

BOSTON GLACIER RESEARCH NATURAL AREA

Supplement No. 6¹*Curt Wiberg and Arthur McKee*²

The Research Natural Area described in this supplement is administered by the U.S. Department of the Interior, National Park Service. National Park Service Research Natural Areas are located within National Parks or Monuments which are administered by Superintendents. A scientist wishing to use one of these tracts should first contact the Superintendent responsible for the Park in which the Research Natural Area is located and outline his proposed research. Because of their long involvement with scientific and educational use of the National Parks and Monuments, the National Park Service has developed some standard procedures covering applications for such uses.

Eventually all research must be approved by the Park Superintendent, Director of the Region, and Chief Scientist. A resources study proposal must be prepared by the principal investigators for the above administrators' review and approval; area research biologists will assist in preparation of the proposal. Formal collecting permits are necessary within the Research Natural Areas as well as the Parks in general. There may be limitations on research activities located on Research Natural Areas within designated Wilderness Areas.

The Research Natural Area described within is a part of a Federal system of such tracts established for research and educational purposes. Each of these constitutes a site where some natural features are preserved for scientific purposes and natural processes are allowed to dominate. Their main purposes are to provide:

1. Baseline areas against which effects of human activities can be compared;
2. Sites for study of natural processes in undisturbed ecosystems; and

3. Gene pool preserves for all types of organisms, especially rare and endangered types.

The total Federal system is outlined in "A Directory of the Research Natural Areas on Federal Lands of the United States of America."³ Of the 64 Federal Research Natural Areas in Oregon and Washington, 45 are described in "Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and Educators,"⁴ along with details on management and use of such tracts: this description is the 6th supplement to that guide.

The guiding principle in management of Research Natural Areas is to prevent unnatural encroachments, activities which directly or indirectly modify ecological processes on the tracts. Logging and uncontrolled grazing are not allowed, for example, nor is public use which threatens significant impairment of scientific or educational values. Management practices necessary for maintenance of the ecosystem may be allowed.

¹Supplement No.6 to "Federal Research Natural Areas in Oregon and Washington: A Guidebook for Scientists and Educators," by Jerry F. Franklin, Frederick C. Hall, C. T. Dyrness, and Chris Maser (USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, 498 p., illus., 1972). The guidebook is available from the Superintendent of Documents. U.S. Government Printing Office, Washington, D.C. 20402, for \$4.90; stock number 001001.00259.

²Curt Wiberg is Associate Professor, Department of Biology, Central Washington State College, Ellensburg. Art McKee is Research Instructor, Department of Forest Science, Oregon State University, Corvallis.

³Federal Committee on Ecological Reserves. A directory of Research Natural Areas on Federal lands of the United States of America. U.S. Dep. Agriculture, Forest Service, 280 p., 1977.

⁴See footnote 1.

Federal Research Natural Areas provide a uniquely valuable system of publicly owned and protected examples of undisturbed ecosystems which are available to the scientist. He can conduct his research with minimal interference and reasonable assurance that investments in long-term studies will not be lost to logging, land development, or similar activities. In return, the scientist wishing to use a Research Natural Area has some obligations. He must:

1. Obtain permission from the appropriate administering agency before using the area;⁵
2. Abide by the administering agency's regulations governing the use of the natural area including specific limitations on the type of research, sampling methods, etc. allowed; and

⁵There are five agencies cooperating in this program in the Pacific Northwest: Forest Service in the U.S. Department of Agriculture; Bureau of Land Management, Fish and Wildlife Service, and the National Park Service in the U.S. Department of Interior; and the Energy Research and Development Administration.

3. Inform the administering agency on the progress of the research, published results, and disposition of collected material.

The purposes of these limitations are simple to insure that the scientific and educational values on the tract are not impaired, to accumulate a documented body of knowledge about the tract, and to avoid conflict between new and old studies. Research on Research Natural Areas must be essentially nondestructive in character - destructive analysis of vegetation is generally not allowed nor are studies requiring extensive forest floor modification or extensive soil excavation. Collection of plant and animal specimens should be restricted to the minimum necessary for provision of vouchers and other research needs and in no case to a degree which significantly reduces species population levels. Such collections must also be carried out in accordance with applicable State and Federal agency regulations. Within these broad guidelines, the appropriate uses of Research Natural Areas are determined on a case-by-case basis by the administering agency.

