 1963; Meier, 1965).

In British Columbia, the maximum Neoglacial advance of the Sphinx Glacier in the Mt. Garibaldi area has been dated at about 460 years ago (Barendsen _et al_, 1957). Mathews (1951) indicates that glaciers in that area subsequently advanced several times during the early part of the eighteenth and the middle of the nineteenth centuries.

On Mt. Olympus in the Olympic Mountains of Washington the age of the maximum advances of the Blue Glacier have been determined as occurring 700 years ago (Heusser, 1957). The Blue Glacier has remained essentially stationary since 1950 (before which it was receding), while the nearby Hoh Glacier, which had its maximum stand about 1810, has been increasing since 1933 (Heusser, 1957).

In the North Cascades, except for an advance of the South Cascade Glacier about 4900 years ago (Meier, 1964), evidence of glacier activity is restricted to the last eight centuries (Miller, 1967). The South Cascade Glacier has been receding ever since 1900 (Porter and Denton, 1967). Two nearby glaciers, Dana and Le Conte, have reacted similarly during the past several centuries (Miller, 1967).

Volcanism

A number of volcanic eruptions occurred in the North American Cordillera during Quaternary time. They were probably less intense than those experienced during late Tertiary time (Wilcox, 1965). In the Cascade Range, Mt. Baker, Mt. Rainier, Mt. St. Helens, Mt. Adams, Mt. Shasta and Mt. Lassen all attained their present heights during Quaternary time (Williams, 1953). The ash layers laid down by these volcanoes provide ideal stratigraphic records for use in many scientific fields.

The North Cascades Complex contains ash layers from Mt. St. Helens, Mt. Mazama and Glacier Peak. The oldest is an eruption from Glacier Peak about 12,000 years ago (Powers and Wilcox, 1964; Fryxell, 1965). The ash-fall is distributed to the east as far away as Montana and Idaho (Wilcox, 1965). One of the most widespread ashes is that from Mt. Mazama. This ash is found north to southern British Columbia and southern Alberta and east to Montana (Wilcox, 1965; Nasmith, Mathews and Rouse, 1967). The date of this massive eruption has been put at 6600 years ago (Rubin and Alexander, 1960; Powers and Wilcox, 1964; Fryxell, 1965). Mt. St. Helens has had several eruptions in the past 30000 years. The ash-falls have been dated at 3000 and 500 years ago (Crandell _et al_, 1962), and at 160 years ago (Mullineaux, 1964). Mt. Rainier ash, dated at 2300 to 2000 years ago (Crandell _et al_, 1962), may possibly occur in the North Cascades, although not reported.

Soils

The soils of the North Cascades are yet to be studied, therefore a brief description of the soils found in the Coastal Western Hemlock and Subalpine Mountain Hemlock Zones of southwestern British Columbia will be presented. Since the geology, climate and vegetation are relatively similar, a general comparison between the Coast Range of British Columbia and the North Cascades may prove useful for the present. Several profile descriptions of soils found in the Subalpine Zone in the North Cascades are also given. These are from my own data and have not yet been completely analyzed.

The nomenclature of soil horizons as used by the Canadian workers is as follows*:

L - Undecomposed litter.

O - Decomposed organic matter with very low mineral content.

A - 1. Surface mineral horizon of maximum organic accumulaion.

2. Surface or subsurface horizons that are lighter in color thàn the underlying horizon and which have lost clay minerals, iron and aluminum.

3. Horizons belonging to both of these categories.

B. - 1. An accumulation of clay, iron, aluminum and organic matter.

2. More of less prismatic or blocky structure, stronger colors than that of the A horizon or the underlying nearly unchanged material.

3. Horizons characterized by both of these categories.

* From Lesko (1961)

C - A horizon of unconsolidated material which is little effected by the influence of organisms and presumed to be parent material of the solum.

D - Any substratum underlying the C or B horizon and which is not the parent material.

G - A gley layer of intense reduction, characterized by the presence of ferrous iron and neutral gray color.

Lower case subscription for the identification of soil sub-horizons:

b - A layer characterized by hard irreversible pedogenic concretions.

c - Hard irreversible pedogenic layer.

e - A layer characterized visibly by the removal of clay, iron, aluminum, and/or humus. Usually lighter colored (higher value) than the layers below or above.

f - A layer enriched by hydrated iron.

h - A mineral layer containing sufficient amount of decomposed organic matter to show visible darkness, at least one Munsell unit darker than the layer immediately below.

j - Juvenal - A layer with weakly expressed characters.

m - (mellowed-mitis) A layer characterized by the loss of water-soluble materials only, usually slightly altered by hydrolysis or oxidation. Usually differing in color and structure from the layer immediately above or below.

p - a relic (not currently dynamic) layer. To be used as prefix.

q - (Whitesides) A compact layer that is apparently cemented when dry, brittle when moist.

r - An inherited consolidated layer - used with C.

w - Water-saterated layer - The apparent water table.

Lesko (1961) described the following soils in the Coastal Western Hemlock Zone:

1. Organic soils

   These are composed of either undecomposed peat of Sphagnum spp., which is saturated with water or, where the peat is older, it has decomposed on the surface and formed a black muck humus. The upper 12 inches of this humus may be drained during the summer.

2. Gley soils

   Typical gley soils in the zone have an O horizon one to six inches thick. The Ah horizon is underlaid by strongly gleyed layers without a noticeable eluvial or illuvial subhorizon.

3. Regosols

   These may be either alluvial or acid regosols. The alluvial deposits are recent with recurring deposition. Profile development is restricted to the formation of an Ah horizon. The acid regosols are found on acid rock outcrops, with an O horizon underlain by an Ae horizon. The A horizon lies directly on the acid parent material.

4. Brunisols

   These soils may have a strong to medium acid O horizon one-half to one inch thick and possibly d,f, or h subhorizons. The Ah horizon is less than two inches deep, may contain gray concretions lacking iron coatings, and may be medium to strongly acid or low in base saturation.

5. Podzols

The podzols may be either gleyed, minimal, or humic soils. The gleyed podzols have an organic O horizon, an eluvial Ae horizon and an illuvial B horizon containing accumulations of organic matter and sesquioxides. In the upper B or Ae horizons gleying may be indicated by mottling. Minimal podzols have an organic O horizon, a light colored eluvial Ae horizon less than one inch deep and an illuvial B horizon which contains accumulations of organic matter and sesquioxides. These soils lack distinct Bl horizons. The humic podzols consist of soils with a moderately thick O horizon, a distinct unsaturated Ae horizon and a friable Bh horizon containing iron in addition to organic matter. A friable Bhf horizon underlies the Bh horizon.

Brooke (1965) described the following soils in the Subalpine Mountain Hemlock Zone:

1. Organic soils

These soils consist of partly to well decomposed bryophytes, sedges, and herbaceous plants with depths over 12 inches. The O horizon is moderate to very acid, with the more acid horizons consisting of greater quantities of bryophytes. Seepage may be abundant at the surface or may not be found until depths of two to three feet are reached. Examples of organic soils in the Subalpine Zone of the North Cascades are presented in tables 1 and 2. These

Table 1. An example of an organic soil in the North Cascades.

Vegetation: <u>Leutkea</u> association.

Parent Material: Volcanic ashes, some mixing with local mica schist.

Topography: 10% slope, straight, lower $\frac{1}{4}$, 5400 feet elevation, southwest aspect.

Drainage: Poor.

Horizon	Depth	
0 1	$\frac{1}{2}$-$\frac{1}{4}$"	Undecomposed herbaceous litter.
0 2	$\frac{1}{4}$-0"	Mixed, partly decomposed organic matter and mineral material; clear, wavy boundary.
A	0-2"	Dark reddish-brown (5YR 3/3) loam; many fine to medium roots; abrupt, smooth boundary; very strongly acid (pH 4.6).
B	2-4"	Dark brown (7.5YR 3/2) loam to sandy loam; many fine to medium roots; abrupt, smooth boundary; strongly acid (pH 5.1).
C	4-6"	Dark reddish-brown (5YR 4/3) loamy sand; many fine roots; clear, smooth boundary, strongly acid (pH 5.1).
II C	6-8$\frac{1}{2}$"	Dark reddish-brown (5YR 3/2) silty loam; many fine roots; clear, smooth boundary; strongly acid (pH 5.0).
III C	8$\frac{1}{2}$-11"	Dark reddish-brown (5YR 4/2) silty loam; few fine roots; abrupt, smooth boundary; strongly acid (pH 5.1).
IV C	11-12$\frac{1}{2}$"	Dark reddish-brown (5YR 2/1) silty loam; very few roots; abrupt, smooth boundary; strongly acid (pH 5.1).
V C	12$\frac{1}{2}$-14$\frac{1}{2}$"	Yellowish-brown (10YR 5/6) loam; ash (Mazama); abrupt, smooth boundary; strongly acid (pH 5.1).
VI C	14$\frac{1}{2}$-19(18)	Dark reddish-brown (5YR 2/1) silty loam; abrupt smooth boundary; medium acid (pH 5.5).
VII C	(18)19-36+	Dark yellowish-brown (10YR 4/4) loam; 30 percent coarse material, 1 to 5 inches across; strongly acid (pH 5.1).

Table 2. An example of an organic soil in the North Cascades.

Vegetation: Carex nigricans association

Parent Material: Mica schist, volcanic ash.

Topography: Level (lacustrine deposit), 5400 feet elevation, southeast basin.

Drainage: Extemely poor.

Horizon	Depth	
O 1	1-$\frac{1}{4}$"	Undecomposed to partly decomposed organic matter.
O 2	$\frac{1}{4}$-0"	Mixed, partly decomposed organic matter and mineral material; clear, wavy boundary.
A 1	0-1"	Dark brown (10YR 3/3) silty loam; many fine to medium roots; abrupt, smooth boundary; strongly acid (pH 5.0).
C	1-2"	Brown (7.5YR 4/2) silty loam; many fine to medium roots; abrupt, smooth boundary; strongly acid (pH 5.2).
II C	2-4"	Brown (10YR 5/3) silty loam; many fine roots; clear, smooth boundary; medium acid (pH 5.5).
III C	4-7"	Grayish-brown (10YR 5/2) loamy sand; many fine roots; abrupt, smooth boundary; medium acid (pH 5.5).
IV C	7-8$\frac{1}{2}$"	Dark brown (10YR 3/3) silty loam; many fine roots; abrupt, smooth boundary; very strongly acid (pH 4.8).
V C	8$\frac{1}{2}$-12"	Yellowish-brown (10YR 5/4) sand; many fine roots; abrupt, smooth boundary; strongly acid (pH 5.2).
VI C	12-14"	Dark brown (10YR 3/3) silty loam; few fine roots; abrupt, smooth boundary; medium acid (pH 5.5).

Table 2. (continued)

Horizon	Depth	
VII C	14-17"	Grayish-brown (10YR 5/2) sandy loam; few fine roots; abrupt, smooth boundary; medium acid (pH 5.5).
VIII C	17-18"	Dark brown (10YR 3/3) sandy loam; abrupt, smooth boundary; medium acid (pH 5.5).
IX C	18-20"	Grayish-brown (10YR 5/2) sandy loam; abrupt, smooth boundary; strongly acid (pH 5.3).
X C	20-20½"	Dark brown (10YR 3/3) sandy loam; abrupt, smooth boundary; medium acid (pH 5.8).
XI C	20½-26"	Yellowish-brown (10YR 6/6) loam; ash (Mazama); abrupt, smooth boundary; strongly acid (pH 5.1).
XII C	26"+	Dark yellowish-brown (10YR 4/4) loam; abrupt, smooth boundary; strongly acid (pH 5.0).

were taken from two adjoining associations. The first, the Leutkea association (p. 85) profile, was located on a slight slope above a filled-in lake. This profile had thin O and A horizons.* A well developed B horizon is found along with numerous volcanic and pedogenic C horizons. The second profile, in a Carex nigricans association (p. 81), was located in the filled-in lake, 6 feet lower and 20 feet away from the Leutkea association profile. The numerous C horizons are also found in the Carex nigricans association but the B horizon is lacking. In both profiles a layer of ash was determined as Mount Mazama ash (James G. Bockheim and Ken Schlichte, personal communication) and dated at 6600 years by Rubin and Alexander (1960), Powers and Wilcox (1964) and Fryxell (1965).

2. Gley soils

The organic horizons of these soils very from 6 to 12 inches in depth. An eluviated Ah horizon may be present. The Ah or B horizon is mottled or gleyed and the soil is strongly to extremely acid. These soils are all under the influence of permanent or almost permanent seepage movement.

3. Regosols

Typical regosols have a thin, one-inch O horizon which is generally well decomposed. Underlying this is a stratified Ah/C horizon which is indiscernible. The stratified horizon is weakly gleyed and consists of narrow Ah horizons

* Nomenclature of soil horizons for the North Cascades profiles from U. S. D. A. (1962).

interbedded with silt loam and silty loam sediments. Horizons are strongly acid and seepage is present beneath them.

4. Ranker-like soils (Regosols)

In the Subalpine Mountain Hemlock Zone these soils are quite common since bedrock or rock outcrops frequently lie close to the soil surface. The soils consist of organic accumulations which may be peeled back from the bedrock. The humus layer may be up to two inches thick containing mineral grains either transported or derived in situ. These mineral grains may also be found as thin seams overlying the bedrock. Above the continuous forest, where these soils are associated with shrubs, podzol rankers may be found. These rankers are extremely acid in reaction. Acid decomposition products from the litter and high precipitation in the zone cause extensive bleaching of mineral grains and eluviation of the thin mineral soil overlying the bedrock.

5. Terrestrial raw soils (Regosols)

These are typified by "alpine rawmark" soils which maintain their immature profile by congeliturbation, soliflucation, snow creep and erosion. Although rapid drainage is present soil moisture remains high during the summers. Horizon development is limited to a slight darkening which may be up to four inches below the surface. Cation exchange capacity of the soil is very low and soil pH is medium to strongly acid. An example of a terrestrial raw soil in the North Cascades is given in table 3.

Table 3. An example of a terrestrial raw soil in the North Cascades.

Vegetation: Saxifraga association. (p. 94).

Parent Material: Andesite

Topography: 10% slope, straight, base of slope, 5200 feet elevation, north aspect.

Drainage: Good.

Horizon	Depth	
C 1	0-3½"	Grayish-brown (2.5Y 2/0) gravelly sandy loam; very few roots, near surface; clear, wavy boundary; medium acid (pH 5.4).
C 2	3½-10"	Dark grayish-brown (2.5Y 3/2) gravelly sandy loam; clear, wavy boundary; medium acid (pH 5.6).
C 3	10"+	95 percent coarse material.

6. Brunisols

These soils are closely related to the brunisols of the Coastal Western Hemlock Zone and are found at lower elevations in the Subalpine Mountain Hemlock Zone. The soils have strongly acid O horizons with a weakly developed Aej or Aejh horizon. The B horizon is a weakly developed illuvium.

7. Subalpine intergrades to podzols

Typical soils in this group occur on moderately well drained to imperfectly drained glacial tills. The O horizon is well developed and sharply separated from the eluviated Ae horizon which is very weakly developed or obscured by the overlying horizon. A fragipan-like layer usually underlies the dark brown, reddish-brown or yellowish-brown B horizon. Cation exchange capacity, calcium and magnesium show a definate change in distribution between the B and BC or BCq horizons.

8. Podzols

The podzols are the most common soils of the forested subzone of the Subalpine Mountain Hemlock Zone. Surface organic accumulation is up to 10 inches deep and extremely acid. The light colored eluviated Ae horizon may be up to five inches thick and weakly to strongly developed. A dark colored B horizon, usually over bedrock or a firm to very firm Bf or BC horizon, is present. Soils are moderately to well drained. An example of a podzol in the North Cascades is given in table 4.

Table 4. An example of a podzol in the North Cascades.

Vegetation: Mountain hemlock - Pacific silver fir association. (p. 89)

Parent Material: Mica Schist.

Topography: 15% slope, top of convex mound, 5420 feet elevation, southeast aspect.

Drainage: Good.

Horizon	Depth	
O 1	5-3"	Heavy mat of undecomposed forest litter.
O 2	3-0"	mixed partly decomposed organic matter and mineral material; gradual, wavy boundary.
A 1	0-2"	Dark reddish-brown (5YR 2/2) sandy loam; many fine to large roots; abrupt, clear boundary; extremely acid (pH 3.7).
A 2	2-6½"	Very dark gray (10YR 3/1) loamy sand; few fine to large roots; abrupt, smooth boundary; extremely acid (pH 4.4).
B 21	6½-10½"	Dark brown (7.5YR 3/2) sandy loam; few fine roots; gradual, wavy boundary; very strongly acid (pH 4.9).
B 22	10½-20½"	Dark reddish-brown (5YR 3/4) sandy loam; few fine roots; abrupt, wavy boundary; strongly acid (pH 5.2).
C	20½-22+	Dark reddish-brown (5YR 3/3) sandy loam; clear, wavy boundary; 40 percent coarse fragments 1 to 6 inches across.

9. Humic podzols

This soil group differs from the previous soil group in that humic podzols contain 10 percent or more organic matter. The O horizon is extremely acid and up to 10 inches deep. An eluviated Ae horizon varies from thin lenses to five inches in depth with gleying occasionally occurring. The soils are poor to well drained and iron is usually present in the B horizon.

The colluvial soils associated with the Valeriana - Veratrum association (p.91), although not described in British Columbia, are quite common throughout the North Cascades. An example of this soil is given in table 5. The steep slopes which cause avalanches or severe snow creep maintain this soil and its vegetative cover. The pH inversion is probably attributed to meltwater bearing bases leached from the more acid soils above (James G. Bockheim, personal communication).

Table 5. An example of a colluvial soil in the North Cascades.

Vegetation: Valeriana-Veratrum association (Rubus parviflorus-Pteridium phase).

Parent Material: Mica Schist.

Topography: 60% slope, straight, upper ½, 5000 feet elevation, southwest aspect.

Drainage: Somewhat excessive.

Horizon	Depth	
O 1	3½-3"	Undecomposed herbaceous litter.
O 2	3-0"	Mixed, partly decomposed organic matter and mineral material; gradual, wavy boundary.
A 1	0-3½"	Dark reddish-brown (5YR 3/2) loam; many fine to large roots; one percent coarse fragments ½ to 1 inches across; abrupt, smooth boundary; medium acid (pH 5.6).
B 21	3½-9"	Dark reddish-brown (5YR 3/3 loam; many fine to large roots; gradual, wavy boundary; one percent coarse fragments, ½ to 2inches across; strongly acid (pH 5.3).
B 22	9-(24)33"+	Dark reddish-brown (5YR 3/3) loam to sandy loam; few fine roots extending to 30 inches; clear, wavy boundary; seven percent coarse fragments, ½ to 3 inches across; strongly acid (pH 5.2).
C	(24)33+	Dark reddish-brown (5YR 3/4) sandy loam; 25 percent coarse fragments, 1 to 6 inches across; strongly acid (pH 5.0).

CLIMATOLOGY

The climate of the North Cascades Complex differs considerably from the northwest boundary to the southeast boundary. The mean annual precipitation varies from 110 inches at the Mt. Baker weather station (two and one-half miles west of the National Park boundary) to 34 inches at Stehekin (see table 6). This difference is due to the barrier set up by the wide Cascade Range. The prevailing flow of air into western Washington during the fall and winter is from the southwest to the west, and as the moist warm air moves inland it rises along the western slopes of the Cascades. As it rises it cools and condensation takes place. Since many peaks separate the Cascade crest from the foothills on the west, precipitation decreases as one proceeds east. A relatively dry season begins about May, reaching a peak in mid-summer and ending during September. However, this dry season is inconsistent and some summers may be fairly wet.

The average annual snowfall is very heavy, but is also quite variable. This snowfall varies from 70 inches at lower elevations and 516 inches at higher elevations west of the Cascade crest to about 470 inches at the crest and 123 inches at Stehekin (see table 7). In 1963-1964 the seasonal snowfall at Stevens Pass (about 40 miles south of the complex) was 692 inches. The snowline along the western slopes of the Cascades ranges from 1500 to 2500 feet elevation. The snow remains on the ground until the latter part of June or the beginning of July.

The mean temperatures of the weather stations in the North Cascades indicate that the area is cool without extremes. In January the mean temperature varies from 21.1°F. at Holden to 35.0°F. at Darrington

Table 6. Average monthly total precipitation data from weather stations in the North Cascades.**

Station	Newhalem	Diablo Dam	Mt. Baker*	Stevens Pass	Stehekin	Holden
Elevation	800'	891'	4150'	4085'	1150'	3436'
Period	(1931-60)	(1931-62)	(1927-51)	(1939-64)	(1931-60)	(1938-57)
Month	Precipitation in Inches					
January	10.88	10.29	11.86	11.26	5.28	5.10
February	8.77	8.55	10.61	8.57	4.34	4.61
March	7.45	6.78	12.12	7.94	3.01	2.87
April	4.75	4.44	8.52	4.65	1.19	1.30
May	2.94	2.48	6.39	3.59	1.00	1.33
June	2.70	2.07	4.73	2.89	.90	1.20
July	1.50	1.24	3.32	1.35	.39	.68
August	1.76	1.33	3.19	1.70	.46	.81
September	4.14	3.49	7.64	4.06	1.22	1.49
October	8.96	8.03	11.34	7.32	3.38	4.04
November	11.04	10.54	13.14	11.25	5.88	5.53
December	13.33	12.32	16.99	12.17	6.75	6.43
Annual Total	76.24	71.56	109.85	76.75	33.80	35.39
Record Annual Maximum	-	94.72 (1953)	141.97 (1927)	117.44 (1959)	52.47 (1933)	45.04 (1955)
Record Annual Minimum	-	50.00 (1942)	74.13 (1929)	42.98 (1952)	19.27 (1944)	18.77 (1952)

* Mt. Baker weather station located at Heather Meadows Recreation Area.

** From U. S. Weather Bureau station climatic summaries (no dates).

Table 7. Average monthly total precipitation (snow or sleet) data from weather stations in the North Cascades.**

Station	Darrington	Diablo Dam	Mt. Baker*	Stevens Pass	Stehekin	Holden
Elevation	550'	891'	4150'	4085'	1150'	3436'
Period	(1931-60)	(1931-62)	(1927-51)	(1939-64)	(1931-60)	(1938-57)
Month	Precipitation in inches					
January	22.1	23.2	88.0	100.4	39.9	76.5
February	12.1	15.4	74.0	78.4	29.3	58.7
March	6.1	9.7	92.3	74.4	8.4	40.9
April	.4	.5	50.2	30.8	.2	6.7
May	-	-	17.5	9.9	-	-
June	-	-	2.3	.6	-	-
July	-	-	-	-	-	-
August	-	-	-	-	-	-
September	-	-	2.6	.5	-	-
October	-	-	14.7	18.6	.4	7.4
November	2.4	5.0	67.6	62.1	12.4	48.4
December	9.4	16.1	106.7	91.2	32.4	67.9
Annual Total	53.3	69.9	515.9	466.9	123.0	306.5
Record Seasonal Maximum	-	-	599.0 (1948-49)	691.5 (1963-64)	-	583.4 (1955-56)
Record Seasonal Minimum	-	-	295.3 (1933-34)	229.6 (1941-42)	-	127.8 (1943-44)

* Mt. Baker Weather station located at Heather Meadows Recreation Area.

** From U. S. Weather Bureau station climatic records (no dates).

(see table 8). The hottest months are July and August, with temperatures reaching almost 80°F. daily at lower elevations and about 3°F. less per 1000 feet rise in altitude. The mean daily temperature at 4 p.m. Pacific Standard Time at Desolation Lookout (two miles east of Ross Lake) and Green Mountain Lookout (15 miles east of Darrington) is about 55°F. in July and August (U. S. Weather Bureau, personal communication).

Month	Darrington Means Daily Maximum	Darrington Means Daily Minimum	Darrington Means Monthly	Diablo Dam Means Daily Maximum	Diablo Dam Means Daily Minimum	Diablo Dam Means Monthly	Mt. Baker Means Daily Maximum	Mt. Baker Means Daily Minimum	Mt. Baker Means Monthly	Stevens Pass Means Daily Maximum	Stevens Pass Means Daily Minimum	Stevens Pass Means Monthly	Stehekin Means Daily Maximum	Stehekin Means Daily Minimum	Stehekin Means Monthly	Holden Means Daily Maximum	Holden Means Daily Minimum	Holden Means Monthly
	Temperature in degrees fahrenheit																	
January	41.4	28.6	35.0	37.3	26.5	31.9	32.5	21.3	26.9	28.7	18.0	23.4	32.9	21.8	27.4	26.8	15.4	21.1
February	45.9	29.8	37.9	41.9	29.2	35.6	38.5	23.8	29.7	33.3	21.3	27.3	38.0	23.6	30.8	34.4	20.8	27.6
March	51.3	32.3	41.8	48.0	31.8	39.9	38.5	25.6	32.1	37.4	22.7	30.1	46.8	28.6	37.7	40.3	24.7	32.5
April	61.1	36.5	48.8	57.4	37.0	47.2	43.1	28.4	35.8	44.8	28.6	36.7	59.2	35.0	47.1	50.4	32.4	41.4
May	67.7	42.0	54.9	65.8	43.2	54.5	50.5	36.0	43.3	51.1	33.7	42.4	68.1	41.8	55.0	60.0	38.9	49.5
June	71.0	47.1	59.1	70.3	48.1	59.2	56.2	39.4	47.8	58.3	39.6	49.0	73.5	47.5	60.5	65.3	43.7	54.5
July	77.6	49.3	63.5	77.9	52.1	65.0	63.9	44.1	54.0	67.9	44.6	56.3	81.2	51.7	66.5	74.9	48.7	61.8
August	77.1	49.3	63.5	76.8	52.2	64.5	66.1	47.3	56.7	66.4	44.8	55.6	79.4	50.2	64.8	73.3	48.9	61.1
September	70.9	46.0	58.5	70.5	48.3	59.4	57.3	41.4	49.4	61.6	40.9	51.3	70.6	43.8	57.2	66.7	44.9	55.8
October	61.0	40.1	50.6	57.9	41.3	49.6	49.5	35.5	42.5	49.1	34.8	42.0	56.9	36.3	46.6	51.3	35.7	43.5
November	48.6	32.7	40.7	45.2	33.8	39.5	40.2	29.1	34.7	36.3	25.7	31.0	42.4	29.6	36.0	35.7	25.9	30.8
December	43.4	30.6	37.0	39.7	30.7	35.2	34.7	23.3	29.0	31.0	21.2	26.1	35.2	26.3	30.8	30.1	20.4	25.3
Year	59.8	38.7	49.3	57.4	39.5	48.5	47.3	32.9	40.1	47.2	31.3	39.3	57.0	36.4	46.7	50.8	33.4	42.1

Table 8 . Monthly temperature data from weather stations in the North Cascades.

