#1704

SUSITNA HYDROELECTRIC PROJECT

FINAL REPORT

BIG GAME STUDIES

Volume VIII DALL SHEEP

Nancy G. Tankersley

ALASKA DEPARTMENT OF FISH AND GAME

Submitted to the Alaska Power Authority

April 1984

DOCUMENT No. 2327

SUSITNA HYDROELECTRIC PROJECT

FINAL REPORT

BIG GAME STUDIES

VOLUME VIII - DALL SHEEP

Nancy G. Tankersley

ALASKA DEPARTMENT OF FISH AND GAME

Submitted to the

Alaska Power Authority

April, 1984

PREFACE

In early 1980, the Alaska Department of Fish and Game contracted with the Alaska Power Authority to collect information useful in assessing the impacts of the proposed Susitna Hydroelectric Project on moose, caribou, wolf, wolverine, black bear, brown bear and Dall sheep.

The studies were broken into phases which conformed to the anticipated licensing schedule. Phase I studies, January 1, 1980 to June 30, 1982, were intended to provide information needed to support a FERC license application. This included general studies of wildlife populations to determine how each species used the area and identify potential impact mechanisms. Phase II studies began in order to provide additional information during the anticipated 2 to 3 year period between application and final FERC approval of the license. Belukha whales were added to the species being studied. In these annual or final reports, we are narrowing the focus of our studies to evaluate specific impact mechanisms, quantify impacts and evaluate mitigation measures.

This is the second annual report of ongoing Phase II studies. In some cases, objectives of Phase I were continued to provide a more complete data base. Therefore, this report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on the selected wildlife species.

The information and conclusions contained in these reports are incomplete and preliminary in nature and subject to change with further study. Therefore, information contained in these reports is not to be quoted or used in any publication without the written permission of the authors.

The reports are organized into the following 9 volumes:

Volume I.	Big Game Summary Report
Volume II.	Moose - Downstream
Volume III.	Moose - Upstream
Volume IV.	Caribou
Volume V.	Wolf
Volume VI.	Black Bear and Brown Bear
Volume VII.	Wolverine
Volume VIII.	Dall Sheep
Volume IX.	Belukha Whale

SUMMARY

Dall sheep studies have focused on the three areas of sheep habitat nearest the proposed Watana and Devil Canyon dams - Mt. Watana, Portage Creek-Tsusena Creek-Denali Highway (access corridor) and the Watana Creek Hills. During Phase I studies, a mineral lick used by a small Dall sheep population was discovered in the Watana Creek Hills, adjacent to the proposed Watana impoundment. A minimum of 31% of the observed 1983 sheep population traveled 5 mi or more to the Jay Creek lick area, which is below alpine sheep habitat in the lower 4 mi of Jay Creek. Sheep travel to this area even though another smaller lick with similar chemical anomalies is located within their alpine range. The Jay Creek lick soil, containing significantly high levels of sodium, is exposed in several areas mostly between 2200-2400 ft. Sheep attracted to the area spent about 14% of the time below 2200 ft. The Watana impoundment normal maximum operating level is designated as 2185 ft with an average annual drawdown of 120 ft , and flood levels up to 2200 ft. Although these proposed impoundment levels will not directly inundate any major licking areas, erosion and ice shelves may result in the loss of licking and resting areas, and inhibit travel along and across Jay Creek to well-used sites. However, erosion may possibly also expose lick soil in new areas. The lick's close proximity to the impoundment will make the sheep seasonally vulnerable to disturbance from construction, transportation and recreational activities. No sheep use of areas on Mt. Watana (directly south of Watana impoundment) or near the Denali Highway access corridor was documented.