BOSTON GLACIER RESEARCH NATURAL AREA

An active glacier in Washington's rugged North Cascades and its associated cirque basin.

The Boston Glacier Research Natural Area was established on February 13, 1973, to provide an example of an active North Cascade glacier with attendant ponds, streams, and plant communities in its associated cirque basin. The 1251 ha (3,090 acre) tract, of which approximately 700 ha (1,730 acres) is occupied by Boston Glacier, is located in Skagit County, Washington, and is administered by North Cascades National Park (Sedro Woolley, Washington). The natural area lies in a cirque at the head of Skagit Queen Creek (fig. BG-1) in the Thunder Creek drainage and has its eastern, southern, and western boundaries determined by the arete which forms a

backdrop for Boston Glacier. It lies at 48° 30' N latitude and 121° 01' W longitude.

Most ice-free areas are relatively recent till and/or colluvium on rock faces of the cirque. A limited area of forest is characterized by *l-suya merlenBI* (Wa and *Abies amabilis* (for list of plant species see Table BG-1). A portion of an adjacent small cirque basin containing a subalpine pond, *Carex-Phyllodoce* meadow, and a rocky slope with pockets of shrub *{VacciniumPhyllodoce}* and tree communities of *Abies amabilis*, *Larix lyalli*, *Abies lasiocarpa*, *Picea albicaulis* and *Tsuga mertensiana* is included within the natural area.

Table BG-1 —Scientific and common names of vascular plant species mentioned in text

<i>Abies amabilis</i> (Dougl.) Forbes	Pacific silver fir
<i>Abies lasiocarpa</i> (Hook.) Nutt.	subalpine fir
<i>Tsuga mertensiana</i> (Bong.) Carr.	mountain hemlock
<i>Larix lyalli</i> Parl	subalpine larch
<i>Pinus albicaulis</i> Engelm.	whitebark pine
<i>Carex nigricans</i> C. A. Mey.	black alpine sedge
<i>Alnus sinuata</i> (Reg.) Rydb.	Sitka alder
<i>Phyllodoce empetriformis</i> (S.W.) D. Don	red mountainheath
<i>Cassiope mertensiana</i> (Bong.) G. Don	western cassiope
<i>Vaccinium deliciosum</i> Piper	blueleaf huckleberry
<i>Vaccinium membranaceum</i> Dougl. ex Hook.	big huckleberry
<i>Rhododendron albiflorum</i> Hook.	Cascades azalea
<i>Luetkea pectinata</i> (Pursh) Kuntze	luetkea
<i>Juniperus communis</i> L.	common juniper
<i>Carex spectabilis</i> Dewey	showy sedge
<i>Arctostaphylos nevadensis</i> Gray	pine-mat manzanita
<i>Chamaecyparis nootkatensis</i> (D. Don) Spach	Alaska-cedar



Figure BG-1.—Boston Glacier as viewed looking south up Skagit Queen Creek.

Access and Accommodations

The Research Natural Area occupies steep, rugged terrain which is reached by a 24 km (15 mile) hike up the Thunder Creek drainage from Colonial Creek Campground on Diablo Lake (fig. BG-2), the last 6.4 km (4 miles) of travel is cross-country through brush up Skagit Queen Creek.

The nearest commercial accommodations are in Newhalem, approximately 16 km (10 miles) west of Colonial Creek Campground on State Highway 20.

Environment

The Boston Glacier Research Natural Area includes the largest single cirque glacier in the North Cascades, presently having a surface area slightly less than 7 km² (Ringe 1973). The Natural Area covers an elevational range from 1 031 m (3,380 ft) to 2779 m (9,112 ft). The topography (fig. BG-3) is generally steep with 20- to 30-degree slopes being common and with slopes of 30 to 90 degrees leading down into Skagit Queen Creek. Gentle slopes are found only on the cirque floor adjacent to the head-

