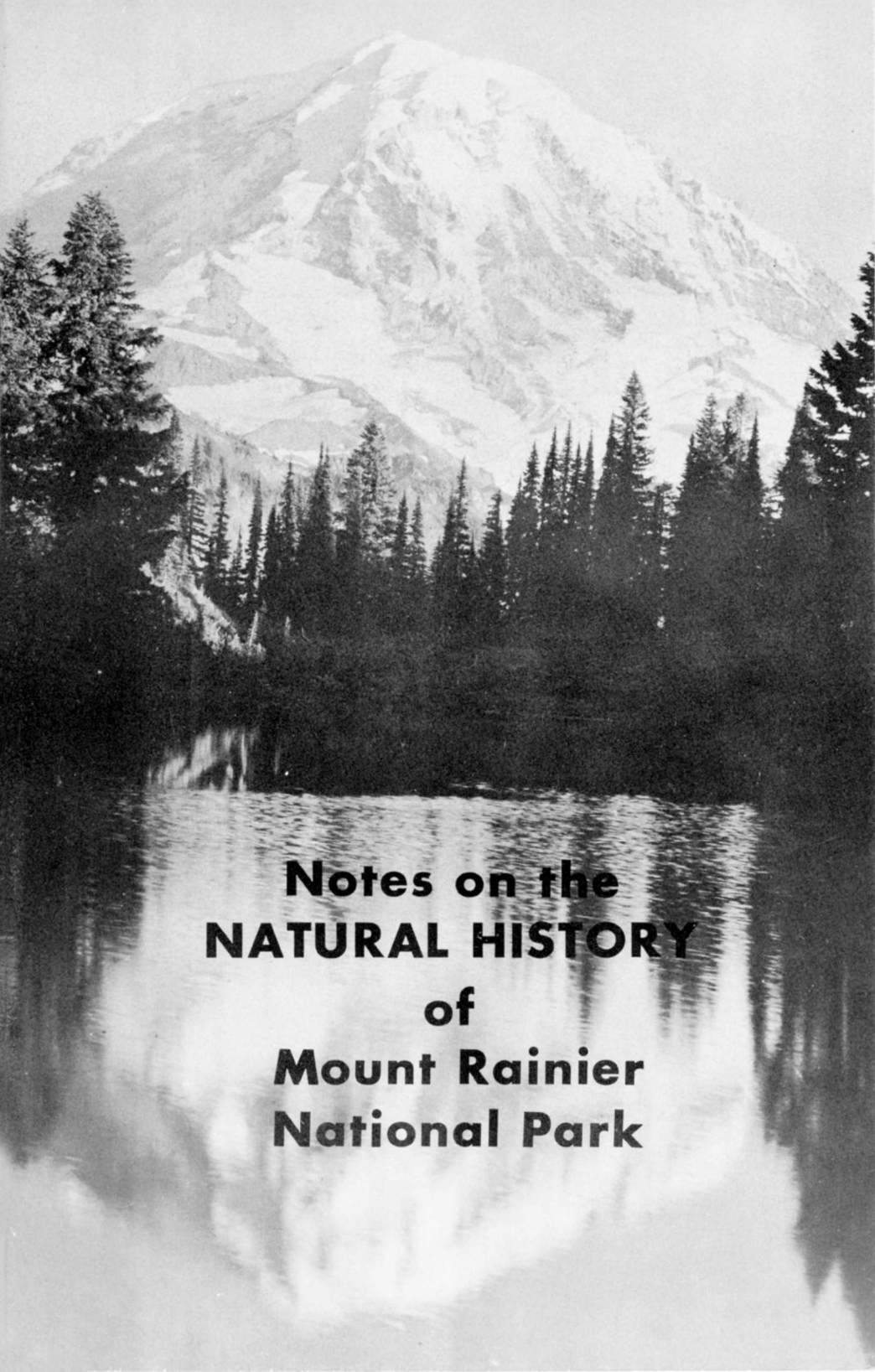


Notes on the NATURAL HISTORY of Mount Rainier National Park

Notes on the NATURAL HISTORY of Mount Rainier National Park

by

Jerry F. Franklin
Principal Plant Ecologist
Pacific Northwest Forest and Range Experiment Station
United States Department of Agriculture
Forest Service

and

Norman A. Bishop
Chief Park Naturalist
Mount Rainier National Park
United States Department of Interior
National Park Service

Published by
Mount Rainier Natural History Association

Cover
Eunice Lake reflects Mount Rainier, ". . . an arctic island in a temperate zone."
National Park Service

Contents

Introduction

These notes were assembled to give the leader and members of visiting groups easy access to some basic facts on the natural history of Mount Rainier National Park. We hope that they will expand your understanding and appreciation of some of the park's features.

We have left to you the responsibility of discovering the interrelationships of the features and phenomena listed in this guide. You may observe, as John Muir did, that: "When we try to pick out anything by itself, we find it hitched to everything else in the universe."

Plants, animals or rocks for exhibit or research my be collected only under permit by members of public museums or scientific or educational institutions. Application for permission to collect must be made to the Superintendent, Mount Rainier National Park, Longmire, Washington 98397.

Climate

The climate of Mount Rainier National Park is cool and moist. Annual precipitation is heavy, ranging from about 60 inches (1.53m) at lowest elevations to over 100 inches (2.54m) in the subalpine regions. Southwesterly winds bear much of the moisture, so a rain shadow occurs on the northeast side of the park in the Sunrise Ridge-White River area. Over 90 percent of the precipitation falls between November and April. Much of the winter precipitation is snow that accumulates into snowpacks 20 to 25 feet (6-7.5m) deep at higher elevations. At Paradise, the average annual snowfall is about 50 feet (15m); the greatest snow depth recorded for the United States was at Paradise—30 feet 7 inches (9.2m) on the ground in mid-March of 1956.