TABLE OF CONTENTS

	Page
SUMMARY	iii
LIST OF TABLES	vii
LIST OF FIGURES	x
INTRODUCTION	1
STUDY AREA	3
Watana Creek Hills	3
Jay Creek Mineral Lick Area	3
Archeology	6
East Fork Mineral Lick	6
METHODS	8
Color-Marking	8
Observations-Jay Creek	8
Observations-East Fork Lick	13
Lick Sampling and Analysis	13
Aerial Surveys	16
RESULTS	17
Jay Creek Lick Area	17
Daily Use by Individuals	17
Seasonal Use	20
Disturbance	20

TABLE OF CONTENTS (cont'd)

	Page
Sex and Age of Lick Users	21
Area Use	22
Elevational Use	24
Activities	28
Other Species	39
East Fork Lick	39
Daily Use by Individuals	39
Sex and Age of Lick Users	44
Other Species	45
Lick Analyses	45
Population Surveys	53
Watana Creek Hills	53
Access Corridor	59
Mt. Watana	64
Hunter Harvest - Watana Creek Hills	64
DISCUSSION	64
Impacts of Watana Impoundment	64
Climatic Impacts	68
Increased Human Access	68
Mitigation Recommendations	70
Recommendations for Further Study	71
ACKNOWLEDGEMENTS	71
LITERATURE CITED	72
PERSONAL COMMUNICATION	76

TABLE OF CONTENTS (cont'd)

		Page
APPENDIX I.	Number of different sheep in various sex and age classes using East Fork lick	77
APPENDIX II.	Daily summary of sheep at Jay Creek mineral lick area	79
APPENDIX III.	Miscellaneous observations of sheep in Jay Creek lick areas	91

LIST OF TABLES

		Page
Table 1.	Sheep color-marked in the Watana Creek Hills in April 1983	9
Table 2.	Largest number of sheep seen in Jay Creek lick area in each sex-age group at one time	19
Table 3.	Sheep crossings between the Bluff area and East Ridge observed from 11 May to 11 July	23
Table 4.	Sheep-hours of use at observed licking sites on the Bluff and East Ridge	33
Table 5.	Adjusted standardized deviates for sheep-hours spent feeding and bedded in four locations of study area	34
Table 6.	Adjusted standardized deviates for sheep-hours spend licking, feeding and bedded in 6 elevational zones in entire viewing area	36
Table 7.	Adjusted standardized deviates of time spent licking, feeding, and bedding on the Bluff in six elevational zones	38

LIST OF TABLES (cont'd)

Page

Table 8. Largest number of different sheep seen in each sex and age group during one day at East Fork lick 41

Table 9. Average number of different sheep seen per day per hour of observation for East Fork and Jay Creek licks from 28 May to 16 June and 22-24 June 43

Table 10. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from Jay Creek lick and control sites 46

Table 11. Water soluble mineral elements and sulfate (ppm) from soil samples taken from Jay Creek lick and control sites 48

Table 12. Water soluble mineral elements and sulfate (ppm) from soil samples taken from East Fork lick and control sites 50

LIST OF TABLES (cont'd)

Page

Table 13. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from the East Fork lick and control sites 51

Table 14. Number of Dall sheep observed in the Watana Creek Hills during an aerial survey on 9 March 1983 54

Table 15. Number of Dall sheep observed in the Watana Creek Hills during an aerial survey on 20 June 1983 56

Table 16. Highest summer counts completed during aerial surveys in the Watana Creek Hills 57

Table 17. Sheep seen on aerial survey west of proposed Denali Highway access route on 11 March 1983 60

Table 18. Sheep seen on aerial survey west of proposed Denali Highway access route on 21-22 June 1983 62

Table 19. Legal ram harvest in Watana Creek Hills, 1980-83 65

LIST OF FIGURES

		Page
Fig. 1.	Susitna Basin study area	4
Fig. 2.	Map of Lower Jay Creek mineral lick area	5
Fig. 3.	Locations of mineral licks and color-marked sheep in Watana Creek Hills	7
Fig. 4.	Aerial photograph of Jay Creek mineral lick area	10
Fig. 5.	Hours of observation in Jay Creek lick area and hours sheep were present	11
Fig. 6.	Lick and control sample locations	14
Fig. 7.	Photograph of lick cavity on East Ridge	15
Fig. 8.	Sheep seen in Jay Creek lick area per day	18

LIST OF FIGURES (cont'd)

Page

Fig. 9. Time sheep spent in various locations of Jay Creek lick area during four periods of summer 25