FLORA

Introduction

In many mountainous areas, the environmental differences associated with changes in the composition, structure, pattern and dynamics of vegetation are well known. In the North Cascades, however, the literature contains only the brief vegetative descriptions of Franklin and Trappe (1963), who made a reconnaissance of the area. The sole other work is the synecological and taxonomical studies of the writer, which have been in progress during the past two summers.

The Coast Range of British Columbia, similar in many respects to the North Cascades, has been the subject of several studies. For the present, general comparisons may have to be drawn between these mountains and those of the North Cascade Complex (west of the Cascade crest).

In British Columbia a comprehensive ecological study and phytogeocoenological classification of both the Coastal Western Hemlock and Subalpine Mountain Hemlock Zones has been carried out by Krajina (1959, 1965) and his students: Lesko (1961), Orloci (1961, 1965), Eis (1962), Peterson (1964) and Brooke (1965). Another of Krajina's students, Archer (1963), worked in the Alpine Zone. Brink (1959) described successional changes in a localized area of the Subalpine Mountain Hemlock Zone in Garibaldi Park.

In the Olympic Mountains of Washington, a general description of the vegetation was given by Jones (1936). Recently, more intensive studies have been completed by Fonda (1967) and Kuramoto (1968).

Mt. Rainier has probably received the most ecological attention of any mountainous area in Washington. Jones (1938), Brockman (1931, 1947, 1949), Higinbotham and Higinbotham (1954), Carpenter (1961), Franklin (1966a) and Franklin and Mitchell (1967) have all contributed to the ecology of this area. The only substantial work, however, is that of Thornburgh (1968) on the southwest side of Mt. Rainier, and Franklin (1966b), who worked from Mt. Rainier south to Mt. Hood in Oregon.

Ecology

The North Cascades Complex possesses a unique and diverse flora. The area occupies parts of two vastly different ecological provinces. These provinces, the Mt. Baker Province west of the Cascade crest and the Wenatchee Province east of the crest, were defined by Franklin (1965a). They are based on differences in geology, topography, soil parent materials, climate, and forest types. Besides the characteristics distinguishing these two provinces, there are also vast vegetational differences within the provinces.

Several workers have developed varying zonal classifications for the Pacific Northwest (see table 9). The first was Merriam's Life Zone concept (Merriam, 1898) which was adapted for the Cascade Range by Piper (1906). The classifications, as on all mountains of some height, occur as climatic zones or belts. However, these zones in the North Cascades are, because of the rugged topography, extremely irregular and often difficult to distinguish as continuous belts. This makes the use of these classifications unsuitable for a general vegetative description of the North Cascades Complex.

Table 9. Zonal classifications of various authors in the mountains of the Pacific Coast (west of the Cascade crest)*

<table>
<tr><th>Merriam's Life Zones in the Cascade Range (Piper, 1906)</th><th>Climax Type Groups in Western Washington (Scott, 1962)</th><th>Bioclimatic Zones in Coastal British Columbia (Krajina, 1965)</th><th>Vegetation Zones in the Cascade Range (Franklin, 1966)</th></tr>
<tr><td>Humid Transition</td><td>Western Hemlock-Western Redcedar</td><td>Douglas-fir--Western Hemlock (Drier Subzone)
COASTAL</td><td>Western Hemlock</td></tr>
<tr><td rowspan="2">Canadian</td><td rowspan="2">Pacific Silver Fir - Western Hemlock</td><td>WESTERN HEMLOCK
Pacific silver fir-Western Hemlock (Wetter Subzone)</td><td>Pacific Silver Fir</td></tr>
<tr><td>Subalpine Mountain Hemlock (Lower Subzone)
COASTAL</td><td rowspan="2">Mountain Hemlock</td></tr>
<tr><td>Hudsonian</td><td>Subalpine Fir-Mountain Hemlock</td><td>MOUNTAIN HEMLOCK
Subalpine Mountain Hemlock (Upper Subzone)</td></tr>
<tr><td>Arctic-Alpine</td><td>Arctic-Alpine</td><td>Alpine</td><td>Alpine</td></tr>
</table>

* Table modified from Franklin (1966)

A greater clarity is achieved by describing those vegetation units which are successionally related to each of the two major climax forest types and those found in the Subalpine Zone of the Mt. Baker Province. The two forest types in this province consist of the Western Hemlock and Pacific Silver Fir Forest Types. Since ecological information is lacking on the two major climax forest types and the Subalpine Zone of the Wenatchee Province, only a general description of these will be given. Grand Fir - Douglas-fir and Engelmann Spruce - Alpine Fir Forest Types constitute the forest climaxes in this province. The Alpine Zone of the complex will also be discussed briefly.

The Subalpine Zone is defined for the purposes of this paper as the meadow area usually occurring above the continuous forest, often supporting numerous tree groups. This term has been utilized rather than the climatic climax types (which may consist of various coniferous species), since these types occupy only a relatively small portion of the area. The upper limit of the zone is the tree line or the limit of tree species in an upright tree form. All vegetation above the Subalpine Zone is included in the Alpine Zone.

The vegetation units in these forest types and zones are continually changing due to the effects of both physical and biotic environmental factors. These changes in environment create different circumstances for life and the processes we call succession. This succession in the Great Smoky Mountains was found by Whitaker (1962) to be one of continuous gradation of stands along environmental gradients. These gradients also exist between the forest types and zones, but have not been stressed because of the lack of information.

The early stages of succession are the primary stage (where no plants have previously existed) or the secondary stage (where a catastrophe has eliminated all or part of the existing vegetation). Further stages are termed seral until the last, or climax, stage is reached. Several climax stages may exist. The "common" or zonal climax is usually referred to as the climatic climax. If a soil difference or topographical feature prevents this, the climax may be further qualified by the adjectives edaphic or topographic. The concept of climax as being the last stage is not necessarily true. The climax is only a relatively stable stage where the vegetation for the present time is self-perpetuating. Changes in the site may be taking place but if no other vegetation is better suited the existing climax may be maintained.

The vegetative units (which are actually communities or associations recognized at a particular time in an abstract sense) may be diagrammed on a simplified chart which illustrates the successional trends within the forest type or zone. Due to the existence of many intermediate communities or associations, these charts illustrate only the main features of each habitat, since otherwise it would become far too complex and unwieldy. However, the comprehension of the basic units and their composition and dynamics is essential for an understanding of the vegetation of the North Cascades Complex.

The communities are defined as vegetative units that may have identical dominant strata. An example of this would be two Douglas-fir (Pseudotsuga menziesii [Mirbel] Franco var. menziesii) stands of different ages and lower strata, but of similar dominant strata, growing side by side. In contrast, the associations are of essentially the same composition in all strata. Since it is the basic unit, the association must occur throughout the ecological province in similar habitats, although sub-associations may be used for slightly different phases.

Since no research has been done on the forest types of the North Cascades, the units named within them are only tentative. I have used my field notes and limited data to arrive at the various units within the forest types of the Mt. Baker Province. Most of these units are classified as communities due to lack of information on all strata. Most of the vegetation data for the communities of the forest types and zones in the Wenatchee Province came from reconnaissance trips made by Jerry F. Franklin and J. M. Trappe (personal communication) and trips by the author to other nearby drainages east of the Cascade crest. Additional information was provided by Carl S. English (personal communication) and Brian O. Mulligan (personal communication).

The Subalpine Zone west of the Cascade crest has received a more thorough treatment because of a greater quantity of data. The Alpine Zone, which is extremely fragmented and small in area within the North Cascades Complex, has received only a brief description.

The several habitats within each forest type and zone all have different successional trends. Each habitat will be discussed from the primary to climax stages in order to lend clarity to the overall dynamics within the forest types and zones.

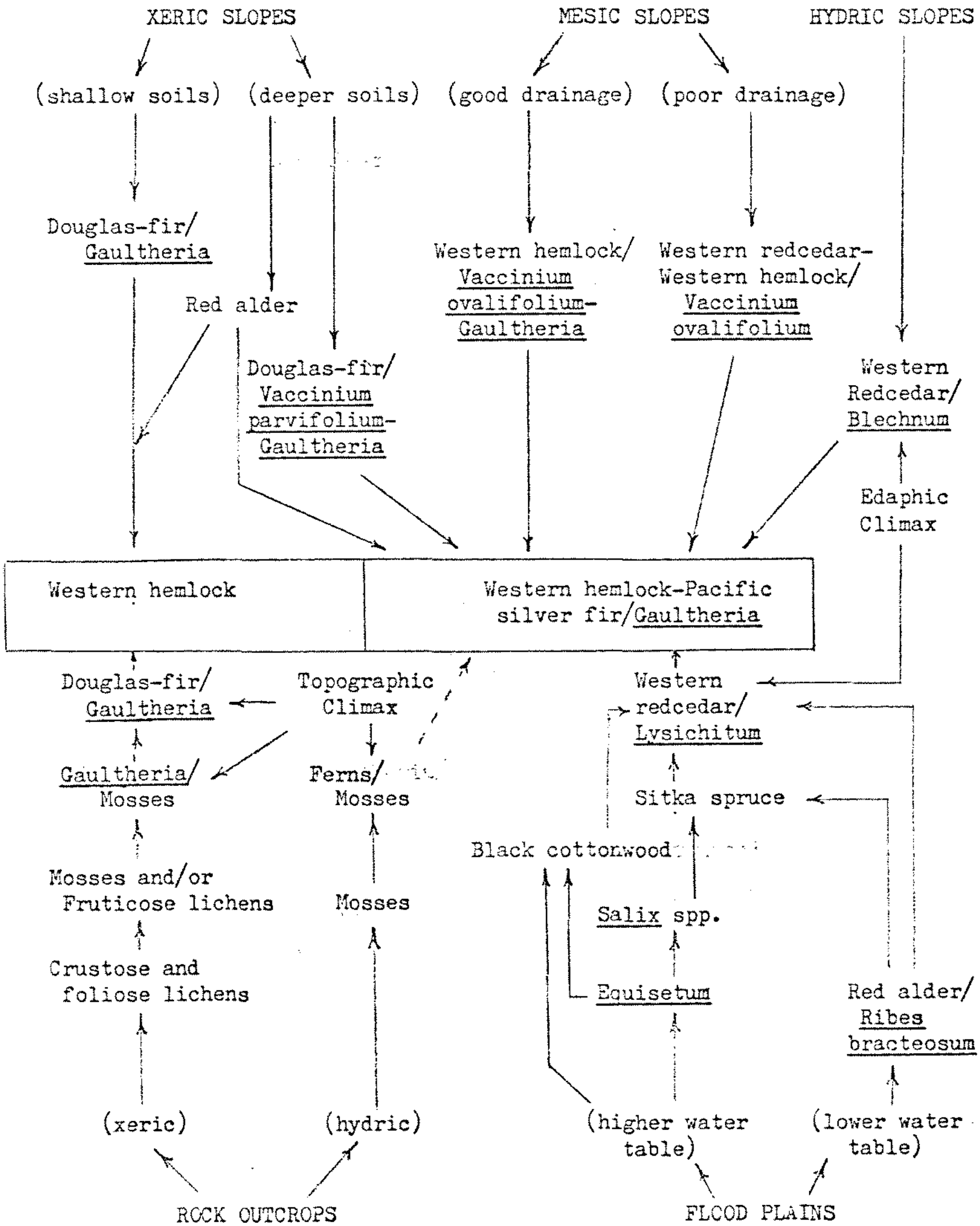
Except in the case of tree species, the international botanical names have been used throughout the text. The use of common names is often misleading and is best avoided.

Western Hemlock Forest Type

This forest type occurs from the lowest elevations in the North Cascades Complex up to about 2500 feet, although climax stands may be found at higher elevations on dry south slopes. The stands consist of western hemlock (Tsuga heterophylla [Raf.] Sarg.) and, to a lesser extent, Douglas-fir and western redcedar (Thuja plicata Donn.). Associates on moist sites are bigleaf maple (Acer macrophyllum Pursh), Pacific silver fir (Abies amabilis [Dougl.] Forbes), paper birch (Betula papyrifera Marsh. var. commuta [Regel] Fern.) and red alder (Alnus rubra Bong.). Black cottonwood (Populus trichocarpa T. & G. ex Hook.), Sitka spruce (Picea sitchensis [Bong.] Carr.), willow (Salix spp.), and occasionally at higher elevations, Alaska-cedar (Chamaecyparis nootkatensis [D. Don.] Spach) are the associates on extremely wet habitats. Sporadically inhabiting the drier sites are grand fir (Abies grandis [Dougl.] Lindl.), lodgepole pine (Pinus contorta Dougl. ex Loud. var. latifolia Engelm.), Pacific dogwood (Cornus nuttallii Aud. ex T. & G.), western white pine (Pinus monticola Dougl. ex D. Don.) and wild cherry (Prunus emarginata [Dougl.] Walpers var. emarginata). Trembling aspen (Populus tremuloides Michx.) may also be found within the complex, since it has been reported from Glacier (Muenscher, 1941). Another species, ponderosa pine (Pinus ponderosa Dougl. ex Loud.), is found on dry south slopes at the northern end of Ross Lake.

General successional trends have been considered within the forest type (see figure 5). The following habitats and vegetative units occur within the Western Hemlock Forest Type.

Figure 5. General successional trends in the Western Hemlock Forest Type.



1. Xeric slopes (shallow soils)

These slopes, often with soil depths of less than 12 inches, are infrequent in the North Cascades and usually occur on south to west convex slopes and ridges. The vegetation on the shallow soils, which may dry rapidly in summer, is one of the first to become a fire hazard during a dry period. After a fire has occurred the soils are highly susceptible to erosion. The following vegetative units are found on this habitat.

a) Douglas-fir/*Gaultheria* community

This community is the pioneer on these sites. Since Douglas-fir will not thrive on poorly drained soils (Isaac and Dimock, 1958), it is found mainly on south to west slopes in the North Cascades. Devolopment of these communities is usually quite slow and often remains in a stagnant condition for many years. Douglas-fir is always the dominant tree species, although western redcedar, because of poorly drained sites, may be an associate. The growth rate of both species is extremely poor. The saplings and seedlings consist mainly of western hemlock, along with some Douglas-fir and western redcedar. *Gaultheria shallon* (Pursh) is always the most dominant and often the only abundant shrub. The herb layer, probably because of the low soil moisture content, is generally poor or lacking. Common mosses are *Hylocomium splendens* (Hedw.) Bry. Eur. and *Dicranum fuscescens* Turn., while *Cladonia* spp. are frequent lichens.

b) Western hemlock community

Since Douglas-fir is an intolerant species, it is slowly replaced by the more tolerant western hemlock (Munger, 1940). The western hemlock community is one of the climatic climax communities or associations in the North Cascades (see figure 6). At higher elevations Pacific silver fir becomes more abundant in the stand as a climax species. The saplings and seedlings consist of western hemlock with only sparse numbers of western redcedar. The dominant shrub is *Gaultheria shallon* with *Vaccinium parvifolium* Smith and *Berberis nervosa* Pursh appearing on the slightly deeper soils. Herbs are uncommon, as in the Douglas-fir/*Gaultheria* community, with only sparse numbers of the ferns *Pteridium aquilinum* (L.) Kuhn var. *pubescens* Underw. and *Polystichum munitum* (Kaulf.) Presl var. *munitum* appearing. *Hylocomium splendens* and *Dicranum fuscescens* are important mosses here also.

2. Xeric slopes (deeper soils)

This habitat usually occurs on moderate southerly slopes with soils two or more feet deep. The soils are well drained and more developed. Vegetation, because of the improved soil condition, attains better growth than on the xeric slope with shallow soils. The following successional trends may be found on these slopes.

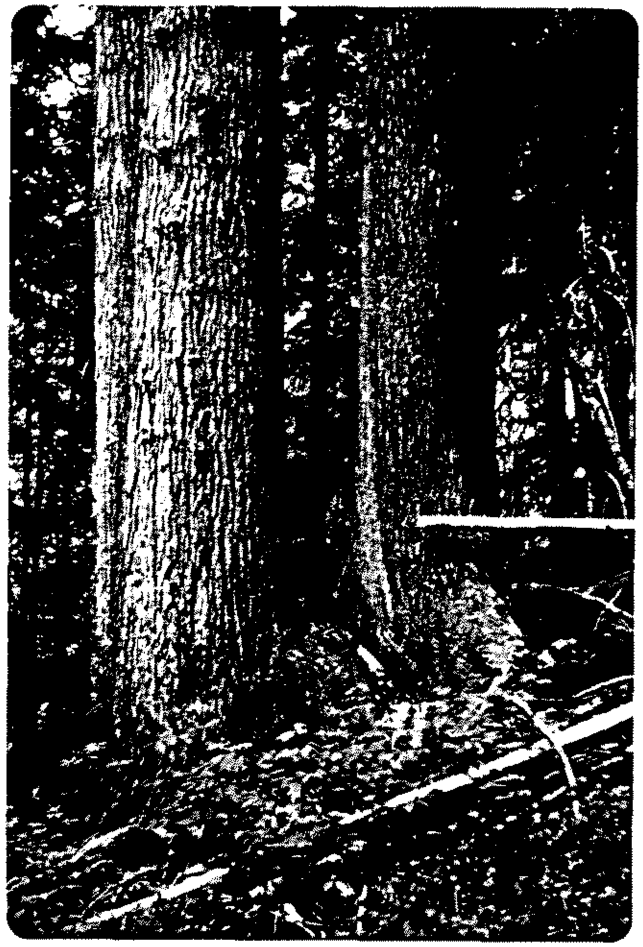


Figure 6 . Western hemlock community in the North Cascades. July 21, 1968; elevation, 2000 feet.

a) Red alder community

The presence of red alder, which requires a fairly abundant soil moisture (Worthington, 1957), indicates the difference between this and the previous habitat. Often the xeric slopes with deep soils may be too dry, as after a fire or logging operation. In this case Acer circinatum Pursh may pioneer on the site. On these drier sites Gaultheria shallon, Epilobium angustifolium L., Pteridium aquilinum var. pubescens and Anaphalis margaritacea (L.) B. & H. may also be abundant.

Red alder, which may be the initial invader or a co-pioneer with Douglas-fir, has a rapid early growth but is short-lived, with a maximum age of about 100 years (Garman, 1953). If a seed source is lacking, the Douglas-fir/Vaccinium parvifolium - Gaultheria association may be bypassed and development will proceed toward the Western hemlock/Vaccinium ovalifolium - Gaultheria community. This may be a common occurrence, since western hemlock is a prolific seeder (Berntsen, 1958) and more tolerant beneath the red alder.

b) Douglas-fir/Vaccinium parvifolium - Gaultheria community

This community may pioneer or, if established with red alder, it will overtop the red alder in about 50 years (Worthington, 1957). Douglas-fir may reach its best growth on habitats intermediate between this habitat and the Mesic slope (good drainage) habitat found on northerly slopes. Douglas-fir may remain as the dominant overstory for several centuries. The saplings and seedlings in this community are mainly western hemlock, but on moister sites and at higher elevations Pacific silver fir is also common. The dominant shrubs are Vaccinium parvifolium and Gaultheria shallon. Other shrubs occurring are Berberis nervosa, Linnaea borealis L. var. longiflora Torr. and Vaccinium ovalifolium Smith. The main herbs are Cornus canadensis L., Polystichum munitum var. munitum and Pteridium aquilinum var. pubescens. Hylocomium splendens, Rhytidiadelphus loreus (Hedw.) Warnst and Dicranum fuscescens are common mosses in the association.

c) Western hemlock - Pacific silver fir/Gaultheria community

This community is the climax for most of the successional trends in the Western Hemlock Forest Type. Its composition may vary depending on the original habitat and its elevation. The most common community composition will be discussed here.

The overstory consists mainly of western hemlock and Pacific silver fir. The latter, because of its need of abundant moisture (Dimock, 1958), is more common on north slopes and at higher elevations.

Grand fir, which is more tolerant than Douglas-fir (Foiles, 1959), may also be found in the early stages of this community. The sapling and seedling layer is mainly western hemlock and Pacific silver fir. A sporadic but conspicuous tree or shrub of this community is the western yew (*Taxus brevifolia* Nutt.). The main shrubs throughout most of the community are *Gaultheria shallon* and *Vaccinium alaskaense* Howell, with *Acer circinatum* and *Rubus spectabilis* Pursh more common on lower or dryer slopes.

At higher elevations and on moister sites *Vaccinium ovalifolium* is frequently found, but *Gaultheria shallon* decreases. The dominant herbs are *Cornus canadensis*, *Blechnum spicant* (L.) With. and *Tiarella trifoliata* L. Herbs joining the community at higher elevations are *Rubus pedatus* J. E. Smith and *Clintonia uniflora* (Schult.) Kunth. Common mosses are *Dicranum fuscescens*, *Hylocomium splendens*, *Rhytidiadelphus loreus*, and at higher elevations, *Rhytidiopsis robusta* (Hook.) Broth.

3. Mesic slopes (good drainage)

The northerly slopes are the most likely location for this habitat in the North Cascades. Soils are deep and abundant moisture is always available to the vegetation.

a) Western hemlock/*Vaccinium ovalifolium* - *Gaultheria* community

Western hemlock, because of its good seed dissemination and ability to germinate well on moist sites, is the pioneer on this habitat. At higher elevations Pacific silver fir is a co-pioneer. The sapling and seedling stratum includes both western hemlock and Pacific silver fir. Common shrub species are Vaccinium ovalifolium and Gaultheria shallon, the latter more frequent on the northwest slopes. Vaccinium alaskaense is also found throughout the community. The most abundant herbs are Tiarella trifoliata, Polystichum munitum var. munitum and Blechnum spicant, with Clintonia uniflora entering the community at higher elevations. The moss layer consists of Dicranum fuscescens, Rhytidiadelphus loreus, and Rhytidiopsis robusta at higher elevations.

b) Western hemlock - Pacific silver fir/Gaultheria community

This community, the general description of which may be found on page 55, attains its best growth in this successional pattern. Development from pioneer to climax forest is relatively fast.

4. Mesic slopes (poor drainage)

These slopes occur mainly on northerly aspects and are usually shallow or have impervious layers just below the surface. Although drainage is poor, water does not accumulate.

a) Western redcedar - western hemlock/Vaccinium ovalifolium community

The ability of western redcedar to grow well on wet soils and northerly aspects (Boyd, 1959) allows it to pioneer on this habitat along with western hemlock. Understory tree species include western hemlock and Pacific silver fir, along with sparse western redcedar reproduction.

Characteristic shrubs in this community are _Vaccinium ovalifolium_, _Oplopanax horridus_ (J. E. Smith) Miq., _Rubus spectabilis_ and _Sambucus racemosa_ L. var. _arborescens_ (T. & G.) ex Gray. The lush herb layer consists of _Tiarella trifoliata_, _Blechnum spicant_, _Clintonia uniflora_, _Athyrium filex-femina_ (L.) Roth, and _Gymnocarpium dryopteris_ (L.) Newm.

b) Western hemlock - Pacific silver fir/_Gaultheria_ community

This is one of the wetter sites on which this climax community may be found. Species such as _Gaultheria shallon_ and _Acer circinatum_ are absent because of the poor drainage. The general description of this community appears on page 55.

5. Hydric slopes

This habitat occurs in depressions, creek sides and ravines. The water table is usually quite high and permanent seepage is characteristic of the soils of this habitat.

a) Western redcedar - _Blechnum_ community

Western redcedar is the major pioneer in this community. Western hemlock and Pacific silver fir may also become established on locally mesic sites. At higher elevations Alaska-cedar may replace western redcedar. Black cottonwood may also grow in locally wet areas, apparently because a high pH, moving water and good nutrient supply are available on slightly deeper soils (Smith, Haddock and Hancock, 1956; Smith, 1957).

The understory tree species may be of two types. If seepage is persistent then an edaphic climax occurs. This is characterized by an understory that resembles the overstory in composition. If succession is occurring, western hemlock and Pacific silver fir will become the most frequent saplings and seedlings because of slightly drier soils.

The most abundant shrubs are Vaccinium alaskaense, Rubus spectabilis and Sambucus racemosa var. arborescens. Blechnum spicant is the most common herb in this lush understory. Cornus canadensis, Tiarella trifoliata, Athyrium filex-femina and Streptopus spp. are also frequent. Common mosses are Rhytidiadelphus loreus and Eurhynchium oreganum (Sull.) Lesq. & James.

b) Western hemlock - Pacific silver/Gaultheria community

When further research has been undertaken in the Western Hemlock Forest Type, the Western redcedar/ Blechnum community will probably be found to be succeeded by a different but closely related climax community other than the Western hemlock - Pacific silver fir/Gaultheria community (p. 55). This is indicated by the lack or sporadic occurrence of Gaultheria shallon and the greater amount of western redcedar on these wetter sites.

6. Flood plains (higher water table)

This habitat occurs on alluvial accumulations on the larger creeks and rivers. The depth of soil above the water level results in various pioneer communities. The best examples of the flood plains habitats in the North Cascades Complex may be found along the Skagit River. The highest water table pioneer community and its successional pattern will be discussed here.

a) Equisetum community

This community forms on the new, bare alluvium and consists of practically pure stands of Equisetum arvense L. This vegetation may last for only a short time before succession takes place. Succession may be caused by a drop in the water level or the accumulation of more soil by the Equisetum arvense during short flooding periods.

b) Salix spp. community

Salix spp., along with several Carex spp., replace the Equisetum community with only a slight decrease in the water table. Lysichitum americanum St. John and members of the Graminae family may also appear. This community, as most of the communities in this habitat, may occasionally remain as an edaphic climax, although it is more likely it will be disturbed by floods or changes in the stream's course.

c) Black cottonwood community

Black cottonwood, the largest hardwood in the Pacific Northwest (Harlow and Harrar, 1958), is quite conspicuous along the Skagit River in the North Cascades Complex. This tree is also the fastest growing of any of its associates (Smith, 1957) and reaches heights of 150 feet or more in the Skagit Valley. It is well adapted to this alluvial habitat since it requires a nutrient-rich soil and abundant moisture (Roe, 1958). The best growth is reached on soils with more than 18 inches of loam or heavy soil above the gravel (Smith et al, 1956; Smith, 1957), although seedlings and saplings may be found on shallower soils. Black cottonwood may be a pioneer or occasionally a seral community. The seral stage may develop within either the Equisetum community or the Salix spp. community. This invasion of the Salix spp. community is possible if space is available or if the Salix spp. are dying because of soil accumulation.