Winter temperatures are relatively warm (mean Januarv temperatures of about 25° to 30° F or -4° to -1° C.) Summers tend to be cool (mean Julv temperatures of 50° to 60° F or 10° to 15° C) and extended periods of cloudiness are not uncommon. Fog and high winds may be expected any day of the year. Yet summer days may me as warm as 95° F (35° C) at Longmire.

Geology

The Ohanapecosh, Stevens Ridge and Fifes Peak formations were deposited as thick beds of lavas and other epiclastic and pyroclastic rocks in Eocene, Oligocene, and early Miocene times (Fiske, Hopkins, and Waters 1963)[1]. The Ohanapecosh, the earliest formation, is composed of basaltic andesite lava flows, rhyolite, breccias and

[1] References listed on page 22.

other volcanic materials; it is more than 10,000 feet (3,300m) thick. At least 5,000 feet (1,500m) of additional other Tertiary formations overlie it. Volcanic activity continued during the Miocene and Pliocene epochs, but plutonic masses (rocks such as granidiorite) were occasionally intruded. Warping of the earth's crust resulted in folding and upwarping of the earlier volcanic beds and elevated the Cascade Range. By the late Pliocene the "foundation" of the mountain was complete.

Beginning about 1,000,000 years ago, building of Mount Rainier volcano began. Flow after flow of andesitic magma filled the valleys and built the mountain peak. Explosive showers of ash, cinders and other pyroclastic materials as well as mudflows played a role. At one time, near the end of the Pleistocene, the cone was nearly 1,000 feet (330m) higher and had nearly half again as much volume as at present. Several gigantic debris flows 5,000 and 3,500 years ago removed much of the former summit. These may have been triggered by steam explosions.

The volcano has continued to erupt to recent times; the last big eruption spread pumice over the northeast flanks of the volcano 2,000 years ago. A small eruption occurred between 1820 and 1854 (Mullineaux et al, 1969), and a steam explosion may have set a series of major rockfalls into motion as recently as 1963 (Crandell and Fahnestock, 1965).

Glaciers have also played an important role in the shaping of the mountain.

Vegetational Zones

Of the Cascade Mountain areas studied to date, Mount Rainier is the richest in flora (Cooke, 1962). A total of about 700 vascular plant taxa have been collected in the park (Jones, 1938). These are divided among the various life forms as follows:

Life Form	Percent of Flora
Phanerophytes (aerial buds, at least 25 cm above ground)	12
Chamaephytes (buds above surface, protected by snow or litter)	8
Hemicryptophytes (buds at soil surface)	51
Oryptophytes (buds buried in soil or under water)	18
Therophytes (overwinter as seeds-annuals or biennials)	9

Among the flowering plants, some 64 families are represented: 84 composites (Compositae); 69 grasses (Gramineae); 39 roses (Rosaceae); 38 heaths (Ericaceae); 36 saxifrages (Saxifragaceae); 37 figworts or snapdgragons (Scrophulariaceae); 27 mustards (Cruci-

ferae); 29 pinks (Caryophyllaceae); 21 lilies (Liliaceae); 16 buttercups (Ranunculaceae); 16 rushes (Juncaceae); and 16 pines (Pinaceae). There are also many mosses, lichens, and liverworts. Bodenberg (1939) identified 133 moss taxa within the park.

In mountainous areas such as Mount Rainier National Park there is a general elevational gradient in climate. The biotic communities tend to be uniform over large parts of the gradient. We can describe these as belts or zones on mountain slopes. Our discussion of park flora and communities is based on a zonal scheme proposed by Franklin and Dyrness (1969) based on climax plant species. Four of their vegetational zones are present in the park: **Tsuga heterophylla** (western hemlock), **Abies amabilis** (Pacific silver fir), **Tsuga mertensiana** (mountain hemlock), and Alpine. The general elevational range for these zones and their relation to Merriam's Life Zones, which are also widely used in this region (Brockman 1949), is shown in Table 1.

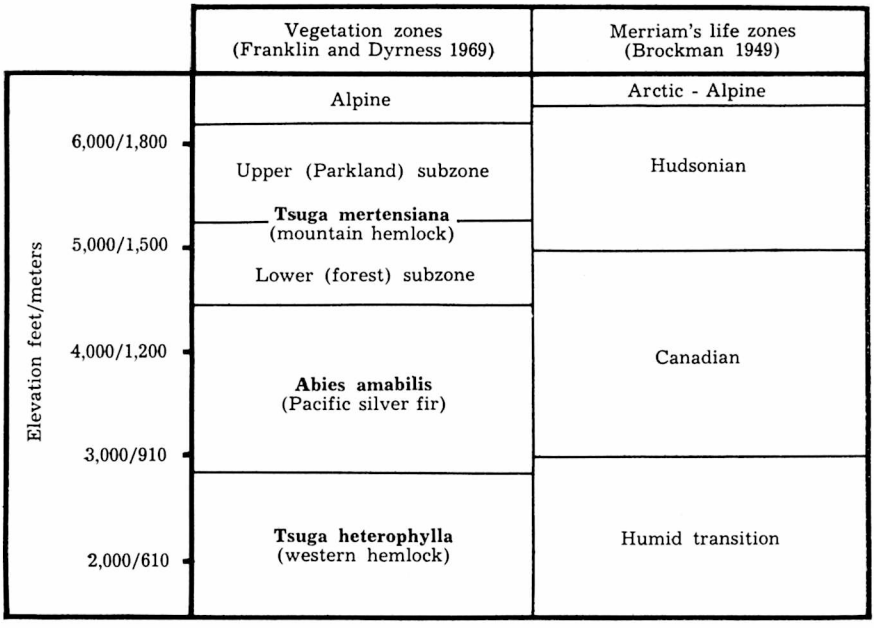


Table 1. Vegetation and life zones in Mount Rainier National Park (elevations of the **Abies amabilis, Tsuga mertensiana,** and Alpine Zones are about 1,000 feet higher in the Sunrise Ridge area on the northeastern slopes of the mountain)