Fig. 10. Time sheep spent in various elevations around Jay Creek lick area 26

Fig. 11. Time sheep spent below 2200 ft and 2300 ft during four periods of summer 27

Fig. 12. Time sheep spent in four activities during four periods of summer 29

Fig. 13. Time sheep spent in various activities at five locations 30

Fig. 14. Photograph of Bluff and East Ridge lick locations 32

Fig. 15. Time sheep spent in activities by elevational zone 35

Fig. 16. Time sheep spent in activities on Bluff by elevational zone 37

LIST OF FIGURES (cont'd)

Page

Fig. 17. Sheep seen at East Fork lick per day 40

Fig. 18. Rate of sheep use of Jay Creek and East Fork licks 42

Fig. 19. Percent by weight of soil with various grain sizes from Bluff, East Ridge, Cabin Ridge and South Field ravine licks 52

Fig. 20. Location of sheep seen on aerial survey of Watana Creek Hills on 9 March 1983 55

Fig. 21. Location of sheep seen on aerial survey of Watana Creek Hills on 20 June 1983 58

Fig. 22. Location of sheep seen on aerial survey west of Denali Highway access corridor on 11 March 1983 61

Fig. 23. Location of sheep seen on aerial survey west of Denali Highway access corridor on 21-22 June 1983 63

INTRODUCTION

Three areas in the vicinity of the Susitna Hydroelectric Project were investigated for project impacts on Dall sheep--the Watana Creek Hills, near Mount Watana, and north and west of the proposed Denali Highway access corridor (Fig. 1). Besides disturbance from construction activities, aircraft traffic, and possibly ground traffic in these areas, probably the major direct impact of the project on sheep will be disturbance of the Jay Creek mineral lick area in the Watana Creek Hills. This lick is adjacent to the proposed Watana impoundment and is used by sheep mostly in early summer. The Jay Creek lick area will be subjected to flooding and erosion, and sheep attracted to the lick will be seasonally vulnerable to human disturbance.

Mineral licks are heavily used by Dall sheep in Alaska and Canada (Dixon 1939, Palmer 1941, Gross 1963, Pitzman 1970, Heimer 1973, Gill 1978). Some sheep have been documented to travel 12 mi out of their way to visit a lick before moving to summer range (Heimer 1973). Heimer (1973) has found that fidelity to the Dry Creek lick in the Alaska Range year after year is high, approximating 100% for ewes, and 80% for rams. Because of the apparent importance of mineral licks to Dall sheep in Alaska, Heimer (1973) recommended that licks be designated critical habitat areas.

Various elements have been suggested as the one sought by ungulates at mineral licks. Essential macro-elements for ungulates are calcium, chlorine, potassium, magnesium, sodium, phosphorus, and sulfur. Essential micro-elements are iodine, iron, copper, zinc, manganese, cobalt, molybdenum, selenium, chromium, tin, vanadium, fluorine, silicon and nickel (Franzmann *et al*. 1975). Hanson and Jones (1976) hypothesized that sulfur may be a major lick attractant. However, as Weeks (1978) pointed out, sulfur is abundant in plant tissues and is not universally found in high levels in natural licks. Hebert and Cowan (1971), Weeks and Kirkpatrick (1976), Fraser and Reardon (1980) and others have presented convincing evidence that sodium is the desired element for moose (*Alces alces*), mountain goats (*Oreamnos americanus*), and white-tailed deer (*Odocoileus virginianus*). At the Dall sheep lick at Dry Creek, Heimer (1973) found 7.3 times as much sodium, 3.0 times as much potassium, 3.6 times as much calcium and 14.9 times as much magnesium in the lick soil compared to soil from nearby areas not eaten by sheep. Because of the high phosphorus content of sheep forage in spring, Heimer (1973) suggested that calcium and magnesium may be the desired elements. However, calcium and magnesium have not been selected by ungulates at lick sites (Stockstad *et al*. 1953, Fraser and Reardon 1980) and there is no evidence for a magnesium appetite even in magnesium-deficient animals (Denton, 1982). Geist (1971a) and Heimer (pers. commun.) have shown that bighorn and Dall sheep exhibit an appetite for sodium by using table salt (NaCl) to bait sheep. Denton and Sabine (1961) reported that a sodium deficiency in domestic sheep does lead to an increased appetite for that element.