Bigleaf maple, a species requiring above normal soil moisture (Ruth and Muerle, 1958), may also be found as an associate on slightly drier sites. The samplings and seedlings invading this community are usually either western redcedar or Sitka spruce.

Along the Skagit River, western redcedar is the most frequently noted seedling.

A number of shrubs may be associated with this community. Some of these are _Acer circinatum_, _Oplopanax horridus_, _Salix_ spp., _Cornus stolonifera_ Michx. var. _occidentalis_ (T. & G.) C. L. Hitchc., _Rubus spectabilis_, _Sambucus racemosa_ var. _arborescens_, _Symphoricarpus albus_ (L.) Blake var. _laevigatus_ (Fern.) Blake and _Rubus parviflorus_ Nutt. var. _parviflorus_. Herbs that may be found with this community are _Equisetum arvense_, _Urtica_ spp., _Lysichitum americanum_, _Polystichum munitum_ var. _munitum_, _Athyrium filex-femina_ and members of the family Graminae.

d) Sitka spruce community

I do not know how extensive this tree species is in the North Cascades Complex. However, single trees have been seen along many of the streams. Tree growth is best on moist sites, but any ground water must be moving (Ruth, 1958).

e) Western redcedar/_Lysichitum_ community

Western redcedar reaches its best growth on alluvial habitats (Boyd, 1959). This community may be climax or it may be invaded by western hemlock and Pacific silver fir. Saplings and seedlings are found only if the water level is quite low. Common shrubs are _Rubus spectabilis_, _Acer circinatum_ and _Sambucus_ racemosa var. arborescens. Lysichitum americanum, Polystichum munitum var. munitum and Blechnum spicant are frequently appearing herbs.

f) Western hemlock - Pacific silver fir/Gaultheria community

This community, which was previously described on page 55, is probably slightly different than the actual climax community succeeding the Western redcedar/Lysichitum community, as indicated by the sporadic occurrence or lack of Pacific silver fir and Gaultheria shallon.

7. Flood plains (lower water table)

This habitat is similar to the previous one except for the lower water table or greater soil depth. The soil surface of this habitat is not subject to frequent flooding.

a) Red alder/Ribes community

Stands of red alder are abundant along the Skagit River and other streams in the North Cascades Complex. Red alder is a pioneer species, and may reach its best growth on these sites (Johnson, 1968). Sitka spruce or western redcedar occur as saplings or seedlings. This community may develop into two different communities: the Spruce community (p. 62) or the Western redcedar/Lysichitum community (p. 62). The latter is the most frequent in the North Cascades. Ribes bracteosum Dougl. ex Hook. is often the dominant shrub, although all of the shrubs listed for the Black cottonwood community (p. 61) may occur here also.

8. Rock outcrops (hydric)

This habitat, although not as frequent as at higher elevations, occurs throughout the Western Hemlock Forest Type. The usual location is on north aspects, although it may also occur in moist ravines or areas where water constantly runs over the outcrops. Erosion resulting from road construction, fire and logging is continually exposing new outcrops.

a) Moss community

The moss community on this wet habitat pioneers in crevices where weathering or soil accumulation has occurred. One of the most common species here is _Polytrichum commune_ Hedw. This community may remain in this stage for a considerable length of time.

b) Fern/Moss community

Through further accumulation of soil and organic matter this community is able to succeed the pioneer community. _Adiantum pedatum_ L., _Montia sibirica_ (L.) Howell var. _sibirica_ and _Gymnocarpium dryopteris_ are the most frequent herbs. _Polytrichum commune_ is a common moss. On southerly slopes shrubs such as _Gaultheria shallon_ may join the community.

The Fern/Moss community may be climax because of the lack of soil accumulation which would permit other plants to invade. Western hemlock and other members of the Western hemlock - Pacific silver fir/Gaultheria community have been noticed on the hydric rock outcrops, indicating a possible succession to this community. This, however, may be rare or difficult to distinguish in the field.

9. Rock outcrops (xeric)

The main difference between this habitat and the preceding one is the much less available moisture on the rock surface. This habitat is found on the southerly slopes of the forest type.

a) Crustose and foliose lichen community

On these rock outcrops many locally small communities may pioneer, since the cracks, shaded areas, and different surface slopes offer innumerable habitats. The most common pioneer community, however, is that formed by crustose and foliose lichens. These plants have the ability to colonize on scant accumulations of soil or on bare rock. Their ability to disintegrate the rock surface by mechanical means was indicated by Fry (1927). This stage may not advance for long periods, however, since the soil may continually be washed away.

b) Moss and/or fruticose lichen community

This community becomes established on the soil provided by the previous community or, more commonly, in depressions and cracks. This stage may be prolonged before the invasion of Gaultheria shallon.

c) *Gaultheria*/Moss community

With increased accumulation of soil and organic matter this community is able to succeed the previous community. *Gaultheria shallon* is the only constant shrub and *Polytrichum commune* is the most frequent moss. The climax stage is usually reached at this point, although a Douglas-fir/*Gaultheria* community (p. 51) of low vigor may be found occasionally. Western hemlock seedlings and small saplings have been noted, indicating the possibility of a Western hemlock climax community (p. 52).

The successional pattern of several other tree species found sporadically throughout the Western Hemlock Forest Type is not clear at the present time. Western white pine is found on a variety of sites, but may be less abundant at the present time because of the introduced white pine blister rust *Cronartium ribicola* Fischer (Boyce, 1961). This pine is quite similar to Douglas-fir in that it pioneers after a fire (Wellner, 1962). Lodgepole pine is also an infrequent species in the zone and may grow on poorly drained or exceedingly well drained sites (Tackle, 1959).

Pacific Silver Fir Forest Type

This forest type generally occurs from 2500 feet up to 4200 feet on north slopes and 5200 feet on south slopes in the North Cascades Complex. It may also be found below 2500 feet in mountain valleys where the cold air drainage creates a cooler environment. The Pacific Silver Fir Forest Type is the most extensive forest type of the entire complex (see figure 7).

Pacific silver fir is the major tree species in the type and, except at lower elevations, mountain hemlock (*Tsuga mertensiana* [Bong.] Carr.) is its most common associate. Western hemlock is found at lower elevations along with less frequent species such as Douglas-fir, western redcedar and western white pine. Alaska-cedar and alpine fir (*Abies lasiocarpa* [Hook.] Nutt.), although not abundant, are usually found at higher elevations in the type.

The diagram of general successional trends (see figure 8), similar to that used for the Western Hemlock Forest Type, shows a development of communities toward only two climax communities. Many others probably exist but will not be understood until further study has been made of them. Franklin (1966b) described 12 Pacific silver fir climax associations in southwestern Washington, and a similar number in the North Cascades would not seem unlikely. The following habitats and vegetative units occur within the Pacific Silver Fir Forest Type. These habitats are similar to those described in the Western Hemlock Forest Type.

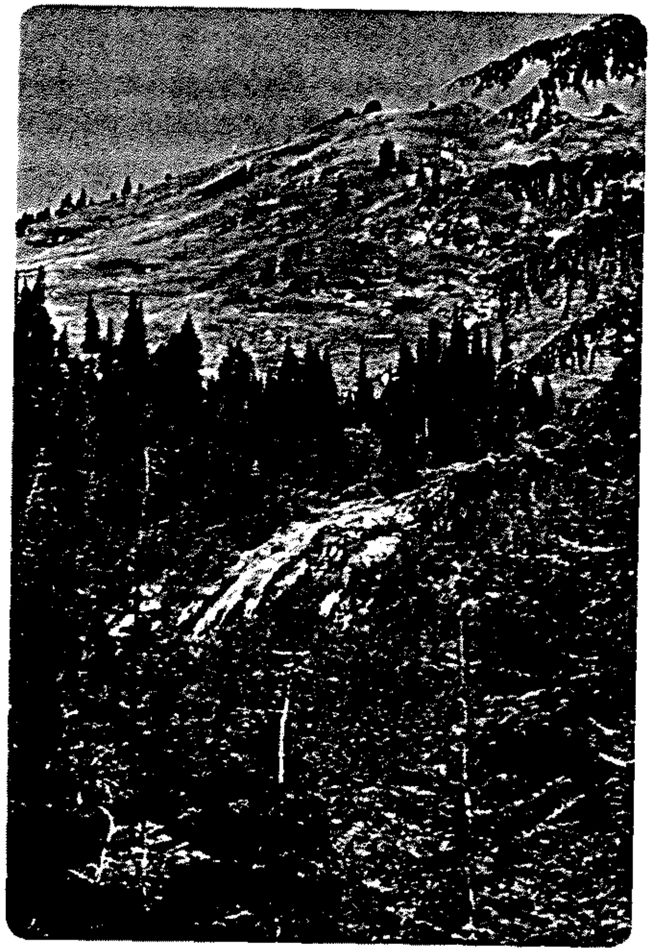
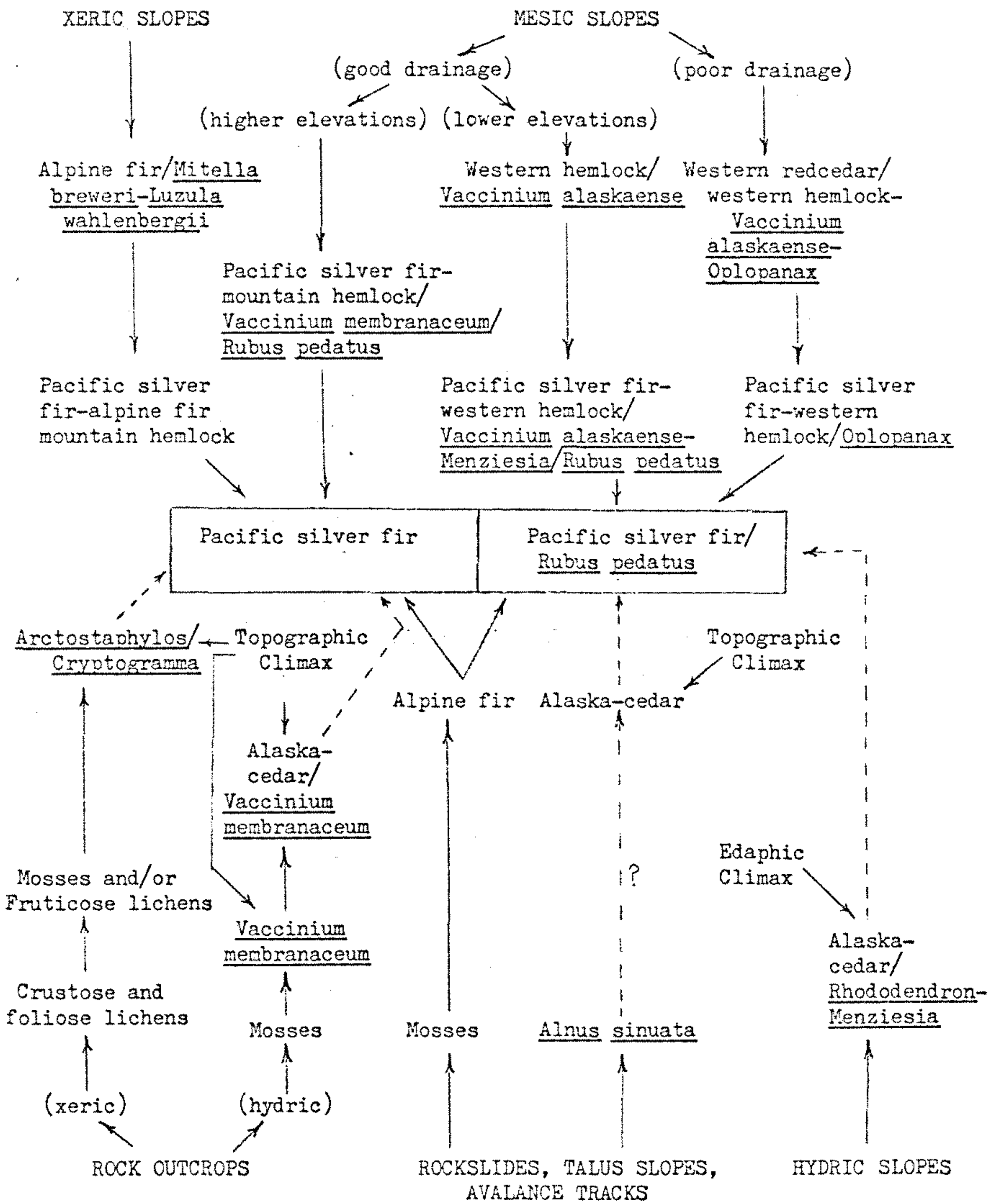


Figure 7. Pacific Silver Fir Forest Type adjoining the Subalpine Zone in the North Cascades. Aug. 7, 1968; elevation, 5800 feet at top of ridge, 3200 feet in foreground.

Figure 8. General successional trends in the Pacific Silver Fir Forest Type



1. Xeric slopes

a) Alpine fir/*Mitella breweri* - *Luzula wahlenbergii* community

There has been no report as yet of a pure alpine fir community within the complex west of the Cascade crest. The existence of such a community north of Mt. Baker, the description of which follows, is an indication that such stands may exist within the complex.

This stand is on deep well drained soil and has a southwest aspect. The overstory is completely dominated by alpine fir, accompanied by a few intermediate mountain hemlock. The saplings and seedlings consist of equal numbers of alpine fir, mountain hemlock and Pacific silver fir. *Vaccinium membranaceum* Dougl. ex Hook. and *Sorbus sitchensis* Roemer var. *sitchensis*, the sole shrubs in the community, are extremely rare. The only abundant herbs are *Mitella breweri* Gray and *Luzula wahlenbergii* Rupr. *Valeriana sitchensis* Bong., *Polygonum bistortoides* Pursh and *Veratrum viride* Ait. also occur in the understory.

b) Alpine fir - Mountain hemlock - Pacific silver fir community

This community, although hypothetical in the North Cascades, is based on the composition of the preceding community. This stand would probably be in a seral stage and would eventually reach a Pacific silver fir climax (p. 71).

2. Mesic slopes (good drainage, higher elevations)

a) Pacific silver fir - Mountain hemlock/*Vaccinium membranaceum*/*Rubus pedatus* community

This community is the most prevalent community at higher elevations and may occur on any aspect. The dominant trees may vary in proportion, although mountain hemlock is probably the most frequent pioneer. The predominant saplings and seedlings are Pacific silver fir, but mountain hemlock is also common. The major shrub is *Vaccinium membranaceum*, with *Menziesia ferruginea* Smith var. *ferruginea*, *Rhododendron albiflorum* Hook., *Vaccinium alaskaense* and *Vaccinium ovalifolium* also appearing. *Rubus pedatus*, the most abundant herb, is accompanied by *Arenaria macrophylla* Hook., *Clintonia uniflora*, *Goodyera oblongifolia* Raf. and *Streptopis roseus* Michx. var. *curvipes* (Vail) Fassett.

b) Pacific silver fir community

The ability of Pacific silver fir to become established on litter and the restriction of both western and mountain hemlock reproduction to rotten logs probably accounts for the widespread occurrence of Pacific silver fir climax stands (Franklin, 1965b; Thornburgh, 1969). However, the high shade tolerance of Pacific silver fir is thought by some to be its most important ecological feature (Hanzlik, 1932; Schmidt, 1957).

The stands may range from pure Pacific silver fir communities to communities with more western hemlock at lower elevations or more mountain hemlock at higher elevations. Only the pure community will be considered here.

The understory cover is often sparse, although a diverse number of shrubs, herbs and mosses may be found within it. Pacific silver fir is the dominant reproducing tree species. Some of the shrubs inhabiting the community are *Gaultheria ovatifolia* Gray, *Menziesia ferruginea* var. *ferruginea*, *Ribes lacustre* (Pers.) Poir., *Rubus parviflorus*, *Sorbus sitchensis* Roemer var. *grayi* (Wenzig) C. L. Hitchc., *Vaccinium alaskaense* and *Vaccinium membranaceum*. Herbs inhabiting the community are *Arenaria macrophylla*, *Clintonia uniflora*, *Pteridium aquilinum* var. *pubescens*, *Pyrola secunda* L. var. *secunda*, *Rubus lasiococcus* Gray, *Rubus pedatus*, *Streptopus roseus* var. *curvipes* and *Valeriana sitchensis*. Common mosses are *Dicranum fuscescens*, *Rhytidiopsis robusta* and *Mnium insigne* Mitt.

2. Mesic slopes (good drainage, lower elevations)

a) Western hemlock/*Vaccinium alaskaense* community

Western hemlock is often the sole pioneer species on this habitat, especially on west to south slopes. On north to east aspects it is usually accompanied by Pacific silver fir or western redcedar. The saplings and seedlings beneath the stands consist of both western hemlock and Pacific silver fir. The most abundant shrub is _Vaccinium alaskaense_. Others that may appear are _Rubus parviflorus_ and _Sambucus racemosa_ var. _arborescens_. _Rubus pedatus_ and _Streptopus amplexifolius_ (L.) DC. var. _americanus_ Schult. are frequent herbs.

b) Pacific silver fir - western hemlock/_Vaccinium alaskaense_ - _Menziesia_/_Rubus pedatus_ community

This seral community has a mixed overstory of western hemlock and Pacific silver fir. The majority of the saplings and seedlings are Pacific silver fir, with a small number of western hemlock. _Vaccinium alaskaense_ and _Menziesia ferruginea_ var. _ferruginea_ are the most frequent shrubs. _Ribes lacustre_, _Rubus spectabilis_, _Sorbus sitchensis_ var. _grayi_ and _Vaccinium membranaceum_ also inhabit the community. Major herbaceous plants are _Rubus pedatus_, _Pyrola secunda_ var. _secunda_ and _Streptopus amplexifolius_ var. _americanus_, along with less frequent species such as _Clintonia uniflora_, _Cornus canadensis_ and _Listera cordata_ (L.) R. Br.

c) Pacific silver fir/_Rubus pedatus_ community

This climax community is usually found with small numbers of mountain hemlock or western hemlock in the overstory. The understory tree species are the same as in the dominant layer. The lower strata are usually lush and dense. Oplopanax horridus, Ribes bracteosum, R. lacustre, Rubus spectabilis, Sambucus racemosa var. arborescens, Vaccinium alaskaense and V. ovalifolium are common shrubs. The most abundant herbaceous species is Rubus pedatus, while Blechnum spicant, Cornus canadensis, Clintonia uniflora, Gymnocarpium dryopteris and Streptopus roseus var. curvipes are its most frequent associates. Rhytidiopsis robusta is a common moss in the community.

4. Mesic slopes (poor drainage)

a) Western redcedar - Western hemlock/Vaccinium alaskaense - Oplopanax community

This community is quite similar to the Western redcedar - Western hemlock/Vaccinium ovalifolium community found in the Western Hemlock Forest Type. The principal distinctions are the greater amount of Pacific silver fir reproduction and the addition of Vaccinium alaskaense to the shrub layer of the Western redcedar - Western hemlock/Vaccinium alaskaense - Oplopanax community.

Western redcedar and western hemlock are the pioneer species. The understory tree species are western hemlock and Pacific silver fir, the latter being the more abundant of the two. Major shrubs in the community are _Vaccinium alaskaense_ and _Oplopanax horridus_. Other shrubs include _Ribes bracteosum_, _R. lacustre_, _Rubus spectabilis_ and _Vaccinium ovalifolium_. Common herbs are _Blechnum spicant_, _Clintonia uniflora_, _Cornus canadensis_, _Gymnocarpium dryopteris_, _Rubus pedatus_, _Smilicina stellata_ (L.) Desf., _Streptopus amplexifolius_ var. _americanus_, _S. roseus_ var. _curvipes_ and _Veratrum virides_. _Rhytidiopsis robusta_ is a frequent moss species.

b) Pacific silver fir - Western hemlock/_Oplopanax_ community

Dominating the overstory in this seral community are western hemlock and Pacific silver fir. The saplings and seedlings are mostly Pacific silver fir. The shrub and herbacious layer, except for a decrease in _Vaccinium alaskaense_ and _Veratrum viride_, is quite similar to that of the preceding community.

c) Pacific silver fir/_Rubus pedatus_ community

The succession of the preceding community would develop toward a Pacific silver fir/_Rubus pedatus_ community similar to that described on page 73.

5. Hydric slopes

This habitat occurs along streams and in ravines and depressions of the forest type. Western redcedar communities may be found at lower elevations. This community is closely related to the Western redcedar/_Blechnum_ community of the Western Hemlock Forest Type (p. 58). The chief difference is in the ground cover species, with the addition of higher elevation elements in the Western redcedar community. This community will therenot be described again here, but its upper elevation associate, the Alaska-cedar/Rhododendron - Menziesia community, will be covered.

a) Alaska-cedar/Rhododendron - Menziesia community

The soils of this community are usually saturated; even during dry periods abundant soil moisture is still available. Perry (1954) found in Canada that Alaska-cedar reacts quite sharply to different growing conditions. This is particularly evident in the North Cascades, where it may be found either as a small, twisted tree or as a good-sized specimen. Alaska-cedar is less tolerant than any of its associates (Anderson, 1959), thus explaining its abundance only on these very wet sites. It is the pioneer and, if continual seepage occurs, the climax tree species as well. Western redcedar may be found with it at lower elevations.

The most abundant shrubs are *Menziesia ferruginea* var. *ferruginea* and *Rhododendron albiflorum*. *Sorbus sitchensis* var. *sitchensis*, *Vaccinium alaskaense* and *V. membranaceum* also occur frequently. Herbaceous shrubs common to the community are *Athyrium filex-femina*, *Lysichitum americanum*, *Rubus pedatus*, *Streptopus amplexifolius* var. *americanus*, *S. roseus* var. *curvipes*, *Valeriana sitchensis* and *Veratrum viride*.

b) Pacific silver fir/Rubus pedatus community

If the edaphic condition of the Alaska-cedar/Menziesia - Rhododendron community changes toward a mesic habitat, then mountain hemlock and Pacific silver fir are able to invade the community. Pacific silver fir is usually the most abundant, and the resultant community would resemble the Pacific silver fir/Rubus pedatus community described on page 73.

6. Rockslides, talus slopes and avalanche tracks

This habitat is a common one in the North Cascades, frequently occurring in the Subalpine Zone as well, but a lack of data restricts the description to the dominant vegetation. The general successional trends (see figure 8) will therefore not be followed, although hypotheses may be drawn.

If the rockslide or snowslide has resulted in soil being mixed with the rocks, immediate invasion by Alnus sinuata (Regl.) Rydb. can be anticipated. It is not certain whether the frequent clumps of Alaska-cedar have invaded with the Alnus sinuata or at a later time.

Other shrubs appearing less frequently are Acer circinatum, A. glabrum Torr. var. douglasii (Hook.) Dippel, Ribes bracteosum and Salix sitchensis Sanson. Galium triflorum Michx., Montia sibirica var. sibirica and Tolmia menziesii (Pursh) T. & G. are common species associated with Alnus sinuata.

On talus slopes or sites where the material consists of rocks and boulders, the primary invasion is similar to that of the rock outcrop (hydric) habitat. Because of the ability of soil to accumulate, herbs and shrubs are able to invade the sites. Alpine fir is often the first tree species to invade this habitat and ususlly forms pure stands. Tree growth is generally extremely slow and a climax community of Pacific silver fir (which has been noted reproducing beneath alpine fir in several locations) may not be reached for a number of years. The eventual composition of the climax community will depend on the elevation and aspect of the habitat.

The possible successional trends have been considered for this habitat, but only in one direction. The frequency of disturbance on these sites is high and succession may be constantly set back. The most adabtable species (Alaska-cedar and *Alnus sinuata*) may be the only ones to survive.

7. Rock outcrops (hydric)

a) Moss community

The pioneering mosses on this habitat are similar to those in the Western Hemlock Forest Type (p. 64). The seral communities differ however, and probably take longer to develop because of the need for a larger amount of soil.

b) *Vaccinium membranaceum* community

The occurrence of this community may be limited and other shrubs may replace *Vaccinium membranaceum* elsewhere in the forest type. *Aruncus sylvester* Kostel and *Sorbus sitchensis* var. *sitchensis* may also appear on these sites along with such herbs as *Adiantum pedatum* L. and *Montia sibirica* var. *sibirica*.

c) Alaska-cedar/*Vaccinium membranaceum* community

Although Alaska-cedar seedlings (and occasionally larger saplings) have been noted invading the preceding community, it is uncertain whether succession is actually taking place or whether a topographic climax has been reached. The occasional presence of mountain hemlock and Pacific silver fir seedlings where large Alaska-cedar saplings exist may indicate an eventual climatic climax community.

8. Rock outcrops (xeric)

a) Crustose and foliose lichen community

Primary succession on this habitat, as on the mesic habitat, is quite similar to its associate in the Western Hemlock Forest Type. A complete description of it may be found on page 65.

b) Moss and/or fruticose lichen community

This community is closely related to its associate at lower elevations. A discussion of this associate may be found on page 65.

c) *Arctostaphylos/Cryptogramma* community

The invasion of such species as *Arctostaphylos uva-ursi* (L.) Spreng. and *Cryptogramma crispa* (L.) R. Br. var. *acrostichoides* (R. Br.) C. B. Clarke takes place once the cracks and crevices have accumulated enough soil. Other species growing within this community are *Amelanchier alnifolia* Nutt. var. *semi-integrefolia* (Hook.) C. L. Hitchc., *Rosa nutkana* Presl var. *nutkana* and *Symphoricarpus albus* var. *laevigatus*. Pacific silver fir seedlings, although of poor form, are infrequently noted. This may possibly point toward a climax community although it is more likely that a topographic climax is reached at this stage.

SUBALPINE ZONE (MT. BAKER PROVINCE)

The Subalpine Zone is generally located above 4200 feet on north slopes and 5200 feet on south slopes. The upper limit depends on the physiography of the particular mountain. The highest tree line noted has been 6500 feet, but often precipitous cliffs prevent a subalpine vegetation from becoming established at this elevation.

The zone consists of a complex vegetation mosaic with a diversity of habitats. The diagram of general successional trends (see figure 9) shows a development of communities and associations toward the zonal climax (Mountain hemlock - Pacific silver fir association). These successional changes occur at a relatively slow rate (compared to lowland forests) and are highly influenced by the length of snow-free season (Brooke, 1965). It can also be seen from the diagram that this climax is often never reached because of topographic and edaphic limitations. The most conspicuous and largest habitat, the subalpine meadow (see figures 10 and 11) will be described first.