TSUGA HETEROPHYLLA (Western Hemlock) Zone

The dense, old-growth forests of the **Tsuga heterophylla** Zone are among the most impressive in the world. These stands of Douglas-fir,**(Pseudotsuga menziesii)**, western hemlock, and western red-cedar **(Thuja plicata)** are often composed of trees that tower 250 feet (76m) or more and reach diameters of 80 to 100 inches (2.02 to 2.54m) at breast height. (fig 1). Other typical forest species are: Pacific yew **(Taxus brevifolia)**, vine maple **(Acer circinatum)**, Oregon grape **(Berberis nervosa)**, salal **(Gaultheria shallon)**, red huckleberry **(Vaccinium parvifolium)**, blackberry **(Rubus ursinus)**, twinflower **(Linnaea borealis** var. **longiflora)**, trillium **(Trillium ovatum)**, trail plant **(Adenocaulon bicolor)**, and western sword fern **(Polystichum munitum)**. Red alder **(Alnus rubra)**, bigleaf maple **(Acer macrophyllum)** and grand fir **(Abies grandis)** are common along streams. A lush growth of ferns and angiosperms, lady fern **(Athyrium filix-femina)**, devils club **(Oplopanax horridum)**, deer fern **(Struthiopteris spicant)**, Dryopteris sp., and coolwort **(Tiarella trifoliata)**, characterize moist sites.

Low-elevation entrance roads, e.g. around the Nisqually and Ohanapecosh entrances, provide excellent opportunities to view old-growth forests of this zone. The Federated Forest State Park along the White River also provides some fine examples of these temperate forests. Much of the zone outside the park was logged or burned during the last 150 years and is now occupied by young seral forests dominated by Douglas-fir. These would be gradually replaced if undisturbed, by climax forests of western hemlock.

Within Mount Rainier National Park the forests of the **Tsuga heterophylla** Zone (and the other zones as well) are preserved as a living museum, in which the exhibits change with the seasons and the ages. Outside of the park much of the zone is utilized for sustained yield of commercial forest products. On the adjacent Gifford Pinchot and Snoqualmie National Forests mature forests are usually clearcut in small 30- to 50-acre patches. These are planted or seeded to Douglas-fir and other trees. On some private lands, such as Weyerhaeuser Company's tree farm along the White River, progressive clearcutting is practiced. These cutover areas are also planted or seeded to produce sustained timber crops.

ABIES AMABILIS (Pacific Silver Fir) Zone

The **Abies amabilis** Zone is the most extensive forested zone in Mount Rainier National Park. The somber forests of this zone are a blend of elements from the lower elevation temperate and higher subalpine regions. Pacific silver fir **(Abies amabilis)**, noble fir **(Abies procera)**, western white pine **(Pinus monticola)**, western hemlock, and Douglas-fir are the most common tree species. Engel-

Bob and Ira Spring

Fig. 1: Giant western redcedars and western hemlocks stand in the Grove of the Patriarchs on the Ohanapecosh River at 2,200 feet (670 m).

mann spruce **(Picea engelmannii)** is also common on the lower slopes and in the valleys of the White River drainage. Typical understory plants include Alaska huckleberry **(Vaccinium alaskaense)**, over-leaved huckleberry **(V. ovalifolium)**, thin-leaved huckleberry **(V. membranaceum)**, bunchberry dogwood **(Cornus canadensis)**, single-flowered clintonia **(Clintonia uniflora)**, beargrass **(Xerophyllum tenax)**, prince's pine **(Chimaphila umbellata)**, one-sided wintergreen **(Pyrola secunda)**, vanilla-leaf **(Achlys triphylla)**, twinflofer, Oregon grape, and the moss, **Rhytidiopsis robusta.**

Fine examples of the forests of the **Abies amabilis** Zone, including successional[2] stages as well as climax[3] stands, can be found along the major roads and trails of the park. Stands on Backbone Ridge and the slopes of Sunrise Ridge illustrate the highly variable composition of the younger seral[4] stands. Two highly tolerant species, Pacific silver fir and western hemlock, compete for climx status. Pacific silver fir is by far the more successful in this struggle.

TSUGA MERTENSIANA (Mountain Hemlock) Zone

Above about the 4,500-foot (1475m) elevation mountain hemlock **(Tsuga mertensiana)** becomes a forest dominant. Other typical tree species in the **Tsuga mertensiana** Zone are Pacific silver fir, subalpine fir **(Abies lasiocarpa)**, Alaska-cedar **(Chamaecyparis nootkatensis)**, whitebark pine **(Pinus albicaulis)** and Engelmann spruce **(Picea engelmannii)**. This zone can be divided into two segments, a lower subzone of continuous closed forest and an upper parkland subzone which is a mosaic of forest patches, tree groups, and subalpine meadows (fig. 2). Typical forest understory plants are beargrass, thin-leaved huckleberry, avalanche lily **(Erythronium montanum)**, dwarf bramble **(Rubus lasiococcus)**, Sitka valerian **(Valeriana sitchensis)**, and broad-leaved arnica **(Arnica latifolia)**. Forests on wet, cool sites have a dense, tangled understory of shrubs such as Alaska and oval-leaved huckleberry, Cascades azalea **(Rhododendron albiflorum)**, and rusty menziesia **(Menziesia ferruginea)**.