Mineral lick use is highly seasonal, occurring mostly in spring and early summer (mid-May through mid-July in interior Alaska). The Dry Creek lick in the Alaska Range has received heaviest use during June. The timing and intensity of use has varied somewhat from year to year depending on weather patterns, which influence sheep movement to licks (Heimer 1973).

The goal of this study was to document the use and importance of the Jay Creek lick to the Watana Creek Hills sheep population. Some aerial observations and limited ground observations during 1980-1982 are reported in Tobey (1981), Ballard *et al*. (1982), and Tankersley (1983). More intense ground and aerial work occurred during 1983 and is the basis for this final report. This included observing and quantifying use of the lick area, classifying the sexes and ages of lick users, determining the seasonal timing of use and chemically analyzing lick samples. Results were compared to use of the East Fork lick (about 7.5 mi north). An additional goal was to document seasonal sheep distribution in the Watana Creek Hills, the area west of the Denali Highway access corridor, and the Mt. Watana area.

STUDY AREA

WATANA CREEK HILLS

The Watana Creek Hills in the northeastern Talkeetna Mountains (Fig. 1) are approximately 20 mi^2. They generally range from 3000 to 5896 ft in elevation, and are roughly bisected by Watana Creek and an unnamed drainage. The vegetation is predominantly woodland spruce in the lower elevations, with birch and willow shrubs, and sedge and grass tundra in higher elevations. Rock cliffs are common in the central hills. Wolves (*Canis lupus*), brown bear (*Ursus arctos*), and in lower elevations black bears (*Ursus americanus*) inhabit the area.

JAY CREEK MINERAL LICK AREA

The Jay Creek mineral lick area occurs in the lower 4 mi of the creek where elevations generally range from 1900 ft to 3000 ft. The vegetation is predominantly spruce woodland with scattered stands of deciduous trees, and birch/willow shrubland. About 2 mi from the mouth on the west side is a large rock bluff (Fig. 2). The Bluff extends along the creek for about 0.2 mi rising to 2550 ft. The Bluff rock is mostly quartz biotite schist with feldspar inclusions in fracture zones and veins. Calcite veins occur along the Bluff face. Some soil, possibly clay weathering products or loess, occurs between the rock crevices and coats some rock surfaces. Much of the lower 200 ft of the Bluff is covered with scree. The Bluff also has stands of aspen and poplar, with scattered spruce trees along the upper portion. Many forbs emerge on the Bluff during May, such as

