SUMMARY OF ENVIRONMENTAL KNOWLEDGE OF THE PROPOSED GRANT LAKE HYDROELECTRIC PROJECT AREA

FINAL REPORT

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INTRODUCTION

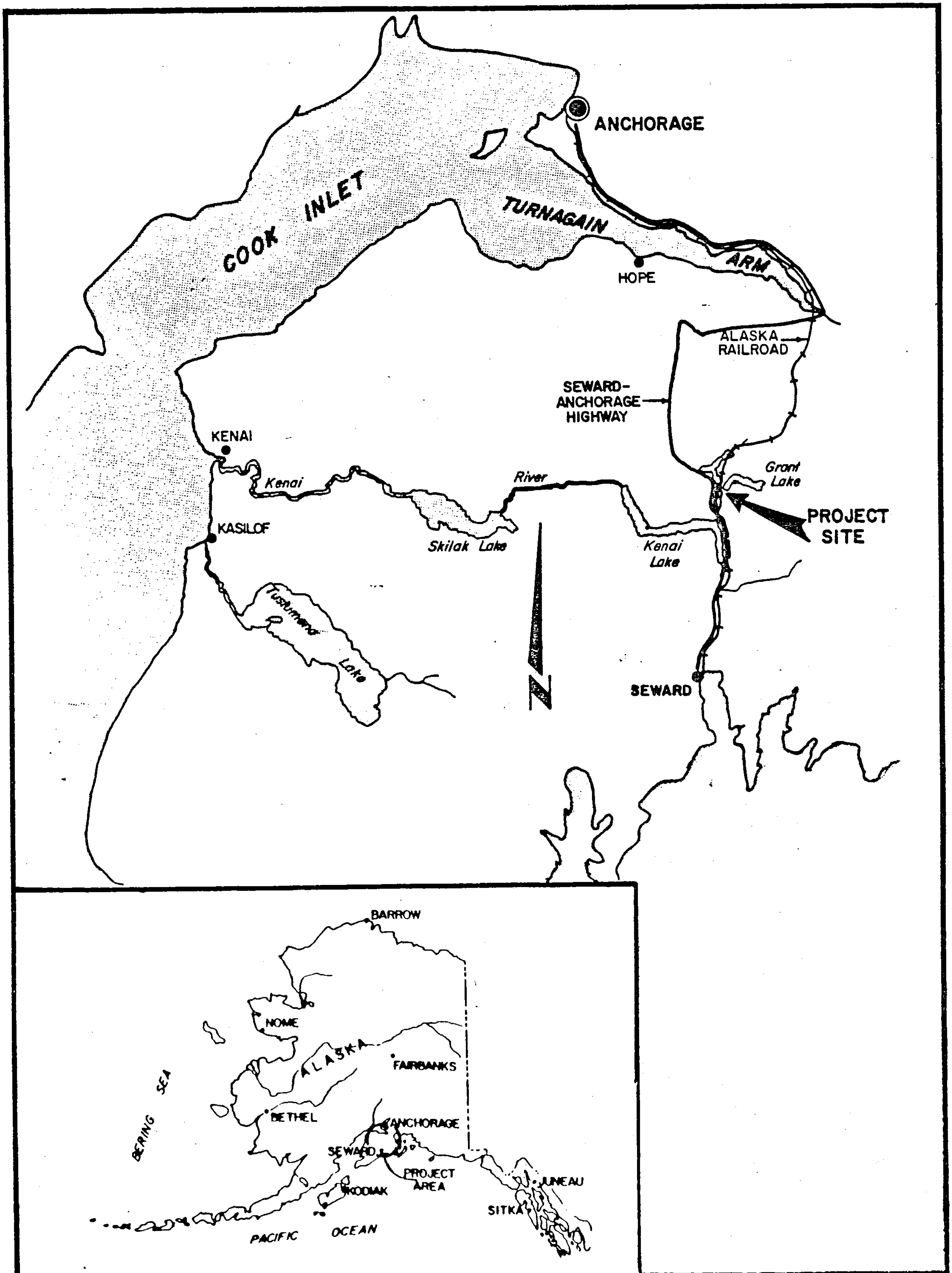
REPORT CONTENTS

This report presents environmental information on the proposed Grant Lake hydroelectric project area (Figure 1). The University of Alaska's Arctic Environmental Information and Data Center (AEIDC) conducted studies of this region under contract to Ebasco Services, Inc. Our staff gathered available published and unpublished environmental and archeological/historical knowledge and supplemented this base of information with specific field investigations in the project area during the period October 1981 through September 1982. Also, knowledgeable state and federal agency representatives and local residents were interviewed to obtain additional information on the natural resources of the area, particularly the human use of resources.

Because environmental information on the Grant Lake project area was unavailable in certain categories, we focused field study efforts to fill gaps in knowledge of fish and wildlife species, archeological and historical resources, and terrestrial and aquatic habitat features. This information will ultimately be required for various construction permits and Federal Energy Regulatory Commission licensing. Field studies were limited to four- or five-day seasonal sampling trips by a multidisciplinary field party in October 1981, March 1982, May 1982, and July/August 1982. Several one-day trips to the project site provided additional fishery and wildlife information.

This report summarizes the data gathered from these brief field surveys. (The results of archeological/historic investigations conducted during June 1982 are included as Appendix A.) Because engineering measurements predominantly appear in English units and other sciences tend to use metric measurements, we were faced with a conversion conflict between consistency and accuracy. Stylistic considerations turned out to be far less compelling than arguments for reporting measurements exactly as they were made by original authors and researchers.

Figure 1. Location of the Grant Lake hydroelectric project.



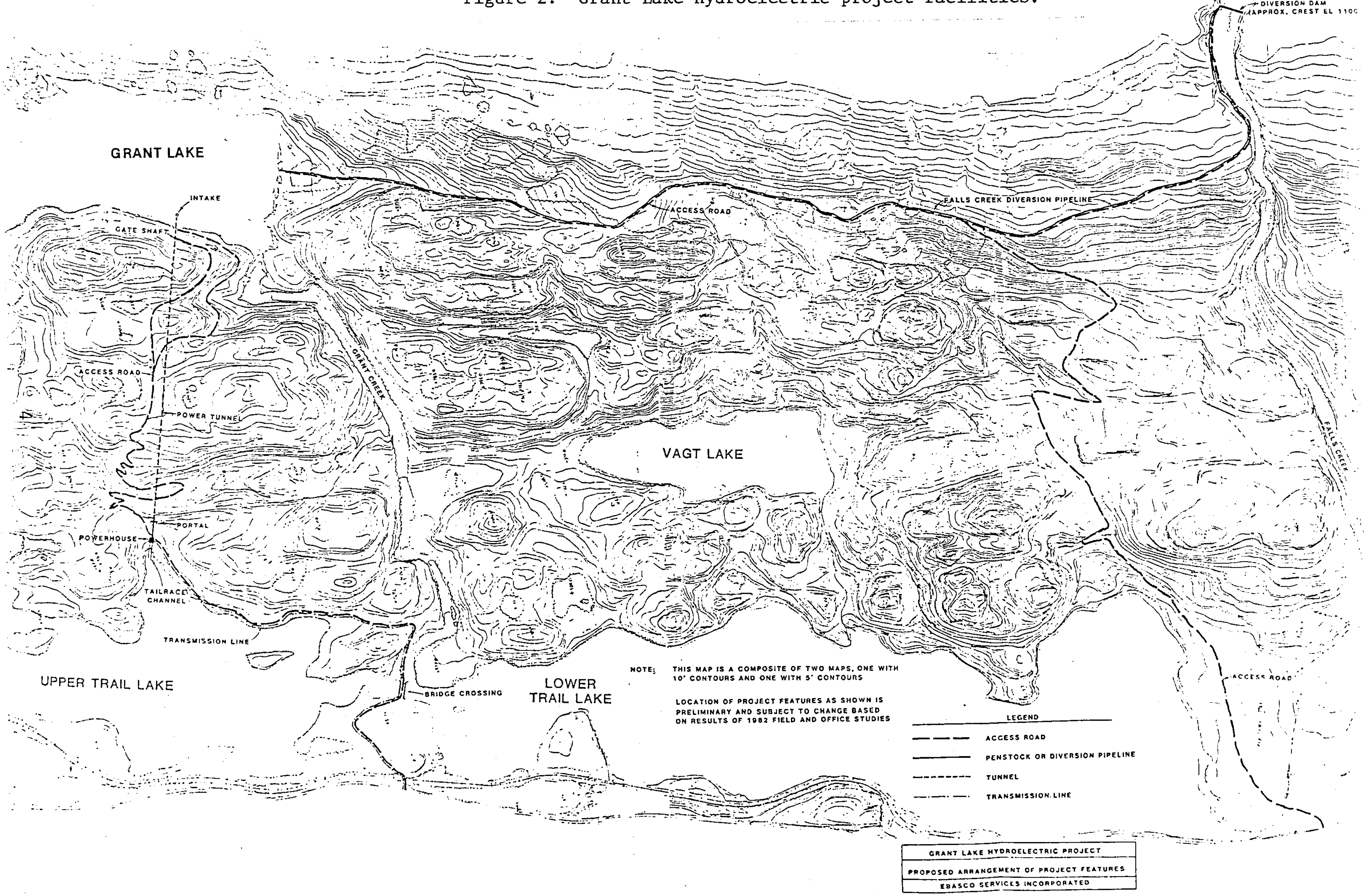
PROJECT FACILITIES

The Grant Lake hydroelectric project site (Figure 2) is approximately 20 miles north of Seward, Alaska. During the 1981 phase of our study, the proposed configuration of this project was to have involved construction of a dam at the outlet of Grant Lake (Grant Creek) and a small dam across a saddle on the western shore of the lower basin of Grant Lake. The lake water surface elevation was to rise and fall annually, and lake shoreline and Inlet Creek floodplain acreage were going to be seasonally inundated. Continuous streamflow in Grant Creek was essentially to have ceased. Streamflow from adjacent Falls Creek was to be diverted to the Grant Lake reservoir by surface conduit, and continuous flow below the diversion (1,000 ft elevation) also was to cease. The first segment of our field investigations, focused on the dam, shoreline inundation, streamflow reduction, and other site-specific impacts related to the original projected configuration.

After the initial engineering and geologic data were evaluated in more detail, Ebasco revised the configuration of the overall project facilities and recommended an alternative scheme in early 1982 (Ebasco Services, Inc. 1982). We immediately shifted the emphasis of the remainder of the field investigations to assess the new project features. As now conceived, the project would tap Grant Lake water via a low-level power tunnel and short length of steel penstock to supply a 6-megawatt powerhouse on Upper Trail Lake. A 180-foot tailrace would be excavated from the powerhouse to Upper Trail Lake. No dams on Grant Lake would be required, and lake level would fluctuate from present level (elevation 690 ft) down to elevation 660 feet. Streamflows in Grant Creek would essentially cease except during brief periods of spill. Falls Creek also would be diverted, and streamflow in the lower basin would cease. The natural constriction at the narrows between the upper and lower basins of Grant Lake (Figure 3) would be blasted and dredged to a width of approximately 25 feet and to a lake bottom elevation of approximately 655 feet.

In addition to these development features, about 2.7 miles of road access from nearby Seward Highway would be constructed to the

Figure 2. Grant Lake hydroelectric project facilities.



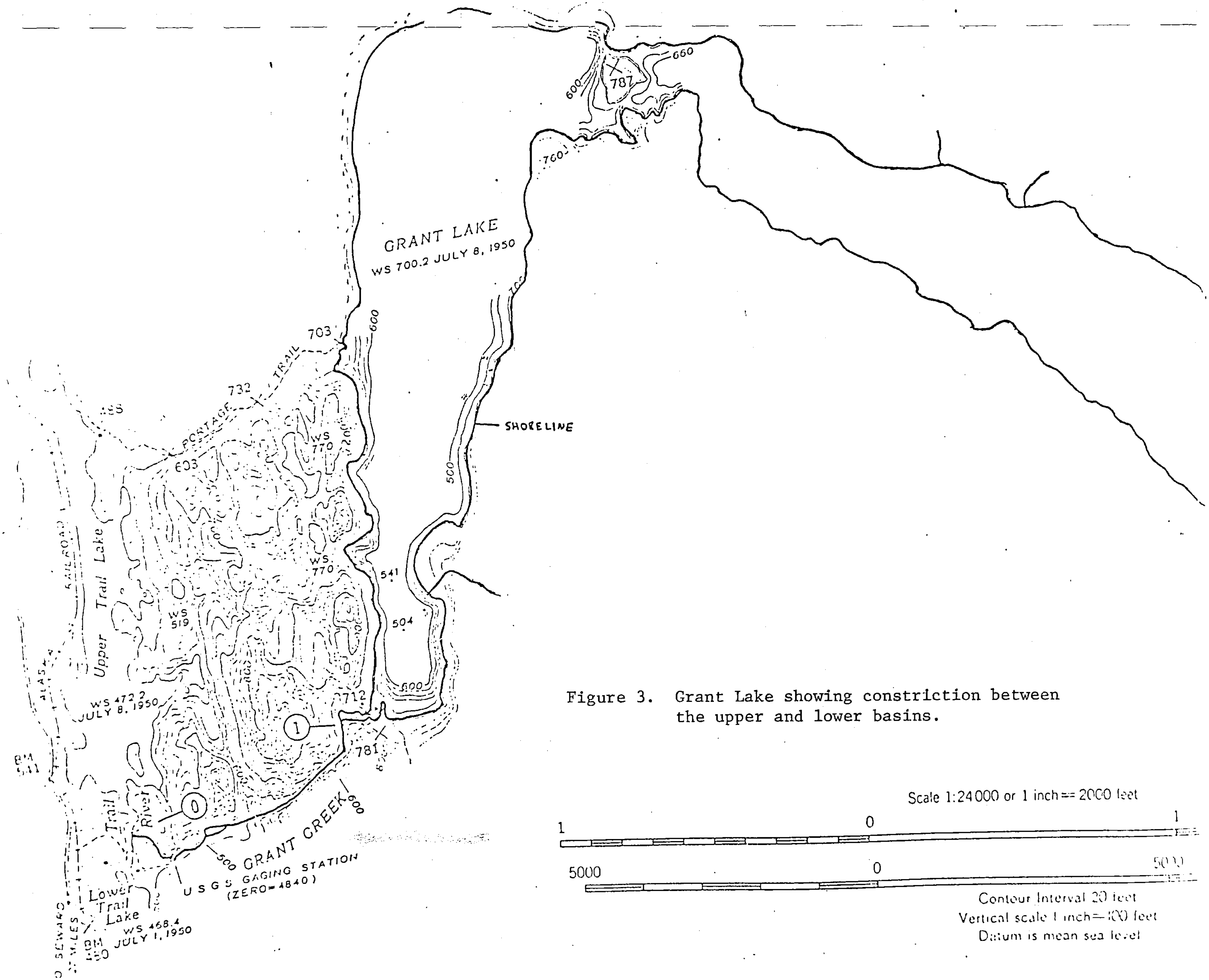


Figure 3. Grant Lake showing constriction between the upper and lower basins.

powerhouse site on Upper Trail Lake and to the intake works on the lower basin of Grant Lake. Road access would not cross Vagt Creek but instead would include a 350-foot bridge across the narrows between Upper and Lower Trail lakes. A 69-kv transmission line would extend from the powerhouse to the City of Seward's Falls Creek metering point.

SCOPE OF AEIDC SERVICES

Our contractual mandate was to gather relevant data through literature review, interview, and limited field study and to produce a summary report that inventories available knowledge and presents data gathered from field investigations in the following categories--water use and quality; aquatic biota; terrestrial biota; vegetation; and archeological and historical resources. Accordingly this report provides a summary of environmental knowledge of the proposed project area based principally on information from literature sources and interviews. Field investigations were brief and confined to the collection of seasonal baseline data.

The proposed Grant Lake hydroelectric project would permanently alter the environmental features of this region with construction of roads, transmission lines, tunnel, powerhouse, penstock, tailrace, and pipelines; by altered streamflows and water quality; and by disturbance of wildlife. Minimizing and mitigating predictable adverse environmental effects would be required. No environmental assessment of potential impacts of the project was made by AEIDC as that responsibility belongs solely to Ebasco. In addition, all graphics presented herein are in draft form. Final illustrations are to be drafted by Ebasco.

METHODS AND PROCEDURES

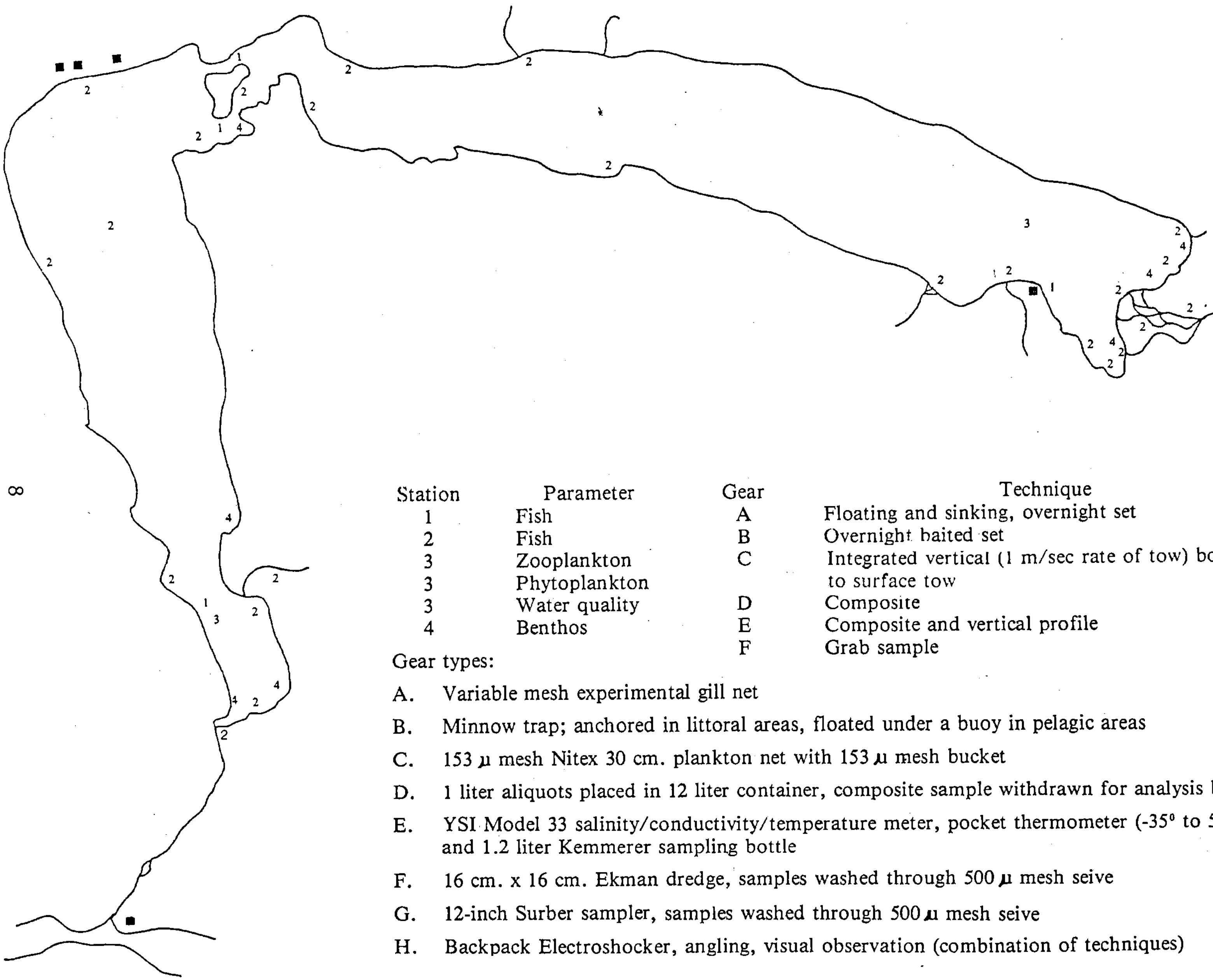
AQUATIC BIOTA

WATER USE AND QUALITY

Limnological and fisheries resource inventories have been compiled for several lakes and streams in southcentral Alaska, principally by the Alaska Department of Fish & Game (ADF&G), the U.S. Geological Survey (USGS), and the U.S. Forest Service (USFS). To augment the information available for the project area, we established a water quality monitoring program for Grant Lake, Grant Creek, Vagt Creek, and Falls Creek. Water quality samples were taken from one of the deepest sections of Grant Lake's upper and lower basins. A sampling station was established in each lake basin on our first field trip and permanent shoreline landmarks were used to facilitate returning to these stations on all subsequent field trips. Vertical measurements were made for temperature, dissolved oxygen, and water clarity (Secchi). Composite water samples were collected from Grant Lake (each basin), Grant Creek, Falls Creek, and Vagt Creek for conductivity, selected ions, nitrate, orthophosphate, alkalinity, hardness, total dissolved solids, suspended solids, turbidity, pH, and coliform bacteria. Turbidity and suspended solids were also measured at 50 m depth in both Grant Lake basins in June and August 1982. Phytoplankton samples were taken and shipped to Ebasco for analysis. During winter, openings in the ice were made with a hand operated ice auger to facilitate use of plankton nets, water sampling bottles, and water quality instrument probes. Figures 4, 5, and 6 show the location of sampling stations.

Water quality measurements were obtained with a YSI Model 33 salinity/conductivity/temperature meter, pocket thermometer (-35° to 50°C), YSI Model 51B oxygen meter, portable field pH meter, and 20-cm Secchi disc. A 1.2-liter Kemmerer sampling bottle was used for collecting water samples. Composite samples were placed in a polyethylene carboy, and 1-liter samples were drawn in polyethylene containers, stored in an iced cooler, and returned within 24 hours to Anchorage for analysis. Chemical and Geological Laboratories of

Figure 4. Aquatic biota sampling techniques and sampling locations, Grant Lake, 1981-1982.



Station	Parameter	Gear	Technique	Replicates
1	Fish	A	Floating and sinking, overnight set	1 series/season except winter
2	Fish	B	Overnight baited set	1 series/season except winter
3	Zooplankton	C	Integrated vertical (1 m/sec rate of tow) bottom to surface tow	2X composite/season
3	Phytoplankton			1 series/season
3	Water quality	D	Composite	1 series/season
4	Benthos	E	Composite and vertical profile	2X composite/season
		F	Grab sample	

Gear types:

A. Variable mesh experimental gill net

B. Minnow trap; anchored in littoral areas, floated under a buoy in pelagic areas

C. 153 μ mesh Nitex 30 cm. plankton net with 153 μ mesh bucket

D. 1 liter aliquots placed in 12 liter container, composite sample withdrawn for analysis by Ebasco

E. YSI Model 33 salinity/conductivity/temperature meter, pocket thermometer (-35° to 50°C), and 20 cm Secchi disc, and 1.2 liter Kemmerer sampling bottle

F. 16 cm. x 16 cm. Ekman dredge, samples washed through 500 μ mesh seive

G. 12-inch Surber sampler, samples washed through 500 μ mesh seive

H. Backpack Electroshocker, angling, visual observation (combination of techniques)

■ Cabin or associated building

Figure 5. Study areas and aquatic biota sampling techniques, Grant Creek, 1981-1982.

Parameter	Gear	Technique	Study Area	Replicates
Periphytes	A	Hand collection	1	1 series/season
Benthos	B	Surber sample	1	1 series/season
Phytoplankton	C	Composite (3 sites)	1-3	1 series
Water quality	D	Composite (3 sites)	1-3	1 series/season
Fish	E	In situ sampling	1-4	1 series/season
Fish	F	Overnight baited set	1-4	1 series/season
Fish	G	Block & removal	1	1 series

Gear types:

A. Scrub brush - 12-inch Surber sampler

B. 12-inch Surber sampler, samples washed through 500 μ mesh seive

C. 1 liter aliquots placed in 12 liter container, composite sample withdrawn for analysis by Ebasco

D. YSI Model 33 salinity/conductivity/temperature meter, pocket thermometer (-35° to 50°C). Samples collected for analysis by Chem-Geo Labs Inc. and Ebasco

E. Backpack Electroshocker, angling, visual observation (combination of techniques)

F. Minnow trap

G. Block study area with net, capture and remove fish with electroshocker

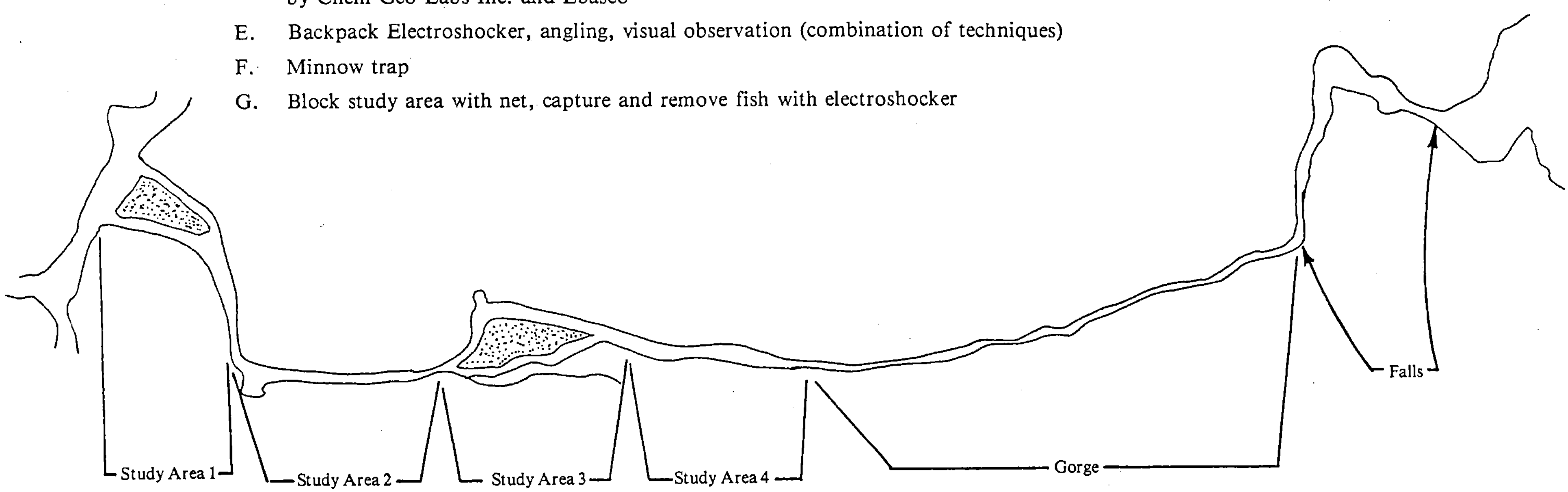


Figure 6. Study areas and aquatic biota sampling techniques, Falls Creek, 1981-1982.

Parameter	Gear	Technique	Study Area	Replicates
Benthos	A	Surber sample	1-2	1 series/season
Phytoplankton	B	Composite (3 sites)	1-2	1 series/
Water quality	C	Composite (3 sites)	1-2	1 series/season
Fish	D	In situ sampling	1-4	1 series/season
Fish	E	Overnight baited set	1-4 and above lower mine areas *	1 series/season

Gear types:

A. 12-inch Surber sampler, samples washed through 500 µ mesh seive

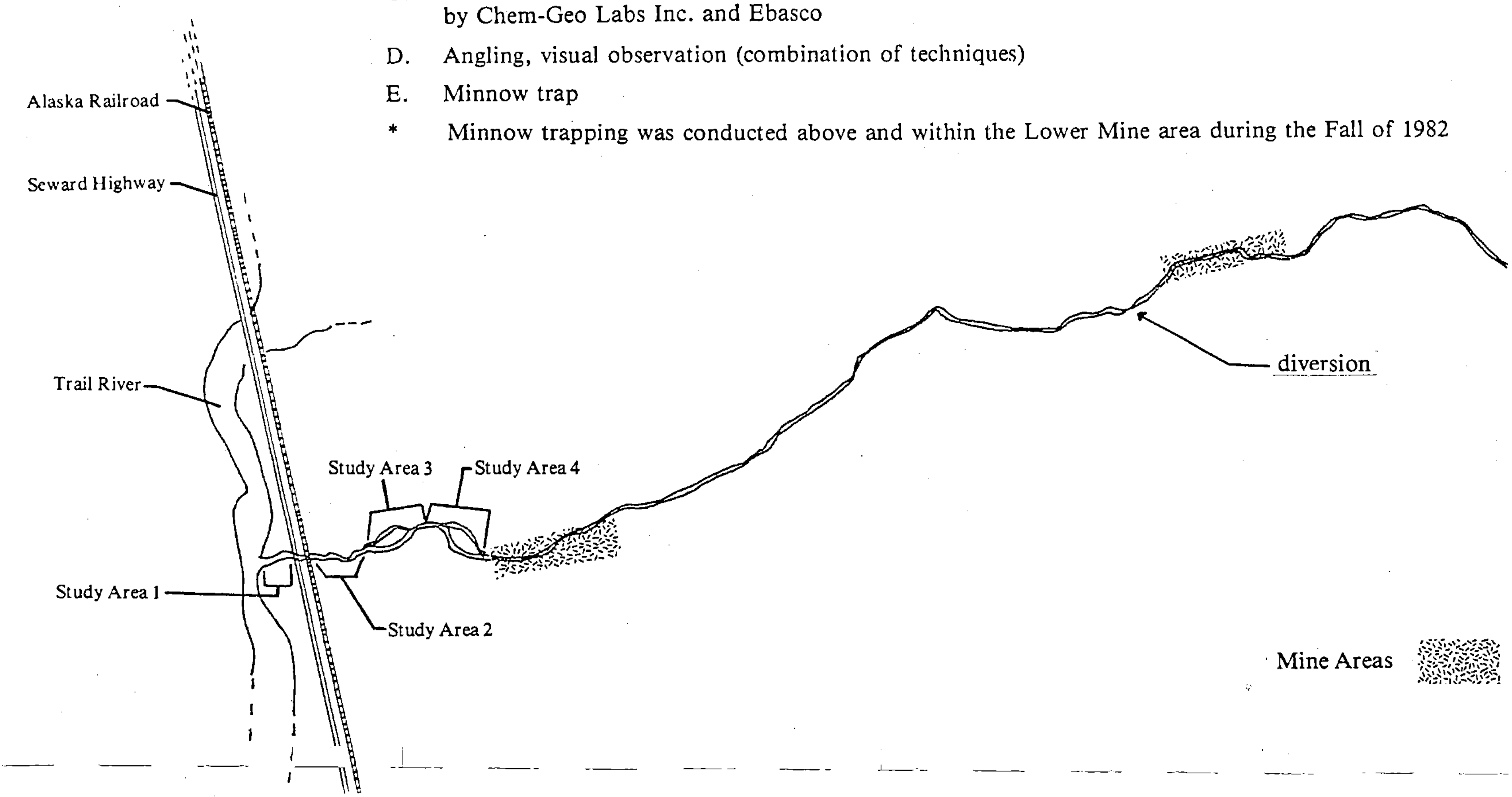
B. 1 liter aliquots placed in 12 liter container, composite sample withdrawn for analysis by Ebasco

C. YSI Model 33 salinity/conductivity/temperature meter, pocket thermometer (-35° to 50°C). Samples collected for analysis by Chem-Geo Labs Inc. and Ebasco

D. Angling, visual observation (combination of techniques)

E. Minnow trap

* Minnow trapping was conducted above and within the Lower Mine area during the Fall of 1982



Alaska, Inc. provided sterile containers for collecting coliform samples. The same firm analyzed the water samples for total dissolved solids, suspended solids, select ions, and chemical nutrients. Amtest Laboratories, Seattle, Washington, supplied special containers and tested additional water samples for heavy metals content.

INVERTEBRATES

Prior to this study, very little background information existed on the aquatic invertebrates in project area waters. We gathered site-specific seasonal data concerning macroinvertebrate and zooplankton distribution and relative abundance.

Zooplankton were collected in each lake basin by making duplicate vertical tows from a 50-m depth to the surface using a No. 10 Nitex net 30 cm in diameter and 1 m long. Straining cloth for the No. 10 Nitex net had an aperture of 153 microns and 45 percent open area. We preserved plankton in 70 percent alcohol and, in our Anchorage laboratory, identified and counted them on a Sedgewick Rafter counting cell. We used a 6-in (152 cm) Ekman dredge to collect lake bottom fauna and a 12-in (30 cm) Surber sampler to collect stream benthos. Lake and stream bottom samples were washed in a screen bucket having 30 meshes per inch. Organisms were preserved in 70 percent alcohol, identified to the lowest possible taxon, and enumerated according to area or volume of habitat originally sampled. Figures 4, 5, and 6 show sampling schedules and site locations.

FISHERIES RESOURCES

The fisheries studies we conducted in the project area sought to identify the seasonal presence of resident and anadromous fish species, their relative abundance, and their habitat use characteristics. In order to accomplish these objectives AEIDC biologists conducted week-long field investigations in October, 1981, and in March, May, June, and August of 1982. We used the following methods to investigate habitats in Grant Lake: a 125-foot variable mesh gill net, with five 25-foot panels ranging in size from 0.5 inch to 2.5 inch bar measurements, set floating and sinking overnight; minnow traps (baited with salmon roe) set overnight, anchored in littoral areas and floated under a buoy in pelagic areas; and visual observation. Figure 4 summarizes sampling locations, parameters, and methods in Grant Lake and Figures 5 and 6 provide this information for Grant and Falls Creek. We divided Grant Creek and Falls Creek into discrete study areas to facilitate the analysis of fish distribution and habitat characteristics. We used the following methods to investigate these rearing and spawning habitats: minnow traps baited with salmon roe set overnight; a backpack electroshocker; angling; visual observation. A block and removal methodology (Zippin 1958) was used to attempt a quantitative assessment of the fish populations in Grant Creek (see results in Appendix B). This methodology was not used in Falls Creek due to high water conditions and the low numbers of fish observed using other methods.

TERRESTRIAL BIOTA

BOTANICAL RESOURCES

Phytoplankton and periphyton samples were taken during each field trip, preserved, and shipped to Ebasco for analysis. We collected phytoplankton in Grant Lake in a 1.2-liter Kemmerer bottle at several surface locations in each basin and one near bottom (50 m) in each basin. Each sample was then added to a 12-liter carboy and two 1-liter aliquots were withdrawn from this composite sample. Surface samples from Grant Creek, Falls Creek, and Vagt Creek were preserved in 70 percent alcohol, concentrated to approximately 100 ml, and retained for analysis by Ebasco staff. Periphyton samples from Grant Creek, Falls Creek, and Vagt Creek were obtained by scrubbing stream bottom surfaces (logs, cobbles, etc.) and then preserving them in 70 percent alcohol for analysis by Ebasco.

We prepared the vegetation association map by using 1978 NASA high-altitude, color-enhanced, infrared photography, corrected to a scale of 1:24,000 with the aid of photomechanical enlargement. We delineated vegetation associations with standard manual air-photo interpretation techniques. Mapping units are generally combinations of plant community types which could be delineated from aerial photos.

The descriptions of the mapping units reflect the variations within each type.

During July 1982 we field checked the preliminary vegetation map prepared in 1981. We visited representative areas of each delineated type as well as questionable areas, previously disturbed areas, and sites to be directly impacted by project development. We did not seek quantitative data on plant distribution, composition, or abundance but instead made qualitative assessment of the relative abundance of dominant plants in areas to be directly affected by the proposed project. Areas slated for modification by project structures were measured and compared to the total available acres of each vegetation type. The vegetation was described in terms of dominant over- and understory plants. Botanical names follow Hulten (1968), and are presented in Appendix C.

WILDLIFE RESOURCES

Prior to the initiation of the field study program, we reviewed the literature and interviewed knowledgeable residents and agency personnel to identify likely components of the project area's fauna. Once this was accomplished, we compiled life histories for each of the major species and species groups thought to reside in the study area. The purpose of this review was twofold: (1) to identify the chief natural limiting factors governing population size of each species and species group in Alaska and (2) to identify those aspects of individual life histories which relate to the timing of key biological events (e.g., den site selection, the rut, parturition, etc.) which may be subject to the influences of human activity.

Beginning in the fall of 1981 and extending through the summer of 1982, we conducted a series of reconnaissance-level field surveys, both foot and aerial, to ascertain the presence, distribution, relative abundance, and use patterns of various species and species groups within the project area and to identify the distribution and relative value of important seasonally-limited habitats and their relationship to project works. Replicate once-per-season foot surveys were conducted on all sites likely to be disturbed or modified as a result of project construction (access road corridors, the powerhouse site, penstock, etc.). Foot surveys were also conducted through adjacent areas to compare habitats at project sites to other habitats in the study area and to migration routes.

Data recorded during foot surveys included the sightings of individual animals and/or sign indicative of their presence (tracks, scat, browse lines, etc.), the type of vegetation community the sighting occurred in, and an appraisal of the habitat quality for each species at each observation site. Habitat quality was subjectively evaluated in the field on the basis of an interpretation of the amount and quality of forage items available at each site along with indications of past use of the available food resource. Replicate systematic aerial surveys were conducted seasonally to augment information gleaned from the ground on the seasonal distribution and relative abundance of each of the species and species groups targeted for the study. Data recorded included species type, numbers, sex and age composition, location, time of day, an estimate of viewing conditions, and sign (tracks in snow, excavations by bears, etc.) indicative of an animal's presence.

Our staff synthesized the results of the literature and field surveys into a description of use of the project area by various species. We then drew correlations between vegetation communities and the observed use by animals, providing an index of habitat use by species by season. Next we identified those natural factors deemed capable of limiting given populations in the study area. A subjective appraisal of habitat quality was also made.

WATER USE AND QUALITY

GENERAL DESCRIPTION OF THE LOCALE AND EXISTING WATER USES

The eastern Kenai Peninsula is in a maritime climatic region, which in Alaska means cool summers, mild winters, high precipitation, and frequent storms with high winds. Precipitation is least in the spring and greatest during the late summer and early autumn. Annual rainfall exceeds 40 inches in the eastern mountainous parts of the study area.

Grant Lake is located in the Chugach Mountains of the Kenai Peninsula approximately 27 miles northeast of Seward at an elevation of 700 ft. Its drainage area is 43.5 square miles. An island and narrows at a right angle separate the lake into two basins with a total surface area of 2.5 square miles. The lower basin is 1.5 miles long and 0.5 miles wide and is flanked by steep mountains on the east and a low divide to the west. The upper basin is 3.5 miles long and 0.5 miles wide and is confined between steep slopes with a flat-bottomed valley containing a major unnamed tributary, herein called Inlet Creek, at its upper end. Several other small glacial streams feed into Grant Lake, causing seasonally moderate to heavy turbidity of the lake waters.

Access to the project area is by the Anchorage-Seward highway and the Alaska Railroad, both of which lie parallel to Trail Lake, crossing the lower sections of Falls and Ptarmigan creeks and running within 0.25 mile of the mouth of Grant Creek. The few residents of the project area primarily live along the highway. Commercial development within the project area has been limited to a hunter's cabin on upper Grant Lake, a recreation cabin at the mouth of Grant Creek, and a few mines, now largely inactive. One cabin and appurtenant mine operation buildings are located on the north side of lower Grant Lake.

Currently, Grant Lake serves as a staging area for sportsmen hunting in the valley above upper Grant Lake basin and in the mountainous area surrounding the lake. Floatplanes utilize both basins, and several areas (including a permanent cabin on the shore of upper Grant Lake) are used as seasonal camps. Hikers and snowmobilers also gain access to Grant Lake from the Trail lakes via a well-used trail.

Several canoes are stored at the trailhead on Grant Lake near the remains of several camping sites. The mine on the lower basin of Grant Lake is accessed by a Cat trail extending from the east shore of Upper Trail Lake to the miner's cabin area. According to Moose Pass residents, a lone individual spends the spring through fall seasons tending a hard rock gold mine in the mountain flank above Grant Lake. Presumed limited domestic use is made of the lake by this individual for wash water and for recreation.

USGS gaged Grant Creek for 11 years, from 1947 to 1959, at a location 0.3 miles upstream from its mouth. This is the primary source of hydrologic data for the Grant Lake basin. The mean annual flow during this period was 198 cfs. Minimum discharge occurred during March and peak discharge during July. Figure 7 summarizes flow data.

Originating from Grant Lake, Grant Creek flows approximately 1.1 miles southwesterly, emptying into the Trail River between Upper and Lower Trail lakes. Very fine glacial flour (a colloidal suspension of very fine inorganic particles) remains in suspension throughout its course. Grant Creek has a stream gradient of 207 ft per mile.

Streamflow in the watershed of the study area is mostly of glacial origin. Flow in these streams is high and reflects the greater precipitation in the mountains. Glacial streams typically display a period of high flow during the summer months and a period of low flow during the winter months.

The quality of surface water in the Kenai River watershed is generally good. Artesian water may contain objectionable quantities of iron or chloride near the coast. Water in glacial streams contains low concentrations of dissolved solids but contains glacial flour and is, therefore, turbid most of the year.

Measured surface water temperature in the Kenai River has been reported to range from near 0 to 17°C. Total ice cover for the Kenai River does not generally occur until mid-November, and ice breakup can occur as early as February. In some years the Kenai River does not freeze over. Large lakes, like Grant, Upper Russian, and Hidden, generally freeze in November and thaw in late April or early May.

Figure 7. Mean monthly streamflow in cfs for Grant Creek, 1947-58.

Month	Minimum	Maximum	Mean
October	91	381	184
November	64	251	189
December	35	121	56
January	28	38	31
February	22	27	23
March	18	22	20
April	20	57	31
May	58	277	152
June	260	786	448
July	388	736	518
August	270	663	413
September	169	551	307

Source: U.S. Fish and Wildlife Service 1961.

The primary access to Grant Creek is by boat across Lower Trail Lake, and the creek receives moderate recreational use, principally fishing, near the confluence with the Trail Lakes system. Moose Pass and other area residents hike the lower 0.5 to 0.75 mile of Grant Creek to fish for Dolly Varden, rainbow trout, or Arctic grayling throughout the spring and summer months. The creek is closed to all salmon fishing (by ADF&G regulation). This trail is well used and parallels the south side of Grant Creek from the mouth to the canyon. Presumably the owner of a cabin near the mouth of the creek obtains water from Grant Creek for various domestic uses during all times of the year.

Vagt Creek drains Vagt Lake, which is a natural lake on a bench above Lower Trail Lake at an elevation of about 575 ft. Vagt Creek is about 1,500 ft in length, 9 ft wide, and has an overall gradient of about 6 percent. Access to Vagt Creek and Vagt Lake is by a trail around the shore of Trail Lake originating from near the highway bridge over Trail River. ADF&G rehabilitated Vagt Lake in 1974 to remove undesirable fish and now manage it as a public recreation fishery, occasionally restocking it with rainbow trout. Hikers frequently travel this trail during summer to access Vagt Lake for various recreational purposes. Evidence of campsites is abundant around the lake perimeter. Another trail parallels Vagt Creek to Lower Trail Lake and appears well used. Sport fishing is poor in Vagt Creek due to its small size and the placement of rock filled gabions at the Vagt Lake outlet, emplaced primarily to prohibit outmigration of stocked rainbow trout.

Falls Creek drains the precipitous area between the Grant Lake and the Ptarmigan Lake watersheds. It is 8 miles in length and has a drainage of 11.9 square miles at its mouth. There are no lakes or major tributaries in the drainage. The water originates mostly from snowmelt and is clear except for periods of turbidity during high water. Mining activities and access roads can be found throughout the valley. An inoperative gold mine is located 3 miles upstream, and an active gold claim exists on the lower stream reach just above the highway. This placer mine operation has extensively channelized lower Falls Creek. In addition to this mining activity, numerous private residences are present near Falls Creek, but actual use of Falls Creek area is generally limited to snowmobile and horseback riding. Moderately turbid water from runoff and from two placer mines probably precludes consumptive use of creek waters.

ALASKA WATER QUALITY STANDARDS

State water quality standards, which provide for the protection of identified uses of Alaska's waters, are under the auspices of the Alaska Department of Environmental Conservation through Alaska Statutes Title 46, Chapter 3. All water bodies in the project area are classified by the State of Alaska as Class C, "Water used for growth and propagation of fish, shellfish, other aquatic life, and wildlife including waterfowl and furbearers."

Water quality criteria, when used in combination with the water use designation, constitute the water quality standard for a particular water body. Water quality standards regulate man-made alterations to the waters of the state. Figure 8 presents water quality criteria applicable to each protected water.

EXISTING WATER QUALITY KNOWLEDGE OF THE PROJECT AREA

Limnological and fisheries resource inventories have been compiled for several lakes and streams in southcentral Alaska, principally by USGS, USFS, U.S. Fish and Wildlife Service (USFWS), and ADF&G (ADF&G 1981; Blanchet 1981; Howse 1972; Still 1976, 1980; USFWS 1961; USGS 1981). The object of these investigations was to gather background data and to determine the relationship of physical, chemical, and biological characteristics to water quality and fish habitat and production. USGS has collected and analyzed water quality samples from surface waters of Alaska since 1949. Figure 9 lists sites and the type of water quality data collected near the proposed Grant Lake hydroelectric project. Figure 10 shows the location of these sites. Most of the streams in southcentral Alaska are similar chemically. Small differences may reflect variations in geology of the drainage basins and morphometry of the streams. Figure 11 provides a summary of the physical-chemical characteristics of these waters collected by USGS in previous years.

Figure 8. Water quality criteria and applicable standards.

Parameter	EPA Criteria[1]	Alaska Standard[2]
Nitrate	Restrictive criteria/not recommended	No standard
Phosphate (ortho)	No recommendation	No standard
Total hardness (as $CaCO_3$)	Equal to alkalinity	No standard
Alkalinity (as $CaCO_3$)	20 mg/l or more except where natural conditions are less	No standard
Total dissolved solids	No recommendation	Not to exceed 1,500 mg/l. Increases in TDS not to exceed one-third of the concentration of the natural condition of the body of water.
Suspended solids	Should not reduce the depth of the compensation point for photosynthetic activity by more than 10% from the seasonally established norm.	No standard
pH	6.5-9.0	6.5-9.0. Not to vary more than 0.5 pH units from natural conditions.
Water clarity (Secchi)	No recommendation	No standard
Turbidity	Depth of light penetration should not be reduced by more than 10%	Not to exceed 25 NTU above natural level for stream, 5 NTU for lakes.
Conductivity	No recommendation	No standard
Coliforms	No recommendation	No standard
Silver	1.2 ug/l	Not to exceed criteria in EPA, 1976
Aluminum	No recommendation	Not to exceed criteria in EPA, 1976
Arsenic	440 ug/l	Not to exceed criteria in EPA, 1976
Gold	No recommendation	Not to exceed criteria in EPA, 1976
Boron	No recommendation	Not to exceed criteria in EPA, 1976
Barium	No recommendation	Not to exceed criteria in EPA, 1976
Bismuth	No recommendation	Not to exceed criteria in EPA, 1976
Calcium	No recommendation	Not to exceed criteria in EPA, 1976
Cadmium	1.5 ug/l	Not to exceed criteria in EPA, 1976
Cobalt	No recommendation	Not to exceed criteria in EPA, 1976
Chromium	2,200 ug/l	Not to exceed criteria in EPA, 1976
Copper	12 ug/l	Not to exceed criteria in EPA, 1976
Iron	1 mg/l	Not to exceed criteria in EPA, 1976
Mercury	3.7 ug/l	Not to exceed criteria in EPA, 1976
Potassium	No recommendation	Not to exceed criteria in EPA, 1976
Magnesium	No recommendation	Not to exceed criteria in EPA, 1976
Manganese	No recommendation	Not to exceed criteria in EPA, 1976
Molybdenum	No recommendation	Not to exceed criteria in EPA, 1976
Sodium	No recommendation	Not to exceed criteria in EPA, 1976
Nickel	1,100 ug/l	Not to exceed criteria in EPA, 1976
Phosphorus	No recommendation	Not to exceed criteria in EPA, 1976
Lead	74 ug/l	Not to exceed criteria in EPA, 1976
Platinum	No recommendation	Not to exceed criteria in EPA, 1976
Antimony	Acute toxicity at 9,000 ug/l	Not to exceed criteria in EPA, 1976
Selenium	200 ug/l	Not to exceed criteria in EPA, 1976
Silicon	No recommendation	Not to exceed criteria in EPA, 1976
Tin	No recommendation	Not to exceed criteria in EPA, 1976
Strontium	No recommendation	Not to exceed criteria in EPA, 1976
Titanium	No recommendation	Not to exceed criteria in EPA, 1976
Tungsten	No recommendation	Not to exceed criteria in EPA, 1976
Vanadium	No recommendation	Not to exceed criteria in EPA, 1976
Zinc	180 ug/l	Not to exceed criteria in EPA, 1976
Zirconium	No recommendation	Not to exceed criteria in EPA, 1976

1. Freshwater aquatic life criteria as given by U.S. Environmental Protection Agency in Quality Criteria for Water, 1976 and in the Federal Register, Vol. 45, No. 231.

2. Water quality parameters for aquatic life as given in Water Quality Standards, Alaska Department of Environmental Conservation, 1979.

Figure 9. Index of surface water quality records for streams in the project area.

Map No.	Station No.	Station Name	Location		Data Available							
					Chemical		Temperature		Sediment		Streamflow	
			Latitude	Longitude	Period of Record	Frequency[1]	Period of Record	Frequency[1]	Period of Record	Frequency[1]	Continuous Record	Partial Record
171	602130149204800	Victor Creek near Lawing	60°21'30"	149°20'48"	1956	I						
172	15244000	Ptarmigan Creek at Lawing	60°24'20"	149°21'45"	1950-53 1955-58	I I					1947-58	
173	603007149261500	Carter Creek near Moose Pass	60°30'07"	149°26'15"	1956	I						
174	15246000	Grant Creek near Moose Pass	60°27'25"	149°21'15"	1950-51 1953 1955-58	I I					1947-58	
175	15248000	Trail River near Lawing	60°26'01"	149°22'19"	1949-53 1955-58 1959-67 1968-69	I I D I	1959-67	D	1967-74	I	1947-74	1975-77
176	15250000	Falls Creek near Lawing	60°25'50"	149°22'10"	1956	I					1913	1963-70 1976

[1]Frequency: I=Intermittent; D=Daily

Source: Still 1976, 1980.

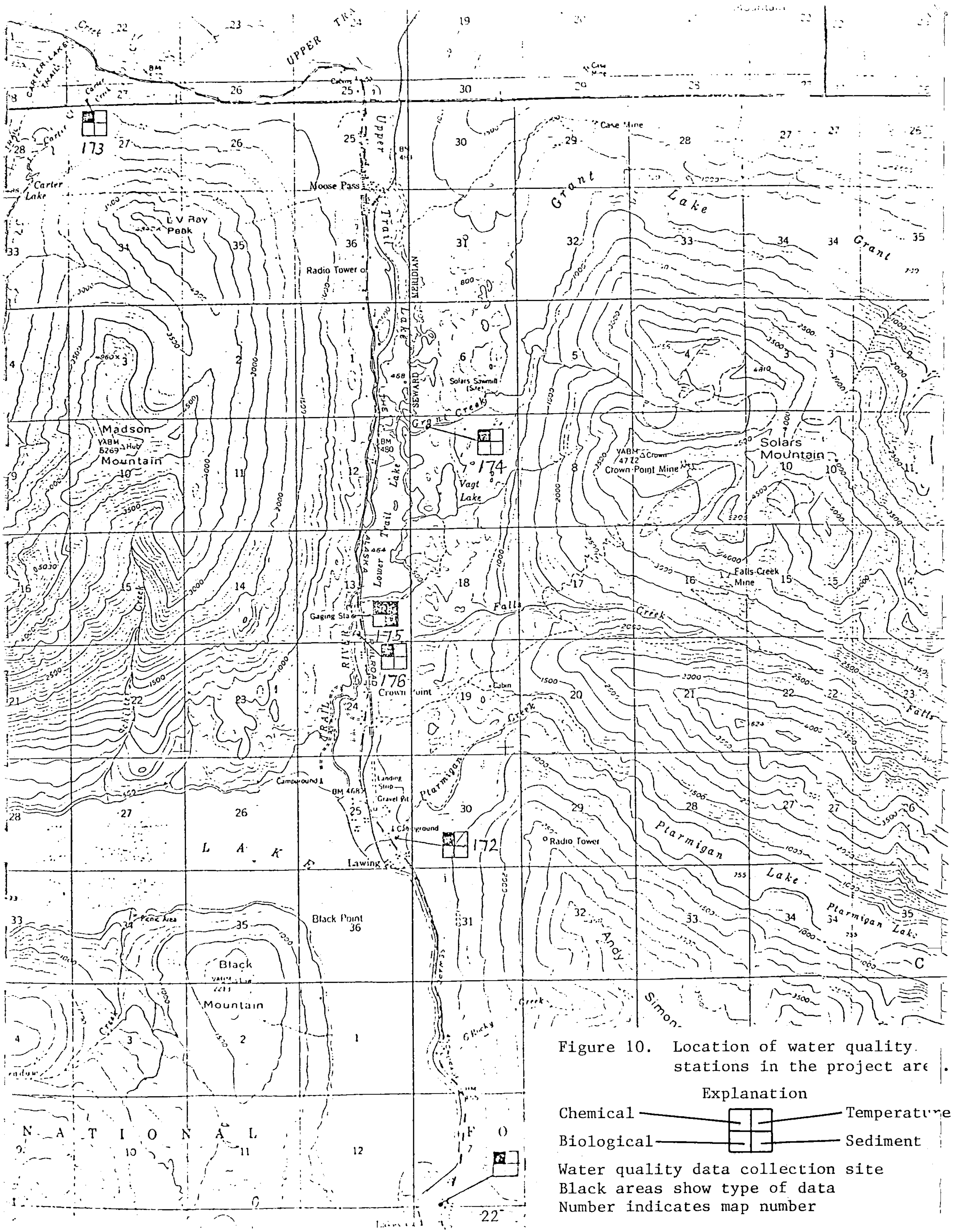


Figure 10. Location of water quality stations in the project are[a].

Figure 11. Water quality analysis of streams in the project area.

Station Name	Date/Time	Temperature (°C)	pH	Conductivity (µmhos/cm)	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)	Nitrogen (mg/l as N)	Nitrogen (mg/l as NO_3)	Chloride (mg/l as Cl)	Silica (mg/l as SiO_2)	Carbon dioxide (mg/l as CO_2)	Sulfate (mg/l as SO_4)	Fluoride (mg/l as F)	Calcium (mg/l as ca)	Magnesium (mg/l as Mg)	Sodium (mg/l as Na)	Potassium (mg/l as K)	Iron (mg/l as Fe)	Dissolved Solids (mg/l)	Streamflow (cfs)
Trail River near Lawing	10/14/49 1545	3.5	6.8	70	24	30	0.16	0.7	0.8	3.0	7.4	7.9	-	-	-	-	-	-	-	318
	07/10/50 N/T	10.5	7.4	73	27	33	0.23	1.0	1.2	3.9	2.1	8.2	-	11	1.3	-	-	150	45	2,180
	10/04/50 N/T	7.0	7.6	68	25	28	0.18	0.8	0.5	4.7	1.2	19	-	8.9	1.5	-	-	150	58	655
	01/30/51 N/T	-	7.1	92	33	42	0.54	2.4	1.2	5.1	5.1	10	-	14	1.8	-	-	140	56	63
	11/12/51 1400	-	7.5	76	30	34	0.18	0.8	2.2	4.3	1.8	8.9	0.1	12	1.1	-	-	120	51	150
	02/27/52 2200	0.0	6.8	101	36	51	0.32	1.4	1.5	5.4	11	15	0.0	18	1.4	-	-	110	67	73
	04/22/52 1400	2.0	7.3	104	36	41	0.25	1.1	2.0	5.2	3.5	13	0.1	14	1.4	-	-	100	64	62
	05/20/52 1900	4.0	7.0	92	33	44	0.27	1.2	1.5	4.8	6.4	12	0.1	15	1.5	-	-	190	58	160
	06/19/52 2300	9.0	7.4	80	31	34	0.36	1.6	2.2	4.0	2.4	11	0.1	12	1.1	-	-	70	57	1,400
	02/24/52 1455	12.0	6.4	70	25	34	0.32	1.4	0.8	4.1	19	14	0.1	11	1.7	1.2	0.8	290	50	2,810
	08/21/52 1800	10.5	6.4	62	24	28	0.16	0.7	0.5	17	18	7.6	0.0	11	0.5	0.7	0.8	190	53	1,200
	09/30/52 2000	8.0	7.1	65	22	28	0.16	0.7	0.0	3.3	3.4	7.7	0.1	10	0.8	1.0	0.7	150	38	1,080
	01/30/53 1900	0.0	7.0	94	34	44	0.36	1.6	1.0	5.6	6.7	11	0.0	15	1.3	1.4	0.8	80	58	140
	04/15/53 1530	0.5	7.2	109	35	45	0.25	1.1	4.0	5.1	4.3	9.7	0.2	16	1.0	3.3	1.1	20	63	109
	08/04/53 1730	10.5	6.1	58	21	25	0.25	1.1	0.5	3.3	32	7.5	0.0	8.9	0.7	0.9	0.6	260	36	2,550
	09/08/55 N/T	-	6.9	69	25	29	0.20	0.9	0.5	4.5	6.0	8.0	0.0	10	0.9	0.9	0.6	0	41	1,080
	04/03/56 N/T	-	7.6	94	34	42	0.18	0.8	1.2	4.5	1.7	10	0.0	15	1.2	1.6	1.3	0	56	320
	05/30/56 1230	-	7.3	86	30	37	0.29	1.3	0.8	3.9	2.9	7.5	0.0	13	1.2	1.2	0.7	0	47	657
	07/03/56 N/T	-	6.8	86	29	36	0.36	1.6	0.5	7.0	8.9	9.0	0.1	13	0.8	2.1	0.4	0	52	1,920
	10/03/57 N/T	5.5	7.2	75	25	32	0.23	1.0	1.0	3.3	3.0	10	0.0	11	1.2	0.6	0.8	0	44	647
	11/06/57 0950	4.5	7.0	83	26	36	0.25	1.1	0.5	4.0	5.1	10	0.0	13	0.8	1.1	1.0	170	47	1,030
	12/11/57 1100	0.5	6.8	99	36	44	0.32	1.4	0.5	5.0	11	9.0	0.1	15	1.5	1.7	0.8	130	57	265
	01/22/58 1030	0.0	7.4	99	35	44	0.32	1.4	1.0	5.2	2.7	9.0	0.0	15	1.5	1.4	0.7	0	56	218
	02/19/58 1115	-	6.7	105	34	48	0.27	1.2	2.0	6.8	13	12	0.0	15	2.4	1.4	0.6	0	62	101
	05/21/58 0945	7.0	6.7	88	30	40	0.34	1.5	2.0	4.8	11	10	0.1	15	0.8	1.0	0.6	180	54	668

Figure 11 (Continued). Water quality analysis of streams in the project area.

Station Name	Date/Time	Temperature (°C)	pH	Conductivity (μmhos/cm)	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)	Nitrogen (mg/l as N)	Nitrogen (mg/l as NO_3)	Chloride (mg/l as Cl)	Silica (mg/l as SiO_2)	Carbon dioxide (mg/l as CO_2)	Sulfate (mg/l as SO_4)	Fluoride (mg/l as F)	Calcium (mg/l as ca)	Magnesium (mg/l as Mg)	Sodium (mg/l as Na)	Potassium (mg/l as K)	Iron (mg/l as Fe)	Dissolved Solids (mg/l)	Streamflow (cfs)
Trail River near Lawing	7/16/58 1000	10.5	5.9	75	22	34	0.16	0.70	2.0	3.5	54	8.0	0.1	11	1.5	0.7	0.6	70	41	1700
	8/20/58 1754	9.5	6.8	73	25	31	0.05	0.20	0.5	2.9	7.9	75	0.1	10	1.4	0.6	0.7	60	39	1670
	12/03/58 N/T	0.0	6.6	91	31	42	0.00	0.00	1.0	4.5	15	13	0.0	14	1.7	1.2	0.6	120	55	179
	1/24/59 1000	-	6.2	97	30	42	0.02	0.10	1.5	4.9	36	11	0.0	15	1.0	1.1	0.5	0.0	53	91
	4/07/59 N/T	-	7.3	105	35	46	0.25	1.1	3.0	5.1	3.4	12	0.0	16	1.4	1.6	0.6	120	62	87
	7/11/59 N/T	-	7.3	73	25	36	0.20	1.9	1.5	6.0	2.4	8.0	0.0	11	1.2	1.1	0.4	70	50	1890
	9/20/59 1015	10.0	7.4	71	27	36	0.14	0.60	2.5	3.1	2.1	10	0.0	11	1.9	1.2	0.2	70	47	433
	10/29/59 1300	4.0	7.0	77	27	38	0.18	0.80	3.0	3.6	5.3	12	0.0	13	1.4	1.5	0.6	20	52	1130
	1/11/60 N/T	-	7.4	93	34	42	0.27	1.2	1.5	6.5	2.6	10	0.0	15	1.0	1.8	0.8	20	58	142
	4/06/60 1530	0.5	7.4	102	37	48	0.29	1.3	3.5	5.5	2.9	11	0.0	17	1.4	1.6	0.4	240	64	86
	5/10/60 1500	4.5	7.3	87	31	41	0.41	1.8	3.0	5.5	3.0	5.0	0.0	14	1.4	1.5	0.5	100	51	1340
	7/08/60 1630	9.0	7.4	77	28	40	0.20	0.90	2.0	4.5	2.2	10	0.2	13	1.7	1.1	0.6	100	51	1750
	10/11/60 N/T	-	7.3	76	27	36	0.14	0.60	2.0	3.9	2.6	10	0.0	13	0.7	1.4	0.7	60	49	335
	1/11/61 N/T	-	7.3	97	34	46	0.38	1.7	1.0	5.7	3.4	11	0.0	15	1.9	1.3	0.6	20	59	237
	4/28/61 1530	5.0	7.4	96	36	48	0.43	1.9	2.5	5.4	2.8	13	0.0	16	1.9	1.3	0.5	40	64	242
	5/30/61 1400	6.5	7.7	87	31	41	-	-	1.5	5.1	1.2	10	0.0	13	2.1	1.0	0.4	50	52	1290
	7/11/61 N/T	-	7.5	72	25	33	0.16	0.70	1.0	4.0	1.5	9.0	0.0	12	0.7	0.8	0.4	20	43	2620
	10/11/61 N/T	-	7.2	77	28	36	0.16	0.70	1.0	3.5	3.4	8.0	0.0	12	1.5	0.7	0.6	20	45	413
	1/21/62 N/T	-	7.5	98	38	48	0.32	1.4	1.5	5.0	2.3	11	0.1	17	1.6	1.5	0.6	70	62	90
	4/11/62 N/T	-	7.5	102	38	47	0.23	1.0	2.0	5.2	2.3	9.0	0.0	17	1.2	1.6	0.5	0	60	179
	7/11/62 N/T	-	7.3	70	25	34	0.14	0.60	1.0	4.1	2.5	8.0	0.2	11	1.5	0.7	0.3	30	43	2010
	10/11/62 N/T	-	7.4	71	24	32	0.07	0.30	1.5	4.3	1.8	9.0	0.1	12	0.9	0.7	0.5	50	44	266
	1/11/63 N/T	-	7.9	100	35	47	0.11	0.50	2.0	4.0	0.9	12	0.1	16	1.5	1.4	0.7	30	59	119
	4/11/63 N/T	-	7.6	99	34	44	0.43	1.9	1.5	5.8	1.6	10	0.0	16	1.1	1.4	0.4	20	58	95
	7/11/63 N/T	-	7.6	73	26	32	0.16	0.70	1.0	3.3	1.3	6.0	0.0	12	0.7	0.9	0.3	20	41	2580

Figure 11 (Continued). Water quality analysis of streams in the project area.

Station Name	Date/Time	Temperature (°C)	pH	Conductivity (μmhos/cm)	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)	Nitrogen (mg/l as N)	Nitrogen (mg/l as NO_3)	Chloride (mg/l as Cl)	Silica (mg/l as SiO_2)	Carbon dioxide (mg/l as CO_2)	Sulfate (mg/l as SO_4)	Fluoride (mg/l as F)	Calcium (mg/l as ca)	Magnesium (mg/l as Mg)	Sodium (mg/l as Na)	Potassium (mg/l as K)	Iron (mg/l as Fe)	Dissolved Solids (mg/l)	Streamflow (cfs)
Trail River near Lawing	10/11/63 N/T	-	7.2	70	23	30	0.11	0.50	1.5	2.3	2.8	8.0	0.0	10	1.2	1.8	0.3	80	39	608
	1/1/64 N/T	-	7.3	96	33	47	0.07	0.30	2.1	3.6	3.2	13	0.0	16	1.7	1.3	0.0	20	58	175
	4/1/64 N/T	-	7.3	106	36	49	0.14	0.60	2.5	2.5	3.5	12	0.0	18	1.0	1.5	0.0	40	60	303
	7/1/64 N/T	-	7.1	75	24	34	0.09	0.40	2.1	7.5	3.7	11	0.0	11	1.6	1.8	0.0	20	50	2010
	10/1/64 N/T	-	7.1	81	25	35	0.14	0.60	1.8	3.8	3.8	12	0.1	13	0.6	2.2	1.7	80	51	612
	1/1/65 N/T	-	7.5	114	39	50	0.18	0.80	2.8	5.2	2.4	14	0.1	18	1.2	2.5	1.0	40	69	215
	4/23/65 N/T	-	7.1	108	37	45	0.36	1.6	2.1	4.9	5.7	10	0.1	13	3.0	2.0	0.8	20	60	428
	7/11/65 N/T	-	7.4	82	27	36	0.25	1.1	1.1	4.4	2.1	9.6	0.2	11	2.1	1.5	0.8	20	48	2500
	10/13/65 N/T	-	7.4	78	28	34	0.00	0.00	0.7	3.3	2.2	9.1	0.0	12	1.0	0.6	0.4	0	44	511
	1/10/66 N/T	-	7.8	109	42	50	0.00	0.00	0.7	4.8	1.3	11	0.0	18	1.2	1.5	0.0	0	62	127
	4/11/66 N/T	-	7.4	115	38	52	0.02	0.10	1.4	4.6	2.9	11	0.0	18	1.7	1.2	1.0	40	62	127
	6/14/66 N/T	-	7.1	82	26	42	0.11	0.50	1.4	3.8	4.1	12	0.1	12	2.9	0.6	0.4	80	49	2010
	7/1/66 N/T	-	7.9	100	25	33	0.00	0.00	0.0	2.8	0.6	9.6	0.0	8.4	2.9	0.6	0.0	20	39	2020
	9/11/66 N/T	-	6.9	73	23	32	0.02	0.10	0.0	4.2	5.6	12	0.0	12	0.5	0.5	12	-	43	3360
	11/13/66 N/T	-	7.5	84	28	37	0.29	1.3	0.7	4.3	1.7	11	0.0	13	0.9	1.5	0.6	0	50	726
	1/02/67 N/T	-	7.6	97	40	52	0.20	0.90	0.4	5.2	2.0	15	0.0	19	1.3	2.4	0.6	0	69	113
	2/04/67 N/T	-	7.6	122	43	55	0.07	0.30	0.4	5.3	2.1	14	0.1	20	1.3	2.3	0.4	0	70	100
	3/19/67 N/T	-	7.2	123	43	52	0.09	0.40	0.0	4.6	5.4	14	0.0	16	1.3	2.1	0.4	0	65	90
	6/15/67 N/T	9.5	7.0	89	30	40	0.32	1.4	0.0	4.0	5.8	12	0.0	14	1.0	0.8	0.1	0	51	1810
	*8/04/67 N/T	12.0	7.1	66	22	28	0.23	1.0	0.7	2.0	3.4	10	0.1	10	0.8	0.9	0.1	310	38	1700
	*9/08/67 N/T	8.5	7.0	67	22	32	0.09	0.40	0.7	4.1	4.3	9.0	0.1	9.5	1.3	0.9	0.9	380	40	4100
	10/18/67 1020	-	7.4	86	28	38	0.36	1.6	0.7	4.3	2.2	11	0.1	14	0.9	0.8	0.7	350	51	571
	2/15/68 1140	0.5	7.6	118	42	52	0.29	1.3	1.4	5.4	2.0	14	0.0	19	1.2	1.3	0.4	280	69	191
	1/16/69 1400	0.5	7.9	105	34	42	0.20	0.90	0.7	4.0	0.8	10	0.0	15	1.1	1.5	0.2	830	54	63
	*9/17/74 1130	9.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3030

Figure 11 (Continued). Water quality analysis of streams in the project area.

Station Name	Date/Time	Temperature (°C)	pH	Conductivity (µmhos/cm)	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)	Nitrogen (mg/l as N)	Nitrogen (mg/l as NO_3)	Chloride (mg/l as Cl)	Silica (mg/l as SiO_2)	Carbon dioxide (mg/l as CO_2)	Sulfate (mg/l as SO_4)	Fluoride (mg/l as F)	Calcium (mg/l as ca)	Magnesium (mg/l as Mg)	Sodium (mg/l as Na)	Potassium (mg/l as K)	Iron (mg/l as Fe)	Dissolved Solids (mg/l)	Streamflow (cfs)
Ptarmigan Creek at Lawing	7/10/50 N/T	10.0 10.0	7.3 7.3	113 113	37	52	0.36	1.6	0.8	4.7	3.6	15	-	18	1.7	-	-	50	65	285
	8/22/50 N/T	11.0	-	93	30	41	0.25	1.1	0.6	4.3	-	14	-	13	2.1	-	-	60	56	248
	10/04/50 N/T	6.5	7.2	-	34	41	0.59	2.6	0.4	7.6	4.2	14	-	15	3.2	-	-	20	72	10
	2/27/52 2145	0.0	7.2	143	46	70	0.29	1.3	0.2	4.7	5.7	32	0.0	26	1.3	-	-	10	98	12
	5/20/52 1900	6.5	7.2	99	31	47	0.54	2.4	1.0	5.3	3.8	15	0.0	16	1.7	-	-	90	62	25
	6/19/52 2200	6.5	7.4	113	38	55	0.34	1.5	2.2	4.7	2.9	19	0.1	19	1.8	-	-	70	74	200
	7/24/52 1445	-	6.8	110	35	50	0.36	1.6	0.2	6.3	11	17	0.0	16	2.2	1.3	0.9	60	67	296
	8/21/52 N/T	-	6.7	104	35	46	0.43	1.9	0.5	7.7	14	15	0.1	16	1.6	1.5	0.8	70	66	135
	9/16/52 2000	8.5	7.0	108	34	50	0.29	1.3	0.2	5.2	6.7	19	0.1	17	1.9	1.3	0.8	60	67	86
	1/30/53 1900	0.0	6.9	121	39	54	0.34	1.5	0.5	4.8	9.7	17	0.1	19	1.6	1.5	1.1	110	71	-
	4/15/53 0600	2.0	7.2	117	36	55	0.59	2.6	0.5	5.7	4.4	17	0.1	19	1.9	1.5	1.1	30	71	31
	8/06/53 1700	11.0	6.1	95	32	52	0.27	1.2	0.5	4.7	50	13	0.0	15	1.1	1.2	0.7	40	57	279
	1/21/55 N/T	-	6.5	121	38	54	0.23	1.0	0.4	4.7	23	14	0.0	19	1.6	0.8	0.7	40	75	31
	9/08/55 N/T	-	6.9	108	36	48	0.27	1.2	0.5	5.8	8.9	16	0.1	16	1.9	1.3	0.8	0	65	118
	5/01/56 N/T	-	7.4	115	35	49	0.70	3.1	1.2	5.9	2.7	15	0.0	17	1.7	1.5	0.8	0	67	37
	5/31/56 1000	-	7.1	112	35	49	0.52	2.3	0.8	4.8	5.5	16	0.0	18	1.1	1.3	1.0	0	66	82
	7/03/56 N/T	-	8.5	136	45	53	0.36	1.6	1.2	17	0.2	16	0.4	19	1.4	6.2	1.0	0	91	268
	10/03/57 1230	5.5	7.1	113	39	60	0.25	1.1	0.5	4.6	6.1	18	0.1	18	3.5	1.5	1.0	50	72	98
	11/06/57 N/T	5.0	6.7	209	39	70	0.38	1.7	15	5.5	15	16	0.0	25	1.9	1.7	1.1	60	91	220
	12/11/57 1055	1.0	7.1	121	42	52	0.34	1.5	1.0	5.2	6.5	14	0.0	18	1.8	2.2	1.0	60	70	50
	1/22/58 1000	0.0	7.3	122	41	55	0.32	1.4	1.5	5.1	4.0	14	0.0	19	1.9	1.8	1.2	0	71	33
	2/19/58 1115	-	7.6	129	42	58	0.23	1.0	1.5	4.8	2.0	18	0.0	19	2.4	1.7	1.1	0	75	20
	5/21/58 0930	9.0	7.0	115	37	55	0.56	2.5	2.5	5.2	7.2	17	0.1	18	2.5	1.3	0.8	0	72	106
	7/16/58 0945	10.5	7.0	116	38	55	0.27	1.2	2.5	4.8	7.4	17	0.0	18	2.5	1.2	0.8	50	71	251
	10/20/58 1800	10.0	6.9	110	34	50	0.20	0.9	2.5	4.3	8.5	16	0.1	17	1.7	1.2	0.6	30	65	230

Figure 11 (Continued). Water quality analysis of streams in the project area.