The extensive meadows of the parkland subzone are one of the outstanding features of the park, rich in abundant and vividly colored wildflowers. Because of the short, intense growing season great masses of flowers bloom at one time. Usually meadows are at their peak of color and variety in late July and early August. Some of the more common meadow plants are avalanche lily,

[2] sequential changes of species in a plant community growing on a site as conditions change

[3] stable community in balance with the local environment

[4] in the process of change or succession

USDA Forest Service

Fig. 2: Scattered groups of subalpine fir and whitebark pine among subalpine meadow of fescue and lupine on Sunrise Ridge at 6,400 feet (1950 m).

glacier lily **(Erythronium grandiflorum)**, western anemone or pasqueflower **(Anemone occidentalis)**, red heather **(Phyllodoce empetriformis)**, white heather **(Cassiope mertensiana)**, purple aster **(Aster ledophyllus)**, mountain phlox **(Phlox diffusa)**, lupines **(Lupinus spp.)**, paintedcups **(Castilleja spp.)**, monkeyflowers **(Mimulus spp.)**, blue gentian **(Gentiana calycosa)**, bistort **(Polygonum bistortoides)**, cinquefoil **(Potentilla flabellifolia)**, Sitka valerian, Alaska spireaea **(Luetkea pectinata)**, and louseworts **(Pedicularis spp.)**.

The **Tsuga mertensiana** Zone, particularly the parkland subzone, can be easily viewed along the higher roads and trails of Mount Rainier National Park. Two favorite locations are Paradise and Sunrise.

Alpine Zone

The parkland subzone of the **Tsuga mertensiana** Zone grades gradually into the Alpine Zone. Krummholz ("crooked wood") may extend up to 6,500 feet (1950m) but the zone is basically treeless,

existing only above the forest line. Most of the flowering plants are found lower in the zone between 6,000 and 7,500 feet (1,800 - 2,300m). Above that elevation the zone is characterized by glaciers, perpetual snowfields, and barren rocks.

Many of the plants found lower in the zone are the same as those found in the subalpine meadows: heathers, Sitka valerian, Alaska spiraea, lupines, paintedcups, and bistort, for example. Some of the plants more characteristically confined to the Alpine Zone are: mountain buckwheat (**Eriogonum pyrolaefolium**), pussypaws (**Spraguea umbellata**), moss campion (**Silene acaulis**), willow grass (**Draba aureola**), smelwskia (**Smelowskia ovalis**), Tolmie's saxifrage (**Saxifraga tolmiei**), alpine Jacobs ladder (**Polemonium pulcherrimum** var. **pilosum**), Indian pink (**Castilleja angustifolia**), golden fleabane (**Erigeron aureus**), dryad (**Dryas octopetala**), mountain sorrel (**Oxyria digyna**) and many species of grasses, sedges and rushes. You will notice that the alpine plant communities above Paradise and at Sunrise differ markedly, due to a great difference in both soils and precipitaetion.

Even though most vascular plants occur below 7,500 feet (2,300m) elevation, some are found as high as 10,000 feet (3,300m). A few mosses grow in the steam-altered clay in the summit crater, and lichens are found growing on the rocks rimming it at 14,300 feet (4,350m).

Of several green algae that grow in the snow, **Chlamydomonas nivalis**, is called red snow or watermelon snow because of the red tint it gives the snow.

Mammals and Birds

Many animals are found within Mount Rainier National Park. The mammals are best known (Potts and Grater 1949); some of the more common ones are listed in Table 2 along with their distribution by zones.

Birds are also common, although most are migratory species that occur only as summer residents. Four members of the grouse family live in as many vegetation zones in the park: ruffed grouse, **Bonasa umbellus**, reside in the lower forests; blue grouse, **Dendragapus obscurus**, and the Franklin's grouse, **Canachites canadensis franklinii**, make their homes in the higher forests; white-tailed ptarmigan, **Lagopus leucurus**, nests above treeline, changing from brown in summer to white in winter. Three other birds nest in the alpine zone: horned lark, **Eremophila alpestris**, water pipit, **Anthus spinoletta**, and gray-crowned rosy finch, **Leucosticte tephrocotis**. Four members of the crow family are outstanding among the mountain's birds; Steller's jays, **Cyanocitta stelleri**, live in the lower forests. Gray jays, **Perisoreus canadensis**, stay all year in the park, from low forests to the subalpine. Clark's nutcrackers, **Nuci-**

fraga columbiana, live all year near treeline. Common ravens, **Corvus corax,** spend the year hovering and wheeling over high ridges and are seen on the mountain's summit, even in midwinter. Others of the more characteristic birds are the winter wren **Troglodytes troglodytes;** varied thrush, **Ixoreus naevius;** Oregon junco, **Junco oregonus;** red-tailed hawk, **Buteo borealis;** and rufus hummingbird, **Selasphorus rufus;** and dipper or water ouzel, **Cinclus mexicanus,** a slate-gray bird found along and in mountain streams. A complete bird checklist is available at visitor center desks.

TABLE 2—Common mammals in Mount Rainier National Park and their distribution by vegetative zones.

Common Name	Scientific Name	Zone				
				Tsme[5]		
		Tshe	Abam	Forest	Park	Alpine
Pacific beaver	**Castor canadensis leucodonta**	X	X	-	-	-
Columbia blacktail deer	**Odocoileus hemionus columbianus**	X	X	X	X	-
Black bear	**Ursus americanus altifrontalis**	X	X	X	X	-
Pacific raccoon	**Procyon lotor psora**	X	-	-	-	-
Cooper chipmunk	**Tamias towsendii cooperi**	X	X	X	X	-
Golden-mantled ground squirrel	**Citellus saturatus**	-	X	X	X	-
Douglas pine squirrel	**Tamiasciurus douglasii douglasii**	X	X	X	X	-
Cascade flying squirrel	**Glaucomys sabrinus fuliginosus**	X	-	-	-	-
Varying hare	**Lepus americanus**	X	X	X	X	-
Mink and weasel	**Mustela spp.**	X	X	X	X	-
Mountain coyote	**Canis latrans lestes**	X	X	X	X	-
Bobcat	**Lynx rufus fasciatus**	X	-	-	-	-
Mice	**Peromyscus and Microtus spp.**	X	X	X	X	X
Moles and pocket gophers	**Scapanus and Thomomys spp.**	X	X	X	X	X
Hoary or whistling marmot	**Marmota caligata cascadensis**	-	-	-	X	X
Cascade pika or cony	**Ochotona princeps brunnescens**	-	X	X	X	X
Northwestern pine marten	**Martes americana**	X	X	X	X	-
Cougar	**Felis concolor oregonensis**	X	X	X	X	-
Mountain goat	**Oreamnos americanus americanus**	-	X	X	X	X
Yellow-haired porcupine	**Erethizon dorsatum epixanthum**	X	X	X	X	-