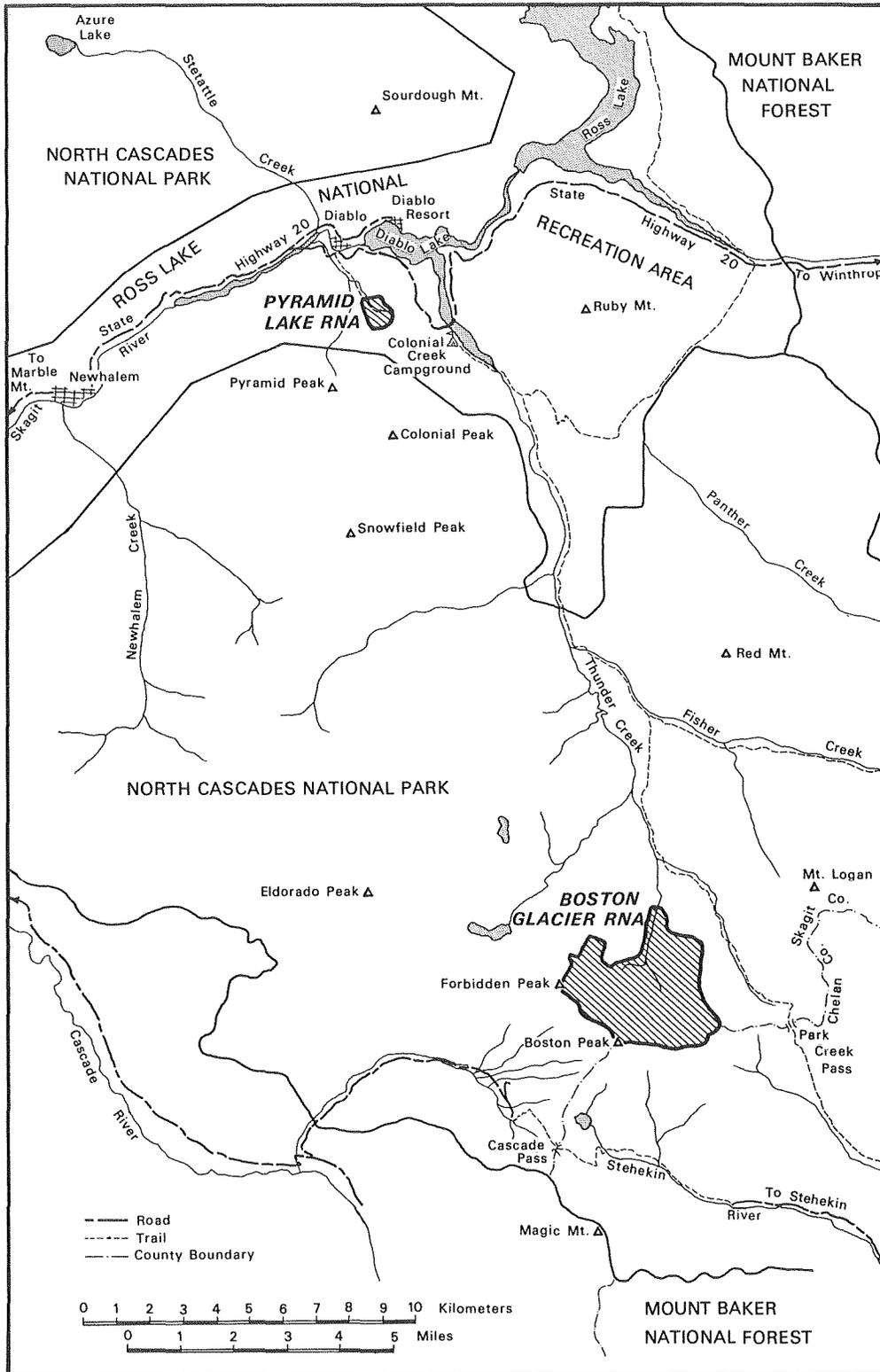


Figure BG-2.— Location of Boston Glacier Research Natural Area in relation to State Highway 20, Thunder Creek and Colonial Creek Campground on Diablo Lake.