1. Meadows

The meadows consist of relatively gentle topography which contributes to poorly drained soils. These soils range from the continuously saturated soils of the _Carex nigricans_ association to the more mesic soils of the Mountain hemlock - Pacific silver fir association. Due to volcanic ash, stratified soil horizons are common in this habitat.

a) _Carex nigricans_ association

The filled-in lakes, edges of lakes and streams, and poorly drained depressions and flat areas are the

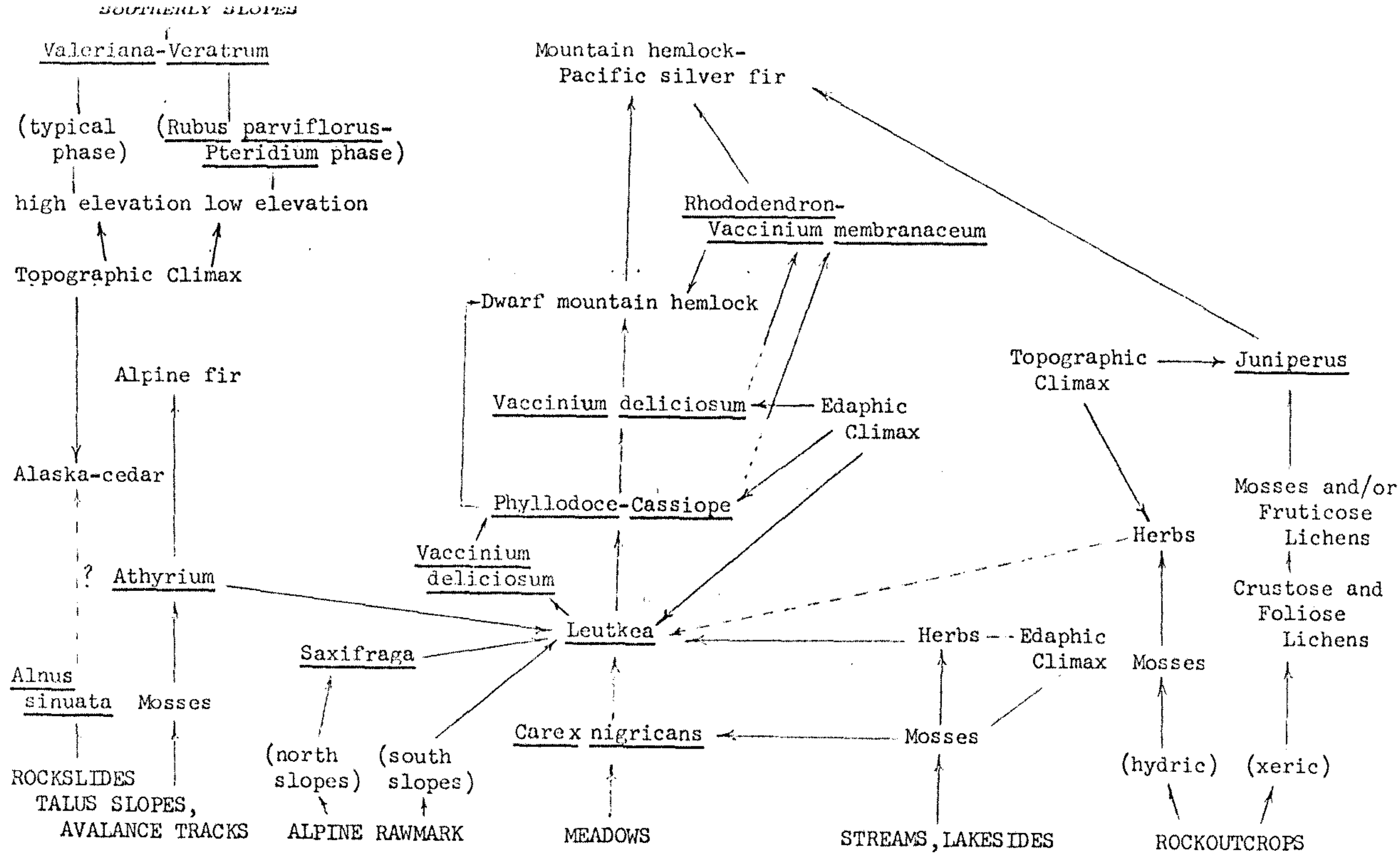


Figure 9. General successional trends in the Subalpine Zone.

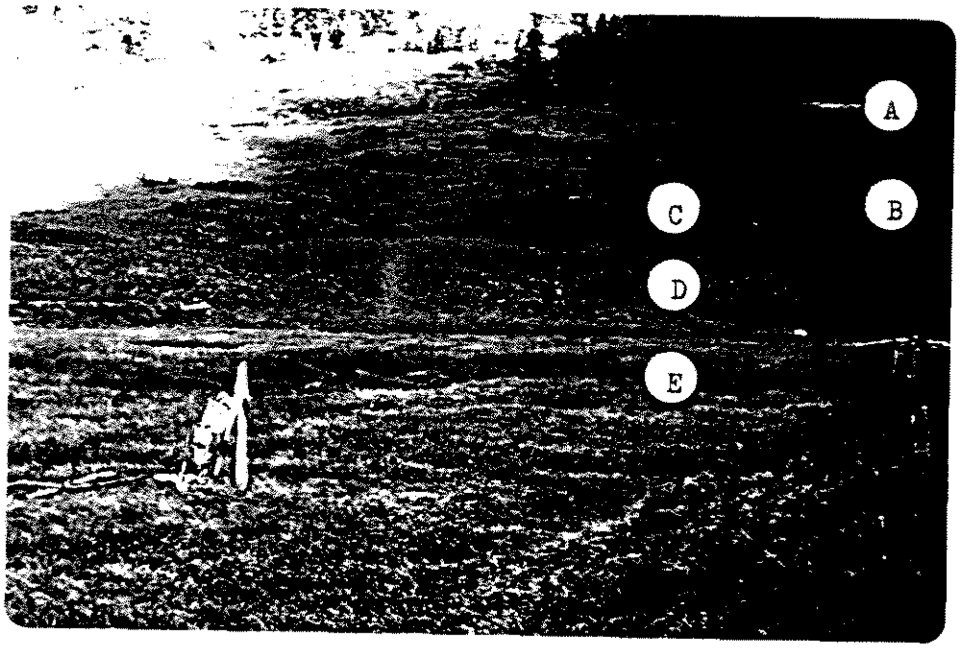


Figure 10. Subalpine meadow zonation in the North Cascades. The associations are: A, Mountain hemlock - Pacific silver fir; B, *Phyllodoce* - *Cassiope*; C, *Vaccinium deliciosum*; D, *Leutkea*; E, *Carex nigricans*. Aug. 14, 1968; elevation, 5400 feet.

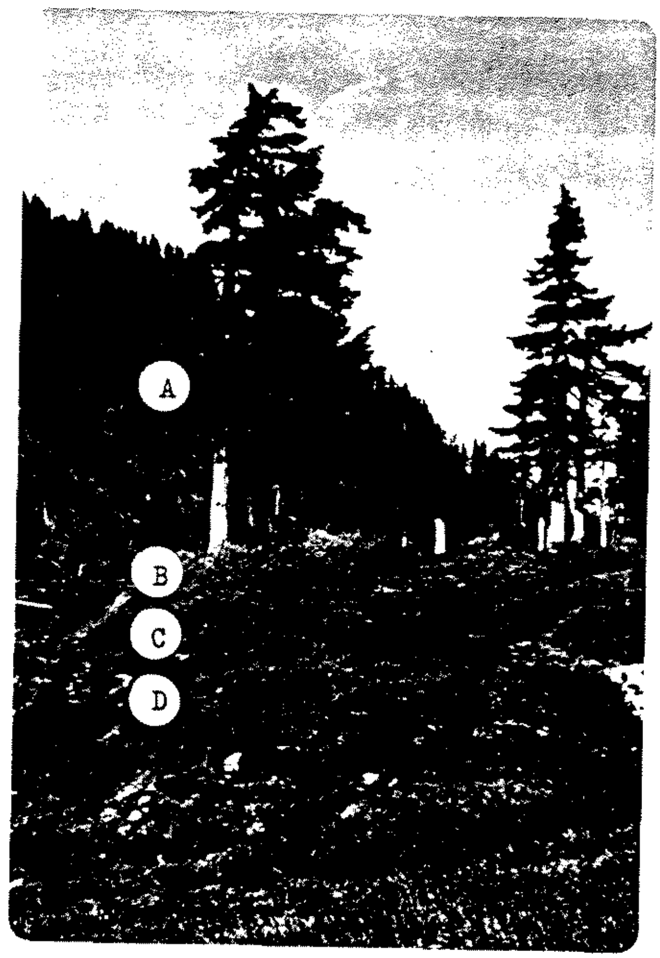


Figure 11. Vegetation patterns accentuated by fall color in a Subalpine Zone meadow in the North Cascades. The associations are: A, Mountain hemlock; B, <u>Vaccinium membranaceum</u> - <u>Rhododendron</u>; C, <u>Vaccinium deliciosum</u>; D, <u>Phyllodoce</u> - <u>Cassiope</u>. Sept. 22, 1968; elevation, 4400 feet.

sites on which this hydric association is found. Carex nigricans C. A. Mey. is the pioneer species except near lakes and streams where it is usually seral. The association is often a near pure stand (see figure 10). Species that may frequent the association but have low cover values are Carex spectabilis Dewey, Deschampsia atropurpurea (Wahlenb.) Scheele var. latifolia (Hook.) Scribn. ex Macoun, Epilobium alpinum L. var. clavatum (Trel.) C. L. Hitchc., Equisetum arvense, Leptarrhena pyrolifolia (D. Don) R. Br. ex Ser. and Juncus drummondii E. Meyer var. subtriflorus (E. Meyer) C. L. Hitchc. Common mosses in the association are Pogonatum alpinum (Hedw.) Roehl., Pohlia cardotii (Ren.) Broth., Polytrichadelphus lyallii Mitt. and Polytrichum sexangulare Brid.

b) Leutkea association

Leutkea pectinata (Pursh) Kuntze, of all the subalpine species, is one of the most widespread plants. It is able to pioneer on xeric alpine rawmark (see p. 94) or appear as a seral species on rock slides, talus slopes, avalanche tracks, rock outcrops, along streams and lakesides and in the meadows. It may also occur as an edaphic climax if the soil moisture remains too abundant during the summer. With further investigation the Leutkea association will probably be subdivided into several phases or subassociations according to its various habitats.

Some of the species first invading the pioneer Leutkea association and those habitats where soil development is not well advanced are *Castilleja parviflora* Bong. var. *albida* (Penn.) Ownbey, *Deschampsia atropurpurea* var. *latifolia* and *Hieracium gracile* Hook. In the meadow habitat many associates, including the just-mentioned species, appear with *Leutkea pectinata*. The more frequent are *Anemone occidentalis* Wats., *Carex nigricans*, *Epilobium alpinum* var. *clavatum*, *Erythronium grandiflorum* Pursh var. *grandiflorum*, *Luzula wahlenbergii*, *Polygonum bistortoides* Pursh, *Potentilla flabellifolia* Hook. ex T. & G. and *Valeriana sitchensis*. Common mosses here are *Pogonatum alpinum* and *Polytrichadelphus lyallii*.

c) *Phyllodoce* - *Cassiope* association

This association may be found invading all but the wettest *Leutkea* association. In British Columbia Peterson (1964) and Brooke (1965) found that this stage of succession preceded the *Vaccinium deliciosum* stage. In the North Cascades this is not always the case; occasionally the stages seem to be reversed, with *Phyllodoce empetriformis* (Sev.) D. Don, and less frequently, *Cassiope mertensiana* (Bong.) G. Don var. *mertensiana* invading the *Vaccinium deliciosum* association (see figure 10). The *Phyllodoce* - *Cassiope* association, although seral on many habitats, may often occur as an edaphic climax because of high soil moisture.

Phyllodoce empetriformis and *Cassiope mertensiana* var. *mertensiana* are the major constituents of the association although the latter is often less abundant. Other vascular plants frequently noted are *Deschampsia atropurpurea* var. *latifolia*, *Leutkea pectinata*, *Lupinus latifolius* Agardh var. *subalpinus* (Piper & Robins) C. P. Smith, *Polygonum bistortoides*, *Lycopodium sitchense* Rupr., and *Vaccinium deliciosum* Piper. Occasionally *Phyllodoce glanduliflora* (Hook.) Colville is found with *Phyllodoce empetriformis*. The lower stratum in this association consists of *Cetraria glauca* (L.) Ach., *Dicranum fuscescens*, *Polytrichum piliferum* Hedw., *Rhacomitrium canescens* var. *epilosum* (H. Muell.) Milde and *Stereocaulon albicans* Th. Fr.

d) *Vaccinium deliciosum* association

This association, one of the more successionally advanced in the subalpine meadows, invades both the *Leutkea* and the *Phyllodoce* - *Cassiope* associations. The sites and soils of the *Vaccinium deliciosum* and *Phyllodoce* - *Cassiope* associations appear to be quite similar. The *Vaccinium deliciosum* association may also be found as an edaphic climax.

The dominant species is always *Vaccinium deliciosum*. Its most frequent associates are *Anemone occidentalis*, *Castilleja parviflora* var. *albida*, *Erigeron* peregrinus (Pursh) Greene ssp. callianthemus (Greene) Cronq. var. scaposus (T. & G.) Cronq., Hieracium gracile, Leutkea pectinata, Lycopodium sitchense, Polygonum bistortoides and Rubus pedatus. Constant mosses are Dicranum pallidisetum (Bailey) Irel. and Polytrichum piliferum.

e) Dwarf mountain hemlock association

The mountain hemlock is the major pioneer tree species in the Subalpine Zone of the Mt. Baker Province. The trees are usually found on slopes, ridges and mounds, indicating the need for relatively good drainage. The most recent invasion of the meadows by this tree species occurred about 30 to 40 years ago, a period that apparently was favorable for germination and seedling survival. Alpine fir may also invade the meadows but is not abundant except in meadows near and east of the Cascade crest. Mountain hemlock and alpine fir have also been noted invading meadows in the Coast Range of British Columbia (Brink, 1959), on Mt. Rainier (Brockman, 1949; Franklin, 1966a; Franklin and Mitchell, 1967) and in the Cascades of Oregon (Van Vechten, 1960; Swedburg, 1961).

The Dwarf mountain hemlock association succeeds either the Phyllodoce - Cassiope or Vaccinium deliciosum associations. Although the trees may appear singly it is more common to find them as dense clumps.

The growth of these trees is extremely slow until the maximum snow level is reached. At this height the radiant energy absorbed by the tree needles and trunk hastens the melting and may provide an extended growing season of up to six weeks longer than nearby snow-covered associations. Landsberg (1958) shows that evergreen trees reflect only seven percent of the radiant energy received while fresh snow reflects 80 to 90 percent.

The understory of the Dwarf mountain hemlock association is similar to that of the associations it invades. The cover percentage, however, decreases considerably. As the association becomes taller and the growing season longer, additional species such as *Sorbus sitchensis* var. *sitchensis* and *Vaccinium membranaceum* become established. Young reproduction of mountain hemlock, Pacific silver fir and occasionally alpine fir may also be noted.

f) Mountain hemlock - Pacific silver fir association

After more than a century the Dwarf mountain hemlock association develops into the zonal climax Mountain hemlock - Pacific silver fir association. This association is the familiar tree group appearing in the meadows throughout the Subalpine Zone. As the overstory becomes more dense the herbs and shrubs beneath it greatly diminish in abundance and often only a few mosses exist. *Luzula wahlenbergii*, *Pyrola secunda* var. *secunda*, *Rhododendron albiflorum*, *Rubus lasiococcus*, *Vaccinium membranaceum* and *Valeriana sitchensis* grow wherever there is an occasional opening.

The inability of Pacific silver fir to reproduce as efficiently within the group as it does at lower elevations results in a dual climax in the Mt. Baker Province. The composition of the stands remains generally the same as the group expands and invades the *Vaccinium membranaceum* - *Rhododendron* association.

g) *Vaccinium membranaceum* - *Rhododendron* association

When the Mountain hemlock - Pacific silver fir association becomes well established a number of shrubs usually develops around the periphery. This periphial association, *Vaccinium membranaceum* - *Rhododendron*, is able to invade the *Phyllodoce* - *Cassiope* and *Vaccinium deliciosum* associations as a result of the more favorable microclimate created by the tree group.

In the Coast Range of British Columbia the *Vaccinium membranaceum* - *Rhododendron* association is called the climax association for the Subalpine Zone (Peterson, 1964; Brooke, 1965). Evidence in the North Cascades shows that this is not the zonal climax but only a "feed-back" caused by the beneficial effect of the Mountain hemlock - Pacific silver fir association on the microenvironment. Instead of invading the latter association as a climax association would, the *Vaccinium membranaceum* - *Rhododendron* association itself is succeeded by the Mountain hemlock - Pacific silver fir association, or occasionally by the Dwarf mountain hemlock association.

The dominant and constant species are *Rhododendron albiflorum* and *Vaccinium membranaceum*, although *Menziesia ferruginea* var. *ferruginea* and *Sorbus sitchensis* var. *sitchensis* are often abundant. Other frequent species are mountain hemlock, Pacific silver fir, *Phyllodoce empetriformis*, *Rubus pedatus* and *Vaccinium deliciosum*. Alaska-cedar may also grow here as a shrub, but never in abundance. Species found in the lower stratum are *Cladonia gracilis* (L.) Willd., *Dicranum fuscescens* and *Stereocaulon albicans*.

2. South slopes

On the steep 30 to 60 percent south slopes where deep colluvial or residual soils have developed, the *Valeriana* - *Veratrum* association is always conspicuous. This widespread association occurs as two subassociations throughout the Mt. Baker Province.

The first, the typical subassociation, is apparently both pioneer and climax, being maintained by snowcreep and recurrent avalanches. Diversity is very low, and along with *Valeriana sitchensis* and *Veratrum viride*, the dominant species, are *Arnica latifolia* Bong. var. *latifolia*, *Carex spectabilis* Dewey, Lupinus latifolius var. subalpinus, Polygonum bistortoides and Senecio triangularis Hook.

The second, the Rubus parviflorus - Pteridium subassociation, is found at lower elevations than the previous subassociation. It is often associated with avalanche tracks as well as steep slopes on south exposures, and is also both pioneer and climax.

The lower elevation, deep soils, abundant moisture and extremely long growing seasons create an ideal environment for a diverse flora. Further investigation on a unit such as this, which may cover many acres, will probably show a mosaic of smaller areas of different sizes or ages. These areas, which represent varying phases of regeneration, have been termed a microsere by Daubenmire (1968).

Since the flora is so diverse and many species have a high frequency, only the most dominant plants will be mentioned. Rubus parviflorus var. parviflorus and Pteridium aquilinum var. pubescens have the highest cover values. Other dominant species are Angelica arguta Nutt., Epilobium angustifolium L., Heracleum lanatum Michx., Valeriana sitchensis and Veratrum viride.

3. Rockslides, talus slopes, avalanche tracks

This habitat is similar to the Rockslides, talus slopes and avalanche tracks habitat of the Pacific Silver Fir Forest Type (see p. 77). Because of the similarity only the one successional trend toward the Alpine fir community (see figure 9) will be described. It should be emphasized here, however, that succession toward the mountain hemlock - Pacific silver association may also occur.

a) Moss community

This community is the pioneer on the boulder-strewn rockslides with northern exposures and may represent an extremely long successional stage. Some of the mosses in the community are *Arctoa starkii* (Web. & Mohr) Hoeski, *Pohlia cruda* (Hedw.) Ledb. and *Rhacomitrium sudeticum* (Funck.) B. S. G.

b) *Athyrium distentifolium* community

Invasion by vascular plants takes place with accumulation of soil on this habitat. Although many of the species from the wetter habitats are able to grow, the most abundant is *Athyrium distentifolium* Tausch ex Opiz var. *americanum* (Butters) Cronq. This fern, which grows between the rocks, is often the only conspicuous plant on the site. The mosses mentioned in the previous association, although slightly less abundant, still remain.

The successional stage following this consists of an Alpine fir community or the Mountain hemlock - Pacific silver fir association. The status of this high elevation Alpine fir community is unknown, but if enough openings exist it is probable that both mountain hemlock and Pacific silver fir will invade. In this habitat vegetative units are often successionally set back by recurrent disturbances.

4. Alpine rawmark

The term "alpine rawmark" has been used by Kubiëna (1953) to describe coarse- to fine-textured, poorly drained soils that have gravitational movement. These soils in the North Cascades are found on steep slopes and lack a continuous plant cover. Because of the soil movement the soils are poorly developed. The habitat occurs on all aspects, with the north and south aspects being discussed here.

The alpine rawmark habitat on north slopes has a very short growing season. These are the last snow-free areas in the Subalpine Zone. The *Saxifraga* assocation dominates these extremely hydric sites. *Saxifraga tolmiei* T. & G. var. *tolmiei* is the most frequent species. Its most common herbaceous associates are *Deschampsia atropurpurea* var. *latifolia*, *Leutkea pectinata*, *Juncus drummondii* var. *subtriflorus*, *Luzula wahlenbergii*, *Oxyria digyna* (L.) Hill, *Petasites frigidus* (L.) Fries var. *palmatus* (Ait.) Cronq. and *Saxifraga punctata* L. var. *canadensis* (Calder & Savile) C. L. Hitchc. This association is usually succeeded by the *Leutkea* association (see p. 85), which may be climax if the soil movement continues. In a few areas where the late snow cover restricts the invasion of *Leutkea pectinata*, the association may remain in a climax state. This is usually indicated by the addition of *Saxifraga lyallii* Engl. var. *lyallii* as an abundant member of the association.

On south slopes where soils become relatively drier during the summer the pioneer is the *Leutkea* association. This community is discussed on page 85.

5. Streams, lakesides

This habitat has not been thoroughly studied in the Subalpine Zone. The habitat may vary considerably depending on topography, length of snow runoff and the type of strata where the lake is situated or through which the stream is travelling. Since the number of plots established in this habitat did not provide sufficient information on the dynamics of these sites, only the more important constituents will be discussed.

Where water perpetually saturates the nearby banks, mosses are the most abundant plants. This Moss community may consist of Aulocomium palustre (Hedw.) Schwaeger, Drepanocladus aduncus (Hedw.) Warnst., D. uncinatus (Hedw.) Warnst., Mnium lycopodioides Schwaegr., Philonotis fontana var. pumila Brid. and Sphagnum spp. Petasites frigidus var. palmatus seems to be the only plant able to grow in continuously running water, although others such as Caltha biflora DC. var. biflora, Epilobium alpinum var. clavatum, Hippuris montanus Ledeb., Juncus drummondii var. subtriflorus, Leptarrhena pyrolifolia, Mimulus lewisii Pursh., M. tilingii Regel var. caespitosus (Greene) Grant, Parnassia fimbriata Konig. var. fimbriata, Saxifraga punctata var. canadensis and Viola adunca Sm. var. adunca are able to withstand some seepage or periodic flooding. Others that are growing along the streams or lakes but on slightly elevated and less hydric sites are Carex nigricans, Leutkea pectinata, Phleum alpinum L., Potentilla flabellifolia, Ranunculus eschscholtzii Schlect. var. suksdorfii (Gray) Benson, Veronica cusicki Gray and V. wormskjoldii Roem. & Schult.

The communities of this habitat may remain as climaxes or, with a change in water level, proceed toward the _Carex nigricans_ or _Leutkea_ associations (see p. 81 and 85).

6. Rock outcrops (hydric)

The successional trends in this habitat are similar to those described for the Western Hemlock Forest Type (see p. 64). The vegetation, because of the higher altitude, is different and will be briefly discussed.

a) Moss community

Common mosses of this community are _Arctoa starkei_, _Bartramia ithyphylla_ Brid. and _Pohlia drummondii_. This stage may remain for a long period before a more favorable microenvironment enables herbaceous plants to invade.

b) Herb community

Some of the more frequent herbs in this community are _Athyrium distentifolium_ var. _americanum_, _Heuchera micrantha_ Dougl. ex Lindl. var. _diversifolia_ (Rydb.) R. B. & L., _Saxifraga lyallii_ var. _lyallii_ and _Tiarella unifoliata_ Hook. Although _Leutkea pectinata_ may appear infrequently, there is some doubt as to whether succession proceeds beyond this stage, other than in a few local instances.

7. Rock outcrops (xeric)

As the early successional stages are similar to those described for the Western Hemlock Forest Type (see p. 65), only the _Juniperus_ community will be discussed here.

The *Juniperus* community is usually found in the Subalpine Zone on rock outcrops or extremely shallow soils with southerly aspects. The most frequent associates of the dominant shrub, *Juniperus communis* L. var. *montana* Ait., are *Arctostaphylos uva-ursi*, *Arenaria capillaris* Poir. var. *americana* (Maguire) Davis, *Pachystima myrsinites* (Pursh) Raf., *Phlox diffusa* Benth. var. *longistylis* (Wherry) Peck and *Sibbaldia procumbens* L. Mosses remaining from the preceding successional stage are *Grimmia alpestris* (Web. & Mohr.) Schleich, *Polytrichum piliferum* Hedw., *Rhacomitrium canescens* var. *ericoides* (Brid.) B. S. G., *Tortula norvegica* (Web.) Wahlenb. ex Lindb. and *Weissia controversa* Hedw.

This community often remains as a topographic climax because of the lack of soil accumulation. Invasion by mountain hemlock and Pacific silver fir, however, may be noted on many of the higher mountains.

Alpine Zone

In the North Cascades this zone is extremely fragmented, with most vegetation units being quite small. The only nearby area in which Alpine Zone studies have been undertaken is the Coast Range of British Columbia, where Archer (1963) found that *Phyllodoce empetriformis* and *Cassiope mertensiana* were the zonal climax species. He also describes krummholz stands in which alpine fir succeeds Alaska-cedar and is in turn replaced by mountain hemlock. Succession in krummholz stands has not been studied in the North Cascades, but alpine fir always seems to be the pioneer (see figure 12). This has been noted elsewhere in the Cascades by Franklin and Mitchell (1967).

The coastal British Columbian associations described by Archer very likely exist in the North Cascades too, as the macroenvironment is relatively the same in both areas. Since the extensiveness of these associations within the Alpine Zone of the Mt. Baker and Wenatchee Provinces is not known, only a brief description of the plants and habitats will be given in table 10. Similarities between these and the associations described for the Subalpine Zone (Mt. Baker Province) are noticeable and indicate a close relationship between the zones.