[5]Tsme—**Tsuga menziesii**
Tshe—**Tsuga heterophylla**
Abam—**Abies amabilis**

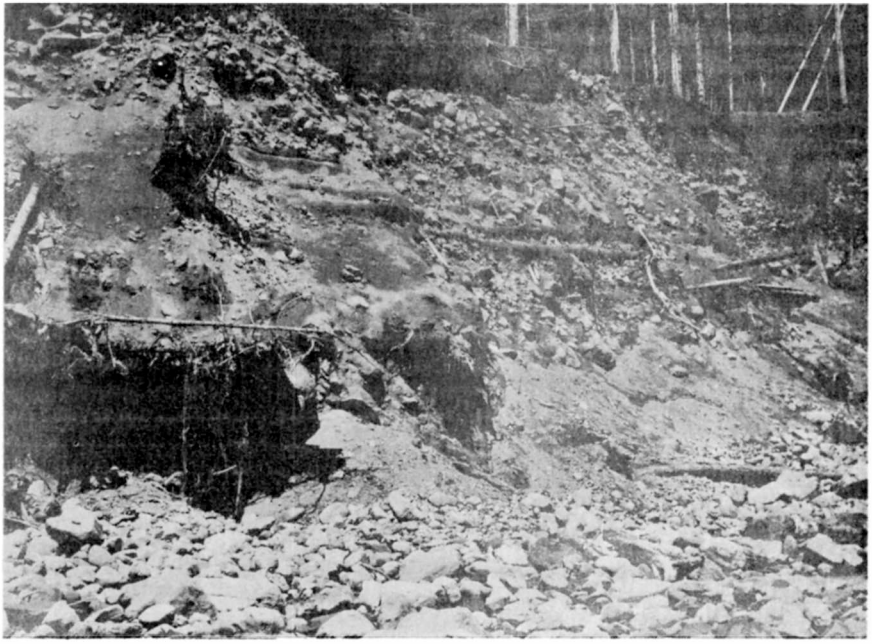
Kautz Creek Debris Flow

Debris flows caused by steam explosions, heavy rainfall, or glacier outbursts have been common during the postglacial history of

Mount Rainier (Crandell and Mullineaux 1967). The Kautz Creek debris flow provides a recent example. During heavy rains in October 1947, a temporary natural dam of ice and boulders formed far up the drainage. The dam collapsed, producing flood surges that swept the upper canyon, removing an estimated 50 million cubic yards (37 million m^3) of rock, dirt and other debris (fig. 3). Much of this material was deposited in the broader lower valley of Kautz Creek and Nisqually River, burying the old road up to 50 feet (16 m) deep in debris and killing the trees by uprooting them or suffocating their roots.

The progress of soil and plant development on the debris flow has been studied by University of Washington scientists (Frehner, 1957). Many of the original forest species, such as Douglas-fir, have reestablished themselves on the deposits, specially where old snags remain. Red alder, black cottonwood **(Populus trichocarpa),** and willows **(Salix spp.)** have been important pioneers as have many mosses and lichens such as **Rhacomitrium canescens** var. **ericoides.** The alder plays an especially important role in soil development because of the nitrogen-fixing bacteria in its roots.

A self-guiding nature trail is available for those interested in viewing the debris flow and revegetation of the area at close range.



National Park Service

Fig. 3: **The remains of former forests** protrude from the bank of upper Kautz **Creek, where the 1947 debris** flow dug a new channel. In the Kautz **valley, six debris flows** preceded the 1947 one within the last few **thousand years.**

Longmire

The modern history of Mount Rainier National Park began at Longmire. James Longmire with George B. Bayley discovered the mineral springs in 1883 and built a health resort on the site in the next few years (fig. 4). The Longmires sold their mineral claim in 1916. A cabin constructed by Elcaine Longmire in 1888, can still be found on the Trail of the Shadows.

There are about 50 hot springs and mineral springs in and around the Longmire Meadows. A typical mineral spring is Iron Mike which has water high in iron and leaves a rust-colored deposit. The hot springs range in temperature from about 75° to 85° F (24° to 29° C). Similar springs occur in other parts of the park, e.g. at Ohanapecosh where their biology has been studied in detail (Stockner, 1967).

A self-guided nature trail, Trail of the Shadows, will take you around the meadows and springs and through low-elevation temperate forest.

National Park Service

Fig. 4: Longmire's Springs hotel and baths, ca. 1904.

Nisqually Glacier

The 37 square miles (98 m^2) of glaciers that cover Mount Rainier make up one of the largest single-peak glacial systems in the contiguous United States. These glaciers have been the major factor in eroding and sculpturing Mount Rainier into its present form. The silt-laden glacial streams show that the glaciers are active. These large, accessible glaciers have excited amateur and professional observers for many years; see, for example, Bender and Haines (1955), Harrison (1956), Hubley (1956), Johnson (1960), Meier (1960), Meier and Post (1962), and Sigafoos and Hendricks (1961).