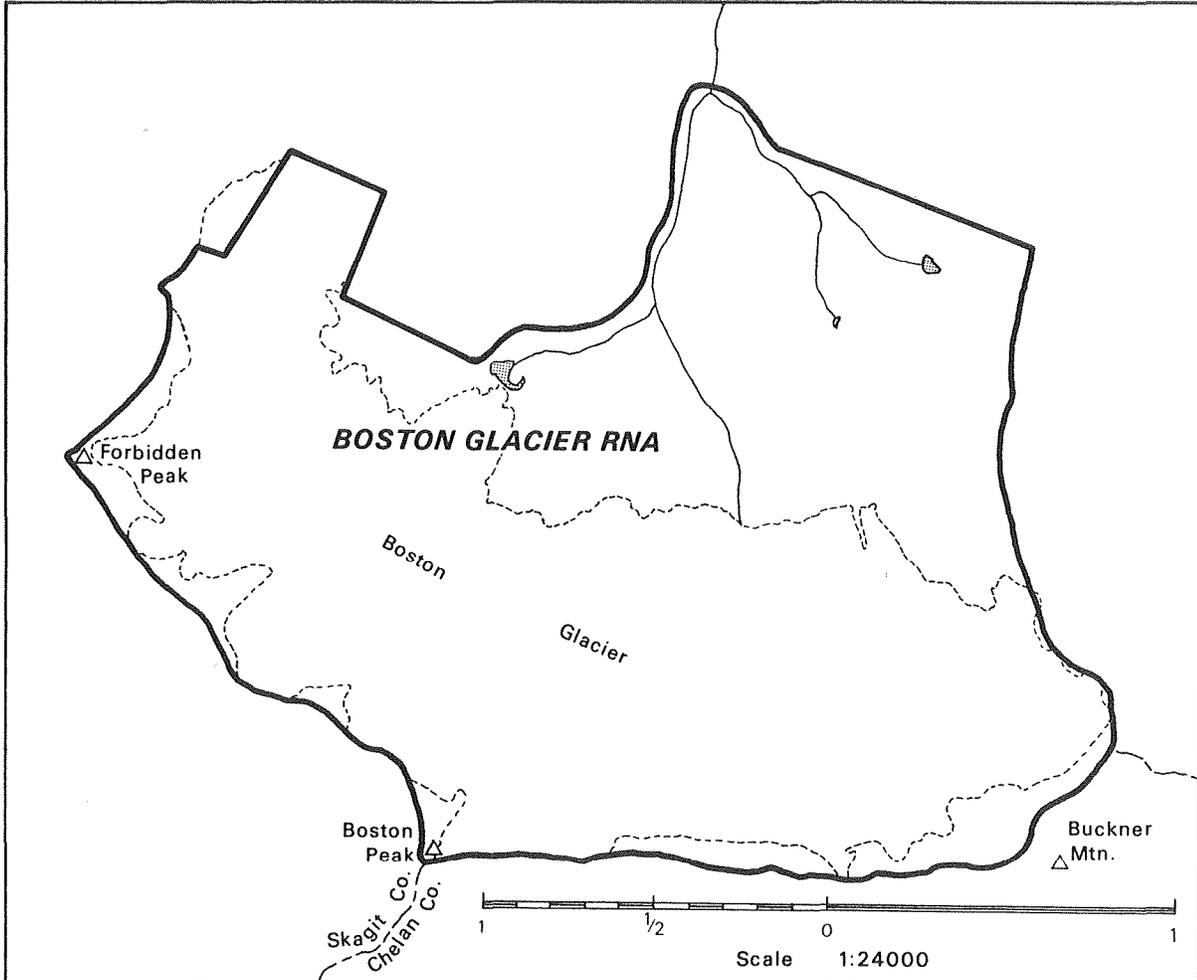


Figure BG-3.— Topographic map of Boston Glacier Research Natural Area. Because of the active nature of the glacier's terminus, the margin shown on the map may not be accurate.

waters of Skagit Queen Creek, which is only reached with difficulty because of the precipitous terrain. An arete formed by Buckner Mountain, Horseshoe Peak, Boston Peak, Forbidden Peak, and Ripsaw Ridge establishes all but the northerly boundary of the Natural Area. Two-thirds of the Natural Area is covered by the glacier with much of the remainder occupied by precipitous rock outcrops or boulder/stony till which has been worked by glacial meltwater and supports little if any vegetation. The cirque opens almost due north with the headwall shielding the accumulation basin from the sun much of the time (fig. BG-1).

The cirque basin contains the headwaters of

Skagit Queen Creek and provides the Natural Area with approximately 1.6 km (1 mile) of rapidly flowing glacial streams (fig. BG-3).

A wet, cool maritime climate prevails. Annual precipitation is heavy with maxima occurring in December and January and minima in July and August. Less than 10 percent of the precipitation occurs from June through August. Summers are cool and days are frequently cloudy. The following weather data are taken from Diablo Dam and Stehekin weather stations which are 24 km (15 miles) north and 32 km (20 miles) southeast, respectively, of Boston Glacier. Both stations are significantly warmer and drier than the Research Natural Area.