Station Name	Date/Time	Temperature (°C)	pH	Conductivity (µmhos/cm)	Alkalinity (mg/l as $CaCO_3$)	Hardness (mg/l as $CaCO_3$)	Nitrogen (mg/l as N)	Nitrogen (mg/l as NO_3)	Chloride (mg/l as Cl)	Silica (mg/l as SiO_2)	Carbon dioxide (mg/l as CO_2)	Sulfate (mg/l as SO_4)	Fluoride (mg/l as F)	Calcium (mg/l as ca)	Magnesium (mg/l as Mg)	Sodium (mg/l as Na)	Potassium (mg/l as K)	Iron (mg/l as Fe)	Dissolved Solids (mg/l)	Streamflow (cfs)
Grant Creek near Moose Pass	7/05/50 N/T	8.5	7.1	71	25	34	0.32	1.4	1.0	4.9	3.8	9.5	-	11	1.7	-	-	40	-	497
	10/07/50 N/T	6.5	7.0	67	21	29	0.41	1.8	0.8	5.3	4.2	8.2	-	10	0.9	-	-	80	42	139
	1/30/50 N/T	-	7.2	76	23	29	0.59	2.6	1.2	4.2	2.8	8.2	-	10	0.9	-	-	50	44	19
	4/16/53 1115	2.0	7.2	75	24	32	0.25	1.1	1.5	3.4	2.9	12	0.1	11	1.2	1.8	0.9	20	47	26
	1/21/55 N/T	0.0	7.0	73	25	32	0.05	0.2	0.3	3.9	4.8	12	0.1	11	1.1	0.5	0.6	40	44	50
	5/1/56 N/T	-	7.4	72	24	30.	0.23	1.0	0.0	4.0	1.8	9.2	0.1	11	0.5	1.0	1.0	0	42	20
	5/30/56 1100	-	7.0	67	23	29	0.14	0.6	0.2	3.3	4.5	6.7	0.0	11	0.3	0.7	0.5	0	37	157
	7/03/56 N/T	-	7.0	73	21	30	0.27	1.2	0.2	4.9	4.2	8.0	0.0	11	0.5	1.2	0.4	0	40	460
	10/03/57 1400	6.5	7.0	65	22	32	0.18	0.8	0.5	3.2	4.3	9.5	0.0	9.1	2.4	0.9	0.8	60	40	143
	12/11/57 1115	1.0	6.7	70	23	29	0.20	0.9	2.0	3.3	8.9	7.0	0.1	9.9	1.2	1.3	1.3	80	41	61
	1/22/58 1330	0.0	7.2	75	26	33	0.20	0.9	1.0	4.7	3.2	9.0	0.0	11	1.5	1.1	0.7	0	46	51
	2/19/58 1130	-	7.2	76	26	32	0.27	1.2	1.0	4.4	3.2	8.0	0.0	10	1.8	0.9	0.6	0	44	30
	4/21/58 1000	5.0	6.4	81	22	34	0.18	0.8	2.0	3.6	17	9.0	0.0	10	2.1	0.8	0.6	70	42	156
	7/16/58 1030	11.0	6.3	71	21	32	0.20	0.9	2.0	3.7	20	10	0.1	11	1.0	0.7	0.6	30	42	393
	8/21/58 0920	10.5	6.8	73	24	32	0.07	0.3	0.5	3.2	7.4	9.0	0.1	10	1.6	0.6	0.7	50	40	390
Falls Creek near Lawing	5/1/56 N/T	-	7.0	94	26	39	-	-	1.0	-	5.1	11	-	14	0.9	1.7	0.6	-	-	-
	7/03/56 N/T	-	6.6	91	16	22	-	-	1.0	-	7.6	6.5	-	7.9	0.5	1.1	0.8	-	-	-
Victor Creek near Lawing	5/01/56 N/T	-	6.8	119	30	52	-	-	3.3	-	9.1	18	-	19	1.0	2.3	0.9	-	-	-
Carter Creek near Moose Pass	4/30/56 N/T	-	7.4	74	24	32	1.1	4.9	1.0	5.6	1.8	4.8	0.0	12	0.4	1.5	0.9	0	45	-

N/T=No time

*Suspended sediments sampled these dates: 8/04/67-16 mg/1, 9/08/67-40 mg/1, 9/17/74-30 mg/1

Source: U.S. Geological Survey 1981

A limited limnological survey by USFWS (1961) was conducted in 1960 at Ptarmigan and Grant lakes. A temperature profile obtained in July 1960 at Ptarmigan Lake showed a smooth decline in temperature from 58°F at the surface to 40°F at 230 ft with no thermocline. Figure 12 provides the water chemistry data obtained for Ptarmigan Lake on the same date. Temperature profiles were obtained for both upper and lower Grant Lake in July 1960. Upper Grant Lake varied from 49°F on the surface to 41°F at 200 ft with no evidence of a thermocline. Temperatures for lower Grant Lake varied from 55°F at the surface to 39°F at 200 ft with evidence of a thermocline beginning to form between 10 and 25 ft below the surface. Figure 12 gives water chemistry data collected on that date for Grant Lake.

ADF&G and USFS conducted a limnological survey of Grant Lake in 1981. Figures 13 and 14 give thermal, dissolved oxygen, and solar illuminance profiles for June 1981 at Grant Lake. During this survey Grant Lake showed sufficiant oxygen at depth, a thermocline near 20 m, and a 1 percent incidence light level of 19 m in the lower basin and 13 m in the upper basin. The water column above the 1 percent incidence light level contains sufficient light for photosynthesis to take place.

Most freshwater productivity studies on the Kenai Peninsula have been conducted on the larger salmon-producing streams, particularly the Kenai and Russian rivers. USGS has expended minimal effort in past years, and ADF&G has only in recent years expanded their freshwater productivity research.

Water chemistry data collected by USGS (1981) indicated that project area waters have low to moderate levels of alkalinity and hardness. Sufficient dissolved oxygen is present throughout the year, and conditions are conducive to year-round fish survival. Nutrient content of the water is generally low except where the nutrients from salmon carcasses (principally phosphorus and nitrogen) are introduced after the spawning season. Grant Creek is the only water body in the project area with a large enough salmon population to produce nutrients from salmon carcasses.

Figure 12. Water quality analysis (surface) of Ptarmigan and Grant lakes, July 15, 1960.

Lake	CO_2 (ppm)	HCO_3 (ppm)	DO (ppm)	pH	Turbidity[1] (ppm)
Ptarmigan	0.4	31.0	5.4	7.4	-
Grant	0.5	27.0	5.6	7.2	12.5

[1]As reported by U.S. Fish and Wildlife Service (1961).

Source: U.S. Fish and Wildlife Service 1961.

Figure 13. Vertical temperature, dissolved oxygen, and solar illuminance profiles, Grant Lake, lower basin, June 10, 1981.

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/1)	Solar Illuminance (foot candles) Up
Incidence			1500
Surface	10.0	11.3	620
0.5			690
1.0	9.8	11.5	550
1.5			620
2.0	9.0	11.7	620
2.5			600
3.0	8.8	11.8	550
3.5			490
4.0	8.5	11.8	450
4.5			380
5.0	8.2	11.9	370
6.0	8.2	11.9	300
7.0	7.8	12.0	230
8.0	7.5	12.1	230
9.0	7.2	12.1	150
10.0	7.2	12.1	150
11.0			95
12.0			82
13.0			66
14.0			57
15.0	6.5	12.2	45
16.0			37
17.0			26
18.0			21 [1]
19.0			16
20.0	5.7	12.1	13
21.0			12
25.0	4.8	12.2	
30.0	4.5	12.0	
40.0	4.2	12.0	
50.0	4.0	11.9	

[1] 1% incidence light level.

Source: Alaska Department of Fish and Game 1981.

Figure 14. Vertical temperature, dissolved oxygen, and solar illuminance profiles, Grant Lake, upper basin, June 10, 1981.

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/l)	Solar Illuminance (foot candles) Up
Incidence			7100
Surface	11.8	11.6	4100
0.5			3500
1.0	8.6	11.8	2200
1.5			2500
2.0	7.2	11.9	2000
2.5			760
3.0	7.9	12.0	850
3.5			1150
4.0	7.8	12.0	1200
4.5			1000
5.0	7.7	12.1	820
6.0	7.5	12.0	590
7.0	7.4	11.8	410
8.0	7.2	11.9	300
9.0	7.0	12.0	230
10.0	6.8	11.9	190
11.0			130
12.0			99 [1]
13.0			77
14.0			56
15.0	5.9	12.4	41
16.0			
17.0			
18.0			
19.0			
20.0	6.0	12.3	
30.0	5.0	12.6	
40.0	4.9	12.6	
50.0	4.8	12.6	
60.0	4.5	12.6	

[1] 1% incidence light level.

Source: Alaska Department of Fish and Game 1981.

Figure 15. Vertical temperatures profiles of Grant Lake, lower basin.

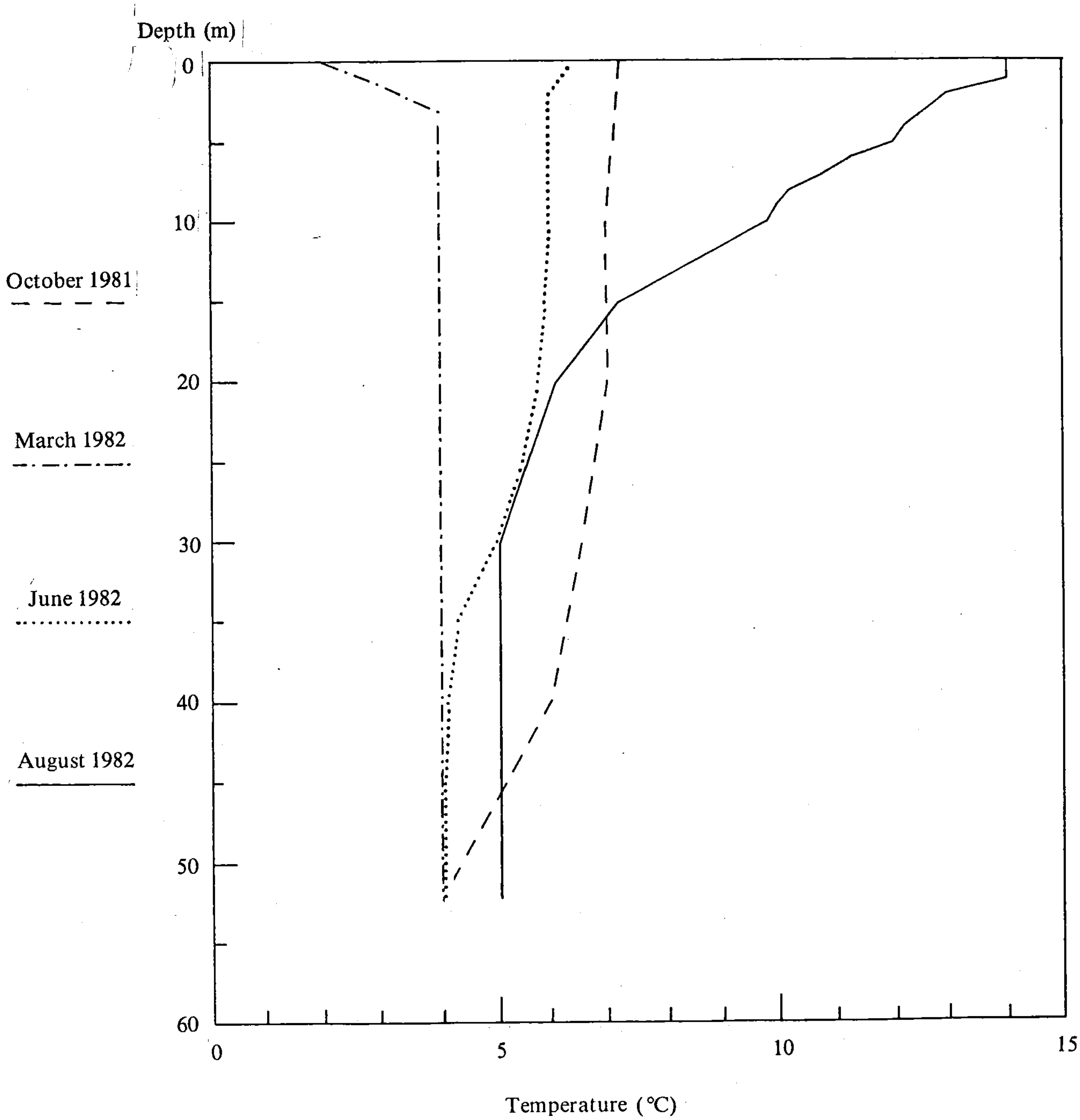


Figure 16. Vertical temperature profiles of Grant Lake, upper basin.

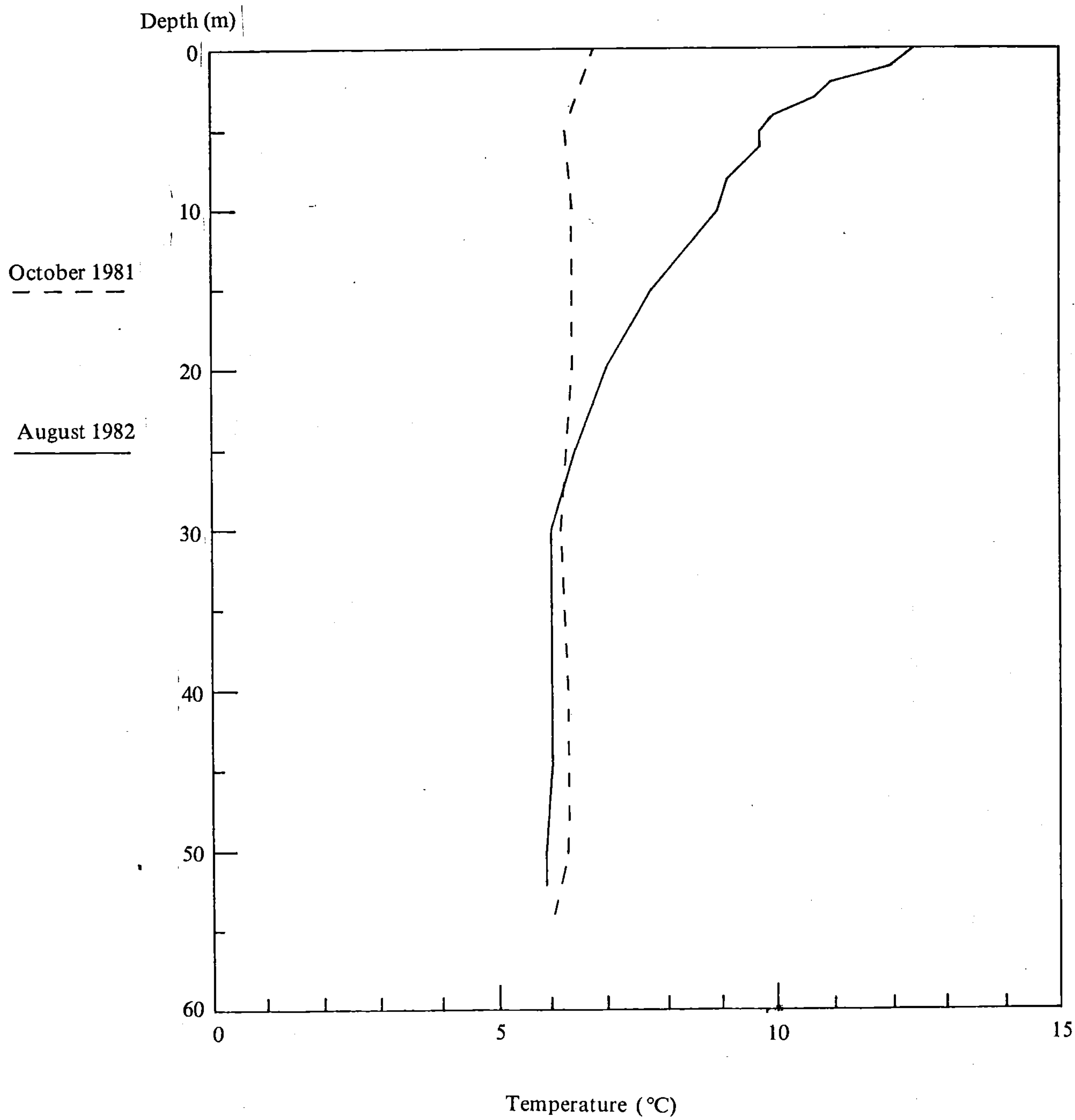


Figure 17. Dissolved oxygen measurements for Grant Lake.

Depth (m)	Dissolved Oxygen (mg/1) October 1981 Lower Basin	Dissolved Oxygen (mg/1) October 1981 Upper Basin	Dissolved Oxygen (mg/1) June 1982 Lower Basin	Dissolved Oxygen (mg/1) June 1982 Upper Basin
Surface	10.75	10.5	14.0	14.5
1			13.5	
2			13.5	
3			13.5	
4			13.5	
5			13.5	
6			13.5	
7			13.5	
8			13.5	
9			13.5	
10			13.5	
15			12.9	
20			12.5	
25			12.5	
30			12.4	
35			12.4	
40			12.0	
45			11.8	
50			11.0	
52	9.75		10.8	
54		10.25		

Figure 18. Water quality data for Grant Lake.

Parameter	October 1981[1]	March 1982[1]	June 1982		August 1982	
			Lower Basin	Upper Basin	Lower Basin	Upper Basin
Nitrate (mg/l)	0.21	0.34	0.31	0.38	0.11	ND
Orthophosphate (mg/l)	ND[2]	0.13	ND	ND	ND	ND
Total hardness (mg/l as $CaCO_3$)	32	30	27	31	33	27
Alkalinity (mg/l as $CaCO_3$)	20	28	20	10	24	24
Total dissolved solids (mg/l)	51	87	33	28	41	47
Suspended solids (mg/l)	8.6	4	1.3	2	1.3	1.3
pH (standard units)	6.2	7.3	NM[3]	NM	7.6	7.3
Water clarity (m)	2	NM	5	2.5	2	0.5
Turbidity (NTU)	3.8	0.46	0.24	0.4	0.67	1.9
Conductivity (umhos/cm)	61	8	59	48	61	48
Coliforms (#/100 ml)	0	0	0	0	0	0
Sulfate (mg/l)	NM	6.3	5.9	6.5	4.5	4.8
Chloride (mg/l)	NM	ND	2	ND	ND	ND

1. Composite sample
2. ND = not detectable
3. NM = not measured

RESULTS OF THE FIELD PROGRAM

Water samples were collected in both basins of Grant Lake as well as Grant Creek, Vagt Creek, and Falls Creek in October 1981. Grant Lake as well as Grant Creek and Vagt Creek were sampled in March 1982, and both basins of Grant Lake, Grant Creek, and Falls Creek were sampled in June and August 1982. Figures 15 and 16 illustrate the vertical temperature profiles for both lake basins. Figure 17 provides dissolved oxygen data, and Figure 18 gives other water quality data obtained for Grant Lake. Additional suspended solids and turbidity measurements were taken for both basins of Grant Lake in June and August 1982. Figure 19 provides the results. Dissolved oxygen measurments were not taken in March and August 1982 due to equipment failure, and adverse weather conditions in June 1982 precluded any midlake sampling efforts in the upper basin. Figures 20, 21, and 22 provide water quality data for Grant, Falls, and Vagt creeks, respectively.

Lakes in general are broadly classified into two opposing types: eutrophic (rich in nutrients) and oligotrophic (poor in nutrients) (Ruttner 1971). Grant Lake is an oligotrophic lake, as are most deep wilderness area lakes of southcentral Alaska. Most temperate lakes, like those on the Kenai Peninsula, undergo freely circulating periods (holomictic) and are generally thermally stratified with two circulation periods each year (dimictic). Although most deep lakes are dimictic, some do not mix completely during each circulation period. Incomplete spring mixing occurs more often than incomplete fall mixing because breakup occurs shortly before the summer solstice when heat transfer to the water is rapid, causing stratification which limits circulation. The results of our water quality sampling program indicate that water bodies in the Grant Lake hydroelectric project area have characteristics similar to other water bodies in the Kenai River drainage.

The process of thermal stratification can be important to organisms inhabiting lakes since oxygen depletion can occur in noncirculating waters below the thermocline. Textbook thermoclines are not usually found in glacial systems because insufficient sunlight penetrates to heat the turbid water and stimulate mixing. Observa-

Figure 19. Water quality data for Grant Lake, 50 m depth.

Parameter	June 1982 Lower Basin	June 1982 Upper Basin	August 1982 Lower Basin	August 1982 Upper Basin
Turbidity (NTU)	0.28	0.43	0.24	0.46
Suspended Solids (mg/1)	1.1	1.9	0.3	1.0

Figure 20. Water quality data for Grant Creek.

Parameter	October 1981	March 1982	June 1982	August 1982
Nitrate (mg/l)	0.18	0.36	0.25	ND
Orthophosphate (mg/l)	ND[1]	0.04	ND	ND
Total Hardness (mg/l as $CaCO_3$)	31	30	28	28
Alkalinity (mg/l as $CaCO_3$)	18	26	19	24
Total dissolved solids (mg/l)	34	84	31	48
Suspended solids (mg/l)	0.6	1	1	4.3
pH (standard units)	6.2	7.2	NM[2]	7.2
Temperature (^{o}C)	6.0	1.0	6.5	12.5
Turbidity (NTU)	0.82	0.41	0.35	1.1
Conductivity (μmhos/cm)	51	14	60	NM
Coliforms (#/100 ml)	0	0	0	0
Sulfate (mg/l)	NM	6.2	4.0	4.9
Chloride (mg/l)	NM	ND	ND	ND

1. ND = not detectable
2. NM = not measured

Figure 21. Water quality data for Falls Creek.

Parameter	October 1981	June 1982	August 1982
Nitrate (mg/l)	0.11	0.12	ND
Orthophosphate (mg/l)	ND[1]	ND	ND
Total Hardness (mg/l as $CaCO_3$)	39	27	25
Alkalinity (mg/l as $CaCO_3$)	24	17	20
Total dissolved solids (mg/l)	60	24	33
Suspended solids (mg/l)	ND	86	2.3
pH (standard units)	6.3	NM[2]	7.3
Temperature (^{o}C)	3.5	4.0	5.5
Turbidity (NTU)	0.37	6.0	0.48
Conductivity (µmhos/cm)	60	150	45
Coliforms (#/100 ml)	0	0	0
Sulfate (mg/l)	NM	5.4	4.8
Chloride (mg/l)	NM	ND	ND

1. ND = not detectable
2. NM = not measured

Figure 22. Water quality data for Vagt Creek.

Parameter	October 1981	March 1982
Nitrate (mg/l)	0.44	0.9
Orthophosphate (mg/l)	ND[1]	ND
Total Hardness (mg/l as $CaCO_3$)	32	27
Alkalinity (mg/l as $CaCO_3$)	26	28
Total dissolved solids (mg/l)	46	94
Suspended solids (mg/l)	ND	5
pH (standard units)	6.1	6.6
Temperature (^{o}C)	6.5	1.0
Turbidity (NTU)	0.22	0.24
Conductivity (umhos/cm)	66	NM[2]
Coliforms (#/100 ml)	0	0
Sulfate (mg/l)	NM	3.7
Chloride (mg/l)	NM	ND

1. ND = not detectable
2. NM = not measured

tions at Grant Lake in the months of June and August, 1982, and October, 1981, showed it to be gradually stratified with evidence of a thermocline in August and no significant decrease in dissolved oxygen with depth. Grant Lake showed the most stratification in August.

The effect of pH values on fish has been investigated since the 1920's. The pH of natural waters varies from about 4 to 9, the lower values being found in boggy areas, the higher ones in alkaline streams in drier portions of the United States. Ellis, Westfall, and Ellis (1946) stated that more common values range from 6.7 to 8.6 and that in 90 percent of the areas where freshwater fish were found, the pH range was 6.7 to 8.2. Normally, the lower the pH value, the lower the mineral content. Generally, waters slightly on the alkaline side support more fish than waters on the acid side. The pH of Grant Lake, Grant Creek, Falls Creek, and Vagt Creek are slightly acidic to slightly basic (6.0 to 7.6) and reflect typical pH levels measured by ADF&G throughout the Kenai drainage (J. Koenigs, pers. comm.; USGS 1981).

Specific conductance is a measure of a water's capacity to carry an electric current. It is directly proportional to the concentration of dissolved solids and is an indication of nutrient availability. Most lakes surveyed by ADF&G in southeast Alaska have a specific conductance of less than 50 micromhos/cm (Schmidt and Robards 1975), which suggests low productivity. Watsjold (1976), in studies of upper Cook Inlet basin lakes, stated that on the basis of conductance values alone, waters with values less than 100 micromhos/cm generally yield poorer catches than those having greater electrolyte concentrations. Limited data are available on fresh waters of the Kenai Peninsula. Water bodies in the project area surveyed by USGS have a specific conductance varying between 50 and 135 micromhos/cm (USGS 1981). Our studies have determined that specific conductance in project area waters usually varies between 50 and 70 micromhos/cm.

Values for hardness and alkalinity (as $CaCO_3$) below 40, pH values below 7.5, and specific conductance between 50 and 70 for project area waters indicate soft waters with only moderate productivity potential. The project area waters are characterized by a predominance of Ca++ among cations and HCO^{3-} among anions.

Small differences in chemical composition that occur between Grant Lake, Grant Creek, Falls Creek, Vagt Creek, and other water bodies in southcentral Alaska probably reflect differences in drainage basin geology, altitude, and morphometric characteristics. The low specific conductance, low concentrations of dissolved solids, and low alkalinity and hardness indicate low productivity for project area waters. The results from our field trips are similar to USGS (1981) data from the project area and indicate that project area water bodies have chemical and physical characteristics similar to those measured elsewhere in the Kenai drainage basin (J. Koenigs, pers. comm.; USFWS 1961; USGS 1981).

AQUATIC BIOTA

MACROPHYTES

We found two conspicuous macrophytes in the small lakes and ponds in the study area. These were water lilies and buckbean. White water crowfoot grows along the shore of Grant Lake but is abundant only at the outlet of the lake. A small stand of a sedge was found in a protected cove at the narrows between the upper and lower Grant Lake basins. This sedge was also seen bordering a small stream near Grant Lake. Though USFWS (1961) found two species of green filamentous algae, brown algae, water milfoil and cattail in the project area waters, these species were not observed during the 1981-82 field investigations.

INVERTEBRATES

EXISTING KNOWLEDGE OF THE PROJECT AREA

Food production areas are an important habitat component for juvenile salmon and trout. Density of fish may be regulated by the abundance of food which may come from the substrate, the surrounding land, or the plankton of a lake. The aquatic invertebrates are an important index of the productivity and quality of an aquatic environment. Plankton constitute an important component in the aquatic food chain and provide a food storage base for fish and other aquatic organisms.

The makeup of the zooplankton in glacier-influenced aquatic systems generally renders these lakes less productive for raising fish than clear water systems. In such systems zooplankton populations are generally comprised of copepods and rotifers with a marked absence of cladocerans (J. Koenings, pers. comm.). Cladocerans are common in clear water systems and are easier prey for sight feeders like fish than are copepods. Rotifers are generally too small and transparent to make up a significant portion of the diet of fish.

Macroinvertebrates constitute a major consumer group in the aquatic ecosystem. Included are organisms that dwell in or on the lake or flowing-water substratum. The group is composed primarily of immature or larval insects--an important link in the aquatic food chain which provides a forage base for most fish and larger aquatic vertebrates. This group feeds on detritus, other insects, bacteria, plankton, and larval fish. Changes or disruptions in the aquatic environment, such as in temperature regimes, turbidity, sedimentation of the stream bed, and dissolved oxygen concentrations, can markedly influence the number and types of macroinvertebrates present. Such changes ultimately can alter the numbers and types of fish that the water body can sustain. Since macroinvertebrates are sampled easily and are quickly affected by changes in water quality, they can serve as convenient early indicators of possible changes in water quality (U.S. Army Corps of Engineers 1978).

Hynes (1970) stated that the benthic fauna of streams is remarkably similar worldwide and that alpine cold-water streams are occupied by a definite, although limited, very-cold-water tolerant macroinvertebrate fauna, which is adapted to specific conditions sharply defined by consistently low temperatures and (often) unique characteristics of glacial meltwater. The implication is that even relatively minor alterations in such habitats may reduce both the specifically adapted macroinvertebrate fauna and the corresponding fish fauna.

Bottom fauna have been collected throughout Alaska by various groups (Craig and McCart 1974, Craig and Wells 1975, Elliott and Reed 1973, McCoy 1974, Nauman and Kernodle 1974). The most abundant benthic organisms found in Alaska are Dipterans. Ephemeroptera, Plecoptera, and Trichoptera are generally abundant in streams, and Oligochaeta and Pelecypoda are often common in lakes. Little specific information is available for the Kenai drainage.

Zooplankton were collected by ADF&G from both Grant Lake basins in June 1981 and August 1982. Figure 23 lists the zooplankton organisms found in 1981 and their density. The 1982 data is still incomplete but preliminary results show a similar make-up of organisms as in 1981 (B. Aetland, pers. comm.). Preliminary results indicate that Grant Lake may be one of the most productive lakes in the Kenai system based on the existing large populations of copepods and rotifers (J. Koenigs, pers. comm.).

Figure 23. Identification and enumeration of zooplankton for Grant Lake, June 1981.

Taxa	Number (Organisms/m^3) Lower Basin	Upper Basin
Eucopepoda (copepods)		
Cyclopoida	1,558	13,654
Nauplii	2,384	740
Rotatoria (rotifers)		
Kellicottia	2,273	4,269
Asplanchna	385	1,154

Source: Alaska Department of Fish and Game 1981.

In 1959-60 the U.S. Fish and Wildlife Service surveyed Grant Lake at the mouths of its various tributaries to determine the species composition of aquatic invertebrates. At the time of this study caddis flies, stone flies, blackflies, and snails were recorded (USFWS 1961).

Figure 24 gives the results of a macroinvertebrate survey conducted by WAPORA, Inc. during early June 1977. This cursory study was limited to the mainstem Kenai River and the lower reaches of major tributaries. The study concentrated on mayflies and stone flies because these groups are known to be important to immature salmon as a food source and because they are often sensitive to changes in stream conditions. Sampling procedure involved kicking the substrate upstream from a stationary small-mesh screen or net and hand-picking larger rocks and logs. Species identifications were based on adult, mature pupae, and occasionally on larvae of well-studied genera. Several forms indicative of very cold environments were found to be widespread in the study area (U.S. Army Corps of Engineers 1978).

Figure 25 gives the results of a survey by the USFS during June 1972 on Vagt Lake and tributaries. The area was found to be rich in blackflies and chironomids and to have average numbers of mayflies, stone flies, and caddis flies. The abundance of benthic invertebrates collected by Howse (1972) led him to believe that Vagt Lake provided an average food source for fish.

RESULTS OF THE FIELD PROGRAM

Zooplankton were collected by AEIDC in each basin of Grant Lake in October 1981 and March, June, and August 1982. Figure 26 lists zooplankton types and their density for each lake basin. Two species of rotifers and one cyclopoid copepod species appear to dominate the zooplankton composition in Grant Lake. This agrees with the 1981 preliminary findings by ADF&G. The near absence of cladocerans would be expected in a glacier-fed lake. The presence of large numbers of copepods, although not as suitable as cladocerans from a purely food source point of view, would make Grant Lake a compatible environment for a pelagic fish nursery.

Figure 24. Macroinvertebrates collected in June 1977 by WAPORA, Inc., by site.

Taxa	Collection Location[1]
P-Annelida	
C-Hirundinella (leeches)	
Haemopsis marmorata (tentative)	9
Placobdella parasitica (tentative)	9
P-Arthropoda	
C-Crustacea	
O-Amphipoda (scuds)	
F-Gammaridae	
Gammarus lacustris	9
G. (Anisogammarus) confevicolus	1
C-Insecta	
O-Coleoptera (beetles)	
F-Gyrinidae	
Gyrinus picipes	5
G. minutus	4
G. pleuralis (tentative)	4
F-Hydraenidae	
Octhebius disrectus	1
F-Dytiscidae	
Agabus anthracinus	2, 5
A. verus	4
Illybius augustior	2, 4, 5
Hydroporus tartaricus	5, 15
H. occidentalis	15
H. griseostriatus (tentative)	2
H. tademus	15
Hygrotus sp.	4
Rhantus wallisi (tentative)	2, 4
R. suturellus	15
F-Hydrophilidae	
Helophorus auricollis	15
H. fenniculus	15
H. splendenoides (tentative)	2
Hydrobius fusipes	4
O-Diptera (flies)	
F-Chironomidae (at least 4 species)	1, 5, 7, 11, 13, 16
F-Dolichopodidae (undet. genus, larvae in coastal marsh)	1

Figure 24 (Continued). Macroinvertebrates collected in June 1977 by WAPORA, Inc., by site.

Taxa	Collection Location[1]
F-Empididae	11
Wiedomannia sp. (tentative)	16
Undetermined genus	16
F-Tipulidae	
Tipula sp.	4
F-Simuliidae (diversity not considered)	2, 13, 16
F-Tabanidae	
Tabanus sp. (coastal marsh only)	1
O-Ephemeroptera	
F-Ephemerellidae	
Ephemerella (*Drunella*) *doddsi*	6, 13, 16
E. inermis	2, 5, 6, 7, 10, 13-15
F-Baetidae	
Baetis sp. (two tails)	11, 13, 15, 16
Baetis sp. (three tails)	2, 4-6, 10-14
Baetis sp.	3
F-Heptageniidae	
Epeorus (*Ironopsis*) sp.	16
Cinygma sp.	11
Cinygmula sp.	10, 12, 13, 16
F-Siphlonuridae	5, 16
Ameletus validus	16
O-Hemiptera (true bugs)	
F-Corixidae	15
F-Salididae	
Soldula sp.	1
O-Odonata (dragonflies and damselflies)	
F-Aeshnidae	
Aeshna juncea	4, 5
O-Plecoptera (stoneflies)	
F-Pteronarcidae	
Pteronarcella badia	7, 11-13
F-Perlidae	
Alloperla sp.	5, 6, 10-12, 14, 15

Figure 24 (Continued). Macroinvertebrates collected in June 1977 by WAPORA, Inc., by site.

Taxa	Collection Location[1]
F-Perlodidae	
Isoperla sp.	2, 4-7, 10-14, 16
F-Nemouridae	
Nemoura (*Zapoda*) sp.	5, 16
F-Leuctridae	
Leuctra occidentalis (tentative)	16
F-Capniidae	
Eucapnopsis brevidens	13, 16
O-Trichoptera (caddisflies)	
F-Rhyacophilidae	
Rhyacophila sp. 1	2
Rhyacophila sp. 2	15, 16
Rhyacophila sp. 3	13, 16
F-Glossosomatidae	
Glossosoma alascense	5
G. intermedium	5, 13
Glossosoma sp.	5, 12, 16
F-Philopotamidae	
Wormaldia sp.	16
F-Hydropsychidae	
Arctopsyche ladogensis	13
Hydropsyche sp. (H. bifida group)	12
F-Hydroptilidae	
Oxyethira sp.	9
F-Limnephilidae	2, 3, 8, 9, 16
Ecclisomyia conspersa	2, 12-14
Nemotaulius hostilis	1
Hesperophylax designatus	5
Onocosmoecus unicolor	2-7, 9-16
Limnephilus sp.	2
Unidentified genera	
White median stripe, gills all single	6
F-Leptoceridae	
Ceraclea excisa	9

Figure 24 (Continued). Macroinvertebrates collected in June 1977 by WAPORA, Inc., by site.

Taxa	Collection Location[1]
F-Empididae	11
Wiedomannia sp. (tentative)	16
Undetermined genus	16
F-Tipulidae	
Tipula sp.	4
F-Simuliidae (diversity not considered)	2, 13, 16
F-Tabanidae	
Tabanus sp. (coastal marsh only)	1
O-Ephemeroptera	
F-Ephemerellidae	
Ephemerella (Drunella) doddsi	6, 13, 16
E. inermis	2, 5, 6, 7, 10, 13-15
F-Baetidae	
Baetis sp. (two tails)	11, 13, 15, 16
Baetis sp. (three tails)	2, 4-6, 10-14
Baetis sp.	3
F-Heptageniidae	
Epeorus (Ironopsis) sp.	16
Cinygma sp.	11
Cinygmula sp.	10, 12, 13, 16
F-Siphlonuridae	5, 16
Ameletus validus	16
O-Hemiptera (true bugs)	
F-Corixidae	15
F-Salididae	
Soldula sp.	1
O-Odonata (dragonflies and damselflies)	
F-Aeshnidae	
Aeshna juncea	4, 5
O-Plecoptera (stoneflies)	
F-Pteronarcidae	
Pteronarcella badia	7, 11-13
F-Perlidae	
Alloperla sp.	5, 6, 10-12, 14, 15

Figure 24 (Continued). Macroinvertebrates collected in June 1977 by WAPORA, Inc., by site.

Taxa	Collection Location[1]
F-Lepidostomatidae	
Lepidostoma roafi	12
F-Brachycentridae	
Brachycentrus americanus	2, 4, 5, 7, 8, 10, 12-15
P-Mollusca	
C-Gastropoda (snails)	
Stagnicola sp. (heavy bodied)	9
Stagnicola sp. (slender bodied)	9, 10
Gyraulus sp.	2, 3, 5, 9, 10
C-Pelecypoda (clams)	
F-Unionidae	
Anodonta imbecilis	10
F-Sphaeriidae	
Sphaerium sp.	2

[1] Site Key

1 - Kenai River marshes near mouth
2 - Beaver Creek at Sterling Highway
3 - Kenai River between Moose River and Soldotna Creek
4 - Slikok Creek at Kasilof Road
5 - Soldotna Creek at Sterling Highway
6 - Kenai River at Soldotna Campground
7 - Funny River
8 - Kenai River between Beaver Creek and Soldotna Creek
9 - Moose River
10 - Kenai River at Naptown rapids
11 - Killey River at mouth
12 - Hidden Creek at road to Skilak Lake Campground
13 - Russian River
14 - Kenai River below mouth of Russian River
15 - Juneau Creek at mouth
16 - Cooper Creek approximately one-quarter mile above mouth

Source: U.S. Army Corps of Engineers 1978.

Figure 25. Invertebrates found in Vagt Lake and tributaries, June 1972, by the U.S. Forest Service.

Invertebrates	Abundance[1]
Stone Flies - Plecoptera	Average
Blackflies - Diptera simuliidae	Rich
Mayflies - Ephemeroptera	Average
Flatworm - Planaria	Average
Freshwater Shrimp - Gammarus	Very Few
Water Boatman - Hemiptera corixidae	Few
Water Strider - Hemiptera gerridae	Few
Midge Larvae - Diptera chironomidae	Rich
Mosquito - Diptera culicidae	Average
Caddis Flies - Trichoptera brachycentrus	Average
Whirligig Beetles - Coleoptera gyrinidae	Few
Snails - Mollusca gastropoda	Few

[1]Abundance descriptors are reported as found in original report.
Source: Howse 1972.

Figure 26. Identification and enumeration of zooplankton from Grant Lake.

Taxa	Organisms/m³							
	October 1981		March 1982		June 1982		August 1982	
	Lower Basin	Upper Basin	Lower Basin	Upper Basin	Lower Basin	Upper Basin	Lower Basin	Upper Basin
Eucopepoda (copepods)								
Cyclopoida	1,831	1,197	1,165	761	1,214	2,738	4,225	7,859
Nauplii					143	327	169	86
Cladocera (water fleas)	14							
Rotatoria (rotifers)								
Kellicottia	183	2,606	109	211	1,738	1,518	845	3,211
Asplanchna	296	296			71	119	338	10,563

Figure 27. Identification and enumeration of benthic organisms from Grant Lake.

	Organisms/m^2					
	October 1981		June 1982		August 1982	
	Lower Basin	Upper Basin	Lower Basin	Upper Basin	Lower Basin	Upper Basin
TAXA						
Diptera						
Chironomidae (midges)	201	678	488	430	431	775
Plecoptera (stone flies)	14					
Trichoptera (caddis flies)	7		100	14	65	
Oligochaeta (aquatic worms)	21	76	86	473	215	473
Nematoda (round worms)			14	14		
Hirudinea (leeches)			14			43
Bivalvia (clams)	36		402	43	129	
Gastropoda (snails)	7		158	14	65	43
Gammaridae (scuds)			14			

Bottom fauna collected from Grant Lake by AEIDC in October 1981 and June and August 1982 by dredging and screening are identified and enumerated in Figure 27. Samples collected during these surveys contained relatively few insects and showed little diversity, which is typical for cold-water, glacier-fed systems with small littoral zones. The most common groups were chironomids, oligochaetes and bivalves. These organisms are not always readily available to fish, which suggesting that Grant Lake, especially the upper basin, would not provide the most suitable habitat for adult insectivorous fish like grayling but may have sufficient plankton populations to support juvenile salmonids.

Adult mayflies, blackflies, caddis flies, and crane flies were seen near the lake, and caddis larvae and water boatmen were observed in fish minnow traps.

Bottom fauna collected by AEIDC in October 1981 and March, May, and August 1982 from Grant Creek are identified and enumerated in Figure 28. Samples collected during these surveys showed limited diversity, which is common in cold-water, glacier-fed streams of Alaska and is consistent with other area-wide observations (J. Koenigs, pers. comm.). The most common organisms were chironomids. Grant Creek also had sufficient numbers of mayflies and stone flies, which, along with the larger midge population, could support both juvenile and adult fish populations.

Bottom fauna collected by AEIDC in October 1981 from Vagt Creek are identified and enumerated in Figure 29. Samples collected from Vagt Creek showed the most diversity of the locations sampled. This would be expected as Vagt Creek is not glacial or as cold as the other project area systems. Chironomids, stone flies, and freshwater clams were the most abundant taxa.

Bottom fauna collected by AEIDC in October 1981 and June and August 1982 from Falls Creek are identified and enumerated in Figure 30. These samples were nearly devoid of invertebrate life. Lower Falls Creek appears to be the least productive system surveyed in the project area.

Figure 28. Identification and enumeration of benthic organisms from Grant Creek.

	Organisms/m^2			
	October 1981	March 1982	May 1982	August 1982
TAXA				
Diptera				
Chironomidae (midges)	6,677	7,457	2,387	3,296
Empididae (dance flies)			7	27
Simuliidae (blackflies)	11	11		11
Ephemeroptera (mayflies)	162	156	297	130
Plecoptera (stone flies)	183	102	48	86
Trichoptera (caddis flies)	11	22	7	5
Coleoptera (beetles)			4	
Oligochaeta (aquatic worms)		6	11	
Hirudinea (leeches)			7	
Bivalvia (clams)	124	16	271	49
Hydracarina (water mites)	6	6	7	
Corixidae (water boatman)			7	

Figure 29. Identification and enumeration of benthic organisms from Vagt Creek.

TAXA	Organisms/m^2 October 1981
Diptera	
Chironomidae (midges)	194
Simuliidae (blackflies)	11
Heleidae (biting midges)	11
Rhagionidae (snipe flies)	75
Ephemeroptera (mayflies)	54
Plecoptera (stone flies)	172
Trichoptera (caddis flies)	43
Oligochaeta (aquatic worms)	118
Bivalvia (clams)	140
Gastropods (snails)	11
Gammaridae (scuds)	22
Homoptera (leaf hoppers)	11

Figure 30. Identification and enumeration of benthic organisms from Falls Creek.

	Organisms/m^2		
	October 1981	June 1982	August 1982
TAXA			
Diptera			
Chironomidae (midges)	27	59	38
Empididae (dance flies)		11	
Simuliidae (blackflies)		11	
Ephemeroptera (mayflies)		76	313
Plecoptera (stone flies)		27	17
Trichoptera (caddis flies)		11	
Coleoptera (beetles)			5
Homoptera (leaf hoppers)	6		5

FISHERIES RESOURCES

INTRODUCTION

The Grant Lake hydroelectric project would affect two aquatic systems: the Grant Lake and Grant Creek drainage and the Falls Creek drainage. A third system, Vagt Creek and Lake, was examined during the early phase of study (autumn and winter), but due to realignment of project features (Ebasco Service, Inc. 1982) this drainage no longer was considered part of the project area, and no further study of it was conducted.

Grant Creek and Falls Creek provide habitat for several species of salmonids which contribute to the fishery in the Kenai River drainage (Figure 31). Twenty-one species of fish have been reported in the Kenai River drainage (Figure 32). The Kenai River is one of the most important upper Cook Inlet systems in terms of habitat for reproduction of anadromous fish. These include five species of Pacific salmon, Dolly Varden char, and eulachon. Historical sport and commercial harvest data for chinook salmon in the Kenai River are presented in Figure 33. Sport harvest data for other anadromous salmonids are presented in Figure 34. Available Cook Inlet commercial harvest data for other anadromous salmonids does not adequately reflect the Kenai River portion and it is therefore not presented. The sport and commercial fishery for salmon is a major component of the Kenai area economy.

The following discussion of the aquatic systems affected by the proposed project begins with a brief geographic description of project waters, followed by species accounts of the aquatic resources found in project waters. A separate chapter (pp. 190) discusses the significance of these resources.

Grant Lake

The two basins of Grant Lake are surrounded by precipitous mountains, and the shoreline in most areas is equally precipitous with bedrock outcroppings interspersed with gravel beaches. Both basins are deep and appear to have relatively uniform bottoms covered with deposits of thick clay and silt. Shoreline vegetation consists of

Figure 31. Kenai River drainage.

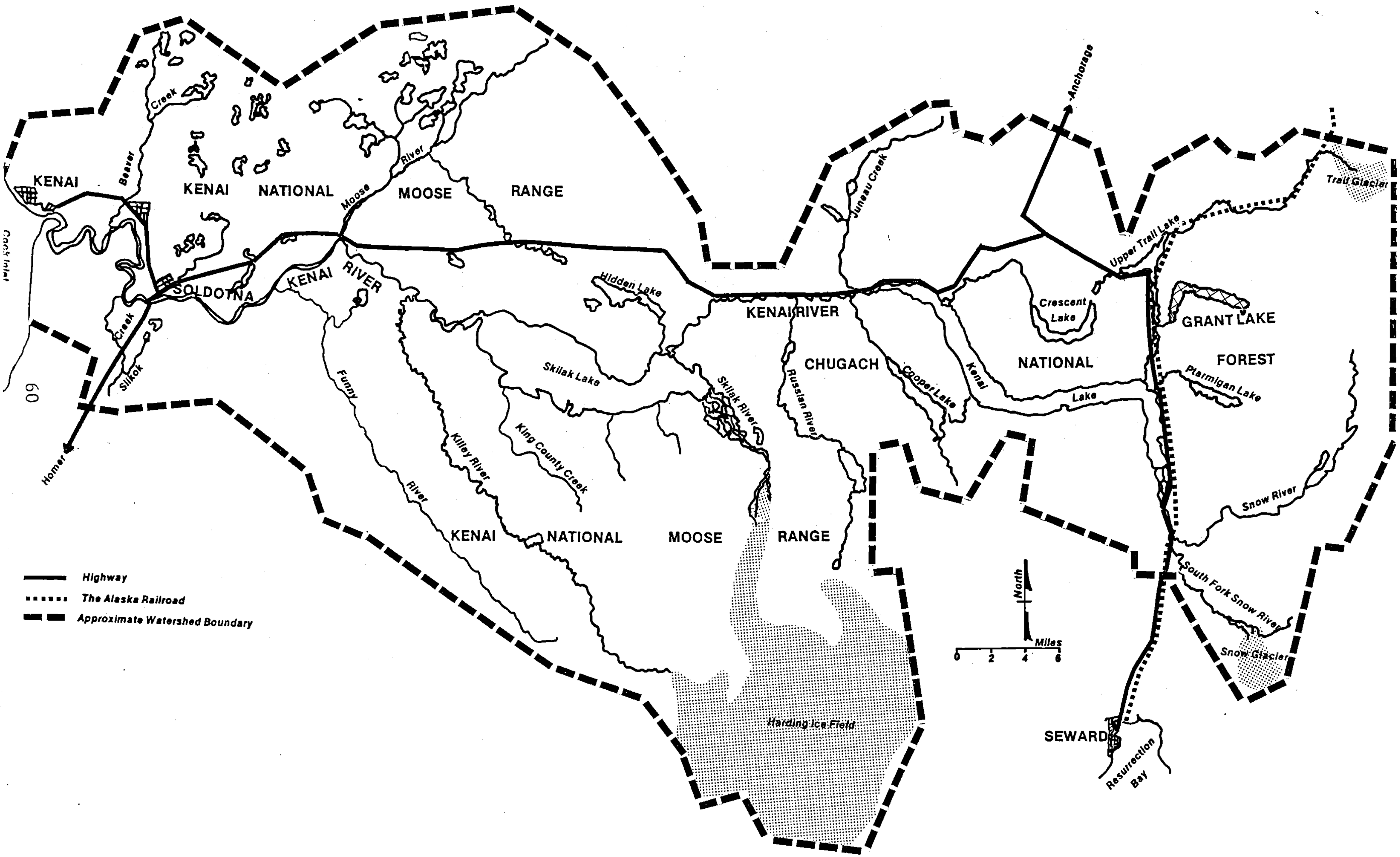


Figure 32. Fish species reported to occur in the Kenai River system, by specific location.[1]

Species	Collection Location[2] Mainstem Kenai	Selected perennial tributaries
Arctic lamprey (*Lampetra japonica*)	none	6-8
*king (chinook) salmon (*Oncorhynchus tshawytscha*)	1-5	6-11, 15-20
*sockeye (red) salmon (*Oncorhynchus nerka*)	1-5	10-11, 13-15, 17-21
*silver (coho) salmon (*Oncorhynchus kisutch*)	1-5	all except 12
chum (dog) salmon (*Oncorhynchus keta*)	1,2	none
pink (humpback) salmon (*Oncorhynchus gorbuscha*)	1-5	6, 7, 9, 10, 15
*rainbow trout (*Salmo gairdneri*)	2-15	all except 12
*Dolly Varden (*Salvelinus malma*)	1-5	all except 12
northern pike (*Esox lucius*)	none	8
lake trout (*Salvelinus namaycush*)	2-5	19
eulachon (*Thaleichthys pacificus*)	1,2	none
longfin smelt (*Spirinchus thaleichthys*)	1,2	none
sculpin (*Cottus* sp.)	2-5	all
*slimy sculpin (*Cottus cognatus*)	2-4	7-10, 13, 15, 16
*coastrange sculpin (*Cottus aleuticus*)	2,4	9, 13
staghorn sculpin (*Leptocottus armatus*)	1	none
*round whitefish (*Prosopium cylindracum*)	2-5	none
*threespine stickleback (*Gasterosteus aculeatus*)	1-5	all
ninespine stickleback (*Pungitius pungitius*)	none	6-8
Pacific herring (*Clupea harengus pallasi*)	1 only	none
starry flounder (*Platichthys stellatus*)	1 only	none
longnose sucker (*Catostomus catostomus*)	none	14
*Arctic grayling (*Thymallus arcticus*)	3-5 (including Kenai Lake to Snow River)	21

1. Adapted from Kenai River Review, 1978, U.S. Department of the Army, Alaska District Corps of Engineers.
2. Location (refer to Figure 31).

1. Intertidal
2. Lower Kenai (intertidal to Skilak Lake)
3. Skilak Lake
4. Upper Kenai (Skilak Lake to Kenai Lake)
5. Kenai Lake
6. Beaver Creek
7. Slikok Creek
8. Soldotna Creek
9. Funny River
10. Moose River
11. Killey River
12. King County Creek
13. Hidden Creek
14. Jean Creek
15. Russian River
16. Cooper Creek
17. Juneau Creek
18. Quartz Creek
19. Trail Creek
20. Ptarmigan Creek
21. Snow River

* Species observed to date in project waters.

Figure 33. Sport and commercial harvest of chinook salmon bound principally for the Kenai River, 1947-1981.

Year	Early Run Harvest			Late Run Harvest			Total Harvest		
	Sport	Commercial	Total	Sport[1]	Commercial	Total	Sport	Commercial	Total
1974	1,685	167	1,852	3,325	5,404	8,729	5,010	5,571	10,581
1975	615	181	796	2,700	3,497	6,197	3,315	3,678	6,993
1976	1,554	876	2,430	5,859	7,361	13,220	7,413	8,237	15,650
1977	2,173	1,058	3,231	5,514	7,613	13,127	7,697	8,671	16,358
1978	1,542	858	2,400	8,271	10,786	19,057	9,813	11,644	21,457
1979	3,661	1,073	4,734	5,798	7,188	12,986	9,459	8,261	17,720
1980	1,946	663	3,130	4,355	8,055	12,410	6,301	8,718	15,540
1981	4,525	946	5,471	5,455	7,696	13,151	9,980	8,642	18,622
1982[2]	5,466	1,100	6,566	4,810	11,500	16,310	10,276	12,600	22,876
Mean	2,574	769	3,401	5,120	7,677	12,799	7,696	8,451	16,200

1. Includes the sport harvest at the mouth of Deep Creek
2. 1982 data are preliminary

Source: Hammerstrom 1980; S. Hammerstrom, pers. comm.

Figure 34. Sport harvest of salmon (excluding chinook) in the Kenai River, 1976-1980.

Year	Effort man-days	Sockeye salmon[1]	Coho salmon	Pink salmon	Rainbow trout	Dolly Varden	Total harvest
1976	80,506	719	13,808	21,443	1,797	4,957	42,724
1977	102,203	1,436	10,056	100	2,474	8,058	22,124
1978	118,307	2,180	11,585	17,011	3,118	11,695	45,589
1979	126,585	1,907	14,479	------	3,100	11,764	39,545
1980	103,460	1,862	25,255	7,415[2]	1,541	5,965	42,038
1981	178,716	19,721	20,827	86	18,685*	34,862	94,181
Mean[3]	118,226	3,478	12,001	N/A	3,839	9,663	35,775

1. Sockeye salmon estimates do not include an estimate for the shore harvest outside the creel census area. The creel census area includes two mainstem Kenai River segments, one below Soldotna, one below Skilak Lake.
2. Pink salmon estimates are only valid for the creel census area, and significant harvest occurs below the creel census area.
3. 1982 data have not been summarized (S. Hammerstrom, pers. comm.).

Source: Hammerstrom 1982.

*Creel census data for the years 1976-1980 reflect harvests below Skilak Lake only. 1981 data reflects system-wide harvests.

lowbush cranberry, ferns, alders, spruce, hemlock, and a few cottonwoods near inlet stream deltas. The shoreline is littered with floating and sunken organic debris and patches of thick macrophyte growth in the few littoral areas. The upper basin is more turbid than the lower, presumably because of a shallow set of narrows separated by an island that divides the basins and precludes complete mixing of their waters. Several large log jams have collected above shore areas that are to the lee of the normal wind patterns as well as at the toe of several large avalanche slopes and at the shallow narrows separating the basins. The water surface of the lake appears to fluctuate moderately, probably rising to its highest during summer runoff and falling to a low point in late winter. The distance from the lake surface to the high water mark was approximately six feet in October 1981; however, it was at or above this mark in August 1982.

Numerous short streams originate in the nearly vertical mountains surrounding much of the lake. Three glacial streams also enter the lake, as do two moderately turbid streams at the upper end of the upper basin.

Previous investigations (USFWS 1961) indicated that Grant Lake supports a small population of coastrange sculpin and dense populations of threespine stickleback. Falls in the outlet stream preclude inmigration of other fish species, and none was found during our sampling. Our investigations have confirmed the presence of stickleback and sculpin in both basins of the lake. No fish were found in any of the inlet streams, and no other species of fish was taken in the lake.

The turbidity and cold water of Grant Lake and its tributaries appear to limit their potential as fisheries habitat for most game fish. However, the lake may prove to be a suitable nursery area for planktivorous species, such as juvenile sockeye salmon. ADF&G has been studying Kenai drainage lakes for five years to locate suitable sockeye nursery areas for juveniles produced from the Trail Lake Hatchery (currently beginning its first year of operation). In 1981 ADF&G sampled Grant Lake, and preliminary indications are that it has the second highest plankton concentrations of the lakes ADF&G tested on the Kenai Peninsula. ADF&G's data also indicated a deeper light penetration in the lower basin than expected (L. Flagg, pers. comm.). Pathology investigations have confirmed the presence of IHN virus in several proposed sockeye juvenile nursery lakes in the Kenai drainage. Sockeye spawners in Grant Creek have not been examined for the presence of IHN virus, but they do not currently utilize Grant Lake as a nursery area. Grant Lake waters should, therefore, present no viral danger to artificially cultured fish (J. Sullivan, pers. comm.).

Grant Creek

Previous ADF&G investigations of Grant Creek focused on its use by salmon species as a spawning stream. All investigators have noted that the glacial turbidity and turbulence of the creek hampers accurate surveying and spawner enumeration. From its origin in Grant Lake, it flows approximately one mile in a southwesterly direction and discharges into the isthmus between upper and lower Trail Lake. In the upper section it courses over three substantial waterfalls, through a rocky gorge, and over large rubble and boulders. The lower section is somewhat less turbulent, having fewer boulders and more frequent gravel shoals, although the gradient of the lower 0.5-mile segment is still fairly steep. The width of the stream is approximately 40 to 70 feet. Cover for juvenile fish is available along stream margins and in backwaters, deep pools, and in a few small side channels that offer lower velocities during low flows. Interstitial space among cobbles and coarse gravels also provides cover for small fish.

Chinook and sockeye salmon spawn in Grant Creek. Figure 35 presents recorded peak escapement counts for the years 1952-82. These counts are probably low due to the turbidity which limits accurate visual estimates. Grant Creek may also be used for spawning and is definitely used as a nursery habitat by coho salmon, Dolly Varden, rainbow trout, and coastrange sculpin. Grant Creek is in the upper portion of the Kenai drainage. Radio tag studies of chinook salmon movement patterns by the USFWS in the Kenai system indicate that tributary spawners are early run fish that arrive in the Kenai drainage between mid-May and early July (C. Burger, pers. comm.). Previous investigators have concentrated their escapement surveys on

Figure 35. Peak salmon escapement counts for Grant Creek, 1952-1982.

Year	Species: King Salmon Number of Spawners	Species: Sockeye Salmon Number of Spawners
1952	0	250
1953	12	13
1954	6	45
1957	8	0
1959	28	0
1961	86 Total Salmon*	
1962	2	324
1963	33	41
1976	29	0
1977	0	4
1978	5	0
1979	42	29
1980	5	0
1981	45	19
1982	46**	135**
Average	19	61

*Not included in averages.

**Source: AEIDC 1982.

Source: Alaska Department of Fish and Game 1952-1981.

Grant Creek in mid-August and early September, indicating that a delay of one to two months occurs between entry into the Kenai River and the arrival of chinook spawners at Grant Creek. Sockeye salmon also appear to enter Grant Creek almost concurrent with the chinook run.

USFWS periodically sampled Grant Creek with minnow traps from July 1959 through January 1961 (USFWS 1961). Captured species included king salmon, coho salmon, Dolly Varden, and coastrange sculpin (Figure 36). USFWS (1961) also reported that sport fishing pressure was light due to the turbidity and distance of the stream from the highway. This report indicated that anglers usually caught one to five fish and that there was an occasional take of 10 to 15; Dolly Varden represented the bulk of the catch, but a few rainbows were also taken. There are no reliable estimates of current fishing effort in Grant Creek waters.

Creel census information was collected by ADF&G at the mouth of Grant Creek only during 1964 (Figure 37). Our personnel talked with two local residents who were fishing in Trail River at the mouth of Grant Creek in August 1982. They caught two small Dolly Varden and one small rainbow trout in about an hour. No round whitefish have been reported in the literature except in a 1964 creel census, when the Seward ADF&G biologist caught one specimen while fishing (T. McHenry, pers. comm.).

Moose Pass area residents estimated that 500 to 600 man-days of fishing occur on Grant Creek each year, primarily for Dolly Varden and rainbow trout. A well-established trail exists along both banks of the creek from the mouth to the gorge. Residents also reported that the population of Dolly Varden has dropped considerably over the years. Grant Creek is closed to sport fishing for salmon by ADF&G regulations, although evidence of illegal fishing was discovered by AEIDC. McHenry (pers. comm.) indicated that actual fishing pressure is probably much lower than local residents estimates due to access difficulty.

An examination of the 11-year streamflow data (Figure 38) from the USGS gage on Grant Creek indicated that June through August are the months of highest flow and that discharge is still fairly high during September through November. High stream discharges during peak

Figure 36. Fish species collected by minnow trap by USFWS in Grant Creek, July 1959 through January 1961.

Month	Species: King salmon	Coho salmon	Dolly Varden	Sculpin
January	X			
February	X			X
March				X
April	X		X	
May		No sampling		
June	X		X	X
July	X		X	X
August	X	X	X	X
September	X	X		
October	X	X		X
November	X	X		
December		No sampling		

Source: U.S. Fish and Wildlife Service 1961.

Figure 37. Creel census conducted at the mouth of Grant Creek by ADF&G 1964.

Date	No. of anglers	Species	No. of fish	Catch per effort
5/21/64	2	RWF	1	0.25 per hour
6/4/64	3	RB DV RWF	3 3 1	0.67 per hour
6/9/64	3	RB	2	0.26 per hour

Source: McHenry, pers. comm. 1981.

Figure 38. Monthly and annual mean discharge (cfs) at the USGS gage on Grant Creek.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
Mean	184	189	56	31	23	20	31	152	448	518	413	307	198
Percent	8	5	2	1	1	1	1	7	20	23	18	13	

Source: U.S. Fish and Wildlife Service 1961.

spawning activity complicate spawner identification and enumeration. During the lower flows of October 1981, Grant Creek was still turbid, swift, and deep enough to prevent crossing on foot and to hamper observation.

Falls Creek

Falls Creek is a clear, cold stream that drains the precipitous mountains between the Ptarmigan and Grant Creek watersheds. Eight miles long, it is tributary to the Trail River below Lower Trail Lake. An inactive placer mine is located approximately three miles upstream from the mouth. A series of falls and cascades approximately one mile from the mouth prevents fish passage above that point. An active gold mine is located just east of the highway and railroad trestle. Three to four acres adjacent to the active channel in the lower 0.5 miles are covered with tailings, and 100 yards of the streambed in this area have been relocated.

The lower mile of Falls Creek appears to provide limited suitable habitat for salmon spawning. Investigations by USFWS in 1959 and 1960 indicated that no adult salmon use the stream; however, local residents and the Seward ADF&G biologist reported (T. McHenry, pers. comm.) that salmon may use the lower 100 feet of Falls Creek. Cold water temperatures may limit its production potential.

USFWS also sampled Falls Creek with minnow traps from June to November 1959. Figure 39 gives the results of that effort. They noted that although traps were set from the mouth to approximately one mile upstream, all king salmon juveniles were taken from the lower 200 yards of the stream.

We observed no salmon utilization of Falls Creek during our investigations.

Vagt Lake and Creek

Vagt Lake is on a bench above Lower Trail Lake at an elevation of approximately five hundred and seventy-five feet. It has one major inlet entering from the the southeast and an outlet which is a tributary to Lower Trail Lake. Vagt Lake and Creek system is managed by ADF&G and the Chugach National Forest as a recreational fishery. A

Figure 39. Species taken by the USFWS using minnow traps in Falls Creek, June through November 1959.

Month	Species: King salmon	Dolly Varden	Sculpin
June		X	
July		X	
August	X	X	X
September	X	X	
October	X		
November		X	

Source: U.S. Fish and Wildlife Service 1961.

maintained trail to the lake provides hiking access for sport fishermen. The trail begins at the south end of Lower Trail Lake. Another trail follows the outlet stream from its mouth to the lake.

The lake provides excellent habitat for the maintenance of fish populations, although spawning areas are minimal. There are small areas of suitable gravel in the inlet stream but stocking by ADF&G maintains the sport fish population. In 1963 ADF&G stocked 49 Arctic grayling adults in Vagt Lake and in 1965 added 170 grayling adults. In 1972 sampling of the lake by ADF&G determined the presence of resident populations of rainbow trout, Dolly Varden, sculpin, and numerous stickleback; however, no grayling were captured in the system.

Subsequent to those investigations a trickle-type dam was constructed by ADF&G and USFS at the lake outlet to restrict outmigration of stocked fish. Inmigration from lower Trail Lake is effectively restricted by a falls approximately sixty feet above the mouth of the creek. The lake was rehabilitated by ADF&G with rotenone in 1973 and stocked with 26,200 rainbow trout in 1974. This stocking effort was successful and produced good sport fishing opportunity for rainbow trout. ADF&G supplemented this fishery in July 1980, stocking it with 8,600 rainbows (L. Larsen, pers. comm.).

The total length of the outlet stream (Vagt Creek) is about fifteen hundred feet. The upper section of the creek has a moderate gradient, stable bank structure and an adequate pool:riffle ratio for fish production (75%:25%) (Howse 1972). There is cover available in the debris jams and along the grassy undercut banks, but there is little spawning gravel available. The lower section is in a narrow bedrock canyon with steeper gradient and fewer areas of cover.

We sampled Vagt Creek with minnow traps and a backpack electroshocker in October 1981. Minnow trapping was unproductive in the stream segment above the falls. In the lower 30 yards of the stream below the falls, one juvenile coho salmon (78 mm) was trapped after an eight-hour set. Electroshocking the entire creek above the falls produced a total of six small rainbow trout (100 to 160 mm). Shocking below the falls resulted in the capture of seven cohos (58 to 71 mm), one rainbow trout (44 mm), and one sculpin.

During the winter of 1982, Vagt Creek was found to be completely frozen, with a minimal flow below the ice and large aufeis areas at the mouth and at several locations midway between the mouth and the outlet of Vagt Lake.

Subsequent to these investigations, it was determined that the preferred plan developed by Ebasco would have no impact on Vagt Lake or Creek. As a result, we conducted no further investigations on the Vagt Creek basin.

FISHERIES INVESTIGATIONS

The biological characteristic of the Kenai River drainage that is of most current interest to man is its use as a spawning and rearing area by salmon. Information pertaining directly to the aquatic biota of the watershed, therefore, is limited primarily to that which relates directly to salmon. Previous investigations of the waters that will be impacted by the Grant Lake hydroelectric project have also focused on salmon use. Figure 40 illustrates some life history features of the three species of salmon known or suspected to utilize Grant Creek and Falls Creek for spawning.

We began fisheries investigations in October 1981 to verify and expand the information pertaining to the utilization of these systems by salmon and other species. The following provides life history information as well as the habitat utilization characteristics of the species found in the project waters.

King (Chinook) Salmon

King salmon enter the Kenai system in two distinct runs. The first begins in late May, peaks in mid-June, and ends in early July. The second run begins in early July, peaks in late July, and ends by mid-August. Radio tagging experiments conducted by USFWS in the past three years indicated that early run fish spawn exclusively in tributary systems of the Kenai, and late run fish spawn exclusively in the mainstem Kenai (C. Burger, pers. comm.). Previous investigations have concentrated on escapement surveys on Grant Creek in August and early September. Grant Creek fish are early run fish that arrive in the Kenai between mid-May and early July. This indicates a delay of one to two months between entry into the Kenai River and arrival at the upper end of the Kenai drainage at Grant Creek.

King salmon prefer to spawn in deeper water and will utilize substrate of larger-size particles for redds than other species of salmon. Both males and females are aggressive on the spawning grounds. Each female may be attended by several males but attempts to spawn only with the dominant male. Smaller males may dart into the redd and deposit sperm as the eggs are released. After spawning, the female digs at the upstream end of the nest and covers the eggs with gravel. The females may dig more than one redd and spawn with more than one male. Fecundity varies with the size of the female, but the average for early run Kenai fish is 9,000 eggs/female and 12,000 eggs/female for late run fish (W. Heard, pers. comm.).

Fertilized eggs hatch the following spring, and the alevins spend two to three weeks in the gravel before emerging as free-swimming fry. Most juvenile kings will spend one year in fresh water before migrating to sea in late June. During this period, they feed chiefly on terrestrial insects, chironomids, corixids, caddis flies, mites, spiders, aphids, small crustaceans--virtually anything available to them, although they do not appear to eat fishes during their freshwater life. Adults return after two to six years at sea. An estimated 50,000 kings spawn in the Kenai River drainage annually. Several Kenai River tributary systems support escapements of several thousand kings; however, upstream tributaries average escapements of 50 to 200 fish (C. Burger, pers. comm.).

King salmon utilize Grant Creek for spawning and rearing. Previous investigators (USFWS, 1961) have found rearing kings in Grant Creek in all months except March and May (Figure 36). Recorded peak spawner escapement counts for the years 1952 through 1982 are presented in Figure 36. The average peak count of spawning kings during this period is 19; however, the run fluctuates year to year. The largest number recorded was 46 in 1928. Observation conditions in 1982 were excellent. Some previous counts may have been low due to the poor observation conditions and high flows that are common in August Figure 38). No kings were recorded in the 1952 and 1977 surveys.

Figure 40. Generalized, Kenai River life history information for Pacific salmon known or suspected to spawn in Grant Creek.

Species of salmon[1]	Time spent in fresh water after emergence from gravel	Time spent at sea	Age at spawning	Average weight of adults		Average eggs per female	
				early run	late run	early run	late run
King salmon	3-12 months	1-6 years	3-7	30.0 lbs	37.0 lbs	9,000	12,000
Red salmon	12-36 months	1-4 years	3-6	5.0 lbs	7.0 lbs	3,700	3,500
Silver salmon	12-36 months	1 year	3-4	7.9 lbs	10.2 lbs	3,700	4,100

1. Exceptions to these general characteristics occur frequently.

Source: Merrell 1970.
C. Burger, pers. comm.
S. Hammerstrom, pers. comm.
K. Tarbox, pers. comm.

Previous investigators found rearing king salmon in Falls Creek during fall (Figure 39) but found no adult spawners using the creek. Local residents reported that the lower 100 feet at the outlet may have been utilized by spawning salmon in past years. We found no utilization of Falls Creek by king salmon during its investigations in 1981 and 1982. This may be the result of increased placer mining activity in the lower segment of the Creek.

Our field activities began in October 1981, too late for spawner enumeration; however, we observed king salmon in spawning coloration during an earlier (August 1981) preliminary field trip. At that time Grant Creek was at an extremely high stage, and turbid water conditions precluded an accurate enumeration of spawners. As noted previously (Figure 38), the months of highest flow in Grant Creek are from June through August, and flows remain fairly high until November. These high discharges during peak spawning activity have hampered previous attempts at spawner identification and enumeration.

During the lower flows of October 1981, Grant Creek remained swift, turbid, and deep enough to preclude crossing on foot. Careful observation as well as electroshocking and angling did not result in the discovery of any adult king salmon during at this time; however, ten partially decomposed carcasses were counted from the mouth upriver to the gorge. ADF&G enumerated 45 kings during their survey in August 1981 (Figure 35).

During March 1982 the low flows in Grant Creek enabled a detailed evaluation of the availability of the spawning gravel in Grant Creek. The overall nature of the substrate materials in Grant Creek is determined partially by the steep gradient and generally high velocities of the creek, which tend to wash smaller spawning materials out of the system. Substrate materials are very coarse throughout the entire length of the creek, ranging in size from small to large cobbles (64 to 250 mm) up to a mixture of large cobbles and very large boulders (250 mm and larger) near the mouth of the gorge. Very few patches of gravel (2 to 64 mm) are present in any river segment, and many of these are armored with medium to coarse cobbles. The areas that contain substrates that offer better than average potential for salmonid spawning, as determined by a subjective visual evaluation during

March 1982, are depicted in Figure 41. The margins of the creek were dewatered in March; however, some streamflow does occur through margin substrates in many locations. There is extensive flow beneath the bank ice shelves in many locations as well as many aufeis beds, indicating a potential contribution of groundwater to winter flow.

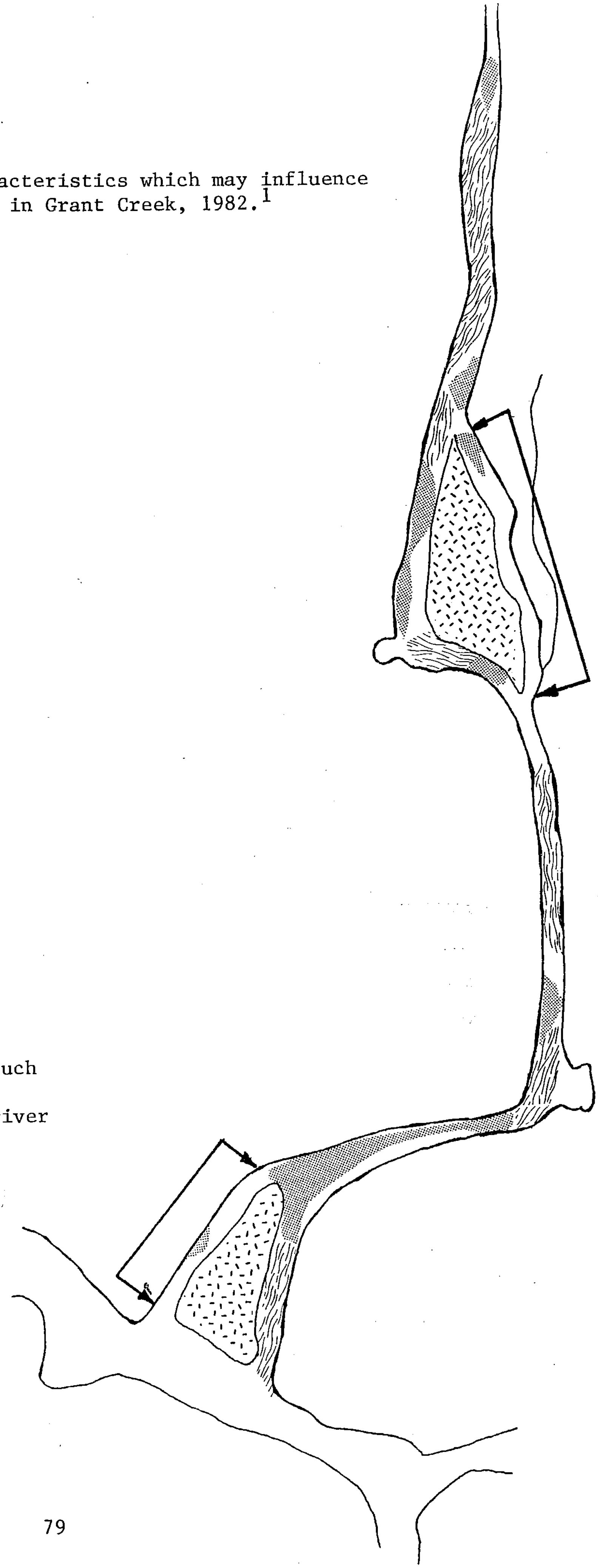
During early August 1982, we surveyed Grant Creek for spawning kings. We counted a total of 12 in study areas 1, 2, and 3 (Figure 4). These adults had apparently recently entered the system and were moving about a great deal from area to area, and probably were in the process of selecting spawning areas. Only one female in study area 1 seemed to hold position throughout the survey period. No active spawning activity was observed in early August. Several of the deep pools may have held additional unobserved king adults; however, using an electroshocker in one such area produced no additional fish.