Nisqually Glacier (fig. 5) and its tributary, Wilson Glacier, cover about 2.2 square miles (5.7 km^2). The story of the behavior of

National Park Service

Fig. 5: Nisqually Glacier from Nisqually Glacier Vista near Paradise.

this glacier since its most recent maximum advance has been unravelled through botanical studies (tree dating of moraines), historical records, observations of the glacial front since 1918, and surface profile surveys on the lower glacier since 1942. Steven M. Hodge, University of Washington began studying its flow dynamics in 1968.

Between 1840 and 1951 the Nisqually Glacier terminus retreated continuously on an average of 70 feet (23 m) annually. About 1885 it stood at the present site of the Nisqually River Bridge. Starting in 1945, the glacier's mass budget was positive for 7 consecutive years as a result of surpluses of snow and ice accumulation over the annual loss through melting. As a consequence, the terminus of Nisqually Glacier began advancing in 1951 and continued to do so until the mid-1960's. Most glaciers on Mount Rainier and in the Pacific Northwest have responded similarly to a cooler, moister climatic regime since the mid-1940's, but seem to be stabilizing or retreating now.

Plant succession on deglaciated areas has not been studied in detail, but many of the tree species found in adjacent forests will invade these sites directly. Sitka alder **(Alnus sinuata)** thickets are often conspicuous prior to development of a closed forest canopy. Alder plays an important role as a nitrogen fixer. Lodgepole pine **(Pinus contorta)** is common on modern moraines of the Emmons Glacier on the northeastern side of the park.

Ricksecker Point

The Tatoosh Range to the southeast is about 15 million years older than Mount Rainier and is composed of intrusive (granitic) rather than extrusive (volcanic) rocks. This small but spectacular range is east-west oriented. Peaks, from west to east, are Eagle, Chutla, Wahpenayo, Lane, Plummer, Pinnacle, The Castle, Unicorn, and Stevens. Unicorn Peak, 6,939 feet high (2,300 m), is the tallest in the range. In the distance, to the southwest, is Sawtooth Ridge with High Rock the dominant peak. A Forest Service fire lookout is located on this 5,687 foot (1,800 m) point.

In the roadcut, a glacial moraine overlies a brecciated lava flow from Mount Rainier volcano. Cushman Crest to the northwest and Rampart Ridge to the southwest are also Mount Rainier lava flows.

Half a mile east up the road, a roadcut shows five distinct layers from bottom to top: brecciated lava flow; glacial till; a layer of ash from the explosion of Mount Mazama in Oregon 6,600 years ago; a veneer of material from the 5,000-year old Paradise debris flow; and ash from Mount St. Helens that was erupted 3,000 to 3,500 years ago (Crandell and Mullineaux, 1967).

Between Ricksecker Point and Narada Falls is an area of subalpine forest that was burned over in the late 1800's and has been referred to as the Silver Forest. A young, highly mixed forest, including subalpine fir, Pacific silver fir, noble fir, western hemlock and mountain hemlock, western redcedar, and Alaska-cedar now occupy most of the area.

Narada Falls

Narada Falls is 168 feet (55 m) high, 3 feet (1 m) higher than the famous Niagara Falls. It was named after a Hindu priest or philosopher by some members of the Tacoma Theosophical Society in 1893. Paradise River drops over the contact of a Mount Rainier lava flow on the west and granodiorite on the east.

On the slopes above the road and the waterfall is a dense subalpine forest of mountain hemlock, Pacific silver fir and Alaska-cedar. The dense understory of shrubs-huckleberries, rusty menziesia and Cascades azalea-is typical of cool, wet sites in this zone.

Paradise

Paradise is famed for its flower fields and fine vistas of Mount Rainier. Here you will find many species. You will see a variety of plant communities, each adapted to a particular set of environmental conditions. Communities of pink and white heather, often with **Vaccinium deliciosum** (which produces a delicious fruit) are found on better drained sites with a longer growing season. Some of the most beautiful communities are the lush (up to 3 or 4 feet or 1 to 1.2 m in height) stands of Sitka valerian, bistort, lupine, false hellebore **(Veratrum viride)**, arnica and sedges **(Carex spp.)**. Other sites, with short growing seasons due to persistent winter snowpacks, are dominated by **Carex nigricans** or cryptogams and Tolmie's saxifrage.

Trees make up part of this subalpine mosaic with subalpine fir and mountain hemlock the most common species in the valley. Groups and stringers of trees grow in and around the meadows. Typically, the development and expansion of these groups has been a gradual process (Franklin and Mitchell, 1967). However, between about 1910 and 1940 a very extensive invasion of meadows by trees took place. Many of the lower meadow areas are now dominated by saplings resulting from these invasions (fig. 6). Subalpine meadow invasion is widespread in the coastal mountains of the Northwest. Tree ages correlate well with the periodic retreat of the glaciers. A warmer, drier climatic regime earlier in the century seems to be responsible for these invasions. At that time, glaciers in the region suffered a loss in mass.

USDA Forest Service

Fig. 6: Subalpine firs invaded Paradise meadows between 1910 and 1940 as a result of a warmer, drier climatic period.

The soil at Paradise that supports the subalpine trees and wildflowers overlies a fascinating series of geologic strata. Several layers of volcanic ash lie near the surface. Below them, angular rock fragments in a yellowish-brown matrix of sand, silt and clay were deposited some 5,000 years ago by a gigantic avalanche that started near the summit of the mountain and swept down the Nisqually Glacier and overflowed into Paradise Park. It continued down the Nisqually valley more than 20 miles (34 km) as a debris flow, leaving a thin veneer of rock and mud as high as 800 feet (250 m) on the valley walls upvalley from Ricksecker Point.

Park Naturalists offer information, publications, motion pictures, and talks at the visitor center. They lead walks in the nearby flower fields. Two self guiding trails are provided: a short trip through meadows and forests to a high vista of Nisqually Glacier and a longer trip (3 miles or 4.8 km) to the Paradise Ice Caves.