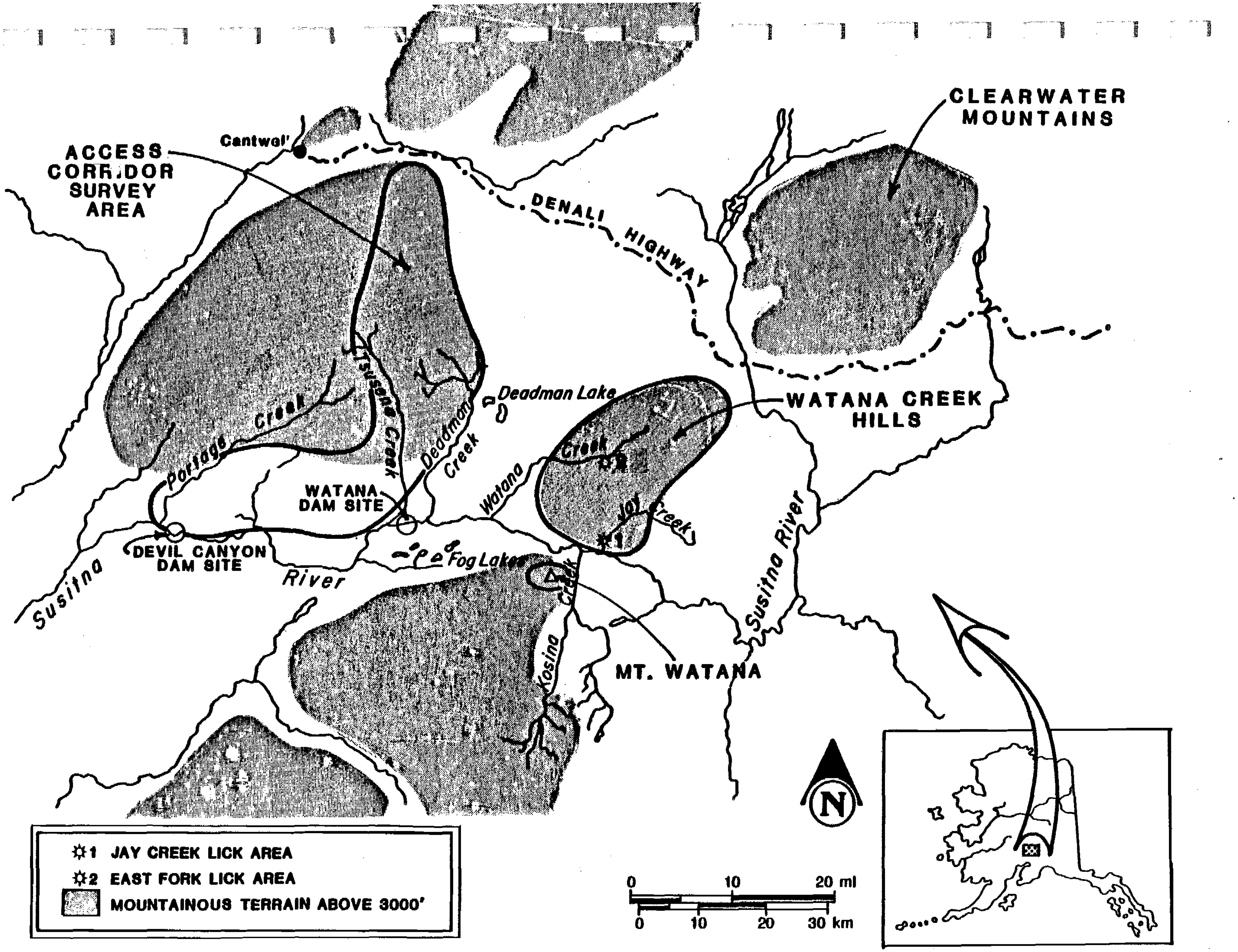

Figure 1. Susitna Basin study area.