During the third week of August, 1982, Grant Creek was resurveyed for spawning activity and a total of 46 kings were recorded (Figure 42). Water conditions were nearly ideal for observation from the river banks, except in deeper holes. Several pairs of kings were seen in areas of fairly large substrate; however, they seemed to have no difficulty digging through the top layer of cobbles to the medium gravels below.

Figure 43 shows the results of investigations of the utilization of Grant Creek by juvenile king salmon using minnow trap and electroshocker. A length/frequency histogram of king salmon juveniles caught in minnow traps in Grant Creek is presented in Figure 44. A length/frequency histogram of fish captured during the performance of the bloc and removal exercise is presented in Appendix A, Exhibit 2.

It was apparent during the winter investigations that the juvenile king salmon collected by electroshocker were primarily utilizing habitat in the interstitial spaces of the large and medium size cobble substrate. Grant Creek was open and flowing during winter. Shelf ice forms along the margins of the creek, but no fish were collected beneath it. Juveniles were collected only in the lower two sampling areas of Grant Creek during March and May 1982. The only individuals trapped in June were in the upper sampling areas. All

Figure 41. Principal physical characteristics which may influence salmon spawning success in Grant Creek, 1982.[1]



[1]Medium to coarse gravels, or areas of such gravel under an armor layer of cobble. Small patches may also exist in other river sections

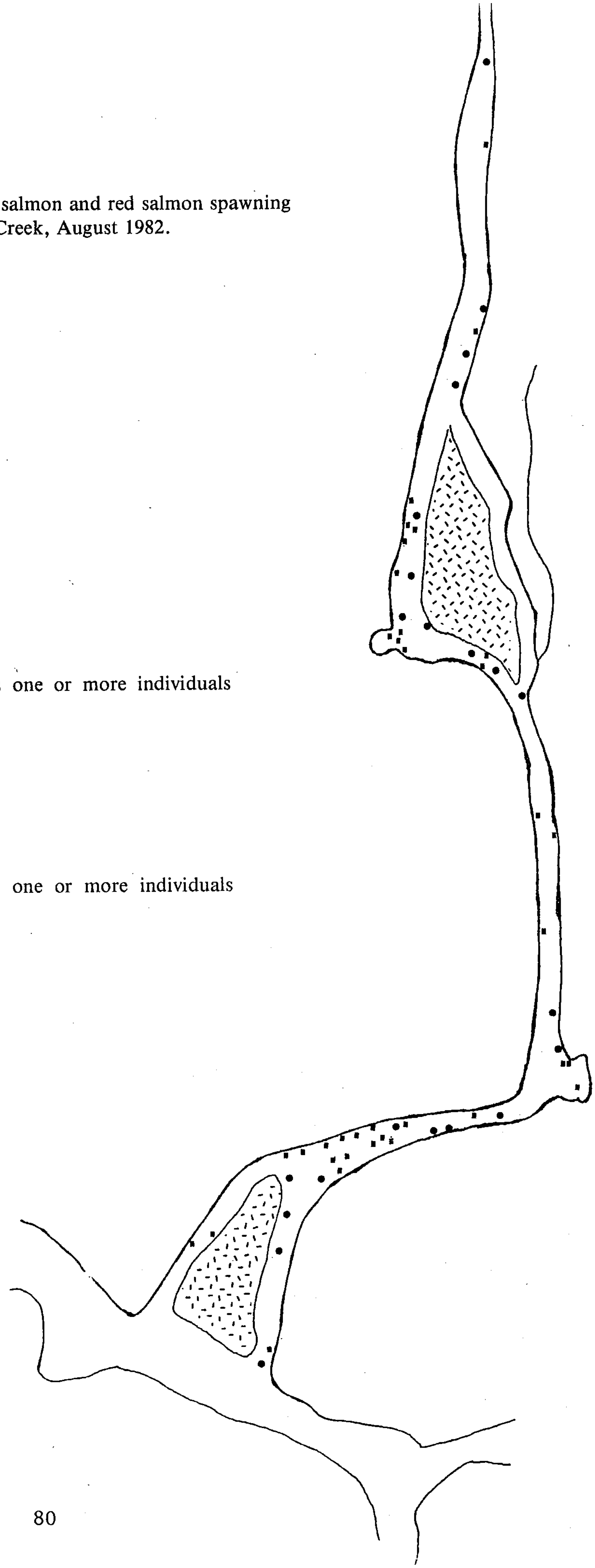
No surface flow observed in March 1982

High-velocity rapids

Possible spawning gravels

Islands

Figure 42. Location of king salmon and red salmon spawning activities, Grant Creek, August 1982.



● King salmon spawners (indicates one or more individuals -total observed = 46)

■ Red salmon spawners (indicates one or more individuals -total observed = 135)

Islands

Figure 43. Grant Creek juvenile king salmon taken by minnow trap and electroshocker, October 1981 - August 1982.

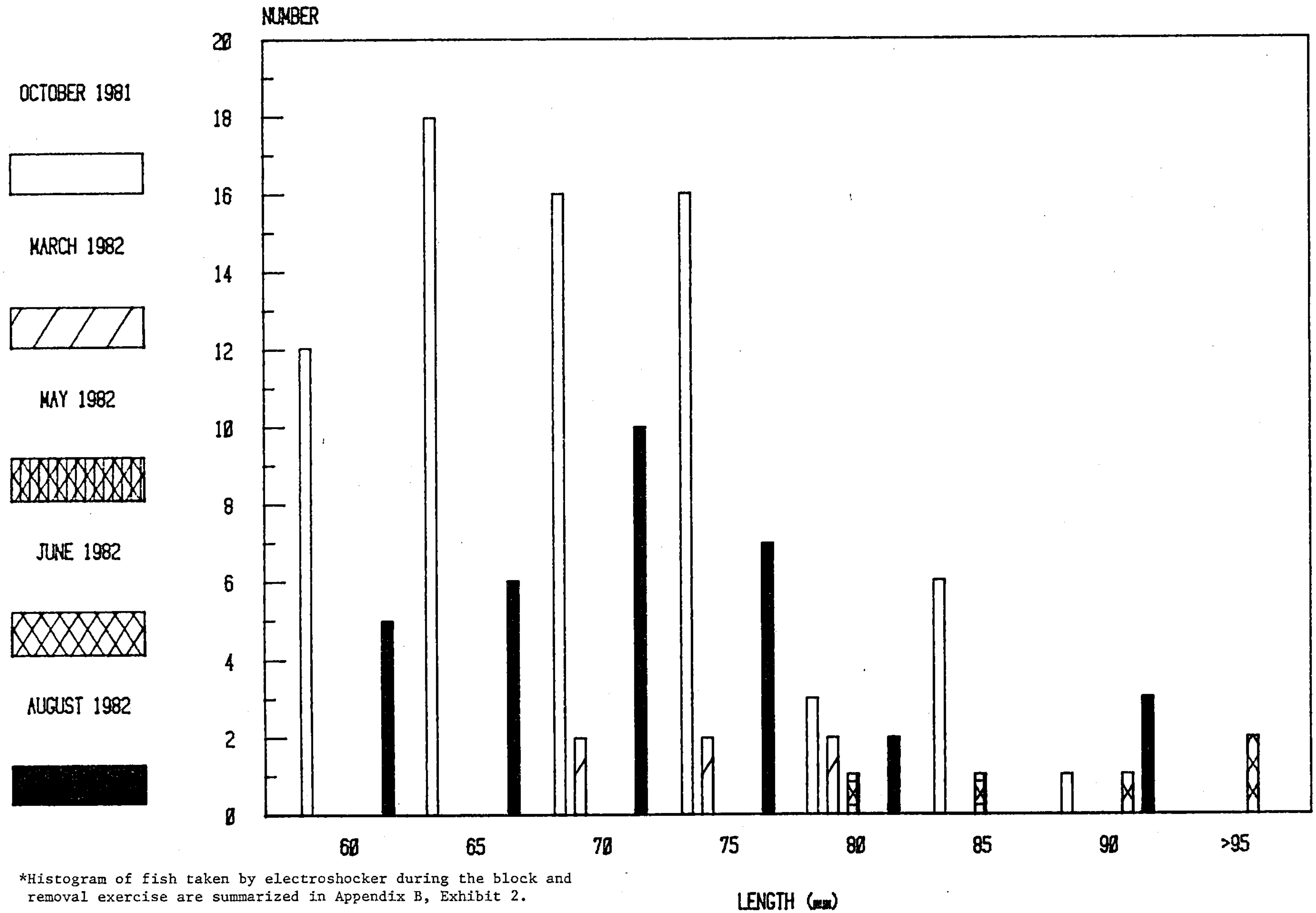
Location	October 1981	March 1982	May 1982	June 1982	August 1982
Minnow Trap:					
Sample area 1	3	5	1	0	21
Sample area 2	17	1	1	0	3
Sample area 3	37	0	0	0	8
Sample area 4	14	0	0	4	2
Total Fish	71[1]	6	2	4	34
Total Trap Hours	80	306	162	108	126
Catch Per Hour	0.89	0.02	0.01	0.04	0.27
Electroshocker:	21	6	79*	**	**

1. Two additional juvenile kings (70 and 81 mm) were taken by angling.

*All fish were fry or alevins taken while performing the block and removal methodology (Zippen 1958). See Appendix B.

**No electroshocker sampling conducted.

Figure 44. Length/frequency histogram of king salmon juveniles taken by minnow traps, Grant Creek, 1981-1982.*



*Histogram of fish taken by electroshocker during the block and removal exercise are summarized in Appendix B, Exhibit 2.

juveniles collected in June 1982 were larger than average (90 to 100 mm).

During the performance of the block and removal population study in May 1982 (Appendix B), king alevins were stimulated to leave the gravel prematurely by the electroshocker. The presence of these fish confirmed spawning activity and overwinter survival in the potential spawning gravels previously delineated in sample area No. 1 (Figure 41).

During the fall 1982 trapping effort, juvenile king salmon were found in all sampling areas but were most numerous in the lower and mid-river segments. These juveniles generally exhibited a preference for habitat that contained moderate velocity (1 to 2 fps), such as the margin of the main channels. They also were present in areas of generally high velocity, where large substrate or organic debris provided cover and some relief from high velocities.

These data would indicate that the king salmon juveniles utilize Grant Creek for rearing year round, although we suspect that some individuals may leave the system to overwinter in Trail Lakes or become very inactive during winter and seek interstitial habitat in the coarse substrate of the stream. Some juvenile king salmon may enter Grant Creek from Trail Lakes for opportunistic feeding, especially in the fall. At this time the water of Trail Lake becomes very turbid compared to the waters of Grant Creek.

Sockeye (Red) Salmon

Sockeye salmon arrive in the Kenai system in two discrete runs. The first run begins in mid- to late May and continues through late June. The second begins in late June and continues through late August. Most sockeye runs occurring above Skilah Lake are lake-run fish (C. Burger, pers. comm.). Sockeye prefer a spawning substrate of fine gravel, and eggs are usually deposited in pockets overlying larger gravel. Early run fish are estimated to average 3,700 eggs per female, and late run spawners average 3,500 eggs per female. Hatching occurs in 50 to 80 days, depending on water temperature. Newly emerged fry migrate to lakes to rear and remain for one or two years before migrating seaward.

Sockeye salmon are known to utilize Grant Creek for spawning. The young presumably outmigrate to rear in the Trail Lake system. No sockeye juveniles have been observed in Grant Creek. Figure 35 provides the recorded peak spawner escapement counts for the years 1952 through 1982. The average number of sockeye enumerated in peak counts is 61; however, the run fluctuates greatly from year to year. The largest number recorded was 324 in 1962. None was recorded in counts in 1957, 1959, 1976, 1978, or 1980.

Some local residents have reported sockeye spawning in the lower reaches of Falls Creek; however, USFWS studies in 1959 and 1960 indicated that no adult sockeyes were in the stream. No ADF&G escapement surveys have been recorded. We found no evidence of sockeye spawning in Falls Creek; however, 10 sockeye carcasses were observed at low water along the banks of Trail River near the confluence of Falls Creek in October 1981. No sockeye were enumerated in August 1982 in this area due to the turbidity of the water.

Sockeye enter Grant Creek in August and early September. No sockeye, live or dead, were observed by AEIDC in October of 1981. During the third week of August of 1982, 135 sockeye were counted in Grant Creek under good observation conditions. The majority were in previously identified areas of potentially suitable gravel (Figure 41); however, several pairs were observed in areas of small cobbles and had successfully dug redds through the cobbles to the underlying gravels.

Coho (Silver) Salmon

Coho salmon enter the Kenai in two runs--the first beginning in late July and continuing until mid-August, the second from mid-August to December. Cohos prefer a substrate of medium-size gravel. Spawning behavior is very similar to that of the king salmon. It is estimated that the fecundity of early run females is 3,700 eggs and that fecundity of late run females, 4,100 eggs. Hatching occurs in 35 to 50 days, depending on water temperature. The alevins remain in the gravel for two to three weeks and then emerge as free-swimming, actively feeding fry. Some fry migrate immediately to sea, but most remain in fresh water for one or two years.

Coho salmon are known to utilize Grant Creek for rearing. Previous investigators found juvenile cohos only in the time period from August through October (Figure 36). No previous investigators reported cohos spawning in Grant Creek, and no escapement data are available.

The major food for juvenile cohos is terrestrial insects, especially diptera and hymenoptera. The diet may also include mites, beetles, aphids, thrips, collembola, spiders, and perhaps zooplankton. Most feeding is at the surface. Larger coho juveniles may often be serious predators of young sockeye salmon (Roos 1960).

During October 1981 and again in August 1982 we actively searched for evidence of coho spawning activity but found none. Some cohos enter the Kenai system very late in the year and may not arrive to spawn in Grant Creek until November and late December. No field investigations were conducted during these months.

The results of investigations of the utilization of Grant Creek by juvenile coho salmon using minnow trap and electroshocker appear in Figure 45. A length/frequency histogram of juvenile cohos trapped in Grant Creek is presented in Figure 46. A length/frequency histogram of fish captured during the performance of the block and removal exercise is presented in Appendix B, Exhibit 2.

Coho juveniles were less abundant than king salmon juveniles and did not utilize as wide a range of habitat as did juvenile kings. Juvenile cohos showed a preference for shallow water with low velocity and an abundance of detrital cover. This type of habitat was generally found only in the deep pools and backwater areas in the lower study areas. Juvenile cohos appeared to be restricted to the lower three study areas, and none was found in the uppermost study area. The extremely small size (40 mm) of several of the coho juveniles trapped in August 1982 (Figure 46) strongly suggests that cohos do spawn in Grant Creek. These small fish generally do not venture far from their natal areas, and the stretch of high velocity water near the mouth of Grant Creek would pose a major impediment to the immigration of such small fish.

These data would indicate that coho juvenile utilize Grant Creek for rearing but are present in small numbers. Older, larger juvenile

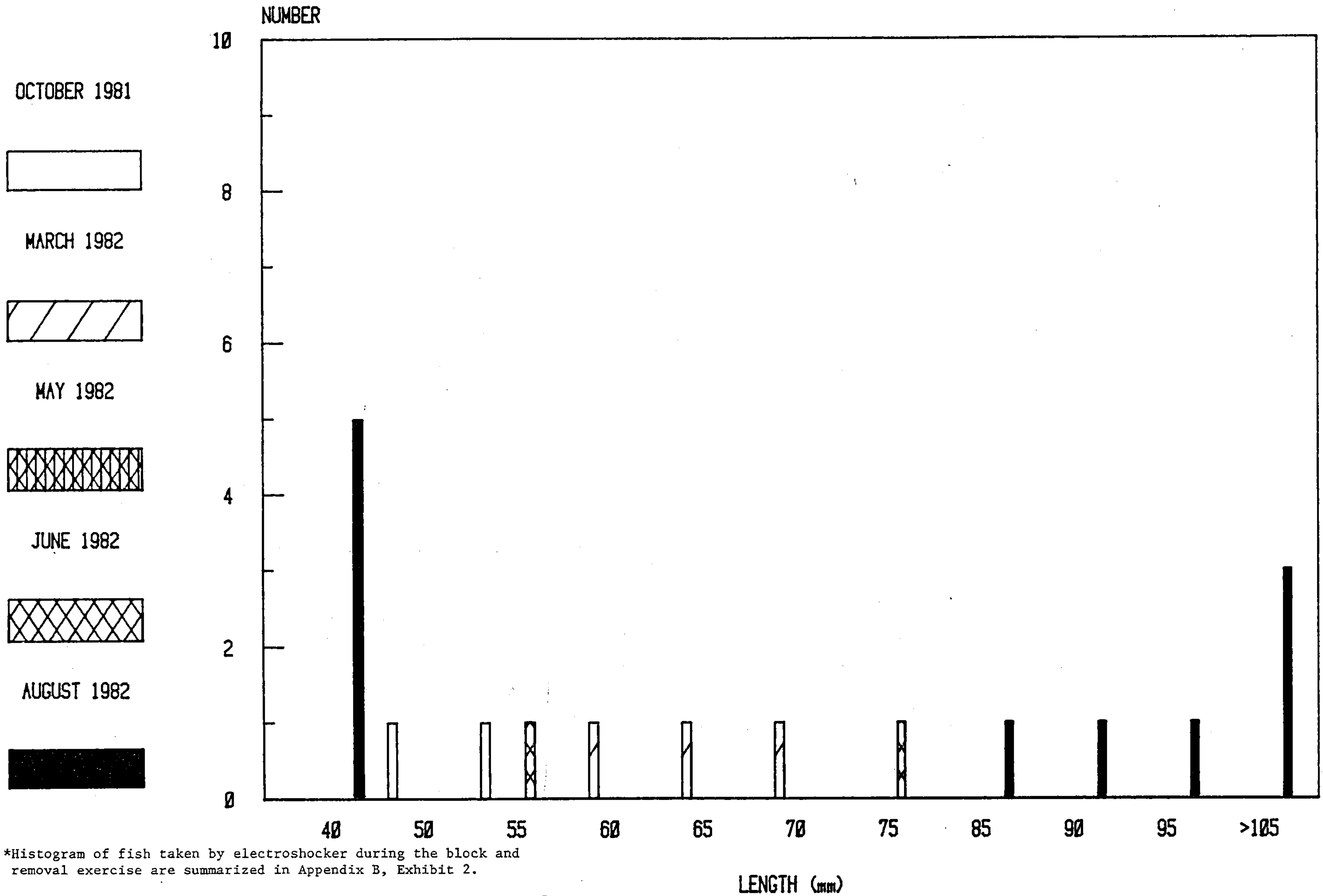
Figure 45. Grant Creek juvenile coho salmon taken by minnow trap and electroshocker, October 1981 - August 1982.

Location	October 1981	March 1982	May 1982	June 1982	August 1982
Minnow Trap:					
Sample area 1	0	4	0	2	5
Sample area 2	0	0	0	0	6
Sample area 3	2	0	0	0	0
Sample area 4	0	0	0	0	0
Total Fish	2	4	0	2	11
Total Trap Hours	80	306	162	108	126
Catch Per Hour	0.03	0.01	0	0.02	0.09
Electroshocker:	8	0	11*	**	**

*Taken while performing the block and removal methodology (Zippin 1958). See Appendix B.

**No electroshocker sampling conducted.

Figure 46. Length/frequency histogram of coho salmon juveniles taken by minnow traps, Grant Creek, 1981-1982.*



*Histogram of fish taken by electroshocker during the block and removal exercise are summarized in Appendix B, Exhibit 2.

cohos may be recruited to Grant Creek from the turbid waters of Trail Lake during the late summer and fall or are progeny of Grant Creek stocks.

Rainbow Trout

Rainbow trout begin to seek out shallow gravel riffles to spawn during late winter or early spring when water temperatures begin to increase. A redd is prepared in fine gravels by the female before she releases from 200 to 8,000 eggs, depending on her size. Hatching normally occurs from a few weeks to several months after spawning, depending on water temperatures. Emergence occurs several weeks after hatching. Fry are usually seen in groups sheltered along stream or lake margins. Small trout feed mainly on crustaceans, plant material, and aquatic insects until they are large enough to feed on other fish.

Rainbow trout are known to utilize Grant Creek for juvenile rearing and adult foraging. No observations have been made of rainbow spawning in Grant Creek; however, several adults were present in the creek in May and June. Rainbows are actively sought by fishermen at the mouth and in the upstream pools of Grant Creek.

The results of investigations of the utilization of Grant Creek by juvenile rainbows using minnow traps and electroshocker are presented in Figure 47. A length/frequency histogram of rainbows trapped in Grant Creek is presented in Figure 48. A length/frequency histogram of fish captured during the performance of the capture of the block and removal exercise is presented in Appendix B, Exhibit 2. Though limited in number, juvenile rainbows seemed to be uniformly distributed in all study areas in habitats ranging from shallow, slow water to deep holes with moderate velocity. Like other salmonids, rainbows are inactive in winter and most active in the fall months.

The small size of several of the rainbows (45-50 mm) taken in October of 1981 suggests that rainbow spawning may have occurred in Grant Creek the previous spring (Figure 48). The majority of the juvenile rainbows rearing in Grant Creek are probably recruited from the Trail Lakes system.

Figure 47. Grant Creek rainbow trout taken by minnow trap and electroshocker, October 1981 - August 1982.

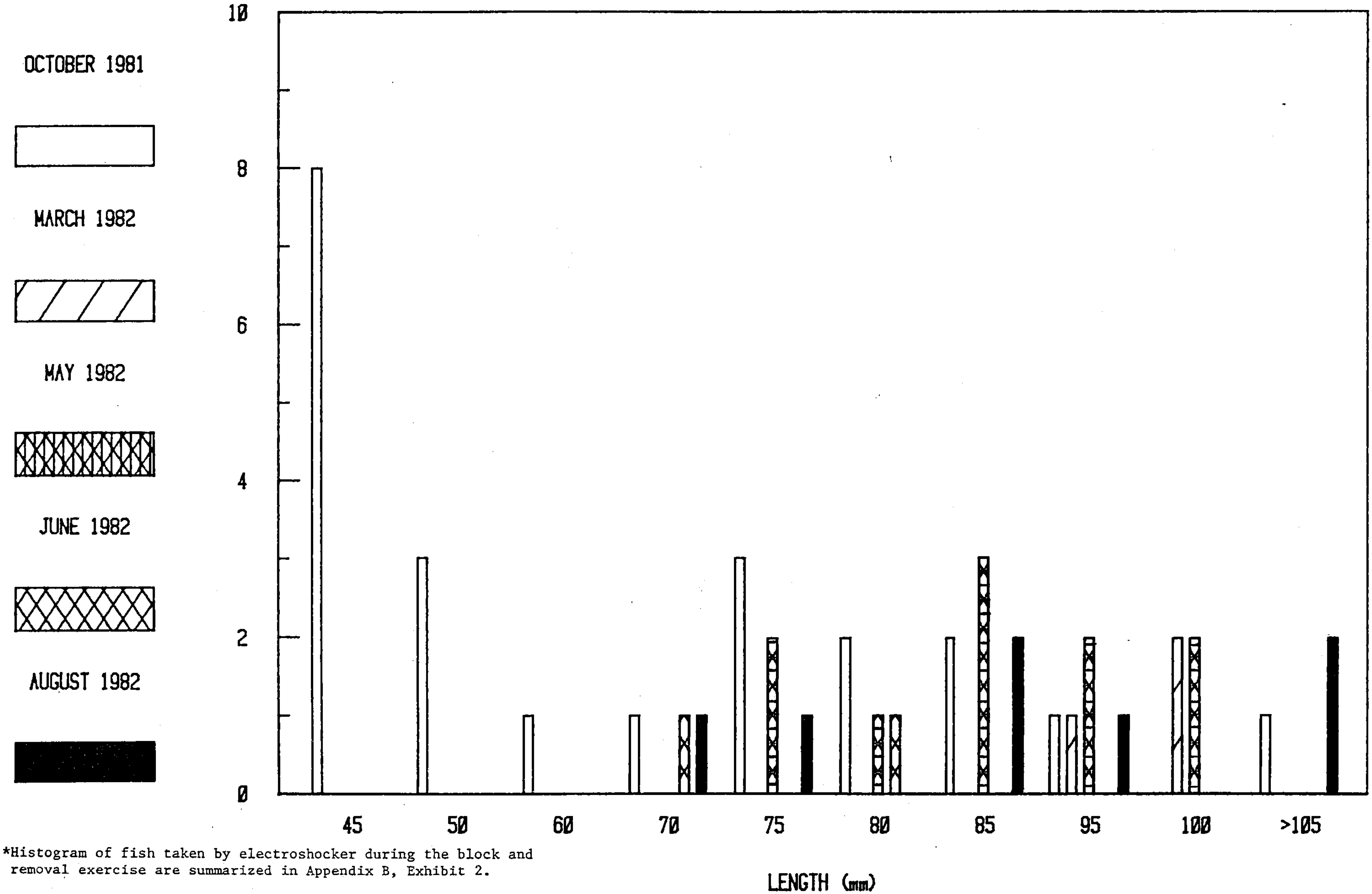
Location	October 1981	March 1982	May 1982	June 1982	August 1982
Minnow Trap:					
Sample area 1	12	3	0	2	4
Sample area 2	2	0	7	1	1
Sample area 3	6	0	3	1	2
Sample area 4	3	0	0	0	0
Total Fish	23[1]	3	10	3	7[2]
Total Trap Hours	80	306	162	108	176
Catch Per Hour	0.29	0.01	0.06	0.03	0.06
Electroshocker:	15	1	7*	**	**

1. A 27 cm rainbow was taken by angling at the mouth of Grant Creek.
2. Three additional rainbows (20 to 30 cm) were taken by angling in Grant Creek.

*Taken while performing the block and removal methodology (Zippen 1958). See Appendix B.

**No electroshocker sampling conducted.

Figure 48. Length/frequency histogram of rainbow trout juveniles taken by minnow traps, Grant Creek, 1981-1982.*



*Histogram of fish taken by electroshocker during the block and removal exercise are summarized in Appendix B, Exhibit 2.

Dolly Varden

Dolly Varden spawn in October and November. These char prefer medium to large gravel for redds, and the female may deposit 600 to 6,000 eggs, depending on her size. The eggs develop slowly through the winter period and hatching occurs in March or April. The alevins remain in the gravel until emergence in late April to mid-May. The young feed actively as soon as they emerge. Major foods include insects, spiders, and annelids as well as snails, fish eggs, and various small fishes. The fry tend to be inactive except when feeding, and they grow quite slowly. In nonanadromous populations in Alaska the young may spend from several months to three or four years in streams and then move to a lake. Juveniles of the anadromous form rear in streams three or four years before a seaward migration in late May. Sexual maturity is reached in three to six years in both types of populations. Males often mature a year earlier than females. Not all adults migrate into fresh water to spawn; some may enter streams only to feed. Dollys can spawn more than once, returning to their natal stream in mid-July to late September. Spawning mortality varies, but a small number lives to spawn more than twice. Few appear to live longer than eight years (Armstrong 1969).

Dolly Varden are known to utilize Grant Creek for rearing. Previous investigations have recorded their presence during the months of March through September (Figure 36). Rearing Dollys have also been recorded in Falls Creek during summer and fall (Figure 39). No observations have been made of Dolly Varden spawning in either Grant or Falls Creeks; however, adults have been observed in Grant Creek during the fall. Dollys are actively sought by fishermen at the mouth and in upstream pools of Grant Creek as well as in the Trail lakes.

The results of minnow trapping investigations of the utilization of Grant Creek by juvenile Dolly Varden are presented in Figure 49. A length/frequency histogram of Dolly Varden trapped in Grant Creek is presented in Figure 50. A length/frequency histogram of fish captured during the performance of the block and removal exercise is presented in Appendix B, Exhibit 2.

Figure 49. Grant Creek Dolly Varden taken by minnow trap and electroshocker, October 1981 - August 1982.

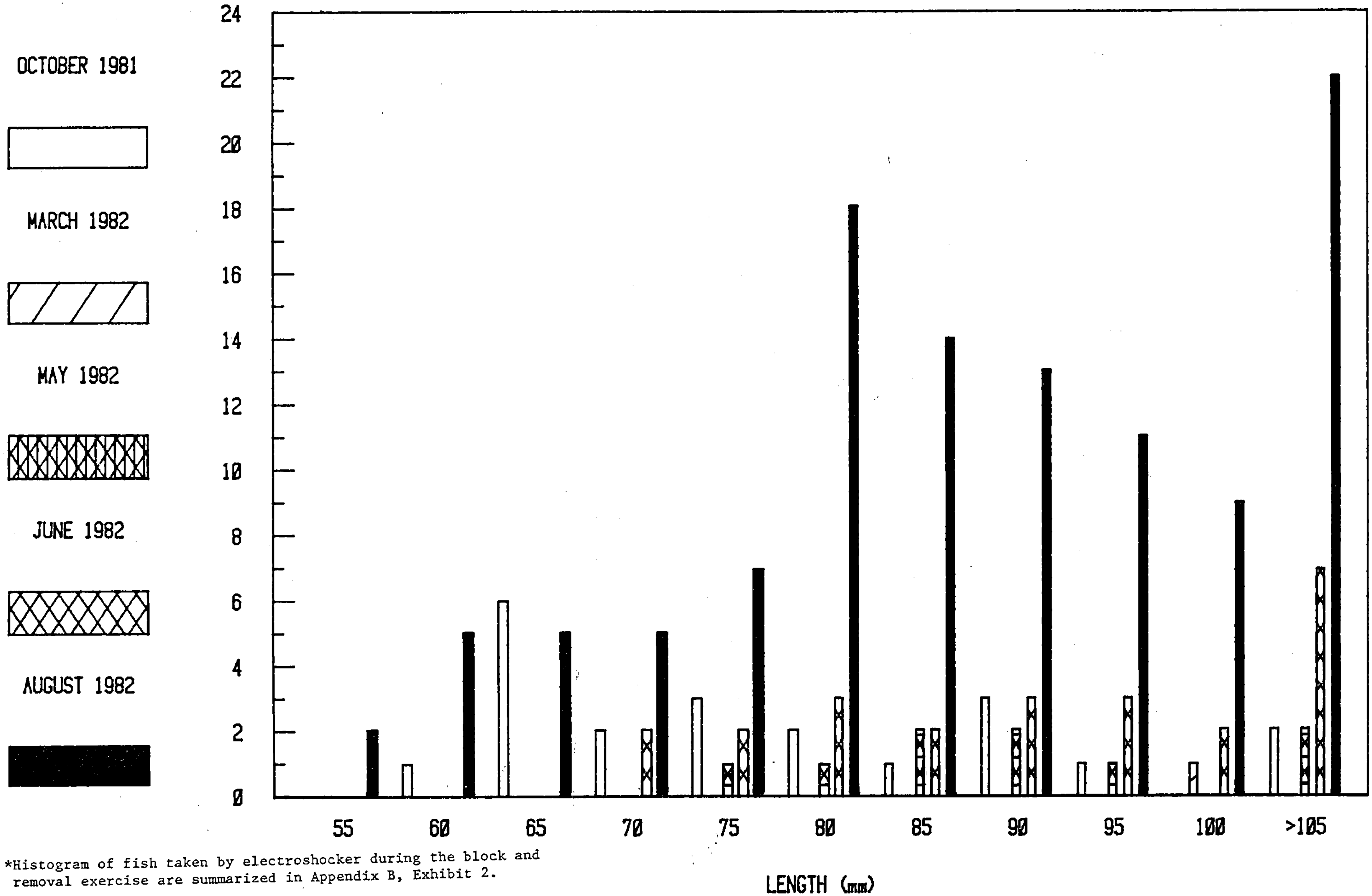
Location	October 1981	March 1982	May 1982	June 1982	August 1982
Minnow Trap:					
Sample area 1	10	0	3	15	21
Sample area 2	1	0	6	5	34
Sample area 3	9	0	0	1	26
Sample area 4	2	1	0	3	32
Total Fish	22	1	9	24	113[1]
Total Trap Hours	80	306	162	108	126
Catch Per Hour	0.28	.01	0.06	0.22	0.90
Electroshocker:	3	1	22*	**	**

1. Twenty additional Dolly Varden (20 to 30 cm) were taken by angling in Grant Creek.

*Taken while performing the block and removal methodology (Zippen 1958). See Appendix B.

**No electroshocker sampling conducted.

Figure 50. Length/frequency histogram of Dolly Varden juveniles taken by minnow traps, Grant Creek, 1981-1982.*



*Histogram of fish taken by electroshocker during the block and removal exercise are summarized in Appendix B, Exhibit 2.

The results of investigations using minnow traps of the use of Falls Creek by juvenile Dolly Varden are presented in Figure 51. A length frequency histogram of these fish is presented in Figure 52.

Dolly Varden juveniles were the most ubiquitous fish found in Grant Creek. They were distributed in all study areas in a wide variety of habitats, including shallow, slow water; deep pools; stream margins in sections with high velocities; mid-channel in areas where large boulders or debris protected them from high velocities; and in temporary backwaters and side channels during high flows.

The Dolly Varden captured in Grant Creek in May (including those taken during the electroshocking conducted during the block and removal exercise) and June of 1982 were all 65 mm or larger (Figure 52). The absence of fry indicates that Dollys do not spawn in Grant Creek. In August 1982 Dolly Varden ranging from 55 mm to 30 cm were observed in nearly every location in which observations were made. This would indicate a high level of rearing recruitment from the Trail lakes system, which was extremely glacially turbid relative to Grant Creek at this time. Grant Creek and other relatively clear streams may play an important role in the production of Dolly Varden in the highly turbid Trail lakes area. Like the other salmonids of Grant Creek, Dolly Varden became much less evident in the winter months.

Dolly Varden were the only fish species caught in Falls Creek. They were distributed throughout the creek in a diverse range of habitats, including the area being actively placer mined. The cold water and mining activity of Falls Creek provided marginal habitat, and the utilization of the creek was considerably less than that of Grant Creek. In the winter, Falls Creek was frozen solidly to the thalweg and offered no overwintering habitat. No evidence of adult Dolly Varden or spawning activity was recorded in Falls Creek.

Sculpins

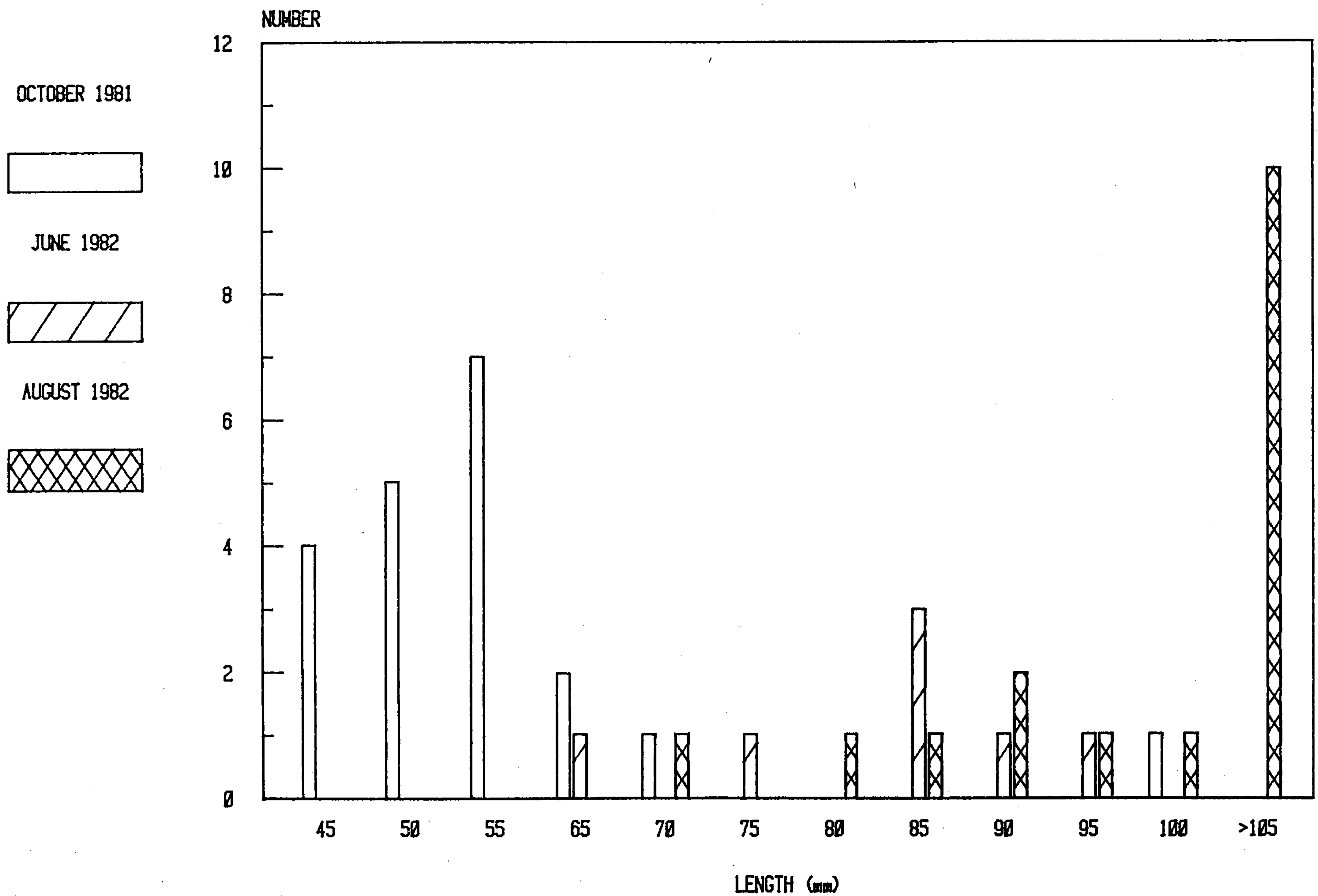
Sculpin spawn in spring and may continue spwaning through the summer, usually in the lower reaches of a stream. The males build a nest in a protected spot and defend the area after mating. Sexual maturity is reached in the third and fourth year. Slimy sculpin

Figure 51. Falls Creek Dolly Varden taken by minnow trap, October 1981 - August 1982.

Location	October 1981	March 1982	May 1982	June 1982	August 1982
Sample area 1	1	Frozen to thalweg	Frozen to thalweg	2	1
Sample area 2	3			4	11
Sample area 3	0			0	0
Sample area 4	16			1	4
Total Fish	20			7	16[1]
Total Trap Hours	108			108	72
Catch Per Hour	0.19			0.06	0.22

1. Two Dolly Varden (70 and 110 mm) were taken in traps set for 16 hours above the active placer mine area. Several other Dolly Varden (70 to 120 mm) were observed in the pump intake pool within the active placer mine area.

Figure 52. Length/frequency histogram of Dolly Varden juveniles taken by minnow traps, Falls Creek, 1981-1982.



apparently do not migrate except for spawning and are quite sedentary. The coastrange sculpin may migrate seasonally, downstream in the spring and upstream in the fall or winter.

The slimy sculpin is almost exclusively insectivorous in its food habits, feeding on diptera larvae, ephemeroptera, and trichoptera. Smaller fish feed most heavily on diptera, especially chironomids. The food of the coastrange sculpin consists mainly of benthic insect larvae and nymphs, including trichoptera, plecoptera, and ephemeroptera. It may also prey on salmon fry and does compete for food with coho salmon fry (Ringstad 1974).

Sculpins are found both in Grant Lake and in Grant Creek. The sculpin uniformly found in Grant Lake is the slimy sculpin--*Cottus cognatus* (Richardson)--and the species found in Grant Creek (except at the outlet of the lake above the falls) is the coastrange sculpin--*Cottus aleuticus* (Gilbert). Previous investigators recorded sculpin in Grant Lake (USFWS 1961) and Grant Creek during most months of the year (Figure 36).

In our investigations of Grant Lake, slimy sculpin were trapped in very small numbers, especially relative to stickleback (500/1). They were found in shallow littoral areas in both basins, usually in coves with evident detrital cover. Two were found in Grant Creek in a large pool between the upper and lower falls. The number of coastrange sculpin found in Grant Creek was moderate. Nineteen were taken in traps and 70 by electroshocker during the entire field study. They were present in all seasons of the year and in all study areas except the uppermost. In both swift-running and quiet water they were found hugging the bottom, often in the heads and tails of riffles.

Stickleback

Previous investigators found threespine stickleback--*Gasterosteus aculeatus* (Linnaeus)--in Grant Lake in large numbers (USFWS 1961). Stickleback are often important food for larger fishes or birds. Breeding occurs in spring and summer. The male builds the nest and guards it after spawning. Sexual maturity is reached in the first or second year. Sticklebacks mostly eat zooplankton and insects, but their diet can be very diverse.

In our investigation of Grant Lake, stickleback were found mainly in moderately shallow littoral areas in both basins; however, the numbers of fish per trap in the lower basin and narrows area exceeded those in the upper basin ten to one. No stickleback were found in areas of disturbed shoreline or in the pelagic zone.

Incidental Fishes

Both adult grayling and whitefish have been reported in Grant Creek (Figure 37, AEIDC 1980). These species are believed to be opportunistically feeding in Grant Greek and are not regular residents or spawners in the system. We collected one grayling in October 1981 in Study Area 3 of Grant Creek; none were collected at any other time. No whitefish were observed or collected during our study.

TERRESTRIAL BIOTA

BOTANICAL RESOURCES

INTRODUCTION

The Kenai Peninsula-Prince William Sound region is the northern limit of the coastal hemlock-spruce forest which stretches nearly two thousand miles from Oregon to Alaska. In southcentral Alaska this type is generally limited by steep mountains and glaciers to a narrow coastal fringe (Ruth and Harris 1979). The primary species present in the coastal forest are western hemlock and Sitka spruce. Mountain hemlock often takes the place of western hemlock, and white spruce often replaces Sitka spruce as a major component of this forest type on the Kenai Peninsula. White spruce/Sitka spruce hybrids are found on the Kenai Peninsula (Viereck and Little 1972). Common understory plants include alder, rusty menziesia, various blueberries, and highbush cranberry. Areas of poor drainage often support open bogs, typically vegetated with low shrubs, mosses, and sedges (Viereck and Little 1972). Timberline on the Kenai Peninsula is generally at 1,000 to 1,500 ft (Ruth and Harris 1979).

Grant Lake lies in a valley with steep, avalanche-prone slopes. The mountain tops are essentially barren of plant life and have numerous permanent snowfields. Barren areas are common throughout the alpine and subalpine areas in the form of talus slopes, cliffs and rock outcrops, and drainage areas. Alpine areas are restricted and often interspersed with barren areas. The subalpine mosiac of alder thickets and grass/forb meadows is the most dominant vegetation type in the Grant Lake basin and is the primary association in the Falls Creek drainage. The Inlet Creek valley of Grant Lake supports a mature balsam poplar association along the delta and conifer stands farther up valley. Conifer stands occur in some avalanche-free sites around the lake. The area between Grant Lake and the Trail lakes is forested with conifers and mixed conifer/broadleaf stands which are broken by several ponds and numerous bogs.

The high snowfall and frequent avalanche activity are important forces in the distribution of plant communities in the study area.

Tall, stiff-stemmed plants, such as trees, are usually absent from avalanche chutes since they are regularly broken off by the force of an avalanche. Shorter, relatively flexible plants, such as alder and grasses, are not as easily damaged and are often pioneer species in revegetation of disturbed sites.

DESCRIPTION OF MAPPING UNITS

A species list is included as Appendix C and a map delineating vegetation associations in the project area is included as Appendix D.

Conifer Forest

This vegetation association type is represented in the study area primarily by white spruce and western hemlock in pure or mixed stands. Mountain hemlock occurs at higher elevations. Understory shrubs are primarily rusty menziesia, early blueberry, and Alaska spirea. Devil's club can be found in moist areas and along drainages. Forest openings may support Sitka alder, serviceberry, Pacific red elder, and Sitka mountain ash. Other common shrubs in this type are trailing black currant and American red currant. The ground cover in this type is primarily a carpet of *Sphagnum* spp. and other mosses with five-leaf bramble, and lingonberry trailing over the moss carpet. (This association corresponds to Viereck, Dyrness, and Batten's (1982) Level III closed needleleaf forest except for the black spruce bogs which correspond to Level II open needleleaf forest.)

Conifer forest occurs primarily between Grant Lake and Upper Trail Lake, in patches along the shores of Grant Lake, in the valley of the inlet stream, and between the mouth of the Falls Creek valley and the Trail River. Areas of poor drainage may support open stands of black spruce with an understory of Labrador tea, lingonberry, and dwarf blueberry growing over a layer of sphagnum moss and lichens (primarily *Cladonia* spp.). These black spruce bogs occur along the Trail lakes and scattered throughout the lower elevations around ponds and adjacent to the more open wet meadows.

Broadleaf Forest

This association is dominated by cottonwood with an understory of rather tall (15-25 ft) feltleaf willow, Sitka willow, Sitka alder, and occasional white spruce. The ground cover is extremely sparse and consists of scattered patches of horsetail and river beauty. Frequent flooding is probably a very important force in this type. (This type corresponds with the Level IV closed balsam poplar forest of Viereck, Dyrness, and Batten (1982).)

This association occurs in the project area only along Inlet Creek and on a small delta to the west of the main delta. Inlet Creek does not have a well-defined channel and appears to shift its course across the delta frequently. During July 1982 the main body of the stream was flowing directly through a mature cottonwood stand.

Mixed Broadleaf/Needleleaf Forest

This type is dominated by paper birch and white spruce with western hemlock on relatively warm, dry sites. Cool wet sites are often dominated by black spruce. The common understory plants of this type are rusty menziesia, highbush cranberry, early blueberry, American red currant, and prickly rose. Devil's club is found in wet places and along streams. Open sites often support Sitka alder thickets. The ground cover in the mixed forest is primarily mosses, bunchberry, five-leaf bramble, and lingonberry. The mixed forest type occurs in the project area in a band along the Trail Lakes and in the Vagt Lake area. (This type corresponds with Viereck, Dyrness, and Batten (1982) Level III closed mixed forest.)

Riparian Scrub

This is a rather simple association. It consists almost entirely of willows. Plants such as river beauty, fireweed, horsetail, and, on drier sites, bluejoint make up the understory vegetation. (This type corresponds with Viereck, Dyrness and Batten (1982) Level III open tall shrub scrub.) Distribution of this type is very restricted in the project area, occurring only along the Inlet Creek, on the Grant Lake delta, and interspersed with the broadleaf forest.

Upland Scrub

This community makes up most of the subalpine vegetation in the study area. It is primarily composed of Sitka alder thickets in a complex mosaic with the grass/forb meadow type. Because of this complexity, we included most of the grass/forb meadows in this unit on the map. (A description of the meadow type follows.) This closed scrub community has a poorly expressed understory composed primarily of ladyfern. In some avalanche chutes the alder is mixed with willows. Rusty menziesia may form substantial portions of this type along the conifer/scrub interface. (It corresponds with Viereck, Dyrness, and Batten (1982) Level IV closed tall alder scrub.) This association generally occurs from 700-2,500 ft along the mountain slopes throughout the study area.

Grass/Forb Meadow

This community forms a mosaic with the upland scrub type described above. As stated, because of the complexity of the association and the small size of these meadows in the study area, we included most of them in the upland scrub unit on the maps. The larger meadows were mapped separately. The primary constituent of this type is bluejoint grass. Salmonberry, red raspberry, fireweed, cow parsnip, false hellebore, and goatsbeard are found throughout these meadows but generally are sparse. Dry, rocky slopes often support prickly rose, yarrow, arctic sagewort, cranesbill, and harebell. Monkeyflower is conspicuous along drainages. (These types correspond to Viereck, Dyrness and Batten (1982) Level III mesic graminoid herbaceous and Level III mesic forb herbaceous.) These meadows are located primarily along the slopes of both Grant Lake and the Falls Creek valley, but small meadows also can be found in the mixed forest and conifer forest types.

Bog (Wet Meadow)

Sphagnum mosses form the basis of this type. The bogs vary from extremely wet, floating mats to firm, treed bogs with a high proportion of shrubs. Often there is a small pond or wet spot near the center of the bog. The wettest of these communities support sphagnum, sundews, buckbean, scattered white beakrush and sedges. The ponds themselves often support buckbean and yellow pond lily. The drier bogs may support scattered black spruce, dwarf birch, labrador tea, lingonberry, dwarf blueberry, crowberry, and cloudberry. (This type corresponds to Level III wet graminoid herbaceous and Level IV open low shrub scrub, ericaceous shrub-sphagnum bog of Viereck, Dyrness, and Batten (1982).) These bogs are most common in the project region in areas of low relief in the mixed and conifer forest types, often surrounding ponds or lakes. Most of them occur between Grant Lake and the Trail lakes. Some of the smaller or more forested bogs are included in the forest classes.

Alpine Tundra

Tundra vegetation can vary considerably depending on the microclimate of a site. In many areas, subalpine communities intergrade with tundra types, making the delineations between these types somewhat arbitrary. Therefore, this description is a generalization of many types which occur in patches throughout the alpine zone. Lichens are conspicuous in many alpine areas, the most prevalent being *Cladonia* spp. and *Stereocaulon* spp. Prostrate willows, such as ovalleaf willow and arctic willow form a mat over the lichens in many alpine areas, as does bearberry. Graminoids, such as woodrush, finely-awned sedge, and fescue, are interspersed throughout tundra areas, especially on most sites. Alaska moss heath, Aleutian mountain heather, and crowberry can cover large areas on the alpine slopes. *Luetkea pectinata* and sweet coltsfoot grow in moist places such as snowbeds and along drainages. Bog blueberry grows in patches on sunny slopes. Shrubby willows such as barclay willow, feltleaf willow, and diamondleaf willow grow along some of the alpine drainages. (The alpine tundra type correlates to Level III open dwarf shrub scrub of Viereck, Dyrness, and Batten (1982).) Alpine tundra in the study area is limited by the steep barren mountain tops, talus slopes, and permanent snowfields. It is most extensive on south-facing slopes above 2,000 ft.

Barren

These areas are mountain tops, talus slopes, cliffs, and snowfield which have less than 10 percent coverage in plants.

VEGETATION OF IMPACT SITES

Figure 53 relates the amount of each vegetation type to the amount likely to be modified by project structures.

Grant Lake Drawdown Area

The area that would be exposed by the drawdown of Grant Lake is essentially barren of macrophytes with the exception of two areas. A protected cove at the neck between the upper and lower basins of Grant Lake supports a small stand of the sedge *Carex rhynchophysa*. The outlet of Grant Lake has a robust stand of white water crowfoot. This plant provides habitat for a great many freshwater clams and snails. Grant Lake was the only location where the white water crowfoot was found in the study area. *C. rhyncophysa* was also found along a Grant Creek tributary stream.

Falls Creek Inundation

The proposed Falls Creek damsite is located in a steepwalled canyon with very little vegetation, primarily alders, scattered mosses and saxifrages. It is anticipated that the dam and inundation would effect no more than 1 acre (D. Smith, pers. comm.) and should not impact any major plant communities. Construction of the dam may disturb an area of transition between conifer forest and upland scrub and grass/forb meadow. These are very common types in the study area.

Falls Creek Diversion Tunnel and Access Road

The preliminary design of the Falls Creek diversion tunnel and accompanying access road places them along the interface between the conifer and mixed forest types and the upland scrub type. The scrub in this area is primarily alder and rusty menziesia with little or no understory aside from patches of bluejoint. The tunnel and road might be routed through a large bluejoint meadow which borders the southern end of Grant Lake. Grass in this nearly pure stand grew to nearly

Figure 53. Amount of cover types to be altered by project structures.

	Conifer forest	Mixed forest	Broadleaf forest	Riparian scrub	Upland scrub	Grass/forb meadow	Bog	Alpine	Barren	Aquatics (Grant Lake)
Total acres in study area	3,914	1,156	92	100	6,299	900	156	5,966	17,470	< 1
Total acres to be altered:										
Drawdown area									70	< 1
Falls Creek inundation									< 1	
Falls Creek diversion tunnel and access road	4				2	< 1				
Falls Creek/Trail Lake access road	1	4			< 1					
Grant Lake/powerhouse access road	7	2					< 1			
Powerhouse site		1					1			
Total area to be altered:										
Acres	12	7	0	0	Approx. 2	< 1	Approx. 1	0	Approx. 70	< 1
Percent	< 1%	< 1%	0%	0%	< 1%	< 1%	< 1%	0%	< 1%	Approx. 100%

Note: These figures are approximations based on preliminary sitings of project structures and may change significantly when exact sites are chosen. Numbers have been rounded to the nearest integer. Areas for project structures are based on figures from D. Smith (pers. comm.).

seven ft during the 1982 field season. Patches of cow parsnip and occasional willow also occur in the area. The forest types tend to be slightly more open along this edge, as the trees are near their altitudinal limits. This openness allows the understory to grow more profusely than it does in closed areas. The forest and scrub are very common types in the study area. The meadow areas along this route are not unique in composition, although they occur at a much lower elevation, have less of a slope, and are generally larger than most meadows in the area.

Falls Creek/Trail Lakes Access Road

This structure would primarily cross through the mixed and conifer forest types in an area characterized by rolling hills and small drainages. Some small bogs might also be disrupted by project construction. None of these areas is particularly unique relative to the rest of the study area, although the bogs are the least common vegetation type.

Grant Lake/Powerhouse Access Road

This structure would be routed through conifer forest and bog communities for most of its length. As with the other access roads, there are no affected areas which are unique relative to the rest of the study area.

Powerhouse Site

The proposed powerhouse site is in a paper birch stand at the interface between a mixed forest and a bog community. The understory is almost entirely rusty menziesia. The ground cover is moss with lingonberry, five-leaf bramble, and bunchberry. The bog community is very shrubby with scattered black spruce. The shrubs are shrubby cinquefoil, dwarf birch, labrador tea and dwarf blueberry. Ground cover is mosses (primarily Sphagnum spp.) and lichens (primarily Cladonia spp.) with crowberry, lingonberry and cloudberry. As with the other project structures, the vegetation types that are likely to be affected are well represented in the study area.

SUCCESSIONAL TRENDS

There are several major factors that influence succession, including the type of seedbed available, vegetative community present before disruption, seed and propagule sources, degree of disruption, and climatic and weather conditions. Of these, the type of seedbed is one of the most influential. If the exposed soil has a large component of unweathered parent material and has never supported plant life, the invasion and development of vegetation associations is called primary succession. In secondary succession, the seedbed has previously supported vegetation. Past vegetation may have been destroyed by such forces as fire, cultivation, or timber harvest. The soil, including humus, remains, and there are usually some residual plants, propagules, or seeds (Daubenmire 1968).

The type of succession will influence the types of associations and the rate of replacement that will develop within the community. Secondary seres profit greatly from a seedbed which has an active soil fauna, residual plants, and an abundance of available nutrients. This abundance of nutrients is due to the presence of organic matter, minerals which have been broken down by plant exudates, and the ability to retain water. Primary seres must cope with a comparatively sterile environment. Mineral soils do not retain water well, nutrients may be severely unbalanced or physiologically unavailable, and there may be a lack of good rooting medium. The rate of recovery can be extremely slow under these circumstances.

In the study area, primary succession areas include landslides, talus slopes, cliffs, mountaintops, recently glaciated areas, lakeshores, streambeds, and associated gravel deposits. Though plant growth in some of these areas may be limited by continual perturbation or extreme physiological factors such as cold temperatures, other areas may become well vegetated in less than 50 years (Holmes 1981). An important characteristic of "good" sites seem to be a large proportion of fine particles in the soil. Surface depressions appear to be important colonizing sites because of the collection of fine particles, loose organic matter, and moisture as well as protection from sun and wind (Holmes 1981).

Source of seeds or other propagules near the bare area is also important in determining the pioneering species. Large bare areas tend to vegetate from the edges inward due to the proximity of seed sources. In the harshest areas Stereocaulon spp., Umbilicaria spp. and other lichens and some mosses would most likely prevail. Where the amount of fine particles is greater, herbaceous species such as fireweed and woody plants such as birch and willow may invade. Shrubs such as highbush cranberry and red raspberry may invade in areas with a moderate content of fine particles. The nitrogen fixing shrub alder appears to colonize sites where fine particles make up a high percentage of the substrate (Holmes 1981). Areas such as lakeshores and stream courses may be affected by hydrologic changes which could influence colonization. Permanent flooding would limit plant species to aquatic and emergent species if substrates are suitable. Lowering of water levels or changes in stream courses could make some areas available for plant colonization.

Willow is a common pioneer species along rivers and streams. Lowering of water levels in streams may have some effect on adjacent vegetation communities through a decrease in seasonal flooding as well as a possible decrease in available water. This would depend a great deal on the groundwater situation in the area. An example of this type of change would be a movement from a riparian willow community to an alder, birch, or cottonwood association.

The types of areas which support secondary succession include avalanche chutes, burns, bladed roads, blowdowns, and any other surface perturbation in already vegetated areas. In addition, succession is an ongoing process within any given vegetation type. Again, this process may be limited by the physiological limits of plant growth, environmental conditions, substrate, and propagule sources. The severity of disturbance can have profound effects on the revegetation of a site. Severely disturbed sites would probably have fewer viable residual plants, and would take longer to revegetate.

Bladed roads and other severe disturbance which remove and compact the soil destroy most of the previous vegetation and take the longest to recover. Invading species are often fireweed, lupine, and alder. Alder can form dense thickets along unused roads within a few years.

Avalanches generally do not remove all of the vegetation in their path, however, most tree species are destroyed. More flexible plants, such as alder, willow, graminoids, and other herbaceous species, generally survive. Because avalanches tend to recur in the same pathway, many avalanche chutes exhibit a scrub community even though they may have the potential to support forest communities.

Fire sweeping through an area, may leave many plants essentially unharmed or may destroy all aboveground plant tissue. Rarely will it destroy all roots and underground propagules, which often send up shoots within a year of the fire. Fireweed is well known for flourishing after a fire.

The Kenai Peninsula has been the site of many forest fires. The two largest in recent history occurred in 1947 (421,000 acres) and in 1969 (86,000 acres). Neither burned the study area. Periodic burning of area forests has been attributed with creating favorable moose habitat. Successional trends after fire are essentially dependent on the previous vegetation (Spencer and Hakala 1964; Hakala et al. 1971). At lower elevations burned over areas tend to favor hardwood browse species such as aspen, willow, and birch. In time, and without the influence of fire, conifers eventually dominate (Spencer and Hakala 1964).

ENDANGERED SPECIES

Currently, no indigenous Alaska plant species are listed by the U.S. Fish and Wildlife Service as threatened or endangered. However, there are 31 species currently under review (Federal Register, Vol. 45, No. 242, Monday, December 15, 1980). Of these, only one *Puccinellia triflora* has been reported on the Kenai Peninsula. This alkali grass is found in the coastal wetlands of the Cook Inlet-Kenai Peninsula area (Murray 1980). Since no habitat is available within the study area, this species would not be expected to occur and was not found during field investigations.

WILDLIFE RESOURCES

INTRODUCTION

The fauna of the Kenai Peninsula is relatively simple compared to that of the mainland because physiography poses a formidable barrier to animal migration. The peninsula is connected to the mainland only by a mountainous isthmus about 12 miles across. Many species which are widely distributed and locally abundant in interior Alaska, e.g., ground squirrels and pikas, are absent from the Kenai Peninsula.

This section reviews the distribution and relative abundance of birds and mammals within the study area. Information presented here is based on a comprehensive statewide literature review, interviews with knowledgeable residents and agency personnel, and aerial and foot surveys of the project area. At Ebasco's request, we made subjective population estimates for select species. Note that most of our estimates pertain strictly to those animals present within the study area in a given season in a given year. This is an important point since most of the species involved are wide ranging during warmer months. We do not know whether or not these numbers describe a discrete population or whether they represent only part of that population. Also, remember that the reliability of a given estimate varies in relation to the level of information available at the time the estimate was made. For example, estimates supported by long-term trend data are probably more reliable than those which are not. Again, keep in mind that all estimates presented in this study are specific to a single instant in time. We made no attempt to account for naturally occurring changes in population numbers through time nor did we attempt to evaluate the influence of hunter-induced mortality on our estimates. Also at Ebasco's request, we focused on several species and species groups more than others. These are moose, Dall's sheep, mountain goat, bears, beaver, ptarmigan, spruce grouse, raptors, and waterfowl.

AMPHIBIA

Wood frogs (Rana sylvatica) are widely distributed throughout low-lying habitats on the Kenai Peninsula (Hodge 1976; D. Spencer, pers. comm.). Suitable breeding, rearing, and over-winter habitats are found in the western part of the study area between Grant and Trail lakes. Specimens were often noted on the benchland west of Grant Lake and along Grant Creek. Although historical sightings of both the rough-skinned newt and boreal toad exist from Cook Inlet it is doubtful that either species occurs in the study area (Hodge 1976). Recent sightings are conspicuously absent and both records represent range extensions. In all probability these sightings reflect chance encounters since neither species has been sighted on the Kenai Peninsula in recent years.

AVES

The Alaska avifauna is vast and diverse, comprising approximately 382 species (Kessel and Gibson 1978). Of these, about 130 species are found on the Kenai Peninsula or in its coastal waters (USFS unpublished). It appears likely that approximately 108 species could either inhabit or migrate through the Grant Lake project area. Comprehensive avian studies have not been previously conducted within project boundaries.

Figure 54 lists birds that may occur in the project area, their scientific names, breeding status, relative abundances, and breeding habitats. (Abundance ratings refer only to numbers within project boundaries.) This information was compiled from a literature review and on-site field investigations. Figure 55 compares avifauna habitat types to vegetation associations. The majority of information gathered on birds was incidental to other surveys. Abbreviated accounts of the major species groups as well as individual accounts of upland game birds are presented below.

During our field studies 63 species of birds were observed. This represents 48 percent of the total number of species present on the Kenai Peninsula and 58 percent of those species which could seasonally use the project area. The probability of observing all the species listed in Figure 54 in any one year is remote. The 63 species observed probably represents the majority of the bird types which utilized the Grant Lake study area in 1981-82. It is also representative of the type and number of birds found in other mountain valleys

Figure 54. Avifauna which probably inhabit or migrate through the Grant Lake study area.

A - Abundant
C - Common
FC - Fairly common
U - Uncommon
R - Rare
XX - Primary breeding habitat
X - Secondary breeding habitat
(1) - Habitat types follow Kessel 1979.
(2) - Abundance categories follow the U.S. Forest Service unpublished. Applies to study area only.
* - Endangered species.

Species		Observed During 1981-82 Field Season	Breeding: Known Breeders	Breeding: Inferred Breeders	Abundance[2]	Breeding Habitats in the Grant Lake Study Area[1]: Lacustrine Waters and Shorelines	Fluviatile Waters and Shorelines	Cliffs, Cutbanks, and Block Fields	Wet Meadow	Dwarf Shrub Meadow	Dwarf Shrub Mat	Low Shrub Thicket	Medium Shrub Thicket	Tall Shrub Thicket	Deciduous Forest	Coniferous Forest	Mixed Coniferous-Deciduous Forest	Scattered Woodland and Dwarf Forest	Migratory Only
Common Loon	*Gavia immer*	X	X		FC	XX	X												
Yellow-billed Loon	*Gavia adamsii*				R														X
Arctic Loon	*Gavia arctica*	X	X		U	XX	X												
Red-throated Loon	*Gavia stellata*				R	XX	X												
Red-necked Grebe	*Podiceps grisegena*				R	XX	X												
Horned Grebe	*Podiceps auritus*				U	XX	X												
Whistling Swan	*Olor columbianus*				R														X
Trumpeter Swan	*Olor buccinator*				U	X			XX	X									
Canada Goose	*Branta canadensis*				U	X			X	XX									
Mallard	*Anas platyrhynchos*	X		X	C	XX	X		X	X									
Pintail	*Anas acuta*				FC	XX	X			X									
Green-winged Teal	*Anas crecca*	X		X	U					XX									
Blue-wing Teal	*Anas discors*				R	X			XX	X									
American Widgeon	*Anas americana*	X	X		U	X			XX	X									
Lesser Scaup	*Aythya affinis*	X			U	X			XX										
Common Goldeneye	*Bucephala clangula*	X	X		FC	X	X											XX	
Barrows Goldeneye	*Bucephala islandica*	X			FC	X	X											XX	
Buffelhead	*Bucephala albeola*				U	X	X											XX	
Harlequin Duck	*Histrionicus histrionicus*	X		X	R		XX								XX			XX	
Common Merganser	*Mergus merganser*	X			C	X	X											XX	
Red-breasted Merganser	*Mergus serrator*	X			FC	X	X		X	X									
Goshawk	*Accipiter gentilis*				U										X	X	XX		
Sharp-shinned Hawk	*Accipiter striatus*	X			C										X	XX	X		
Red-tailed Hawk	*Buteo jamaicensis*				U			X						X	X	X	X		
Rough-legged Hawk	*Buteo lagopus*				U			XX											
Marsh Hawk	*Circus cyaneus*				R				XX	X									
Golden Eagle	*Aquila chrysaetos*	X		X	C			XX									X		
Bald Eagle	*Haliaeetus leucocephalus*	X			FC										XX	X	X		
Merlin	*Falco columbarius*				R			X							X	X	XX		
American Kestrel	*Falco sparverius*	X			R										X	X	XX		
Spruce Grouse	*Canachites canadensis*	X	X		FC											X	XX		
Willow Ptarmigan	*Lagopus lagopus*	X		X	C							X	XX	X					
Rock Ptarmigan	*Lagopus mutus*	X		X	C						XX	X							
White-tailed Ptarmigan	*Lagopus leucurus*				U						XX	X							
Sandhill Crane	*Grus canadensis*				R														X
Semipalmated Plover	*Charadrius semipalmatus*				U	XX	XX												
Black-bellied Plover	*Pluvialus squatarola*				U					X	XX								
Common Snipe	*Capella gallinago*	X		X	FC				X	XX									

Figure 54 (Continued). Avifauna which probably inhabit or migrate through the Grant Lake study area.

A - Abundant
C - Common
FC - Fairly common
U - Uncommon
R - Rare
XX - Primary breeding habitat
X - Secondary breeding habitat
(1) - Habitat types follow Kessel 1979.
(2) - Abundance categories follow the U.S. Forest Service unpublished. Applies to study area only.
* - Endangered species.

Species		Observed During 1981-82 Field Season	Breeding: Known Breeders	Breeding: Inferred Breeders	Abundance[2]	Lacustrine Waters and Shorelines	Fluviatile Waters and Shorelines	Cliffs, Cutbanks, and Block Fields	Wet Meadow	Dwarf Shrub Meadow	Dwarf Shrub Mat	Low Shrub Thicket	Medium Shrub Thicket	Tall Shrub Thicket	Deciduous Forest	Coniferous Forest	Mixed Coniferous-Deciduous Forest	Scattered Woodland and Dwarf Forest	Migratory Only
						Breeding Habitats in the Grant Lake Study Area[1]													
Whimbrel	*Numenius phaeopus*				R				XX	X	X								
Eskimo Curlew*	*Numenius borealis*				R					XX	X								
Spotted Sandpiper	*Actitis macularia*	X		X	FC	XX	XX			X	X								
Least Sandpiper	*Calidris minutilla*				U														X
Wandering Tattler	*Heteroscelus incana*	X			U	X	XX												
Greater Yellowlegs	*Tringra melanoleuca*	X		X	C				X	XX									
Lesser Yellowlegs	*Tringra flavipes*	X		X	C					XX									
Long-billed Dowitcher	*Limnodromus scolopaceus*				U														X
Northern Phalarope	*Phalaropus lobatus*				U				XX	X									
Glaucous-winged Gull	*Larus glaucescens*				U			XX											
Herring Gull	*Larus argentatus*				R														X
Mew Gull	*Larus canus*	X			U			X	XX										
Arctic Tern	*Sterna paradisaea*	X			FC				XX	X									
Great Horned Owl	*Bubo virginianus*				U			X							X	X	X		
Great Grey Owl	*Strix nebulosa*				U										X	XX	X		
Hawk Owl	*Surnia ulula*				U										X	X	XX		
Boreal Owl	*Aegolius funereus*				U											XX	X		
Saw-whet Owl	*Aegolius acadicus*				U										X	XX	X		
Belted Kingfisher	*Megaceryle alcyon*	X		X	C			XX											
Yellow-shafted Flicker	*Colapter auratus auratus*	X			U										XX	X	X		
Hairy Woodpecker	*Picoides villosus*	X		X	U										XX	X	X		
Downy Woodpecker	*Picoides pubescens*				R										XX	X	X		
Northern Three-toed Woodpecker	*Picoides tridactylus*	X		X	FC											XX	X		
Traill's (Willow) Flycatcher	*Empidonax traillii*	X		X	FC							X	XX	X				X	
Olive-sided Flycatcher	*Nuttallornis borealis*				U											XX	X	X	
Violet-green Swallow	*Tachycineta thalassina*	X		X	A			X							X	X	X	X	
Tree Swallow	*Iridoprocne bicolor*	X		X	A										X	X	X	X	
Bank Swallow	*Riparia riparia*	X		X	C			XX											
Cliff Swallow	*Petrochelidon pyrrhonata*				U			XX											
Grey Jay	*Perisoreus canadensis*	X		X	C										X	XX	X	X	
Black-billed Magpie	*Pica pica*	X			C									XX	XX		X	X	
Northern Raven	*Corvus corvax*	X			C			X							X	X	X		
Black-capped Chickadee	*Parus atricapillus*	X	X		A									X	XX	X	X		
Boreal Chickadee	*Parus hudsonicus*				FC									X	X	XX	X		
Dipper	*Cinclus mexicanus*	X	X		A		XX												
Red-breasted Nuthatch	*Sitta canadensis*				R										X	XX	X		
Brown Creeper	*Certhia familiaris*				U										X	XX	X		
Winter Wren	*Troglodytes troglodytes*				U										X	X	X		

Figure 54 (Continued). Avifauna which probably inhabit or migrate through the Grant Lake study area.

A - Abundant
C - Common
FC - Fairly common
U - Uncommon
R - Rare
XX - Primary breeding habitat
X - Secondary breeding habitat
(1) - Habitat types follow Kessel 1979.
(2) - Abundance categories follow the U.S. Forest Service unpublished. Applies to study area only.
* - Endangered species.

Species		Observed During 1981-82 Field Season	Breeding: Known Breeders	Breeding: Inferred Breeders	Abundance[2]	Breeding Habitats in the Grant Lake Study Area[1]: Lacustrine Waters and Shorelines	Fluviatile Waters and Shorelines	Cliffs, Cutbanks, and Block Fields	Wet Meadow	Dwarf Shrub Meadow	Dwarf Shrub Mat	Low Shrub Thicket	Medium Shrub Thicket	Tall Shrub Thicket	Deciduous Forest	Coniferous Forest	Mixed Coniferous-Deciduous Forest	Scattered Woodland and Dwarf Forest	Migratory Only
American Robin	*Turdus migratorius*	X		X	C									X	XX		X	X	
Varied Thrush	*Ixoreus naevius*	X		X	C									X		XX	X	X	
Hermit Thrush	*Catharus guttatus*	X	X		C									X	X	XX	X	X	
Swainson's Thrush	*Catharus ustulatus*	X		X	FC									XX		XX	X	X	
Grey-cheeked Thrush	*Catharus minimus*	X		X	R								XX	X				X	
Golden-crowned Kinglet	*Regulas satrapus*				U											XX	X		
Ruby-crowned Kinglet	*Regulas calendula*	X		X	A											XX	X		
Water Pipit	*Anthus spinotetta*	X		X	C					X	XX								
Bohemian Waxwing	*Bombycilla garrulus*	X	X		U											XX	X	X	
Northern Shrike	*Lanius excubitor*	X			U							X	X	XX	X	X	X	X	
Orange-crowned Warbler	*Vermivora celata*	X		X	C							X	XX		X				
Yellow Warbler	*Dendroica petechia*	X		X	C							X	X	XX					
Myrtle Warbler	*Dendroica coronata*	X		X	A											XX	X		
Townsend's Warbler	*Dendroica townsendi*	X	X		A									X		XX	X		
Blackpoll Warbler	*Dendroica striata*				U											XX	X		
Northern Waterthrush	*Seiurus noveboracensis*				FC	X	X		XX	X									
Wilson's Warbler	*Wilsonia pusilla*	X	X		A							X	XX	X					
Pine Grosbeak	*Pinicola enuncleator*	X		X	C											XX	X		
Grey-crowned Rosy Finch	*Leucosticte tephrocotis*	X			FC						XX								
Hoary Redpoll	*Carduelis hornemanni*				U						XX	X	X						
Common Redpoll	*Carduelis flammea*				C						XX	X	X	X		X		X	
Pine Siskin	*Carduelis pinus*				U											XX	X		
White-winged Crossbill	*Loxia leucoptera*				U											XX	X		
Savannah Sparrow	*Passerculus sandwichensis*	X		X	C					XX	X	X	X						
Slate-colored Junco	*Junco hyemalis*	X		X	FC												XX	X	
Tree Sparrow	*Spizella arborea*	X			FC														X
White-crowned Sparrow	*Zonotrichia leucophrys*	X		X	C							XX	X	X				X	
Golden-crowned Sparrow	*Zonotrichia atricapilla*	X		X	A						X	XX	X	X					
Fox Sparrow	*Passerella iliaca*	X			U								XX	X				X	
Lincoln's Sparrow	*Melospiza lincolnii*	X			U					X		XX	X						
Song Sparrow	*Melospiza melodia*	X			U				XX	X									
Lapland Longspur	*Calcarius lapponicus*				U					X	XX								
Snow Bunting	*Plectrophenax nivalis*				U														X

Sources: Kessel 1979
Gabrielson and Lincoln 1959
U.S. Forest Service unpublished.
Tarres 1980
Bellrose 1978
Kortright 1967

Figure 55. Comparison of avifauna habitat types to vegetation associations.*

Vegetation Associations	Habitat types **												
	Lacustrine waters and shorelines	Fluviatile waters and shorelines	Cliffs, cutbanks, and block fields	Wet meadow	Dwarf shrub meadow	Dwarf shrub mat	Low shrub thicket	Medium shrub thicket	Tall shrub thicket	Decidous forest	Coniferous forest	Mixed coniferous/ decidous forest	Scattered woodland and dwarf forest
Conifer forest	X	X		X	X						X	X	X
Broadleaf forest	X	X							X	X			
Mixed broadleaf/ needleleaf forest	X	X						X	X			X	X
Riparian scrub	X	X					X	X	X				
Upland scrub		X						X	X				
Grass/forb meadow		X		X									
Bog (wet meadow)	X	X		X	X						X		X
Alpine tundra		X		X		X	X						
Barren			X										

* A vegetation association may occur in multiple habitat types. Additionally, several habitat types may be found within any one plant association.
** Habitat types follow Kessel 1979.

of the Kenai Mountains. Of the 63 species observed, 43 species were known or inferred breeders within the Grant Lake study area. Only passeriformes were present in large numbers. An ice-free area at the outlet of Grant Lake was an important winter feeding ground for a small flock of mallards during the winter of 1981-82. This area proved to be one of the most important avian habitats within the project area.