Reflection Lakes

Reflection Lakes are set in a broad pass at the heads of two valleys that drain eastward into the Cowlitz River and westward into the

Nisqually River. The pass roughly marks the southward limit of Mount Rainier lava flows that are banked against the 15-million-year-old granodiorite of the Tatoosh Range.

Reflection Lakes and their nearby sister, Louise Lake, are tarns lying in basins carved by glaciers. The brush cover around the lakes is mainly the result of a fire that burned during the last half of the 19th century. Huckleberries dominate and give the slopes a brilliant red hue in the fall. Cascades mountain-ash adds color to that of the huckleberries.

Box Canyon

The Cowlitz River has cut this gorge or box canyon to a depth of 180 feet (59 m) at the road bridge. Glaciers rounded and polished the surrounding rocks. You can see glacial striations on many of the exposed rocks. Plants are slowly covering the rocks.

To the south and west is Stevens Canyon, named after the son of the first territorial governor of Washington State. This is a typical u-shaped glacial valley. Mount Adams, a 12,307 foot (3,750 m) composite volcano, is visible 40 miles (64 km) to the south.

Backbone Ridge

A fire swept Backbone Ridge and the adjacent canyon of the Cowlitz River about 100 years ago. You can see evidence of the fire in many areas: fire-scarred snags stand above the new forest. The forest here is dominated by a variety of shade-intolerant seral species—Douglas-fir, noble fir and western white pine—all of which depend on periodic fires to remove competing species. In the absence of disturbance, these seral or pioneer species slowly lose out to the more tolerant species such as Pacific silver fir that can reproduce successfully under its own cover.

Between Backbone Ridge and the Ohanapecosh River, you can see portions of the Gifford Pinchot National Forest. The patches in the forest are a result of clearcut timber harvest by contract loggers operating under the multiple use program of the United States Forest Service. Timber, forage, and wildlife production, as well as recreation and watershed protection, are considered in managing National Forests.

Trail of the Patriarchs

A trail leads a mile north from the Stevens Canyon Entrance, then across a steel suspension bridge and through age-old forest to the giant trees composing the "Grove of the Patriarchs" on a terrace

of the Ohanapecosh River (fig. 1). Although this area is near the boundary between the **Abies amabilis** and **Tsuga heterophylli** Zones, the forest provides some fine examples of conditions in the latter zone. Yellowstone elk, **Cervus canadensis**, are also found in this area.

Avalanche Tracks

During the winters, heavy accumulations of snow on ridgetops and in small basins sometimes fall in avalanches down the steep mountain slopes, destroying any forests in their path (fig. 7). On sites swept by recurrent snow avalanches permanent avalanche communities develop, dominated by Sitka alder. This shrub has supple, strongly bowed stems that can bend under the snow and emerge unharmed after repeated avalanches have passed over it. The only conifer capable of surviving and reproducing on these sites is Alaska-cedar. It is often a member of the stable avalanche community. Since these sites are often very wet the understory is typically rich in herbs, ferns, devil's club, and sedges.

USDA Forest Service

Fig. 7: Recurrent snow avalanches prevent the growth of tall trees, but vine maple and Alaska-cedar hang onto the unstable slopes.

Sunrise Ridge - Yakima Park

Sunrise Ridge offers unusually broad views of Mount Rainier and extensive subalpine meadows (fig. 2). Since the ridge is on the northeastern side of the mountain it lies in the rain shadow of Mount Rainier. A coarse-textured soil of pumice also mantles much of this ridge. Consequently, the character of the subalpine communities is decidedly different than that found at most other locations in the park. **Festuca viridula-Lupinus latifolius** (fescue-lupine) communities dominate the slopes of the ridge. Associated with these dominants are many other species such as bistort, **Polygonum newberryi,** broadleaf arnica, and scarlet paintbrush **(Castilleja miniata)**. Whitebark pine is much more common in this part of the park, forming scattered tree groups with subalpine fir as well as most of the krummholz along the ridgetops.

A visitor center and small lodge are located at Sunrise. The many trails radiating from this area provide opportunity to enjoy the meadows at first hand and to view Mount Rainier and Emmons glacier.

Shadow Lake Area

A small picnic area is located at the end of the Sunrise Ridge road near Shadow Lake. A short walk along the Burroughs Mountain trail will bring you into the steep slopes of the White River canyon. From these slopes spectacular views of Emmons Glacier and the Little Tahoma Peak avalanche deposits are available (fig. 8).

Emmons Glacier is the largest glacier in the United States, outside of Alaska. It covers nearly 5 square (13 km^2) miles. After receding continuously from 1700 the Emmons Glacier began in the early 1950's to advance as much as 115 feet (35m) annually, but is now stable. The debris covering the lower part of the glacier is from a major rockfall from Little Tahoma Peak.

In December 1963, rockfalls from Little Tahoma having a total volume of 14 million cubic yards (10 million m^3) avalanched 4 miles (6.5 km) onto Emmons Glacier and down the White River valley (Crandell and Fahnestock, 1965). These were dry landslides, rock-fragment flows, composed of mixtures of rock debris and air. The falling material trapped and compressed air that gave the avalanches their flowing motion that reached speeds of 100 to perhaps 300 miles per hour (480 kph). The avalanche deposits visible below the glacier covered the recent morainal materials for about 6,000 feet (1,900 m) and as much as 100 feet (33 m) deep.

About 5,000 years ago, nearly half a cubic mile (800 m^3) of mud flowed from the summit of Mount Rainier, submerging the White

USDA Forest Service

Fig. 8: Emmons Glacier (center) is darkened by debris from a rockfall that fell 4 miles (6.4 km) from Little Tahoma Peak in 1963. Yellow patches in Glacier Basin (right) are remnants of the Osceola Mudflow of about 5,000 years ago.