Figure 12. Alpine fir "krummholz" on a high ridge in the Alpine Zone of the North Cascades. *Vaccinium deliciosum* (red leaves), *Phyllodoce empetriformis* and *Cassiope mertensiana* in foreground. Sept. 30, 1968; elevation, 6400 feet.

Table 10. Associations recognized in the Alpine Zone of the Coastal Range in British Columbia.*

Association	Habitat Characteristics	Common Plants
Gymnomitrium varians-Polytrichum norvegicum	Fine silts, prolonged snow.	Gymnomitrium varians, Polytrichum norvegicum, Carex nigricans
Polytricum piliferum	Coarse sands and gravels, prolonged snow.	Polytricum piliferum, Carex nigricans, Gymnomitrium varians, Saxifraga tolmiei var. tolmiei
Caricetum nigricantis	Acid soils, prolonged snow.	Carex nigricans, Polytricum norvegicum
Valerianetum sitchensis	Alluvial soils.	Valeriana sitchensis, Carex spectabilis, Lupinus lepidus var. lobbii.
Caricetum spectabilis	Recently glaciated, unstable soils.	Carex spectabilis, Lupinus lepidus var. lobbii
Leutkeetum pectinatae	Recently glaciated, coarse sand.	Leutkea pectinata, Lupinus lepidus var. lobbii, Hieracium gracile
Anaphaleto-Lupinetum arctici	Recently glaciated, boulder fields.	Anaphalis margaritacea, Lupinus lepidus var. lobbii, Carex spectabilis, Leutkea pectinata
Mimuleto-Epilobietum latifolii	Near streams, hydric soils.	Mimulus lewisii, Epilobium latifolium, Juncus drummondii
Junipereto-Penstemonetum menziesii	Rock outcrops.	Juniperus communis var. montana, Penstemon menziesii
Silenetum acaulis	Thin podzolized soils.	Silene acaulis, Saxifraga bronchialis var. austromontana
Sibbaldietum procumbentis	Thin, acid soils.	Sibbaldia procumbens, Antennaria alpina var. media, Polytrichum piliferum
Phyllodoce-Cassiopetum mertensianae	Near krummholz, west to south slopes.	Phyllodoce empetriformis, Cassiope mertensiana var. mertensiana, Carex spectabilis
Abieteto-Chamaecyparetum nootkatensis	Ridges, low snow depths.	Abies lasiocarpa, Chamaecyparis nootkatensis, Phyllodoce empetriformis, P. glanduliflora

* - Associations taken from Archer (1963)

Subalpine Zone (Wenatchee Province)

The dominance of the Subalpine Zone by mountain hemlock gradually decreases as the Cascade crest is approached. Within the Wenatchee Province alpine fir becomes the major pioneer and dominant tree species. Its associates near the crest are mountain hemlock and Pacific silver fir, while further east alpine larch (*Larix lyalli* Parl.) and whitebark pine (*Pinus albicaulis* Engelm.) become more frequent. This change in species composition reflects a lower precipitation and a drier climate than is found on the western slopes of the Cascades. Because of the different environment, the meadows contain many new elements from the drier areas of the eastern slopes, although still maintaining many of the west side herbs.

Succession of the tree clumps in this zone is uncertain, although the main pioneer tree species appears to be alpine fir. Alpine larch (which was observed invading meadows near Hart's Pass) and whitebark pine may also pioneer. In open stands development toward a mountain hemlock - Pacific silver fir climax may evolve. This successional trend was noted on Mt. Rainier by Franklin and Mitchell (1967). If the stands remain closed with a dense overstory, succession may be similar to that found in the Mt. Baker Province, with no single species being climax.

Engelmann Spruce - Alpine Fir Forest Type

The valley slopes within the Wenatchee Province are extremely rocky (see figure 13). In addition to this the general southerly exposure and relatively low precipitation result in a dry environment. The climax species on these slopes are Engelmann spruce (*Picea engelmannii* [Parry] Engelm.) and alpine fir (Jerry F. Franklin, personal communication). Alpine fir is the most abundant species further east toward McAlester Mtn. and east of Lake Chelan. Where soil is more abundant this forest type is probably similar to that described for northern Idaho (Daubenmire, 1952; Le Barron and Jemison, 1953). There it is the climatic climax, and "As a topoedaphic climax, peninsular strips of it extend to rather low elevations where they often expand to cover the floors of frost pockets in valleys surrounded by some representative of the *Thuja* - *Tsuga* zone" (Daubenmire, 1952). Of the several climax associations of the *Picea engelmanni* - *Abies lasiocarpa* Zone described by Daubenmire (1952), two of them may be comparable to the Engelmann Spruce - Alpine Fir Forest Type communities. The first, the *Picea* - *Abies*/*Pachystima* association, occupies the lower part of the main area of the spruce - fir zone in northern Idaho. Seral trees in this association may be western white pine, grand fir and Douglas-fir, with lesser numbers of western larch (*Larix occidentalis* Nutt.) and lodgepole pine. Common understory shrubs are *Pachystima myrsinites*, *Xerophyllum tenax* (Pursh) Nutt., *Menziesia ferruginea* and *Rubus parviflorus*. The second association, the *Picea* - *Abies*/*Menziesia* association, is found at higher elevations in the spruce - fir zone. The only seral trees here are western white pine and western larch. The dominant

Figure 13. Engelmann Spruce - Alpine Fir Forest Type in the Stehekin River drainage. Alnus sinuata is conspicuous on the slopes. Elevation about 4000 feet (foreground). Photo by Brian O. Mulligan, August 21, 1965.

shrubs are Menziesia ferruginea, Rhododendron albiflorum, Ledum glandulosum Nutt., Sorbus sitchensis and S. scopulina Greene. Goodyera oblongifolia and Luzula glabrata (Hoppe) Desv. are the most constant representatives of a sparse herbaceous flora.

Although the Engelmann Spruce - Alpine Fir Forest Type in the complex is the climatic climax, the composition of the climax forest may differ, depending on the particular site. This is caused both by the greater tolerance of alpine fir (Alexander, 1958a) and the ability of alpine fir to grow on soils too wet or too dry for Engelmann spruce (Alexander, 1958b).

Grand Fir - Douglas-fir Forest Type

This forest type occurs along the valleys, stream terraces and lower south slopes in the Wenatchee Province (see figure 14). The main pioneer tree species on the glacial till and alluvial soils of the valleys is ponderosa pine. Ponderosa pine is able to attain its best growth on well drained soils (Curtis and Lynch, 1957) such as these. Douglas-fir is both a seral and climax species along the streams and forms almost pure stands on the south slopes east of the Stehekin River and Lake Chelan. Grand fir is also climax in the more mesic areas.

In north-facing drainages Douglas-fir, grand fir, western hemlock, western redcedar and western white pine form mixed conifer stands. On wetter areas the climax in these mixed stands is western hemlock and western redcedar, while on the more mesic sites grand fir is probably climax.

This forest type may be similar to the pine - larch - Douglas-fir type group and interior Douglas-fir - grand fir (hemlock - cedar) type group described by Scott (1962) for the Canadian Zone east of the Cascade crest. According to Scott (1962), a typical stand in the first type group might consist of an overstory of pine and western larch. The latter apparently is lacking within the complex but is common further south on the east slope of the Cascades. A few Douglas-fir and grand fir may be found in the overstory, but they are more abundant in the understory where they are the dominant species. The pine - larch - Douglas-fir type group is subclimax and is succeeded by the Douglas-fir - grand fir (hemlock - cedar) type group if disturbance does not recur. On the moister or higher sites grand fir is the more important species, although western hemlock and western redcedar may also be climax here.

Figure 14. Douglas-fir - Ponderosa pine/Arctostaphylos nevadensis community in the lower Stehekin valley. Rainbow Falls in background. Photo by Brian O. Mulligan, Aug. 20, 1965.

Black cottonwood is a conspicuous tree along the stream banks of this forest type (Brian O. Mulligan, personal communication). Red alder and bigleaf maple are also established along the streams with occasional stands of lodgepole pine.

Taxonomy

Introduction

Plant collecting in the Pacific Northwest began about 200 years ago. Since then, with only a few exceptions, the area has been thoroughly botanized. One of the exceptions is the area now encompassed by the North Cascades Complex west of the Cascade crest. The only extensive plant collections have been limited to Sourdough Mountain in the National Park, and along the Skagit River, both by W. C. Muenscher (1941). Others who collected on the western boundaries or nearby were J. W. Thompson (whose specimens are in the herbarium of the University of Washington), and H. St. John and E. Hardin (1929). Lichens have been collected on the park boundary (Ruth Mountain) and nearby Mt. Baker by G. E. Howard and L. Sunquist (Howard, 1950). The portion of the complex east of the Cascade crest has received much more attention. Collections made by A. D. E. Elmer, E. R. Lake, W. R. Hull, K. Whited, H. St. John and G. H. Ward are in the herbarium of Washington State University (Ward, 1948). Lichens were also collected in this area by G. E. Howard (1950).

The following plant checklist, which includes the vascular plants, mosses and lichens, is based on my collections. In order to make the list as complete as possible, the herbarium of the University of Washington was examined for supplementary specimens. The published floras of Clark and Frye (1928), St. John and Hardin (1929), Muenscher (1941) and Howard (1950) also provided additional species. Most of the listings for the area east of the Cascade crest were taken from the unpublished thesis of Ward (1948). All species listed were collected in the National Park Complex or within 14 miles of the western boundaries, the only exception to this being a few species from Railroad Creek, about four miles south of the Lake Chelan National Recreation Area. Those collected outside the boundaries are listed with the assumption that, since similar habitats occur within the boundaries, the plants are almost certain to occur there also.

A number of the species have been introduced by man from other parts of the world. These are usually roadside plants, but occasionally they may be found far from roads. The introduced species have been marked with an asterisk in the checklist.

Classification and nomenclature for the vascular plants follows the treatment of Hitchcock, et al (1955, 1959, 1961, 1964 and vol. 1 [in preparation]). Classification of the mosses (Musci) follows that of Grout (1928, 1933, 1936) and nomenclature is from Lawton (1965). The classification and nomenclature of the remainder of the mosses (Hepaticae) follows Conard (1956). Classification and nomenclature of the lichens is that used by Howard (1950).

The checklist has been arranged by families of vascular plants, mosses, and lichens. Each species is followed by a numerical designation of the types or zones in which it has been found. The numbers used for these are:

1. Western Hemlock Forest Type
2. Pacific Silver Fir Forest Type
3. Subalpine - Alpine Zones (Mt. Baker Province)
4. Subalpine - Alpine Zones (Wenatchee Province)
5. Engelmann Spruce - Alpine Fir Forest Type
6. Grand Fir - Douglas-fir Forest Type

The Subalpine Zone has been included with the Alpine Zone, since the latter is relatively small and contains very few plants found exclusively above the Subalpine Zone.

I would like to thank Dr. C. Leo Hitchcock for the use of the manuscript of volume one of Vascular Plants of the Northwest. This has made possible a uniform treatment of the nomenclature and classification in the plant checklist. Until this volume is published, the worker in the North Cascades will find Henry (1915), Peck (1941), Eastham (1947) and A. S. Hitchcock (1950) useful for the monocotyledonous plants.

Plant Checklist

Vascular Plants

LYCOPODIACEAE

<u>Lycopodium annotinum</u> L.	1,2
<u>Lycopodium clavatum</u> L.	1,2,3,4,5
<u>Lycopodium complanatum</u> L.	1
<u>Lycopodium selago</u> L.	4
<u>Lycopodium sitchense</u> Rupr.	3,4

SELAGINELLACEAE

<u>Selaginella wallacei</u> Hieron	2,3

EQUISETACEAE

<u>Equisetum arvense</u> L.	1,2,3
<u>Equisetum fluviatile</u> L.	1
<u>Equisetum kansanum</u> Schaffn.	4
<u>Equisetum laevigatum</u> A.Br.	6
<u>Equisetum telmateia</u> Ehrh.	1,2

OPHIOLOSSACEAE

<u>Botrychium lanceolatum</u> (Gmel.) Ångströn	3
<u>Botrychium lunaria</u> (L.) Swartz var. <u>onondgense</u> (Underw.) House	3
<u>Botrychium multifidum</u> (Gmel.) Trevis.	2,3
<u>Botrychium virginianum</u> (L.) Swartz	1

POLYPODIACEAE

<u>Adiantum pedatum</u> L.	1,2
<u>Asplenium trichomanes</u> L.	1,2
<u>Asplenium virides</u> Huds.	3
<u>Athyrium distentifolium</u> Tausch ex Opiz var. <u>americanum</u> (Butters) Cronq.	3,4
<u>Athyrium filix-femina</u> (L.) Roth	1,2,3,6
<u>Blechnum spicant</u> (L.) With.	1,2,3
<u>Cheilanthes gracillima</u> D. C. Eat.	3,5,6

Cheilanthes _siliquosa_ Maxon	6
Cryptogramma _crispa_ (L.) R. Br. var. _acrostichoides_ C. B. Clarke	2,3,4,5,6
Cystopteris _fragilis_ (L.) Bernh.	1,2
Dryopteris _austriaca_ (Jacq.) Woynar ex Schinz & Thell.	2
Gymnocarpium _dryopteris_ (L.) Newm.	1,2
Polypodium _glycyrrhiza_ D. C. Eat.	1
Polypodium _hesperium_ Maxon	2,4
Polystichum _andersonii_ Hopkins	2,4
Polystichum _lonchitis_ (L.) Roth	2,3,4,5
Polystichum _mohrioides_ (Bory) Presl	3
Polystichum _munitum_ (Kaulf.) Presl var. _munitum_	1,2,3
Pteridium _aquilinum_ (L.) Kuhn var. _pubescens_ Underw.	1,2,3
Thelypteris _limbosperma_ (Allioni) H. P. Fuchs	3
Thelypteris _phegopteris_ (L.) Slosson	3
Woodsia _scopulina_ D. C. Eat.	1,6

TAXACEAE

Taxus _brevifolia_ Nutt.	1,2,4,5,6

CUPRESSACEAE

Chamaecyparis _nootkatensis_ (D. Don) Spach	2,3,4,5
Juniperus _communis_ L. var. _montana_ Ait.	3
Thuja _plicata_ Donn.	1,2,6

PINACEAE

Abies _amabilis_ (Dougl.) Forbes	1,2,3,6
Abies _grandis_ (Dougl.) Lindl.	1,2
Abies _lasiocarpa_ (Hook.) Nutt.	2,3,4,5
Larix _lyallii_ Parl.	3,4
Picea _engelmannii_ (Parry) Engelm.	4,5
Picea _sitchensis_ (Bong.) Carr.	1
Pinus _albicaulis_ Engelm.	3,4
Pinus _contorta_ Dougl. ex Loud. var. _latifolia_ Engelm.	1,2,3,6
Pinus _monticola_ Dougl. ex D. Don	1,2,3,4,5
Pinus _ponderosa_ Dougl. ex Loud.	2,5

Pseudotsuga menziesii (Mirbel) Franco var. *menziesii*	1,2,3,5,6
Tsuga heterophylla (Raf.) Sarg.	1,2,3,5,6
Tsuga mertensiana (Bong.) Carr.	2,3,4,5,6

POTAMOGETONACEAE

Potamogeton alpinus Balbis var. *tenuifolius* (Raf.) Ogden	1
Potamogeton natans L.	6
Potamogeton nodosus Poir.	1

JUNCACEAE

Juncus balticus Willd. var. *montanus* Engelm.	2
Juncus balticus Willd. var. *balticus*	1,2
Juncus drummondii E. Meyer var. *subtriflorus* (E. Meyer) C. L. Hitchc.	3,4
Juncus ensifolius Wiks. var. *ensifolius*	1,2,5
Juncus ensifolius Wiks. var. *montanus* (Engelm.) C. L. Hitchc.	1,2
Juncus falcatus E. Meyer var. *sitchensis* Buch.	3
Juncus filiformis L.	3
Juncus mertensianus Bong.	3,4,5
Juncus parryi Engelm.	3
Juncus regelii Buch.	2,3,4,5
Luzula campestris (L.) DC. var. *frigida* Buch.	1,2
Luzula glabrata (Hoppe) Desv.	2,3
Luzula parviflora (Ehrh.) Desv.	1,2,3
Luzula wahlenbergii Rupr.	3,4

CYPERACEAE

Carex aurea Nutt.	5
Carex breweri Boott var. *paddoensis* (Suksd.) Cronq.	3
Carex brunnescens (Pers.) Poir.	3
Carex cusickii Mackenzie	4
Carex deweyana Schw.	6
Carex illota L. H. Bailey	2,3,5
Carex laeviculmis Meinsh.	1,2,5

Carex lasiocarpa Ehrh.	6
Carex lenticularis Michx. var. *lenticularis*	2,3
Carex leporina L.	3
Carex leporinella Mack.	3
Carex luzúlina Olney	3
Carex lyngbyei Hornem.	1
Carex mertensii Prescott ex Bong.	4,5,1,2,3
Carex microptera Mack.	1,2,3
Carex nigricans C. A. Mey.	3,4
Carex oederi Beaux.	5
Carex pachystachya Cham.	3,4
Carex phaeocephala Piper	3,4
Carex preslii Steud.	4,5,6
Carex pyrenaica Wahl.	3
Carex rossii Boott	4
Carex rostrata Stokes ex With.	1,4,5,6
Carex scopulorum Holm	5
Carex sitchensis Prescott	1
Carex spectabilis Dewey	2,3,4
Carex straminiformis Bailey	3
Eriophorum polystachion L.	2,3
Scirpus cespitosus L.	4,5
Scirpus microcarpus Presl.	6

GRAMINAE

Agropyron spicatum (Pursh) Scribn. & Smith var. *spicatum*	6
Agropyron caninum (L.) Beauv. var. *latiglume* (Scribn. & Smith) C. L. Hitchc.	5
Agropyron caninum (L.) Beauv. var. *andinum* (Scribn. & Smith) C. L. Hitchc.	5
Agrostis aequivalis (Trin.)	3
Agrostis exarata Trin.	2,3
Agrostis humilis Vasey	3,4
Agrostis idahoensis Nash	2,3,4
Agrostis scabra Willd.	3,4

<u>Agrostis</u> <u>thurberiana</u> A. S. Hitchc.	3
<u>Alopecurus</u> <u>aequalis</u> Sobol.	5
<u>Bromus</u> <u>carinatus</u> Hook. & Arn. var. <u>carinatus</u>	1,2,3,4,5
<u>Bromus</u> <u>ciliatus</u> L.	2
<u>Bromus</u> <u>suksdorfii</u> Vasey	2
<u>Calamagrostis</u> <u>canadescens</u> (Michx.) Beauv. var. <u>lactea</u> (Beal) C. L. Hitchc.	2,3,4,5,6
<u>Cinna</u> <u>latifolia</u> (Trevir.) Griseb.	1,5
*<u>Dactylis</u> <u>glomerata</u> L.	1,2,3
<u>Danthonia</u> <u>intermedia</u> Vasey	3,4
<u>Deschampsia</u> <u>atropurpurea</u> (Wahlenb.) Scheele var. <u>latifolia</u> (Hook.) Scribn.	3,4
<u>Deschampsia</u> <u>cespitosa</u> (L.) Beauv. var. <u>cespitosa</u>	5
<u>Deschampsia</u> <u>elongata</u> (Hook.) Munro ex Benth	5
<u>Elymus</u> <u>glaucus</u> Buckl. var. <u>breviaristatus</u> Davy	1,2,3,5,6
<u>Elymus</u> <u>hirsutus</u> Presl.	3
*<u>Festuca</u> <u>elatior</u> L.	1
*<u>Festuca</u> <u>myuros</u> L.	1
<u>Festuca</u> <u>occidentalis</u> Hook.	5
<u>Festuca</u> <u>octoflora</u> Walt.	5
<u>Festuca</u> <u>subulata</u> Trin.	2
<u>Festuca</u> <u>viridula</u> Vasey	3,4,5
<u>Glyceria</u> <u>elata</u> (Nash) M. E. Jones	6
<u>Glyceria</u> <u>striata</u> (Lam.) A. S. Hitchc.	5
<u>Hordeum</u> <u>murinum</u> L.	1
<u>Koeleria</u> <u>cristata</u> Pers.	1
<u>Lolium</u> <u>perenne</u> L.	5
<u>Melica</u> <u>harfordii</u> Boland.	5
<u>Melica</u> <u>subulata</u> (Griseb.) Scribn. var. <u>subulata</u>	6
<u>Muhlenbergia</u> <u>filiformis</u> (Thurb.) Rydb.	3
<u>Phleum</u> <u>alpinum</u> L.	3,4
*<u>Phleum</u> <u>pratense</u> L.	1,2,5
<u>Poa</u> <u>alpina</u> L.	3,4

* - introduced species

*Poa annua L.	1
Poa canbyi (Scribn.) Piper	3
Poa cusickii Vasey var. epilis Scribn.	3
Poa leptocoma Trin. var. leptocoma	3
Poa secunda Presl.	5
Poa stenantha Trin.	3
Sitanion hystrix (Nutt.) J. G. Smith	3
Stipa occidentalis Thurb. ex Wats. var. minor (Vasey) C. L. Hitchc.	5
Trisetum cernuum Trin.	1
Trisetum spicatum L.	3

TYPHACEAE

Typha latifolia L.	6

ARACEAE

Lysichitum americanum St. John	1,2

LILACEAE

Allium acuminatum Hook.	4,5
Allium cernuum Roth	3
Brodiaea hycinthina (Lindl.) Baker	5
Camassia quamash (Pursh) Greene var. maxima (Gould) C. L. Hitchc.	1,2
Clintonia uniflora (Schult.) Kunth	1,2,3,4,5
Disporum hookeri (Torr.) Nicholson var. oreganum (Wats.) Q. Jones	1,2,4
Disporum smithii (Hook.) Piper	1,2
Disporum trachycarpum (Wats.) Benth & Hook.	1,2
Eryothronium grandiflorum Pursh var. grandiflorum	3
Fritillaria lanceolata Pursh	3
Lilium columbianum Hanson	2,3,4,5,6
Llyodia serotina (L.) Sweet	3
Maianthemum dilatum (Wood) Nels. & Macbr.	1
Smilacina racemosa (L.) Desf.	1,2
Smilicina stellata (L.) Desf.	1,2

Stenanthium occidentale Gray	3
Streptopus amplexifolius (L.) DC. var. americanus Schult.	1,2,4
Streptopus roseus Michx. var. curvipes (Vail) Fassett	2,1,4
Streptopus streptopoides (Ledeb.) Frye & Rigg var. brevipes (Baker) Fassett	2
Tofieldia glutinosa (Michx.) Pers. var. occidentalis (Wats.) C. L. Hitchc.	3,4,5
Trillium ovatum Pursh	1,2,5
Veratrum virides Ait.	2,3,4,5

ORCHIDACEAE

Calypso bulbosa (L.) Oakes	1,2
Corallorhiza maculata Raf.	1,6
Corallorhiza mertensiana Bong.	1,2
Corallorhiza striata Lindl.	1
Goodyera oblongifolia Raf.	1,2,6
Habenaria dilatata (Pursh) Hook. var. leucostachys (Lindl.) Ames	1
Habenaria dilatata (Pursh) Hook. var. dilatata	1
Habenaria saccata Greene	1,2,3,4
Habenaria unalascensis (Spreng.) Wats.	2,3,5
Listera caurina Piper	1,2,5
Listera cordata (L.) R. Br.	1,2
Spiranthes romanzoffiana Cham. var. romanzoffiana	1,2

SALICACEAE

Populus tremuloides Michx.	1
Populus trichocarpa T. & G. ex Hook.	1,2
Salix arctica Pall.	3
Salix barclayi Anderss.	3,4
Salix cascadensis Cockerell	3
Salix commutata Bebb	3,4
Salix lasiandra Benth. var. lasiandra	1,6
Salix nivalis Hook.	3

Salix sitchensis Sanson	1,2,3,4,5,6
Salix scouleriana Barratt	4

BETULACEAE

Alnus rubra Bong.	1,2
Alnus sinuata (Regel) Rydb.	2,3,4,5,6
Betula occidentalis Hook. var. occidentalis	1,2
Betula papyrifera Marsh. var. commutata (Regel) Fern.	1
Corylus cornuta Marsh. var. californica (DC.) Sharp	1

URTICACEAE

Urtica dioica L. var. lyallii (Wats.) C. L. Hitchc.	1,2,4

LORANTHACEAE

Arceuthobium campylopodium Engelm.	1,2,5
Arceuthobium douglasii Engelm.	1

ARISTOLOCHIACEAE

Asarum caudatum Lindl.	1

POLYGONACEAE

Eriogonum elatum Dougl. ex Benth	5
Eriogonum pyrolaefolium Hook. ex A. Murr.	5
Eriogonum umbellatum Torr. var. subalpinum (Greene) M. E. Jones	3,6
Oxyria digyna (L.) Hill	3,4,5
*Polygonum aviculare L. var. littorale (Link) Mert. & Koch	1,2
Polygonum bistortoides Pursh	2,3,4
Polygonum douglasii Greene var. latifolium (Engelm.) Greene	2,5
Polygonum majus (Meisn.) Piper	5
Polygonum minimum Wats.	3,4
Polygonum nuttallii Small	1,6
Polygonum persicaria L.	6
Polygonum viviparum L.	3
*Rumex acetosella L.	1,2,3,6
Rumex obtusifolius L.	1,2,3
Rumex salicifolius Weinm. ssp. triangulivalvis Danser var. angustivalvis Danser	4

PORTULACACEAE

Claytonia lanceolata Pursh var. chrysantha (Greene) C. L. Hitchc.	3
Montia parviflora (Moc.) Greene var. parviflora	1,4,5
Montia sibirica (L.) Howell var. sibirica	1,2,3,4,5

CARYOPHYLLACEAE

Arenaria capillaris Poir. var. americana (Maguire) Davis	3,4
Arenaria lateriflora L.	2
Arenaria macrophylla Hook.	1,2,3
Arenaria obtusiloba (Rydb.) Fern.	3
Sagina occidentalis Wats.	1,5
Sagina saginoides (L.) Britt.	1,2,3
Silene acaulis L. var. exscapa (Allioni) DC.	1,2,3,5
Silene antirrhena L.	1,6
Silene douglasii Hook. var. douglasii	3
Silene menziesii Hook. var. menziesii	1
Silene menziesii Hook. var. viscosa (Greene) Hitchc. & Maguire	1
Silene parryi (Wats.) Hitchc. & Maguire	1,2,3,4,5
Silene scouleri Hook.	3
Silene suksdorfii Robins	3
Stellaria calycantha (Ledeb.) Bong. var. sitchensis (Steud.) Fern.	1,2,3
Stellaria crispa Cham. & Schlecht.	1