Loons and Grebes

Four species of loon and two of grebes inhabit the Kenai Peninsula (Gabrielson and Lincoln 1959). There are no published reports of project area use by loons and grebes. However, a pair of common loons were observed breeding on Vagt Lake during the summer of 1976 (Trudgen, pers. comm.). Common and red-throated loons are fairly common breeders on the peninsula, and both migrate south during winter. The yellow-billed loon is a migrant though some apparently winter on the Kenai Peninsula (Gabrielson and Lincoln 1959). This species' typical breeding grounds are much further north than the project area. Arctic loons are also migrants through the Kenai Peninsula; however, we observed a pair nesting on Grant Lake. Red-necked and horned grebes summer on the Kenai Peninsula, migrating south in fall. Some horned grebes have been reported to occur year-round on the Kenai Peninsula (Gabrielson and Lincoln 1959).

Nesting habitat for loons and grebes within the Grant Lake study area is limited (Figure 56). Vagt Lake provides some of the more suitable available habitat due to a ready food source (small fish) and lake margins which are adequate for nest construction (marshy areas and a small island); however, the size of the lake prohibits nesting by more than one pair. Grant Lake also provides some nesting habitat in isolated areas. More than one pair could easily nest on this lake. The small ponds located on the bench between Grant Lake and Trail lakes are poor nesting habitat because of their small size and lack of food sources.

We noted several common loons during the study period. The birds were observed on Grant Lake, flying overhead, on Trail lakes, and on Vagt Lake. A pair observed during June on Vagt Lake were assumed to

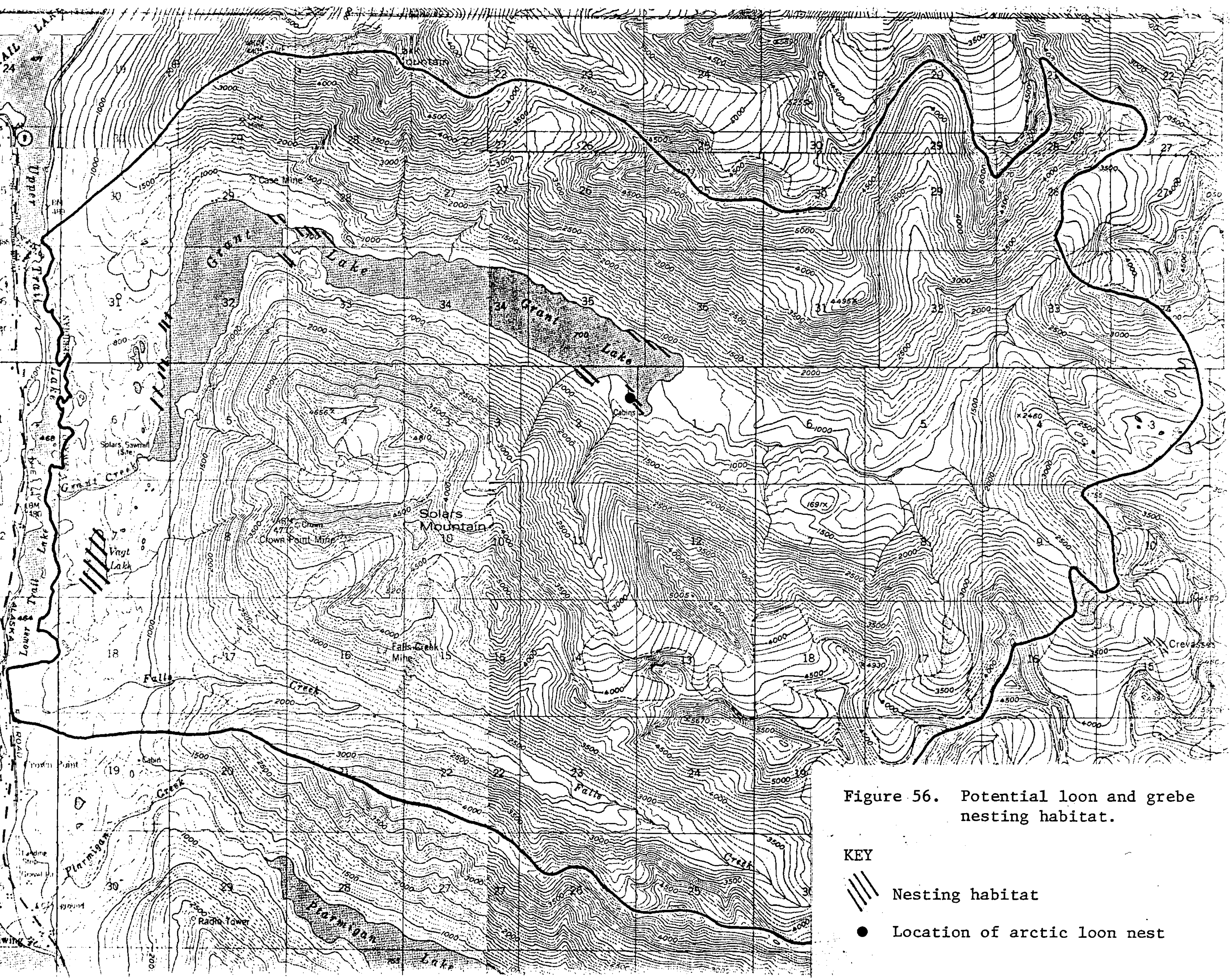


Figure 56. Potential loon and grebe nesting habitat.

KEY

//// Nesting habitat

● Location of arctic loon nest

be nesting. A pair of Arctic loons nested on Grant Lake during the summer of 1982. This is an unusual occurrence as most Arctic loon nesting takes place much further north. R. Richie (pers. comm.) stated that a few pairs have been known to nest on the Kenai Peninsula, but there are no published records. Gabrielson observed a pair at the mouth of the Kenai River and suspected they were nesting but could not confirm it (Gabrielson and Lincoln 1959). It is not known whether these birds will return to the same nesting grounds during ensuing years. Figure 57 gives the timing of significant biological events for this group of birds.

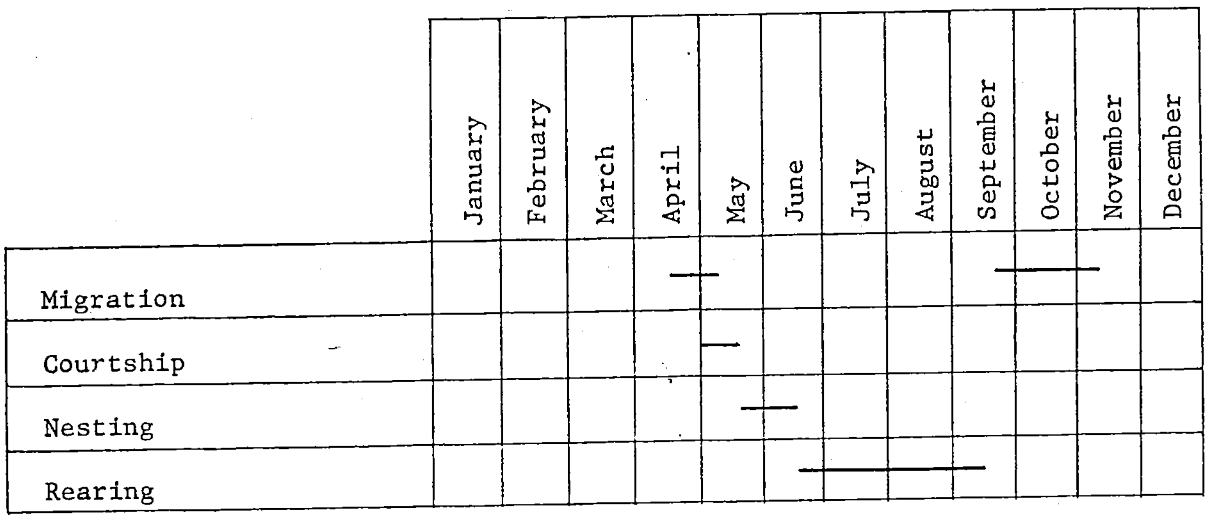
Swans and Geese

Trumpeter swans and one race of Canada goose (Western Canada goose) are common breeders on Kenai Peninsula lowlands (Gabrielson and Lincoln 1959, Hansen et al. 1971). There are no published reports stating that either species have been observed nesting in the Grant Lake area. Most nesting habitat for these species occurs westward of the project area where the Kenai Peninsula forms a broad low level plain, dotted with numerous lakes and ponds. Whistling swans are common migrants through the Kenai Peninsula area (USFS, unpublished) but few if any, stop for appreciable periods of time. Migrational routes tend to follow the coastline, seldom reaching far inland.

These birds generally nest in areas of extensive marsh land or areas typified by numerous pot hole lakes and ponds. Such areas do not exist within the Grant Lake study area. There is a possibility that some birds may nest along Vagt Lake or the small ponds between Grant Lake and Trail lakes since some suitable nesting habitat is available, however, this use is unlikely. We did not observe any geese or swans during the study period.

A subspecies of Canada goose, the Aleutian Canada Goose, is noteworthy as it is one of three Alaska birds listed as a threatened or endangered species. Its breeding range is limited to the Aleutian Islands hundreds of miles southwest of the study area. The fall migration apparently proceeds nonstop directly across the Gulf of Alaska to northern California. There are no known published records of this marine-oriented species occurring on the Kenai Peninsula. It

Figure 57. Timetable of significant biological events for loons and grebes--southcentral Alaska.



Source: Gabrielson and Lincoln 1959.
Terres 1980.
Kessel and Gibson 1978.

appears highly unlikely that any members of this race would occur within the project area.

Ducks

Several species of ducks inhabit the Kenai Peninsula. Species composition ranges from such common breeders as mallards and buffelheads to uncommon migrants such as the ringed-neck duck. We observed a total of nine species of ducks within the project area during the study period. Two species were known to breed and two others were suspected of breeding in the area. An American widgeon nest containing six eggs were observed along the fringes of Upper Trail Lake, and a female common goldeneye and a single downy young were observed on Grant Lake. A pair of harlequins was observed on Inlet Creek and appeared to be on a nesting territory. Additionally, a green-winged teal was also seen along Inlet Creek and was assumed to be nesting.

The project area offers varied, though limited, types of duck habitat (Figure 58). There are areas, principally around Vagt Lake and the bench ponds, which are suitable for such ground-nesting ducks as mallards and American widgeons. In addition, there are standing dead trees which are suitable for tree-nesting species such as mergansers and goldeneyes. The latter areas are scattered throughout the study area and are adjacent to water sources.

During the period of time when Grant Lake is iced over an area at the outlet of the lake remains ice free (Figure 58). This area proved to be a winter feeding area for a flock of mallards. As many as 30 birds were recorded in the opening. Upon closer examination of the area, we found the lake bottom to be rich with white-water crowfoot. Additionally, attached to the plants were an abundance of freshwater snails, clams, and insect larva. Feeding areas become severly restricted during winter, therefore any area with open water and a ready supply of food may be critical to the survival of these birds. With the exception of two pools in Grant Creek this is the only area within the entire project area that remained ice-free and has an abundant available food source throughout the winter of 1981-82.

In summary, waterfowl nesting habitat is very limited within project boundaries. There were no concentrations of any breeding

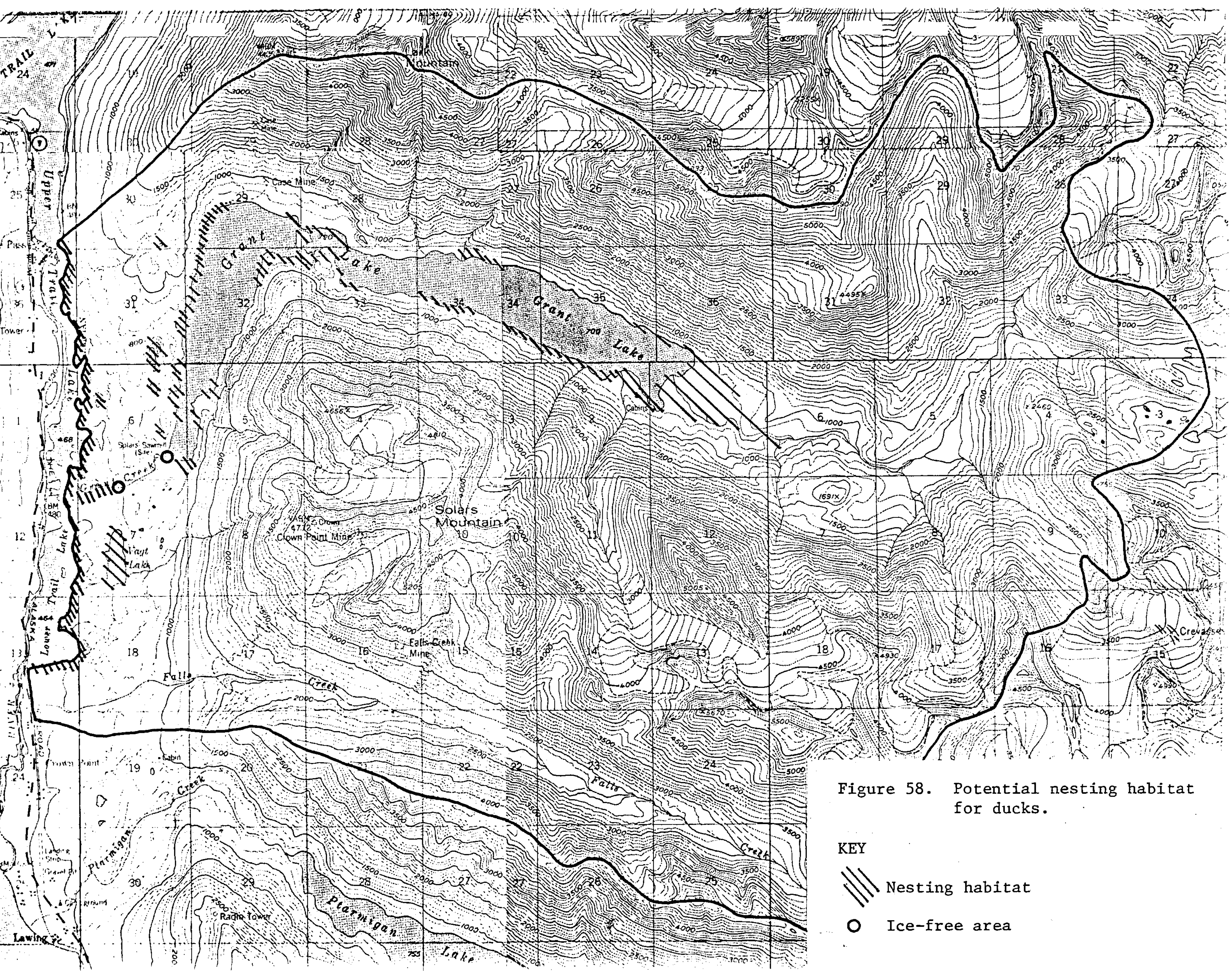


Figure 58. Potential nesting habitat for ducks.

birds, and only four out of 15 species that could nest there were either known or suspected breeders (Figure 54). The ice-free area at the outlet of Grant Lake appears to be an important winter feeding area. We observed a minimum of 30 birds utilizing this small area during the winter of 1981-82. Figure 59 presents a timetable of significant biological events for ducks, geese, and swans.

Raptors

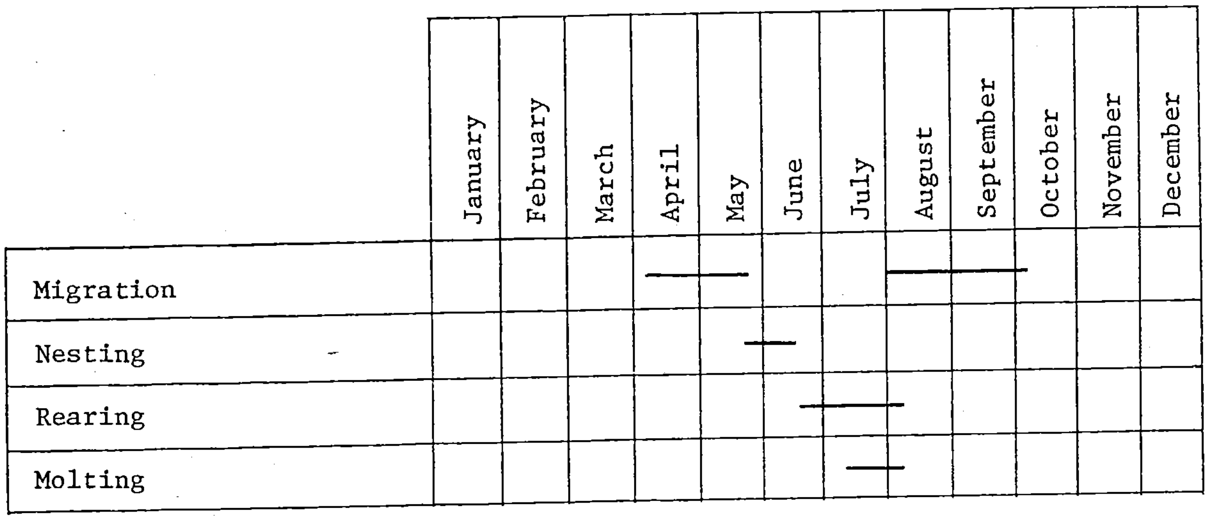
There are five hawk species, two species of eagle, and two falcon species utilizing the Kenai Peninsula for breeding or migrational purposes (Gabrielson and Lincoln 1959; USFS, unpublished). Quinlan (1978) observed a breeding pair of goshawks near Kenai Lake. She also saw red-tailed and sharp-shinned hawks during her studies. The USFS (unpublished) stated that goshawks, sharp-shinned, marsh and red-tailed hawks are uncommon residents of Chugach National Forest. Rough-legged hawks have also been observed on the Kenai Peninsula, although not within the project area (D. Spencer, pers. comm.).

A single sharp-shinned hawk was observed during field studies. This bird was observed in a small drainage along the south shore of Grant Lake's upper basin. The expanses of forested area provide nesting habitat for goshawks, red-tailed hawks and sharp-shinned hawks (Appendix D). Similarly, there are several cliffs which appear to be suitable for nesting rough-legged hawks. Nesting habitat for marsh hawks is mostly confined to the bog areas. The lack of observations does not necessarily mean there were no birds within project boundaries, but if present, numbers would probably be low.

A single American kestrel was observed on the northern slopes of Grant Lake's upper basin above the beaver ponds at the east end. It gave no indications of breeding.

Bald eagles are regularly observed on the Kenai Peninsula (Gabrielson and Lincoln 1959), and a single bald eagle was observed along Grant Lake during October 1981. Bald eagles regularly congregate near any stream with salmonid runs, generally in proportion to the quality of feeding areas and suitability of nesting habitat. The small Grant Creek fish run is not of sufficient magnitude to sustain fish-eating birds in concentrated numbers. No nesting platforms were found.

Figure 59. Timetable of significant biological events for ducks, geese, and swans--southcentral Alaska.



Source: Gabrielson and Lincoln 1959.
Bellrose 1980.
Kessell and Gibson 1979.
Hansen et al. 1971.

We regularly observed golden eagles, both juveniles and adults, within the project area. First sightings occurred during aerial surveys in April of 1982 and continued during each ensuing trip to the project area. All the birds sighted were well within the alpine zone. Lymann Nichols (pers. comm.) regularly observes golden eagles in the Grant Lake area during his surveys of mountain goat and Dall's sheep. He believes that they nest in the area but has never found a nest site. Figure 60 depicts raptor nesting habitat in the project area.

Three races of peregrine falcon, two of which are endangered, are present in Alaska. *Falco peregrinus anatum* and *F. p. tundrius*, the endangered races, breed in moderate numbers throughout interior and arctic Alaska, respectively (D. Roseneau, pers. comm.). Exposure to pesticides apparently resulted in a sharp decline of the breeding population (Cade and Fyfe 1970; Hickey 1969) though populations now seem to be recovering (D. Roseneau, pers. comm.). Records presented by Gabrielson and Lincoln (1959) indicated that these birds were once fairly common migrants through the Kenai Peninsula. Few have been seen in recent years. Most sightings are reported from recognized migration corridors which parallel the outer coasts. It appears unlikely that these birds occur within the project area. The nonendangered race, *F. p. peali*, is primarily a coastal species and also has not been sighted in the interior of the Kenai Peninsula.

Spruce Grouse

Four species of grouse inhabit Alaska, but only one, the spruce grouse, occurs on the Kenai Peninsula. Spruce grouse have been studied most intensively of all upland game birds on the Kenai Peninsula. Mixed forests of black and white spruce along with birch and poplar, at varying successional stages provide ideal habitat (Ellison 1973, 1974; Weeden 1965). Homogenous stands of coniferous or deciduous trees provide marginal habitat for spruce grouse.

The closed nature of the coniferous forests at Grant Lake may preclude a high density of these birds. There are isolated areas of mixed forest communities, principally along Trail lakes and along the Vagt Lake trail, which offer the best spruce grouse habitat in the project area (Figure 61).

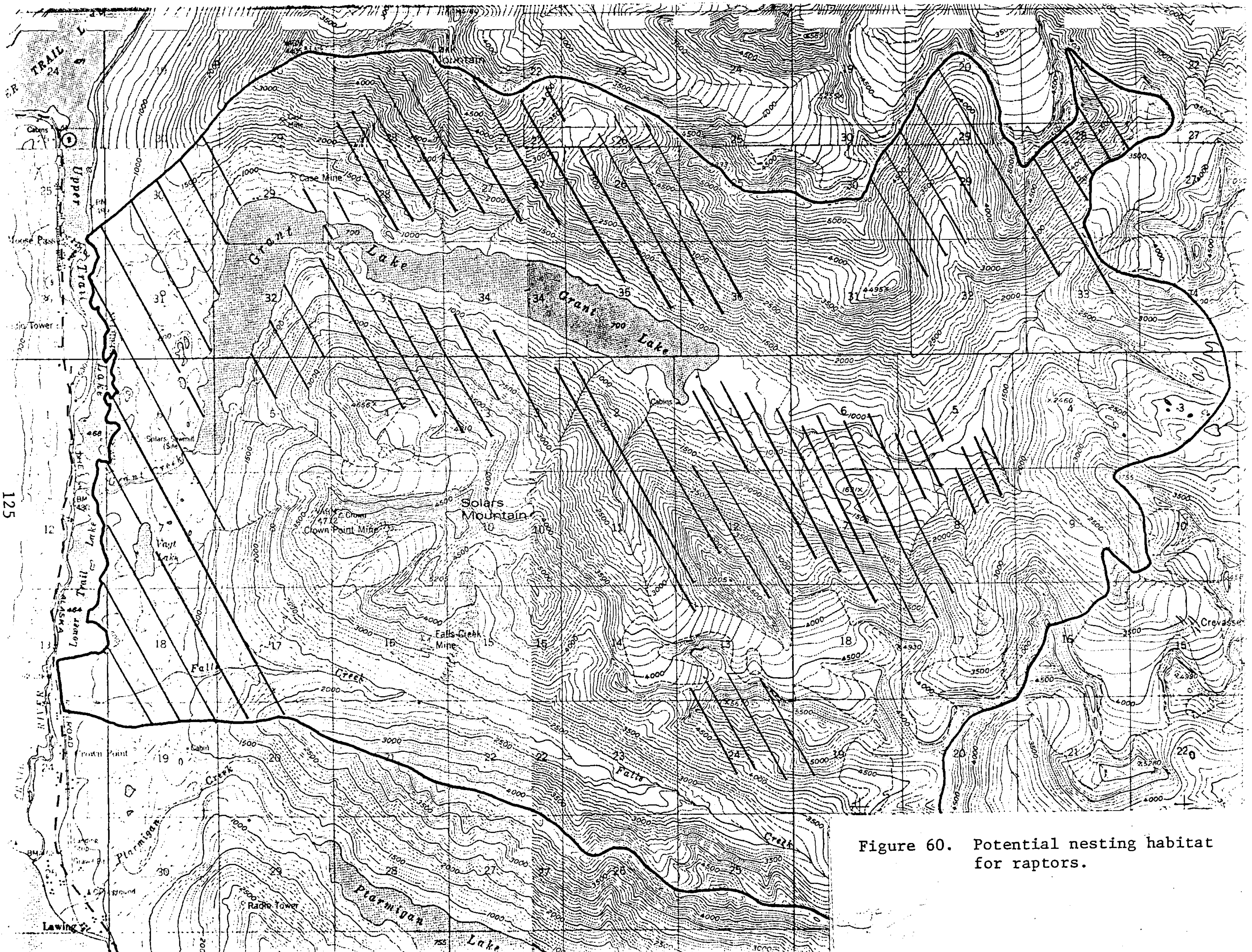


Figure 60. Potential nesting habitat for raptors.

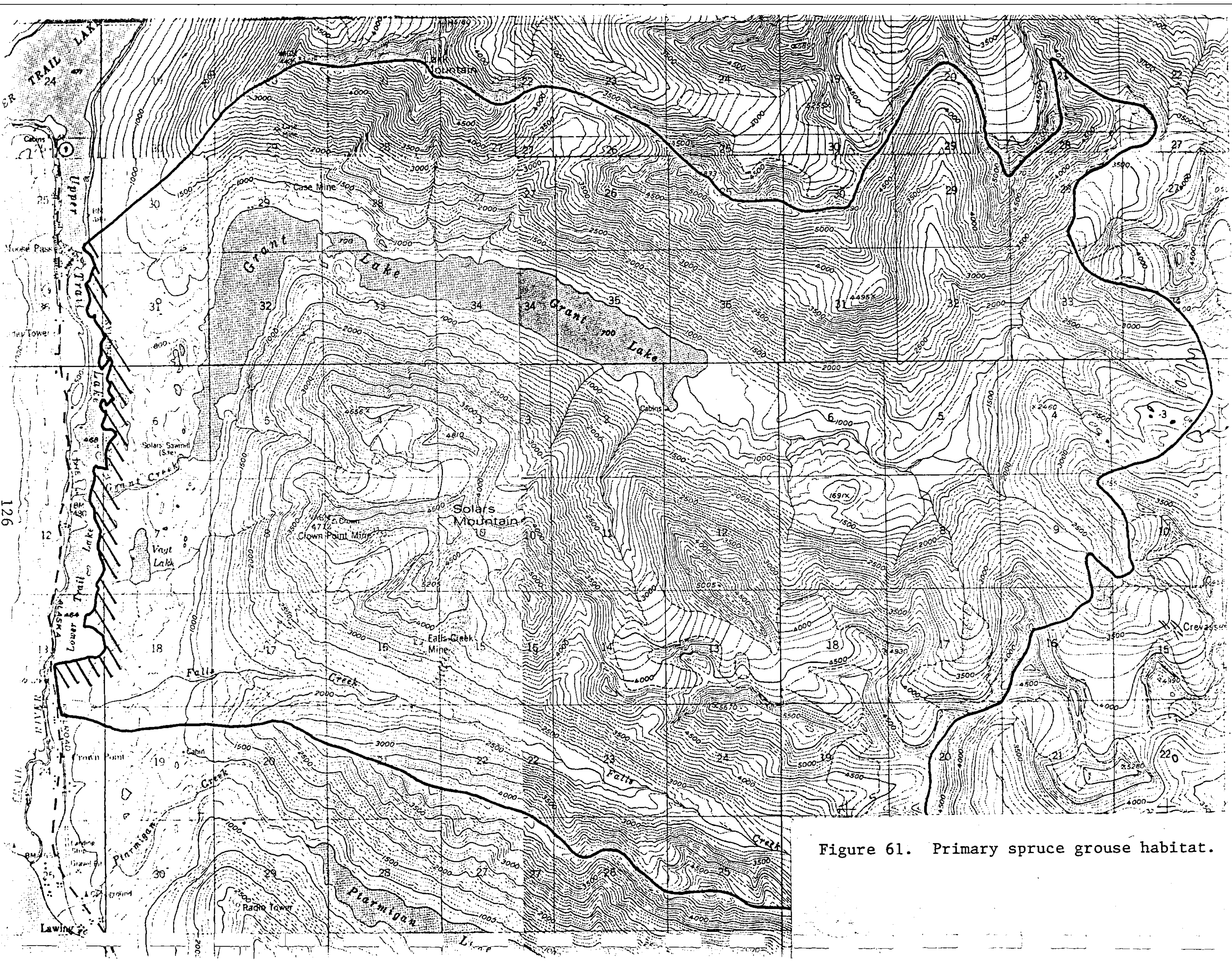


Figure 61. Primary spruce grouse habitat.

A total of only eight adults and one chick was observed, though more than one chick in the area could be assumed. Production of spruce grouse on the Kenai Peninsula is high. Average clutch size is 7.5 eggs. Hatching success has been reported at 91 percent (Ellison 1971, 1973, 1974). Chick survival to the fledgling stage is also high. Ellison (1974) reported a 5.9 juvenile per adult ratio in July and a 5.5 juvenile per adult ratio in August, indicating a minimal loss to the brood. These high production figures, contrasted with the low number of birds observed, also indicate a low population within the study area.

The food habits of spruce grouse have been well documented (Crechton 1963; Ellison 1966, 1976; Jonkel and Green 1963; Weeden 1965; Zwickel, Boog, and Brigham 1974). During winter months the major food is spruce needles. As spring approaches and ground vegetation reappears, birds eat progressively fewer spruce needles and begin consuming other foods. By summer the principal dietary items include cranberry, notably those persisting from the previous fall, as well as blueberry (leaf buds and leaves), unripened crowberries, and lichens. Other major foods at this time include cranberries, Carex seeds, and horsetail. As fall approaches, the diet gradually shifts once again to spruce needles. Other fall foods include cranberries, blueberry leaves and fruit, and seeds from various plants. All these food items are available in varying amounts in the Grant Lake study area (see botanical section).

Natural predators of spruce grouse which could inhabit the Grant Lake area include hawk owls, great horned owls, and goshawks. Fox and lynx, which are known to inhabit the area, are also predators. Ellison (1974) witnessed a goshawk leaving a kill and commonly observed them flying just below treetop searching for prey. Spruce grouse will often feed near the treetops making them easy prey. The effect of natural predation on populations is unknown. Hunting is also a mortality factor near population centers or along roadways (Ellison 1973, 1974). The extent of the hunting pressure in the Grant Lake area is unknown. C. Judkins (pers. comm.) indicated a higher population of grouse in years past. He believed the principal reason for their recent decline was hunting pressure. Better spruce grouse habitat within the project area is adjacent to areas easily accessible to hunters (Vagt Lake trail, mining roads, etc.).

In summary, the spruce grouse population in the Grant Lake area appears low. The normally high production of spruce grouse on the Kenai Peninsula and the low numbers observed by AEIDC personnel indicate low numbers present. Perhaps this is due to a number of factors. First, much of the study area is closed coniferous forest providing only marginal habitat for any large density of birds. Second, local hunting pressure may have a significant effect on local populations of spruce grouse. Food resources do not appear to be lacking, and predator populations do not appear high enough to limit populations of spruce grouse. Figure 62 presents a timetable of significant biological events or spruce grouse.

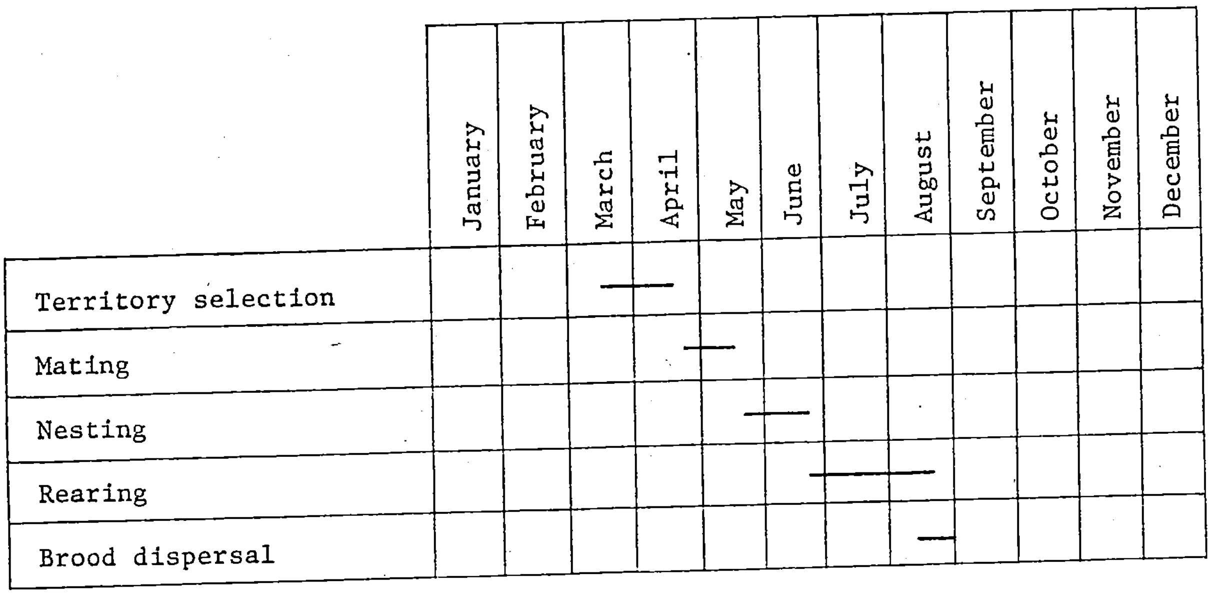
Ptarmigan

Three species of ptarmigan--willow, rock, and white-tail--inhabit the Kenai Peninsula. Even though ptarmigan are highly coveted game birds, few Alaskan studies have been made on them and no comprehensive studies of these birds have been undertaken on the Kenai Peninsula. During the studies at Grant Lake we did not conduct any specific alpine surveys strictly assessing ptarmigan habitat. Rather, information was gathered incidental to other surveys being conducted in the alpine areas (e.g., bear denning surveys and botanical surveys).

Habitat for ptarmigan is found throughout alpine or subalpine zones near or above timberline. Because each species has different habitat preferences, all three can, and often do, coexist at different altitudinal levels on the same mountain. Weeden (1965) described habitat preferences of the three species (Figure 63).

The Grant Lake area provides habitat for all three species (Figure 64). Most ptarmigan habitat within the project area is located along the south-facing slopes at and above 1,500 ft in elevation. Our personnel observed many small flocks of willow and rock ptarmigan both in the Grant Lake and Falls Creek drainages but no large flocks were seen. Most groups numbered between three and 10 birds. Several single birds were also observed.

Figure 62. Timetable of significant biological events for spruce grouse--southcentral Alaska.



Source: Ellison 1971; 1973; 1974.
Weeden 1965.

Figure 63. Summary of habitat preferences of ptarmigan in central Alaska.

Season	Willow Ptarmigan	Rock Ptarmigan	White-tailed Ptarmigan
SUMMER (May-September)			
Terrain	Level ground with minor relief features, or gentle to moderate mountain slopes and terraces. Frequently at bottom of valleys.	Moderately sloping ground in hilly country; middle slopes of mountains.	Steep slopes and ridges, often around cirques and high, stony benches; ledges, cliffs and rocky outcrops common.
Vegetation (General)	Luxuriant growth of plants over most of ground; shrubs usually 3-8', scattered in variable quantities through areas dominated by grasses, sedges, mosses, dwarf shrubs and low herbs.	Vegetative cover nearly complete, but sparse on driest and highest exposed sites. Shrubs 1-4' concentrated in shallow ravines, on soil-creep lobes, in hollows, etc. Most plants less that 1'. Creeping woody plants, rosette plants, sedges, lichens abundant and dominant over wide areas.	Plants rarely form continuous cover over ground, except in most protected, moist sites. Shrubs almost absent, except for dwarf forms. Wide variety of plants present in small quantities.
Relation to Timberline	Usually at upper edge of timber, among widely scattered trees. Sometimes slightly below true timberline where expanses of treeless areas exist because of poor drainage, cold microclimate, etc.	Lowest breeding birds at extreme upper fringe of trees. Most birds from 100-1000' above local timberline.	Above timberline. Occasionally within 100-200' (vertical) of last trees, usually 500-2000' above forest.
Territories (Males)	Include shrubby and "open" vegetation types (with plants less than eyelevel to ptarmigan). Cocks habitually use elevated points (rocks, trees, hummocks) during courtship. Males rest during day in small clumps of shrubs at edges of open areas.	Higher proportion of "open" vegetation than in willow ptarmigan territories; some contain no shrubs. Cock sits on rock, knolls, etc. with no overhead vegetation during active courtship periods and occasionally in rest of day.	Unknown
Nests	Protected by vegetation (usually shrubby) from above and side. One open side bordering open area. In the males' territory.	Concealing vegetation usually present over nest, but small proportion of nests with no overhead concealment. Site very similiar to those selected by willow ptarmigan.	Unknown. In Rocky Mtn. areas, usually on ledge or in rocky areas beside a boulder. Few nests in vegetation tall enough for concealment.
Broods	Habitat similiar to nest sites. Young chicks tend to use areas of very low vegetation. Older broods use thickets for escape cover. Moist areas preferred, with great floral diversity.	Similiar to nest sites. Broods tend to congregate in moist swales on ridges and upper slopes. Dense shrubs avoided. Young escape primarily by flying out of sight over knolls.	Poorly known. Broods seem to prefer most moist areas, especially near snowpatches; Chicks hide among rocks, and broods rarely seen in places without large rocks and ledges.
WINTER (October-April)	Willow thickets along watercourses, areas of tall shrubs and scattered trees at timberline; burns, muskegs, and river banks below timberline.	Shrubby slopes at timberline. Rarely in riparian willows. In large openings of forest where shrubs (especially birch) are scattered and project above snow. Often in windier areas than willow ptarmigan, where snow is shallower.	Most stay above timberline. Apparently feed on steep cliffs, ridgetops, benches where wind blows snow away, or on shrub-strewn slopes.

Source: Weeden 1965.

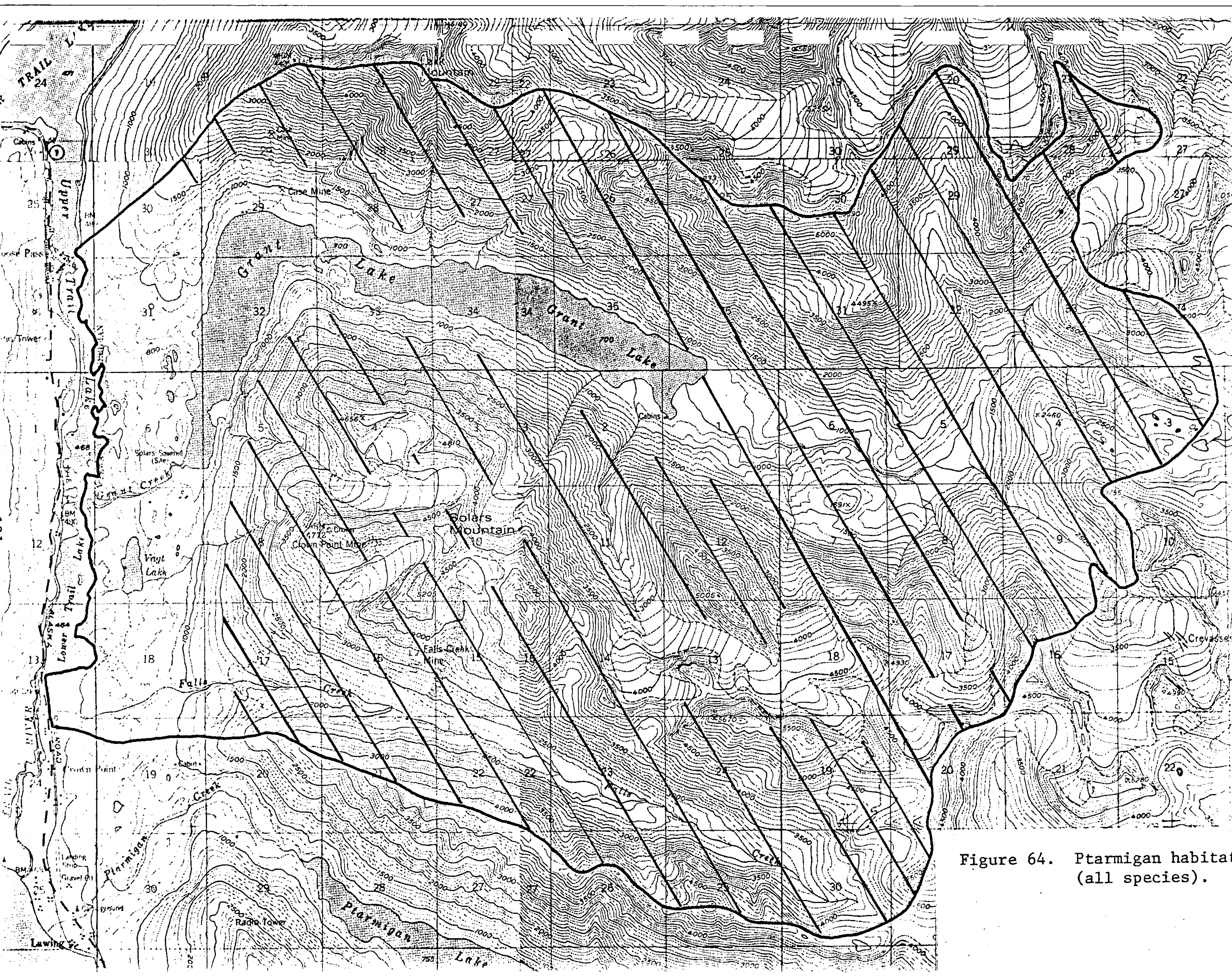


Figure 64. Ptarmigan habitat (all species).

Food items for ptarmigan consist mainly of buds, twigs, leaves, and flowers. Some animal matter is taken (insects) but not in large quantities (Moss 1972; Weeden 1963, 1965). During winter willow buds and twigs and birch catkins and twigs are the principal food items. Additional small quantities of cranberries and aspen buds and twigs are eaten. As snow retreats in spring, food sources increase in diversity. Willow and birch are still a major portion of the diet; however, other foods include horsetail tips, bearberries, fly larvae, and caterpillers. During the summer months food items shift from twigs and buds to include mostly fruit and leaves of blueberry. Other foods include cranberries, crowberries, and flowers. During fall food habits parallel those of spring, shifting back to buds and twigs. The Grant Lake area provides all these foods though none in great abundances (refer to botonical section).

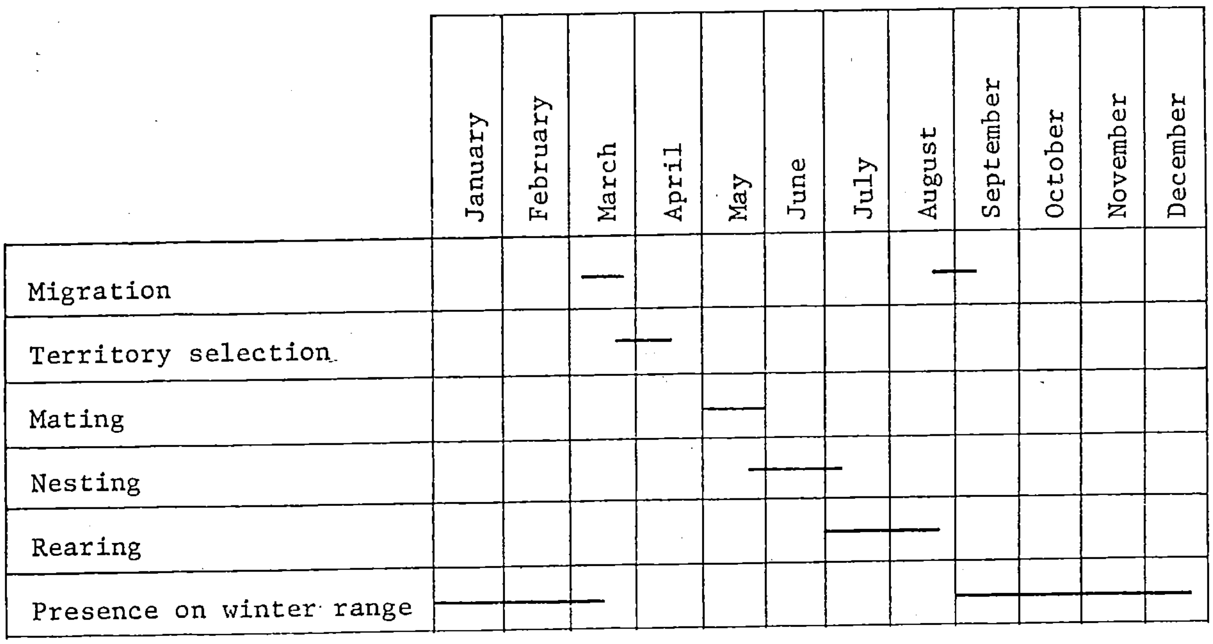
Natural predators of ptarmigan known to inhabit the study area include golden eagles, fox, lynx, coyote, wolf, marten, weasel, ermine, and wolverine. Ptarmigan play an important role as a prey species, and many carnivors depend on them, especially during the winter months. The effects of such predation on populations have not been determined. Hunting pressure in the area is unknown, though this pressure is probably very light. Weeden (1965) said localized hunting pressure has the potential of diminishing stocks. However, population fluctuations are a natural phenomenon, and any reduction in numbers is unlikely to be caused by hunting pressure.

Populations of rock and willow ptarmigan in the Grant Lake area are probably average for the Kenai Peninsula as a whole. Neither species were overly abundant but both were commonly observed in appropriate habitats. Though no white-tailed ptarmigan were seen, this does not mean that none occur since there is suitable habitat in the study area. Figure 65 presents a timetable of significant biological events for ptarmigan.

Cranes

The sandhill crane is the only crane species present in Alaska. These birds favor large marshes for nesting purposes. Cranes migrate over the Kenai Peninsula, and some nesting occurs in the western por-

Figure 65. Timetable of significant biological events for ptarmigan--Alaska.



Source: Weeden 1965.
DeLeonardis ND.
Roberts 1963.

tion; however, no nesting habitat is available within the project area and no cranes were observed.

Shorebirds

There are numerous species of shorebirds on the Kenai Peninsula. Reported nesting of semipalmated plovers are lacking within the project area, though these birds are known to be fairly common inland nesters on the Kenai Peninsula (Gabrielson and Lincoln 1959). We did not observe any nesting during field studies. Black-bellied plovers are more common along the coastal areas of the Kenai Peninsula. We did not observe any black-bellied plovers, and the probability of these birds occurring within the project area is low. We observed five species of shorebirds during the 1981-82 field season. Of these, four were assumed to be breeding (Figure 54). Both species of yellowlegs were observed breeding in bogs on the bench between Grant and Trail Lakes. The spotted sandpiper was along Inlet Creek and the common snipe along Upper Trail Lake. Though no nests were found, adult activity indicated nesting.

The Eskimo curlew is listed on the endangered species list and has occasionally been observed on the Kenai Peninsula. Accounts of these birds are mainly historical, and many people believe the bird may be extinct. Principal breeding grounds appear limited to the arctic coastal plains. Few have been sighted in recent years. Robbins et al. (1966) reported one sighted in Galveston, Texas in 1959. Figgins (1904) reported the taking of a specimen in the Kenai Mountains near Homer. He speculated that the species was a fairly common fall migrant there.

Gulls and Terns

As with shorebirds, gulls are more common along the outer Kenai Peninsula. Three species are known to travel inland (Figure 54). We observed one species of gull, mew gulls, during field studies. They did not appear to be nesting. Arctic terns are common nesters on the Kenai Peninsula. They are often observed over Kenai and Tern Lakes, both of which are only short distances from the project area. Sowls et al. (1978) reported a breeding colony at Tern Lake. Several terns were observed within the project area during field studies, though no nesting activities were seen. Most of the birds seemed to be migrants.

Owls

Five species of owls are known to inhabit the Kenai Peninsula (Gabrielson and Lincoln 1959). Studies by Lewandoski and Rice (1980) indicated that great horned owls are the most abundant species and exhibit a preference for coniferous forest habitat. No owls were observed during the field studies; however, suitable habitat occurs throughout the Grant Lake area, and they probably are present.

Kingfishers

Gabrielson and Lincoln (1959) reported the belted kingfisher is common throughout the state but never in large numbers. Kingfishers were commonly observed by AEIDC personnel around the Trail lakes and Grant Creek and it appears that the bird probably nests within the area.

Flickers and Woodpeckers

One species of flicker and three species of woodpeckers reportedly occur in all suitable habitats on the Kenai Peninsula (Gabrielson and Lincoln 1959; Quinlan 1978). We observed flickers and hairy and northern three-toed woodpeckers on the bench between Grant and the Trail lakes. There were many snags and dead standing trees in all forest types throughout the study area. Most of these displayed woodpecker sign, including feeding holes and excavated nesting holes.

Passerines

Two species of flycatcher are known to inhabit the Kenai Peninsula (Gabrielson and Lincoln 1959), but only Traill's flycatcher was observed within project boundaries. Most were seen in the area between Grant and Trail lakes in mature forest.

Four species of swallow occur on the Kenai Peninsula. Both violet green and tree swallows were abundant within the project area.

Lesser numbers of bank swallows were also commonly seen. All three species were believed to be breeding.

Grey jays, black-billed magpies, and northern ravens were all observed during our field studies. These were seen throughout the study area in all vegetation types.

Black-capped chickadees were abundant within the mature spruce forests. Flocks of up to 20 birds were common, many containing young-of-the-year. Boreal chickadees are also found on the Kenai (Gabrielson and Lincoln 1959); however, none was seen within the project area.

We observed several dippers along the flowing creeks within the project area. Young were seen along both Grant and Inlet creeks, indicating breeding in those areas.

Five species of thrush occur within project boundaries. They are American robin, and varied, hermit, Swainson's and grey-cheeked thrushes. The first four are common breeders, and the hermit thrush is most conspicuous. Grey-cheeked thrushes were rarely observed but were assumed to breed within the project area.

Both ruby-crowned and golden-crowned kinglets are known to occur on the Kenai Peninsula (USFS unpublished; Gabrielson and Lincoln 1959). Ruby-crowned kinglets were abundant in the project area in all coniferous forests.

A large flock of bohemian waxwings were observed feeding on insects at the mouth of Grant Creek. Numerous young were present in the flock.

We observed five species of warbler during field studies. They were orange-crowned, yellow, myrtle, Townsend's and Wilson's warblers. These were commonly seen throughout the upland scrubs and riparian scrub communities. (Note that warblers were also observed on the benchland between Grant Lake and Trail lakes in scrub communities too small to be mapped individually.) All were suspected to be breeding.

No less than 16 species of the family Fringillidae (grosebeaks, finches, sparrows, and buntings) are found on the Kenai Peninsula (Gabrielson and Lincoln 1959). Eleven of these species were observed during our field study. The most abundant species were golden-growned sparrows, which were observed mainly in upland shrub along the mountain slopes.

In summary, the avifauna of the Grant Lake area is varied, though few birds are present in large numbers. The most important habitat may be the ice-free areas in Grant Lake and Grant Creek. These areas provided an abundant supply of food for a flock of mallards during the winter of 1981-82. Spruce grouse numbers appear low within the project area primarily due to the poor quality of the habitat. Ptarmigan numbers are moderate; however, the use of this resource for food or recreational hunting is slight, probably due to the difficulty in gaining access to those areas where the birds are likely to be.

MAMMALS

The mammalian fauna of the study area is comprised of a nearly equal mix of herbivores and carnivores (Figure 66). This circumstance is not unique in Alaska and is representative of the mammalian fauna of the Kenai Peninsula as a whole. In general, the habitat is marginal for mammals and supports few individuals of most species. Notable exceptions are some south-facing alpine and sub-alpine communities, which are important to resident bovids.

The mammalian fauna present is highly mobile; most species and species groups are migratory moving seasonally between disparate ranges in response to changing environmental and physiological conditions. Movements between ranges are influenced to some degree by the rugged physiography of the region and by the phenology of snow melt. Several distinct traditional movement corridors of large mammals were noted.

Figure 66 lists observed and/or likely components of the mammalian fauna, their scientific names, and their relative abundance in the study area. The list represents a synthesis of published and unpublished reports, interviews with long-time area residents, and the results of our field surveys. The list is thought to be complete. As noted previously, subjective population estimates have been provided for select species and for species groups at Ebasco's request. Limitations on these data are defined elsewhere.

Soricidae

Little can be said of either the distribution or abundance of shrews in the study area other than that they appear to be ubiquitous

Figure 66. Mammals of the study area.

	Occurrence in study area	Relative abundance	Subjective population estimates, Summer, 1982	Source
Soricidae (Shrews)				
Sorex cinereus	P	?	NE	1,2*
Sorex obscurus	?	?	NE	2*
Sorex palustris	?	?	NE	1,2*
Sorex vagrans	?	?	NE	1*
Microsorex hoyi	P	?	NE	1,2
Vespertilionidae (bats)				
Myotis lucifugus	P	?	NE	1,2
Leporidiae (hares)				
Lepus americanus	Y	C	NE	1,2,3
Sciuridae (Squirrels)				
Marmota caligata	Y	C	NE	1,2,3
Tamiasciurus hudsonicus	Y	C	NE	1,2,3
Glaucomys sabrinus	P	?	NE	1,2
Castoridae (beavers)				
Castor canadensis	Y	C	32-40	1,2,3
Cricetidae (New world mice)				
Clethrionomys rutilus	Y	?	NE	1,2,3
Microtus pennsylvanicus	P	?	NE	1,2**
Microtus oeconomous	P	?	NE	1,2**
Microtus gregalis	P	?	NE	1,2**
Lemmus sibiricus	?	?	NE	2
Synaptomys borealis	P	?	NE	1,2
Zapodidae (Jumping mice)				
Zapus hudsonicus	?	?	NE	1,2
Erethizontidae (porcupine)				
Erethizon dorsatum	Y	C	NE	1,2,3
Canidae (wild canines)				
Canis latrans	Y	C	NE	1,2,3
Canis lupus	Y	C	6	1,2,3
Vulpes vulpes	Y	R	NE	1,2,3
Ursidae (bears)				
Ursus americanus	Y	C	20-40	1,2,3
Ursus arctos	Y	C	≤ 10	1,2,3

Figure 66 (continued). Mammals of the study area.

	Occurrence in study area	Relative abundance	Subjective population estimates, Summer, 1982	Source
Mustelidae (weasels and allies)				
Martes americana	Y	R	10-100	1,2,3
Mustela erminea	Y	C	NE	1,2,3
Mustela nivalis	Y	C	NE	1,2,3
Mustela vison	Y	R	< 5	1,2,3
Gulo gulo	Y	C	< 5	1,2,3
Lutra canadensis	Y	R	< 5	1,2
Felidae (lynx)				
Felis lynx	Y	R	NE	1,2,3
Cervidae (moose)				
Alces alces	Y	C	20-30	1,2,3
Bovidae (mountain goat and sheep)				
Oreamnos americanus	Y	C	50	1,2,3
Ovis dalli	Y	C	30	1,2,3

Key

NE = No Estimate
Y = Yes (sight records extant)
P = Probable (suitable habitats occur in study area)
? = Unknown
C = Common - species appears to be utilizing all available habitats
R = Rare - species is present in low density; it does not appear to be realizing the maximum potential of the habitats

Sources:

1. Manville, R.H. and S.P. Young, 1965. Distribution of Alaskan Mammals, U.S. Bureau of Sport Fisheries and Wildlife. Circular 211. U.S. Government Printing Office; Washington, D.C. 74 pp.

2. Hall, E.R. and K.R. Kelson; 1959. The Mammals of North America. The Ronald Press Company, New York. 2 volumes.

3. AEIDC, this study.

* Sorex tracks observed but we were unable to differentiate them to species level.

** Microtus tracks observed but we were unable to differentiate them to species level.

in all forest and scrub associations. Evidence of the presence of shrews in the study area was limited to the sighting of tracks during the midwinter foot survey. Since all of the shrews known to inhabit the Kenai have similar gaits, and since most, with the exception of Microsorex hoyi, are about the same size, differentiation of tracks to the species level is impossible based on track sets alone. Shrew sign was more abundant in older forest communities, becoming conspicuously less noticeable above timberline. Nowhere was it absent, however.

Vespertilionidae.

The little brown bat (Myotis lucifugus) is a common resident of southcentral Alaska, but little is known of its life history. Nocturnal in lower latitudes, these bats are crepuscular in Alaska. Individuals are frequently observed in summer, hunting along stream courses for insects. Most, if not all, little brown bats presumably migrate to warmer latitudes with the onset of cooler weather in fall. None was sighted by AEIDC personnel in the study area during the course of this study but they undoubtedly occur.

Leporidae

Low numbers of snowshoe hares are found throughout all forest and low-lying scrub associations of the study area (Figure 67). This observation is based mainly on the results of the midwinter foot survey which coincided with a period of ideal tracking conditions. Two days prior to the survey the study area received a fresh layer of light, powdery snow averaging 2 inches in depth. The snowfall was sufficient to obliterate all tracks made up to that time. Tracks laid subsequent to the snowfall were admirably preserved by the low ambient daytime temperatures (0°F to -5°F) which prevailed through the duration of the survey.

In dense, well stocked popualtions, snowshoe hares utilize well defined runways to travel between portions of their territories. No evidence of runways was found in the study area indicating that the population is relatively low. In other areas of the Kenai Peninsula, hare populations are reaching cyclic highs (Sparkes, pers. comm.); low numbers in the study are may be indicative of poor range quality.

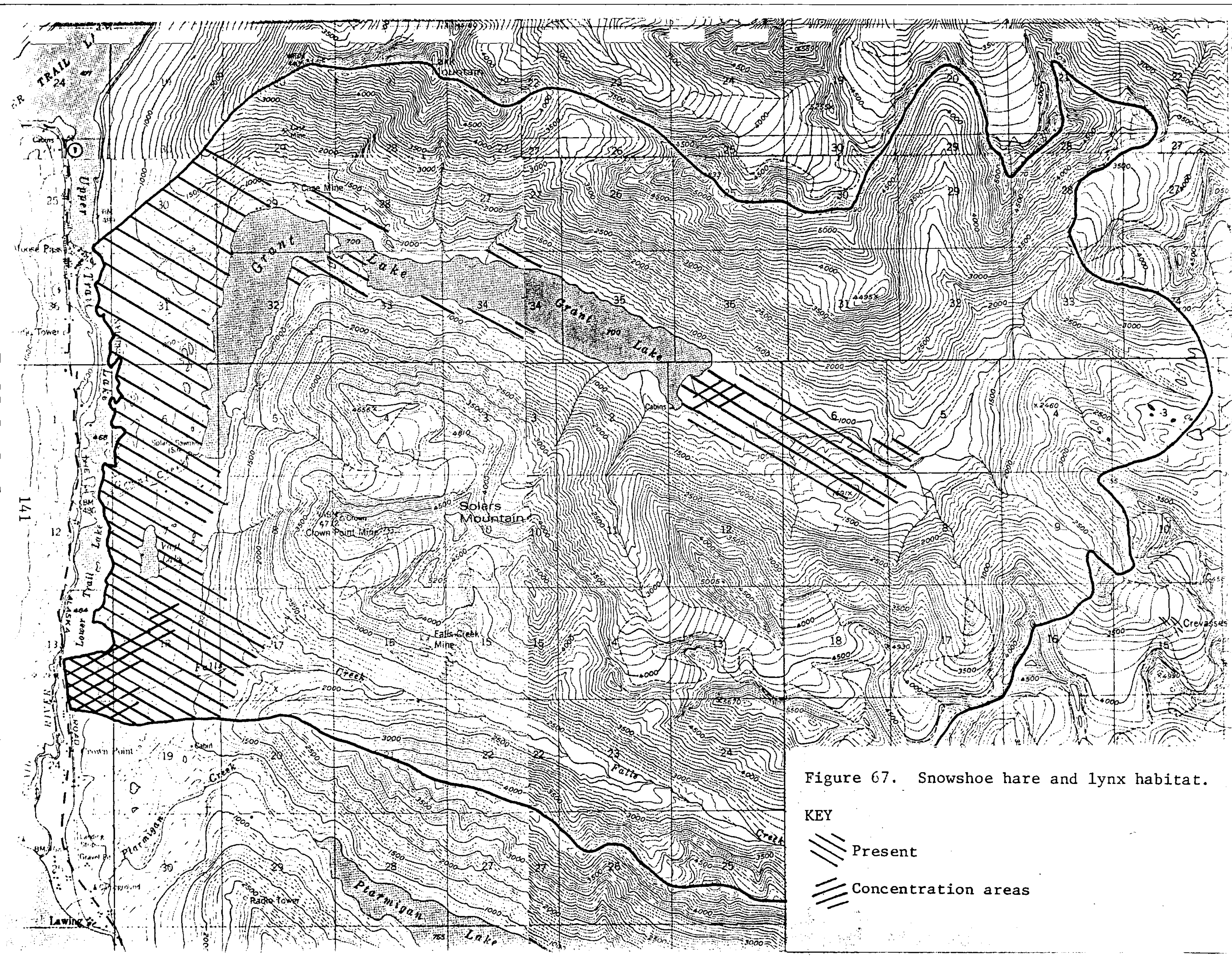


Figure 67. Snowshoe hare and lynx habitat.

Based on the tracking evidence, low-lying areas bordering Trail lakes constitute the center of hare distribution and abundance in the project area. Suitable forage items in these areas are sparse however, limiting their potential as hare habitat. Further, preferred winter browse species, such as willow and birch, show evidence of overcropping indicating that the population has exceeded the limited carrying capacity of the range. Most browse regeneration in these areas occurs as new growths of adventitious shoots. Primary regeneration through adventitious shoots is a widely accepted indicator of over-use of the resource by hares.

Despite their relatively low numbers, hares appear to play an important role in the energetics of the study area. Cursory field examination of predator scats indicates that hares form the dietary mainstay of coyotes and lynx. Scat examination also indicates that hares are important dietary supplements for bears, wolves, and wolverine.

This group of predators is relatively abundant in the study area and the finding of hare remains in the majority of predator scats is probably significant.

Sciuridae

Marmots are common residents of alpine tundra communities within the study area (Figure 68). These animals are one of the most conspicuous mammals present. Numerous observations of both den sites and animals were made during the course of our field studies. In general, marmots ranged between altitudes of 1,500 to 3,000 ft throughout the study area. Sign and sightings were most abundant in the upper Falls Creek drainage, although other areas also showed marmot concentrations (Figure 68). Some indication of predations on marmots by bears and coyotes was noted, and marmots may play an important role in determining seasonal distribution of bears.

Red squirrels are conspicuous and present throughout the conifer forests of the project area. Greatest squirrel activity was noted in the areas of larger Sitka spruce timber.

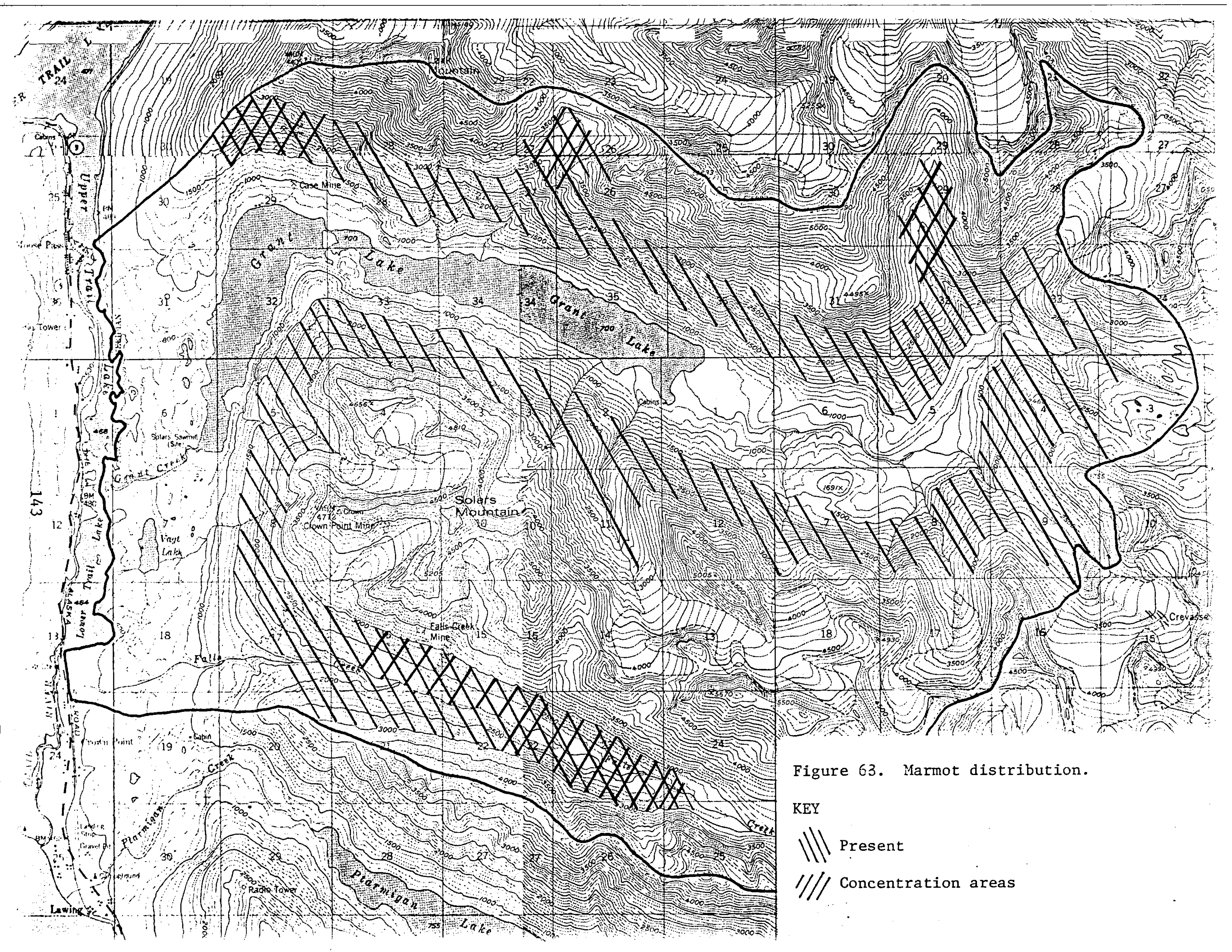


Figure 63. Marmot distribution.

KEY

\\\ Present

/// Concentration areas

No flying squirrels were noted, however Grant Lake is within the probable range of this species. The nocturnal and secretive nature of these species renders them difficult to observe or to determine their presence.

Castoridae

Although beavers (Castor canadensis) are one of the most abundant furbearing mammals in Alaska, they are not common in the study area. We found recent evidence of beaver to be scarce and with few exceptions confined to Grant Lake proper and its terminal tributaries. Several factors are responsible for limiting study area beaver both arealy and numerically.

High-quality forage items are severely limited in the study area. Beavers subsist largely on the cambium layer of certain deciduous trees and shrubs. Preferred deciduous foods are confined to plants in the family Salicaceae (willow, aspen, cottonwood) and to a lesser extent to birch (Yeager and Rutherford 1957; Murray 1961). In general, beavers seem to prefer communities dominated by a species of Populus, but willow communities are probably more stable and, hence, more productive through time (Murray 1961). During summer, beaver supplement their diet with considerable amounts of herbaceous and aquatic vegetation.

Since the cambium layer represents a very small percentage of a plants' total mass, beaver require large quantities of browse to survive. The minimum daily maintenance requirement of captive adult beaver has been calculated by Cowan et al. (1957). During summer individual adult beaver require a minimum of 1.5 lbs. of aquatic vegetation per day; minimum winter requirements are set at 1.5 lbs. of green aspen or 1.7 lbs. of green willow per day (Cowan et al. 1957).

The requirements of free-ranging beaver are undoubtedly higher than those reported above. Wild beaver probably utilize upwards of 5.5 lbs. of suitable browse per day. This equates to roughly one ton of browse per beaver per year (Yeager and Rutherford 1957). Assuming that these figures are representative of daily food requirements, the average beaver colony requires somewhere between 4 to 8 acres of aspen or 12 to 15 acres of willow per year to maintain vitality (Yeager and Rutherford 1957).

Large, contiguous stands of high quality beaver forage items are at a premium in the study area (Appendix D). Areas with suitable forage are limited to the lower reaches of Inlet Creek and its broad delta, the outwash plains of a few of Grant Lake's terminal tributaries and the lower reaches of Grant and Falls creeks. Few of these areas have potential as beaver habitat, however. Most stream courses in the study area are ill-suited for beaver colonization. Stream bottoms and stream and lake banks are usually comprised of large cobble or exposed bedrock, which are not conducive to either dam construction or maintenance or to the establishment of subterranean lodges. Cobble basements are often permeable to water, negating or seriously compromising the purpose of the dam (Boyce 1974). Most streams in the study area also experience recurring catastrophic freshets. Floods pose formidable problems for beaver and are a significant limiting factor throughout their range (Rutherford 1952; Yeager and Rutherford 1957).

Only one area within the project boundaries meets all of the criteria of prime beaver habitat. This area centers on the northern corner of Inlet Creek's delta. It is bordered on the west by Grant Lake, on the north by steep mountain slopes, and on the south by a distributary of Inlet Creek (Figure 69). The entire area used by beaver occupies the foot of a large active avalanche shoot. Evidence of the influence of snowslides on the vegetation is readily apparent. Recurring snowslides may be advantageous for beaver by helping to retard the sere, which is dominated by a willow association.

Four lodges occur in this area (Figure 70); only one appears to be active (Figure 70, number 1). Beaver activity in this area centers on a small fluvial system which apparently had its origins as a distributary of Inlet Creek. At present, it is not part of the Inlet Creek system, per se, but its headwaters remain close to active channels of Inlet Creek and it may be under influence of groundwater flow from the parent system.

This site is central to the maintenance of beaver in the project area for several reasons. First, it is surprisingly stable. Isolated

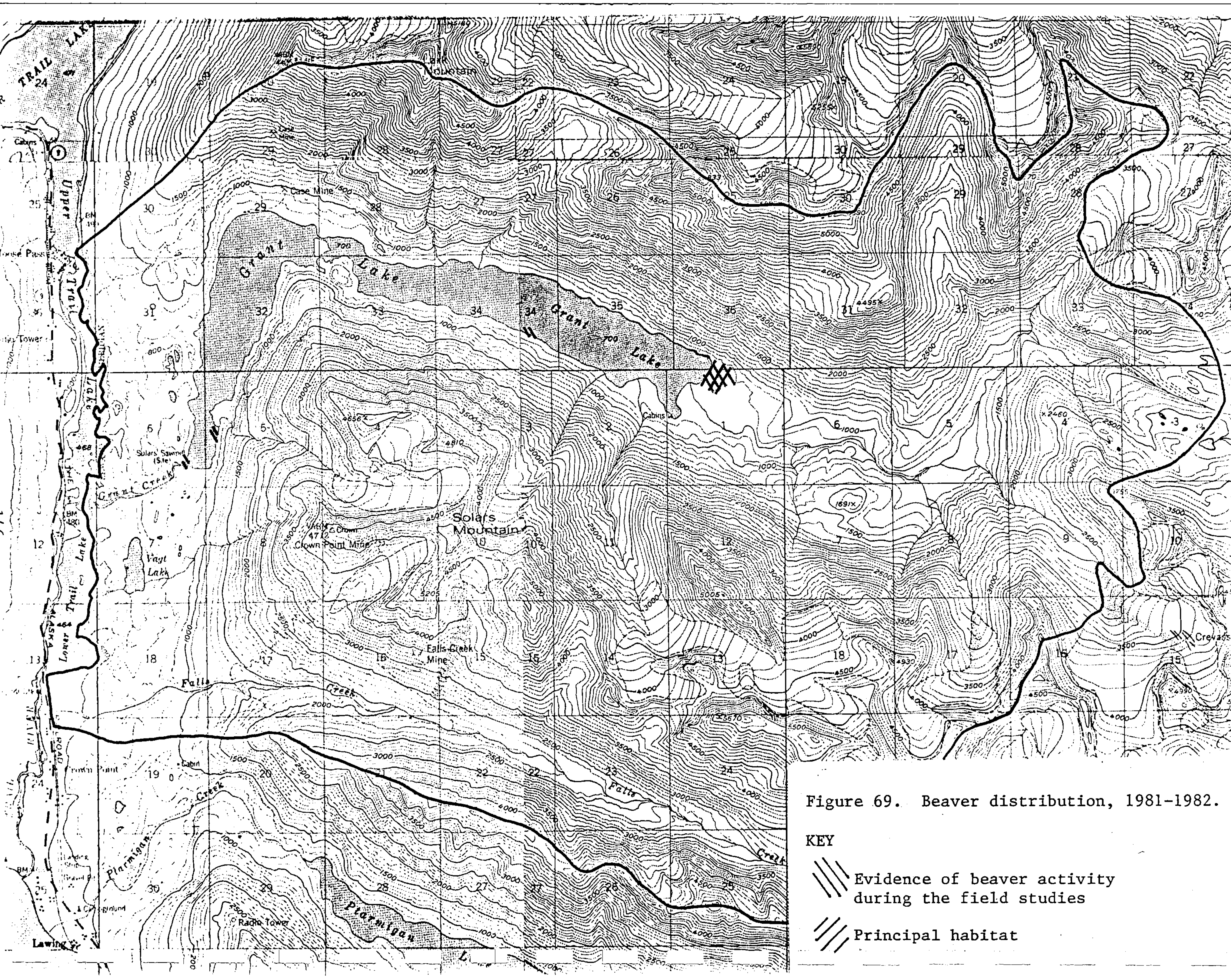


Figure 69. Beaver distribution, 1981-1982.