	Diablo Dam	Stehekin
Mean January temperature	-0.17°C (31.7°F)	-2.56°C (27.4°F)
Mean July temperature	18.33°C (65.0°F)	19.17°C (66.5°F)
Mean January minimum temperature	-3.17°C (26.3°F)	-5.67°C (21.8°F)
Mean July maximum temperature	25.50°C (77.9°F)	27.33°C (81.2°F)
Average annual precipitation	1 816 mm (71.56 in)	858 mm (33.8 in)
June to August precipitation	118 mm (4.64 in)	113 mm (4.45 in)
Average annual snowfall	177 cm (69.7 in)	307 cm (121.0 in)

Geology of Boston Glacier and Vicinity⁶

The bedrock in the area of Boston Glacier is loosely described as Skagit Gneiss, pre-Upper Jurassic in age. Considerable amounts of granitic rocks were observed in the vicinity of the glacier; however, the gneiss in this region is likely more of migmatite - alternating layers of gneissic and granitic rocks. Gneiss and granite are both massive and relatively resistant to erosion, consequently their modification by glacial activity tends to produce the sharp peaks and jagged ridges that characterize the North Cascades.

The intrusion of granitic bodies and the metamorphic changes that occur when gneiss is formed often produce some concentrations of metallic minerals, and this has occurred in this region. There are two sites of mining claims in the immediate vicinity of the Research Natural

Area, but none are known to exist within the boundaries.

The surface of Boston Glacier is extensively crevassed (fig. BG-4), even up to the headwall of the cirque. These crevasses indicate that this is an active glacier, and they also suggest that the floor of the cirque is either quite irregular or it slopes rather steeply in a downvalley direction. Since much of the glacier terminates on a steep, rock face, it seems likely that the cirque floor also slopes toward this face. The rock face in front of the glacier has been extensively smoothed and polished by previous glacial advances, and the smoothed surfaces also appear along the east side of the glacier.

Boston Glacier presently ends in a vertical ice wall in numerous places along its terminus. During the period of observation, the glacier was constantly calving large masses of ice from these ice walls. The blocks of ice cascaded down the steep rock face in front of the terminus with a thunder-like roar. The total effect is enhanced by the reverberations of the sound

⁶Condensed from Ringe, D. 1973. Geology of Boston Glacier and Vicinity. Unpublished report to the U.S. Forest Service on file at Forestry Sciences Laboratory, Corvallis, Oregon.



Figure BG-4.—Looking west-southwest across Boston Glacier to Ripsaw Ridge and Boston Peak.

in the semi-enclosed basin causing one to suspect that this phenomenon led to the naming of Thunder Creek, the major tributary a couple of miles north of Boston Glacier.

Hubley (1956) stated that Boston Glacier had advanced rapidly between 1950 and 1955 as determined from aerial photographs taken in those years. LaChapelle (1962) also indicated that the glacier had advanced appreciably between 1947 and 1955, but the terminus showed little change in position between 1955 and 1959. These changes were determined through comparison of oblique aerial photographs taken during each of the 3 years.

Comparison of vertical aerial photographs taken in 1956 and 1963 reveals that Boston Glacier receded and thinned somewhat during that interval. The only portion of the glacier that showed a marked advance during the 1956-63 period was a small lobe in the westcentral terminus which advanced about 122 m (400 ft). LaChapelle (1962) noted that this same lobe started its advance between 1947 and 1955. Most of the rest of the terminus showed signs of retreating from 30 to 120 m (100 to 400 ft) during the 1956-63 interim. Although visual observations are seldom equal to photographs for comparative purposes, the terminus of Boston Glacier, as it was observed in Septem-

ber 1973, appears to be little changed from its 1963 position.

The aerial photographs taken in September of 1956 and 1963 showed that the firn limit on Boston Glacier extended almost to the terminus, and very little open ice was exposed on the surface of the glacier. Even in September 1973, after an unusually small snowfall in the Cascades, at least two-thirds of the glacier surface was covered with firn. The observable characteristics of the glacier-firn limit, crevasses, calving, shape and position of the terminus indicate that Boston Glacier is active.

Although it is obvious that Boston Glacier has been much larger in the past than it is today, no special attempt was made to determine the maximum thickness of the ice. The valley of Skagit Queen and Thunder Creeks is Ushaped all the way to Diablo Lake (fig. BG-5) so Boston Glacier is just a remnant of what was once the principal glacier of an extensive system of valley glaciers which occupied this entire drainage basin. It appears that 1.6 km (1 mile) north of the present terminus of the glacier, the thickness of the ice was in excess of 610 m (2,000 ft).