NYMPHAEACEAE

Nuphar polysepalum Engelm.	1,2

RANUNCULACEAE

Actaea rubra (Ait.) Willd.	1,2
Anemone lyallii Britt.	1,2,3
Anemone multifida Poir var. multifida	3
Anemone occidentalis Wats.	2,3,4,5
Aquilegia formosa Fisch.	2,3,4,5
Caltha biflora DC. var. biflora	3
Caltha biflora DC. var. rotundifolia (Huth) C. L. Hitchc.	3
Delphinium menziesii DC. var. menziesii	2,3

Ranunculus eschscholtzii Schlect. var. *eschscholtzii*	3
Ranunculus eschscholtzii Schlect. var. *suksdorfii* (Gray) Benson	3
Ranunculus macounii Britt. var. *macounii*	1
Ranunculus orthorhynchus Hook. var. *orthorhynchus*	3
Ranunculus repens L. var. *repens*	1
Thalictrum occidentale Gray	2,3,4,5,6

BERBERIDACEAE

Achlys triphylla (Smith) DC.	1,2
Berberis aquifolium Pursh	1
Berberis nervosa Pursh	1,2,3,5

FUMARIACEAE

Dicentra formosa (Andr.) Walpers	1,2,3,4,5

CRUCIFERAE

Arabis drummondii Gray	1,2,3,4,5,6
**Arabis glabra* (L.) Bernh.	1,2,3
Arabis hirsuta (L.) Scop.	1,2,3
Arabis lyallii Wats.	3
Arabis lyrata L.	3
Barbarea orthoceras Ledeb.	1
Cardamine oligosperma Nutt. var. *oligosperma*	3,5
Cardamine pennsylvanica Muhl.	2
Draba lonchocarpa Rydb. var. *thompsonii* (C. L. Hitchc.) Rollins	3
Draba praealta Greene	3
Draba stenoloba Ledeb.	3
Lepidum densiflorum Schrad.	1
Rorippa islandica (Oed.) Borbas	1
Smelowskia ovalis M. E. Jones	3
Subularia aquatica L.	1

CRASSULACEAE

Sedum divergens Wats.	3,4
Sedum lanceolatum Torr. var. *lanceolatum*	1,2,3

Sedum oreganum Nutt.	1,2,3,4,5,6
Sedum roseum (L.) Scop. var. intergrifolium (Raf.) Berger	3
Sedum stenopetalum Pursh	1,2,3

SAXIFRAGACEAE

Elmera racemosa (Wats.) Rydb. var. puberulenta C. L. Hitchc.	1,2,3,4
Heuchera glabra Willd. ex R. & S.	3,4
Heuchera micrantha Dougl. ex Lindl. var. diversifolia (Rydb.) R. B. & L.	3
Leptarrhena pyrolifolia (D. Don) R. Br. ex Ser.	3,4
Mitella breweri Gray	2,3
Mitella caulescens Nutt.	1
Mitella pentandra Hook.	1,2,3,4,5
Mitella trifida Grah.	1
Parnassia fimbriata Konif. var. fimbriata	2,3,4
Saxifraga arguta D. Don	3,4
Saxifraga bronchialis L. var. austromontana (Wieg.) Piper	3
Saxifraga debilis Engelm. ex Gray	3
Saxifraga ferruginea Grah. var. macounii Engl. & Irmsch.	3,4
Saxifraga lyallii Engl. var. lyallii	3
Saxifraga mertensiana Bong.	3,4
Saxifraga oppositifolia L.	3
Saxifraga punctata L. var. canadensis (Calder & Savile) C. L. Hitchc.	3,4
Saxifraga tolmiei T. & G. var. tolmiei	3,4
Suksdorfia ranunculifolia (Hook.) Engl.	1,4
Tellmia grandiflora (Pursh) Dougl.	1,2,4,5,6
Tiarella laciniata Hook.	1
Tiarella trifoliata L.	1
Tiarella unifoliata Hook.	1,2,3,4
Tolmiea menziesii (Pursh) T. & G.	1,2,3,6

GROSSULARIACEAE

Ribes bracteosum Dougl. ex Hook.	1,2,3,4
Ribes howellii Greene	2,3,4
Ribes lacustre (Pers.) Poir	1,2,3,4,5

Ribes laxiflorum Pursh	4
Ribes sanguineum Pursh	1,5
Ribes triste Pall.	1
Ribes viscosissimum Pursh var. viscosissimum	6
Ribes watsonianum Koehne	1,6

ROSACEAE

Amelanchier alnifolia Nutt. var. semiintegrifolia (Hook.) C. L. Hitchc.	1,2,3,4,5
Aruncus sylvester Kostel.	1,2,3,4
Fragaria vesca L. var. crinita (Rydb.) C. L. Hitchc.	1,2
Fragaria virginiana Duchesne var. platypetala (Rydb.) Hall	1,2,3
Geum macrophyllum Willd. var. macrophyllum	1,5,6
Holodiscus discolor (Pursh) Maxim. var. discolor	1,2,3,4,5
Leutkea pectinata (Pursh) Kuntze	3,4
Osmaronia cerasiformis (T. & G.) Greene	1
Physocarpus capitatus (Pursh) Kuntze	1
Potentilla diversifolia Lehm. var. diversifolia	2,3
Potentilla drummondii Lehm.	3
Potentilla flabellifolia Hook. ex T. & G.	3,4
Potentilla fruticosa L.	4
Potentilla glandulosa Lindl. var. glandulosa	2,3,6
Potentilla norvegica L.	1
Potentilla palustris (L.) Scop.	1
Potentilla villosa Pall. ex Pursh	3
Prunus emarginata (Doulg.) Walpers var. emarginata	1,2,3
Prunus virginiana L. var. demissa (Nutt.) Torr.	1
Rosa gymnocarpa Nutt.	1,5
Rosa nutkana Presl var. nutkana	1,2,3,4
Rubus idaeus L. ssp. sachalinensis (Levl.) Focke var. sachalinensis	1
*Rubus laciniatus Willd.	1
Rubus lasiococcus Gray	2,3,4
Rubus leucodermis Dougl. ex T. & G.	1,4
Rubus nivalis Dougl. ex Hook.	2
Rubus parviflorus Nutt. var. parviflorus	1,2,3

Rubus pedatus J. E. Smith	1,2,3,4
Rubus spectabilis Pursh	1,2,3,4
Rubus ursinus Cham. & Schlecht. var. macropetalus (Doug.) Brown	1,4,5
Sibbaldia procumbens L.	3
Sorbus sitchensis Roemer var. grayi (Wenzig) C. L. Hitchc.	2,3,4
Sorbus sitchensis Roemer var. sitchensis	2,3,4
Spiraea betulifolia Pall.	6
Spiraea densiflora Nutt. ex T. & G. var. densiflora	3
Spiraea douglasii Hook. var. douglasii	1,2
Spiraea pyramidata Greene	1,2,3,4

LEGUMINOSAE

*Cytisus scoparius (L.) Link	1
Lathyrus nevadensis Wats. ssp. lanceolatus (Howell) C. L. Hitchc. var. pilosellus (Peck) C. L. Hitchc.	3
Lupinus latifolius Agardh var. latifolius	3
Lupinus latifolius Agardh var. subalpinus (Piper & Robbins) C. P. Smith	3,4
Lupinus lepidus Dougl. ex Lindl. var. lobbii (Gray) C. L. Hitchc.	3
Lupinus saxosus Howell	6
Oxytropis campestris (L.) DC. var. gracilis (A. Nels.) Barneby	3
*Trifolium dubium Sibth.	1
*Trifolium repens L.	1,2,3
Vicia americana Muhl. ex Willd. var. truncata (Nutt.) Brew.	1

CALLITRICHACEAE

Callitriche verna L.	1

EMPETRACEAE

Empetrum nigrum L.	3

CELASTRACEAE

Pachystima myrsinites (Pursh) Raf.	1,2,3,4

ACERACEAE

Acer circinatum Pursh	1,2,3,6
Acer glabrum Torr. var. douglasii (Hook.) Dippel	2,3,4,5
Acer macrophyllum Pursh	1,6

RHAMNACEAE

Ceanothus sanguineus Pursh	1,5
Ceanothus velutinus Dougl. ex Hook. var. *laevigatus* (Hook.) T. & G.	1
Rhamnus purshiana DC.	1

HYPERICACEAE

Hypericum anagalloides C. & S.	1,2,3,4
Hypericum perforatum L.	1

VIOLACEAE

Viola adunca Sm.	3
Viola glabella Nutt.	1,2,3
Viola macloskeyi Lloyd var. *pallens* (Banks) C. L. Hitchc.	3
Viola orbiculata Geyer ex Hook.	2
Viola palustris L.	1,2,3
Viola sempervirens Greene	1

LOASACEAE

Mentzelia dispersa Wats.	6

ONAGRACEAE

Circaea alpina L.	1,2,4
Clarkia rhomboidea Dougl.	6
Epilobium alpinum L. var. *albiflorum* (Suksd.) C. L. Hitchc.	3
Epilobium alpinum L. var. *clavatum* (Trel.) C. L. Hitchc.	3,4
Epilobium alpinum L. var. *gracillimum* (Trel.) C. L. Hitchc.	3
Epilobium alpinum L. var. *lactiflorum* (Hausskn.) C. L. Hitchc.	4
Epilobium alpinum L. var. *nutans* (Hornem) Hook.	3,4
Epilobium angustifolium L.	1,2,3,4
Epilobium glandulosum Lehm.	1
Epilobium latifolium L.	3,4,5,6
Epilobium luteum Pursh	3,4
Epilobium minutum Lindl. ex Hook.	1,2
Epilobium paniculatum Nutt. ex T. & G.	1

Epilobium watsonii Barbey var. *occidentale* (Trel.) C. L. Hitchc.	6
Gayophytum ramosissiumum Torr. & Gray	5

HIPPURIDACEAE

Hippuris montana Ledeb.	3
Hippuris vulgaris L.	1

ARALIACEAE

Oplopanax horridum (J. E. Smith) Miq.	1,2,4

UMBELLIFERAE

Angelica arguta Nutt.	1,2,3,4
Circuta douglasii (DC.) Coult. & Rose	1
Heracleum lanatum Michx.	1,2,3,4
Ligusticum canbyi Coult. & Rose	3,4
Ligusticum grayi Coult. & Rose	3,4
Lomatium brandegei (Coult. & Rose) Macbr.	6
Lomatium martindalei Coult. & Rose var. *angusticum* Coult. & Rose	3
Lomatium nudicaule (Pursh) Coult. & Rose	2
Lomatium triternatum (Pursh) Coult. & Rose	2
Oenanthe sarmentosa Presl ex DC.	1
Osmorhiza chilensis H. & A.	2
Osmorhiza depauperata Phil.	1
Osmorhiza occidentalis (Nutt.) Torr.	6
Osmorhiza purpurea (Coult. & Rose) Suksd.	1,2,3
Sanicula graveolens Poepp. ex DC.	6

CORNACEAE

Cornus canadensis L.	1,2,3
Cornus nuttallii Aud. ex T. & G.	1,6
Cornus stolonifera Michx. var. *occidentalis* (T. & G.) C. L. Hitchc.	1,6

ERICACEAE

Arctostaphylos nevadensis Gray	4
Arctostaphylos uva-ursi (L.) Spreng.	2,3
Cassiope mertensiana (Bong.) G. Don var. *mertensiana*	3,4

Cassiope stelleriana (Pall.) DC.	3,4
Chimaphila menziesii (R. Br.) Spreng.	1,2,5
Chimaphila umbellata (L.) Bart. var occidentalis (Rydb.) Blake	1
Cladothamnus pyrolaeflorus Bong.	2,3
Gaultheria humifusa (Grah.) Rydb.	3
Gaultheria ovatifolia Gray	2,6
Gaultheria shallon Pursh	1
Hypopitys monòtopa Crantz	1
Kalmia polifolia Wang. var. microphylla (Hook.) Rehd.	2,3,4
Kalmia polifolia Wang. var. polifolia	1,2,3
Menziesia ferruginea Smith var. ferruginea	1,2,3,6
Monotropa uniflora L.	1,5
Phyllodoce empetriformis (Sw.) D. Don	3,4
Phyllodoce granduliflora (Hook.) Colville	3
Pterospora andromedea Nutt.	1
Pyrola asarifolia Michx.	1
Pyrola dentata Smith	1
Pyrola picta Smith	1,5
Pyrola secunda L. var. secunda	1,2,3
Pyrola uniflora L.	1
Pyrola virens Schweigg.	1,2
Rhododendron albiflorum Hook.	3,4
Vaccinium alaskense Howell	1,2
Vaccinium caespitosum Michx.	3
Vaccinium deliciosum Piper	3,4
Vaccinium membranaceum Dougl. ex Hook.	2,3,4
Vaccinium ovalifolium Smith	1,2
Vaccinium parvifolium Smith	1

PRIMULACEAE

Dodecatheon conjugens Greene	4
Trientalis arctica Fisch. ex Hook.	1
Trientalis latifolia Hook.	1

GENTIANACEAE

Gentiana calycosa Griseb. var. *asepala* (Maguire) C. L. Hitchc.	4
Gentiana amarella L.	2

MENYANTHACEAE

Menyanthes trifoliata L.	1

APOCYNACEAE

Apocynum androsaemifolium L.	1

POLEMONIACEAE

Collomia grandiflora Dougl. ex Lindl.	1
Collomia heterophylla Hook.	1
Collomia linearis Nutt.	1,2
Microsteris gracilis (Hook.) Greene var. *gracilis*	1,2
Phlox diffusa Benth. var. *longistylis* (Wherry) Peck	3,4
Polemonium pulcherrimum Hook. var. *pulcherrimum*	3

HYDROPHYLLACEAE

Hydrophyllum fendleri (Gray) Heller var. *albifrons* Heller Macbr.	2,3,4
Nemophila parviflora Dougl. ex Benth var. *parviflora*	1
Phacelia hastata Dougl. ex Lehm var. *leptosepala* (Rydb.) Cronq.	3
Phacelia heterophylla Pursh var. *heterophylla*	3,4,5,6
Phacelia nemoralis Greene	1,2,3
Phacelia sericea (Grah.) Gray var. *sericea*	3
Romanzoffia sitchensis Bong.	3,4

BORAGINACEAE

Cryptantha ambigua (Gray) Greene	1
Mertensiana paniculata (Ait.) G. Don	5

LABIATEAE

Galeopsis tetrahit L.	1
Mentha arvensis L. var. glabrata (Benth.) Fern.	1
Prunella vulgaris L.	1,2,3
Scutellaria lateriflora L.	1,5
Stachys cooleyae Heller	1,2,3

SCROPHULARIACEAE

Castilleja elmeri Fern.	2,3
Castilleja hispida Benth. var. hispida	3
Castilleja miniata Dougl. ex Hook.	1,2,3,4,5
Castilleja parviflora Bong. var. albida (Penn.) Ownbey	3,4
Castilleja rupicola Piper	3
Collinsia parviflora Lindl.	1
*Digitalis purpurea L.	1
Mimulus alsinoides Dougl. ex Benth	1
Mimulus guttatus DC. var. guttatus	1
Mimulus lewisii Pursh	2,3,4,5,6
Mimulus moschatus Dougl.	1,4
Mimulus tilingii Regel var. caespitosus (Greene) Grant	3,4
Pedicularis bracteosa Benth. var. latifolia (Pennel) Cronq.	3,4
Pedicularis contorta Benth. var. contorta	3
Pedicularis groenlandica Retz.	3,4
Pedicularis ornithorhynca Benth.	4
Pedicularis racemosa Dougl. ex Hook. var. racemosa	2,3
Penstemon confertus Dougl.	3
Penstemon davidsonii Greene var. menziesii (Keck) Cronq.	3
Penstemon fruticosus (Pursh) Greene var. fruticosus	3
Penstemon procerus Dougl. ex R. Grah. var. tolmiei (Hook) Cronq.	3
Penstemon serrulatus Menzies ex Smith	1,2,3,4,5,6
Verbascum blattaria L.	1
Veronica cusickii Gray	3,4
Veronica scutellata L.	1
Veronica serpyllifolia L.	1
Veronica wormskjoldii Roem. & Schult.	3,4

OROBANCHACEAE

Orobanche _uniflora_ L. var. _minuta_ (Suksd.) Beck	1,2
Orobanche _uniflora_ L. var. _purpurea_ (Heller) Achey	1,2

LENTIBULARIACEAE

Pinguicula _vulgaris_ L.	3,4

PLANTAGINACEAE

*_Plantago_ _lanceolata_ L.	6
*_Plantago_ _major_ L.	1,2,3

RUBIACEAE

Galium _aparine_ L.	1
Galium _biflorum_ Wats.	1,2
Galium _boreale_ L.	1
Galium _trifidum_ L.	1
Galium _triflorum_ Michx.	1,2,3,4
Kelloggia _galioides_ Torr.	5

CAPRIFOLIACEAE

Linnaea _borealis_ L. var. _longiflora_ Torr.	1,2,5
Lonicera _ciliosa_ (Pursh) DC.	1
Lonicera _involucrata_ (Rich.) Banks ex Spreng.	1,6
Lonicera _utahensis_ Wats.	3
Sambucus _racemosa_ L. var. _arborescens_ (T. & G.) ex Gray	1,2,4
Sambucus _cerulea_ Raf.	2
Symphoricarpos _albus_ (L.) Blake var. _laevigatus_ (Fern.) Blake	1,2,3,5,6
Viburnum _edule_ (Michx.) Raf.	1,6

VALERIANACEAE

Valeriana _sitchensis_ Bong.	3,4

CAMPANULACEAE

Campanula _rotundifolia_ L.	1,2,3,4
Triodanis _perfoliata_ (L.) Nieuwl.	1

COMPOSITAE

Achillea millefolium L. ssp. lanulosa (Nutt.) Piper var. lanulosa 1,2

Achillea millefolium L. ssp. lanulosa (Nutt.) Piper var. apicola (Rydb.) Garrett 3

Adenocaulon bicolor Hook. 1,2,4,5,6

Agoseris aurantiaca (Hook.) Greene var. aurantiaca 3,4

Agoseris elata (Nutt.) Greene 3

Agoseris glauca (Pursh) Raf. var. dasycephala (T. & G.) Jeps. 3,4

Anaphalis margaritacea (L.) B. & H. 1,2,3,4

Antennaria alpina (L.) Gaertn. var. media (Greene) Jeps. 3

Antennaria lanata (Hook.) Greene 3,4

Antennaria neglecta Greene 3

Antennaria racemosa Hook. 6

Antennaria rosea Greene 4,5,6

Antennaria umbrinella Rydb. 3

Anthemis arvensis L. 1

Arctium minus (Hill) Bernh. 1

Arnica amplexicaulis Nutt. 3,4

Arnica latifolia Bong. var. gracilis (Rydb.) Cronq. 2,3

Arnica latifolia Bong. var. latifolia 2,3,4

Arnica mollis Hook. 3,4

Arnica parryi Gray 3,4

Arnica rydbergii Greene 3

Artemisia absinthium L. 1

Artemisia ludoviciana Nutt. var. latiloba Nutt. 3

Artemisia norvegica Fries var. saxatilis (Bess.) Jeps. 3

Artemisia suksdorfii Piper 1,6

Artemisia tilesii Ledeb. 3

Artemisia trifurcata Steph. ex Spreng. 3

Aster engelmannii (Eat.) Gray 3,4

Aster foliaceus Lindl. var. foliaceus 3,4

Aster modestus Lindl. 3,5

Aster sibiricus L. var. meritus (A. Nels.) Raup. 3

Aster subspicatus Nees var. subspicatus 1,2

*Chrysanthemum leucanthemum L.	1
*Cirsium arvense (L.) Scop. var. horridum Wimm. & Grab.	1
Cirsium edule Nutt.	3,4
*Cirsium vulgare (Savi) Airy-Shaw	1
Crepis atrabarba Heller ssp. atrabarba	6
Crepis barbigera Leib.	6
Crepis capillaris (L.) Wallr.	1
Erigeron acris L. var. debilis Gray	3
Erigeron annuus (L.) Pers.	1
Erigeron aureus Greene	4
Erigeron compositus Pursh var. glabratus Macoun	3
Erigeron leibergii Piper	5
Erigeron peregrinus (Pursh) Greene ssp. callianthemus (Greene) Cronq. var. angustifolius (Gray) Cronq.	3
Erigeron peregrinus (Pursh) Greene ssp. callianthemus (Greene) Cronq. var. scaposus (T. & G.) Cronq.	3
Erigeron philadelphicus L.	1
Eriophyllum lanatum (Pursh) Forbes var. lanatum	1
Gnaphalium microcephalum Nutt. var. thermale (E. Nels.) Cronq.	1,5
Gnaphalium palustre Nutt.	5
Gnaphalium purpureum L. var. purpureum	1
Gnaphalium uliginosum L.	1
Happlopappus lyallii Gray	3
Hieracium albiflorum Hook.	1,2,3,4
Hieracium cynoglossoides Arv.-Touv.	5
Hieracium gracile Hook.	3,4
Hypochaeris radicata L.	1
Lactuca serriola L.	1
Luina hypoleuca Benth.	1,4
Madia citriodora Greene	1
Madia glomerata Hook.	1
Madia gracilis (Smith) Keck	1
Petasites frigidus (L.) Fries var. palmatus (Ait.) Cronq.	1,2,3
Prenanthes alata (Hook.) D. Dietr.	1,2
Senecio fremontii T. & G.	4
Senecio integerrimus Nutt. var. exaltatus (Nutt.) Cronq.	3

Senecio pseudaureus Rydb.	1
Senecio sylvaticus L.	1
Senecio triangularis Hook.	3,4
Solidago canadensis L. var. salebrosa (Piper) Jones	1,2,3,6
Solidago multiradiata Ait. var. scopulorum Gray	3
Taraxacum ceratophorum (Ledeb.) DC.	3
Taraxacum officinale Weber	1

Mosses

SPHAGNACEAE

Sphagnum girgensohnii Russow	3
Sphagnum teres (Schimp.) Angstr.	3

ANDREAEACEAE

Andreaea blyttii B.S.G.	3
Andreaea nivalis Hook.	3
Andreaea rothii Web. & Mohr var. crassinervia	3

TETRAPHIDACEAE

Tetraphis pellucida Hedw.	1

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid.	3
Ditrichum montanum Leib.	2

DICRANACEAE

Arctoa starkei (Web. & Mohr) Hoeski	3
Dicranella heteromalla (Hedw.) Schimp	3
Dicranoweisia cirrata (Hedw.) Lindb.	1
Dicranoweisia contermina Ren. & Card.	3
Dicranoweisia crispula (Hedw.) Lindb. var. contermina Grout (Ren. & Card.)	3
Dicranum bonjeani De Not	1
Dicranum fuscescens Turn.	1,2,3
Dicranum howellii Ren. & Card.	2
Dicranum pallidisetum (Bailey) Irel.	3
Dicranum scoparium Hedw.	1

POLYTRICHACEAE

Oligotrichum aligerum Mitt.	3
Oligotrichum parallelum (Mitt.) Kindb.	1
Pogonatum alpinum (Hedw.) Röhl var. alpinum	3

Pogonatum alpinum (Hedw.) Röhl var. *septentrionale* (Brid.) Brid.	3
Pogonatum contortum (Schwaegr.) Sull.	1
Pogonatum urnigerum (Hedw.) Beauv.	1
Polytrichadelphus lyallii Mitt.	3
Polytrichum commune Hedw.	1,2
Polytrichum juniperinum Hedw.	1
Polytrichum norvegicum Hedw.	3
Polytrichum piliferum Hedw.	3
Polytrichum sexangulare Brid.	3

BUXBAUMIACEAE

Buxbaumia piperi Best	1

TRICHOSTOMEAE

Weissia controversa Hedw.	3

POTTIEAE

Tortula norvegica (Web.) Wahlenb. ex Lindb.	3

GRIMMIACEAE

Grimmia alpestris (Web. & Mohr) Schleich	3
Rhacomitrium aquaticum (P. Beauv.) Brid.	3
Rhacomitrium aciculare Brid.	1
Rhacomitrium canescens Brid. var. *epilosum* (H. Muell.) Milde	3
Rhacomitrium canescens Brid. var. *ericoides* (Brid.) B.S.G.	3
Rhacomitrium heterostichum (Hedw.) Brid.	1
Rhacomitrium sudeticum (Funck) B.S.G.	3
Rhacomitrium sudeticum (Funck) B.S.G. var. *sudeticum* f. *hevipes* (Kindb.)	3
Rhacomitrium varium (Mitt.) Lesq. & James	1
Scouleria aquatica Hook.	1

ORTHOTRICHACEAE

Amphidium californicum (Hampe) Broth.	1
Ulota megalospora Vent.	1

TIMMIACEAE

Timmia austriaca Hedw.	3

AULACOMNIACEAE

Aulacomnium androgynum Schwaegr.	1
Aulacomnium palustre (Hedw.) Schwaegr.	3

BARTRAMIACEAE

Bartramia ithyphylla Brid.	3
Philonotis fontana (Hedw.) Brid. var. _pumila_ Brid.	3

BRYACEAE

Bryum creberrimum Tayl.	2,3
Bryum cyclaphyllum (Schwaegr.) B.S.G.	3
Bryum sandbergii Holz.	3
Pohlia cardotii (Ren.) Broth.	3
Pohlia cruda (Hedw.) Lindb.	3
Pohlia drummondii (C. Müll.) Andr.	3
Pohlia nutans (Hedw.) Lindb.	3

MNIACEAE

Mnium insigne Mitt.	2,3
Mnium lycopodioides Schwaegr.	3
Mnium marginatum (With.) P. Beauv.	2
Mnium nudum Williams	1
Mnium punctatum Hedw.	1
Mnium venustum Mitt.	1

HYPNACEAE

Brachythecium asperrimum (Mitt.) Sull.	3
Brachythecium collinum (C. Müll.) B.S.G.	3
Brachythecium starkei (Brid.) B.S.G. var. _explanatiem_ (Brid.) Moeuk.	3
Brachythecium velutinum (Hedw.) B.S.G.	3
Calliergonella cuspidata (Brid.) Loeske	1
Drepanocladus aduncus (Hedw.) Warnst.	3