KEY

Evidence of beaver activity during the field studies

Principal habitat

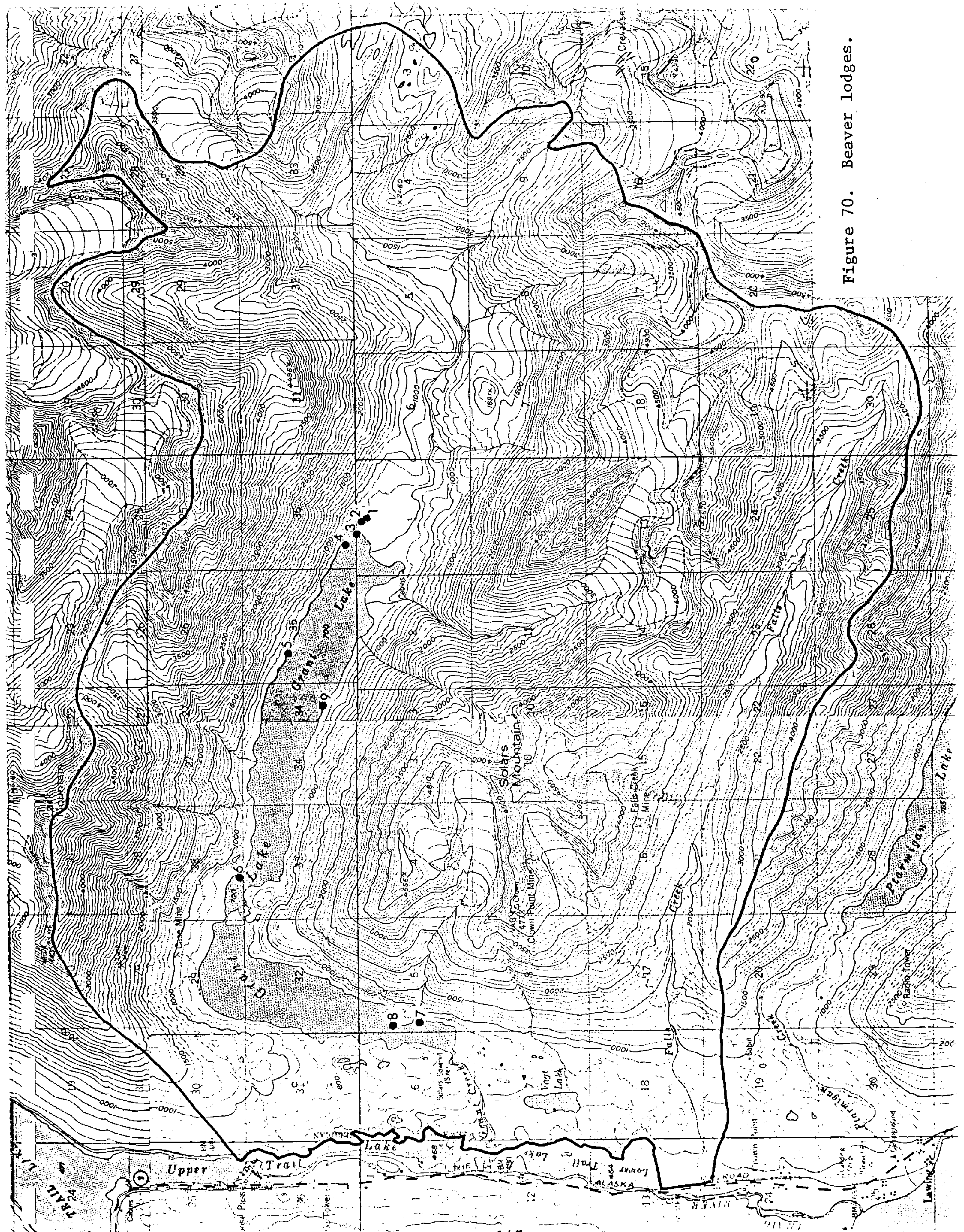


Figure 70. Beaver lodges.

from Inlet Creek, it is spared the ravages of periodic floods. Food is also abundant and will remain so unless the areas' hydrology is changed. Snowslides, which periodically lay waste to the area's vegetation, retard the successional sere in favor of a densely stocked willow community. Second, substrates in this area are comprised chiefly of a thick layer of organic debris, facilitating dam and lodge construction and maintenance. The thick organic mat probably owes its origins to the influence of snowslides.

Small numbers of beaver also reside in Grant Lake, but these habitats are low quality and appear incapable of sustaining beaver over time. Basement materials of the lake banks are comprised of either glacial alluvium or exposed bedrock. As a consequence, lodges are constructed directly on the bank (Figure 70, numbers 4 through 8) where they are exposed to the influences of predators, floating ice in spring, waves, avalanches, and lake level fluctuations resulting from periodic heavy rains and spring breakup. Food items are particularly scarce along the shore of Grant Lake (Appendix D), forcing beaver to consume unpalatable browse such as alder. Although unpalatable species are favored construction materials, beaver seldom consume them except in the most trying of situations (Slough 1978).

The lack of suitable shelter and food combine to limit beaver potential in Grant Lake proper. Only one of the lakes lodges (Figure 70, number 7) showed signs of recent residency, and none showed any evidence whatsoever of winter food caches, either past or present. Food caches are important to beaver since they cannot survive the winter without them. Their absence in Grant Lake is probably significant.

Grant Lake beavers are probably the offspring of the colony located on the delta of Inlet Creek. Sometime between their second and third year young beavers are driven from natal territories by their parents (Boyce 1974). Young apparently disperse in nonrandom fashion, as they are often found considerable distances from the nearest food or water source. Intraspecific combat is common between dispersing young and adult pairs on established territories and interlopers are often killed (Boyce 1974). Since young disperse in all directions without regard to habitat availability, there is some possibility that Grant Lake beavers come from outside the system. Considering local physiography and the area's relative isolation from other suitable beaver habitat, however, it seems likely that Grant Lake beavers are offspring from the colony located at the head of the lake.

We found eight beaver lodges in the study area; all but two appeared to be abandoned (Figure 70, numbers 1 and 7). In addition, we found a pair of beavers on Grant Lake engaged in what appeared to be lodge-building activities (Figure 70, number 9). These animals repeatedly tail slapped upon detection of the survey boat and refused to leave the area when we stopped to investigate. One individual repeatedly closed with the boat, splashing water into it. A single freshly cut alder bough, approximately 1.5 cm. in diameter at the base, was found anchored into the lake bottom. Their strong defense and the anchored stick leads us to believe they were in the process of lodge building at this site. As with other Grant Lake lodges, the site lacked appreciable food resources and offered little protection from either predators or the elements. A single beaver was also observed in Lower Trail Lakes near its outlet.

The study ended before food cache construction began, so we are unable to say with certainty how many of the lodges in the area are actually active and how many are relict. Estimates of average numbers of beaver per colony in Alaska vary from four (Libby 1954) to five (Koontz 1968, Boyce 1974). Assuming that all lodges are active and that all represent colonies of average size, then somewhere between 32 and 40 beaver reside in the area. This figure is probably highly inflated considering the lack of suitable habitat and scant evidence of recent use by beavers. While only two of the lodges showed evidence of current occupancy, there is a possibility that all were occupied. Without a food cache survey little more can be said.

In sum, lack of prime habitat is a serious constraint for local beavers. Predation may also be an important limiting factor considering the exposed nature of most lodges, but no evidence of predation was found. In other areas of North America beaver are subject to heavy predation by wolves (Allen 1979; Mech 1970). This does not appear to be the case on the Kenai Peninsula, however (Peterson and Woolington 1979a, b; Peterson 1982). Beaver remains were present in only 5 percent of 542 randomly collected wolf scats from the Kenai Peninsula (Peterson and Wollington 1979a). Other predators of minor importance to beaver population biology include black and brown bears, wolverine, lynx, and coyotes (Libby 1954); all occur in the study area.

Beaver are the most widely distributed and common furbearer in all of Alaska. Some limited trapping for beaver does occur in this area, but we have been unable to define the level of trapping. Interviews with local residents indicate that trapping intensity varies considerably between and within years, much depending on market conditions. At least one beaver trapper was active in the area during the winter of 1981-82. Based on the evidence at hand, beaver trapping is more a recreational pursuit than a commercial one.

Figure 71 details some of the important milestones in the seasonal cycle of beavers.

Cricetidae

Tracks of microtine rodents were observed on snow in March throughout the study area to the 2,000 ft level, which was the altitudinal limit of foot surveys.

No individual microtines were trapped or observed. The species probably present in the area include M. oeconomus and M. gregalis.

Three specimens of the northern red-backed vole were seen in July 1982 on the Vagt Lake trail. This is a common mammal throughout the Kenai Peninsula.

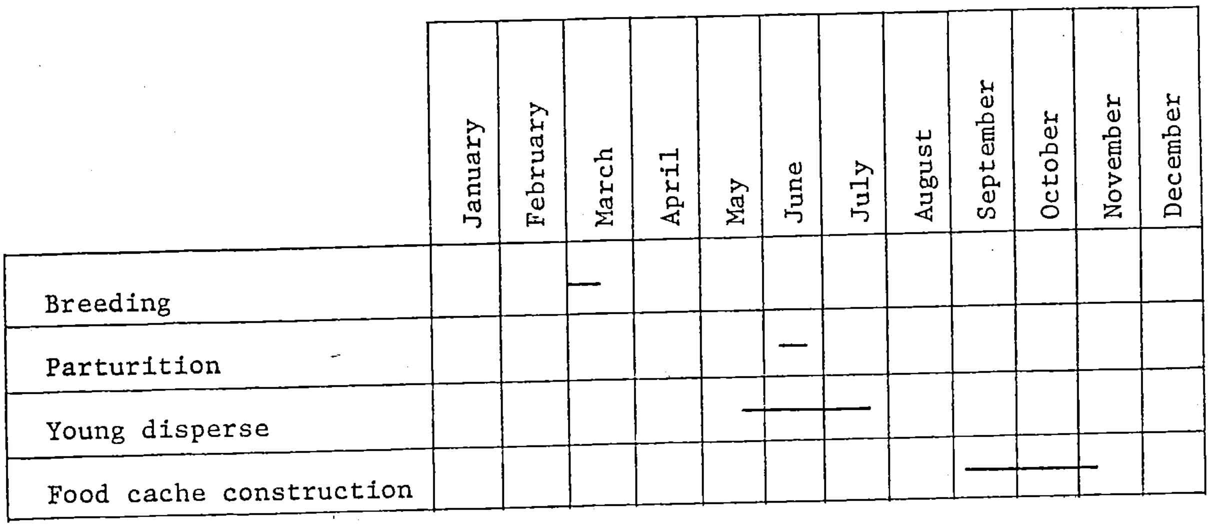
Two species of lemmings may occur in this region, however, they were not verified within the study area.

While the muskrat occurs on the Kenai Peninsula, no evidence of their presence in the study area was noted. The region does not have extensive areas of suitable muskrat habitat.

Erethizontidae

Porcupines are common throughout the coniferous areas of the Kenai Peninsula, particularly in the mountainous regions near timber-

Figure 71. Timetable of significant biological events for beaver--Alaska.



Source: Boyce 1974.
Libby 1954; 1957.
Murray 1961.

line. Populations are highly variable and fluctuate radically over relatively long intervals. Occasional scattered porcupine sign was noted in the study area, generally at altitudes of 500 to 1,000 ft. The species is not abundant at this time within the project area.

Canidae

Three types of wild canines range in the Grant Lake-Falls Creek-Trail lakes regions: wolf, coyote, and red fox. The wolf is a frequent transient; the coyote is probably a resident or common transient in the area; and the red fox is a rare or occasional visitor or recent resident.

The wolf is indigenous to the Kenai Peninsula and existed in significant populations prior to 1900. A period of intensive trapping and poisoning operations followed and by 1915 the wolf was essentially exterminated from the Kenai. The species was apparently absent from the Kenai until the late 1950s. Following the end of predator control programs wolf populations on the adjacent mainland increased and recolonization of the Kenai Peninsula ensued. By 1975 wolves occupied most of the available habitat on the Kenai Peninsula. Peterson and Woolington (1982) reported an early winter population of 185 wolves occupied 13,700 km^2 of the Kenai Peninsula.

The wolves in Grant Lake area are probably the group known as the Mystery Creek pack (Peterson 1982), ranging in the mountain area from Mystery Creek as far east as Grant Lake or perhaps on occasion as far as Nellie Juan Lake.

Wolves have been occasionally reported and taken in the Grant Lake-Trail Lakes area in recent years. On January 13, 1982, AEIDC biologist Spencer and charter pilot Pleuger, while on aerial survey, saw six wolves (two dark phase, four light phase) along the north shore of Grant Lake. In late February, 1982 the Babcock mountaineering party, en route up Lark Mountain by the west ridge, observed two wolves harassing a moose along the shore of Grant Lake (Babcock, pers. comm.). Tracks were also noted in February and March around the northwest corner of Grant Lake and east of Vagt Lake. A single wolf was observed in the upper valley in Inlet Creek during the April 16, 1982 aerial bear denning survey. Back tracking of the animal revealed it had been coursing low-lying bench areas at timberline. Numerous tracks of mountain goats occurred in this area at this time and it seems probable that the wolf was actively hunting them.

The wolf is an effective predator on a large number of animals, including moose, Dall's sheep, mountain goat, snowshoe hare, beaver, and other canids such as coyote and fox. No wolf kills were noted in the Grant Lake-Falls Creek area during the brief field observational periods of this study; however, moose remains were found in several wolf scats.

The coyote is a more recent inhabitant of the Kenai Peninsula, apparently colonizing the area in the early 1930s. It increased rapidly in numbers and has been a prominent and widely distributed member of the local fauna since then.

Coyote sign was noted over much of the area on all field trips. Like the wolf, the coyote is wide ranging and will travel and hunt throughout all habitat types of the study area. It is probably a much more frequent transient or resident of the Grant Lake-Falls Creek area than the wolf. The delta of Inlet Creek was a center of coyote activity during the winter of 1982 where they were hunting for hares and ptarmigan. A frequently used coyote travel route was noted on the benchland between Falls Creek and Grant Lake in the timberline region at the base of the mountain slope.

The red fox is an indigenous member of the Kenai Peninsula fauna. Historical accounts indicate that it may have been abundant at one time. This is no longer the case. Trapping and poisoning activity in the early part of this century (aimed at the elimination of the wolf) apparently included the red fox as an associated casualty. As far as is known fox populations on the Kenai have remained low through much of this century. The animal has not been taken nor observed by any of the trappers known to operate in the Grant Lake-Falls Creek region. A single series of fox tracks was noted by AEIDC on March 1, 1982 in the Vagt Lake area. The red fox, however, is apparently only a rare transient in the study area.

Ursidae

Situated in the southwest portion of the Kenai Peninsula, the Grant Lake project area is mostly comprised of high mountains, often capped with ice fields and surrounded by narrow, deep-gorged valleys with short, swift streams and timbered lowlands. Conifers are the dominant vegetation with Sitka spruce, white spruce, and hemlock the most common. Timberline is relatively low, graduating with increased elevation into shrubs and alpine vegetation zones. The diverse habitats resulting from the area's varied topographic features provide niches for both black and brown bears.

Black bears are one of the most widely distributed and abundant large mammals on the Kenai Peninsula. The timbered and brushy areas of the region afford good protective cover, which probably accounts for their ability to withstand intensive hunting pressure typifying this part of southcentral Alaska. Brown bears, on the other hand, are sparsely distributed throughout much of the region. The Grant Lake project area is peripheral to the Kenai Peninsula proper and mountainous areas of Prince William Sound, where brown bear density is much higher because of better habitat conditions. The following narrative discusses specific population and habitat characteristics of each bear species.

Brown Bear. Taxonomically the terms "brown" and "grizzly" are synonymous and for the purpose of this report, the term brown bear refers only to a single classification and should not be construed as a subspecific designation. The terrestrial part of the Grant Lake study emphasized the delineation of habitats and general movement patterns of bears as inferred from the observed seasonal (relative) distribution and abundance. Field data obtained during fall and summer ground-level surveys and three aerial surveys conducted early in spring provided information on the relative number and seasonal distribution of brown bears in the study area.

Depending upon biological needs and environmental conditions, brown bears utilize two or more activity areas that can be viewed merely as different portions of one all encompassing range. Berns and Hensel (1972) noted that under optimal habitat conditions, activity areas varied in size from several square kilometers to more than 30 km^2. Distances between given activity areas may vary markedly since individual bears may incorporate one or several drainages as part of their year-round range (Berns and Hensel 1972). Similar surveys conducted by the ADF&G in other areas of optimal habitat showed that brown bear movements are confined to limited areas and movements in excess of 48 km were a rarity (ADF&G 1973).

Considering the study area's physiography and it's proximity to human developments and the limited amounts of usable habitat and forage resources within the confined 117 km^2 Grant Lake project area, brown bear numbers would expectly be low, representing but a fraction of the region's total population. The 1981-82 field studies confirmed this expectation. During the study period we observed only 16 widely scattered sets of brown bear tracks and sighted only three individuals; a family group (female with one yearling) and a mature singleton. ADF&G authorities reported that insufficient forage probably primary factor for the low density of annual brown bears in this region (ADF&G 1973). The highest reported brown bear harvest since 1961 for the years 1976, 1980, and 1981 for all of Game Management Unit 7 (Seward) was three bears. For the past 21 years, the annual harvest averaged approximately one bear per year (ADF&G 1982). Considering the intensive hunting pressure in southcentral Alaska these extremely low harvest figures probably reflect the scarcity and low density of brown bears in this region.

The number of brown bears probably range from about 7 to 25 animals in a given year within the Grant Lake project area, which probably represent a small segment of the region's total brown bear population. The period of greatest activity noted during this study occurred in the last half of May, coinciding with den emergence and breeding activities. The May 21 aerial survey, when three brown bears and eight individual sets of brown bear tracks were noted, suggested that upwards of 10 different brown bears visited the Grant Lake project area around mid-May. Another low density indicator concerned the absence of established bear trails, which under ideal habitat conditions occur along water courses, prominent ridgelines, and connecting routes of adjacent drainage systems. In sum, few, if any brown bears reside year-round within the Grant Lake project area and available information indicates that no more than 10 individual bears utilized the study area during the spring and early summer periods of 1982. Given the species wide ranging characteristics and low numbers throughout the eastern half of the Kenai Peninsula we believe that as many as 25 brown bears may be present in the study area in any given year. Interchange between regional subpopulations is relatively intensive, and use of the area by transient bears is common and is primarily related to the seasonal availability of limited food resources. It should be emphasized that brown bear numbers are not constant.

Seasonal activities can be principally categorized into feeding, resting, socializing, traveling, and denning behaviors. Feeding and socializing, as distinct activities, greatly influence the extent of movement. Social activity includes dominance and sexual interactions, the latter of which often impels breeding animals to travel considerable distances. Feeding activity includes stalking, catching, and eating prey and grazing or eating parts of plants. This takes a large part of the activity budget expended in specialized habitats.

Principal feeding habitat in the project area occurs along the south and southeast slopes above the north side of Grant Lake and it's upper valley and in the upper part of the Falls Creek drainage. Habitable terrain is limited spatially by extensive snowfields, glaciers, exposed bedrock, slide and avalanche areas, and surface water. As a consequence, usable habitats are in the form of small discontinuous units having low to moderate forage values.

Forage resources are primarily herbaceous plants (carex-forb meadow variety) found in scattered sites above the north side of Grant Lake and at intermediate elevations of the upper valley's north side; marmot colonies located in most alpine and subalpine areas particularly along the south side of Solar and Lark mountains; and at least three salmon species known to spawn in Grant Creek. Figure 72 depicts the location of major forage resources considered to be of low quality.

Alpine slopes are sparsely vegetated, xeric, and probably of low fertility as a result of severe environmental conditions. Exposed to

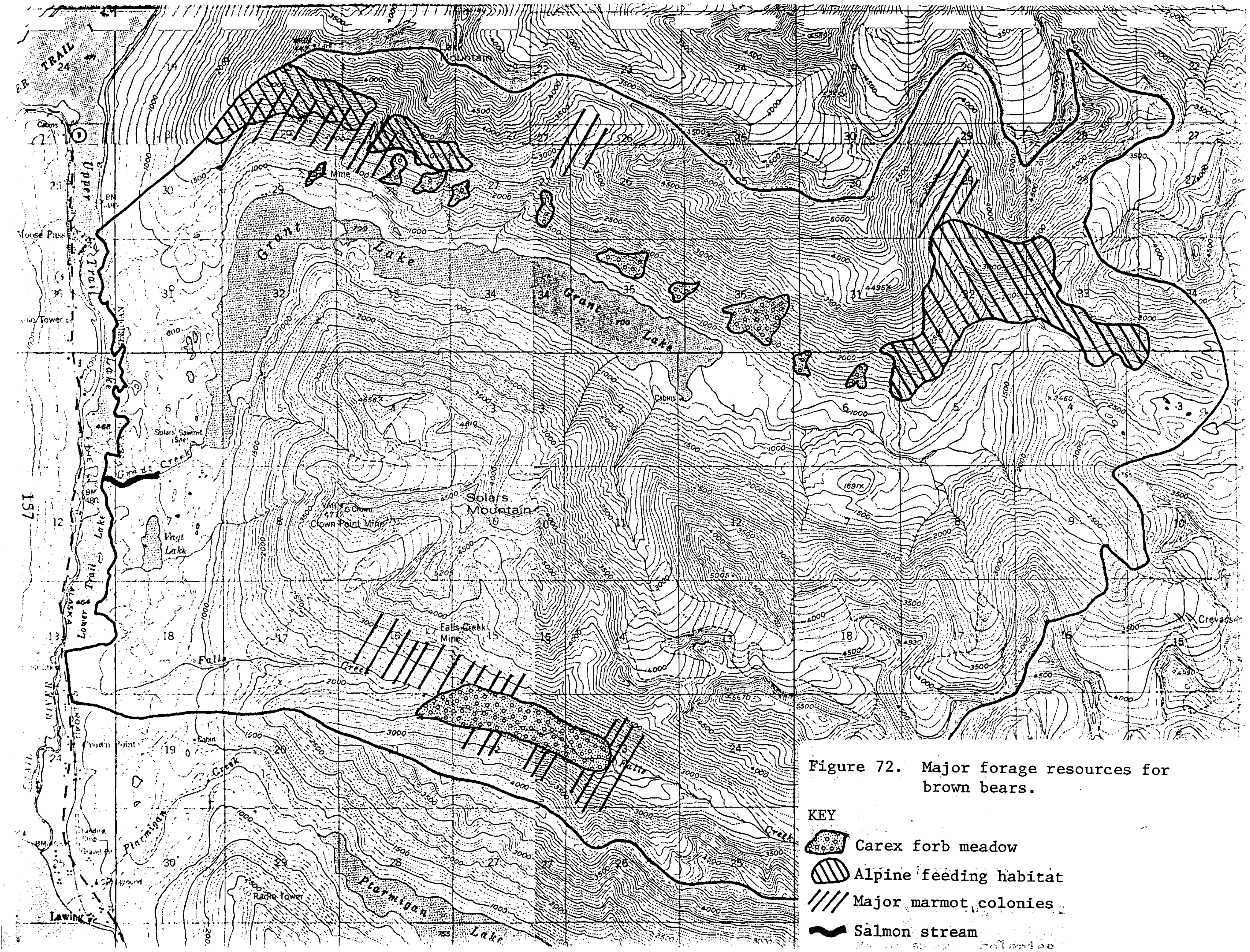


Figure 72. Major forage resources for brown bears.

strong winds and deep snow, vegetated areas appear limited to scattered locales protected by knolls, swales, and the leeward aspects of some ravines. The willow field-subalpine meadow complex on the north side of the upper valley forms a transition zone between the true alpine and lower alder communities. Fertile soil and abundant moisture make it high in plant productivity, which probably accounts for better foraging, but it is limited in size. The south side of the upper valley supports little vegetation except for a discontinuous alder belt, extending along timberline and upward in less precipitous ravines. These slopes are comprised of a glacial rubble and barren, late-snowfall extremely low plant productivity. On the south side of Grant Lake north-facing subalpine slopes contain an abundance of alder interspersed with streamlets, ravines, and avalanche chutes. At lower elevations, coniferous cover occurs along the crest of larger rock outcroppings as well as between ravine and slide areas.

The scattered, low-quality forage resources suggest that the project area is used mainly by transient brown bears. Bear activity in the Grant and Falls Creek drainages evidently peaks several weeks after den emergence in late May when principal activities consist of resting and interacting with other bears while moving randomly along the slopes near the snowline. Interdrainage travel is more pronounced during the breeding season and considerable interchange, at least among older-aged animals, probably occurs between the Grant Lake basin area and adjacent drainage systems, particularly between Trail Creek and Paradise valleys.

Denning habitat was delineated on the basis of sightings of individual bears and their sign at the time of den emergence and on the basis of certain geomorhic and vegetation charcteristics. Three replicate helicopter surveys, flown April 16 and 30, and May 21, were timed to assess den emergence activity and relate those findings to what was believed to be potential denning habitat. A total of 8 survey hours expended on the three surveys resulted in three brown bears and 10 different sets of tracks observed.

Bear tracks first noted on April 30 were at two widely separate places in the Grant Lake area. Other significant observations included the family group and mature singleton noted during the May 21 helicopter survey. The increased activity during the three week interval implied that emergence activity peaked around mid-May. Lateness of spring and extensive foul weather likely delayed den emergence and altered spring movement activities so results may not be representative.

Activity chronology and factors known to affect den site selection enabled the subjective delineation of three units of potential denning habitat (Figure 73 [Note: only those areas considered to have potential as denning habitat were surveyed; therefore this survey is less than the total study area.]). Unit 1 appears to have the most potential, based on amount of observed bear activity and the suitable slope conditions. Soil/rock substrate and vegetation components essential to den site selection are also present. On the south-facing slopes paralleling the north side of the lake basin and lower half of the upper valley, denning would likely occur at an altitudinal range of 360 to 750 m. The best habitat of this unit contains the hilly terrain bordering the alder zone located above the lower half of the upper valley. Extensive areas of surface bedrock, precipitous slopes, and sparse vegetation cover along the westward section reduces habitat potential.

Unit 3 extending along the south-facing slope into the upper part of the Falls Creek valley is considered to have some potential as denning habitat. Bear activity occurred in this area during the den emergence period. Snowpack at the altitude of Unit 3 (750-900 m) should be of sufficient depth, composition, and duration to be usable for denning purposes and good drainage (slope) and open shrub communities could be an added inducement for denning in this unit; however, available space for denning is limited, and in all probability the unit is not heavily used.

The large volume of surface bedrock, precipitous terrain, and sparse vegetation greatly reduces the denning potential along the southern slopes of the lake basin and upper valley. Available denning habitat in Unit 2 is limited to those areas having less rugged relief, mainly ridges paralleling the lower part of the two lateral tributaries entering the southeast section of Grant Lake. The soil substrate, slope, and vegetation provides suitable conditions for den

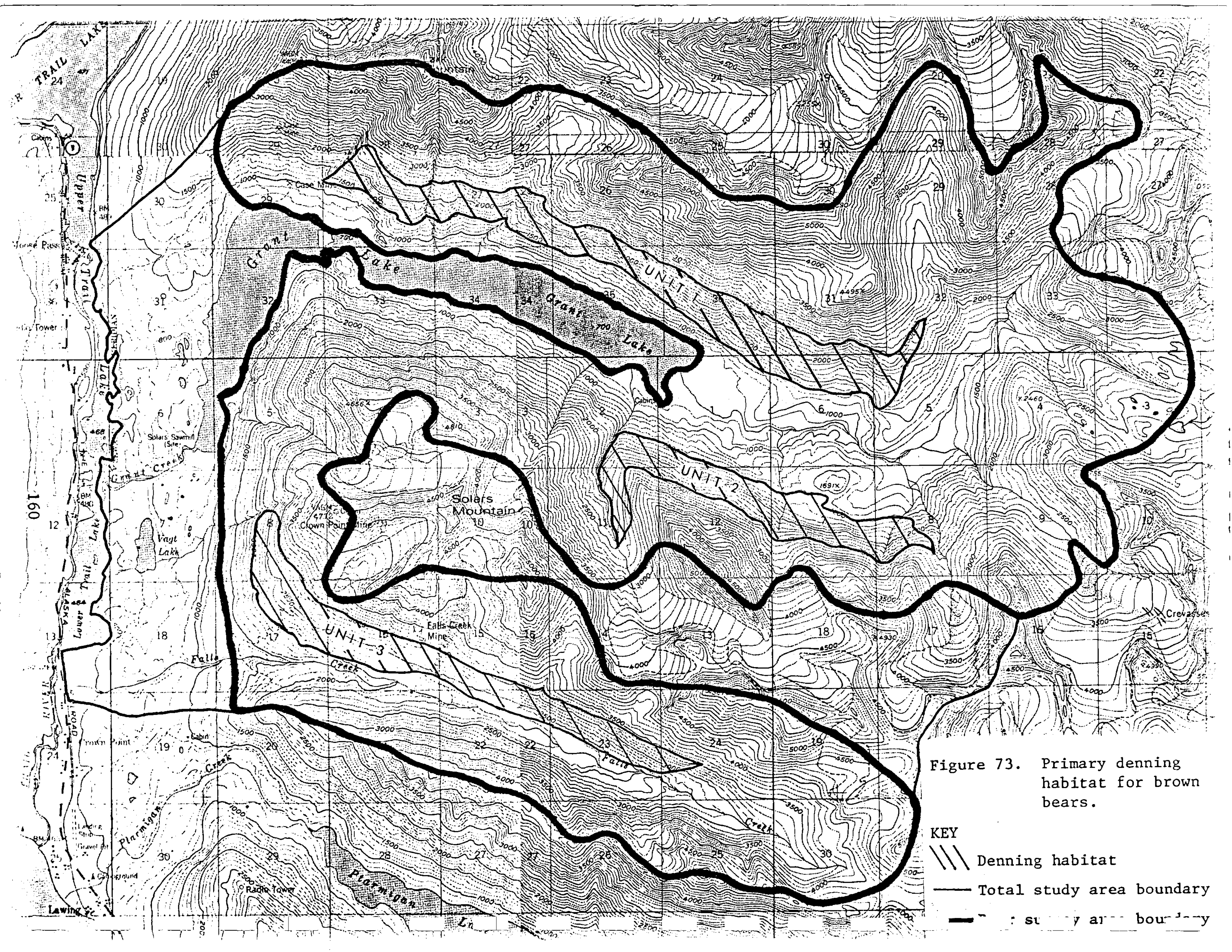


Figure 73. Primary denning habitat for brown bears.

KEY

Denning habitat

Total study area boundary

[illegible] study area boundary

construction. Rocky outcroppings and large boulders provide some caves or natural cavities for denning, but these sites are limited in number. Westward of Unit 2, the slopes are subjected to heavy avalanches and are without suitable substrate to have significant potential as denning habitat.

Approximately 11 percent of the total 105 km^2 bear survey area provides habitat suitable for brown bear denning (Figure 74). The most important habitat is present in the 5.5 km^2 Unit 1, which represent about 47 percent of the total habitat available for denning purposes. It seems reasonable to assume that no more than one or two family groups and possibly two or three solitary animals would den within the Grant Lake project area in any given year.

Certain geomorphic features of the Grant Lake region probably affect movement patterns. High glaciated mountains may prevent or at least deter bears from moving directly south and east of the project area to adjacent Paradise and Snow River drainages. Similarly, the glaciated rugged terrain north of the project area probably impedes movements between Moose Creek and upper portions of the Trail Creek drainage. These obstacles probably impel brown bears to move lateral to valley systems to reach seasonal activity areas in adjacent drainage systems.

The slopes west of Solars and Lark mountains and the ridge partitioning Grant and Trail lakes, constitute the principal travel routes to and from the Grant Lake valley. Of secondary importance to interdrainage travel is the pass intersecting the headwater areas of Moose Creek and the Snow River. The extent these areas are used remains unknown. The absence of interdrainage bear trails reflect the low-density status of the regional brown bear population rather than the absence of traditional movement patterns. Movement patterns exhibited by brown bear after den emergence, are often erratic with some animals negotiating almost any terrain by the most direct route to reach adjacent drainages. Track observations during the May 21 reconnaissance indicated that vertical movements occurred between the upper part of Falls Creek drainage and the Grant Lake valley and tributaries of the Moose Creek drainage. Localized travel between activity areas in the Grant Lake drainage are both lateral and

Figure 74. Location and amount of potential brown bear denning habitat within the Grant Lake study area.

Grant Lake Study Area Denning Habitat	Location	Square Miles	Acres	Hectars
Unit 1	North Grant Lake	2.15	1,376	556
Unit 2	Southeast Grant Lake	1.10	704	285
Unit 3	North Falls Creek	1.20	768	310
Total area of denning units	Lake Basin; Falls Creek	4.45	2,848	651
Total area surveyed		40.20	25,728	10,411

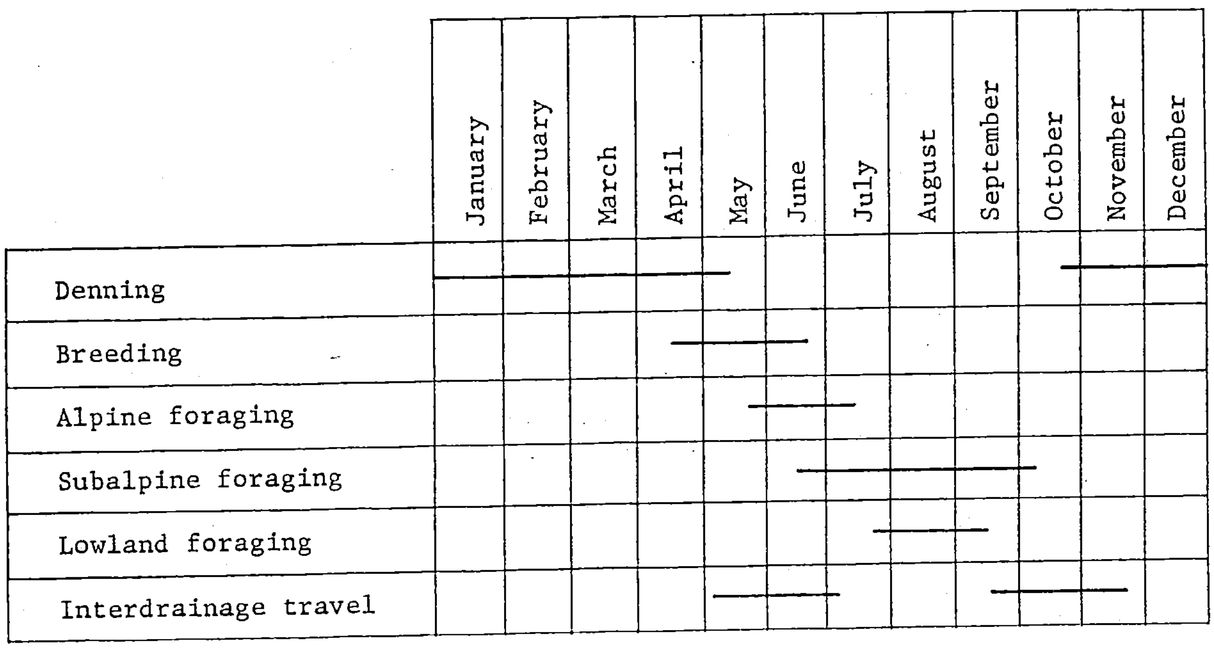
vertical to mountain slopes in response to the seasonal availablility of food sources. Figure 75 depicts prominent activities associated with seasonal range uses.

The reduced spatial distribution and low-quality food sources coupled with the limited denning habitat appears to be the major limiting factors of the regional brown bear population. Residential development bordering the Trail Lake system and extensive use of commercially important fisheries has had a limiting effect on brown bear numbers, but from an historical standpoint the brown bear population probably has never been substantive in this area, a situation primarily attributed to low forage production.

Black Bear. Because black bear have an affinity for forested areas and occupy less range, habitat components are less complex than those of brown bears. Nonetheless, little is known about the habitat requirements of black bear in Alaska. A ground-level reconnaissance during the fall, spring, and summer periods was made to assess relative abundance and general distribution of black bears within the Grant Lake project area. Track, scat, and actual bear sightings were recorded in an attempt to determine the intensity of habitat use relative to the location of proposed project facilities. Black bear activities within the project area are generally associated with valley floors, small alluvial plains, lakeshores, and intervening stream systems. These components are limited in the project area. Recreational facilities and the Moose Pass population center are often visited by foraging black bears under cover of spring foliage.

A total of nine black bears and two track sets, and about 10 scats, presumably of black bear origin, was noted during the three field investigative periods. The majority of bears and sign was observed near Grant Lake during the June 1982 reconnaissance. Concurrently, only one black bear was sighted in the timbered area downstream of the Grant Lake outlet; two track sets were noted along the edge of Lower Trail Lake during the October 1981 reconnaissance. Scat sign was evenly distributed within an altitudinal range of 150 to 300 m in the area between and around the lake systems. Oddly enough,

Figure 75. Timetable of significant biological events for brown bear--southcentral Alaska.



Source: Wilson et al. 1980.

no evidence of black bear activity in the upper Grant Lake valley was discovered during this study.

As with brown bears, the activity patterns of black bears appear to be regulated by the temporal and spatial distribution of food resources. In the Grant Lake project area, black bears probably move from one area to another back again, following essentially the same route without establishing permanent trails. This may be an efficient foraging pattern related to exploitation of food resources having a patchy distribution. Under optimal conditions, a permanent trail network connotes stable and concentrated food resources as well as a high population density. Food resources within the Grant Lake project area appears to be moderate at best.

Studies show that individual black bears occupy a relatively small range most of their lives. Activity patterns are generally stable and habitual from year to year and, depending upon age/sex specific characteristics, home range size was found by some researchers to vary from 60 to as small as 5 km^2 (Reynolds and Beecham 1980; Modafferi 1978). Preferred spring foods consist of grasses, sedges, and scavange, including garbage.

Information obtained through field reconnaissance can be used to speculate on number black bear numbers present in the Grant Lake project area. Based on actual sightings, track and scat sign, it would be reasonable to assume that 20 to 40 black bears range within the Grant Lake project area. Considering the area's size and the relatively small home range size of black bear compared to brown bear, it seems reasonable that 10 to 15 animals range within the project area year-round, and plus or minus 20 black bears intermittently visit the project area as transients. AEIDC biologists believe that the density averages one bear per 40 km^2. In a black bear study in northwestern Prince William Sound, Modafferi (1978) estimated a higher density of one bear per 1.8 km^2 in the Parks Creek subunit of his Prince William Sound study area, which may be attributed to better habitat and forage resources.

The lower alpine zone near the shrubline of Grant Lake and the ridge between the lakes is important habitat during July and August.

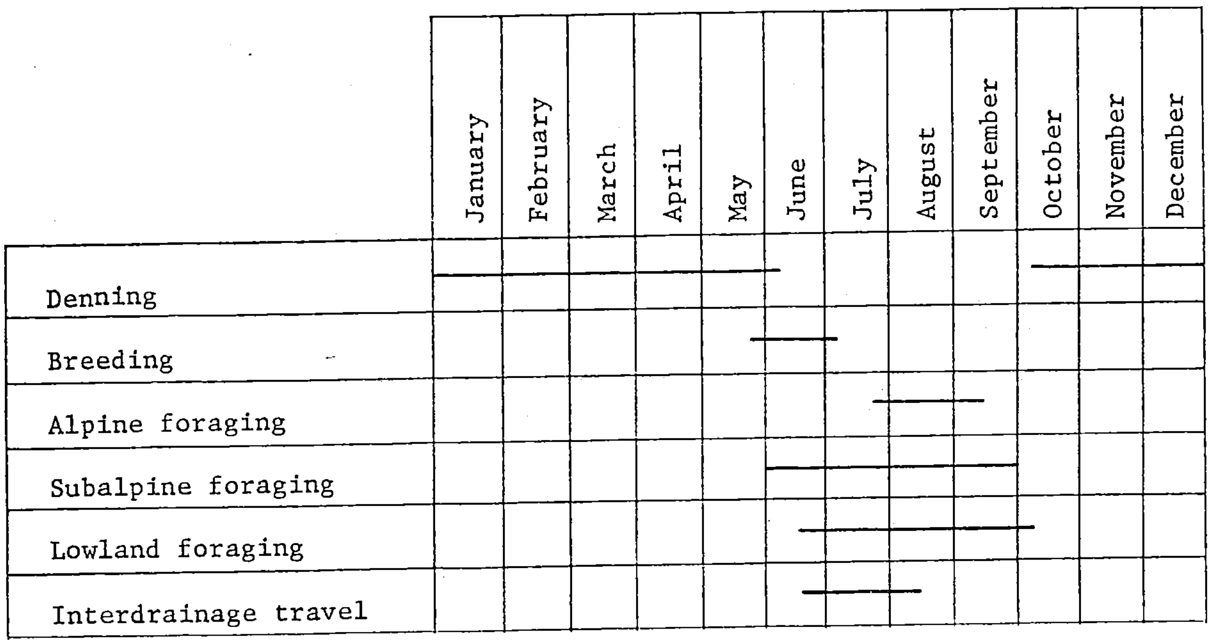
Bears primarily move back and forth from the Trail lakes lowlands to this zone. Although black bears rarely venture far from adequate shrub or tree cover, they move further up the open south-facing slopes to feed upon new, succulent vegetation (forbs and sedge) as the summer progresses. During late July and in August, salmon present in Grant and Falls creeks are sought by black bears. Because salmon are unavailable in great numbers, bears intermittently forage in the subalpine zone until later in August when lowland berries become the prominent dietary attraction. Elderberry, blueberry, rosehips, salmon berries as well as low and highbush cranberries are probably utilized heavily at this time. Figure 76 gives the chronology of range use.

Black bear exhibit a higher degree of variability than brown bear in den site selection--an adaptation that probably reflects habitat diversity throughout their continental range. Protected sites are not always selected, however, as several authorities have reported finding females with young in open depressions under boughs of coniferous trees or in dense thickets (Pelton et al. 1980). The advantage of tree cover and subsurface protection greatly reduced heat loss during cold winters. Black bear dens usually are simple depressions beneath large trees, stumps, and under boulders or the base of rocky outcroppings. Occasionally, man-made structures such as drainage culverts or cabin subspace, may be used as winter den sites.

Black bear dens found on the Kenai Peninsula by Schwartz and Franzman (1980) were on tree-covered slopes of moderate steepness. Reuse of the same den and construction of new dens in old sites were evidently commonplace. Denning characteristics of Grant Lake black bears are probably similar.

Likely denning habitat in the Grant Lake area would include spruce-covered slopes and hillsides. Wet places and open terrain would likely be avoided as places to den. Primary denning habitat for black bears probably occurs in Trail lakes and Moose Creek valleys, whereas the forested habitat along the Trail lakes appears less suitable because of human disturbance and use of the area as a principal route by bears traveling along the valley floor and between connecting tributary systems. The ridge between Grant and Trail lakes south

Figure 76. Timetable of significant biological events for black bear--southcentral Alaska.



Source: Modafferi 1978.
Schwartz and Franzmann 1980.

including Ptarmigan Creek drainage would appear to be usable denning habitat for those black bears resident to this locale year-round.

In contrast to the propensity of brown bears to move laterally along valley bottoms and across alpine slopes, black bear movements tend to be vertical within the same drainage and closely associated with shrub and tree cover. For this reason, the woodland portion of the study area is more important to black than brown bears.

The lack of stable, concentrated food resources and continuous interaction with the human inhabitants of Moose Pass constitute the most prominent limiting factors to black bears in the Grant Lake area. Increased human activity would likely trigger a decline in the number of resident bears, but transient animals would probably be little affected over the long term. The adaptability of black bears to the human element implies that the current number of black bear represent a stationary population.

A less serious limiting factor appears to be the number of bears sacrificed in defense of life and property and those harvested incidental to the taking of other game species by sport hunters. Although the Grant Lake project area is not considered good bear hunting area, moderate hunting pressure is exerted on Dall's sheep, mountain goat, and moose, so black bears are subject some exploitation.

Mustelidae

Marten are indigenous to the Kenai Peninsula and once were prominent in the fur trade. Early in this century marten populations drastically declined, perhaps, like some other furbearers, as a result of heavy trapping and as a side effect of a poisoning campaign against wolves. The animal was slow to recover but is now present over much of the mountain and foothill area of the Kenai Peninsula. A professional trapper and resident of Moose Pass we talked with had not taken marten in the Grant Lake basin but reported a sizeable marten population in the Snow River country southeast of the project area (Candit, pers. comm.). Judkins, also a trapper and resident of Moose Pass, reported that marten was relatively common in lower Falls Creek (pers. comm.). Our field crews noted tracks of a single marten at two locations in March 1982; one on the Inlet Creek delta at the east end of Grant Lake and the other on the timbered ridge north of Falls Creek. The species is present though not abundant in the coniferous forests of the study area.

Weasel are widely distributed throughout the Kenai Peninsula. The Grant Lake area is no exception, and tracks of this mammal were noted throughout all habitat types of the study area. There is considerable variation in density. Sign was most abundant in grassy areas near timberline and around lake margins, probably as a reflection of abundance of voles, the principal prey species.

No mink were sighted by our field crews during the survey period and very little sign indicating their presence was noted. Tracks and scats were most common along the shoreline of Trail lakes near the mouth of Grant Creek and in Grant Creek proper. During March of 1982, we noted a single set of mink tracks along the west shore of Trail River. It ran from open water into a talus pile directly across from the mouth of Grant Creek. The site may have been utilized for denning purposes.

Habitat suitable for mink appears limited to the lower reaches of Falls and Grant creeks and to the shoreline of Trail lakes. Habitats along Trail lakes are probably important only following salmon runs when spawned-out salmon gather in shallows to die. Trail lakes are so glacially turbid that mink are probably unable to locate prey in it at other times.

Based on the information at hand, the mouth of Grant Creek serves as the center of distribution and abundance for this species in the study area. Lack of sighting of individuals coupled with scarcity of sign and limited habitat leads us to believe that very few mink inhabit the study area.

Wolverine are relatively abundant predators on the Kenai Peninsula. Wide-ranging by nature, they can be found in all habitat types, most commonly in mountain areas (Figure 77). In March 1982 our crews noted wolverine tracks in a number of locations; Inlet Creek delta and on to the eastward, traversing the benchland below timberline between Falls Creek and Grant Lake, and the timberline area on the west ridge of Lark Mountain. L. Candit (pers. comm.) reported trapping "seven

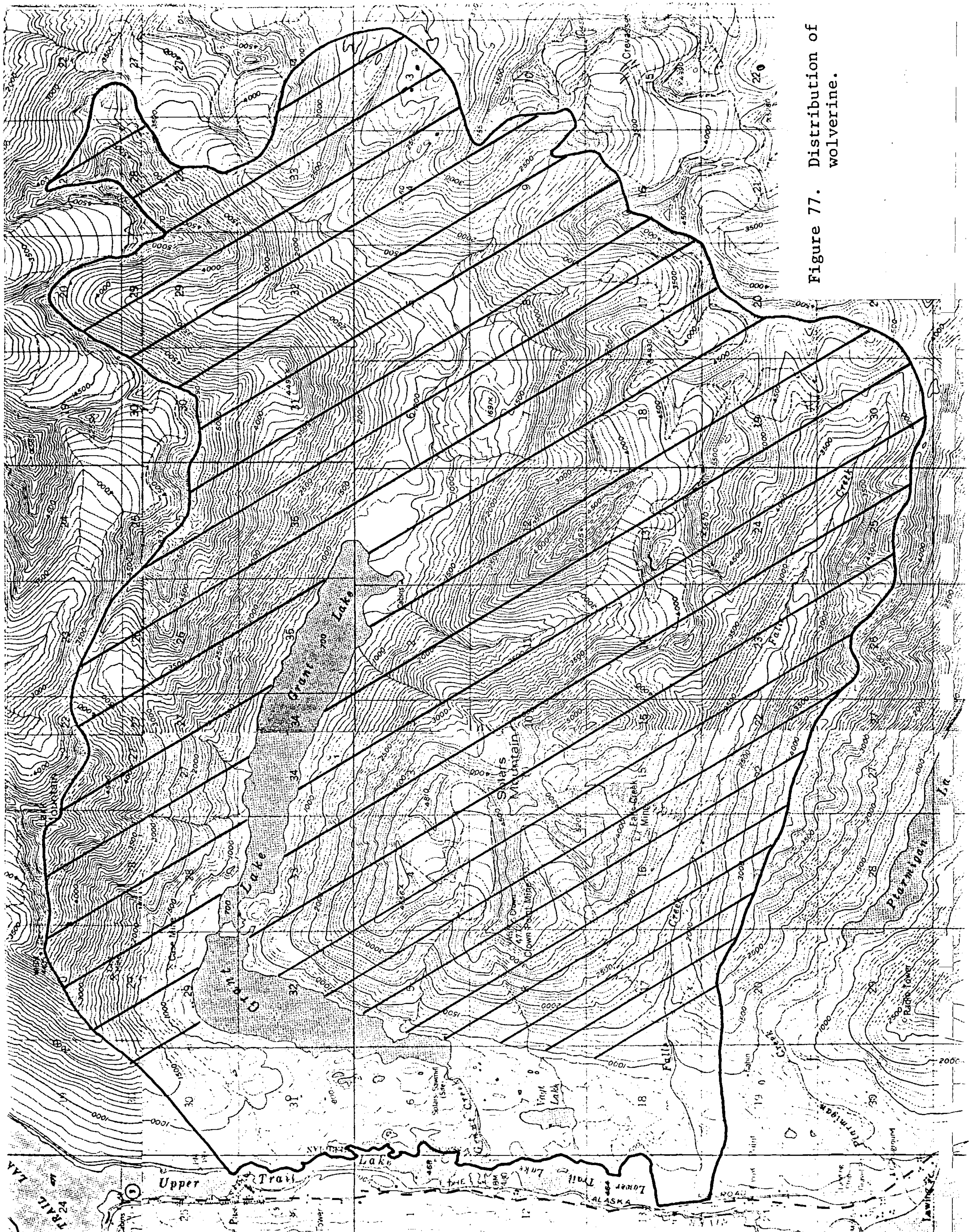


Figure 77. Distribution of wolverine.

or eight" over the course of 20 years of trapping in the Grant Lake drainage basin. At present, the Grant Lake-Falls Creek area is evidently within the travel and hunting range of one or more wolverines. In particular, the Inlet Creek delta was the site of considerable wolverine foraging activity in March of 1982. Several prey species were in this area at the time.

River otter are relatively abundant and widespread on the Kenai Peninsula but no sign of their presence was found in the study area. Suitable habitat for otter is limited to the lower reaches of Grant Creek. Lack of habitat probably precludes the establishment of a resident population. Otters are probably present as transients throuhout the area, however.

Felidae

Lynx are widespread over the Kenai Peninsula. Dependent as they are on the snowshoe hare as a primary food source, lynx distribution and population levels closely shadow that of the hare. Forest and brushland country, where there is an abundance of hardwood browse plants available for hares, is prime lynx habitat. Currently, the hare population on the Kenai Peninsula and, thus, that of the lynx as well, is high. The Grant Lake-Falls Creek area has a relatively low hare population and few areas of concentration so levels of lynx are correspondingly low. Tracks of a single lynx were noted in the timberline area east of Vagt Lake. Lynx would not likely develop much greater abundance here.

Cervidae

Moose, a holarctic species, have been part of the Alaska fauna for at least 175,000 years (LeResche et al. 1974, Pewe and Hopkins 1967). The Alaska race, Alces alces gigas, is one of seven subspecies recognized worldwide and is distinguished principally by its large size. In unexploited populations A. a. gigas males often attain 1,600 pounds at maturity; females seldom exceed 1,000 pounds. Moose are not particularly abundant within the study area at this time. Several factors discussed below are probably responsible for limiting study area moose numbers.

Moose are characteristic inhabitants of subclimax seral stages and typically attain their highest densities in forested areas which have been modified by fire, flood, or some other form of timber removal (Leopold and Darling 1953). Moose are primarily browsers throughout most of the year. This is especially true during winter months. They appear to prefer willow browse to all others (Spencer and Chatelain 1953). Moose utilization of willow seems highly skewed in favor of relatively few types. These are: S. alaxensis, S. novae-angliae, S. interior, S. arbusculoides, and S. pulchra (Milke 1969, Wolff 1976). In some areas (mostly those disturbed by fire) moose utilize birch (Betula spp.) and aspen (Populus spp.) to a greater extent than willow (Spencer and Chatelain 1953; LeResche and Davis 1971, 1973). Use of browse other than willow appears to be related more to availability than species preference. Spencer and Chatelain (1953) believed that winter food varied chiefly according to plant availability on given ranges. Low bush cranberry and foliose lichens apparently serve as important alternate winter foods on some ranges (LeResche and Davis 1973). Use of these low-growing forms is usually restricted by snow cover, and such use is significant only on sheltered ranges.

Mixed species stands of browse generally seem to be of greater value to moose than predominantly pure stands (Spencer and Hakala 1964; Cowan et al. 1950). This seems to apply as well in winter as in summer, even though the nutrient value of winter browse species is uniformly low (Oldenmeyer et al. 1977; Kubota et al. 1970), suggesting that little gain would accrue to moose which had access to mixed species stands.

During warm months the diet of moose consists of the previously listed browse species plus a variety of terrestrial and aquatic plants. Beginning in late May newly emergent grasses and aquatic and marsh vegetation, such as sedges, horsetail, pondweed, buckbean, and water lily are actively sought (LeResche and Davis 1973; LeResche 1966; D. Spencer, pers. comm). Newly emergent aquatic vegetation is rich in sodium (Belovsky and Jordan 1981), and its availability may play a crucial role in moose population dynamics (Belovsky 1981). Lakes and ponds between Grant and Trail lakes support lush buckbean and water lily growth, and much evidence was found of their use by moose. Aquatic plants are eaten with decreasing frequency throughout the summer as palatability decreases. During this period, moose begin to eat increasing amounts of prefloral forbs and mushrooms (LeResche and Davis 1973). Browse use increases as fall approaches and herbaceous vegetation declines in palatability.

Summer range does not appear to be a limiting factor. Ponds and lakes between Grant Lake and the Trail lakes produce abundant aquatics and much evidence of their use by moose was seen. Lower slopes adjacent to Grant Lake support vigorous stands of Calamagrostis canadensis, and suitable browse, while not abundant, occurs throughout the study area. In sum, the study area produces appropriate summer foods in seemingly sufficient quantities.

The chief natural factor limiting moose numbers in the study area appears to be the amount and quality of winter range. With few exceptions the vegetation sere has advanced beyond the stages favoring palatable browse. As a consequence, few places within the study area meet all of the criteria which collectively describe winter range. Remaining winter range is largely confined to the active floodplains of lower Falls and Inlet creeks (Figure 78). In these locations the vegetation sere is periodically retarded by the action of flood waters. Both areas support palatable riparian willows (Appendix D); neither, however, is being utilized to its potential. Examination of browse lines indicates a much greater use in the recent past than at present.

Several factors may be responsible for lack of greater recent use of the study area in winter by moose. Snow depths could occasionally exceed the height of willow stands, even though many plants exceed 4 m in height. Although moose can easily reach browse 3 m above ground level (Wolff 1976), they have difficulty traveling in snow deeper than a meter (Coady 1974). Alternately, access to these isolated stands of winter range could be restricted by snow depth, avalanches, or glare ice on the lakes. The winter of 1981-82 was not particularly severe, however, and it seems likely that other explanations must be sought to explain why most moose left the study area during winter. Lack of use in recent years might reflect the results of increasing hunter-induced

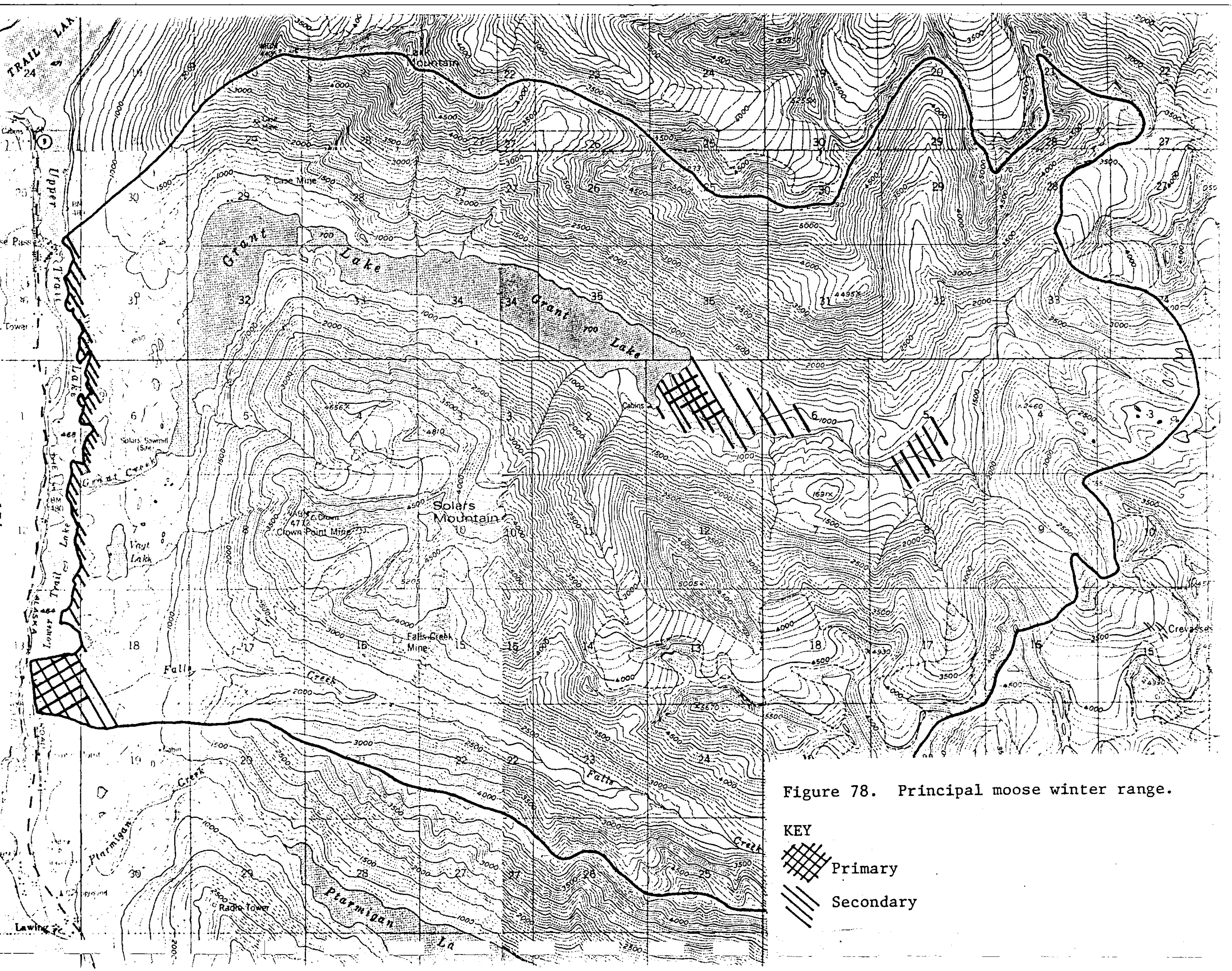


Figure 78. Principal moose winter range.

mortality (Hinman 1979, 1980a, 1980b) but lack of abundant food resources due to the advancing age of the sere in all probability is the chief reason few moose overwinter in the study area.

Most moose within the study area appear to be migratory. Sightings of individuals and sign were more common during the warmer seasons than during winter--despite the severe limitations on visibility imposed by the leaves of deciduous trees and forbes in summer. Several clearly defined traditional travel routes were found, providing a clue as to the normal means of ingress and egress used by moose (Figure 79).

Moose movements on the Kenai Peninsula as a whole peak seasonally in May-June and November-December (Bailey et al. 1978). These peaks represent seasonal movements by migratory stocks moving from lowlands to uplands and uplands to lowlands, respectively. Movements of males generally exceed those of females. Males tend to cover greater distances than females during the rut (Bailey et al. 1978), but these distances vary widely among individual moose and tend to be greatest among the two- and three-year-old age classes (Bailey et al. 1978). Average straight-line distances moved between summer and winter ranges by Kenai Peninsula moose four years of age and older varies between 11.7 to 24.2 km; some two- and three-year-olds move up to 60 km (Bailey et al. 1978).

Home range size varies between habitat types and whether or not an individual moose is migratory. Ranges of nonmigratory lowland moose are apparently smaller than those of nonmigratory upland inhabitants, and upland winter ranges are larger than upland summer ranges (Bailey et al. 1978). LeResche (1974) argued that upland ranges in Alaska are inferior to lowland ranges, noting that densities in the former vary between 0.8 to 1.6 moose/km^2, and densities in the latter appear close to four to six moose/km^2. Upland winter ranges of nonmigratory stocks on the Kenai appear to be five to seven times the size of lowland winter ranges (Bailey et al. 1978).

Based on the results of field and literature survey we estimate that moose numbers within the study area during summer fluctuate between 20 and 30 individuals per year. Assuming these estimates are correct, stocking densities range from 2.3 to 3.5/mi^2 on summer range

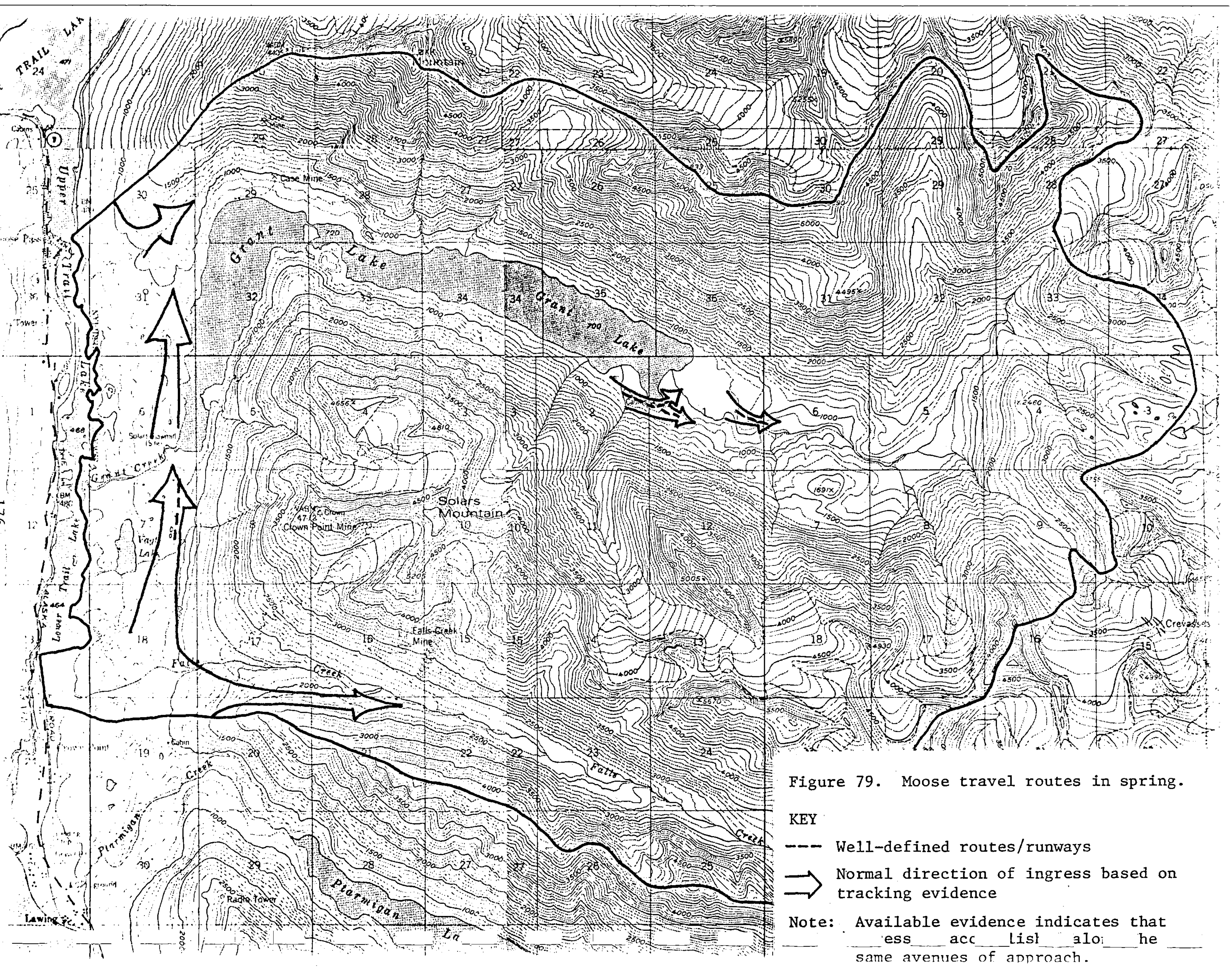


Figure 79. Moose travel routes in spring.

KEY

--- Well-defined routes/runways

⇨ Normal direction of ingress based on tracking evidence

Note: Available evidence indicates that ess acc lis alo he same avenues of approach.

(Figure 80). As noted above, few moose overwinter in the study area. Stocking densities in this range are relatively low compared to other areas on the Kenai Peninsula. Low stocking densities are not surprising, however, considering that range quality is generally poor as a consequence of advanced age, moose production in this area is low (Hinman 1979, 1980a, 1980b), and predation by humans, wolves, and bears throughout the Kenai is high (Hinman 1979, 1980a, 1980b; Chatelain 1950; Franzmann et al. 1980).

From a statewide perspective the moose resources of the study area are relatively insignificant. Viewed from a local perspective, however, the resource takes on added importance. Moose are nowhere abundant in the mountains of the eastern half of the Kenai Peninsula and, consequently, the study area's population is biologically significant to the area as a whole. The population also is important to humans. Hunting pressure is relatively high due to its location adjacent to the road system. Most hunters are local residents, however, in past years Grant Lake attracted as many as four fly-in hunting parties per year (Judkins, pers. comm.). Moose harvest figures are unavailable for the area, but based on the results of our survey we believe that legal annual take could not exceed five. Some indication of illegal hunting was noted during our surveys, but this was never verified. Considering the proximity of the area to human habitations there is a decided potential for illegal hunting to occur. Figure 81 provides a timetable of significant annual events for moose.

Bovidae

Mountain goats inhabit the entire mountain area of the Kenai Peninsula but densities are greatest east of the railroad. The Kenai Peninsula goat population has been relatively stable over a long period. The population is, however, subject to considerable short-term annual fluctuations and shifts in ranges due primarily to winter weather conditions and, in recent years, to hunting pressures. A general overall decline in Kenai Peninsula populations has been noted over the past 10 years. Although current total Kenai mountain goat population estimates are not available, it is probably in the range of one to two thousand animals. In 1979, 1980, and 1981, a total of 41

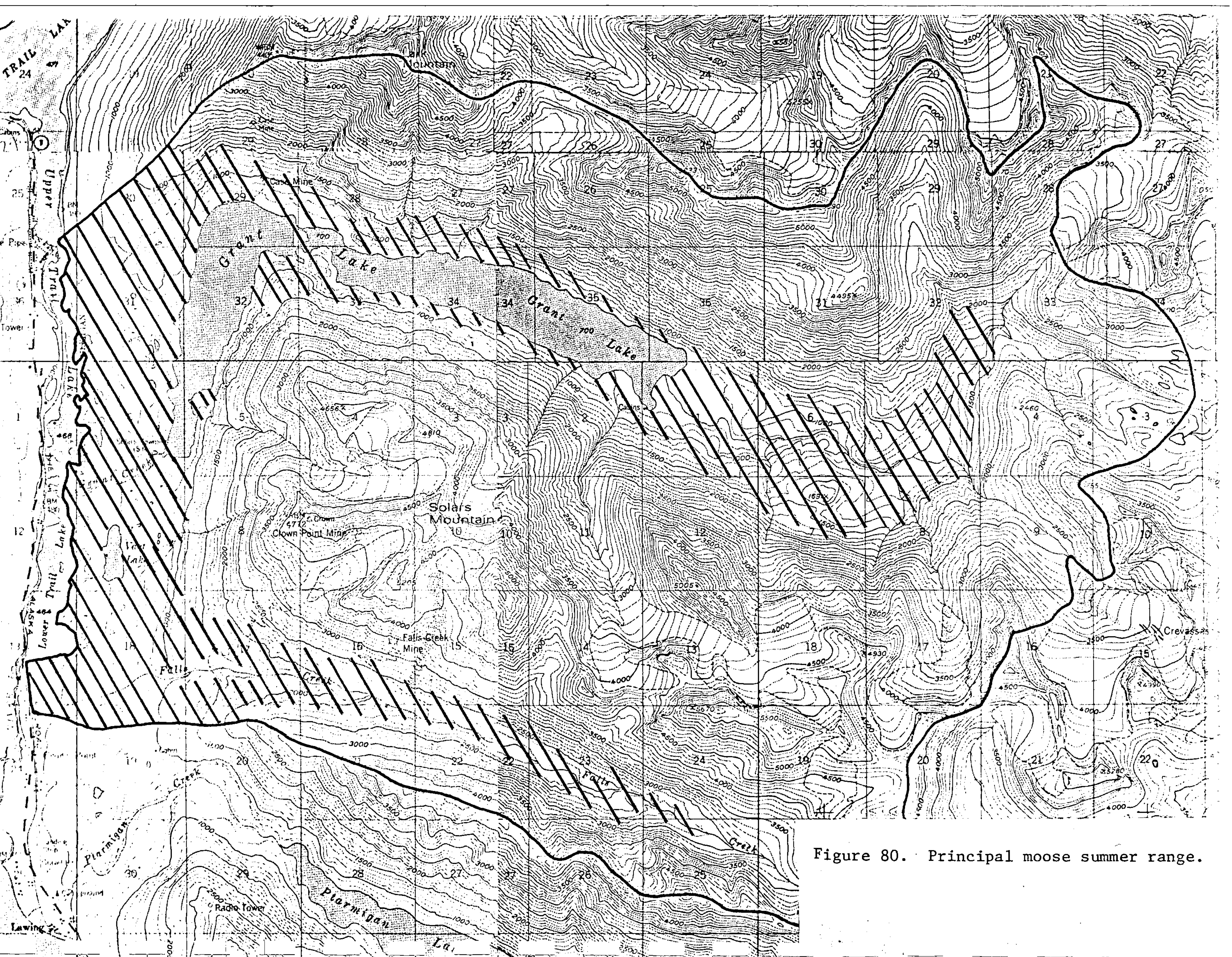
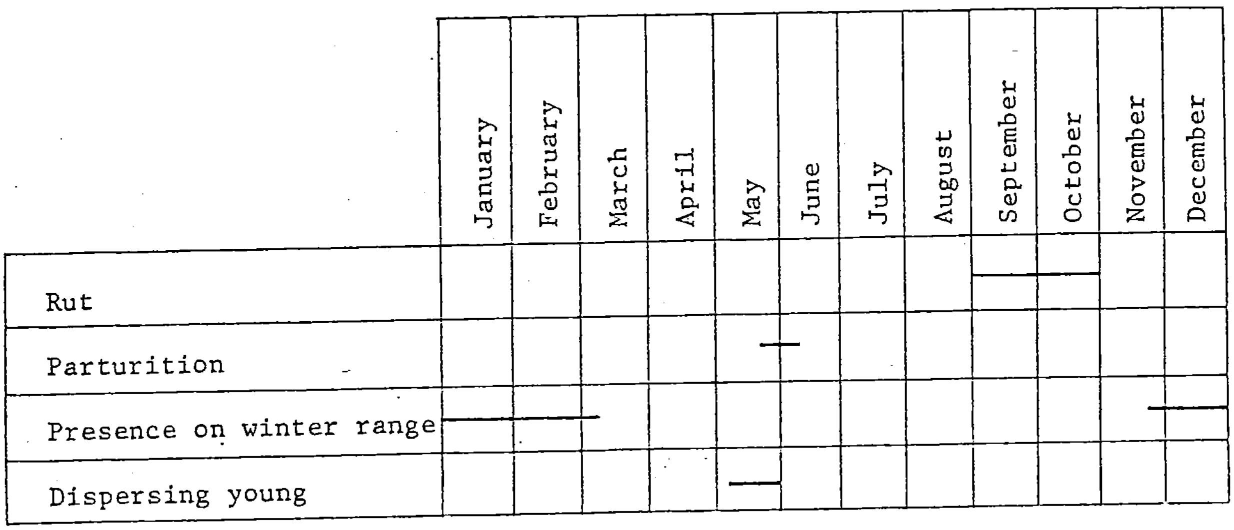


Figure 80. Principal moose summer range.

Figure 81. Timetable of significant biological events for moose--southcentral Alaska.



Source: Bailey et al. 1978.
LeResche 1966; 1972; 1974.
LeResche and Coady 1974.
Spencer and Chatelain 1953.
Chatelain 1950.

goats were captured and equipped with radio collars and subsequently monitored to obtain life history information by the ADF&G (Nichols, pers. comm.). This study area extended from Trail lakes to Kings Bay and from Trail Glacier to Ptarmigan Lake. The Grant Lake drainage is the nucleus of this study area. As a consequence, more accurate data are available for the goats of this region than any other location in Alaska.