Figure BG-5.—View north, down glaciated valley of Skagit Queen Creek from ridge in northwestern portion of Research Natural Area.

Biota

Fully two-thirds of the Boston Glacier Research Natural Area is covered by the ice or rocky outcrops associated with the glacier. The remaining one-third is mostly glacial till, colluvial deposits, and bare rock walls of Skagit

Queen Creek immediately below the glacier (fig. BG-1). The mosaic of vegetation that does exist within the RNA falls within the upper segment of the *Tsuga mertensiana*⁷ zone

⁷Nomenclature follows Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. U. Wash. Press. Seattle. 730 pp. Common names for plant species mentioned are found in the appendix.

together with the alpine *Phyllodoce-Cassiope-Vaccinium* and *Carex nigricans* communities (fig. BG-6) (Franklin and Dyrness 1973). The shrubby riparian vegetation associated with lower Skagit Queen Creek begins a considerable distance outside the Research Natural Area where it is dominated by a dense *Alnus sinuata* community.

A small piece of a subalpine parkland (approximately 60 ha or 150 acres) exists within the northeast portion of the Research Natural Area at about 1 370 m (4,500 ft) extending up a rocky slope to about 2 130 m (7,000 ft.) This includes some of the relatively steep side-slopes



Figure BG-6.—*Phyllodoce-Cassiope-Carex* meadow with small pond in the northeastern portion of the Research Natural Area.

(50°) of the cirque basin for Boston Glacier where they are capable of supporting vegetation (fig. BG-7). The lower side slope vegetation tends toward a closed *A. lries amabihs*-*Tsuya mertensiana* community with an occasional *Pinus albicaulis*. The trees range from 18 to 24 m (60 to 80 ft) in height and 64 to 76 cm (25 to 30 in) in diameter. The understory is dominated by *Rhododendron albi(lorum* and *Vaccinium membranaceum*. In the more open areas within the forested stand *Phyllodoce empetrifol'lnl~s* and *Cassiope mertensiana* become shrubby associates. *P. empetrifol'ln~s* appears to be more dominant at lower elevations than *C. Inertensiana*, with the latter occupying a more dominant role at higher elevations.



Figure BG-7.—Open stand on the steep rocky slope of a small cirque in the northeastern portion of the Research Natural Area.

From this small forest stand, the boundary of the Research Natural Area leads up a ridge formed by the cirque basin to the top of the divide between Skagit Queen Creek and Thunder Creek at 2 133.6 m (7,000 ft). While this ridge is mostly covered with glacial till containing large boulders (commonly more than 0.6 m (2 ft) in diameter), pockets of immature sandy soil support *Larix lyallii* (fig. BG-8), *Alnus amabihs*, *A. lries lu,siocarpa*, *Pinus albicauhs*, *Tsuya merten.siana*, together with *Vaccinium deliciosum*, *Phyllodoce empetr'ifo'lnis*, *Cussiope m.ertensiana*, *Rhododendm alMjloTan*, and

Luetkea pectinata. Colonization and succession relationships would be logical topics for study in these sites. The ridge top at 2 133.6 m (7,000 ft) supports a krumholz community of the above tree species along with *Juniperus comInlnl~s* and *Arctostaphylos nevaden.si.s*.

A *Cell'ex* meadow community exists just inside the northeastern boundary of the Research Natural Area in a small cirque basin. A small tarn <0.04-ha «0.1-acre) is surrounded by a wet meadow dominated by *Carex spectabihs*, *C. niyrican.s*, *Phullodoce enlpetT'fornlI~s*, *Cassiope mertensiana*, *Vaccinium deliciosum* and *Luetkea pectinata* (fig. BG-6). Seedlings and small saplings of *A. lries amabihs*, *A. lasiocal7Ja*, *Pinu,s albicauhs*, *Tsuya m.ertensialw*, *Lm'i;r IUallii* are common. Downslope toward Skagit Queen Creek, *ChamaecUl)(IT/~S IwoIwtensis* becomes a shrubby component of a more heavily forested community.