Drepanocladus _fluitans_ (Hedw.) Warnst.	1
Drepanocladus _uncinatus_ (Hedw.) Warnst.	3
Eurhynchium _oreganum_ (Sull.) Jaeg.	1
Eurhynchium _stokesii_ (Turn.) B.S.G.	1
Homalothecium _nuttallii_ (Wils.) Jaeg.	1
Hygrohypnum _ochraceum_ (Wils.) Loeske	1
Hylocomium _splendens_ (Hedw.) B.S.G.	1,2
Hypnum _circinale_ Hook.	1
Hypnum _dieckii_ Ren. & Card.	3
Hypnum _subimponens_ Lesq.	1
Plagiothecium _denticulatum_ (Hedw.) B.S.G.	1
Plagiothecium _piliferum_ (Hartm.) B.S.G.	1
Plagiothecium _undulatum_ (Hedw.) B.S.G.	1
Rhytidiadelphus _loreus_ (Hedw.) Warnst.	1,2,3
Rhytidiadelphus _squarrosus_ (Hedw.) Warnst.	2
Rhytidiadelphus _triquetrus_ (Hedw.) Warnst.	1
Rhytidiopsis _robusta_ (Hook.) Broth.	1,2,3

LESKEACEAE

Claopodium _bolanderi_ Best	3
Claopodium _crispifolium_ (Hook.) Ren. & Card.	1
Heterocladium _heteropteroides_ Best	1
Lescuraea _baileyi_ (Best & Grout) Lawt.	3
Lescuraea _patens_ (Lindb.) Arn. & Jens	3
Lescuraea _radicosa_ (Mitt.) Moeuk.	3
Lescuraea _saviana_ (De Not.) Lawt.	3

CRYPHAEACEAE

Antitrichia _curtipendula_ (Hedw.) Brid.	1

PTILIDIACEAE

Blepharostoma _trichophyllum_ (L.) Dumort.	2
Ptilidium _californicum_ (Aust.) U. & C.	1
Ptilidium _pulcherrimum_ (Web.) Hampe	1

LEPIDOZIACEAE

Bazzania _denudata_ (Torr.) Trev.	1

CALYPOGEIACEAE

Calypogeia _trichomanis_ (L.) Corda	1

CEPHALOZIACEAE

Cephalozia _bicuspidata_ (L.) Dumont.	2
Cephalozia _lammersiana_ Spruce	1
Cephalozia _media_ Lindb.	1
Cephalozia _pleniceps_ (Aust.) Lindb.	2

JUNGERMANNIACEAE

Lophozia _incisa_ (Schrad.) Dumort.	2
Lophozia _porphyroleuca_ (Nees) Schiffn.	2
Plectocolea _obovata_ (Nees) Mitt.	1
Plectocolea _rubra_ (Gottsche) Evans	2

HARPANTHACEAE

Lophocolea _bidentata_ (L.) Dumort.	1

PLAGIOCHILACEAE

Plagiochila _aspleniodes_ (L.) Dumort.	1

SCAPANIACEAE

Diplophyllum _albicans_ (L.) Dumort.	2
Diplophyllum _ovatum_ Steph.	2
Diplophyllum _taxifolium_ (Wahlenb.) Dumort.	1
Scapania _americana_ K. Müll.	1
Scapania _bolanderi_ Aust.	2
Scapania _dentata_ Dumort.	1
Scapania _oakesii_ Aust.	2
Scapania _undulata_ (L.) Dumort.	2

PORELLACEAE

Porella _navicularis_ (L. & L.) Lindb.	1
Porella _roellii_ Steph.	1

FRULLANIACEAE

Frullania nisquallensis Sull.	1

PELLIACEAE

Pellia epiphylla (L.) Corda	1

BLASIACEAE

Blasia pusilla L.	2

METZGERIACEAE

Metzgeria conjugata Lindb.	1
Metzgeria pubescens (Schrank) Raddi	1

RICCARDIACEAE

Riccardia multifida (L.) S. F. Gray	1

MARCHANTIACEAE

Asterella ludwigii (Schw.) Underw.	2
Marchantia polymorphia L.	1

Lichens

DERMATOCARPACEAE

Dermatocarpon miniatum (L.) Mann	1,2,3

SPHAEROPHORACEAE

Sphaerophorus globus (Huds.) Wainio	1,2,3

GYALECTACEAE

Microphiale lutea (Dicks.) Zahlbr.	1,2,3

COLLEMACEAE

Leptogium lichenoides (L.) Zahlbr.	5

STICTACEAE

Lobaria oregana (Tuck.) Müll.	1,2,3
Lobaria verrucosa (Huds.) Hoffm.	1

PELTIGERACEAE

Solorina crocea (L.) Ach.	3
Solorina saccata (L.) Ach.	3
Nephroma laevigatum Ach.	1
Peltigera aphthosa (L.) Willd. var. _typica_	5
Peltigera canina (L.) Willd.	1,2,3,5
Peltigera canina (L.) Willd. var. _spura_ (Ach.) Schaer. f. _sorediata_ Schaer.	5
Peltigera membranacea (Ach.) Nyl.	6
Peltigera polydactyla (Neck.) Hoffm.	1
Peltigera scutata (Dicks.) Duby	1

LECIDEACEAE

Lecidea albocaerulescens (Wulf.) Ach. var. _flavocaerulescens_ (Hornem.) Schaer.	1,2
Lecidea arctica Somrft.	3
Lecidea contigua (Sm.) Fries	3
Lecidea cyanea (Ach.) Röhl.	3
Lecidea granulosa (Ehrh.) Ach.	1

Lecidea lapicida Ach.	3
Mycoblastus alpinus (Fr.) Kernst.	1,2
Toninia ruginosa (Tuck.) Herre	5

CLADONIACEAE

Pilophoron cereolus (Ach.) Th. Fr.	1
Cladonia chlorophaea (Flk.) Spreng.	1,2,3
Cladonia coccifera (L.) Willd.	1,2,3
Cladonia gracilis (L.) Willd.	1,2,3
Cladonia macrophyllodes Nyl.	3
Cladonia mitis Sandst.	3
Cladonia subsquamosa (Nyl.) Wainio	1
Stereocaulon albicans Th. Fr.	3
Stereocaulon alpinum Laur.	3
Stereocaulon alpinum Laur. var. *alpinum* (La[illegible]. [illegible].	3
Stereocaulon denudatum Flk.	3
Stereocaulon tomentosum Fries	1

UMBILICARIACEAE

Umbilicaria erosa (Web.) Ach.	1,2,3

ACAROSPORACEAE

Biatorella testudinea (Ach.) Mass.	3

LECANORACEAE

Lecanora alpina Somrft.	2,3
Lecanora calcarea (L.) Somrft.	1,2,3
Lecanora laevata (Ach.) Nyl.	2,3
Ochrolechia pallescens (L.) Mass.	1
Icmadophila ericetorum (L.) Zahlbr.	1

PARMELIACEAE

Parmeliopsis diffusa (Web.) Riddle	3
Parmelia enteromorpha Ach.	1,2,3
Parmelia lepidiota (Swartz) Müll. Arg.	5
Parmelia multispora Schneid.	5

Parmelia pannariiformis (Nyl.) Wainio	5
Parmelia pubescens (L.) Wainio	3,5
Parmelia vittata (Ach.) Röhl	1,2
Cetraria arborialis (Merrill) Howard	3
Cetraria glauca (L.) Ach.	1,2,3
Cetraria islandica (L.) Ach.	3
Cetraria tuckermani Herre	1,2,3
USNEACEAE	
Letharia vulpina (L.) Hue	1,2,3
Alectoria fremontii Tuck.	3
Alectoria ochroleuca (Ehrh.) Nyl.	3
Alectoria sarmentosa Ach.	1,2,3
Cornicularia tenuissima (L.) Zahlbr.	1,2,3
CALOPLACACEAE	
Caloplaca jungermanniae (Vahl.) Th. Fr.	3
TELOSCHISTACEAE	
Xanthoria polycarpa (Hoffm.) Oliv.	6
BUELLIACEAE	
Rinodina orbata (Ach.) Wainio	3

FAUNA

Ornithology

Introduction

The avifauna of the North Cascades has received very little attention. The reports of species occurring in the area have been compiled by bird students and collectors over a period of about 120 years. George Gibbs, a geologist with the International Boundary Commission, was probably the first collector (1859-1861) within the North Cascades Complex (Jewett, 1953). Dr. C. B. R. Kennerly, also with the Commission, collected within or near the northern boundaries of the complex during 1860 (Baker, 1900). Allan Brooks, probably the most avid collector in the North Cascades, made many trips to the area from 1887 to 1900 (Brooks, 1917, 1920, 1922). Early collectors in or near the Lake Chelan National Recreation Area were W. L. Dawson (1901), J. H. Bowles (1908), and F. R. Decker (1923).

No scientific studies, other than reconnaissance trips, have been undertaken in the North Cascades. Many helpful references to studies of North Cascades species appearing in other locations may be found in Jewett (1953).

The following bird checklist is based chiefly on the specimens cited in Jewett (1953). More recent information gathered from other sources has provided additional specimens. The species listed include sightings or collections made in or within approximately 15 miles of the complex. Nomenclature (and much of the habitat information) follows the treatment by Larrison and Sonnenberg (1968). The classification is from Jewett (1953).

The checklist has been separated into two sections. The first, regular species, includes only seasonal or permanent residents who may be of importance to the environment of the ecosystem. The second section includes accidental and hypothetical species. Accidental species are defined here as rare species or migrants who have little effect on the environment. Hypothetical species are those which have never been seen in the North Cascades, but since the habitat fulfills their requirements, or their migration flyway is near the area, future sightings of these birds can be expected.

In both sections of the checklist the species have been arranged by families. In the regular species section a numerical designation of the most common habitat(s) in which the species is found is provided. In the second section hypothetical species have been designated by an asterisk while the accidental species have numbers denoting the habitat in which they were sighted or collected.

The avifauna habitats are modified from those forest types and zones described in the ecology section of this survey and are as follows:

1. Western Hemlock Forest Type (streams and lakes)
2. Western Hemlock Forest Type (forests)
3. Pacific Silver Fir Forest Type (streams and lakes)
4. Pacific Silver Fir Forest Type (forests)
5. Subalpine - Alpine Zones
6. Engelmann Spruce - Alpine Fir Forest Type (streams and lakes)
7. Engelmann Spruce - Alpine Fir Forest Type (forests)
8. Grand Fir - Douglas-Fir Forest Type (streams and lakes)
9. Grand Fir - Douglas-Fir Forest Type (forests)

Bird Checklist

Regular Species

GAVIDAE

Gavia immer (Brunnich) Common Loon 1

COLYMBIDAE

Aechmorphorus occidentalis (Lawrence) Western Grebe 1,8

ARDEIDAE

Ardea herodias Linnaeus Great Blue Heron 1,3,8

ANATIDAE

Anas platyrhynchos Linnaeus Common Mallard 1,8

Anas carolinensis Gmelin Green-winged Teal 1,8

Mareca americana (Gmelin) American Widgeon 1

Aythya marila (Linnaeus) Greater Scaup 1

Aythya affinis (Eyton) Lesser Scaup 1

Histrionicus histrionicus (Linnaeus) Harlequin Duck 1,3

ACCIPRIDAE

Accipiter gentilis (Linnaeus) Goshawk 2,4,5,7,9

Accipiter striatus Vieillot Sharp-shinned Hawk 1,3,5,7,9

Accipiter cooperii (Bonaparte) Cooper's Hawk 1,3,5,7,9

Buteo jamaicensis (Gmelin) Red-tailed Hawk 2,5,9

Buteo swainsoni Bonaparte Swainson's Hawk 5

Aquila chrysaetos (Linnaeus) Golden Eagle 5

Haliaeetus leucocephalus (Linnaeus) Bald Eagle 1

PANDIONIDAE

Pandion haliaetus (Linnaeus) Osprey 1

FALCONIDAE

Falco sparverius Linnaeus Sparrow Hawk 1,5,9

TETRAONIDAE

Dendragapus obscurus (Say) Blue Grouse	2,4,5,7,9
Canachites canadensis (Linnaeus) Spruce Grouse	2,4,5
Bonasa umbellus (Linnaeus) Ruffed Grouse	1,2
Lagopus leucurus (Richardson) White-tailed Ptarmigan	5

PHASIANIDAE

Phasianus colchicus Linnaeus Ring-necked Pheasant	1

RALLIDAE

Rallus limicola Vieillot Virginia Rail	1
Fulica americana Gmelin American Coot	1

CHARADRIIDAE

Charadrius vociferus Linnaeus Killdeer	1,2,8,9

SCOLOPACIDAE

Capella gallinago (Linnaeus) Common Snipe	1
Actitis macularia (Linnaeus) Spotted Sandpiper	1,3,5
Tringa solitaria Wilson Solitary Sandpiper	1,3

LARIDAE

Larus glaucescens Naumann Glaucus-winged Gull	1

COLUMBIDAE

Columba fasciata Say Band-tailed Pigeon	2,4,5

STRIGIDAE

Otus asio (Linnaeus) Screech Owl	2,4
Bubo virginianus (Gmelin) Great Horned Owl	2,4,7,9
Surnia ulula (Linnaeus) Hawk-owl	8
Glaucidium gnoma Wagler Pygmy Owl	2,4,7,9
Strix occidentalis (Xantus) Spotted Owl	1,2,3,4
Aegolius acadius (Gmelin) Saw-whet Owl	2,4,5,7,9

CAPRIMULGIDAE

Chordeiles minor (Forster) Common Nighthawk	1,5,7,9

APODIDAE

Cypseloides niger (Gmelin)	Black Swift	1,3,4,5
Chaetura vauxi (J. K. Townsend)	Vaux's Swift	1,2,3,4,6,8

TROCHILIDAE

Selasphorus rufus (Gmelin)	Rufous Hummingbird	2,4,5
Stellula calliope (Gould)	Calliope Hummingbird	5,7,9

ALCEDINIDAE

Megaceryle alcyon Linnaeus	Belted Kingfisher	1

PICIDAE

Colaptes cafer (Gmelin)	Red-shafted Flicker	2,4,5,7,9
Dryocopus pileatus (Linnaeus)	Pileated Woodpecker	2,4,7,9
Asyndesmus lewis (Gray)	Lewis Woodpecker	2
Sphyrapicus varius (Linnaeus)	Yellow-bellied Sapsucker	1,2,8,9
Dendrocopos villosus (Linnaeus)	Hairy Woodpecker	2,4,7,9
Dendrocopos pubescens (Linnaeus)	Downy Woodpecker	1
Picoides tridactylus (Linnaeus)	Northern Three-toed Woodpecker	1,2,3,4,7,9

TYRANNIDAE

Empidonax traillii (Audubon)	Traill's Flycatcher	1,3
Empidonax hammondii (Xantus)	Hammond's Flycatcher	2,4,7,9
Empidonax difficilis Baird	Western Flycatcher	2
Contopus sordidulus Linnaeus	Western Wood Peewee	2,4,7,8,9
Nuttallornis borealis (Swainson)	Olive-sided Flycatcher	4,5,7,9

ALAUDIDAE

Eremophila alpestris (Linnaeus)	Horned Lark	5

HIRUNDINIDAE

Tachycineta thalassina (Swainson)	Violet-green Swallow	2,9
Iridoprocne bicolor (Vieillot)	Tree Swallow	1
Petrochelidon pyrrhonota (Vieillot)	Cliff Swallow	1

CORVIDAE

Perisoreus canadensis (Linnaeus) Gray Jay	4,5,7,9
Cyanocitta stelleri (Gmelin) Steller's Jay	2,4
Corvus corax Linnaeus Common Raven	2,4,5,7,9
Corvus brachyrhynchos Brehm Common Crow	1
Nucifraga columbiana (Wilson) Clark's Nutcracker	5

PARIDAE

Parus atricapillus Linnaeus Black-capped Chickadee	1
Parus gambeli Ridgway Mountain Chickadee	5,7,9
Parus rufescens J. K. Townsend Chestnut-backed Chickadee	1,2,3

SITTIDAE

Sitta canadensis Linnaeus Red-breasted Nuthatch	2,4,5,7,9

CERTHIDAE

Certhia familaris Linnaeus Brown Creeper	2,4,5,7,9

CINCLIDAE

Cinclus mexicanus Swainson Dipper	1,3,5,6,8

TROGLODYTIDAE

Troglodytes troglodytes (Linnaeus) Winter Wren	2,4,7,9
Telmatodytes palustris (Wilson) Long-billed Marsh Wren	1

TURDIDAE

Turdus migratorius Linnaeus Robin	1,3,5,7,9
Ixoreus naevius (Gmelin) Varied Thrush	2,4,7,9
Hylocichla guttata (Pallas) Hermit Thrush	4,5,7,9
Hylocichla ustulata (Nuttall) Swainson's Thrush	2,4
Sialia mexicana Swainson Western Bluebird	9
Sialia currucoides (Bechstein) Mountain Bluebird	5,7,9
Myadestes townsendi (Audubon) Townsend's Solitaire	4,5,7,9

REGULIDAE

Regulus satrapa Lichtenstein Golden-crowned Kinglet	2,4,7,9
Regulus calendula (Linnaeus) Ruby-crowned Kinglet	7,9

MOTACILLIDAE

<u>Anthus spinoletta</u> (Linnaeus) Water Pipit	5

BOMBYCILLIDAE

<u>Bombycilla cedrorum</u> Vieillot Cedar Waxwing	1,8

STURNIDAE

<u>Sturnus vulgaris</u> Linnaeus Starling	1

VIREONIDAE

<u>Vireo olivaceus</u> (Linnaeus) Red-eyed Vireo	1,8
<u>Vireo gilvus</u> (Vieillot) Warbling Vireo	2,4,9

PARULIDAE

<u>Vermivora celata</u> (Say) Orange-crowned Warbler	1,3,7,9
<u>Dendroica petechia</u> (Linnaeus) Yellow Warbler	1
<u>Dendroica coronata</u> (Linnaeus) Myrtle Warbler	2
<u>Dendroica auduboni</u> (Townsend) Audubon's Warbler	1,5,7
<u>Dendroica nigrescens</u> (Townsend) Black-throated Gray Warbler	1
<u>Dendroica townsendi</u> (Townsend) Townsend's Warbler	2,4,5,9
<u>Oporornis tolmiei</u> (Townsend) Macgillivray's Warbler	1,3,5,7,9
<u>Geothlypis trichas</u> (Linnaeus) Yellowthroat	1,8
<u>Wilsonia pusilla</u> (Wilson) Wilson's Warbler	2,4,5,7,9

ICTERIDAE

<u>Euphagus cyanocephalus</u> (Wagler) Brewer's Blackbird	1
<u>Molothrus ater</u> (Boddaert) Brown-headed Cowbird	1

THRAUPIDAE

<u>Piranga ludoviciana</u> (Wilson) Western Tanager	2,4,5,7,9

FRINGILLIDAE

<u>Pheucticus melanocephalus</u> (Swainson) Black-headed Grosbeak	7,8
<u>Hesperiphona vespertina</u> (W. Cooper) Evening Grosbeak	4,5,7,9
<u>Carpodacus cassinii</u> Baird Cassin's Finch	9
<u>Leucosticte tephrocotus</u> (Swainson) Gray-crowned Rosy Finch	5
<u>Spinus pinus</u> (Wilson) Pine Siskin	2,4,5,7,9

Loxia curvirostra Linnaeus	Red Crossbill	2,4,5,7,9
Pipilo erythrophthalmus Bell	Rufous-sided Towhee	1
Junco oreganus (Townsend)	Oregon Junco	1,2,4,7,9
Spizella passerina (Bechstein)	Chipping Sparrow	2,4,5,7,9
Melospiza melodia (Wilson)	Song Sparrow	1
Passerella iliaca (Merrem)	Fox Sparrow	5
Zonotrichia leucophrys (Forster)	White-crowned Sparrow	1

Accidental and Hypothetical Species

COLYMBIDAE

Podiceps grisegena Boddaert	Red-necked Grebe	*
Podilymbus podiceps (Linnaeus)	Pied-billed Grebe	*

ARDEIDAE

Botaurus lentiginosus (Montagu)	American Bittern	*

ANATIDAE

Olor columbianus (Ord)	Whistling Swan	1
Branta canadensis (Linnaeus)	Canada Goose	1
Anas acuta Linnaeus	Pintail	*
Aix sponsa (Linnaeus)	Wood Duck	*
Aythya americana (Eyton)	Redhead	*
Aythya collaris (Donovan)	Ring-necked Duck	*
Aythya valisineria (Wilson)	Canvasback	*
Bucephala islandica (Gmelin)	Barrow's Goldeneye	*
Melanitta deglandi (Bonaparte)	White-winged Scoter	1
Lophodytes cucullatus (Linnaeus)	Hooded Merganser	*
Mergus merganser Linnaeus	Common Merganser	*
Mergus serrator Linnaeus	Red-breasted Merganser	*

* Hypothetical species

ACCIPITRIDAE

Cathartes aura (Linnaeus)	Turkey Vulture	5
Buteo lagopus (Pontoppidan)	Rough-legged Hawk	5
Circus cyaneus (Linnaeus)	Marsh Hawk	*

FALCONIDAE

Falco peregrinus Tunstall	Peregrine Falcon	*
Falco columbarius Linnaeus	Pigeon Hawk	1

PHASIANIDAE

Lophortyx californica (Shaw)	California Quail	1
Oreortyx pictus (Douglas)	Mountain Quail	*

GRUIDAE

Grus canadensis (Linnaeus)	Sandhill Crane	*

SCOLOPACIDAE

Totanus melanoleucus (Gmelin)	Greater Yellowlegs	1
Erolia bairdii (Coues)	Baird's Sandpiper	5

PHALAROPODIDAE

Steganopus tricolor Vieillot	Wilson Phalerope	*

LARIDAE

Larus argentatus Pontoppidan	Herring Gull	*
Larus californicus Lawrence	California Gull	*
Larus delawarensis Ord	Ring-billed Gull	*
Larus canus Linnaeus	Mew Gull	*
Larus philadelphia (Ord)	Bonaparte's Gull	5

ALCIDAE

Brachyramphus marmoratum (Gmelin)	Marbled Murrelet	*

COLUMBIDAE

Zenaidura macroura (Linnaeus)	Mourning Dove	*

TYTONIDAE

Tyto alba (Scopoli)	Barn Owl	*

STRIGIDAE

Strix nebulosa Forster Great Gray Owl	*
Asio flammeus (Pontoppidan) Short-eared Owl	5

APODIDAE

Aeronautes saxatilis (Woodhouse) White-throated Swift	*

PICIDAE

Picoides arcticus (Swainson) Black-backed Three-toed Woodpecker	*

TYRANNIDAE

Tyrannus verticalis Say Western Kingbird	9
Empidonax oberholseri Phillips Dusky Flycatcher	*

HIRUNDINIDAE

Stelgidopteryx ruficollis (Vieillot) Rough-winged Swallow	1
Hirundo rustica Linnaeus Barn Swallow	1

CORVIDAE

Pica pica (Linnaeus) Black-billed Magpie	1

PARIDAE

Parus hudsonicus Forster Boreal Chickadee	5
Psaltriparus minimus (J. K. Townsend) Common Bushtit	*

SITTIDAE

Sitta carolinensis Latham White-breasted Nuthatch	2

TROGLODYTIDAE

Thryomanes bewickii (Audubon) Bewick's Wren	1

MIMIDAE

Dumetella carolinensis (Linnaeus) Catbird	8

BOMBYCILLIDAE

Bombycilla garrula (Linnaeus) Bohemian Waxwing	*

LANIIDAE

Lanius excubitor Linnaeus Northern Shrike	*

VIREONIDAE

Vireo solitarius (Wilson) Solitary Vireo	1

PARULIDAE

Vermivora ruficapilla (Wilson) Nashville Warbler	*
Dendroica occidentalis (Townsend) Hermit Warbler	5,8
Setophaga ruticella (Linnaeus) American Redstart	4

PLOCEIDAE

Passer domesticus (Linnaeus) House Sparrow	1

ICTERIDAE

Sturnella neglecta Audubon Western Meadowlark	1
Agelaius phoeniceus (Linnaeus) Redwing	1

FRINGILLIDAE

Pinicola enucleator (Linnaeus) Pine Grosbeak	4,5
Carpodacus purpureus (Gmelin) Purple Finch	1
Carpodacus mexicanus (P. L. S. Müller) House Finch	*
Spinus tristis (Linnaeus) American Goldfinch	1
Loxia leucoptera (Gmelin) White-winged Crossbill	2
Junco hyemalis (Linnaeus) Slate-colored Junco	*
Passerculus sandwichensis (Gmelin) Savannah Sparrow	1
Spizella arborea (Wilson) Tree Sparrow	*
Spizella breweri Cassin Brewer's Sparrow	*
Zonotrichia querula (Nuttall) Harris' Sparrow	*
Zonotrichia atricapilla (Gmelin) Golden-crowned Sparrow	*
Zonotrichia albicollis (Gmelin) White-throated Sparrow	*
Melospiza lincolnii (Audubon) Lincoln's Sparrow	3

Mammology

Introduction

Because of the great topographic variety in the North Cascades and the resultant numerous habitats, a diverse mammalian fauna exists. Although there are many references to the study of these mammals in other locations (Dalquest, 1948; Hall and Kelson, 1959), there are none which apply to the North Cascades of Washington. Two nearby studies are relevant and of interest. The first was by Larrison (1946) in the central Cascades of Washington. He studied three chipmunk species (*Eutamias* spp.) along a transect that ran both east and west of Snoqualmie Pass. The second study was conducted by Smith (1963, 1965) on tree squirrels (*Tamiaciurus* spp.) just north of the North Cascades Complex. More recently, an intensive blacktail-mule deer (*Dama* spp.) study has been conducted by the British Columbia Fish and Wildlife Service just north of Ross Lake (G. A. West, personal communication). Following is a brief review of the present status of the larger mammals.

1. Deer

Within the complex two species of deer occur: the blacktail deer (*Dama hemionus columbiana* [Richardson]) and the mule deer (*Dama hemionus hemionus* [Rafinesque]). The blacktail ranges from the western boundaries to the vicinity of Ross Lake and the Cascade Crest, while the mule deer is generally found east of the blacktail range. Where the ranges come together most of the deer are hybrids (G. A. West, personal communication). Deer may be found from lower elevations at all times of the year up to the highest meadows during the summer. Populations are abundant in all areas, with the greatest numbers probably occurring within the vicinity of Ross Lake. Canadian studies covering a four-mile distance just north of the border showed a spring deer population of 457 ± 100 and 355 ± 100 for the years 1967 and 1968 respectively (G. A. West, personal communication). West felt that most of these deer spent the summer-fall period in the United States or nearby Manning Provincial Park, since hunting in the area was quite unsuccessful during those two years. At the present time the deer population must be at or below an optimum level since very little sign of deer damage is seen within the complex.