The entire area under study by ADF&G had an estimated population of 246 goats in the summer of 1979 and 1981; a winter of heavy snow and severe avalanche conditions in 1980 induced considerable mortality and reduced productivity. Of this group, about one-quarter (an average of 50) commonly use the Grant Lake basin through much of the year.

Although the entire drainage is used by goats, the most important sections are located on the south-facing slopes of the north half of the drainage--generally small vegetated benches and ridges in the 300 to 1,000 m altitudinal range. Figures 82 through 84 record the locations of goats at seasonal periods as observed during our field studies.

Goat hunting on the Kenai Peninsula is presently rigidly controlled by a permit system that allocates a limited harvest to each unit of range. In 1982, 16 goat hunting permits were issued for the Ptarmigan Lake-Trail Creek-Moose Creek area, including the Grant Lake drainage (area 839).

The northern half of the Grant Lake drainage has been, and is presently, the location of excellent mountain goat habitat and continues to support good seasonal populations of these animals. The primary area of interchange is into the Moose Creek drainage to the northeast and across the glacier to the east to the Kings River-Kings Bay area.

The principal area of goat use in the Grant Lake basin is the north side of the lake. This south-facing slope is utilized in fall, winter, spring, and into early summer. Occupied areas reach from alpine benches downslope into stringers of mountain hemlock.

Food habits during fall, winter, and spring depend largely on weather, as mountain goats readily shift their ranges in response to

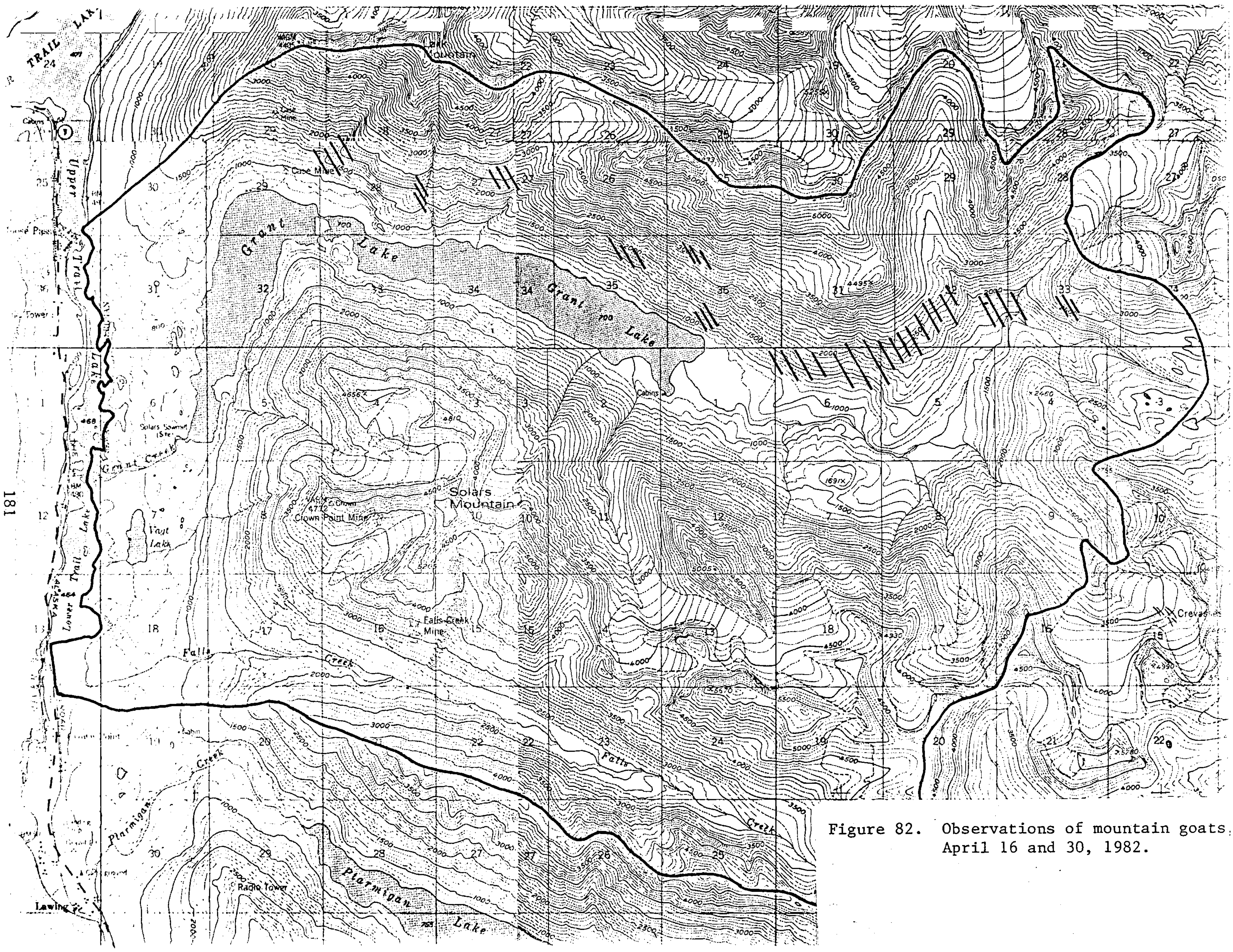


Figure 82. Observations of mountain goats, April 16 and 30, 1982.

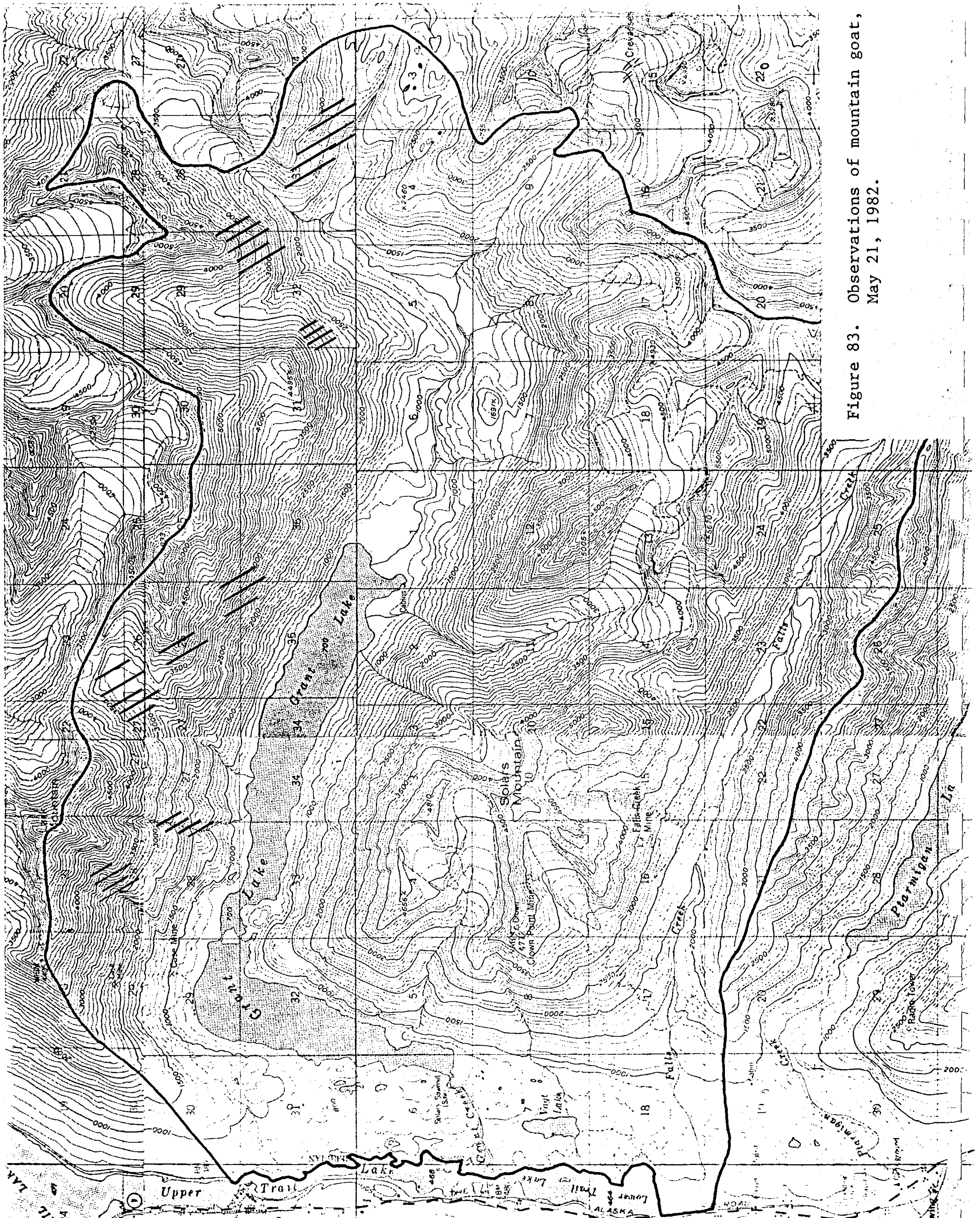


Figure 83. Observations of mountain goat, May 21, 1982.

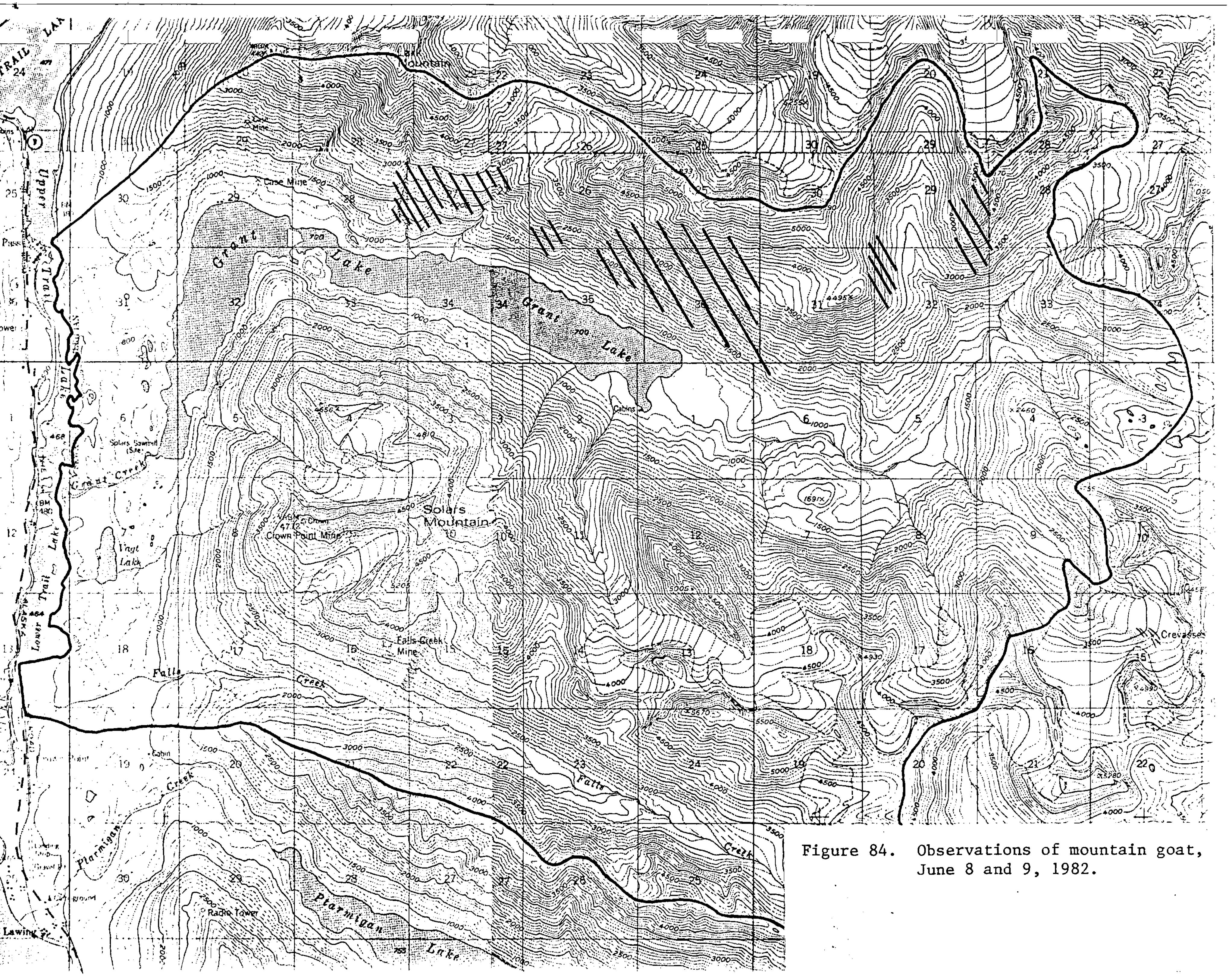


Figure 84. Observations of mountain goat, June 8 and 9, 1982.

changing weather patterns. For example, Hjeljord (1971) described a sudden downslope movement off of a subalpine fall range into an old-growth forest dominated by hemlock following a one and a-half foot snowfall. In limited observations in this habitat type, Hjeljord (1971) noted mountain goats feeding in the understory on Phyllodoce aleutica, Blechnum spicant, and Luetkea pectinata. No other plants were consumed, although bryophytes, Cassiope spp., Rubus spp., Cornus spp., and Vaccinium spp. were present.

Mountain goats often occupy extremely limited ranges during winter (Hjeljord 1971). Two basic habitat types are utilized during winter. Their use apparently depends on the amount and nature of the snow cover. Type one, which appears to be preferred, may be characterized as windblown, south-facing, knife-edged ridges (Schoen 1979; Hjeljord 1971, 1973). These sites, which support low volumes of vegetation (Hansen and Archer 1981), are usually occupied only when snow conditions allow (Hjeljord 1971, 1973). Food items on these sites are limited mainly to those forms which remain upright in the snow, such as Festuca altaica, Carex circinnata, and Carex microchaeta (Hjeljord 1971, 1973; Hansen and Archer 1981). Other forms eaten on alpine winter ranges include willow browse, mountain hemlock, (Hansen and Archer 1981), and bearberry (Klein 1953). Mountain hemlock was present in 70 percent of all fecal samples collected from alpine winter ranges at Grant Lake (Hansen and Archer 1981).

The second major habitat type utilized by mountain goats in winter is subalpine in nature (Hjeljord 1971, 1973; Schoen 1979; Schoen et al. 1980). Subalpine ranges are usually adjacent to steep, rocky valley walls which serve as escape terrain (Hjeljord 1971). Subalpine ranges are usually occupied only during periods of heavy snowfall. Some individuals, however, utilize subalpine ranges throughout winter (Schoen et al. 1980; Hjeljord 1971).

As soon as snow conditions permit in spring, mountain goats begin an upslope migration through the alder zone (Hjeljord 1971, 1973). Early spring ranges are similar in appearance to winter subalpine haunts, but individuals are more dispersed (Hjeljord 1971). Principal food items at this season above timberline include the young leaves of lady fern, Calamagrostis canadensis, and Festuca altaica (Hjeljord 1971).

In summary, the Grant Lake drainage is an important segment of the best mountain goat habitat on the Kenai Peninsula. It supports a long term average of 50 goats; a number subject to considerable seasonal and annual variation. These goats are a part of a group ranging over the Ptarmigan, Grant, Moose Creek, and Kings Bay valley regions. Most goats move out of the Grant Creek drainage for a brief period in midsummer occupying the range in varied numbers the remainder of the year.

The southern side of the Grant Lake drainage and Falls Creek drainage is used to a much lower degree than the north part of the drainage. This south-facing slope is evidently subject to intense avalanche activity and this factor may limit its utility to mountain goats. Although the extent of mortality to sheep and goats from this cause is unknown, avalanches appear to be a significant mortality factor in Alaska. Five of Nichols (1980a) 20 radio-collared goats were killed in one winter by avalanches. Klein (1953) found 10 carcasses in 1952, at least seven of which had died in avalanches. Reports of similar findings are common in literature.

The Dall's sheep is a wilderness animal residing for the most part in rugged alpine and subalpine mountain habitat. Dall's sheep in the Grant Lake project area are distributed in several small bands throughout the study area.

Dall's sheep on the Kenai Peninsula are relatively more abundant on to the interior sections of the Kenai Mountain range than elsewhere. Grant Lake range constitute the outer boundary of sheep range in this area. Ranges in the study area are isolated from ranges to the west by the Kenai-Trail lakes drainage system and the human transportation corridor between Moose Pass and Seward.

Dall's sheep are reported to range over the entire Grant Lake and Falls Creek drainage. In our study, however, they were only noted on the northern half of the Grant Lake drainage. This is evidently their most favored range.

Accurate sheep population data for the entire Kenai Peninsula are not available, however trend counts indicate an overall stable and healthy population. The total recorded harvest of rams in 1981 was 11 (taken by 107 hunters), a decline in both harvest and hunters over past years (Spraker 1982). Population studies of three separate Kenai Peninsula herds in the areas of Crescent and Surprise mountains and the Cooper Landing closed area during the early 1970's revealed that lamb production averaged around 40 lambs per 100 ewes (Nichols 1975). Dall's sheep have a high reproductive potential, and most adult ewes and many yearlings become pregnant even under stressed range conditions. Mortality among lambs is normally low, averaging about 40 to 50 percent.

In May of 1980 and 1981 14 and 47 sheep, respectively, were recorded on the Grant Lake ranges (Nichols, pers. comm.). In early June of 1982, 30 sheep were recorded by AEIDC on the slopes north of Grant Lake. Based on extant trend counts and the results of this survey we conclude that Dall's sheep numbers vary naturally between years and that the range of variation is 10 to 50 animals.

Frequent interchange apparently occurs with the Moose Creek drainage, particularly in the summer period. As with goats, midelevations of the slopes constitute favored range, especially vegetated benches, and the upper edges of timbered areas and exposed ridges where some forage plants are available. We observed sheep at various seasons from the Lark Mountain ridge line above Moose Pass to slopes in the upper basin of the drainage. The location of sheep observations made during this study are displayed in Figures 85 and 86.

Because Dall's sheep are diurnal, they feed almost any time during the long daylight hours of summer. Major feeding periods generally occur early in the morning and late afternoon with some grazing activity about midday. Feeding habitat is typically alpine--steep open grasslands interspersed with broken cliffs and talus slopes in glaciated mountains. Lower portions may extend through subalpine associations to treeline. Such ranges have stands of shrubs and hemlock thickets.

Winter range generally comprises a small sector of the overall range. Good winter range in the Grant Lake basin consists of snow-free sites near escape terrain at the midaltitudinal level of the basin. In early spring, sheep sometimes must move to lower altitudes

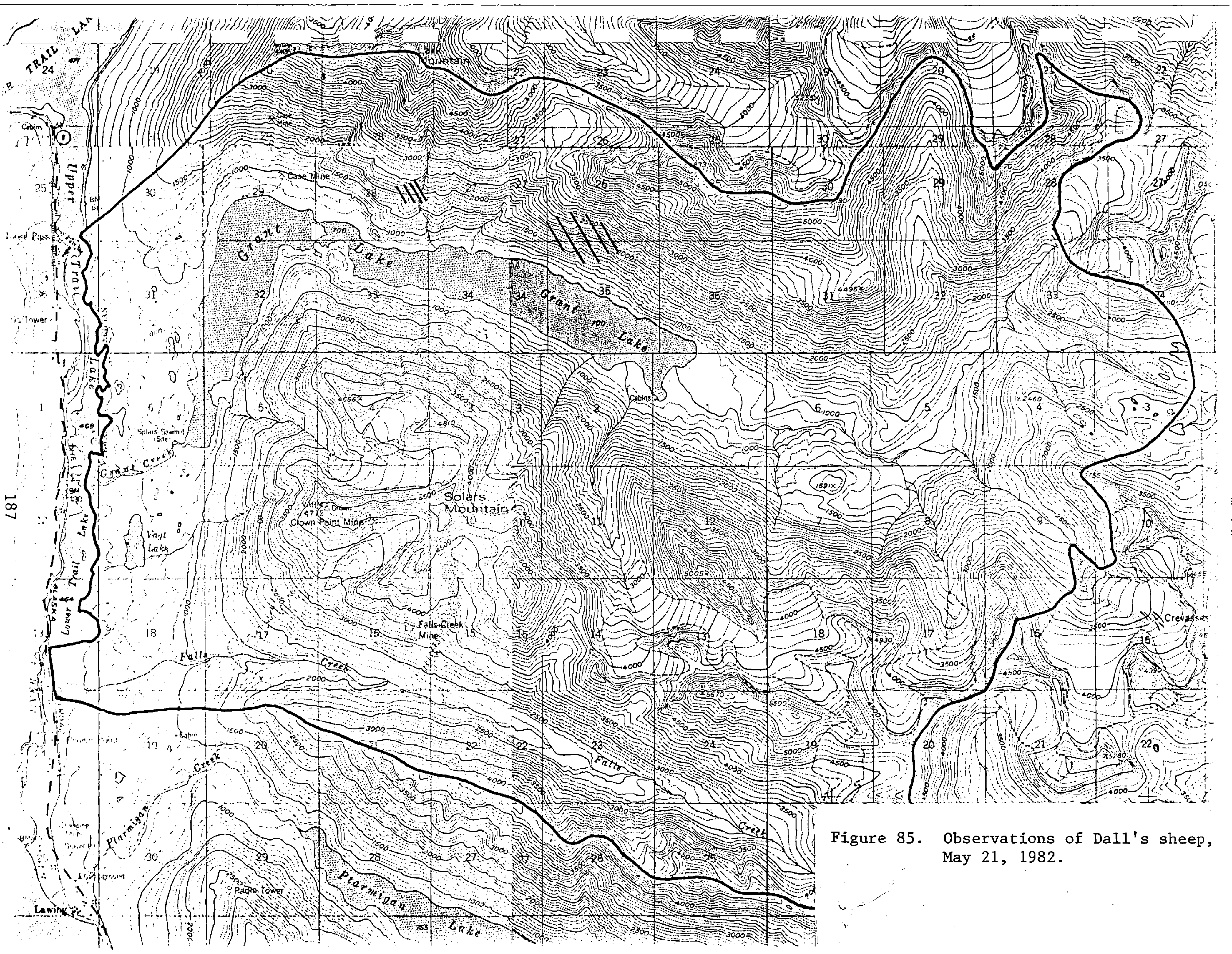


Figure 85. Observations of Dall's sheep, May 21, 1982.

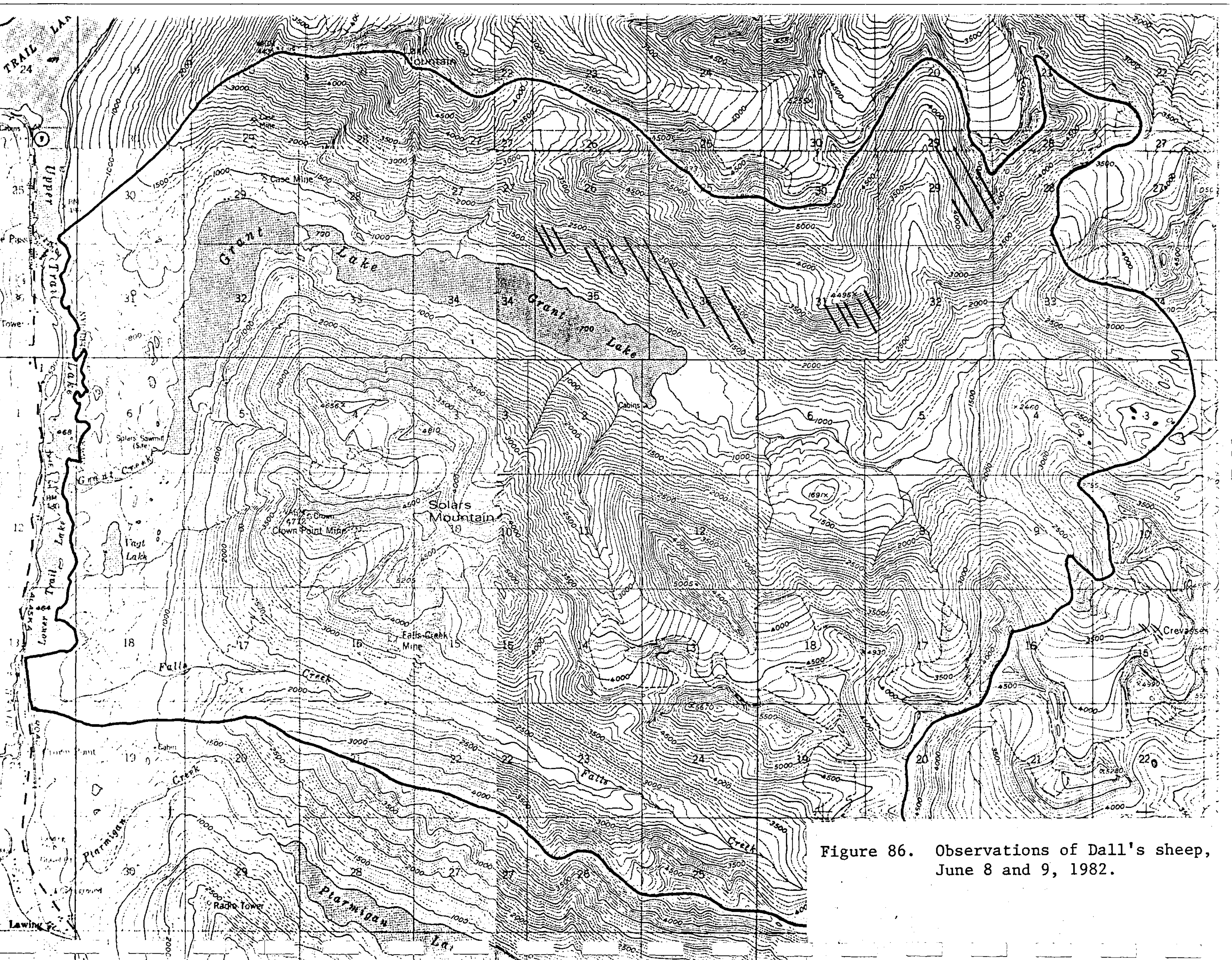


Figure 86. Observations of Dall's sheep, June 8 and 9, 1982.

into subalpine tree cover, where emergent vegetation appears soon after the snow recedes. Within the study area, sheep scats were found in open Calamagrostis cauadensis meadows as low as 1000 ft in altitude.

In sum, early summer movements are characterized by dispersal over all suitable habitat. As the seasons progress toward winter, sheep withdraw to smaller portions of range with the necessary winter habitat. Movement to mineral licks is an important phase of seasonal movements, however, no licks were found during this study.

Winter range is the principal limiting factor. Mortality among young lambs is low during their first summer but is high in winter, reaching 40 to 50 percent. Similarly, the nutritional intake of yearlings supports growth rather than fat storage. As a consequence, winter mortality among non-nursing yearlings appears to be high, and probably approaches 15 to 20 percent. Exceptionally severe winters may cause drastic declines in sheep numbers regardless of population density or range condition.

While coyotes, wolverines, bears, and eagles may prey on sheep, the wolf appears to be the principal predator. Wolves, however, do not appear to exert much influence on sheep numbers in the Grant Lake area except when sheep may be forced by competition to feed distant from escape terrain at the time wolves move through the area.

SIGNIFICANCE OF THE RESOURCES

Plants and animals have intrinsic ecological values which in turn have socioeconomic value. Thus, living resources may be viewed as having two distinct value components. The Grant Lake study area has ecological significance due to its location between two major ecosystems. Communities to the east are dominated by a type of coastal rainforest; and to the west by a more xeric association typical of interior Alaska (Appendix D).

The ecosystem is an ecotone. The study area's biota are enhanced by contributions from each ecosystem plus some unique to the area as a whole. For example, typical maritime species such as mountain goats flourish alongside interior species such as Dall's sheep; hybrids between coastal Sitka spruce and interior white spruce dominate stands of *Picea*; and mountain hemlock, enhanced by the area's abundant precipitation and unhampered by competition from western hemlock, often attain diameters of 1 m or more at breast height. Further, due to the areas relative isolation, several vertebrate populations may be genetically distinct and worthy of note. Known instances are limited to certain salmonids but there is reason to suspect that at least some terrestrial forms are also genetically discrete. The rugged physiography of the area restricts animal movements and some populations may be isolated from others. Isolation of conspecifics by geomorphic features has been implicated elsewhere as one of the principal motive forces driving evolutionary processes.

The study area also has importance in a socioeconomic context. Study area streams contribute small but significant numbers of salmonids to regional fisheries. Area forests, while not rich in merchantible stands, are important sources of fuel and fiber to local residents. These forests also provide habitat for much sought after wildlife species such as bear and moose and are important to the area's hydrologic regime. Citizens also utilize the areas living resources for recreation.

Although systematic data are not extant, it appears likely that use of the area's living resources is not limited to local inhabitants. The study area sits astride one of Alaska's major transportation routes and is located on the Kenai Peninsula, focal point for recreationists in southcentral Alaska. Since recreation in Alaska is heavily oriented towards existing travel corridors it appears likely that the areas resources are used by more than local residents.

Below we discuss the relative significance of the study area's biota from both a socioeconomic and an ecological viewpoint.

AQUATIC

The Grant and the Falls Creek drainages provide fish habitat and production which contributes to the aquatic resources of the Upper Kenai River drainage. Grant Lake is under study by the Alaska Department of Fish and Game (ADF&G) because of its potential as a nursery for salmon juveniles produced by their enhancement efforts in the upper Kenai drainage.

Inaccessible to migrating fish from downstream, Grant Lake possesses neither sport nor commercial fisheries resources. However, it is under study as a potential rearing area for some of the sockeye, chinook, and perhaps coho salmon juveniles to be produced at the ADF&G Trail Lakes hatchery (L. Flagg, pers. comm.). The hatchery (with a 40 million salmon egg capacity) is in its first year of operation with an initial production of sockeye and coho salmon. Preliminary investigations of water quality parameters and the plankton populations of Grant Lake indicate that it should be an excellent nursery area for juvenile sockeye salmon.

An experimental introduction of 1 million sockeye fry into Grant Lake is scheduled for June of 1983. Tentative plans indicate that coho fry will be released into Grant Lake during June of 1983, although the issue of coho and sockeye juvenile competition is still being deliberated. An experimental release of up to 200,000 king salmon in 1984 is being considered as well. An ADF&G program to evaluate the egress of outmigrants from Grant Lake is contemplated for 1983 (L. Flagg, pers. comm.).

Grant Lake contains a large population of threespine stickleback. Juvenile sockeye salmon utilize the same foods as stickleback, so there may be some interspecific competition. In some areas such competition may be a limiting factor to sockeye production. However, there appears to be sufficient dietary differences and abundance of food items in Grant Lake so this issue may not be serious.

Grant Creek's importance to fish production in the Kenai River system is primarily due to its utilization for spawning and rearing by king salmon. These fish contribute to the annual production of approximately 50,000 king salmon in the Kenai River system. The number of king salmon reported to spawn in Grant Creek is small (Figure 35) compared to the overall production of the Kenai system; however, tributary systems above Skilak Lake generally average king salmon escapements of 50 to 200 fish, making the importance of each contributing tributary more significant (C. Burger, pers. comm.). These fish are probably from the early run into the Kenai system, which consists of a distinct group of fish that separate into relatively small spawning runs which utilize headwater tributary systems. Late run fish have been found to limit themselves to the mainstem of the Kenai River for spawning (C. Burger, pers. comm.). In addition, the Grant Creek system is one of the furthest upstream tributaries of the Kenai drainage utilized by king salmon. The genetic characteristics of the king salmon in Grant Creek may give this stock a value which is beyond that given to this run in terms of abundance alone.

Sockeye salmon also spawn in Grant Creek. Historically, the annual run size has been quite variable (Figure 35); however, many more sockeye may spawn in the interconnecting Trail River at the Grant Creek confluence. Actual numbers of spawners at this location are difficult to determine due to the turbidity of Trail River water. The size of the sockeye run in Grant Creek is moderate compared to runs in other tributaries in the Kenai system. As in the case of the Grant Creek king salmon, these sockeye belong to a group of the most upstream spawning stocks in the drainage.

Coho salmon, rainbow trout, and Dolly Varden may also spawn in Grant Creek. Small coho salmon fry observed in August 1982 (Figure 45) indicated that spawning by this species probably occurs in Grant Creek. Juveniles of these species as well as juvenile king salmon utilize Grant Creek for rearing during the summer and fall. Grant Creek, while somewhat turbid, provides a refuge and feeding area for all these species of juvenile fish. Its value may increased as the Trail lakes system becomes extremely turbid due to glacial runoff in the late summer and fall. Its value to juveniles would be limited somewhat by high velocities; however, we found the creek to be heavily utilized by all species, especially Dolly Varden. Substantial rearing habitat is available in the deep pools, backwaters and side channels. Interstitial habitats are also available in the areas of large substrate found throughout Grant Creek.

In summary, Grant Creek currently provides habitat for the production of fish species recognized as valuable to the sport and commercial fisheries on Kenai River stocks, and contributes to the overall fish production and diversity of the Kenai River system.

Falls Creek provides little fishery habitat and appears to support only juvenile Dolly Varden. Cold water, high velocities, and placer mining operations probably limit its productivity. Sockeye salmon are believed to spawn in the Trail River at the mouth of Falls Creek. The number of sockeye using that interface is difficult to determine due to the persistent high turbidity of Trail River water during the summer spawning period.

The Grant Lake and Falls Creek drainages are currently utilized by humans for a number of water-related activities: mining, sport fishing, canoeing, skiing, cabin sites, snowmachining, and other recreational use. Grant Lake has limited accessibility and no sport fish in residence. The principal human activity appears to be related to the mining activity in the lower basin and occasional use of a cabin in the upper basin. A mine access road connects Upper Trail Lake to the north end of the Lower Grant Lake basin. Two canoes were present throughout our study period near the saddle dam site and are assumed to be used by recreational canoeists or hunters. A semi-permanent snowmachine trail exists from Upper Trail Lake to Grant Lake via the saddle dam area.

A regularly used cabin exists near the mouth of Grant Creek. Apparently the owner of this cabin obtained use of this site because of its location on Grant Creek and the fishing and other recreational opportunities available in the area. Access to the creek is difficult and requires a boat; however, local residents fish for Dolly Varden and rainbow trout from the mouth of the creek to the gorge. Grant Creek is closed to salmon fishing.

Falls Creek has several mining claims, both active and inactive. The active placer dam near the mouth has involved rechannelization of Falls Creek. The miner anticipates terminating his activities on Falls Creek in two to three years. Some sport fishing occurs in Trail River near the mouth of Falls Creek although the target species are probably migrating to water bodies in the Trail lakes basin.

In summary, the project drainages do not receive heavy human utilization compared to other subdrainages in the Kenai River basin. The most prevalent water-related activities currently are mining on Grant Lake and Falls Creek and sport fishing in Grant Creek. Future activities in project area waters by ADF&G's salmon enhancement program will undoubtedly change the character of the fishery resource.

TERRESTRIAL

Although not of spectacular quality in terms of the entire Kenai Peninsula, the study areas' terrestrial resources are ecologically significant at least from a local perspective. The most productive, and hence significant, habitats center on the Inlet Creek delta at the east end of Grant Lake, certain south-facing slopes on the north side of Grant Lake, the outlet area of Grant Lake, upper parts of the Grant and Falls creek drainages and the benchland between Vagt Lake and adjacent mountain slopes. In aggregate these units provide seasonal feeding and breeding ranges for ungulates, carnivores, and rodents as well as good nesting habitat for passerine and some raptor species. These habitat units, while limited areally, are central to the maintenance of the larger mammals of the study area.

An ancillary benefit of the area's ecological value concerns its potential for scientific study. Virtually the entire Grant Lake project area lies within the boundary of an ADF&G research area where 41 mountain goats have been instrumented with radio tracking devices during the past three years. These studies are expected to continue well into the future and will contribute information on species ecology and biology applicable to regional management programs. Such information also has educational potential which indirectly adds to the significance of the area's ecological value.

The relative value of the study area's wildlife resources and their specific habitats varies by species abundance or availability and their ranking in terms of socioeconomic importance. For example, although they are little used at present, the dense willow thickets of the Inlet Creek area at the east end of Grant Lake are valuable for the long term maintenance of moose in the study area and, hence, have significance. The same area also supports beaver and other fur animals but these species are not in the public eye to the extent that moose are. Similarly, south-facing slopes north of Grant Lake provide essential seasonal habitat for mountain goat and Dall's sheep, and two bear species. These slopes contribute materially to the perpetuation of regional goat and sheep populations. Goats of the Grant Lake project area represent approximately 28 percent of the regional population and thereby constitute a significant component of the terrestrial resources. Up to 50 animals of each species utilize this unit as winter range and for parturition and the rearing of young. The upper part of the Falls Creek drainage and mountain slopes around much of the Grant Lake basin contain bear denning and feeding ranges; however, these units are insignificant to regional populations. The benchland above Vagt Lake serves the dual purpose of an intradrainage travel route for the more mobile species and winter habitat for the area's limited numbers of moose.

Water and marshland systems have little value to waterfowl with the single exception of the Grant Lake outlet. This small shallow water area appears to be ice free during most of winter and supports a rich Ranunculus (white-water crowfoot) community and associated invertebrates. This community provides feeding and resting habitat for an overwintering flock of mallards.

Wildlife-oriented recreation is the predominate activity within the Grant Lake project area. The Grant Lake basin is in hunting unit 839. This area receives a low to moderate amount of recreational pressure depending upon the availability of hunting permits. The recreational value of sheep and goat hunting in this unit is relatively insignificant compared to more popular hunting areas elsewhere on the Kenai Peninsula. The recreational value of bear and moose hunting also appears to be low by virtue of low numbers and access to better hunting grounds on the Kenai Peninsula. Because of the few moose available, hunting has been restricted in this area to only a ten day season for bulls only. The bear harvest in this area is extremely low, and most of the animals harvested are probably taken incidentally to mountain goats and moose.

Fur animals are significant since they provide some cash income and a recreational outlet. Some limited beaver trapping occurs in this area, but interviews with local residents indicated that trapping intensity varies considerably between and within years depending to a large extent on market conditions. At least one trapper is active in the area. Based on the evidence at hand, beaver trapping is more of a recreational pursuit than one designed to provide a high rate of monetary return.

In a regional context, wildlife-oriented recreation occurring within the Grant Lake project area appears to be insignificant; however, local residents place considerable reliance on the immediate area as a convenient place to participate in various outdoor activities.

BIBLIOGRAPHY

Alaska Dept. of Environmental Conservation. 1979. Water quality standards. Juneau, AK. 34 pp.

Alaska Dept. of Fish and Game. 1952/1980. Escapement count surveys, Grant Creek. Unpublished. (On file at Alaska Dept. of Fish and Game, Soldotna, AK).

_____. 1961. Creel census for Grant Creek. Unpublished. (On file at Alaska Dept. of Fish and Game, Seward, AK). 1 vol.

_____. 1973. Alaska's wildlife and habitat. Juneau, AK. 1 vol.

_____. 1978. Alaska's fisheries atlas. 2 vols.

_____. 1981. Grant Lake survey. Unpublished. (On file at Alaska Dept. of Fish and Game, Soldotna, AK.) 1 vol.

_____. 1982. 1961-81 brown/grizzly bear harvest reports. Unpublished. Juneau, AK. 1 vol.

Allen, D.L. 1979. The wolves of Minong: their vital role in a wild community. Houghton Mifflin, Boston, MA. 499 pp.

Armstrong, R.H. 1969. The sea-run Dolly Varden in Alaska. Alaska Dept. of Fish and Game, Anchorage, AK. Wildlife Notebook Series. 2 pp.

Bailey, T.N., et al. 1978. Kenai Peninsula moose population identity study. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Projects W-17-3, 4, 5, 6, 7, 8, and 9. Final Report. 84 pp.

Banfield, A.W.F. 1974. The mammals of Canada. University of Toronto Press, Toronto, Canada. 438 pp.

Bellrose, F.C. 1980. Ducks, geese, and swans of North America. 3rd ed. Stackpole Books, Harrisburg, PA. 540 pp.

Belovsky, G.E. 1981. A possible population response of moose to sodium availability. Journal of Mammalogy. 62(3):631-633.

Belovsky, G.E., and P.A. Jordan. 1981. Sodium dynamics and adaptations of a moose population. Journal of Mammalogy. 62(3):613-621.

Berns, V.C., and R.J. Hensel. 1972. Radio tracking brown bears on Kodiak Island. Pages 19-25 in S. Herrero, ed. Bears--their biology and management. Proceedings of the 2nd International Conference on Bear Research and Management, University of Calgary, Alberta, Canada, 1970. Environmental Sciences Centre and University of Calgary. International Union for Conservation of Nature and Natural Resources. IUCN new series 23.

Bishop, R.H., and R.A. Rausch. 1974. Moose population fluctuations in Alaska, 1950-1972. Canadian Naturalist. 101:559-593.

Blanchet, D. 1981. Water quality effects of placer mining on the Chugach National Forest, Kenai Peninsula field season, 1980. Unpublished. Chugach National Forest, U.S. Forest Service. 1 vol.

Boyce, M.S. 1974. Beaver population ecology in interior Alaska. M.S. Thesis. University of Alaska, College, AK. 80 pp.

Brady, N.C. 1974. The nature and properties of soils. MacMillan Publishing Co., New York, NY. 639 pp.

CH_2M Hill. 1980. Feasibility assessment hydropower development at Grant Lake. Prepared for City of Seward, AK. 1 vol.

Cade, T.J., and R. Fyfe. 1970. The North American peregrine survey, 1970. Canadian Field-Naturalist. 84(3):231-245.

Chatelain, E.F. 1950. Bear-moose relationships on the Kenai Peninsula. Transactions of the North American Wildlife Conference. 15:224-234.

Choate, T.S. 1963. Habitat and population dynamics of white-tailed ptarmigan in Montana. Journal of Wildlife Management. 27(4): 684-699.

Coady, J.W. 1974. Influence of snow on behavior of moose. Naturaliste Canadien. 101:417-436.

Cowan, I. McT., W.S. Hoar, and J. Hatter. 1950. The effect of forest succession upon the quantity and upon the nutritive values of woody plants used as food by moose. Canadian Journal of Research. 28, Section D(5):249-271.

Cowan, I. McT., A.J. Wood, and W.D. Kitts. 1957. Feed and requirements of deer, beaver, bear, and mink. Transactions of the North American Wildlife Conference. 22:179-188.

Craig, P.C., and P.J. McCart. 1974. Classification of stream types in Beaufort Sea drainages between Prudhoe Bay, Alaska and the Mackenzie Delta. Pages 1-47 in P.J. McCart, ed. Classification of streams in Beaufort Sea drainages and distribution of fish in arctic and sub-arctic drainages. Canadian Arctic Gas Study Ltd./Alaskan Arctic Gas Study Co. Biological Report Series. 17(1).

Craig, P.C., and J. Wells. 1975. Fisheries investigations in the Chandalar River region, northwest Alaska. Pages 1-14 in P.C. Craig, ed. Fisheries investigations in the coastal region of the Beaufort Sea. Canadian Arctic Gas Study Ltd./Alaskan Arctic Gas Study Co. Biological Report Series. 34(1).

Craighead, F.C., and J.J. Craighead. 1972. Data on grizzly bear denning activities and behavior obtained by using wildlife telemetry. Pages 84-106 in S. Herrero, ed. Bears--their biology and management. Proceedings of the 2nd International Conference on Bear Research and Management, University of Calgary, Alberta, Canada, 1970. Environmental Sciences Centre and University of Calgary. International Union for Conservation of Nature and Natural Resources. IUCN new series 23.

Crechton, V. 1963. Autumn and winter foods of the spruce grouse in central Ontario. Journal of Wildlife Management. 27:597.

Cushwa, C.T., and J. Coady. 1976. Food habits of moose, Alces alces, in Alaska: a preliminary study using rumen contents analysis. The Canadian Field Naturalist. 90(1):11-16.

Daubenmire, R. 1968. Plant communities. A textbook of plant synecology. Harper and Row, New York, NY. 300 pp.

DeLeonardis, S. No date. Productivity of the rock and willow ptarmigan. Pages 334-336 in Proceedings of the 2nd Alaskan Science Conference, Mt. McKinley National Park, September 4-8, 1951. Alaska Div., American Association for the Advancement of Science.

Ebasco Services, Inc. 1982. Grant Lake hydroelectric project interim report. Prepared for Alaska Power Authority. Bellevue, WA. 1 vol.

Elliott, S.T., and R.D. Reed. 1973. Ecology of rearing fish. Pages 12-92 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 14. Sport Fish Div., Alaska Dept. of Fish and Game. Project F-9-5. Annual Report.

Ellis, M.M., B.A. Westfall, and M.O. Ellis. 1946. Determination of water quality. U.S. Fish and Wildlife Service. Research Report 9. 122 pp.

Ellison, L.N. 1966. Seasonal foods and chemical analysis of winter diet of Alaskan spruce grouse. Journal of Wildlife Management. 30(4):729-735.

_____. 1971. Territoriality in Alaska spruce grouse. Auk. 88:652-664.

_____. 1973. Seasonal social organization and movements of spruce grouse. The Condor. 75:375-385.

_____. 1974. Population characteristics of Alaskan spruce grouse. Journal of Wildlife Management. 38(3):383-395.

_____. 1976. Winter food selection by Alaskan spruce grouse. Journal of Wildlife Management. 40(2):205-213.

Engel, L.J., and S.M. Logan. 1966. Inventory and cataloging of the sport fish and sport fish waters on the Kenai Peninsula, Cook Inlet-Prince William Sound areas. Pages 59-78 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 7. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-5-R-7. Annual Report.

Erickson, A.W., and J. Nellor. 1964. Breeding biology of the black bear. Pages 5-45 in The black bear in Michigan. Agriculture Experiment Station, Michigan State Univ., East Lansing, MI. Research Bulletin 4.

Evans, C.D., et al. 1972. The Cook Inlet environment, a background study of available knowledge. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK. 229 pp.

Federal Register, 1980. Water quality criteria documents; availability, November 28, 1980. (45)231.

Figgins, J.D. 1904. Field notes on the birds and mammals of the Cook's Inlet region of Alaska. Linnaean Society of New York, 1902-1904. No. 15-16. 24 pp.

Franzmann, A.W., C.C. Schwartz, and R.O. Peterson. 1980. Moose calf mortality in summer on the Kenai Peninsula. Journal of Wildlife Management. 44(3):764-768.

Gabrielson, I.N., and F.C. Lincoln. 1959. Birds of Alaska. The Wildlife Management Institute, Harrisburg, PA. 922 pp.

Geist, V. 1963. Observations on the habitat-directed behavior of Stones sheep (*Ovis dalli stonei*) and the mountain goat (*Oreamnos mountanus*). Pages 29-30 in Proceedings of the 13th Alaskan Science Conference, Juneau, AK, August 22-26, 1962. Alaska Div., American Association for the Advancement of Science.

_____. 1964. On the rutting behavior of the mountain goat. Journal of Mammalogy. 45(4):551-568.

_____. 1967. On fighting injuries and dermal shields of mountain goats. Journal of Wildlife Management. 31:192-194.

_____. 1971. Mountain sheep: a study in behavior and evolution. The University of Chicago Press, Chicago, IL. 383 pp.

Hakala, J.B., et al. 1971. Fire effects and rehabilitation methods--Swanson-Russian Rivers fires. Pages 87-91 in C.W. Slaughter, R.J. Barney, and G.M. Hansen, eds. Fire in the Northern Environment--a symposium. Proceedings of a symposium, University of Alaska, College (Fairbanks), AK, April 13-14. Alaska Forest Fire Council and Alaska Section, Society of American Foresters. Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, Portland, OR.

Haley, R. 1962. Inventory and cataloging of the sport fish and sport fish waters on the Kenai Peninsula and Prince William Sound. Pages 41-56 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 3. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-5-R-3. Annual Report.

Hall, E.R., and K.R. Kelson. 1959. The mammals of North America. The Ronald Press, New York, NY. 2 vols.

Hammarstrom, S.L. 1980. Evaluation of chinook salmon fisheries of the Kenai Peninsula. Pages 40-67 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 21. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-9-12. Job G-II-L. Annual Report.

Hammarstrom, S.L., and J. Wallis. 1980. Inventory and cataloging of Kenai Peninsula, and Cook Inlet drainages and fish stocks. Pages 59-90 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 21. Sport Fish Div., Alaska Dept. of Fish and Game. Project F-9-12. Job G-I-C. Annual Report.

Hansen, R.M., and S.R. Archer. 1981. Range survey of mountain goat wintering areas. Unpublished. Final report for the U.S. Forest Service, Chugach National Forest. 24 pp.

Hanson, H.A., et al. 1971. The trumpeter swan in Alaska. Wildlife Monographs 26. 83 pp.

Hebert, D.M. 1967. Natural salt licks as a part of the ecology of the mountain goat. M.S. Thesis. University of British Columbia, Vancouver, B.C., Canada. 138 pp.

Heimer, W.E. 1974. The importance of mineral licks to Dall sheep in interior Alaska and its significance to sheep management. Pages 49-63 in Proc. Northern Wild Sheep Council. Montana Dept. of Fish and Game.

Hensel, R.J., W.A. Troyer, and A.W. Erickson. 1969. Reproduction in the female brown bear. Journal of Wildlife Management. 33(2):357-365.

Hickey, J.J. 1969. Peregrine falcon populations, their biology and decline. University of Wisconsin Press, Madison, WI. 596 pp.

Hinman, R.A., ed. 1979. Annual report of survey-inventory activities. Part I. Moose, elk, deer. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 9. Project W-17-10. 157 pp.

_____. 1980a. Annual report of survey-inventory activities. Part II. Bison, caribou, moose, and muskoxen. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 10. Project W-17-11. 198 pp.

_____. 1980b. Annual report of survey-inventory activities. Part II. Deer, elk, and moose. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 11. Project W-17-12. 120 pp.

Hjeljord, O.G. 1971. Feeding ecology and habitat preference of the mountain goat in Alaska. M.S. Thesis. University of Alaska, College, AK. 126 pp.

_____. 1973. Mountain goat forage and habitat preference in Alaska. Journal of Wildlife Management. 37(3):353-362.

Hodgdon, H.E., and J.S. Larson. 1973. Some sexual differences in behaviour within a colony of marked beavers (Castor canadensis). Animal behavior. 21(1):147-152.

Hodge, R.P. 1976. Amphibians and reptiles in Alaska, the Yukon, and Northwest Territories. Alaska Northwest Publishing, Anchorage, AK. 89 pp.

Holmes, K.W. 1981. Natural revegetation of dredge tailings at Tok, Alaska. Agroborealis. 13:26-29.

Holmquist, C. 1975. Lakes of northern Alaska and northwestern Canada and their invertebrate fauna. Zoologische Jahrbucher Abteilung fur Systematik Okologie und Geographie der Tiere. 102(3):333-484.

Howse, N.R. 1972. Vagt Lake fisheries habitat survey. Chugach National Forest, U.S. Forest Service. 10 pp.

Hulten, E. 1968. Flora of Alaska and neighboring territories. Stanford University Press, Stanford, CA. 1008 pp.

Hynes, H.B.N. 1970. The ecology of running waters. Liverpool University Press. 555 pp.

Jonkel, C.J., and K.R. Greer. 1963. Fall food habits of spruce grouse in northwestern Montana. Journal of Wildlife Management. 27(4):593-596.

Kessel, B. 1979. Avian habitat classification for Alaska. Murrelet. 60:86-94.

Kessel, B., and D.D. Gibson. 1978. Status and distribution of Alaska birds. Cooper Ornithological Society, Los Angeles, CA. Studies in Avian Biology 1. 100 pp.

Klein, D.R. 1953. A reconnaissance study of the mountain goat in Alaska. M.S. Thesis. University of Alaska, College, AK. 121 pp.

Koontz, K.C. 1968. Small game and furbearers of the Rampart Dam impoundment area. M.S. Thesis. University of Alaska, College, AK. 165 pp.

Kortwright, F.H. 1967. The ducks, geese and swans of North America. Stackpole Co., Harrisburg, PA., and Wildlife Management Institute, Washington DC. 476 pp.

Kubota, J., S. Rieger, and V.A. Lazar. 1970. Mineral composition of herbage browsed by moose in Alaska. Journal of Wildlife Management. 34(3):565-569.

Lawler, R.E. 1963. Inventory and cataloging of the sport fish and sport fish waters on the Kenai Peninsula and Prince William Sound. Pages 145-173 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 4. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-5-R-4. Annual Report.

_____. 1964. Inventory and cataloging of the sport fish and sport fish waters on the Kenai Peninsula, Cook Inlet-Prince William Sound areas. Pages 113-122 in Alaska Dept. of Fish and Game. Federal Aid in Fish Restoration. Vol. 5. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-5-R-5. Annual Report.

Lentfer, J.W., and R.J. Hensel. 1980. Alaskan polar bear denning. Pages 101-108 in C.J. Martinka and K.L. McArthur, eds. Bears--their biology and management. Proceedings of the 4th International Conference on Bear Research and Management, Kalispell, MT, February 1977. Bear Biology Association Conference. Series 3.

Lentfer, J.W., et al. 1972. Remarks on denning habits of Alaska brown bears. Pages 125-133 in S. Herrero, ed. Bears--their biology and management. Proceedings of the 2nd International Conference on Bear Research and Management, University of Calgary, Alberta, Canada, 1970. Environmental Sciences Centre and University of Calgary. International Union for Conservation of Nature and Natural Resources. IUCN new series 23.

Leopold, A.S., and F.F. Darling. 1953. Effects of land use on moose and caribou in Alaska. Transactions of the North American Wildlife Conference. 18:553-560.

LeResche, R.E. 1966. Behavior and calf survival in Alaskan moose. M.S. Thesis. University of Alaska, College, AK. 84 pp.

_____. 1972. Migrations and population mixing of moose on the Kenai Peninsula (Alaska). Pages 185-207 in the Proceedings of the 8th North American Moose Conference Workshop, Thunder Bay, Ontario.

_____. 1974. Moose migrations in North America. Canadian Naturalist. 101:393-415.

LeResche, R.E., and J.L. Davis. 1971. Moose research report. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 12. Project W-17-3. 1 vol.

_____. 1973. Importance of non-browse foods to moose on the Kenai Peninsula, Alaska. Journal of Wildlife Management. 37(3):279-287.

LeResche, R.E., R.H. Bishop, and J.W. Coady. 1974. Distribution and habitats of moose in Alaska. Naturaliste Canadien. 101:143-178.

Lewandoski, K.M., and K.W. Rice. 1980. Owl surveys on the Kenai Peninsula and Afognak Island, Chugach National Forest. Spring 1980. Chugach National Forest, U.S. Forest Service. 15 pp.

Libby, W.L. 1954. A basis for beaver management in Alaska. M.S. Thesis. University of Alaska, College, AK. 80 pp.

_____. 1957. Observations on beaver movements in Alaska. Journal of Mammalogy. 38(2):269.

Lutz, H.J. 1956. Ecological effects of forest fires in the interior of Alaska. U.S. Dept. of Agriculture. Technical Bulletin 1133. 121 pp.

Manzer, J.I. 1976. Distribution, food, and feeding of threespine stickleback, Gasterosteus aculeatus, in Great Central Lake, Vancouver Island, with comments on competition for food with juvenile sockeye salmon, Oncorhyndus nerka. Fishery Bulletin. 74(3):647-668.

McCoy, G.A. 1974. Preconstruction assessment of biological quality of the Chena and Little Chena Rivers in the vicinity of the Chena Lake flood control project near Fairbanks, Alaska. U.S. Geological Survey. Water Resources Investigations 29-74. 84 pp.

McGowan, J.D. 1975. Distribution, density, and productivity of goshawk in interior Alaska. Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Project W-17-3, W-17-4, W-17-5, and W-17-6. Final report. 31 pp.

McKnight, D.E., ed. 1975. Annual report of survey-inventory activities. Part III. Caribou, marine mammals, mountain goat, wolf, and black bear. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 5. Project W-17-6. 196 pp.

_____. 1976. Annual report of survey-inventory activities. Part I. Deer, sheep, bison, mountain goat, elk, and muskoxen. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 6. Project W-17-7. 167 pp.

Mech, L.D. 1970. The wolf. Doubleday, New York, NY. 384 pp.

Mendenhall, W.C. 1900. A reconnaissance from Resurrection Bay to the Tanana River, Alaska, in 1898. Pages 265-340 in United States Geological Survey 20th Annual Report. Explorations in Alaska in 1898. Washington, DC.

Merrell, T. 1970. Alaska's fishery resource: the chum salmon. Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service. Fishery Leaflet 632. 7 pp.

Milke, G.C. 1969. Some moose-willow relationships in the interior of Alaska. M.S. Thesis. University of Alaska, College, AK. 79 pp.

Mills, M.J. 1980. Alaska statewide sport fish harvest studies. Federal Aid in Fish Restoration. Vol. 21. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-9-12. Annual Report. 65 pp.

Modafferi, R.D. 1978. Black bear management techniques development. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Projects W-17-8, and 9. Final Report. 75 pp.

Morrow, J.E. 1980. The freshwater fishes of Alaska. Alaska Northwest Publishing, Anchorage, AK. 272 pp.

Moss, R. 1972. Social organization of willow ptarmigan on their breeding grounds in interior Alaska. The Condor. 74(2):144-151.

Murie, A. 1944. The wolves of Mount McKinley. U.S. National Park Service. North American Fauna Series 5. 238 pp.

Murphy, E.C. 1974. An age structure and reevaluation of the population dynamics of Dall sheep (*Ovis dalli dalli*). M.S. Thesis. University of Alaska, Fairbanks, AK. 113 pp.

Murray, D.F. 1961. Some factors affecting the production and harvest of beaver in the upper Tanana River, Alaska. M.S. Thesis. University of Alaska, College, AK. 103 pp.

_____. 1980. Threatened and endangered plants of Alaska. U.S. Forest Service and U.S. Bureau of Land Management. 59 pp.

Nauman, J.W., and D.R. Kernodle. 1974. Aquatic organisms from selected sites along the proposed Trans-Alaska Pipeline corridor, September 1970 to September 1972. U.S. Geological Survey, Anchorage, AK. 23 pp.

Neiland, K.A. 1977. Sheep disease studies. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 17. Project W-17-9. 11 pp.

Neilsen, C., and K.A. Neiland. 1974. Sheep disease report. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Project W-17-5 and W-17-6. 15 pp.

Nichols, L. 1975. Sheep report. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Project W-17-7. 17 pp.

______. 1976. An experiment in Dall sheep management: progress report. Transactions of the North American Wild Sheep Conference.

______. 1978a. Dall Sheep. Unpublished. Div. of Game, Alaska Dept. of Fish and Game, Cooper Landing, AK. 35 pp.

______. 1978b. Mountain goat aerial survey technique evaluation. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Projects W-17-9 and W-17-10. 31 pp.

______. 1980a. Mountain goat management technique studies. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Projects W-17-9, W-17-10, and W-17-11. Final Report. 51 pp.

______. 1980b. Mountain goat movements study. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 1. Project W-21-1. 9 pp.

Oldemeyer, J.L., et al. 1977. Browse quality and the Kenai moose population. Journal of Wildlife Management. 41(3):533-542.

Peek, J.M., R.E. LeResche, and D.R. Stevens. 1974. Dynamics of moose aggregations in Alaska, Minnesota, and Montana. Journal of Mammalogy. 55(1):126-137.

Pelton, M.R., L.E. Breman, and D.C. Edgar. 1980. Den selection by black bear in the Great Smokey Mountains. Pages 149-152 in C.J. Martinka and K.L. McArthur, eds. Bears--their biology and management. Proceedings of the 4th International Conference on Bear Research and Management, Kalispell, MT, February 1977. Bear Biology Association Conference Series 3.

Pennak, R.W. 1978. Freshwater invertebrates of the United States. John Wiley and Sons, New York, NY. 803 pp.

Peterson, R.O. 1982. Wolf-moose investigations on the Kenai National Wildlife Refuge. Final report. Report for U.S. Fish and Wildlife Service. 1 vol.

Peterson, R.O., and J.D. Woolington. 1979a. The extirpation and reappearance of wolves on the Kenai Peninsula, Alaska. Paper presented at the Portland Wolf Symposium, Portland, OR, August 1970. 21 pp.

______. 1979b. Wolf-moose investigations on the Kenai Peninsula. Quarterly Report 13. Unpublished. Report for U.S. Fish and Wildlife Service. Kenai National Moose Range, Kenai, AK. 7 pp.

Peterson, R.O., and J.D. Wollington. 1979c. Wolf-moose investigations on the Kenai Peninsula. Quarterly Report 12. Unpublished. Report for U.S. Fish and Wildlife Service. Kenai National Moose Range, Kenai, AK. 2 pp.

Pewe, T.L., and D.M. Hopkins. 1967. Mammal remains of pre-Wisconsin age in Alaska. Pages 266-270 in D.M. Hopkins, ed. The Bering land bridge. Stanford University Press, Stanford, CA.

Pitzman, M. 1970. Birth behavior and lamb survival in mountain sheep in Alaska. M.S. Thesis. University of Alaska, Fairbanks, AK. 116 pp.

Quinlan, S. 1978. Effects of controlled burning and succession of white spruce forests on breeding bird communities Kenai Peninsula, Alaska. Unpublished. Chugach National Forest, U.S. Forest Service, Seward, AK.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Pt. 1 of W.R. Meehan, ed. Influence of forest and rangeland management on anadromous fish habitat in western North America. Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, Portland, OR. USDA Forest Service Anadromous Fish Habitat Program. General Technical Report PNW-96. 54 pp.

Reynolds, D.G., and J.J. Beecham. 1980. Home range activities and reproduction of black bears in west-central Idaho. Pages 181-190 in C.J. Martinka and K.L. McArthur, eds. Bears--their biology and management. Papers of the 4th International Conference on Bear Research and Management, Kalispell, MT, February 1977. Bear Biology Association Conference Series No. 3.

Ringstad, N.R. 1974. Food competition between freshwater sculpins and juvenile coho salmon: an experimental and ecological study in a British Columbia coastal stream. Environment Canada. Fisheries and Marine Service Technical Report No. 457. 88 pp.

Robbins, C.S., et al. 1966. Birds of North America, a field guide to identification. Golden Press, New York, NY. 340 pp.

Roberts, H.A. 1963. Aspects of life history and food habits of rock and willow ptarmigan. M.S. Thesis. University of Alaska, College, AK. 108 pp.

Roos, J.F. 1960. Predation of young coho salmon on young sockeye salmon fry at Chignik Alaska. Transactions of the American Fisheries Society. 89(4):377-379.

Ruth, R.H., and A.S. Harris. 1979. Management of western hemlock-Sitka spruce forests for timber production. Pacific Northwest Forest and Range Experiment Station, U.S. Forest Service, Portland, OR. General Technical Report PNW-88. 197 pp.

Rutherford, W.H. 1952. Effects of a summer flash flood upon a beaver population. Journal of Mammalogy. 34(2):261-262.

Ruttner, F. 1971. Fundamentals of limnology. 3rd ed. University of Toronto Press. 295 pp.

Sanders, H. 1973. Resources inventory of the southcentral region. Joint Federal-State Land Use Planning Commission, Anchorage, AK. 310 pp.

Schmidt, A.E., and F.S. Robards. 1975. Inventory and cataloging of the sport fish and sport fish waters in southeast Alaska. Federal Aid in Fish Restoration. Vol. 16. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-9-7. Annual Report. 111 pp.

Schoen, J.W. 1979. Winter habitat use by mountain goats. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol 2. Project W-17-11. 52 pp.

Schoen, J.W., M.D. Kirchoff, and O.C. Wallmo. 1980. Winter habitat use by mountain goats. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 3. Project W-21-1. 13 pp.

Schwartz, C.C., and A.W. Franzmann. 1980. Black bear predation on moose. Div. of Game, Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 1. Project W-17-11 and W-21-1. 82 pp.

Scott, R.F., E.F. Chatelain, and W.A. Elkins. 1950. The status of Dall sheep and caribou in Alaska. Transactions of the North American Wildlife Conference. 15:612-626.

Scott, T.G., and H. Wasser. 1980. Checklist of North American plants for wildlife biologists. The Wildlife Society, Washington, DC. 58 pp.

Scott, W., and E. Crossman. 1973. The freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa, Ontario, Canada. Bulletin 184. 966 pp.

Slough, B.G. 1978. Beaver food cache structure and utilization. Journal of Wildlife Management. 42(3):644-646.

Sowls, A.L., S.A. Hatch, and C.J. Lensink. 1978. Catalogue of Alaska seabird colonies. U.S. Fish and Wildlife Service, Anchorage, AK. 1 vol.

Spencer, D.L., and E.F. Chatelain. 1953. Progress in the management of the moose of southcentral Alaska. Transactions of the North American Wildlife Conference. 18:539-552.

Spencer, D.L., and J.B. Hakala. 1964. Moose and fire on the Kenai. Pages 10-33 in Proceedings of the Tall Timbers Fire Ecology Conference, 3rd, Tallahassee, Florida, April 9-10. Tall Timbers Research Station and Florida State University.

Spraker, T.H. 1982. Sheep survey-inventory progress report. Unpublished. 3 pp.

Still, P.J. 1976. Index of surface water quality records to September 30, 1973, southcentral Alaska. U.S. Geological Survey, Anchorage, AK. Open-file report (Basic Data). 37 pp.

_____. 1980. Index of streamflow and water quality records to September 30, 1978, southcentral Alaska. U.S. Geological Survey, Anchorage, AK. Open-file Report 80-6000. 54 pp.

Telfer, E.S. 1970. Winter habitat selection by moose and white-tailed deer. Journal of Wildlife Management. 34(3):553-559.

Terres, J.K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf, New York, NY. 1109 pp.

U.S. Army, Corps of Engineers. 1978. Kenai River review. Anchorage, AK. 334 pp.

U.S. Environmental Protection Agency. 1977. Quality criteria for water, July 1976. Washington, DC. 1 vol.

U.S. Fish and Wildlife Service. 1961. Ptarmigan and Grant Lakes and Falls Creek, Kenai Peninsula. Juneau, AK. 25 pp.

U.S. Forest Service. No date. Birds of the Chugach National Forest, Seward ranger district. Unpublished. 4 pp.

U.S. Geological Survey. 1981. Surface water quality records, south-central Alaska, 1949-1974. Unpublished computer printout.

Usinger, B.G. 1956. Aquatic insects of California. University of California Press, Berkeley, CA. 508 pp.

Viereck, L.A., and E.L. Little. 1972. Alaska trees and shrubs. U.S. Forest Service, Washington, DC. Agriculture Handbook 410. 265 pp.

Viereck, L.A., C.T. Dyrness, and A.R. Batten. 1982. Revision of preliminary classification system for vegetation of Alaska. Unpublished. 72 pp.

Watsjold, D.A. 1976. Inventory and cataloging. Pages 63-86 in Federal Aid in Fish Restoration. Vol. 17. Sport Fish Div., Alaska Dept. of Fish and Game, Juneau, AK. Project F-9-8. Annual Report.

Weeden, R.B. 1963. Management of ptarmigan in North America. Journal of Wildlife Management. 27(4):673-683.

_____. 1965. Grouse and ptarmigan in Alaska, their ecology and management. Alaska Dept. of Fish and Game, Juneau, AK. Federal Aid in Wildlife Restoration. Vol. 5. Project W-6-R-5. 110 pp.

Wilson, W.J., et al. 1980. An assessment of environmental effects of construction and operation of the proposed Terror Lake hydroelectric facility, Kodiak, Alaska; raptor studies, intragravel water temperature studies. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK. Report for Kodiak Electric Association. 57 pp.

_____. 1980. Environmental studies of the proposed Terror Lake hydroelectric project, Kodiak Island, Alaska. Brown bear studies/mountain goat studies. Arctic Environmental Information and Data Center, University of Alaska, Anchorage, AK. Report for Kodiak Electric Association. 84 pp.

Wolff, J.O. 1976. Utilization of hardwood browse by moose on the Tanana River floodplain of interior Alaska. U.S. Forest Service, Portland, OR. Research Note PNW-267. 7 pp.

_____. 1978. Burning and browsing effects on willow growth in interior Alaska. Journal of Wildlife Management. 42(1):135-140.

Yeager, L.E., and W.H. Rutherford. 1957. An ecological basis for beaver management in the Rocky Mountain region. Transactions of the North American Wildlife Conference. 22:269-300.

Zippin, C. 1958. The removal method of population estimation. Journal of Wildlife Management. 22(1):82-90.

Zwickel, F.C., D.A. Boag, and J.H. Brigham. 1974. The autumn diet of spruce grouse: a regional comparison. The Condor. 76(2):212-213.

PERSONAL COMMUNICATIONS

The following individuals have been interviewed by AEIDC during this study in order to obtain unpublished information on the Grant Lake Hydroelectric Project area. Not all of these individuals have been cited in the text.

Altland, B. Telephone conversation, October 1, 1982. Alaska Dept. of Fish and Game, Soldotna, AK.

Arminski, T. Telephone conversation, December 9, 1981. Habitat Div., Alaska Dept. of Fish and Game, Anchorage, AK.

Babcock, B. Interview, March 3, 1982. Instructor, Anchorage Community College, Anchorage, AK.

Bentz, R. Telephone conversation, December 7, 1981. Sport Fish Div., Alaska Dept. of Fish and Game, Palmer, AK.

Burger, C. Interview and telephone conversations, various dates (1981 and 1982). U.S. Fish and Wildlife Service, Anchorage, AK.

Browning, R. Interview, October 13, 1981. U.S. Forest Service, Seward, AK.

Candit, K. Interview, October 13, 1981. Trapper, resident, Moose Pass, AK.

Engle, L. Telephone conversation, December 7, 1981. Sport Fish Div., Alaska Dept. of Fish and Game, Palmer, AK.

Estes, E. Interviews, 1981 and 1982. Self-employed resident, Moose Pass, AK.

Flagg, L. Interview and telephone conversations, various dates (1981 and 1982). Fisheries Rehabilitation Enhancement and Development Div., Alaska Dept. of Fish and Game, Soldotna, AK.

Hammerstrom, S. Telephone conversations, various dates (1981 and 1982). Sports Fish Div., Alaska Dept. of Fish and Game, Soldotna, AK.

Heard, W. Telephone conversation, December 12, 1981. Auke Bay Laboratory, U.S. National Marine Fisheries Service, Auke Bay, AK.

Judkins, C. Interviews, 1981 and 1982. Owner, Crown Point Lodge, Moose Pass, AK.

Koenigs, J. Telephone conversations, various dates (1981 and 1982). Fisheries Rehabilitation Enhancement and Development Div., Alaska Dept. of Fish and Game, Soldotna, AK.

Larsen, L. Telephone conversation. January 7, 1982. Sport Fish Div., Alaska Dept. of Fish and Game, Soldotna, AK.

McHenry, T. Interview, October 12, 1981. Sport Fish Div., Alaska Dept. of Fish and Game, Seward, AK.

Mills, M. Telephone conversation, January 6, 1982. Sport Fish Div., Alaska Dept. of Fish and Game, Anchorage, AK.

Nicholes, L. Interview, March 5, 1982. Alaska Dept. of Fish and Game, Cooper Landing, AK.

Pfleger, L. Interviews, 1981 and 1982. Self-employed, pilot, resident, Moose Pass, AK.

Quinlin, S. Interview, December 8, 1981. Game Div., Alaska Dept. of Fish and Game, Fairbanks, AK.

Richie, R. Telephone conversation, August, 1982. U.S. Fish and Wildlife Service, Kenai, AK.

Roseneau, D. 1982. Telephone conversation, March 26, 1982. LGL Limited, Fairbanks, AK.

Smith, D. Interview, August 16, 1982. Ebasco Services, Inc., Bellevue, WA.

Spencer, D. Interviews, 1981 and 1982. Arctic Environmental Information and Data Center, Univ. of Alaska, Anchorage, AK.

Spraker, T. Telephone conversation, April 15, 1982. Alaska Dept. of Fish and Game, Soldotna, AK.

Sullivan, J. Telephone conversation, July 16, 1982. Pathology Div., Alaska Dept. of Fish and Game.

Tarbox, K. Telephone conversation, October 20, 1981 and interview, December 11, 1981. Commercial Fish Div., Alaska Dept. of Fish and Game, Soldotna, AK.

Thompson, K. Telephone conversation, October 23, 1981. U.S. Forest Service, Anchorage, Ak.

Trudgen, D. Interview, 1981. Arctic Environmental Information and Data Center, Univ. of Alaska, Anchorage, AK.

Walker, B. Interview, October 13, 1981. U.S. Forest Service, Seward, AK.

Wangaard, D. Telephone conversation, October 20, 1981. U.S. Fish and Wildlife Service, Anchorage, AK.

Webster, K. Telephone conversation, October 1981. Commercial Fish Div., Alaska Dept. of Fish and Game, Anchorage, AK.

Wilson, W.J. Interview, October, 1981. Arctic Environmental Information and Data Center, Univ. of Alaska, Anchorage, AK.

APPENDIX A

Report on

Archeological and Historical Resources,

Grant Lake Hydroelectric Project,

Moose Pass, Alaska

by
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August 20, 1982

Report on Archeological and Historical Resources, Grant Lake Hydroelectric Project, Moose Pass, Alaska

This report describes archeological research conducted for the Arctic Environmental Information and Data Center in conjunction with its environmental studies of the Grant Lake Hydroelectric Project area near Moose Pass, Kenai Peninsula, Alaska. The research was completed in two phases. The first, a literature search and examination of air photos, covered the general project area. The second, an archeological field survey, focused upon areas to be affected by the construction and operation of project alternative F, which consists of a small dam on Falls Creek and a pipeline which will divert water from the creek to Grant Lake, an underground lake tap between Grant Lake and a powerhouse on Upper Trail Lake, and associated access roads and transmission line corridors. The report summarizes the results of the literature search pertinent to alternative F, describes the methods and results of the archeological survey, and discusses probable project impacts upon the cultural resources identified.

Methodology

A literature search completed in January 1982 identified several sites of potential historical significance within the project area. A field survey, completed in June 1982, was planned both to examine these sites on the ground and to search for previously undocumented sites within the area to be affected by project construction. A subsequent examination of air photos of the project area provided no additional information.