All mammals and birds that have been recorded or are expected to occur within the Natural Area are listed in tables BG-2 and BG-3. The lists are a result of a survey conducted in September, 1972.⁸ *Pika (Ochotona princeps)*⁹ were common in the rockslides in the area and several were sighted. Cone cuttings,

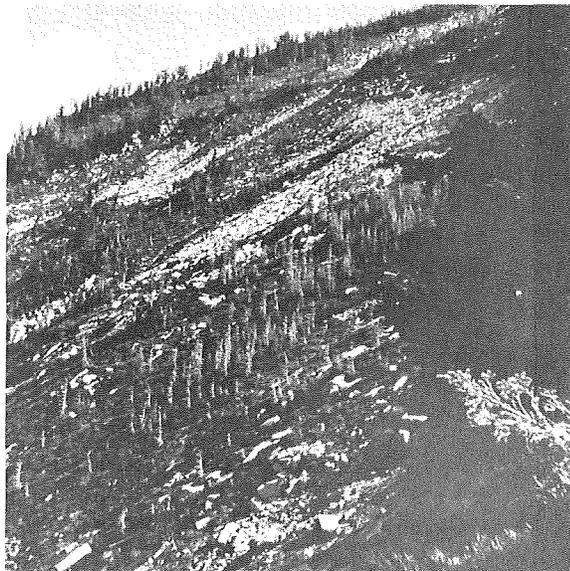


Figure BG-8.—*Larix lyallii* stand on ridgetop.

⁸From Smith, E. R. 1973. Boston Glacier RNA vertebrate species account. Unpublished report to U.S. Forest Service on file at Forestry Sciences Laboratory, Corvallis, Oregon.

⁹Nomenclature follows Hall, H. E. and K. R. Kelson. 1959. The Mammals of North America. The Ronald Press Company, New York.

Table BG-2 — Tentative list of mammals which utilize the Boston Glacier Research Natural Area as residents or transients

Order	Scientific name	Common name
Insectivora	<i>Scapanus orarius</i>	coast mole
	<i>Sorex bendirii</i>	Pacific water shrew
	<i>Sorex cinereus</i>	masked shrew
	<i>Sorex palustris</i>	water shrew
	<i>Sorex vagrans</i>	vagrant shrew
Chiroptera	<i>Eptesicus fuscus</i>	big brown bat
	<i>Lasiurus cinereus</i> ¹	hoary bat
	<i>Myotis californicus</i>	California myotis
	<i>Myotis evotis</i>	long-eared myotis
	<i>Myotis lucifugus</i>	little brown myotis
Lagomorpha	<i>Myotis yumanensis</i>	Yuma myotis
	<i>Lepus americanus</i>	snowshoe rabbit
Rodentia	<i>Ochotona princeps</i>	pika
	<i>Clethrionomys gapperi</i> ¹	Gapper's red-backed mouse
	<i>Clethrionomys occidentalis</i>	western red-backed mouse
	<i>Erethizon dorsatum</i> ¹	porcupine
	<i>Eutamias amoenus</i>	yellow-pine chipmunk
	<i>Eutamias townsendi</i>	Townsend's chipmunk
	<i>Glaucomys sabrinus</i>	northern flying squirrel
	<i>Marmota caligata</i>	hoary marmot
	<i>Microtus longicaudus</i>	long-tailed vole
	<i>Microtus richardsoni</i> ¹	water vole
	<i>Neotoma cinerea</i>	bushy-tailed wood rat
	<i>Peromyscus maniculatus</i> ¹	deer mouse
	<i>Phenacomys intermedius</i>	heather vole
	<i>Spermophilus saturatus</i>	Cascade golden-mantled ground squirrel
	<i>Tamiasciurus douglasi</i> ¹	Douglas squirrel
	<i>Tamiasciurus hudsonicus</i> ¹	red squirrel
	Carnivora	<i>Canis latrans</i> ¹
<i>Felis concolor</i>		mountain lion
<i>Gulo luscus</i>		wolverine
<i>Lynx canadensis</i>		lynx
<i>Lynx rufus</i>		bobcat
<i>Martes americana</i>		marten
<i>Martes pennanti</i>		fisher
<i>Mustela erminea</i>		ermine
<i>Mustela frenata</i>		long-tailed weasel
<i>Procyon lotor</i>		raccoon
Artiodactyla	<i>Ursus americanus</i>	black bear
	<i>Vulpes fulva</i>	red fox
	<i>Odocoileus hemionus</i>	mule deer
	<i>Oreamnos americanus</i> ¹	mountain goat

¹Species observed or previously cited as seen.