River valley below Sunrise beneath at least 500 feet (152 m) of mud and rock debris. This Osceola Mudflow traveled 65 miles (105 km) downvalley, and spread over 65 square miles (117 km^2) in the Puget Sound Lowland, where Enumclaw and Buckley are today. Half a dozen debris flows have thundered down the White River valley during the last 6,600 years, probably as a result of eruptions or steam explosions.

Many similar debris flows have occurred on other flanks of the mountain. In the process, 1,000 feet (330 m) or more of the volcano's summit has fallen away. The present summit cone was probably built by eruptions about 2,000-2,350 years ago.

Brown-skinned visitors from the plains to the east may have watched in awe as the mountain erupted in the last several thousand years. They hunted deer and gathered berries in the parks and forests of Tahoma - The Mountain (Rice, 1965).

References

Bender, V. R., and Haines, A. L.
1955. Forty-two years of recession of the Nisqually Glacier on Mount Rainier. Erdkunde 9(4): 275-281, illus.

Bodenburg, E. T.
1939. Moss flora of Mount Rainier National Park. Mount Rainier National Park Nature Notes 17 (1 and 2), 83p., illus.

Brockman, C. Frank
1947. Flora of Mount Rainier National Park. U. S. Nat. Park Serv., 170p., illus.

Brockman, C. Frank
1949. Trees of Mount Rainier. Univ. Wash. Press., 49p., illus.

Cooke, William Bridge
1962. On the flora of the Cascade Mountains. Wasmann Journal Biol. 20: 1-67.

Crandell, Dwight R., and Fahnestock, Robert K.
1965. Rockfalls and avalanches from Little Tahoma Peak on Mount Rainier Washington. U.S. Geol. Survey Bull. 1221-A, 30p., illus.

*Crandell, Dwight R., and Mullineaux, Donal R.
1967. Volcanic hazards at Mount Rainier Washington. U. S. Geol. Survey Bull. 1238, 26p., illus.

*Fiske, R. S., Hopson, C. A., and Waters, A. C.
1963. Geology of Mount Rainier National Park, Washington. U. S. Geol. Survey Prof. Paper 444, 93p, illus.

Franklin, Jerry F., and Dyrness, C. T.
1969. Vegetation outline of Oregon and Washington. U.S.D.A. Forest Serv. Res. Pap. PNW-80, 216p., illus.

Franklin, Jerry F., and Mitchell, Russel G.
1967. Successional status of subalpine fir in the Cascade Range. U.S. D.A. Forest Serv. Res. Pap. PNW-46, 16 p., illus.

Frehner, Hans K.
1957. Development of soil and vegetation on the Kautz Creek flood deposit in Mount Rainier National Park. Unpublished thesis, University of Washington, 83p., illus.

Harrison, A. E.
1956. Fluctuations of the Nisqually Glacier, Mount Rainier, Washington, since 1750. J. Glaciol. 2:675-683, illus.

Hubley, Richard C.
1956. Glaciers of the Washington Cascade and Olympic Mountains; their present activity and its relation to local climatic trends. J. Glaciol. 2:669-674, illus.

Johnson, F. Arthur
1960. Variation in surface elevation of the Nisqually Glacier, Mount Rainier, Washington. Int. Assoc. Sci. Hydrology Bull. 19:54-60., illus.

*Jones, George Neville
1938. The flowering plants and ferns of Mount Rainier. Univ. Wash. Pub. in Biol. 7:1-92, illus.

*Kirk, Ruth
1968. Exploring Mount Rainier. Seattle and London: Univ. Wash. Press, 104p., illus.

Meier, Mark F.
1960. Distribution and variation of glaciers in the United States exclusive of Alaska. Int. Assn. Sci. Hydrol., Pub. 54: 420-429, illus.

Meier, Mark F., and Post, Austin S.
1962. Recent variations in mass net budgets of glaciers in western North America. Int. Assn. Sci. Hydrol. Pub. 58: 63-77, illus.

Mullineaux, D. R., Sigafoos, R. S., and Hendricks, E. L.
1969. A historic eruption of Mount Rainier, Washington. U. S. Geol. Surv. Prof. Pap. 650-B: B15-B18, illus.

Potts, Merlin K., and Grater, Russell K.
1949. Mammals of Mount Rainier National Park. Longmire, Wash.: Mount Rainier Nat. Hist. Assn., 87p., illus.

Rice, David G.
1965. Archeological Test Excavations in Fryingpan Rockshelter, Mount Rainier National Park. Wash. State Univ., Lab Anthropol. Rep. No. 33, Pullman, 13p., illus.

Richardson, Donald
1968. Glacier outburst floods in the Pacific Northwest. U. S. Geol. Survey Prof. pap. 600-D: D79-D86, illus.

*Sigafoos, Robert S., and Hendricks, E. L.
1961. Botanical evidence of the modern history of Nisqually Glacier, Washington. U. S. Geol. Surv. Prof. Pap. 387-A, 20p., illus.

Stockner, John G.
1967. Observations of thermophilic algal communities in Mount Rainier Yellowstone National Parks. Limnol. and Oceanogr. 12 (1): 13-17.

*For sale by the Mount Rainier Natural History Association, Longmire, Washington, 98397.

Mount Rainier National Park is administered by the National Park Service, a bureau of the Department of the Interior.

The Department of the Interior - The Nation's principal natural resource agency - bears a special obligation to assure that our expendable resources are conserved, that our renewable resources are managed to produce optimum benfits, and that all resources contribute their full measure to the progress and prosperity of the United States . . . now and in the future.

Nearly surrounding Mount Rainier National Park are the Snoqualmie and Gifford Pinchot National Forests, administered by the U.S.D.A. Forest Service.

The Forest Service of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives - as directed by Congress - to provide increasingly greater service to a growing Nation.