The literature search focused upon archeological, ethnographic, and historical sources which deal with the Kenai Peninsula of Alaska, the general project area. Its purpose was to identify known cultural resources which might be affected by construction or operation of the Grant Lake project, to assess the area's potential for containing cultural resources which have not yet been identified, and to provide background data for assessing the significance of those resources. In addition, the Alaska Heritage Resources Survey Inventory (AHRS), as of 22 July 1981, and the National Register of Historic Places, up to 12 January 1982, were checked for listings of cultural resources located within the project area. The archeologist in the Supervisor's Office on the Chugach National Forest provided supplementary information from his files.

The field survey had two goals. First, it was to locate and examine all sites identified in the literature search which will be directly affected by project construction or operation. Second, it was to identify previously unknown or unrecorded sites in the project area. Prior to the field work a survey plan describing the methods to be employed was submitted for comment to the Forest Supervisor of the Chugach National Forest, the State Historic Preservation Officer, and the Director of the Alaska Regional Office of the National Park Service. The Forest Supervisor accepted the plan as it was. The State Historic Preservation Officer accepted the plan but suggested that a follow-up survey be conducted after actual construction sites and material sources had been identified on the ground. The National Park Service made no formal comment.

The field survey was undertaken in early June. Due to a late spring the understory was just beginning to leaf out and ground visibility was extremely good for a forest environment. The survey began with a brief aerial reconnaissance of the project area in a small airplane. In particular, we flew over the east shore of Upper Trail Lake, circled over lower Grant Lake, and followed the general route of the diversion pipeline from Grant Lake to Falls Creek. Due to the mountainous terrain, we had to maintain a relatively high altitude and the forest canopy obscured much of the ground. The flight did, however, help us to get our bearings. Because none of the construction sites or routes had yet been marked on the ground, foot survey was confined to proposed construction locations which were easily identifiable due to their proximity to natural or man-made landmarks. These locations were: 1) an area south of Vagt Lake Trail which will be traversed by an access road; 2) the proposed site of the Falls Creek diversion dam in Section 17, T. 4 N., R. 1 E., Seward Meridian; 3) the proposed site of the diversion pipeline outlet at the south end of Grant Lake and the Solars Sawmill site at the outlet of the lake; 4) the proposed site of the powerhouse, substation, and tailrace in the NW¼SW¼ Section 6, T. 4 N., R. 1 E., Seward Meridian, and part of what we believed to be the old trail between Solars Sawmill and this cove; 5) the east end of the proposed bridge site at the narrows between Upper and Lower Trail lakes; 6) the east shore of Upper Trail Lake from the proposed bridge site to the powerhouse site in the NW¼SW¼ Section 6, T. 4 N., R. 1 E., Seward Meridian; and 7) the island and adjacent shore between the upper and lower portions of Grant Lake. We did not examine the east shore of Lower Trail Lake as proposed in the survey plan because construction of an access road in this area is no longer being considered.

In general, the survey consisted of an examination on foot of the ground's surface and any existing exposures such as uprooted trees, road cuts, and erosion cuts. A limited number of small test pits were dug in areas without natural exposures which appeared to be relatively high in archeological potential; all tests were backfilled. No artifacts were collected in the course of the survey. Survey methods for specific project segments are described below.

1) Area between Vagt Lake Trail and an existing access road in Section 13, T. 4 N., R. 1 W., Seward Meridian: A pipeline access road will pass through this area. We covered the area, from the Alaska Railroad track to the point where the 500-foot contour crosses the trail, in a series of 12 north-south transects. The first transect ran parallel to and approximately 15 m east of the railroad track. The second transect ran roughly parallel to and approximately 10 m east of the first. The remaining transects were spaced at intervals of approximately 30 to 35 m. The area is forested but fairly clear of underbrush except for a stand of low willows near the west end of the trail. We also walked along the Vagt Lake Trail from its beginning to a point just beyond its right-angle turn in Section 18, T. 4 N., R. 1 E., Seward Meridian. The proposed route approaches the portion of the trail which lies between the 500-foot contour and the bend.

2) North bank of Falls Creek between the Alaska Railroad track and the proposed site of a diversion dam in Section 17,

T. 4 N., R. 1 E., Seward Meridian: The area north of the creek between the railroad track and approximately the 530-foot contour, where an existing access road comes down to a placer claim on the creek, is relatively level with open forest. We covered a swath 20 to 25 m wide along this portion of the creek. Crossing the access road, we continued along the creek bank for a short distance until its increasing steepness forced us to climb back up to the road. The existing access road runs parallel to but well above the creek bed nearly to the point where the 600-foot contour crosses the creek. Here the road veers north around a small knoll; we continued east through heavy brush, staying as close to the bank as possible. We crossed the access road again at a point where the creek forces its way past a resistant rock promontory. The creek elevation here is approximately 895 feet. We continued east through open, old-growth forest along a trail brushed for the north boundary of the Marathon 1 placer claim, parallel to the creek but well above it. Beyond Marathon 1, we proceeded parallel to the creek through heavy brush along the flagged northern boundaries of the Marathon 2 and 3 claims. The farthest point reached upstream was slightly beyond the intersection of the NE corner of the Marathon 3 with the NW corner of the Four Jokers 1 placer claims, where the existing access road again approaches the creek. We believed this to be in the vicinity of the proposed dam site. We returned to the Alaska Railroad track via the existing access road.

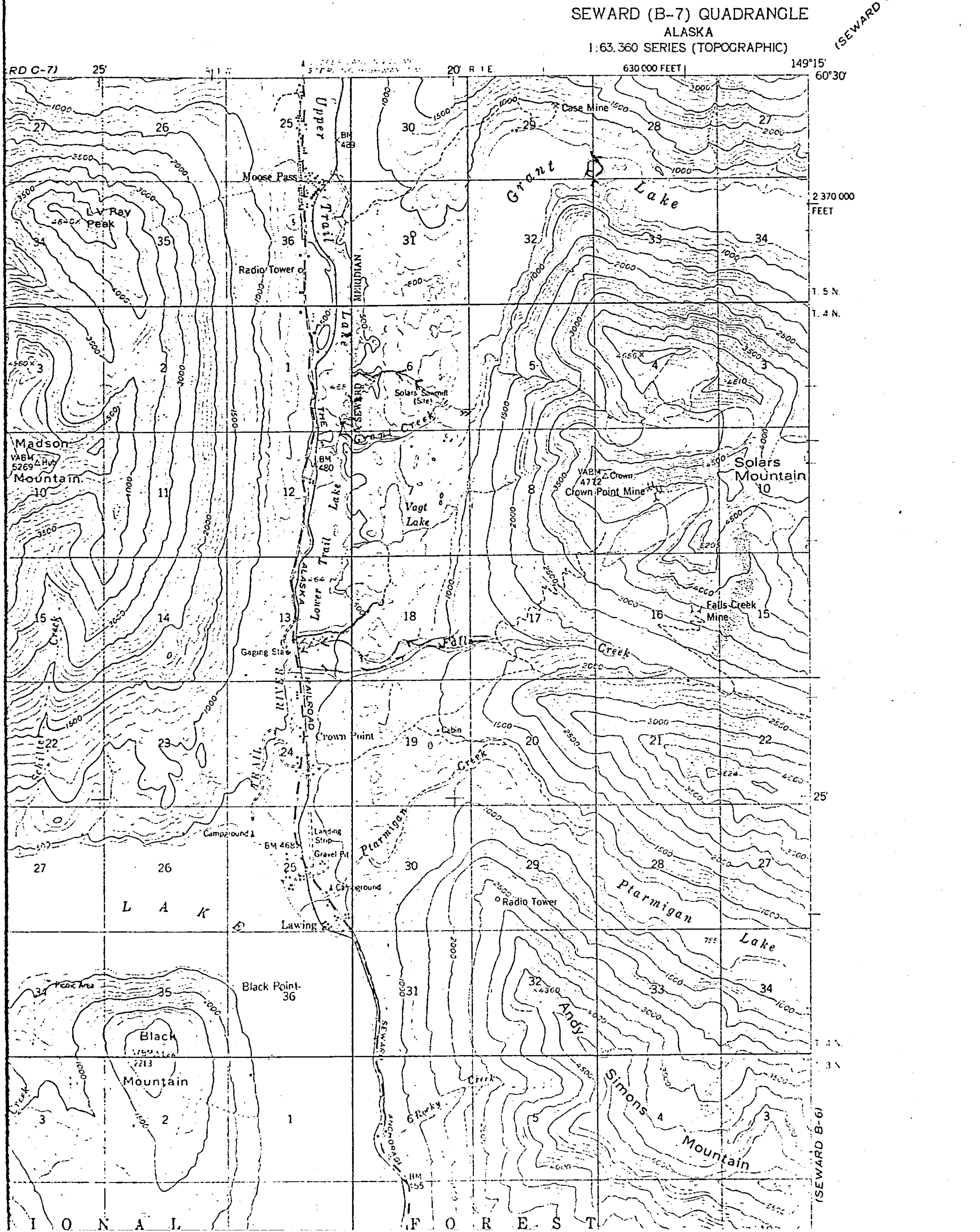
3) Proposed pipeline outlet, south end of Grant Lake: The archeologist walked five transects between a grove of alders on the east and a patch of beaver-felled birch and the forest on

the west, zigzagging upslope. A broad band of slope wash on the east was also examined; it appears to be fairly recent for it lies in a thin layer atop the thick grasses which cover the area. The shaley beach between the alder grove and the birch stand was also examined.

4) Solars Sawmill overland to the proposed powerhouse site in Section 6, T. 4 N., R. 1 E., Seward Meridian: We examined the sawmill site, then set out along a trail which we believed to be that leading to Upper Trail Lake shown on the 1953 USGS map. The trail, however, had been quite recently brushed in places, marked with flagging tape, and turned decidedly north. We took a fainter western branch but lost it on the edge of a muskeg and simply continued on to the powerhouse site. We walked completely around the cove on which the powerhouse site is located, both on the beach and inland as far as the steep hill which rises to the east of the site. The higher ground here is covered with open growth of scrub spruce while the lower areas are marshy. The upper part of the small stream which flows into the bay here is lined with alders.

5) The shoreline of Upper Trail Lake from the powerhouse site to the east end of the proposed bridge site at the mouth of Grant Creek: This is the proposed route of an access road. The archeologist walked south along the shore of Upper Trail Lake from the proposed powerhouse site, staying generally on the first terrace above the lake. The shore is covered with open forest except for an area of thick brush and scrub spruce near the narrows. The small, elongate island which splits the mouth of Grant Creek was also examined. This is the east end of a proposed

Areas covered in survey.



bridge site. The archeologist walked around the knoll on the north side of Grant Creek before returning along the same route.

6) Island between upper and lower Grant Lake and adjacent points of land: The lake is very shallow here and may be dredged to increase water flow. We walked completely around the island and along the shore of both adjacent points of land where dredging equipment might be based. The island is steep and rocky and mountain hemlock obscures the ground in places. There were, however, a number of natural exposures among the moss and reindeer lichens. The adjacent point of land to the north, covered with open forest, offered a more extensive area of relatively level ground backed by steep rock outcrops. The extreme south point was steeper with sparser vegetation.

The aerial photos provided to the archeologist were taken at a relatively high altitude due to the mountainous terrain in this region. They yielded no additional information on the distribution of cultural resources within the project area.

Results

The prehistoric and early historic periods are poorly documented in the project area. No sites relating to these periods were identified in the literature search, though it is quite possible that sites of this age do exist within the area. Written references to the area deal primarily with the development of gold mining and the Alaska Railroad in the period after 1900. All of the historic sites identified in the project area post-date 1900 and many relate to the railroad or mining industry.

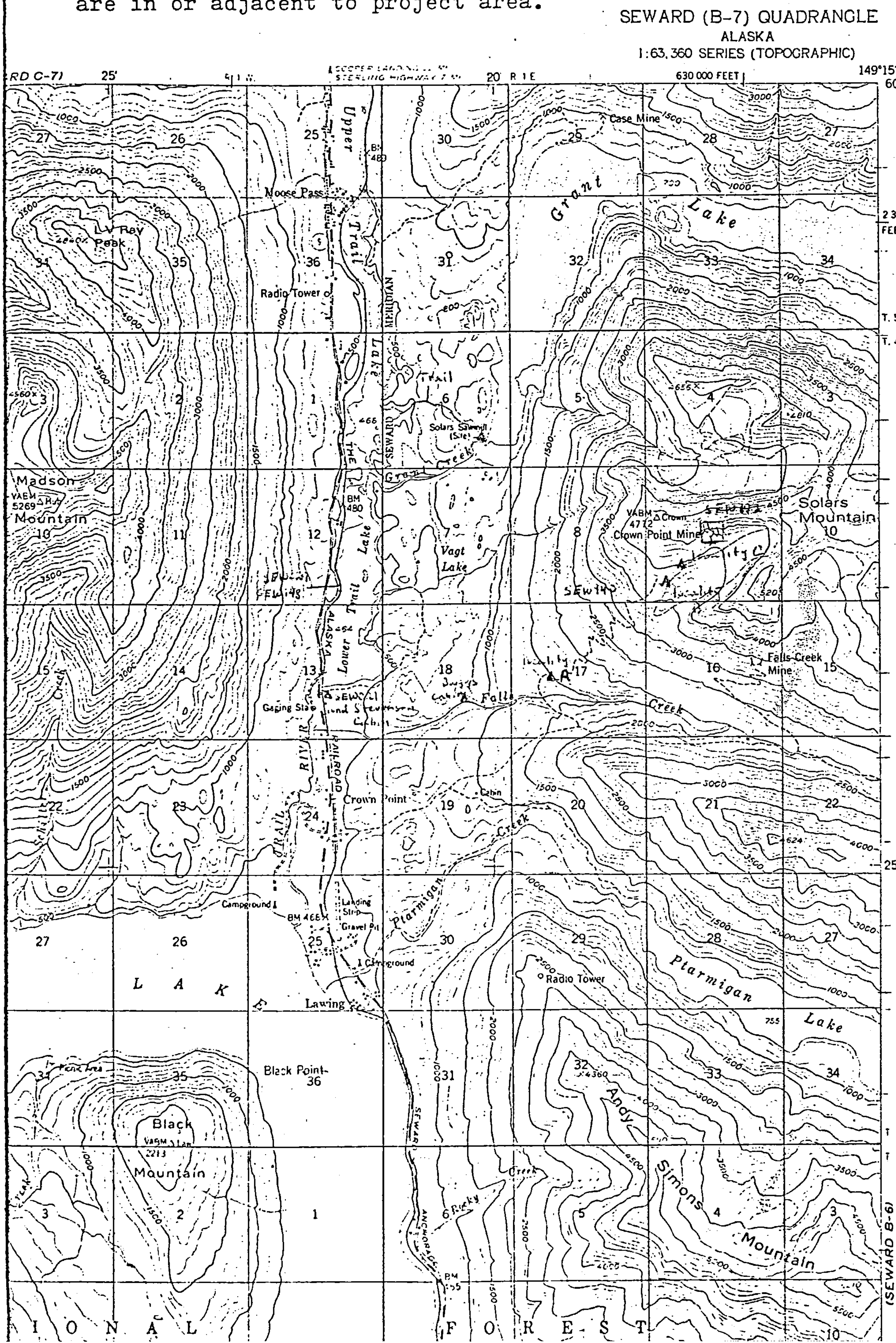
Table 1. Cultural resources identified in the literature search.

AHRS #	Sites within project area
SEW021	Crown Point/Trail Creek Station
SEW029	Alaska Northern Railway
SEW148	Iditarod Trail (on National Register of Historic Places)
none	Solars Sawmill
none	Stevenson Cabin
none	Trail between Solars Sawmill and Upper Trail Lake
	Adjacent to project area on Falls Creek
none	Baggs Cabin
none	Crown Point Mine structures, localities A, B, and C
SEW140	Crown Point Mountain Trail
SEW192	Crown Point Mine

Results of the field survey, like the description of survey methods, are organized by specific project segment.

1) Area between Vagt Lake Trail and an existing access road: This area is adjacent to the Alaska Northern Railway (SEW029) and the Iditarod Trail (SEW148), both of which roughly coincide with the present route of the Alaska Railroad track. The literature search identified two other sites in this area, Crown Point/Trail Creek Station (SEW021) and the Stevenson Cabin. These may be different names for a single site. The Crown Point Mine, which lies above Falls Creek, was known at the turn of the century as the Stephenson or Stevenson Bros. property. In 1910 this mining property was deeded to the Kenai-Alaska Gold Co., which in 1915 had a large log house with an office and warehouse at Crown Point

Locations of sites identified in literature search which are in or adjacent to project area.



or Trail Creek Station, a stop on the Alaska Northern Railway (Martin et al. 1915:157-159; Barry 1973:145). The Stevenson Cabin, shown at approximately this location on a map compiled by D. H. Sleem in 1910 (Mattson, personal communication), may have been associated with the earlier owners of the mining claim and simply ceded to the Kenai-Alaska Gold Co. when it took over the mine. The archeological survey did not resolve this question. The single overgrown cabin foundation which we located in this vicinity, associated with historic-age debris and several pits, is not that of a "large log house." Other historic-age debris was found scattered through the forest along the first north-south transect through this survey area, but we located no other structures. Diffuse charcoal was noted in the existing road cut, but this may be due to past forest fires in the area. A small test pit dug atop the rocky knoll where the Vagt Lake Trail makes a right-angle turn yielded 21 cm of culturally sterile soil over bedrock.

2) North bank of Falls Creek to proposed diversion dam: The literature search identified one site, the Baggs Cabin, on lower Falls Creek. Although it lay on our route to the diversion dam site, we could not locate it. We did, however, find a sluice, a historic-age campsite, and the remains of the C. M. Brosius cabin further upstream as well as the NW and NE corner stakes for the Marathon 1, 2, and 3 placer claims, posted by Perry N., Perry S., and Thomas Buchanan of Seward in 1981, and the NW corner of the adjacent Four Jokers 1 placer claim. Slightly north of the latter, on the road leading up to the Crown Point Mine, are the remains of a log structure and some historic debris. Other sites

identified in the literature search, the Crown Point Mine (SEW192), Crown Point Mountain Trail (SEW140), and Crown Point Mine structures at localities A, B, and C, lie above the area of direct project impact and were not visited.

3) Pipeline outlet, south end of Grant Lake: This appears to be an old slide area. A shovel test pit dug through the sod approximately 10 m inland from the beach in line with the standing survey marker revealed 24 cm of very wet, fine-grained, red-brown soil above gravel or stones. No cultural material was found.

4) Solars Sawmill overland to proposed powerhouse site: The literature search identified two sites in this area, Solars Sawmill and a trail between the mill and Upper Trail Lake. We found the sawmill site to be as described by Yarborough, who visited it in October 1981 (Yarborough 1981). We believe we located at least part of the trail between the mill and Upper Trail Lake which is shown on the 1953 USGS map. Although it had been recently brushed in places, it was flanked by old cut stumps and some older wooden treads still bridged short wet sections. As noted above, we did not find a branch of the trail that led to the proposed powerhouse site on Upper Trail Lake as indicated on the USGS map. A crew of biologists reported a well-constructed trail, with historic debris, leading east out of the next large cove to the north, but they lost it at the edge of a muskeg. The old Portage Trail which leads from the railroad bridge at Moose Pass through a pass in Section 31, T. 5 N., R. 1 E., Seward Meridian (Plafker 1955:plate 2), is also reported by the biological crew to be well corduroyed and easy to follow. Both areas are outside the present project area and were not

included in the archeological survey. No cultural material, other than a recent campfire, was found on the shores of the powerhouse cove. Two small test pits, one on the south promontory defining the cove and one on a small peninsula on the south side of the cove, revealed 10 cm of vegetation and culturally sterile soil above bedrock. The soil under several uprooted trees in the area yielded diffuse traces of charcoal, but there is also evidence of an old burn in the area.

5) Shoreline of Upper Trail Lake from the powerhouse site to the mouth of Grant Creek: No cultural material other than occasional modern debris washed up on the beach was found. One roughly rectangular hole, approximately 1 m by 2 m, was noted at the west end of the island which splits the mouth of Grant Creek. Its bottom was obscured by shallow water, but a shovel probe immediately struck gravel. It could be the natural result of fluctuating creek and lake levels. There was no associated cultural material.

6) Island between upper and lower Grant Lake and adjacent points of land: Aside from old signs of small-scale logging on the north adjacent point and a recent survey marker on the south adjacent point, we noted no evidence of human activity.

As noted, the State Historic Preservation Officer recommended a second phase of archeological survey and testing once locations of all construction sites, routes of access roads, transmission lines, and pipelines, and material sources are identified on the ground. The following areas appear to warrant further survey.

1) The access road which parallels part of Vagt Lake Trail. The proposed road passes through an area of high archeological

potential and we did not locate the portion which will pass south of the existing access road.

2) The access road between Grant Lake and the proposed powerhouse site.

3) The pipeline route between the diversion dam and its intersection with the access road which parallels Vagt Lake Trail. The remainder of the pipeline route passes over what appears to be a slide area. While it may warrant a walk-over and examination of any natural exposures, any cultural material is likely quite deeply buried.

4) The access road between the powerhouse and the highway, especially the portion between the highway and the bridge across the Trail Lakes narrows, as the latter area was not examined in the present survey.

Cultural Resources Within the Project Area

The Alaska Northern Railway (SEW029) and Iditarod Trail (SEW148 and National Register of Historic Places) routes, the Solars Sawmill site, and the trail between the Sawmill and Upper Trail Lake will likely be directly affected by project construction. The Crown Point Mountain Trail (SEW140), Crown Point Mine (SEW192) and associated structures at localities A, B, and C, structural remains along the lower mine access road, the Brosius cabin, sluice, and camp identified along Falls Creek, and the Baggs Cabin site will at most be only indirectly affected by project construction and operation. Crown Point/Trail Creek Station and the Stevenson cabin will be affected only if the proposed access road in this area is moved to the north. It must be remembered, however, that not all construction locations have been identified on the ground and examined by an archeologist. The project area may also contain previously unrecorded cultural resources which could be directly or indirectly affected by project construction.

The Iditarod Trail and Alaska Northern Railway roughly coincide with the present route of the Alaska Railroad through the project area. The Iditarod Trail was blazed in 1908 by the Alaska Road Commission as a winter route between the port of Seward and the gold fields of Nome and the interior. Its importance dwindled with the decline in gold production in the interior and with the advent of airmail service in the 1920s (BLM 1981:19-31). It has recently been designated a national historic trail and is listed on the National Register of Historic Places. The first spike of the Alaska Central Railroad was driven in Seward in 1904 and by 1905 fifty miles of track had been constructed. The Alaska Central went into receivership in 1907, but in 1909 the Alaska Northern Railway was formed. It constructed an additional 21 miles of track before going bankrupt in 1911. The tracks were still used, however, by a gas car which regularly transported mining supplies from Seward to the wagon road at Moose Pass (Barry 1973:114-116). When construction of the Alaska Railroad from Seward to Fairbanks commenced in 1915, this section of track was improved and the old right-of-way is still used by the present-day railroad (Barry 1973:144-147). It is listed in the AHRS Inventory.

The Solars Sawmill site consists of a collapsed wooden structure; a roofless standing cabin of milled lumber with attached woodshed, both in very poor condition; an outhouse, tipped over; two small piles of rusted cans; two pairs of mining-car wheels; and assorted historic debris. Three large pulleys mounted on heavy timbers, wire cable, and two frameworks of timbers leading down into Grant Creek constitute the remains of the mill itself. The available literature provides little information on the establishment or operation of this site. A report compiled by the USDA-Forest Service in 1924 mentions that an area at the head of Grant Lake had been cut over for a sawmill at the foot of the lake, but maps which accompany the report do not show the mill site (Holbrook 1924; R. Quillum, USDA-FS Seward, personal comm.). A local resident very knowledgeable about the history of the area provided more information. He believes that the mill first operated around 1927 or 1930. It was never a commercially viable mill, but was run from time to time by Al Solars, its owner, until his death around 1941. The processed lumber was hauled out over a trail by dog team, a little being sold to the railroad and some being sold locally, but the mill never produced much. This account fits the published information. When Plafker visited the area for the USGS in 1952, the mill was abandoned and the lumber trail had fallen into disuse. When M. Yarborough visited this site in 1981, he found a date of 13 January 1958 on a magazine used as insulation in the standing cabin, but it is quite likely that the cabin was periodically occupied and modified after the mill itself was abandoned.

The Crown Point Mountain Trail, Crown Point Mine, and associated structures at localities A, B, and C all lie beyond the area of direct project impact. The Black Butte vein was discovered here in 1906 by J. W. and C. E. Stephenson or Stevenson; it was one of the earliest major discoveries in the Falls Creek drainage. In 1910 the property was deeded to the Kenai-Alaska Gold Co. which, in 1911, constructed a road from the railroad to the mine and a stamp mill, assay office, and other buildings in the vicinity of locality A. In 1912 an 8200-foot aerial tram was completed between the mine and the mill. The mine was closed down in 1917 (Martin et al. 1915:157-159; Johnson 1912:148, 150, 1919:175). Its present name relates to the period 1935-1940 when it was operated by the Crown Point Mining Co., C. Brosius and Associates, of Seward (Stewart 1937:48, 1939:39, 1941:74). It was opened again in the late 1950s. The mine is presently connected to the highway by a rough, fairly steep access road. As mentioned above, our survey extended only as far as the proposed diversion dam site and therefore did not include the Crown Point mining properties. The trail and mine are included in the AHRS Inventory.

The remains of a structure of unpeeled logs located along the Crown Point Mine access road also appear to lie outside the area of direct project impact. It, too, may have been associated with the mine. It is in very poor condition; only the SW corner still stands a few tiers high. A thick growth of grass covers plank flooring and rusted cans inside the structure. Corrugated metal roofing lying around the outside of the structure is also nearly obscured by the grass. A piece of machinery, probably a boiler, lies on the opposite side of the road.

The Brosius cabin and the sluice and camp identified along Falls Creek lie west of the proposed route of the diversion pipeline and pipeline access road. All appear to be associated with mining in the area. A recent branch of the mine's access road cuts through a trash deposit between the cabin and camp. Only two walls of the roofless cabin of unpeeled logs still stand. It may have caught fire, as one of the roof beams is charred. The cabin contains a great deal of trash, including old shoes, kitchen utensils, and bed frames. A faded sign which reads "C. M. Brosius Seward" was found in the cabin near the doorway. As mentioned above, C. Brosius and Associates operated the Crown Point Mine in 1935-1940. A shed, now collapsed, adjoined the cabin's north wall and a small structure is dug into the bluff immediately south of the cabin. The latter has been undercut by the recent road and erosion, and its precarious position precluded a closer examination. The camp site west of the cabin appears to be of approximately the same age. A sluice fashioned of pipe and corrugated metal roofing lies in the bed of a small stream a short distance west of the camp and may have been contemporaneous with the camp site.

The Baggs Cabin site, well to the west of the proposed construction, was not located. It is shown on a map compiled by D. H. Sleem in 1910 (Mattson, personal communication) and may be associated with mining activity in the area.

Crown Point/Trail Creek Station and the Stevenson Cabin site lie north of the proposed route of an access road. As noted above, these may be distinct sites or different names for a single site. The Stevenson cabin is shown on a map dated 1910 (Mattson, personal communication) and may have been associated with the Stevenson brothers who discovered gold at what was later to become the Crown Point Mine. Trail Creek Station, in approximately the same location, was a stop at Mile 26 on the Alaska Northern Railway at a slightly later date. In 1915 the Kenai-Alaska Gold Co., which had taken over the Stevenson mining claims, had a large log house with an office and warehouse at this same milepost (Barry 1973: 145). The overgrown cabin foundation which we located here is small, measuring only about 4 m by 5 m. The poor state of preservation of the foundation logs suggests that the structure could indeed date to early in the twentieth century. It is associated with a scattering of rusted cans, metal bands, and other debris; a heap of large rusted cans or buckets; and two small square pits, one filled in, the other more recent in appearance. Two larger pits nearby, one round and one rectangular and filled with machinery, may also be associated with it. We found no remains of a "large log house." Crown Point/Trail Creek Station is listed in the AHRS Inventory.

Potential Project Impacts upon Known Cultural Resources

Direct impacts

Two proposed access roads will cross the routes of the Iditarod Trail (SEW148 and National Register of Historic Places) and the Alaska Northern Railway (SEW029). These routes are now occupied by the Alaska Railroad and are already crossed by a number of access roads.

The Solars Sawmill site may be directly affected. In one project alternative a bridge joining two access roads will occupy part of the site. In other project alternatives an access road will pass to the north of the site and thus not directly affect it. Such a road could, however, open the site to vandalism. The structures at the site are in poor condition and the winter snows could cause the last one to collapse within a few years. The remaining pulleys from the mill will probably withstand many more years of weathering, but could easily be pushed into the creek and lost. There are also a few artifacts at the site, such as a galvanized sink, mining-car wheels, and metal parts of the pulleys, which might be attractive to collectors.

The trail between the sawmill and Upper Trail Lake will be crossed or followed in places by an access road. As noted above, the west half of this trail is not well defined. No historic artifacts were found along the portion we were able to follow.

Indirect impacts

The Crown Point Mountain Trail (SEW140), Crown Point Mine (SEW192) and associated structures at localities A, B, and C, and the structural remains along the lower mine access road all lie north and east of the project area and will not be directly affected by project construction or operation. All are presently accessible from the highway by a mining road, but beyond approximately one-half mile a four-wheel-drive vehicle with a winch is needed. Construction of an access road to the proposed pipeline and diversion dam may improve access to these sites somewhat and may increase the risk of vandalism. This would most likely affect the structural remains on the lower mining road and locality A, the closest to the project area.

The Brosius cabin, sluice, camp, and Baggs Cabin site lie west of the project area. Construction of the diversion dam would dewater Falls Creek and thus slightly change the settings of sites located at the edge of the canyon above the creek, but is not expected to increase erosion or otherwise affect these sites.

Crown Point/Trail Creek Station (SEW021) and the Stevenson Cabin site lie north of a proposed access road near a USDA-Forest Service recreation trail and an existing access road. They are not expected to be affected by project construction or operation.

References Cited

Alaska Department of Natural Resources, Division of Parks
1981 Alaska Heritage Resources Survey Index, updated July 22, 1981. On file at Office of History and Archeology, Division of Parks, Anchorage.

Barry, Mary J.
1973 A History of Mining on the Kenai Peninsula. Alaska Northwest Publishing, Anchorage.

Iditarod National Historic Trail Project Office, BLM
1981 The Iditarod National Historic Trail, Seward to Nome Route. Vol. 1: A Comprehensive Management Plan. Bureau of Land Management, Anchorage District Office, Anchorage.

Johnson, B. L.
1912 Gold Deposits of the Seward-Sunrise Region, Kenai Peninsula. In: Mineral Resources of Alaska: Report on Progress of Investigations in 1911, by A. H. Brooks et al., pp. 131-173. USGS Bull. 520. Government Printing Office, Washington, D. C.

1919 Mining in Central and Northern Kenai Peninsula. In: Mineral Resources of Alaska: Report on Progress of Investigations in 1917, by G. C. Martin et al., pp. 175-176. USGS Bull. 692. Government Printing Office, Washington, D. C.

Martin, G. C., B. L. Johnson, and U. S. Grant
1915 Geology and Mineral Resources of Kenai Peninsula, Alaska. USGS Bull. 587. Government Printing Office, Washington, D. C.

Mattson, John
Personal communications. Archeologist, Supervisor's Office, Chugach National Forest, Anchorage.

Plafker, George
1955 Geologic Investigations of Proposed Power Sites at Cooper, Grant, Ptarmigan and Crescent Lakes, Alaska. USGS Bull. 1031-A. U.S. Government Printing Office, Washington, D. C.

Stewart, B. D.
1937 Report of the Commissioner of Mines to the Governor for the Biennium Ended December 31, 1936. Territory of Alaska, (Juneau?).

1939 Report of the Commissioner of Mines to the Governor for the Biennium Ended December 31, 1938. Terrritory of Alaska, (Juneau?).

Stewart, B. D. (cont.)
1941 Report of the Commissioner of Mines to the Governor for the Biennium Ended December 31, 1940. Territory of Alaska, (Juneau?).

Yarborough, Michael R.
1981 Archeological survey of proposed drilling sites, Grant Lake, Alaska. Cultural Resource Consultants, Anchorage.

Addendum:

Holbrook, Wellman
1924 Land Classification Report on the Kenai Peninsula Division of the Chugach National Forest, Alaska. On file at Seward District Office, Chugach National Forest, Seward, Alaska.

Appendix: Site Reports

Site name: Cabin foundation

Pertinent dates: approx. A.D. 1910

Location: SW$\frac{1}{4}$ NW$\frac{1}{4}$ SE$\frac{1}{4}$ Section 13, T. 4 N., R. 1 W., Seward Meridian

Description: The foundation lies in a level clearing now vegetated with grass and willows 5 m south of the beginning of the Chugach National Forest's Vagt Lake Trail, which parallels the south shore of Lower Trail Lake, and approximately 20 m east of the Alaska Railroad track. The closest source of water is Lower Trail Lake.

This roughly square foundation of decaying logs, covered with moss, grass, and willows, measures approximately 5 m NS by 4.4 m EW. Though the poor condition of the wood prevented an accurate count, it appears that only one or two tiers of logs remain in place in each wall. At least two grass-covered logs lie outside the foundation, parallel to the east wall from which they may have fallen.

Associated features include a dump of large rusted cans or buckets to the south and a small, square depression to the northeast. The latter measures approximately 1.05 m NS by 0.9 m EW. A shovel test 30 cm deep in its center revealed an organic layer, varying from 2 cm thick on the north to 18 cm thick on the south, underlain by cultural material and gray clayey soil mottled with sand and gravel. The cultural material consisted of a few fragments of rusted cans, a few small pieces of glass, and a carpal or tarsal bone of a large herbivore. This material was not collected. The test pit hit water at 25 cm below surface and was abandoned and backfilled at a depth of 30 cm below surface. The depression may represent an outhouse hole or trash pit which was later filled in. Other trash, including rusted metal bands, cans, a piece of pipe, a rubber overshoe, and half of a light blue glass insulator which bears the inscription BROOKFIE__, lies scattered around the foundation.

Other features which may be of more recent vintage are a square pit filled with water right at the south edge of the Vagt Lake Trail; a large rectangular hole, just inland from the float-plane dock, which contains a boiler, a metal rod, and a machine part; and a pair of railroad-car wheels and a large machine part immediately east and a recent round pit east and slightly south of the rectangular hole.

Significance: Crown Point/Trail Creek Station (SEW 021) and a structure known as the Stevenson cabin are both reported to have been located at approximately this location. The Stevenson cabin, shown on a map compiled by D. H. Sleem in 1910, may have been associated with the Stephenson or Stevenson brothers, who discovered gold at what was later to become the Crown Point Mine. Trail Creek Station, in approximately the same location, was a stop at Mile 26 on the Alaska Northern Railway at a slightly later date. In 1915 the Kenai-Alaska Gold Co., which had taken over the Stevenson mining claims in 1910, had a large log house with an office and warehouse at this same milepost (Martin et al. 1915: 157-159; Barry 1973:145). The poor state of preservation of the cabin foundation which we located here suggests that the structure could indeed date to early in the twentieth century. The foundation does not appear to be that of a "large log house," but we found no other structural remains in the area. If Crown Point/Trail Creek Station and the Stevenson cabin are in fact separate sites, the foundation discovered more likely represents the latter.

Danger of destruction: There is no danger of destruction other than that due to natural weathering.

References:

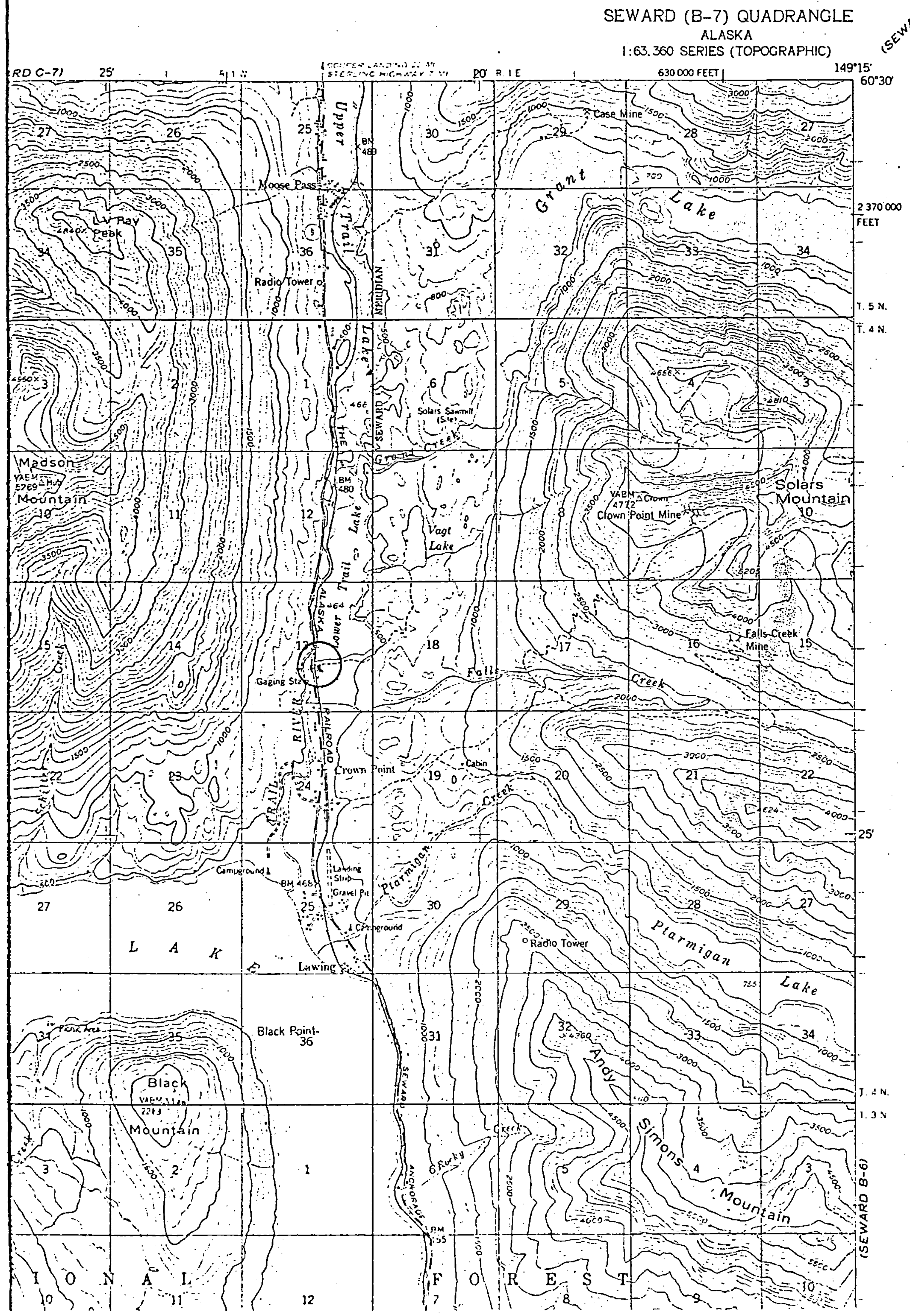
Barry, Mary J.
1973 A history of mining on the Kenai Peninsula. Alaska Northwest Publishing, Anchorage.

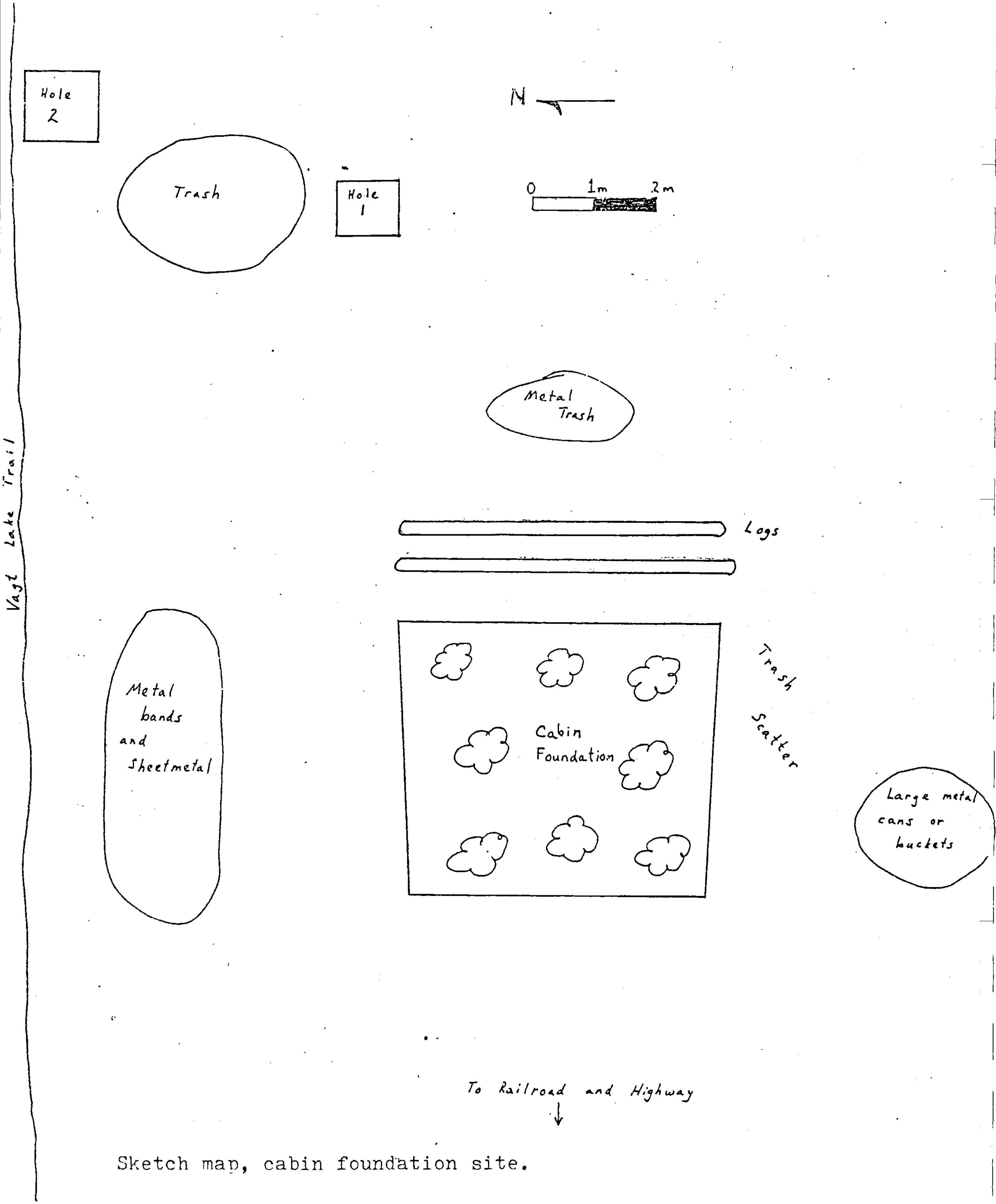
Martin, G. C., B. L. Johnson, and U. S. Grant
1915 Geology and mineral resources of Kenai Peninsula, Alaska. USGS Bull. 587. Government Printing Office, Washington, D. C.

Sleem, D. H.
1910 Map of Kenai mining district and Moose Pass regions, Kenai precinct, Alaska. Information from this map provided by Forest Archeologist, Chugach National Forest, Anchorage, Alaska.

Owner of property: Chugach National Forest
2221 E. Northern Lights Blvd., Suite 238
Anchorage, Alaska 99502

Location of cabin foundation.





Sketch map, cabin foundation site.

Cabin foundation. Southeast corner of cabin foundation with some of vegetation cleared away, looking west.

Cabin foundation. Heap of large cans or buckets south of cabin foundation, looking south.

Cabin foundation. Metal bands to north of cabin foundation, looking north.

Site name: Solars Sawmill

Pertinent dates: approx. A.D. 1924-1941

Location: NW¼ SE¼ SE¼ Section 6, T. 4 N., R. 1 E., Seward Meridian

Description: The sawmill is located on a peninsula on the north side of the rapids at the outlet of Grant Lake. The peninsula is steep, with several small, relatively level benches or terraces upon which the structural remains are found. The area around the site supports a mature spruce forest in which a few sawn stumps are visible and part of the site occupies a lichen-covered rock outcrop which overlooks the rapids.

The sawmill site consists of a collapsed wooden structure, a standing cabin with an attached woodshed, an outhouse, three large pulleys, two timber frameworks leading down into Grant Creek, and assorted historic debris. The site was visited in 1981 by M. Yarborough, who measured and briefly described the structures. In 1982 we recorded additional details of construction and obtained some local information on the history of the site.

The collapsed wooden structure is located on the lowest bench on the east side of the peninsula, just east of the rapids. It was built of milled lumber, but its form and size are indiscernible in its present condition. Its debris covers an area of approximately 7 m^2 (Yarborough 1981:2). Two pairs of mining-car wheels lie under some young spruce between this structure and the rock outcrop upon which the remains of the mill itself are located.

The standing cabin, constructed of milled lumber, is located in the forest on a small bench above and about 10 m west of the collapsed structure. It measures approximately 6 m NS by 4 m EW (Yarborough 1981:3). It is in very poor condition, as the roof and west wall have collapsed and the south and east walls lean outward at precarious angles. The gable roof consisted of tar paper sandwiched between two layers of vertical planks. The walls were insulated with newspaper and magazines sandwiched between a layer of horizontal planks on the inside and vertical planks on the outside. Yarborough (1981:3) found a date of 13 January 1958 on one of the magazines. Slats nailed vertically over chinks between the outside planks further reduced cold drafts. The cabin had two windows, a small one in the center of the west wall and one twice as wide in the center of the east wall. It also had two doors, one in the north wall which led into an attached shed and one in the south wall. A wooden door missing most of its panels lies just south of the cabin. Among the debris inside the cabin are a bed in the northwest corner with a large galvanized sink resting upon it, a set of shelves lying on the floor near the east windows, and fragments of window glass. The stove was probably located in the southwest corner. A collapsing shed, built of milled lumber and measuring about 2 m NS by 4 m EW, is attached to the north wall of the cabin. (Yarborough 1981:3). It had a shed-type roof which sloped down toward the north and is filled with scrap lumber. It apparently served as a woodshed. Trash scattered outside the cabin included a bucket, stove parts, and rusted cans. Two "Preferred Stock" coffee cans and a large "Schilling" black pepper can still bear identifiable labels.

A trail leads from the standing cabin west to an outhouse which has tumbled part way down a steep slope. Two small piles of rusted cans lie just north of the outhouse.

Three large pulleys mounted on heavy timbers lie on a rock outcrop overlooking the rapids, southeast of the outhouse and west of the collapsed structure. A framework of timbers leads down into Grant Creek on each side of the rock outcrop. The pulleys, frameworks, and associated wire cable constitute the remains of the mill itself.

The 1953 USGS map shows a trail between Upper Trail Lake and the mill site. Signs of logging and a few traces of wooden treads bridging short muddy stretches were visible along the portion of the trail we were able to follow, but we lost the trail in the vicinity of the divide between Upper Trail and Grant lakes.

Significance: A report compiled by the USDA-Forest Service in 1924 mentions that an area at the head of Grant Lake had been cut over for a sawmill at the foot of the lake, but maps which accompany the report do not show the mill site (Holbrook 1924; R. Quillum, USDA-FS Seward, personal communication). A local resident very knowledgeable about the history of the area provided more information. He believes that the mill first operated around 1927 or 1930. It was never a viable mill, but was run from time to time by Al Solars, its owner, until his death around 1941. The processed lumber was hauled out over a trail by dog team, a little being sold to the railroad and some being sold locally, but the mill never produced much. This account agrees with what little published information is available. When Plafker visited the area for the USGS in 1952, the mill was abandoned and the trail had fallen into disuse (Plafker 1955:2, 12). Given the date of January 1958 found on one of the magazines used as insulation in the standing cabin, it is quite possible that this cabin was periodically occupied and modified by hunters or trappers after the mill itself was abandoned.

Danger of destruction: The structures at the site are in poor condition and the winter snows could cause the last one to collapse within a few years. The site is presently protected from vandals by its difficult access, but if access were improved a few of the artifacts remaining at the site, such as the galvanized sink and mining-car wheels, might prove attractive to collectors.

References:

Holbrook, Wellman
1924 Land classification report on the Kenai Peninsula division of the Chugach National Forest, Alaska. On file at Seward District Office, Chugach National Forest, Seward, Alaska.

Plafker, George
1955 Geologic investigations of proposed power sites at Cooper, Grant, Ptarmigan and Crescent lakes, Alaska. USGS Bull. 1031-A. Washington, D. C.: U. S. Government Printing Office.

Yarborough, Michael
1981 Archeological survey of proposed drilling sites, Grant Lake, Alaska. Anchorage: Cultural Resource Consultants.

Owner of property: Chugach National Forest
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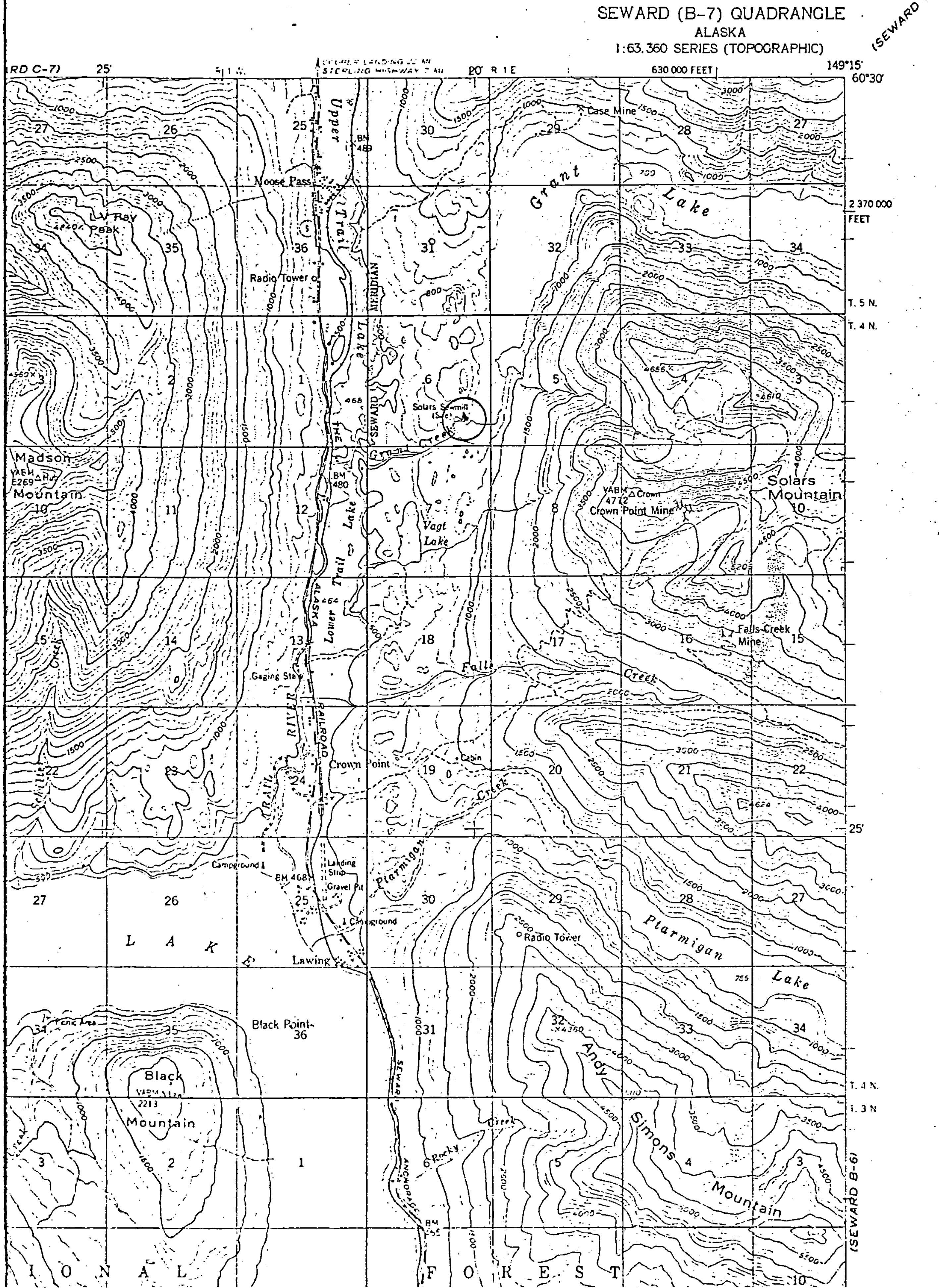
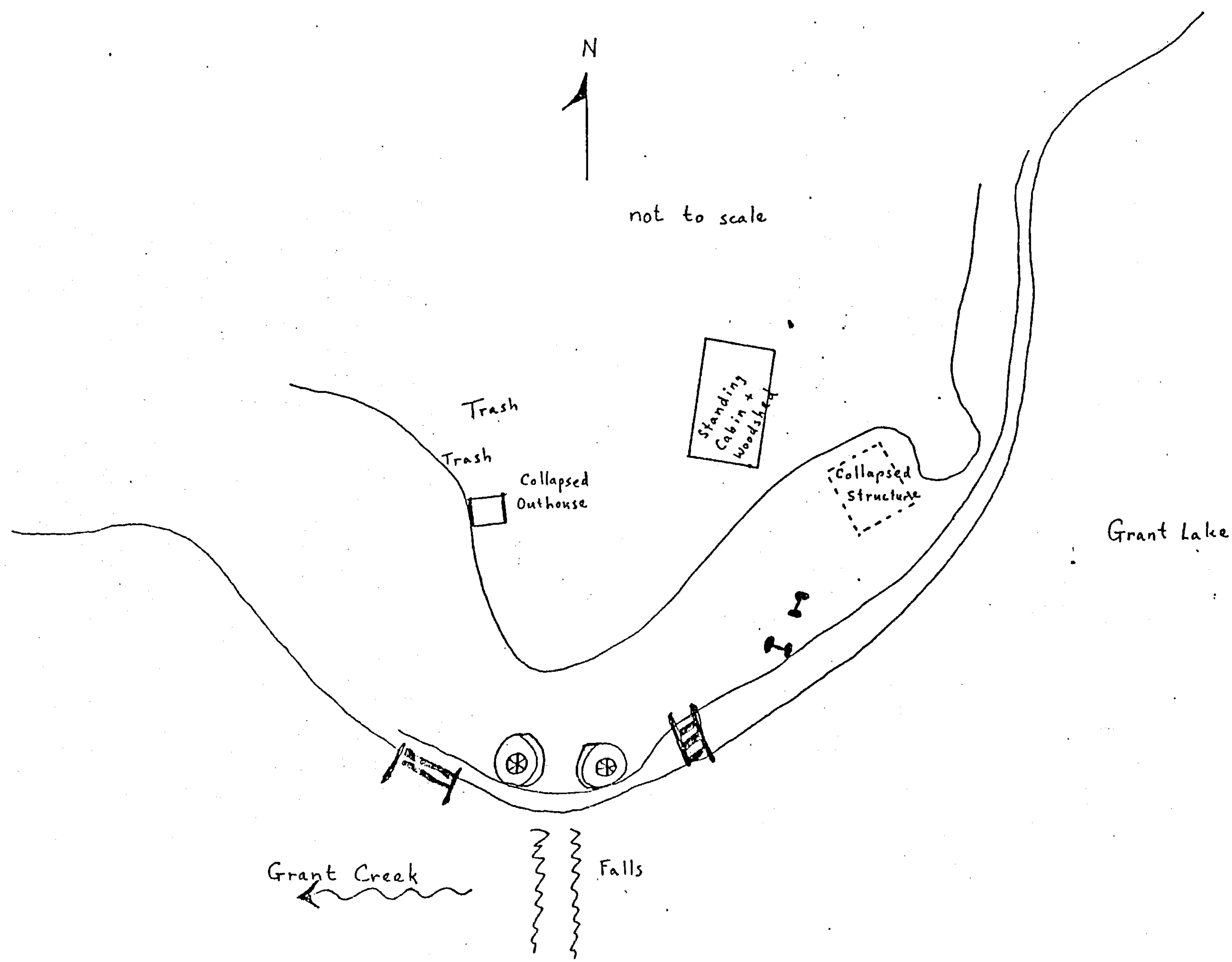
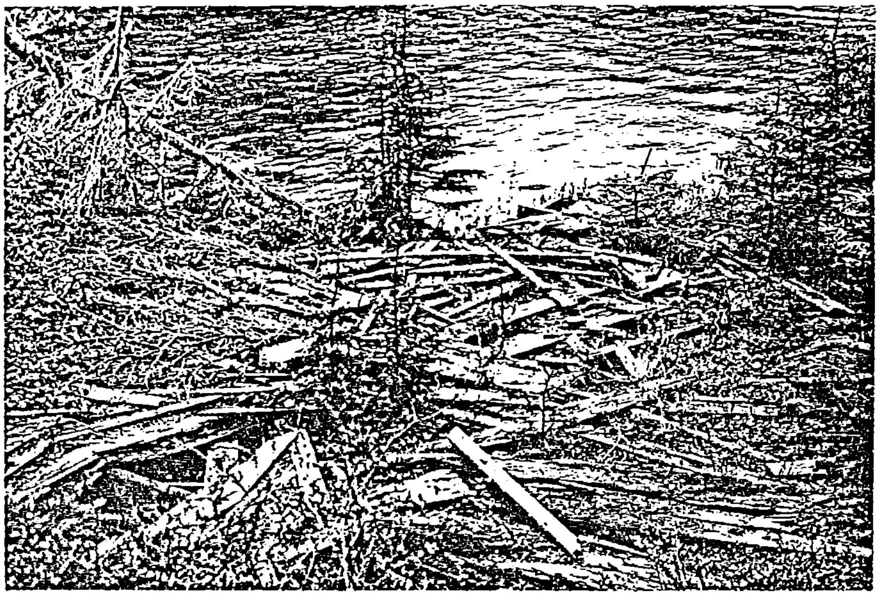
Anchorage, Alaska 99502

Location of Solars Sawmill.

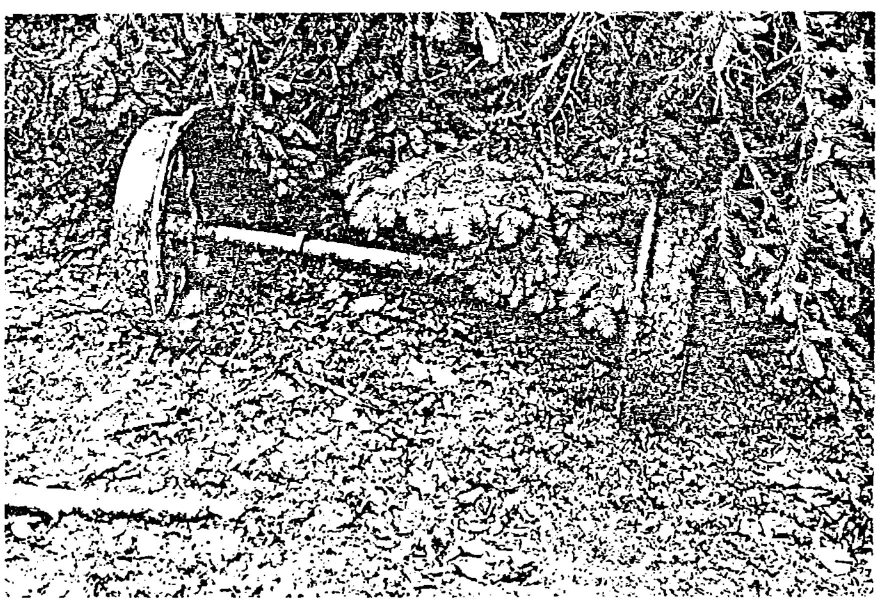




Sketch map, Solars sawmill site.



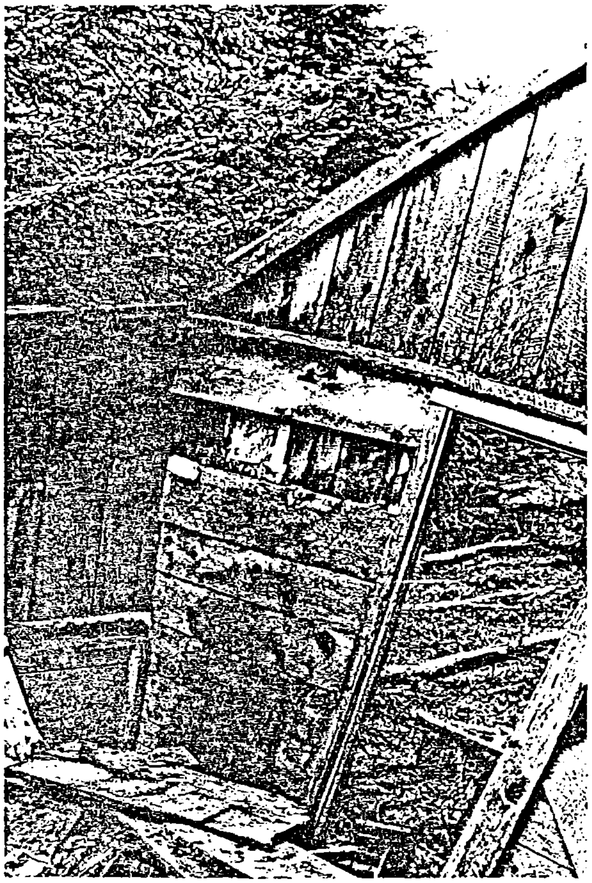
Solars sawmill. Collapsed structure, looking roughly south.



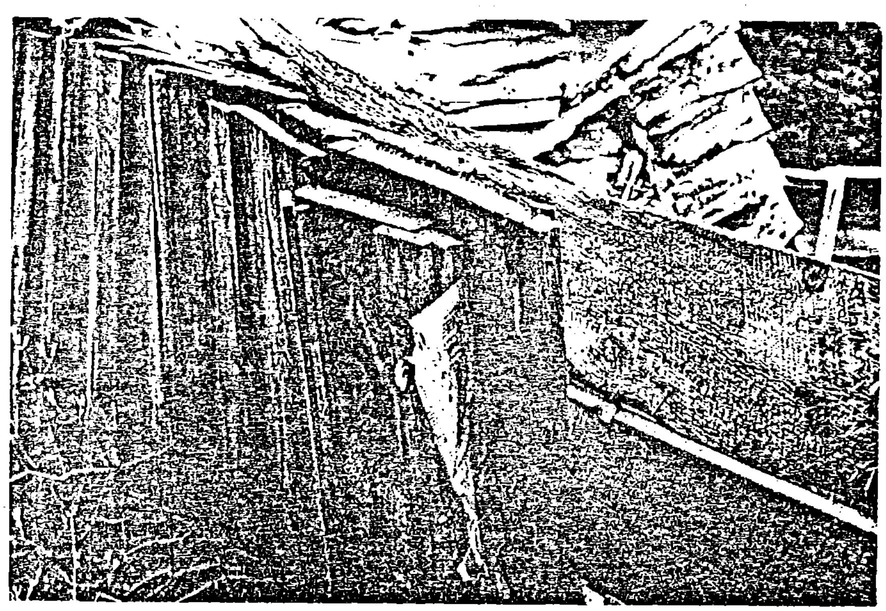
Solars sawmill. Mining-car wheels west of collapsed structure.

Solars sawmill. Collapsed roof of standing cabin, looking roughly north.

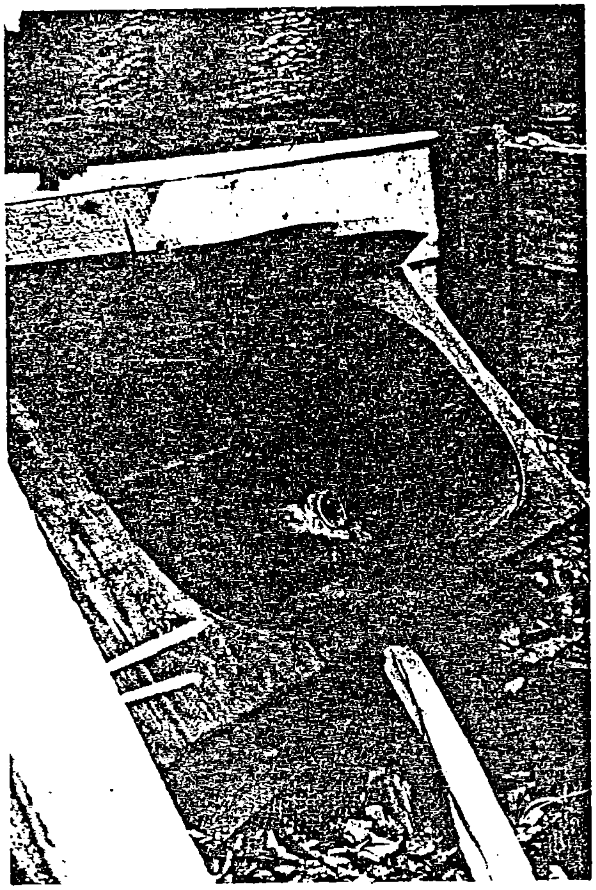
Solars sawmill. Outside view of south wall of standing cabin, looking roughly north. Door lies in foreground.



Solars sawmill. Inside view of south wall of standing cabin, looking southeast.

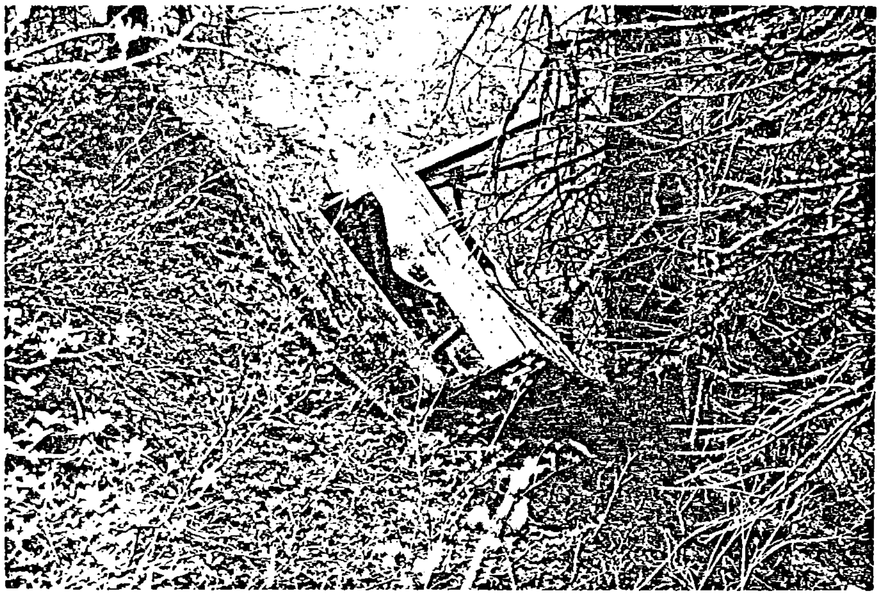


Solars sawmill. Standing cabin, detail of construction of west wall, looking roughly east.

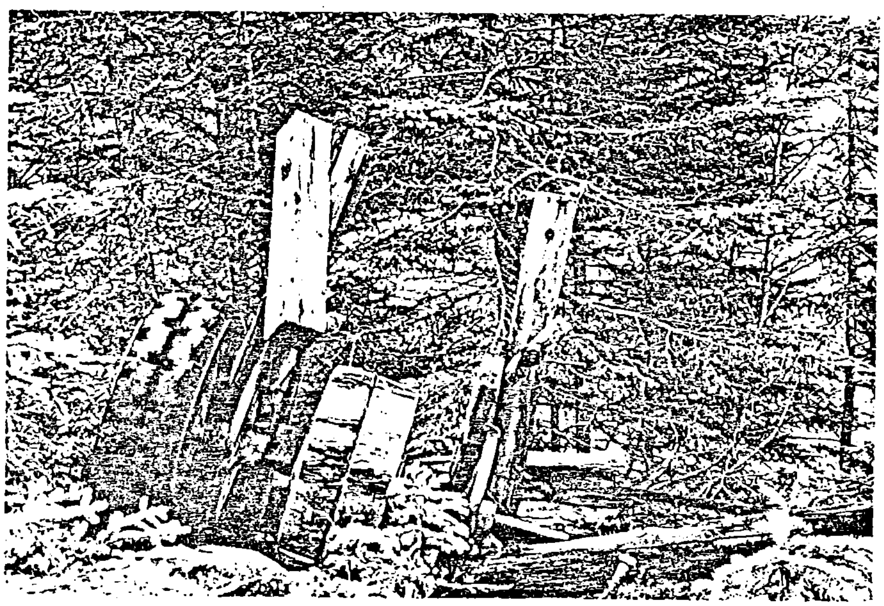


Solars sawmill. Galvanized sink in northwest corner of standing cabin.

Solars sawmill. Collapsing woodshed attached to north wall of standing cabin, looking roughly east.

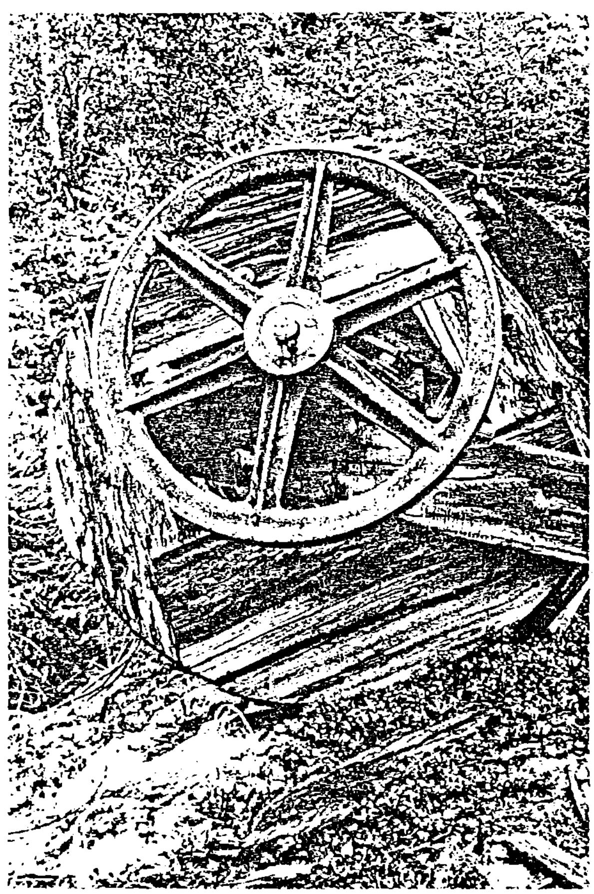


Solars sawmill. Outhouse, looking roughly south.

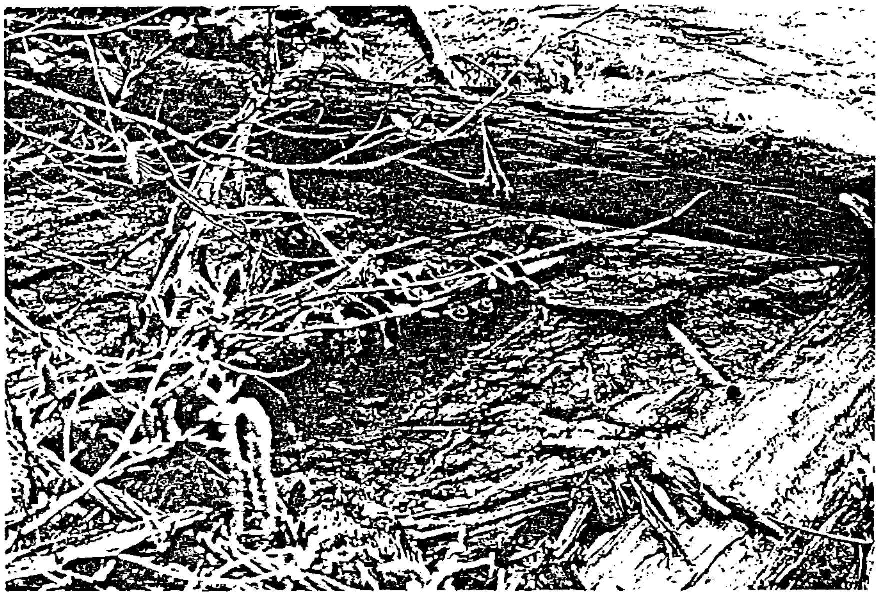


Solars sawmill. Large pulleys mounted on heavy timbers.

Solars sawmill. Large pulley.



Solars Sawmill. Large pulley.



Solars sawmill. Timber framework leading down into Grant Creek west of pulleys, looking roughly east, upstream.

Solars sawmill. Wire cable at framework leading down into Grant Creek west of pulleys.

Site name: Sluice

Pertinent dates: approx. A.D. 1940

Location: SW$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ Section 18, T. 4 N., R. 1 E., Seward Meridian

Description: The "sluice" is located on the north bank of the Falls Creek canyon, on the first small tributary stream to Falls Creek above the Alaska Railroad. The creek is bridged by a plank. We found no cultural material upstream from the plank. Slightly below the plank the stream forks around a deposit of large, loose cobbles. On the east fork the stream is directed through a piece of stovepipe, below which the stream bed is lined with pieces of corrugated sheet metal bent into a trough. The metal trough extends to the edge of the canyon and the stream drops straight down to Falls Creek, about 50 feet below. Scattered along the sides of the east stream fork are pieces of lumber, pieces of a wooden trough which may have been replaced by the sheet metal, and wire cable.

The remains of a campsite and a ruined cabin dating to approximately 1935-1940 lie within a few hundred feet to the east.

Significance: The "sluice" is probably associated with gold prospecting on Falls Creek. The area has been prospected from the first decade of the twentieth century to the present. Recently staked placer claims are located approximately 500 feet up Falls Creek from this site and an active placer claim is located near the mouth of Falls Creek. The small stream could also have served as a water source for the nearby camp and cabin, as Falls Creek flows at the bottom of a deep canyon here.