Table BG-3 — Tentative list of birds which utilize the Boston Glacier Research Natural Area

Scientific name	Common name
<i>Accipiter cooperii</i>	Cooper's hawk ¹
<i>Accipiter gentilis</i>	goshawk ¹
<i>Accipiter striatus</i>	sharp-shinned hawk
<i>Aegolius acadicus</i>	saw-whet owl
<i>Aquila chrysaetos</i>	golden eagle ¹
<i>Asio otus</i>	long-eared owl
<i>Bubo virginianus</i>	great horned owl
<i>Buteo jamaicensis</i>	red-tailed hawk ¹
<i>Carpodacus cassinii</i>	Cassin's finch
<i>Carpodacus purpureus</i>	purple finch
<i>Certhia familiaris</i>	brown creeper
<i>Chaetura vauxi</i>	Vaux's swift
<i>Cinclus mexicanus</i>	dipper
<i>Colaptes auratus</i>	yellow-shafted flicker ¹
<i>Columba fasciata</i>	band-tailed pigeon
<i>Contopus sordidulus</i>	western wood peewee ¹
<i>Cyanocitta stelleri</i>	Steller's jay ¹
<i>Cypseloides niger</i>	black swift ¹
<i>Dendragapus obscurus</i>	blue grouse ¹
<i>Dendrocopos pubescens</i>	downy woodpecker
<i>Dendrocopos villosus</i>	hairy woodpecker
<i>Dendroica auduboni</i>	Audubon's warbler ¹
<i>Dendroica coronata</i>	myrtle warbler
<i>Dendroica petechia</i>	yellow warbler
<i>Dendroica townsendi</i>	Townsend's warbler ¹
<i>Dryocopus pileatus</i>	pileated woodpecker
<i>Empidonax</i> sp.	flycatcher
<i>Falco columbarius</i>	pigeon hawk
<i>Falco sparverius</i>	sparrow hawk ¹
<i>Glaucidium gnoma</i>	pygmy owl
<i>Haliaeetus leucocephalus</i>	bald eagle
<i>Hesperiphona vespertina</i>	evening grosbeak
<i>Hylocichla guttata</i>	hermit thrush
<i>Hylochichla ustulata</i>	Swainson's thrush
<i>Ixoreus naevius</i>	varied thrush
<i>Junco oreganus</i>	Oregon junco
<i>Lagopus leucurus</i>	white-tailed ptarmigan
<i>Leucosticte tephrocotis</i>	gray-crowned rosy finch
<i>Loxia curvirostra</i>	red crossbill
<i>Myadestes townsendi</i>	Townsend's solitaire ¹
<i>Nucifraga columbiana</i>	Clark's nutcracker
<i>Nuttallornis borealis</i>	olive-sided flycatcher
<i>Oporornis tolmiei</i>	MacGillivray's warbler
<i>Otus asio</i>	screech owl
<i>Parus gambeli</i>	mountain chickadee ¹
<i>Passerella iliaca</i>	fox sparrow
<i>Perisoreus canadensis</i>	gray jay
<i>Pinicola enucleator</i>	pine grosbeak
<i>Piranga ludoviciana</i>	western tanager

Disturbance

The *Carex* meadow in the northeastern portion of the Research Natural Area near the Skagit Queen Mine is slightly disturbed from past working. This old mine represents the only human disturbance in this highly inaccessible natural area.

Research

Aside from being included in some glacial aerial photographic studies (Hubley 1956, LaChapelle 1962, Post *et al.* 1971), little research has been conducted on the Boston Glacier Research Natural Area. A limited amount of limnological data has been collected on the pond.¹⁰ Boston Glacier Research Natural Area is an excellent site for studies dealing with glaciers and their impact in the ecosystem as the glacier is presently active, having fluctuated considerably over the past 25 years. An on-going program of observations would allow the study of these fluctuations, their causes, and the response of flora and fauna to them.

Maps and Aerial Photographs

Special maps applicable to the natural area include: topographic Forbidden Peak, Cascade Pass, and Mt. Logan, Washington; 7.5' Quadrangles, scale 1:24,000 issued by U.S. Geological Survey in 1963; Geologic Map of Washington, scale 1:500,000 (Hunting *et al.* 1961). The Superintendent, North Cascades National Park, (Sedro Woolley, Washington) can provide details on the most recent aerial photo coverage and forest type maps for the area.

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¹⁰Wassem, C. Robert. Personal communication.