2. Black Bear

The black bear (Ursus americanus Pallas) is found in a variety of habitats throughout the complex. During the winter the bear hibernates but from spring onward he is frequently seen. In the fall he may be found from high in the meadows, where he feeds on the berries of Vaccinium spp., down to the lowland rivers where his diet consists of spawning salmon (Oncorhynchus spp.) No population figures are available but from the frequent sightings it can be assumed they are abundant throughout the complex.

3. Mountain Goat

The rugged mountains of the North Cascades provide an ideal habitat for the mountain goat (Oreamnos americanus [Blainville]). Their sure-footed ability to climb the most precipitous cliffs protects all but the very young or very old goats from all predators except man. Most of the higher mountains within the complex support a goat population, but their numbers are not known.

4. Elk

There is no native population of elk (Cervus canadensis [Erxleben]) within the complex. On the western boundaries, however, elk which were originally planted in the Nooksack Rivers area have thrived and the herds are now expanding. Elk have been sighted on the Cascade River (Jerry Wood, personal communication) and have also been noted near Baker Lake. These animals are likely to occur within the complex at the upper ends of these drainages. East of the Cascade crest elk have been seen in the Stehekin Valley (Kenney, 1968).

5. Moose

The moose (Alce americana shirasi Nelson) is a non-resident but often finds his way into the complex. Moose have been sighted near the northern end of Ross Lake (Mary H. Douglas, personal communication; Jerry Wood, personal communication) and also in the Stehekin Valley (Kenney, 1968). Since very little suitable moose habitat is available in the complex it is doubtful whether any but a few sporadic "visiting" moose will be seen.

6. Grizzly Bear

At one time it was thought that the grizzly bear (Ursus horribilis Ord) might be extinct in Washington (Dalquest, 1948). In recent years, however, several have been sighted and one animal was shot near Cascade Pass (Roger J. Contor, personal communication; Jerry Wood, personal communication). The grizzly's aversion to civilization will probably make this mammal even more scarce than he is at the present time.

7. Wolverine

The wolverine (_Gulo luscus luteus_ Elliot) is an extremely rare mammal in the North Cascades. Being a boreal species, he is much more abundant in the Arctic. The wolverine has probably been rare ever since the retreat of the continental glaciers. Since each animal requires a large boreal-like range, suitable habitat is insufficient in the North Cascades to support an abundant population (Dalquest, 1948). In 1965 I sighted a wolverine near the boundary of the complex southeast of Mt. Shuksan. There have been no other reports to my knowledge within recent years.

8. Timber Wolf

The present status of the timber wolf (_Canis lupus fuscus_ Richardson) in Washington is uncertain. He may be extinct, although trappers reported a few between Lake Chelan and Mt. Baker over 20 years ago (Dalquest, 1948).

The mammal checklist which follows is based on the specimens cited in Dalquest (1948) and Hall and Kelson (1959). The animals listed include specimens collected in the complex or within 15 miles of its boundaries. Nomenclature, with a few modifications, is that of Dalquest (1948). The classification follows the treatment of Hall and Kelson (1959).

The species have been arranged by families of mammalian fauna. The habitat is numerically designated for each mammal; the numbers are defined as follows.

1. Western Hemlock Forest Type (streams and lakes)
2. Western Hemlock Forest Type (forest)
3. Pacific Silver Fir Forest Type (streams and lakes)
4. Pacific Silver Fir Forest Type (forest)
5. Subalpine - Alpine Zones
6. Engelmann Spruce - Alpine Fir Forest Type (streams and lakes)
7. Engelmann Spruce - Alpine Fir Forest Type (forest)
8. Grand Fir - Douglas-fir Forest Type (streams and lakes)
9. Grand Fir - Douglas-fir Forest Type (forest)

Mammal Checklist

SORICIDAE

Sorex cinereus Kerr Cinerous Shrew	2,4
Sorex vagrans Baird Wandering Shrew	1,3
Sorex palustris navigator (Baird) Mountain Water Shrew	3,5
Sorex bendirii (Merriam) Bendire Water Shrew	1,3
Sorex trowbridgii Baird Trowbridge Shrew	2,4,5

TALPIDAE

Neürotrichus gibbsii (Baird) Gibb's Shrew-mole	1,3,5
Scapanus townsendii (Bachman) Townsend's mole	2
Scapanus orarius True Coast Mole	2,4

VESPERTILIONIDAE

Myotis lucifugus (Le Conte) Big Myotis

Myotis yumanensis (H. Allen) Yuma Myotis

Myotis evotis (H. Allen) Long-eared Myotis

Myotis californicus (Audubon and Bachman) California Myotis

Lasionycteris noctivagans (Le Conte) Silver-haired Bat

Eptesicus fuscus bernardinus Rhoads Big Brown-bat

Lasiurus borealis teliotis (H. Allen) Red Bat

Lasiurus cinereus cinereus (Beauvois) Hoary Bat

Corynorhinus rafinesquii (Lesson) Long-eared Bat

OCHOTONIDAE

Ochotona princeps (Richardson) Pika	5

LEPORIDAE

Lepus americanus Erxleben Snowshoe Rabbit	2,4,5

APLODONTIDAE

Aplodontia rufa (Rafinesque) Mountain Beaver	2,4

SCIURIDAE

Tamias amoenus Allen Yellow-pine Chipmunk	9
Eutamias townsendii Bachman Townsend's Chipmunk	2,4

Marmota flaviventris avara (Bangs) Yellow-bellied Marmot	5
Marmota caligata cascadensis Howell Hoary Marmot	5
Citellus saturatus (Rhoads) Golden-mantled Ground Squirrel	7,9
Tamiasciurus hudsonicus (Erxleben) Red Squirrel	2,4
Tamiasciurus douglasii douglasii (Bachman) Douglas' Squirrel	2,4
Glaucomys sabrinus (Shaw) Northern Flying Squirrel	2

CASTORIDAE

Castor canadensis Kuhl Beaver	1,3

CRICETIDAE

Peromyscus maniculatus (Wagner) Deer Mouse	2,4,5
Neotoma cinerea Ord Bushy-tailed Wood Rat	4,5
Clethrionomys gapperi (Vigors) Gapper Red-backed Mouse	5
Clethrionomys californicus occidentalis (Merriam) Western Red-backed Mouse	2
Phenacomys intermedius Merriam Heather Vole	5
Microtus townsendii (Bachman) Townsend's Meadow Mouse	1
Microtus longicaudus (Merriam) Long-tailed Meadow Mouse	2,4,5
Microtus richardsoni (De Kay) Water Rat	5
Microtus oregoni oregoni (Bachman) Creeping Mouse	1,2,3,4,5
Ondatra zibethicus (Linnaeus) Muskrat	1
Synaptomys borealis wrangeli Merriam Northern Lemming Mouse	5
Zapus princeps Allen Big Jumping Mouse	1

ERETHIZONTOIDEA

Erethizon dorsatum (Linnaeus) Porcupine	2,4

CANIDAE

Canis latrans lestes Say Coyote	2,4,5
Canis lupus fuscus Richardson Timber Wolf	
Vulpes fulva cascadensis Merriam Red Fox	5

URSIDAE

Ursus americanus Pallas Black Bear	1,2,4
Ursus horribilis Ord Grizzly Bear	4

PROCYONIDAE

Procyon lotor (Linnaeus)	Raccoon	2,4

MUSTELIDAE

Martes americana Merriam	Western Marten	4,5
Martes pennanti (Erxleben)	Fisher	2,4
Mustela erminea Linnaeus	Ermine	2,4
Mustela frenata Lichtenstein	Long-tailed Weasel	2,4
Mustela vison energumenos (Bangs)	Mink	1
Gulo luscus luteus Elliot	Wolverine	5
Spilogale gracilis Merriam	Spotted Skunk	2
Mephitis mephitis (Schreber)	Striped Skunk	2
Lutra canadensis (Schreber)	River Otter	1

FELIDAE

Felis concolor Linnaeus	Cougar	2,4,5
Lynx canadensis canadensis Kerr	Canadian Lynx	5
Lynx rufus (Schreber)	Bobcat	2,4

CERVIDAE

Cervus canadensis (Erxleben)	Elk	1,2
Alces alces shirasi Nelson	Moose	1
Dama hemionus columbiana (Richardson)	Black-tailed Deer	2,4,5
Dama hemionus hemionus (Rafinesque)	Mule Deer	7,9

BOVIDAE

Oreamnos americanus (Blainville)	Mountain Goat	5

Limnology

Introduction

One of the greatest assets of the North Cascades Complex is the great number of alpine lakes. These glacial cirque lakes, generally found above 2500 feet, are visited only infrequently by those few who manage to penetrate the highly inaccessable areas where the lakes are located.

Limnological studies have never been undertaken in the North Cascades. There is, however, limited data on fish plantings made by the Washington State Department of Game and various high lake fishing groups, along with scattered reports sent in by high lake fishermen to the Game Department. These infrequent reports and the lack of research have resulted in an inadequate alpine lake management program. In most cases the biological and chemical properties of the lakes are unknown and stocking is undertaken only if a lake is barren or becoming depleted.

The fish must adapt to a harsh environment, for the high altitudes ensure that the lakes are frozen for the greater part of the year (see figure 15). Generally the lakes open up in July and remain open till near the beginning of October. Occasionally, after a winter of exceptionally heavy snowpack, the lakes at the highest elevations will remain frozen all summer.

Five species of fish now inhabit the alpine lakes of the complex: rainbow trout (<u>Salmo gairdnerii gairdnerii</u> Richardson), cutthroat trout (<u>Salmo clarkii clarkii</u> Richardson), Montana black-spotted trout (<u>Salmo clarkii lewisi</u> [Girard]), California golden trout (<u>Salmo aqua-bonita</u>

Figure 15. Copper Lake in the north unit of the North Cascades National Park. Aug.16, 1967; elevation, 5250 feet.

roosevelti Evermann) and eastern brook trout (Salvelinus fontinalis [Mitchill]). Almost all fish fry which are presently being aerially planted in the lakes are cutthroat trout from eastern Washington. This strain of fish is the only one small enough for planting at the time the lakes are open (Lewis Lund, personal communication). The fishes' ability to reproduce and their rates of growth vary considerably from lake to lake. Robertson (1947), working in the alpine lakes of the Rockies, felt that food supply was the main factor effecting growth rates, but also speculated that the chemical composition of the water may be of importance.

The following list presents lake location, size, planting date (with species planted) and reports of high lake fishermen. The names, locations and surface areas of the lakes are taken from Woolcott (1964, 1965). The planting information, which is incomplete because of the lack of data at this time, was provided by the Washington State Game Department (personal communication). The information on fish caught in the high lakes of the complex was provided by the Game Department (personal communication), Carl Gardner (personal communication) and my own data.

Each section has been alphabetically subdivided into sixteenths to designate locations within the section, as follows.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Abbreviations used for the fish species are:

Rainbow trout	-	RB
Cutthroat trout	-	CT
Montana black-spotted trout	-	MBS
California golden trout	-	GT
Eastern brook trout	-	EB

List of alpine lakes

NORTH CASCADES NATIONAL PARK

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed	40	10	3 R	5100	16.0	E	-	-
Copper	40	10	25 N/P	5250	8.0	E	MBS-39 EB-57 CT-60	MBS-64 (2 lb.) CT-67 (8")
Unnamed	40	11	12 B	5300	14.0	NE	-	-
Unnamed	40	11	15 K	5100	1.0	N	-	-
Bear	40	11	24 B	5800	23.0	W	-	-
Unnamed	40	12	30 M	6550	5.0	SW	-	-
Hanging	41	10	36 E/F	4550	74.0 (in U.S.)	N	-	-
Silver (Glacier)	41	12	34 Q	6700	164.0	E	GT-61	-
Egg	39	10	3 G/H	5260	2.0	N	-	-
Unnamed	39	10	21 D	5360	2.0	E	-	-
Unnamed	39	10	33 G	4100	3.0	S	-	-
East(upper)	39	11	2 K	5600	2.0	SE	-	-
Tiny	39	11	2 N	6100	.2	SE	-	-
East(lower)	39	11	2 Q/R	5500	7.5	S	-	-
Revielle #1	39	11	3 E	5000	4.0	NE	-	-
Revielle #2	39	11	3 E	5000	3.0	NE	-	-
Tapto #1	39	11	9 A/H	5750	10.0	S	-	-
Tapto #2	39	11	9 A/H	5750	.5	S	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Tapto #3	39	11	9 A/H	5750	.2	S	-	-
Tapto #4	39	11	9 A/H	5750	2.0	S	-	-
Middle(lower)	39	11	10 A	5600	2.5	SE	-	-
Middle(upper)	39	11	10 B	5700	4.0	SE	-	-
Unnamed	39	11	13 F	5360	1.0	NE	-	-
Unnamed	39	11	13 L/M	5250	3.0	NW	-	-
Unnamed	39	11	19 D	5500	2.0	S	-	-
Wiley	39	11	24 B	6650	6.0	N	-	-
Unnamed	39	11	25 R	3640	4.5	NE	-	-
Price	39	9	23 D	3895	40.0	NW	-	-
Unnamed	39	12	1 P	5200	2.0	N	-	-
Unnamed	39	12	12 J	5000	1.0	SE	-	-
Riley	39	12	18 M/N	6500	2.5	SE	-	-
Luna	39	12	31 F	4900	17.0	N	-	-
Noname	39	13	21 H/J	3900	10.0	NE	RB-47	RB -68
Skymo	39	13	27 W	4500	22.5	NE	-	-
Unnamed	39	13	30 J	5600	9.0	S	-	-
Blum #1	38	10	22 N	5900	3.0	W	-	-
Blum #2	38	10	27 D/E	5660	3.0	W	-	-
Blum #3	38	10	27 L/M	5000	14.0	W	GT-60	-
Blum #4	38	10	27 M	4950	7.0	W	EB	-
Unnamed	38	10	25 R	4880	1.5	N	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed	38	11	10 M/N	4880	11.4	SE	-	-
Unnamed	38	12	11 Q	6000	3.0	SE	-	-
Azure	38	12	21 N	4200	89.0	E	GT-61?	RB-65 (9")
Sourdough	38	13	21 N/P	4400	33.4	NW	-	EB-66 (10")
Sulphide	38	9	1 N	3800	16.0	SE	-	-
Unnamed	37	10	1 M	5200	2.0	E	-	-
Unnamed	37	10	2 C	5020	16.0	S	-	-
Ipsoot	37	10	8 C/D	4500	9.0	N	RB-51	CT-68
Unnamed	37	10	10 C/D	5350	1.5	SE	-	-
Unnamed	37	10	10 M	4550	2.5	SE	-	-
Unnamed	37	10	11 E/M	4470	8.0	W	-	-
Berdeen	37	10	11 F	5000	127.0	S	RB-46 CT-67	CT-68 (11", 16")
Green	37	10	15 E	4300	80.1	N	RB-46 CT-67	RB, CT-68 (12")
Unnamed	37	10	21 A/B	4850	2.5	E	-	-
Unnamed	37	10	26 K	3800	4.0	N	-	-
Diobsud (west)	37	10	31 J	4490	2.0	S	-	-
Diobsud (middle)	37	10	32 M	4475	3.5	S	CT-60	MBS-65
Diobsud (east)	37	10	32 P	4075	2.5	S	-	MBS-65
Mt. Triumph #1	37	11	3 E	3950	5.0	E	-	-
Mt. Triumph #2	37	11	3 N	4800	9.0	NE	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed #1	37	11	4 A	4800	1.5	SE	-	-
Unnamed #2	37	11	4 A	5100	2.5	SE	-	-
Unnamed	37	11	9 B	5650	1.0	S	-	-
Thornton (middle)	37	11	14 K/L	4680	11.0	SE	RB,GT CT-53	GT-67 (9") RB-65
Thornton (upper)	37	11	14 M	5040	31.0	SE	CT-68	RB-65
Thornton (lower)	37	11	23 A	4450	56.0	S	RB-45 CT-52	CT-67 (2 lb.)
Triumph	37	11	21 E	3650	4.0	N	-	-
Unnamed	37	13	19 C	5200	3.5	W	-	-
Unnamed	36	12	13 H	5200	1.5	N	-	-
Unnamed	36	12	13 L	5200	2.5	N	-	-
Unnamed	36	12	23 H/J	5150	1.5	NW	-	-
Stout	36	12	24 E/M	5200	24.0	W	CT-53	-
Unnamed	36	12	26 J	5400	4.0	NW	-	-
Monogram	36	12	32 N/P	4850	28.0	SW	MBS-49 CT-61,64	CT-68 (12")
Intermittent	36	13	7 G	5600	2.0	NW	-	-
Unnamed	36	13	8 N	5000	4.0	SE	-	-
Unnamed	36	13	18 N	5400	4.5	N	-	-
Unnamed	36	13	18 N/P	5400	11.0	N	-	-
Unnamed	36	13	21 M/N	5200	11.0	N	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed	36	13	21 P	5400	15.0	N	-	-
Unnamed	36	14	13 N	5600	10.5	N	-	-
Unnamed	36	14	24 E	6000	3.0	N	-	-
Unnamed	36	14	34 M	4600	1.0	N	-	-
Unnamed	36	14	35 F	5200	9.0	N	-	-
Unnamed	35	12	24 K	6000	5.0	N	-	-
Hidden	35	12	25 N	6000	55.0	SE	-	RB-68 (12")
Unnamed	35	13	2 Q	5200	2.0	N	-	-
Moraine	35	13	11 S	4500	52.0	E	-	-
Unnamed	35	14	2 F/L	6200	?	N	-	-
Unnamed	35	14	17 M	4900	4.0	N	-	-
Unnamed	35	16	9 A	5000	6.0	NW	-	-
Doubtful	35	14	31 K	5385	29.9	SE	CT-50	-
Silent (upper)	35	16	11 SW	6975	3.2	S	-	-
Silent (lower)	35	16	11 SW	6700	3.0	S	-	-
Unnamed	35	16	17 P	5800	1.5	SE	-	-
Unnamed	35	16	26 Q	5630	2.2	N	-	-
Last Chance	35	16	36 A	6230	1.4	SE	-	-
[illegible]lton	34	14	6 J/K	4570	4.3	NW	-	-
[illegible]apper	34	14	9 R	4165	146.9	E	CT	
[illegible]een View	34	16	8 B/C	5455	40.4	E	-	-
[illegible]ddell	34	16	24 D	4932	10.3	N	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed	34	16	24 M	5385	1.9	NW	-	-
Unnamed	34	16	24 N	6102	1.8	N	-	-
Unnamed	34	17	15 M	5600	3.5	N	-	-
Kettling	34	17	16 H	5500	10.3	N	-	-
Dagger	34	18	7 B/C	5500	10.6	W	MBS-34	MBS-53, 58
Stiletto	34	18	6 C	6800	9.3	S	-	-
Unnamed	34	18	5 N/P	6000	2.5	W	-	-
ROSS LAKE NATIONAL RECREATION AREA								
Hozomeen	40	14	7 L	2800	111.0	N	EB,CT	EB-68 (12") RB-68 (11")
Ridley	40	14	18 Q/K	3000	14.0	W	-	-
Willow	40	14	20 N	2900	27.0	E	CT-58	-
Bouck	37	12	13 P/Q	4000	14.2	N	-	CT-65 (10")
LAKE CHELAN NATIONAL RECREATION AREA								
Unnamed	34	17	22 G	5800	4.8	NE	-	-
McAlester	34	17	24 K/Q	5500	15.3	NW	RB-42 CT-41,60	-
Unnamed	34	17	25 M	6000	2.6	S	-	-
Intermittent	34	17	28 K	5300	6.0	NW	-	-
Rainbow (lower)	34	17	33 K	5500	12.4	SE	-	-
Rainbow (upper)	34	17	33 L/M	6000	4.0	E	-	-

List of alpine lakes (cont.)

Lake	Township N	Range E	Section	Elevation (feet)	Size (acres)	Aspect	Planting Date and Species	Reports
Unnamed	34	17	34 A	5800	2.4	S	-	-
Unnamed	34	18	31 G/H	6300	11.4	N	-	-
Unnamed	33	16	24 J	6271	1.0	NE	-	-
Battalion	33	17	19 F/L	5334	6.4	E	-	-
Unnamed	33	18	6 E	6000	4.4	NW	-	-
Unnamed	33	18	34 B	6800	1.5	S	-	-
Triplet #1	32	18	11 A/H	6100	3.0	NW	-	-
Triplet #2 & #3	32	18	11 A/H	6300	4.0	NW	-	-

MANAGEMENT AND RESEARCH RECOMMENDATIONS

In facilitating the purposes and objectives of the National Park system a sound management program must be established. If this program is to be adequate it must be based on a thorough knowledge of the natural biotic systems. The lack of information pertaining to the North Cascades National Park is quite evident throughout this survey. Since excellent general research and management recommendations have been presented by Leopold *et al* (1963), only a few of the specific problems that may arise within the North Cascades National Park in the near future will be discussed here. Many other problems will undoubtedly appear as soon as experts from various fields become acquainted with conditions within the park ecosystem.

The National Recreation Areas will not be considered separately in this section since most of my recommendations for the National Park would also be applicable to them. My only additional recommendation for the Recreation Areas is in reference to logging. Much of the two areas seems unsuitable for conventional clearcut logging. If logging is undertaken, it should be restricted to those areas where desirable reproduction may be rapidly established or is already present, or perhaps where selection or shelterwood systems are feasible.

Because of the inaccessability of the North Cascades National Park, its ecosystems are fortunately still in a relatively natural condition. Commercial grazing, which was widespread in most of the national parks before they entered the park system (Leopold *et al*, 1963), was found to be unsuccessful except near the Cascade crest in the North Cascades National Park (Fred Bryson, personal communication). The mountains of the north unit and much of the south unit were comparatively isolated, and in the several years that grazing was attempted, too many sheep were lost in getting them to the meadows (Fred Bryson, personal communication). Because access was easier from the eastern slopes of the Cascade Range, the alpine meadows near the crest were used by sheep until 1940, and still show signs of destructive grazing (Thornburgh, 1962).

Since the vegetation (especially at high elevations) and the soils are extremely delicate, the use of pack animals often results in devastation. The poor condition of some of the existing trails with which the foot traveller must contend is further indication of the alienism of pack animals in the wetter western part of the park. When the animals are released in the meadows it takes very little time for just a few to disturb the area for that season and possibly the next. Several such instances during a season may cause the biotic communities to be permanently damaged or at least altered for many years.

The use of pack animals, especially in the north unit of the park, should be approached with caution. If pack animals are used they should carry their own feed. At campsites they sould be restricted to enclosures provided for them by the park. Packers should use only those sites equipped with these enclosures. A similar system has met with some success in the U. S. National Forests of Idaho (Carl Gardner, personal communication).

The pressure of frequent human use may also cause meadow damage, and it would be advisable to limit trails to the continuous forests as much as possible. When a high viewpoint is desirable the trails should be constructed through rocky terrain if possible rather than through the easily destructible meadows.

Disturbance has not yet been widespread since only a few trails traverse the park or lead to lakes and lookouts. Areas showing damage are presently limited to such easy access areas as Cascade Pass and the Thornton Lakes.

When a primitive area such as the North Cascades National Park begins to feel the impact of man, the elimination of native plant species and introduction of exotics usually takes place. At this time very few exotics are inhabitants of the National Park and most or all of these are found along the trails where disturbance has occurred. Although not desirable, such introduced plants are not a threat in pioneer roles but would be if they assumed a climax role (David R. M. Scott, personal communication). A careful watch should be kept for potential climax exotics. An example would be Trifolium repens which has been noted growing along the trails and in nearby meadows just west of the park. With respect to native plants, none are known to have been eliminated or endangered as yet within the park boundaries.

Very little research has been conducted which deals with disturbance problems (Thornburgh, 1962; Arno, 1966) except for the studies by Thornburgh (1962) at Image Lake about 13 miles south of the National Park. Thornburgh found, after doing a soil and vegetation study in the Subalpine Zone, that the trampling of man and his pack animals caused denudation or a vegetational change in the meadows and that recovery of the vegetation was extremely slow. He suggested that the exclusion of pack animals might prevent further deterioration.

The management problems which will result from high density visitor use in the Subalpine Zone should receive immediate attention. Study plots should be established in presently disturbed areas and potential damage areas, as well as in control areas. These control areas might be set up as Natural Areas reserved solely for research. These research preservations, of which several are needed because of the diverse and unique habitats within the park, should be located away from potential visitor areas. Long-term study programs for both ecologic education and continuous research may be conducted in these Natural Areas. This research may also aid in the development of a comprehensive interpretation of the natural biotic systems. Urgent applied research could be conducted in these preserves. An example of this might be developmental techniques for high-altitude plant propagation for the re-establishment of vegetation on denuded areas.

The need for a biological protection program has been noted in most of the national parks. Insects, diseases and animals often threaten the continued existence of a desired environment and therefore require control or elimination. The status of insects and diseases within the park is not fully known at this time. There are, however, some that are known to exist in nearby areas that should be of immediate concern because of their possible introduction into the park. An example of this is the balsam woolly aphid (*Chermes piceae* [Ratzeburg]) which has recently been noted on Mt. Rainier and in a localized area about 40 miles north of there (Franklin and Mitchell, 1967). This insect, which attacks the true firs, is most damaging to alpine fir in the Pacific Northwest (Mitchell, 1966). As there is no control as yet for this insect, this would be a potential area for research. There may be effective control methods in existence which, although previously rejected by various concerns for economic reasons, should now be reconsidered in the light of the policies and objectives of the National Park Service (Charles H. Driver, personal communication).

The excess populations of ungulates, a problem in many parks, does not seem to be an immediate problem in the North Cascades National Park. Hunting pressure has always been light within the park boundaries due to inaccessibility. The ungulates, in the absence of evidence of browse damage, would appear to be self-regulating. The study of the ecology of these animals should not be delayed, however, since problems may arise at any time. The status of the timber wolf and, if extinct, the possibility of his re-introduction should also be studied.

The many alpine lakes which are well known for their majestic beauty and challenging fishing should be managed in a manner which will maintain these goals. The present stocking program should be continued only after limnological research provides the information needed for adequate management of previously planted lakes. This study should consider the fish population that can be supported by a given lake. Since most of these lakes are relatively small the fish populations cannot be maintained if easy access is available. As these lakes also serve as campsites, the indiscriminate use of axes (which are unnecessary in the high country) and fire can soon mar and permanently damage the fragile communities surrounding the lakes. Wood for fires should come from smaller downed dead trees and the larger material should not be disturbed. This large material constitutes a microhabitat, and may be an important part of the natural biotic community.

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