Danger of destruction: There is no danger of destruction other than that due to natural weathering.

References: None.

Owner of property: Chugach National Forest
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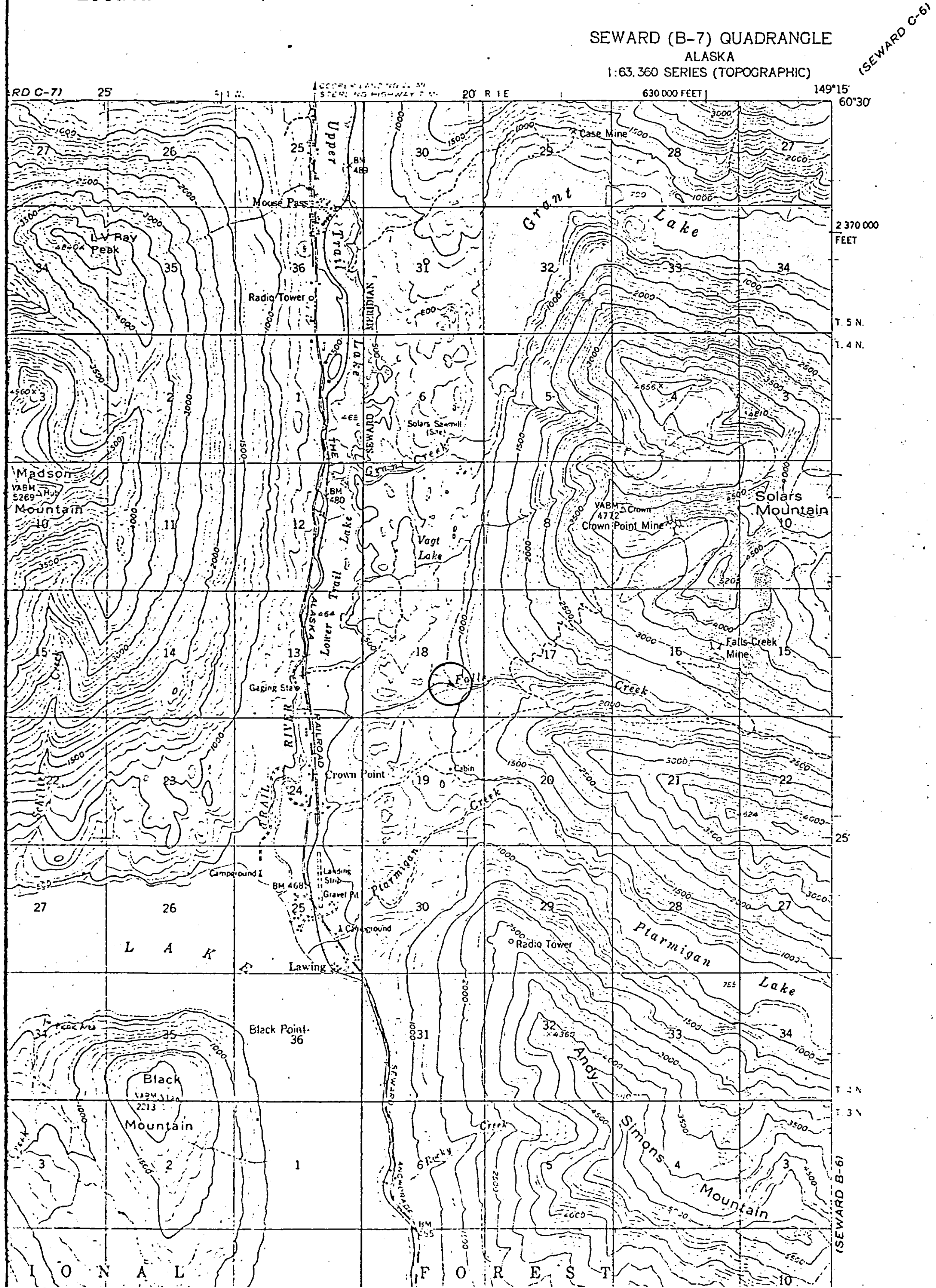
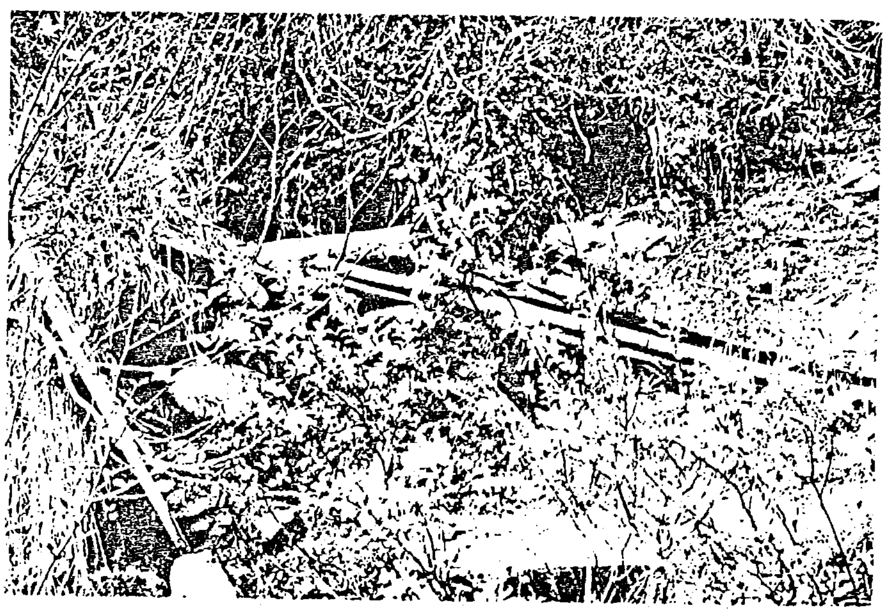
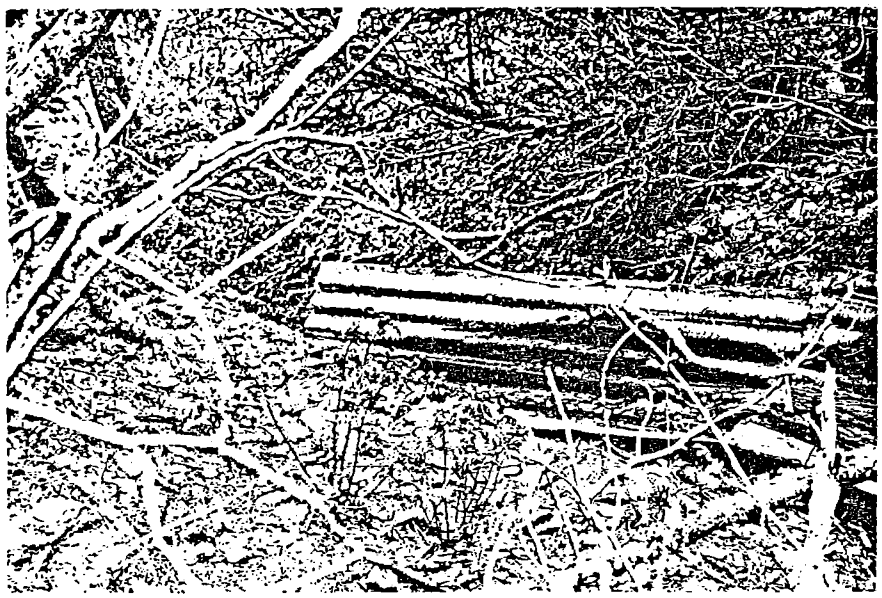
Location of sluice.



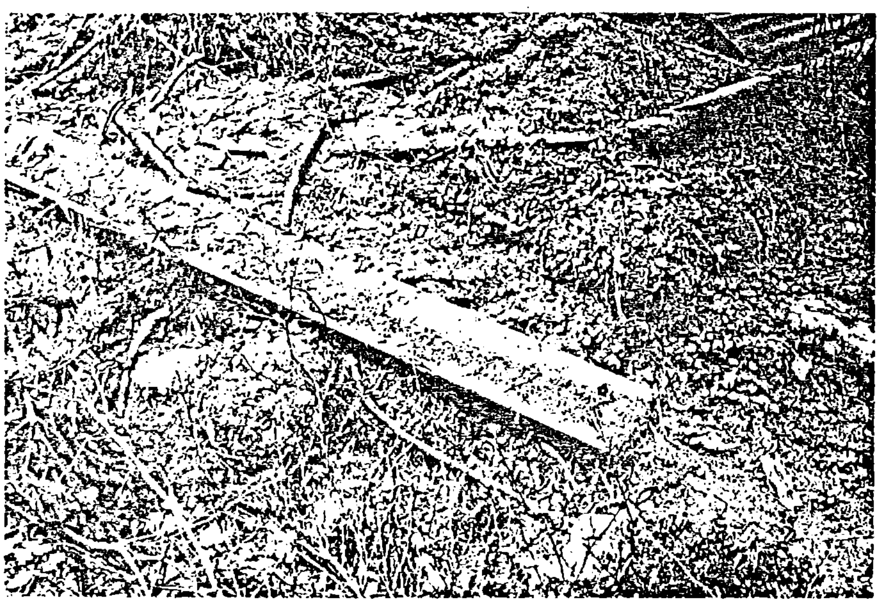
"Sluice" site. Sluice, pipe, and cobble deposit which divides stream into two forks, looking north upstream.



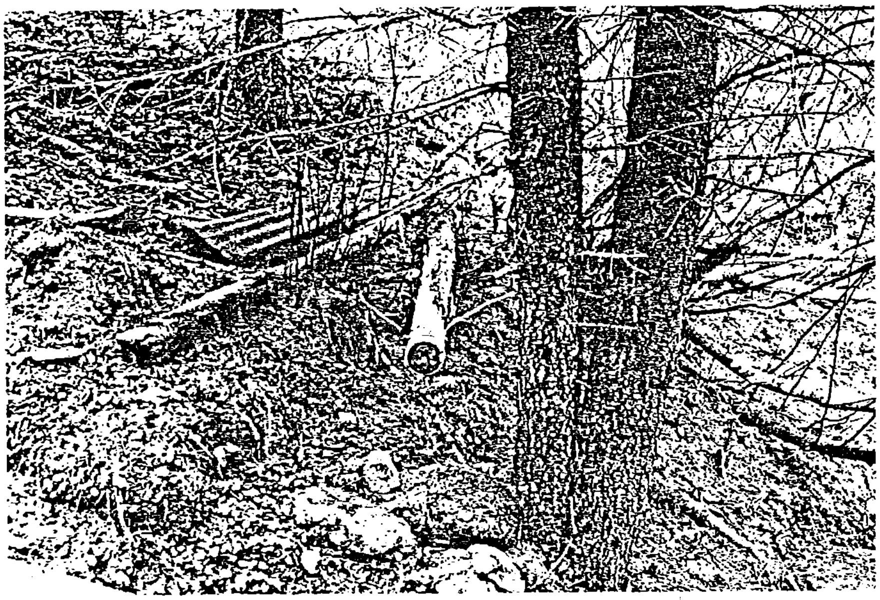
"Sluice" site. Pipe and corrugated sheet metal trough through which water flows, looking east.



"Sluice" site. Corrugated sheet metal trough.



"Sluice" site. Wooden trough on east bank next to sluice, possibly replaced with the corrugated sheet metal.



"Sluice" site. Debris associated with sluice, looking east across stream.

Site name: Camp

Pertinent dates: some time in the period A.D. 1940-1960

Location: SW$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ Section 18, T. 4 N., R. 1 E., Seward Meridian

Description: The camp is located on the north bank of the Falls Creek canyon approximately 100 m west of the northwest corner of the Marathon 1 placer claim and an equal distance downstream from the waterfall where the 895-foot contour crosses Falls Creek. It lies in a small clearing surrounded by a very dense growth of young spruce with trunks approximately 1 to 2 inches in diameter. The nearest sources of water are a small stream with a sluice a short distance to the west and Falls Creek which flows through the canyon about 50 feet below.

The camp area measures approximately 3.6 m NS by 6.5 m EW. Along the south edge lie some planks and corrugated metal roofing. A cache box, with quarter-inch wire mesh covering the top, is nailed to the south side of a large spruce above a table which is also nailed to the tree. Leaning against the north side of the same tree is a ladder, made of unpeeled saplings, which leads up to a board nailed to the spruce about 3 m above the ground. Boards are nailed at about 3 m and 4 m above the ground on another spruce a short distance to the north. Some lumber lies between the two trees, which may have supported some type of cache. Other material scattered about the site includes a Borden's Evaporated Milk crate, a Sherwin-Williams Paint crate, a large square can with a wire handle, pieces of pipe, a small metal door, a plastic potato bag which says "Alaska Nuggets--Palmer, Alaska," a large bent piece of rusted sheet metal, approximately one-eighth inch thick, with regular perforations, and two wooden wheels with rims of galvanized sheet metal with regular perforations. Some cans and other trash also lie in a heap southwest of the clearing.

A road cut which extends from the Crown Point Mine road down toward Falls Creek lies immediately east of the camp and the Brosius cabin, probably occupied in the period 1935-1940, lies slightly to the north on the opposite side of the road.

Significance: The camp is very likely associated with gold prospecting on Falls Creek. The area has been prospected from the first decade of the twentieth century to the present. Judging from the size of the young spruce around the clearing, the camp is at least 20 years old and may be older. It may be associated with the nearby Brosius cabin, which probably dates to the period 1935-1940.

Danger of destruction: There is no danger of destruction other than that due to natural weathering.

References: None.

Owner of property: Chugach National Forest
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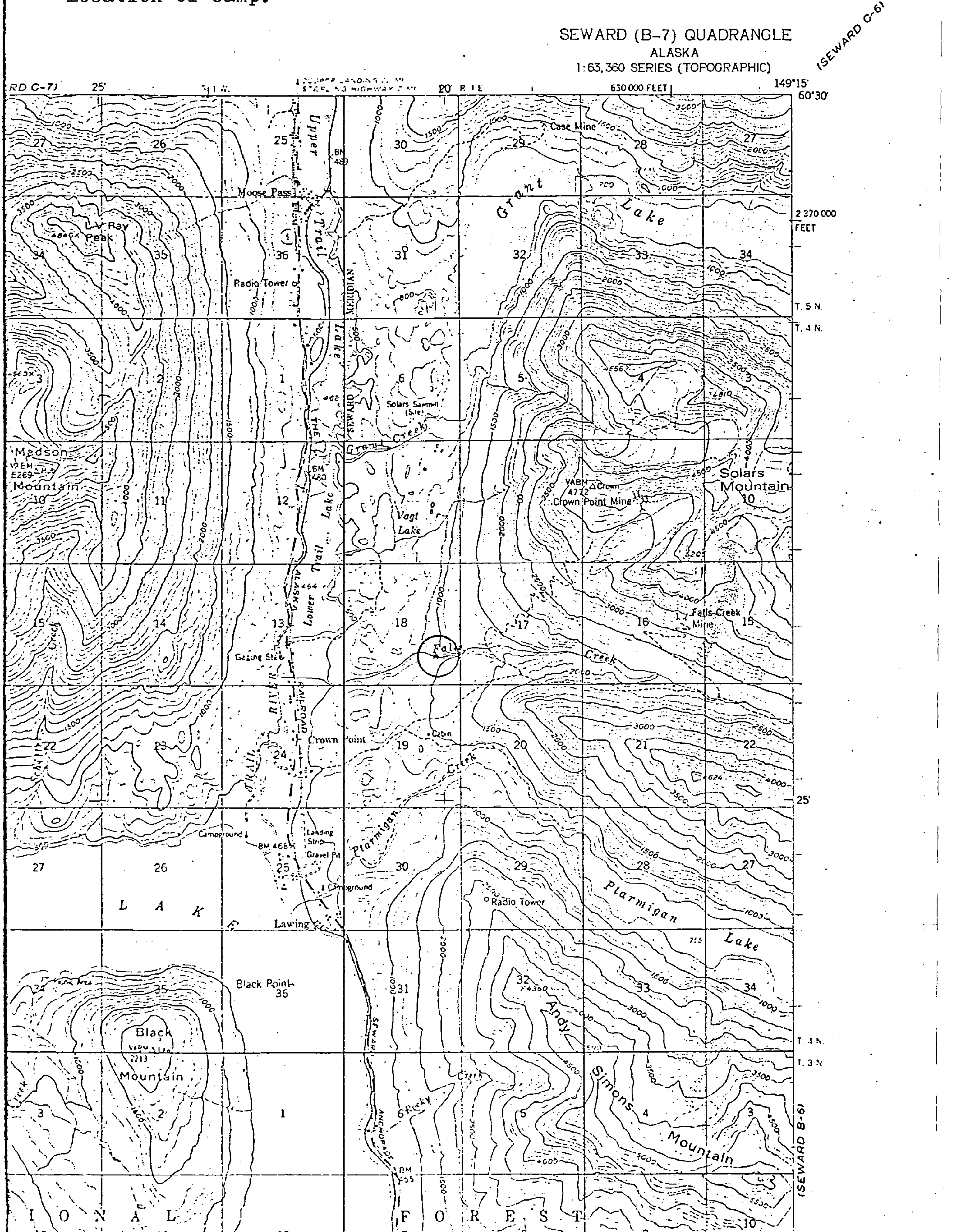
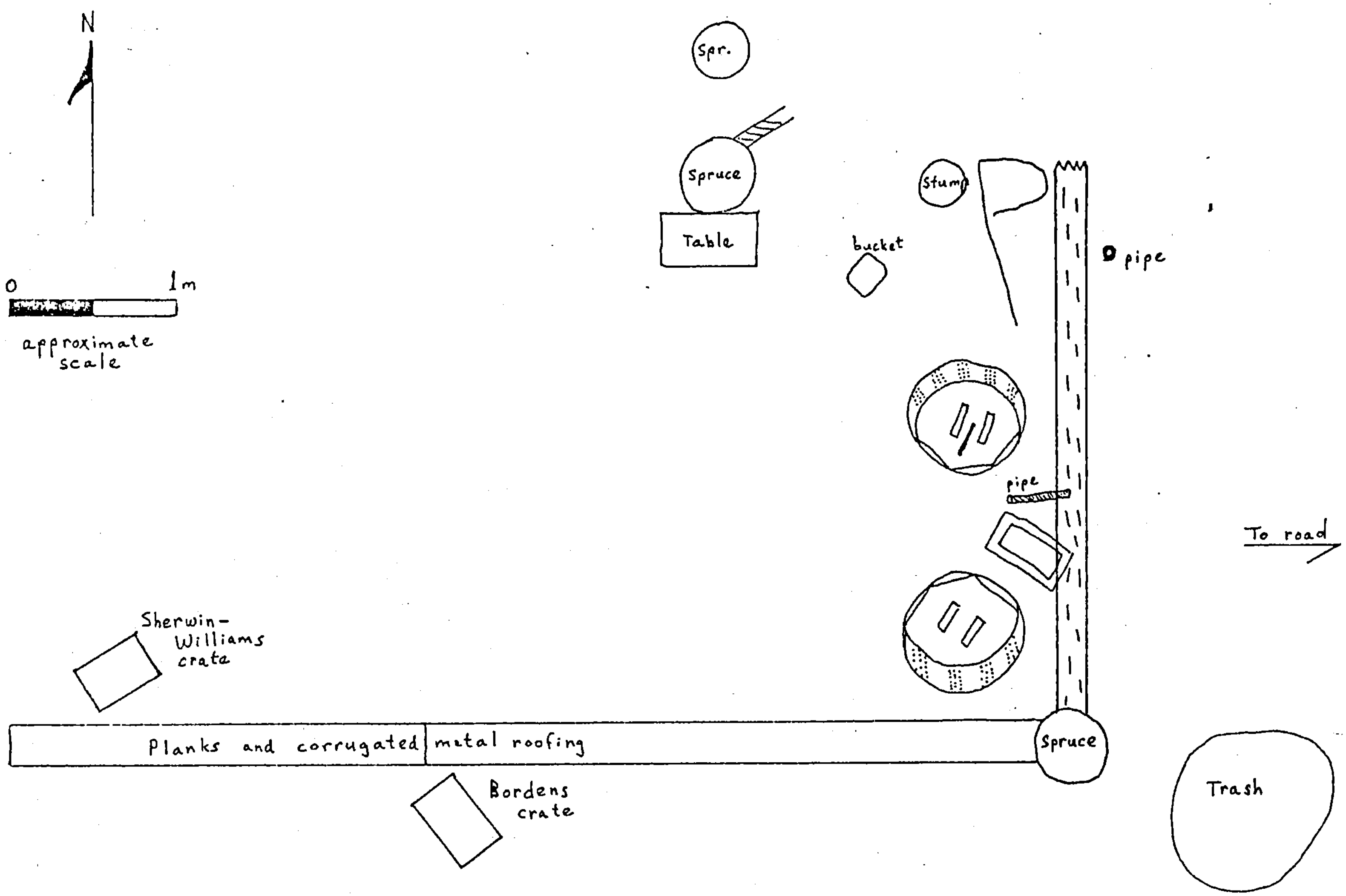
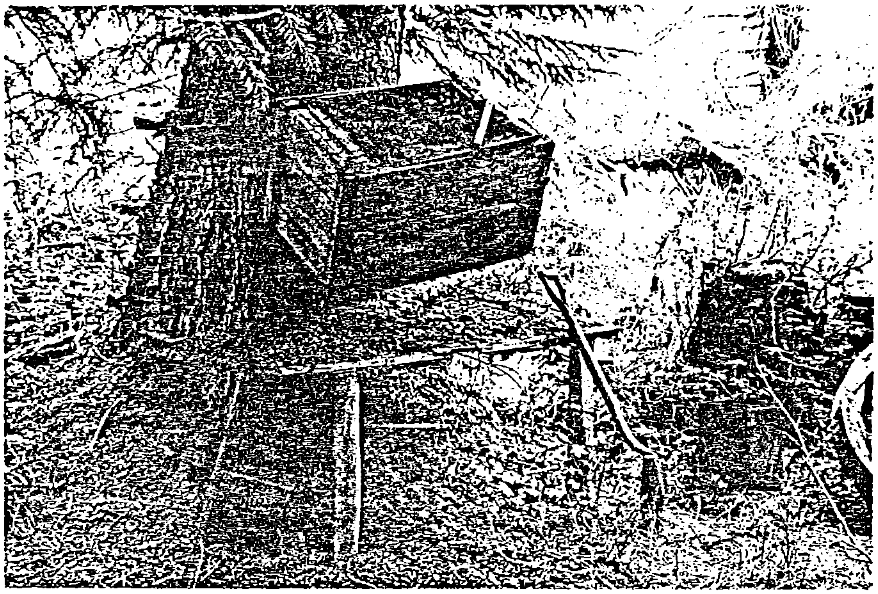
Location of camp.





Sketch map, camp site.



Camp site. Cache box and table nailed to spruce and scattered camp debris, looking north. Shovel provides scale.

Camp site. Ladder of unpeeled saplings and board nailed horizontally to spruce ca. 3 m above ground, looking west. Cache box and table nailed to tree are visible at left.

Camp site. Wooden wheels with metal rims, looking east. A metal door with a plastic potato bag lies between them.

Camp site. View of perforated sheet metal rims on wooden wheels, looking east. A large bent piece of perforated sheet metal is visible at top left.

Site name: Brosius Cabin

Pertinent dates: A.D. 1935-1940

Location: SW$\frac{1}{4}$ NE$\frac{1}{4}$ SE$\frac{1}{4}$ Section 18, T. 4 N., R. 1 E., Seward Meridian

Description: The structure is located on the north side of Falls Creek canyon on a small bench some 50 to 75 feet above the creek. The northwest corner of the Marathon 1 placer claim lies about 30 m uphill to the northeast, and a waterfall where the 895-foot contour crosses Falls Creek is located an equal distance upstream. Immediately to the west of the cabin is a steep road spur which leads from the Crown Point Mine road down toward Falls Creek. The cabin ruins stand in a clearing, but young spruce grow near it and mature spruce forest grows to the east and north. The nearest sources of water are Falls Creek and a small stream with a sluice some 100 m to the west.

The cabin measures 5.1 m NS by 6.3 m EW. It was built of unpeeled double-notched logs chinked with moss. On the inside of the north wall laths were nailed over the chinking, presumably to reduce drafts. The north wall and the west wall between the northwest corner and the door jamb still stand eight logs high. The east wall stands eight logs high at the north end and five or six logs high at the south end. The remaining walls have collapsed. The east wall has a central window frame without glass and, as mentioned, there was a door in the west wall. Nails pounded into the north wall probably served as hooks on which to hang things. No flooring was noted, but may be present.

The structure appears to have had a shed roof which slanted down toward the south. A small fragment of the roof preserved in the northeast corner consisted of several layers of a coarse fabric resembling burlap covered with a sparkling sandy material, possibly decayed shingles, sandwiched between corrugated sheet metal on the inside and tar paper on the outside. A charred beam leaning against the wall near the northwest corner suggests that the roof burned. I did not note any charring of the standing walls, but a dense scatter of charcoal fragments extends from the southwest corner half way along the collapsed south wall.

A shed measuring 2.95 m NS by 4.4 m EW was attached to the cabin's north wall. It has completely collapsed, but machine parts and pieces of metal roofing lie among the ruins.

A great deal of trash is associated with the cabin. One metal bed frame stands in the southeast corner and another lies nearby, outside the cabin. A stove may once have stood in the southwest corner where there is a concentration of charcoal. A piece of stovepipe lies nearby, outside the doorway. Inside the cabin, the heaviest concentration of trash lies in the southwest quarter and included boots, shoes, a can of eating utensils, and machine parts. A wooden sign lying just inside the door bears faint lettering which reads "C. M. Brosius--Seward." Outside the cabin are pieces of metal roofing and rusted cans. The existing road appears to have cut through a trash heap, as rusted cans are also found in the berm on the opposite side of the road. East of the cabin is the hood of a car or truck. A railing has been nailed to a tree at the edge of the cliff east of the cabin, forming a little walkway.

An associated structure is dug into the hillside below and southwest of the cabin. As it has been undermined by the road cut and erosion, I did not descent to measure or examine it closely. It appears to be built of milled lumber and has a roof of corrugated sheet metal. It appears too large to have been an outhouse.

Significance: This cabin is most likely related to gold mining in the area. The Crown Point Mine, which lies north of Falls Creek near the summit of a nearby mountain, was operated by the Crown Point Mining Company, C. Brosius and Associates, Seward, in the period 1935-1940 (Stewart 1937:48, 1939:39, 1941:74).

Danger of destruction: There is little danger of destruction other than that due to natural weathering. The associated structure dug into the hillside may soon be lost to erosion. Although a mining road passes right by the cabin, it is impassible without a four-wheel-drive vehicle. Most "collectables" appear already to have been salvaged by the former owner or removed by later visitors.

References:

Stewart, B. D.

1937 Report of the Commissioner of Mines to the Governor for the biennium ended December 31, 1936. (Juneau?): Territory of Alaska.

1939 Report of the Commissioner of Mines to the Governor for the biennium ended December 31, 1938. (Juneau?): Territory of Alaska.

1941 Report of the Commissioner of Mines to the Governor for the biennium ended December 31, 1940. (Juneau?): Territory of Alaska.

Owner of property: Chugach National Forest
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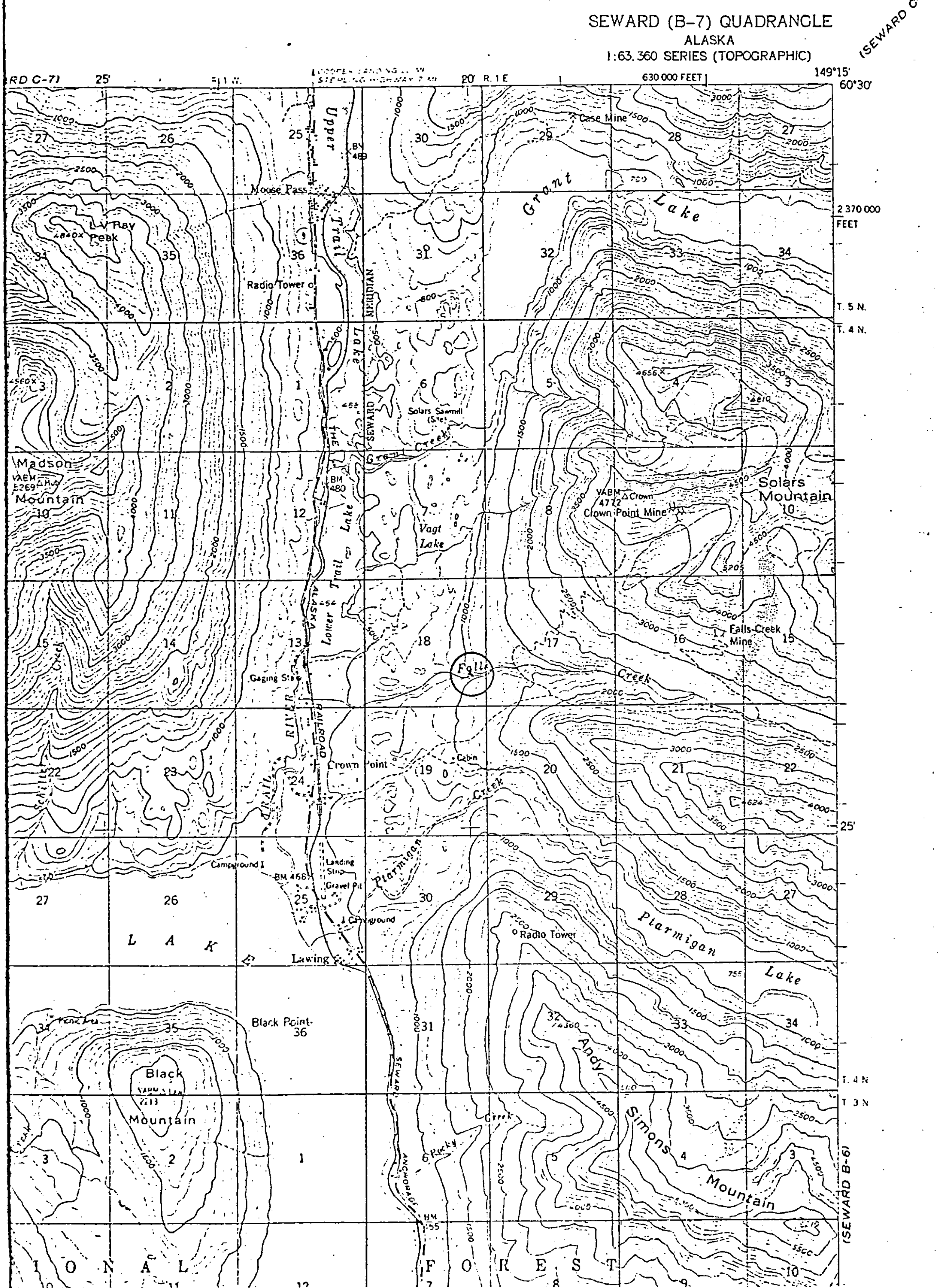
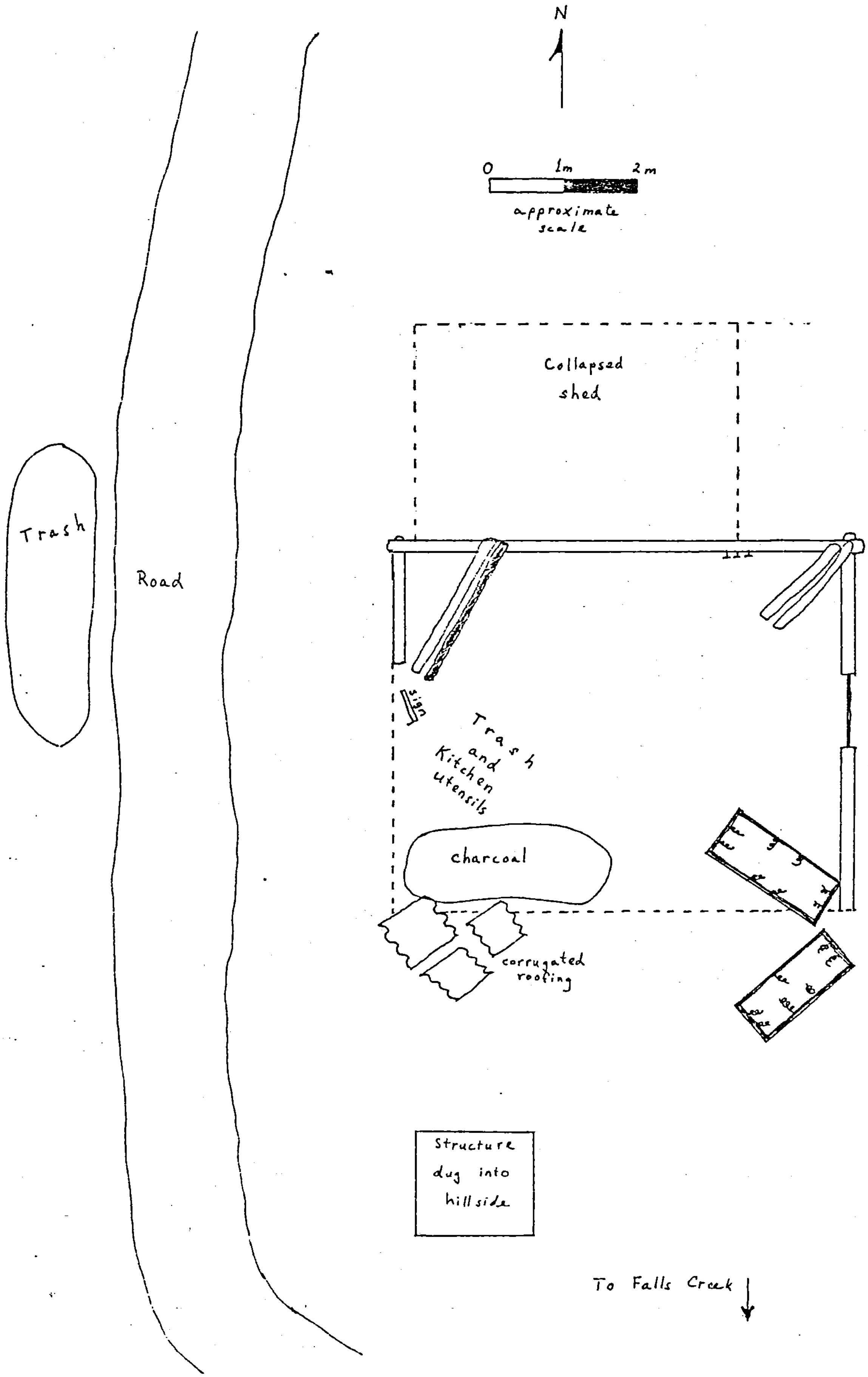
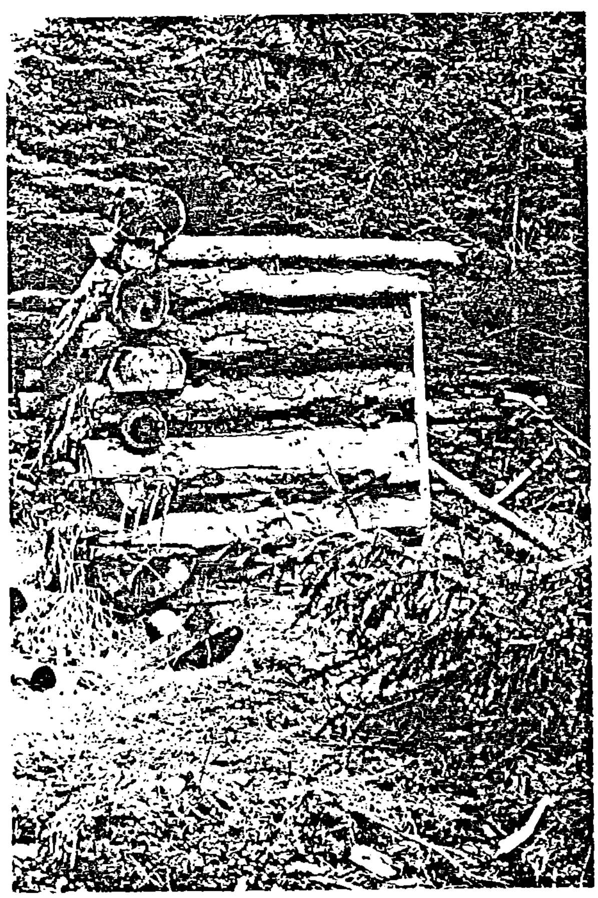
Location of Brosius cabin.



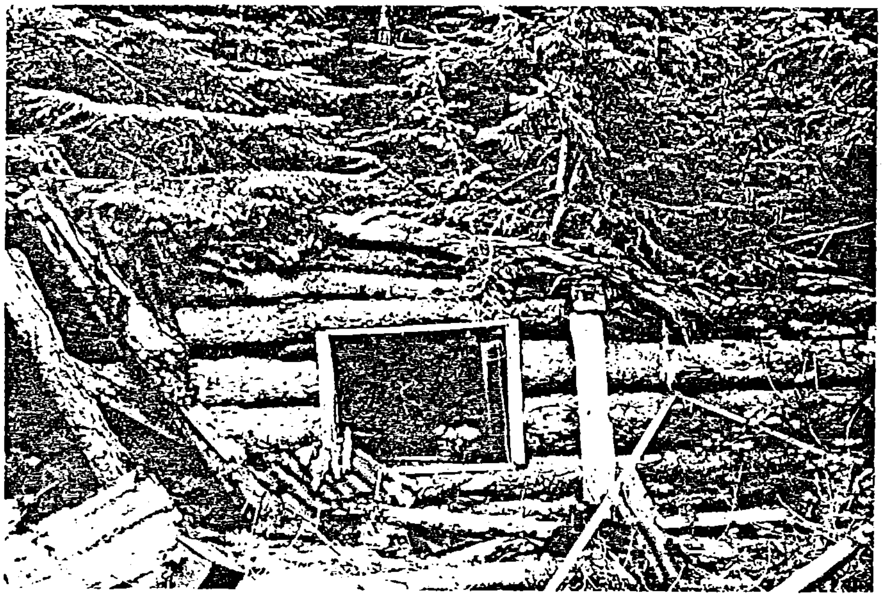


Sketch map, Brosius cabin.

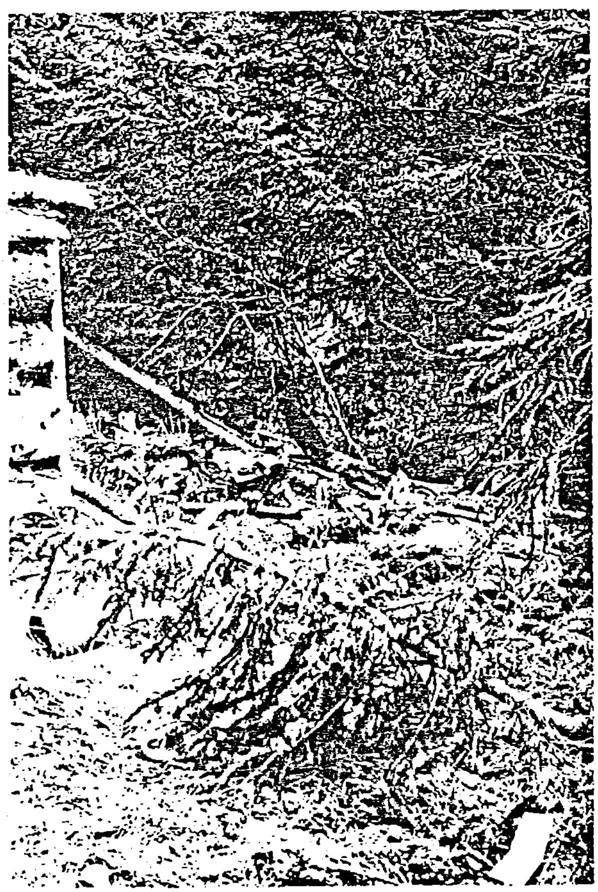
Brosius cabin. Detail of construction of northwest corner, looking south.



Brosius cabin. West wall of cabin, looking east.



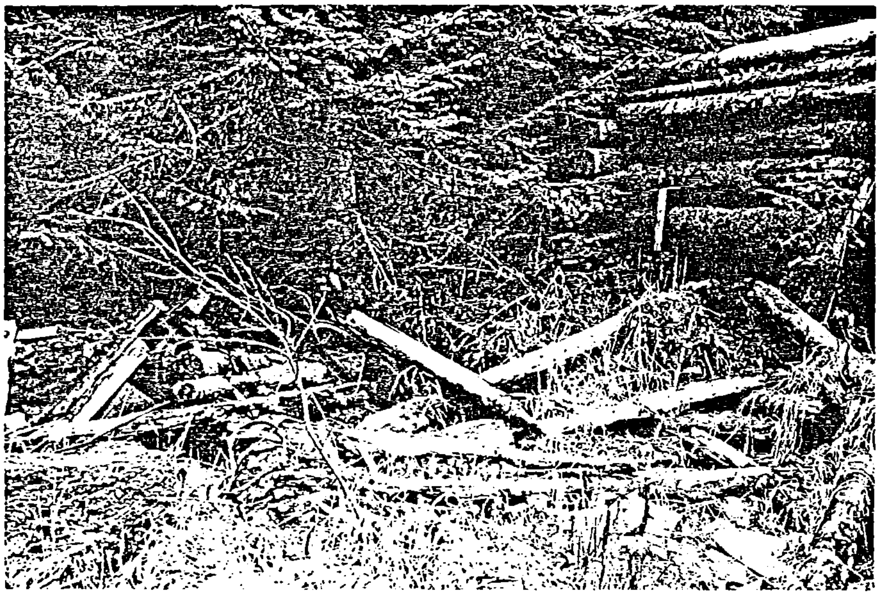
Brosius cabin. Interior view of east wall, looking east. Note bed frame at right.



Brosius cabin. Collapsed portion of west wall and collapsed south wall, looking southeast. North side of door jamb is visible at left.

Brosius cabin. Roofing preserved in northeast corner, looking northeast.

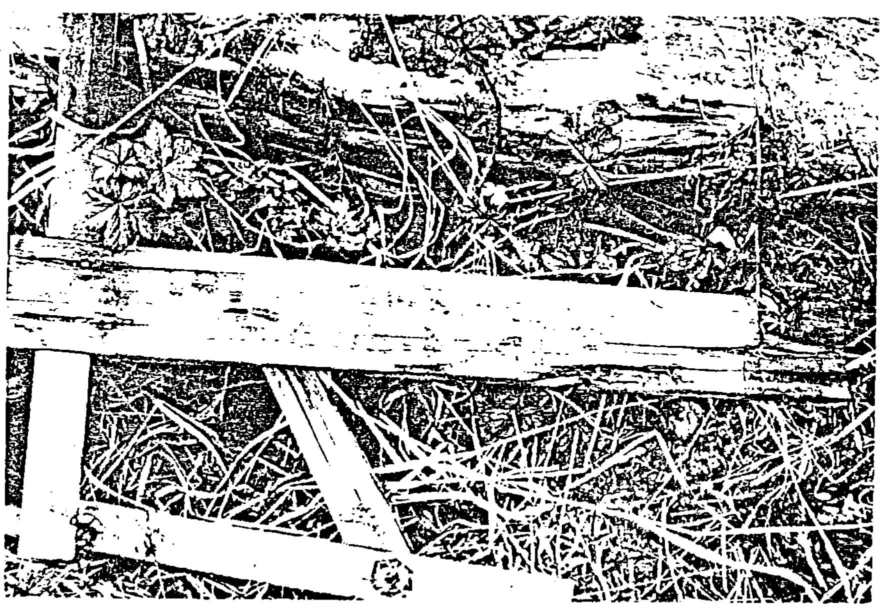
Brosius cabin. One charred and one uncharred roof beam inside cabin near northwest corner, looking west. Note moss chinking between logs and laths nailed over cracks.



Brosius cabin. Collapsed shed north of cabin, looking east.

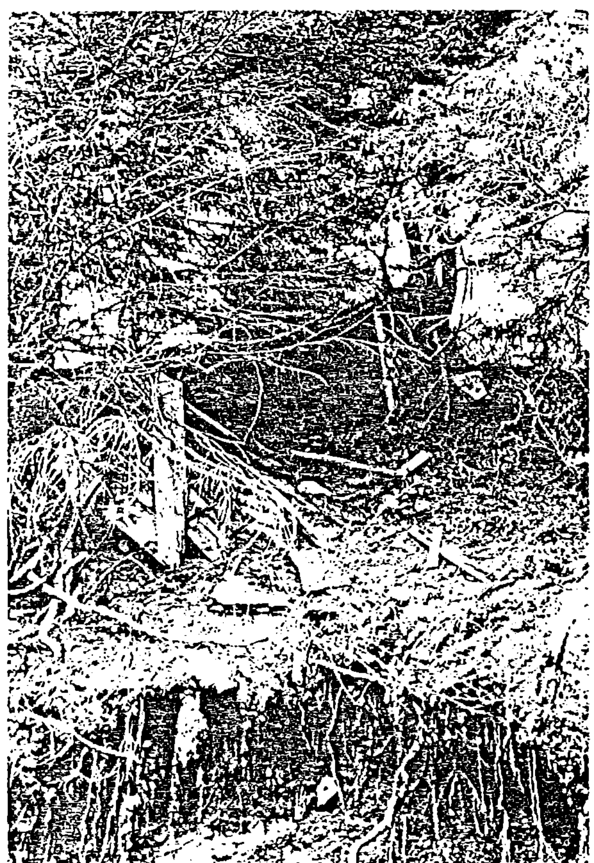
Brosius cabin. Interior view of southeast corner, looking southeast.

Brosius cabin. Trash inside cabin near south-west corner, looking south. Note heavy concentration of charcoal at center left.



Brosius cabin. Sign inside cabin near door: "C. M. Brosius--Seward."

Brosius cabin. Corrugated metal roofing outside cabin near southwest corner, looking northeast.



Brosius cabin. Structure built into hillside south of cabin, looking north from road cut.

Brosius cabin. West wall of structure built into hillside south of cabin, looking east.

Brosius cabin. Roof of structure built into hill-side south of cabin, looking south and down from cabin.

Site name: Log structure

Pertinent dates: approx. A.D. 1940

Location: NW¼ SW¼ Section 17, T. 4 N., R. 1 E., Seward Meridian

Description: This collapsed structure lies approximately 75 m north of the edge of Falls Creek canyon in a large, fairly level, grassy clearing dotted with cow parsnip just below treeline. The Crown Point Mine road passes immediately north of it and the juncture of the NE corner of the Marathon 3 placer claim with the NW corner of the Four Jokers 1 placer claim lies a short distance to the south. The nearest source of water which we identified is Falls Creek, but several small mountain streams cross the road to the west and may cross it to the east as well.

The structure was built of unpeeled logs which have been flattened on the inside surface. Only the southwest corner is still relatively intact, and that stands only a few tiers high. The structure's dimensions were approximately 3.6 m NS by 4.85 m EW, but accurate measurement is difficult because the east and north walls appear to have fallen outward. The north wall was at least five logs high when it collapsed. No windows are evident, but the doorway appears to have been in the west wall. Under the grass inside the structure is a plank floor which runs EW and corrugated metal roofing lies under the grass around the outside. Recent and old cans were found in and on the grass inside the structure.

Associated material includes a small rusted boiler on the opposite side of the road and a small, square depression which lies 4.4 m east and slightly south of the structure. The latter measures approximately 1.2 m by 1.2 m and may have served as an outhouse or cache hole. A bulldozed clearing and a recent campsite in the trees south of the structure are most likely associated with the recent staking of the Marathon and Four Jokers placer claims.

Significance: This structure is most likely associated with gold mining in the area, possibly with the Crown Point Mine which lies near the summit of the mountain rising to the north.

The gold vein at the Crown Point Mine was discovered in 1906 by J. W. and C. E. Stephenson or Stevenson and developed in earnest by the Kenai-Alaska Gold Co. in the period 1910-1916 (Martin et al. 1915:157-159; Johnson 1919:175). It was opened again in the period 1935-1940 by the Crown Point Mining Co., C. Brosius and Associates, of Seward, and operated by others from 1955 until at least 1960 (Stewart 1937:48; 1939:39; 1941:74). The logs of the structure appear to be too sound to date to the 1910s. The structure bears some resemblance to the Brosius cabin located further downstream in that it was built of unpeeled, double-notched logs with a roof of corrugated sheet metal, and may date to approximately the same period (1935-1940).

The maps posted at the corners of the Marathon placer claims identify the structure as an "old barn." It may have served as a waystation on the road up to the Crown Point Mine.

Danger of destruction: There is no danger of destruction other than that due to natural weathering.

References:

Johnson, B. L.
1919 Mining in central and northern Kenai Peninsula. In: Mineral resources of Alaska: report on progress of investigations in 1917, by G. C. Martin et al., pp. 175-176. USGS Bull. 692. Washington, D. C.: Government Printing Office.

Martin, G. C., B. L. Johnson, and U. S. Grant
1915 Geology and mineral resources of Kenai Peninsula, Alaska. USGS Bull. 587. Washington, D. C.: Government Printing Office.

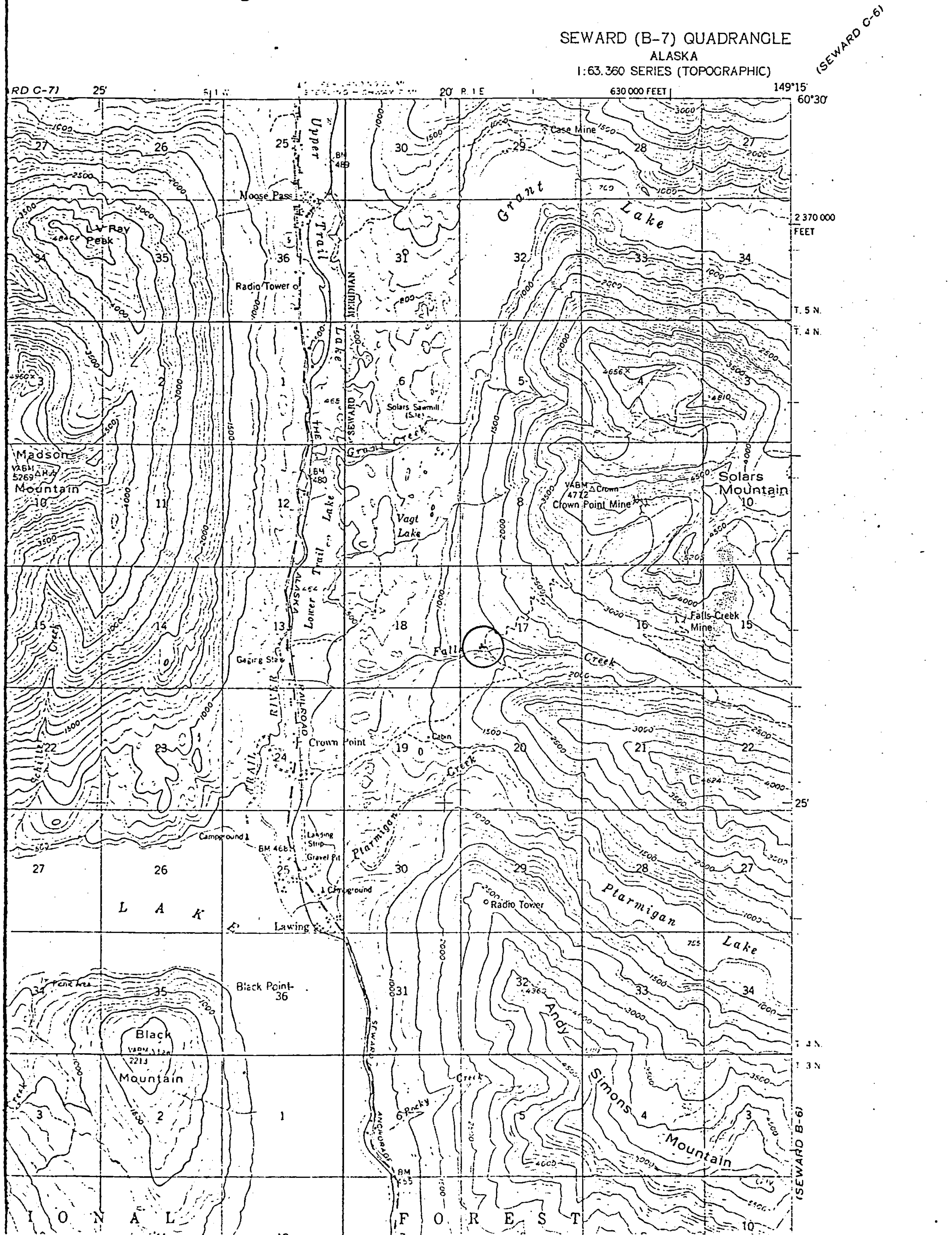
Stewart, B. D.
1937 Report of the Commissioner of Mines to the Governor for the biennium ended Dec. 31, 1936. (Juneau?): Territory of Alaska.

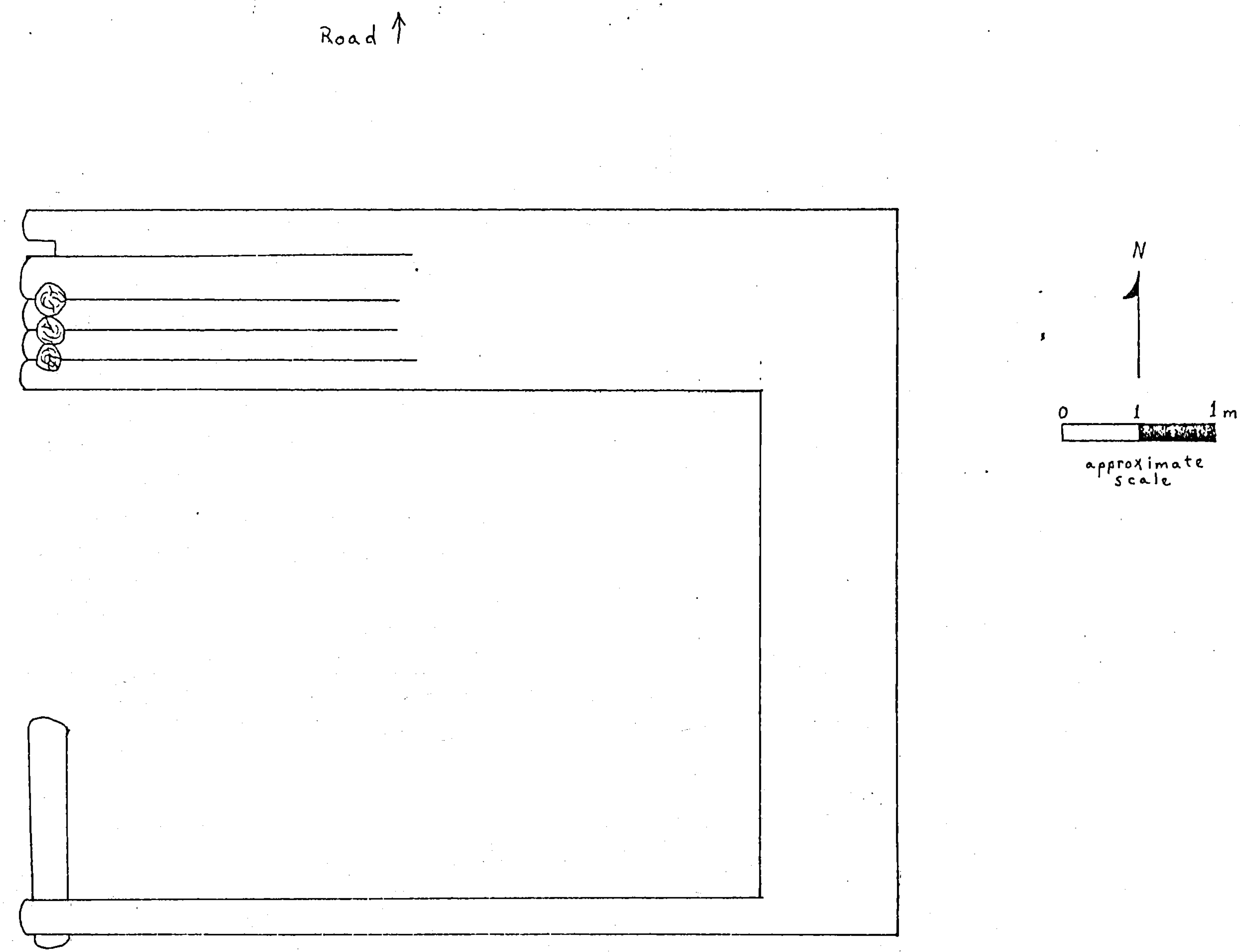
1939 Report of the Commissioner of Mines to the Governor for the biennium ended Dec. 31, 1938. (Juneau?): Territory of Alaska.

1941 Report of the Commissioner of Mines to the Governor for the biennium ended Dec. 31, 1940. (Juneau?): Territory of Alaska.

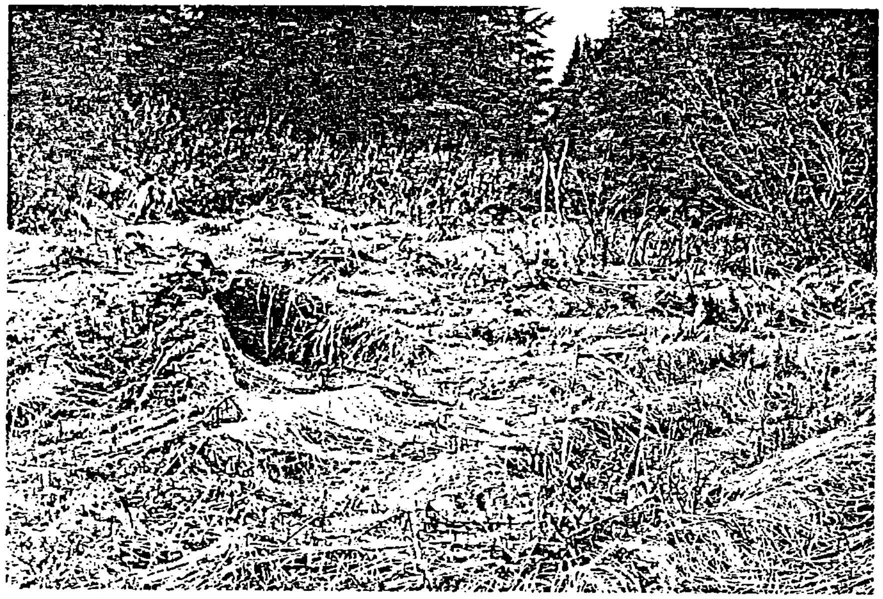
Owner of property: Chugach National Forest
2221 E. Northern Lights Blvd., Suite 238
Anchorage, Alaska 99502

Location of log structure.





Sketch map, log structure.



Log structure. View west across remains of structure.

Log structure. Detail of southwest corner, looking north. This is the only corner of the structure still intact.

Log structure. View south along west wall. Stumps in foreground are remnants of west wall still wedged between logs of the north wall which has fallen outward.

Log structure. Boiler lying across road to north of structure.

APPENDIX B

A CAPTURE AND REMOVAL METHODOLOGY (ZIPPIN 1959) AND ITS APPLICATION TO THE GRANT LAKE PROJECT

We were required by Ebasco Services, Inc. to attempt to quantify the juvenile fish population of Grant Creek using a capture and removal methodology (Zippin 1958). This removal method of population estimation was developed for estimating small mammal populations using kill traps set over several trapping periods. We modified the technique for use in Grant Creek by establishing a net-enclosed study site from which fish could be removed with an electroshocker in several complete passes through the site.

The assumptions that underlie this method are:

1. The population must be essentially stationary, i.e., the joint effect of birth rates, death rates, immigration, and emigration must be negligible during the period of trapping.
2. The probability of capture during a trapping is the same for each animal exposed to capture.
3. The probability of capture remains constant from trapping to trapping, i.e., the animals do not become trap shy and trapping conditions remain the same.

According to the assumptions listed above, it is expected that the number of individuals captured in the first trapping series will exceed the number of individuals captured in the second and following trapping series. The recommended method of estimating population size from data collected in a removal program is the multinominal method outlined by Zippin (1958).

The considerations we faced in attempting the capture and removal method in Grant Greek include:

1. The streamflows during the time of the year when juvenile fish are most active (July through October) are too high to allow effective blocking of a portion of the stream with a seive net. The only suitable period of low flow occurs in early spring; therefore, our attempt took place in May 1982.

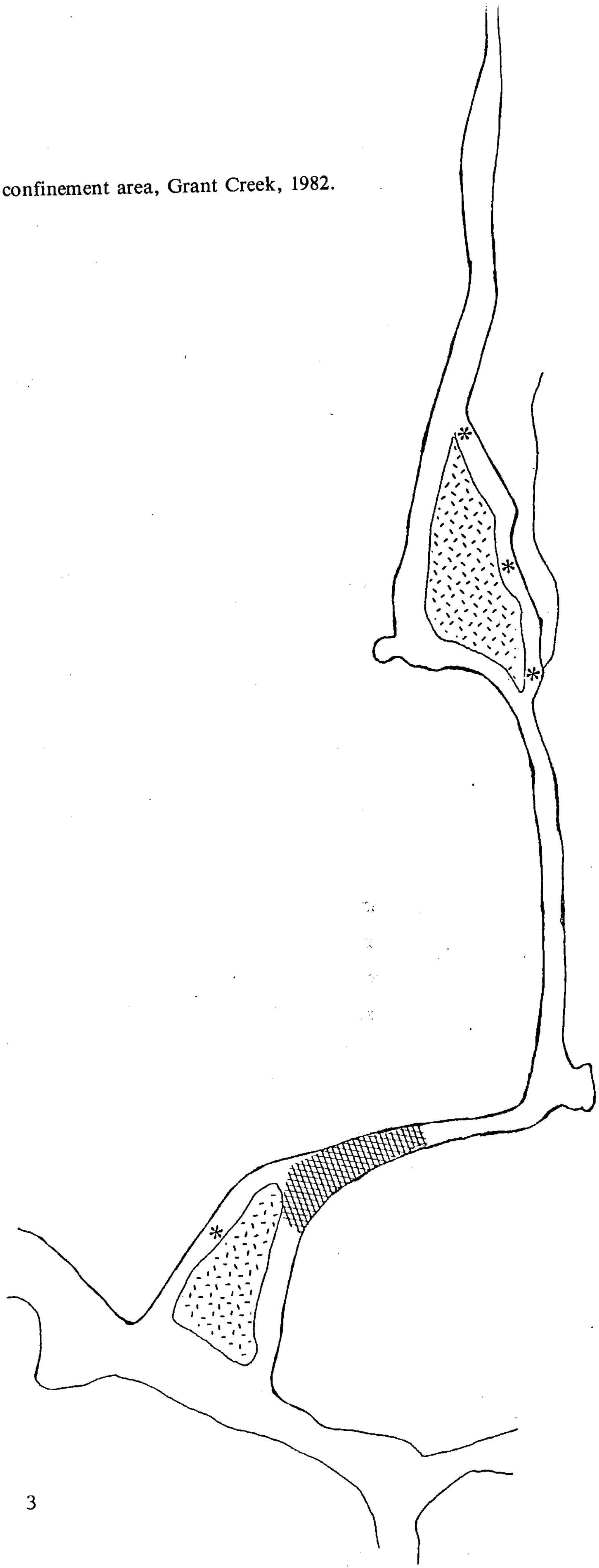
Even though the flows in May were comparatively low, we had extreme difficulty setting and maintaining the ¼-inch mesh seine nets in the high velocity waters of Grant Creek.

2. The difficulty of maintaining our nets and, thus, establishing a discrete population over a long period of time precluded the use of minnow traps and forced us to use an electroshocker. We feel that electroshocking in a stream with very low conductivity (14 to 16 μhos/cm) may be an inefficient sampling technique when used for such an application.

3. Estimates of population size based on data from a removal program are not expected to be very close to the actual population unless large proportions of the population are captured. Ideally, the minimum number of individuals trapped should not be less than 200 (Zippin, 1958). To achieve this level of capture in Grant Creek a fairly large sample area was required.

The methodology was attempted for a 235-foot reach in sample areas 1 and 2 (Exhibit 1). This reach was blocked to the passage of fish by the installation of two 16-inch seine nets across the entire width of the stream. The downstream net persistently became fouled by algae dislodged by the investigators' activities and was breached several times during the course of the effort. It is impossible to determine if this allowed an appreciable immigration or emigration of fish.

Exhibit 1. Capture and removal confinement area, Grant Creek, 1982.



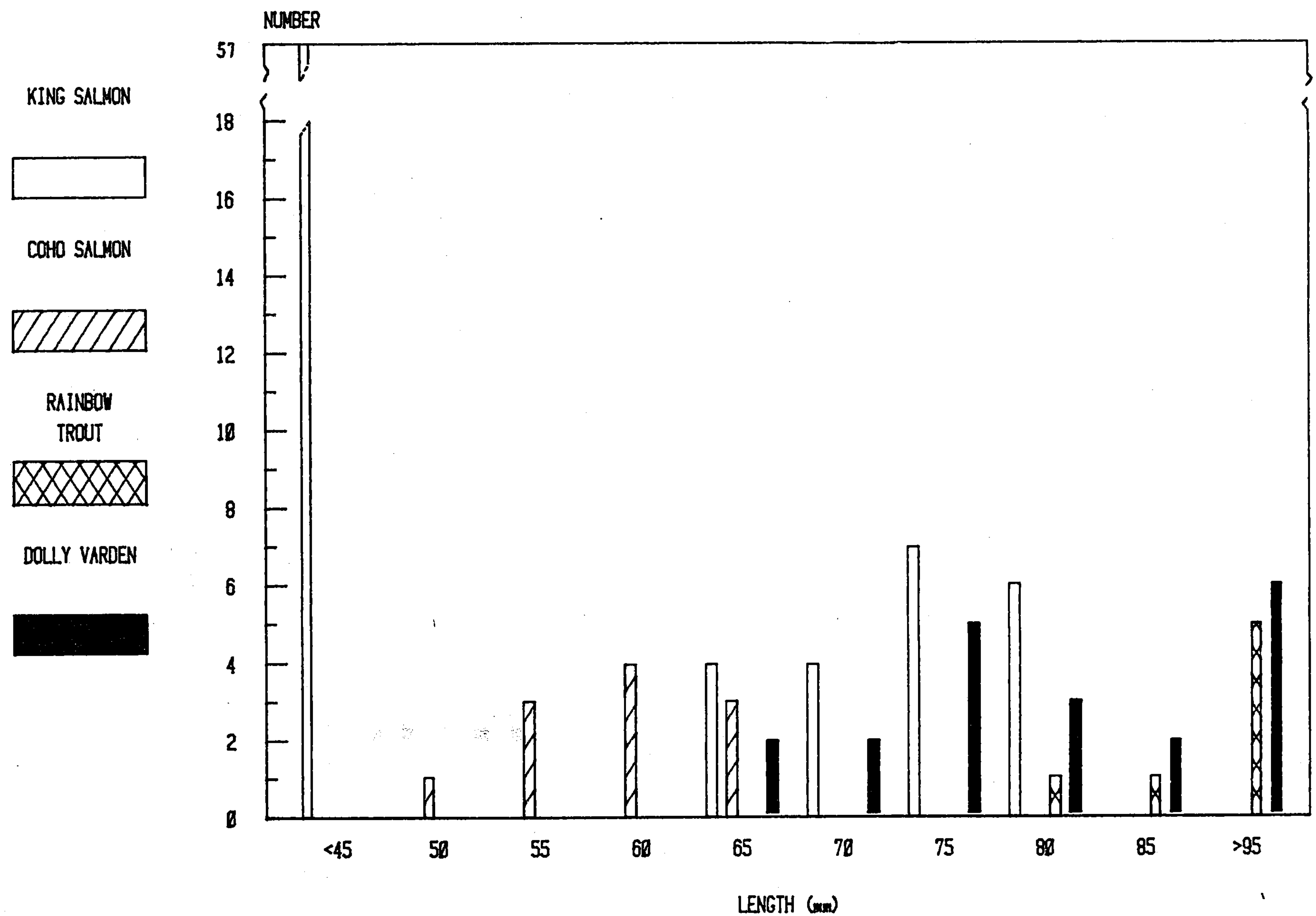
Three passes were made in the study area with the electroshocker, and the captured fish were removed from the area. The results of this effort are as follows:

	NUMBER OF FISH		
	Pass 1	Pass 2	Pass 3
King Salmon	22	42	15
Silver Salmon	3	6	2
Dolly Varden	10	10	2
Rainbow Trout	0	7	0
Sculpin	10	26	12
TOTAL FISH	45	91	31

These data do not conform to the expected results of removal technique. We believe that the majority of these fish, including many developing alevins of fry, were utilizing the interstitial habitat of the study area. Many were not captured in the initial electroshocking; however, they were stimulated to emerge from this habitat into the stream where they were captured on the second electroshocking attempt. This phenomenon and the inability to maintain a discrete study area would render the validity of a population estimate suspicious.

A length/frequency histogram of the king salmon, coho salmon, Dolly Varden, and rainbow trout taken by electroshocker during this exercise is presented in Exhibit 2.

Exhibit 2. Length/frequency histogram of king salmon, coho salmon, Dolly Varden, and rainbow trout taken by electroshocker during the performance of the block and removal methodology, May 1982.



APPENDIX C

PLANT SPECIES IDENTIFIED FROM THE
GRANT LAKE STUDY AREA

BOTANICAL NAMES	COMMON NAMES
Sphagnum sp.	
Cladonia spp.	
Lycopodium complanatum	creeping Jenny
Equisetum arvense	horsetail
Cryptograma crispa	parsley fern
Athyrium filix-femina	ladyfern
Woodsia ilvensis	
Gymnocarpium dryopteris	
Picea glauca	white spruce
* P. sitchensis	Sitka spruce
P. mariana	black spruce
Tsuga heterophylla	western hemlock
T. mertensiana	mountain hemlock
Calamagrostis canadensis	bluejoint
Trisetum spicatum	spike trisetum
Festuca altaica	tufted fescue
F. rubra	
Eriophorum sp.	cottongrass
Rhynchospora alba	white beakrush
Carex microchaeta	finely-awned sedge
C. rhynchophysa	
Luzula walenbergii subsp. piperi	woodrush
Veratrum viride	false hellebore
Allium schoenoprasum	wild chive
Fritillaria camschatcensis	chocolate lily
Streptopus amplexifolius	claspleaf twistedstalk
Populus balsamifera	cottonwood
Salix arctica	arctic willow
S. stolonifera	ovalleaf willow
S. barclayi	barclay willow
S. alaxensis	feltleaf willow
S. pulchra	diamondleaf willow
S. sitchensis	Sitka willow
Betula nana	dwarf birch
B. papyrifera	paper birch
Alnus crispa subsp. sinuata	Sitka alder
Urtica gracilis	slim nettle
Oxyria digyna	mountainsorrel
Montia siberica	Siberian minerslettuce
Nuphar polysepalum	yellow pond lily
Aquilegia formosa	western columbine
Aconitum delphinifolium	monkshood
Anemone richardsonii	
Ranunculus trichophyllus var. trichophyllus	white water crowfoot
R. macounii	
Thalictrum sparsiflorum	fewflower meadowrue

BOTANICAL NAMES	COMMON NAMES
Drosera anglica	sundew
D. rotundifolia	roundleaf sundew
Sedum roseum	roseroot
Boykinia richardsonii	Alaska boykinia
Saxifraga tricuspidata	threebristle saxifrage
S. punctata subsp. pacifica	
Tiarella trifoliata	laceflower
Parnassia palustris	northern grass of Parnassus
Ribes glandulosum	skunk currant
R. laxiflorum	trailing black currant
R. triste	American red currant
Spiraea beauverdiana	Alaska spirea
Luetkea pectinata	
Aruncus sylvester	goatsbeard
Sorbus sitchensis	Sitka mountain ash
Amelanchier alnifolia	serviceberry
Rubus pedatus	strawberry-leaf blackberry
R. chamaemorus	cloudberry
R. idaeus	red raspberry
R. spectabilis	salmonberry
Potentilla fruticosa	shrubby cinquefoil
Sanguisorba stipulata	burnet
Rosa acicularis	pricly rose
Lupinus nootkatensis	nootka lupine
Geranium erianthum	cranesbill
Viola epipsila subsp. repens	marsh violet
Epilobium angustifolium	fireweed
E. latifolium	riverbeauty
Echinopanax horridum	devil's club
Heracleum lanatum	cowparsnip
Cornus canadensis	bunchberry
Moneses uniflora	single delight
Empetrum nigrum	crowberry
Ledum palustre subsp. decumbens	Labrador tea
Menziesia ferruginea	rusty menziesia
Phyllodoce aleutica	Aleutian mountain heather
Cassiope stelleriana	Alaska moss heath
Andromeda polifolia	dwarf bogrosemary
Arctostaphylos uva-ursi	bearberry
A. alpina	alpine bearberry
Vaccinium vitis-idaea	lingonberry
V. caespitosum	dwarf blueberry
V. ovalifolium	early blueberry
V. uliginosum	bog blueberry
Oxycoccus microcarpus	small cranberry
Primula cuneifolia subsp. saxifragifolia	primrose
Trientalis europaea	European starflower
Gentiana glauca	glaucous gentian
Lomatogonium rotatum	star gentian

BOTANICAL NAMES	COMMON NAMES
Menyanthes trifoliata	buckbean
Polemonium pulcherrimum	Jacob's ladder
Myosotis alpestris subsp. asiatica	forget-me-not
Mimulus guttatus	monkeyflower
Veronica wormskjoldii	alpine speedwell
Pedicularis verticulata	lousewort
Galium boreale	northern bedstraw
Sambucus racemosa	Pacific red elder
Viburnum edule	highbush cranberry
Linnaea borealis	northern twinflower
Campanula rotundifolia	harebell
Achillea millefolium	yarrow
Artemisia tilesii subsp. elator	mountain woodworm
A. arctica	arctic sagewort
Petasites hyperboreus	sweet coltsfoot
Arnica frigida	
Taraxacum alaskanum	Alaskan dandelion
Hieracium triste	hawkweed

* Species may occur in the study area but was not observed.