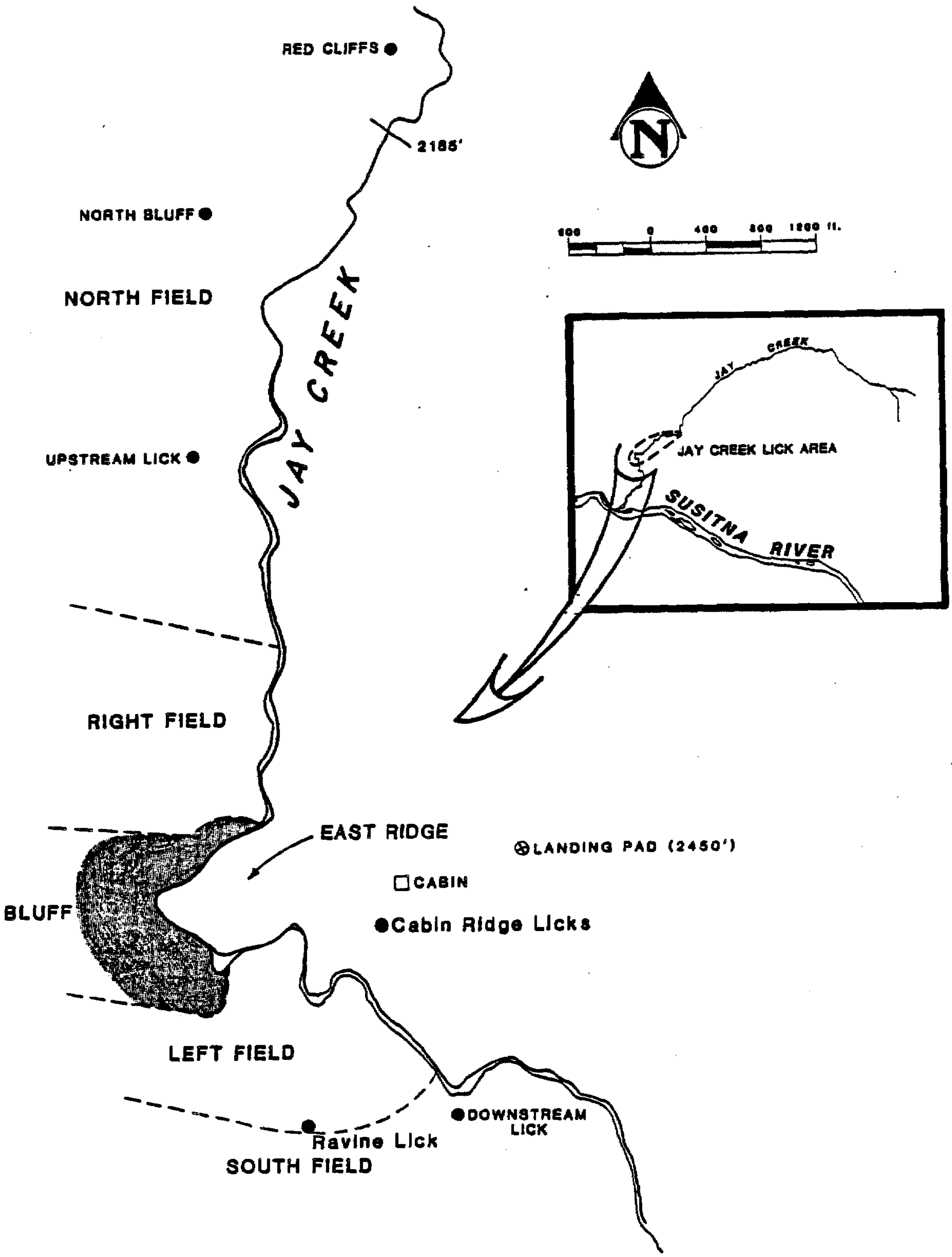

Figure 2. Map of Lower Jay Creek mineral lick area.

anemones, monkshood, saxifrages and pyrola. Lick sites were found on the Bluff (generally 2250-2400 ft), East Ridge (about 2260-2285 ft), downstream (about 1950 ft), and upstream (about 2190 ft, and on north bluff) (Fig. 2). Well-used lick cavities where the fine-grained soil had been eaten were found on East Ridge, Cabin Ridge (about 2290 ft) and in the South Field Ravine (about 2240 ft) (Fig. 2). Sheep trails and scat were found around the red cliffs (Fig. 2) and it appeared this area may be used as a lick, although no lick cavities were located.

Archeology

To date, 22 prehistoric sites have been located in the Jay Creek lick area. Radiocarbon dating on charcoal from two of these sites produced dates which indicated that the oldest component at site TLM 143 (directly north of the Bluff) is about 4100 years old and the oldest component at site TLM 128 (approximately 1.2 mi north of the Bluff) is about 7000 years old. Both of these sites contain animal bones and are probably remains of hunting camps.

EAST FORK MINERAL LICK

The East Fork mineral lick is adjacent to a small tributary of Watana Creek (Fig. 3). Sheep lick at two small areas of wet gray clay exposed on an unvegetated bluff approximately 3500 ft in elevation. The bluff is approximately 250 ft at its base, rising 250 ft high in a triangular shape and is composed of metavolcanic rocks with metabasalts predominating. The surrounding vegetation is predominantly sedge and grass tundra and mat and cushion tundra, with willows and alders lining the creek sides. Steep, rocky cliffs are common in the area. Sheep are common in the area year-round, and caribou (mostly bulls) roam the Watana Creek area during summer.

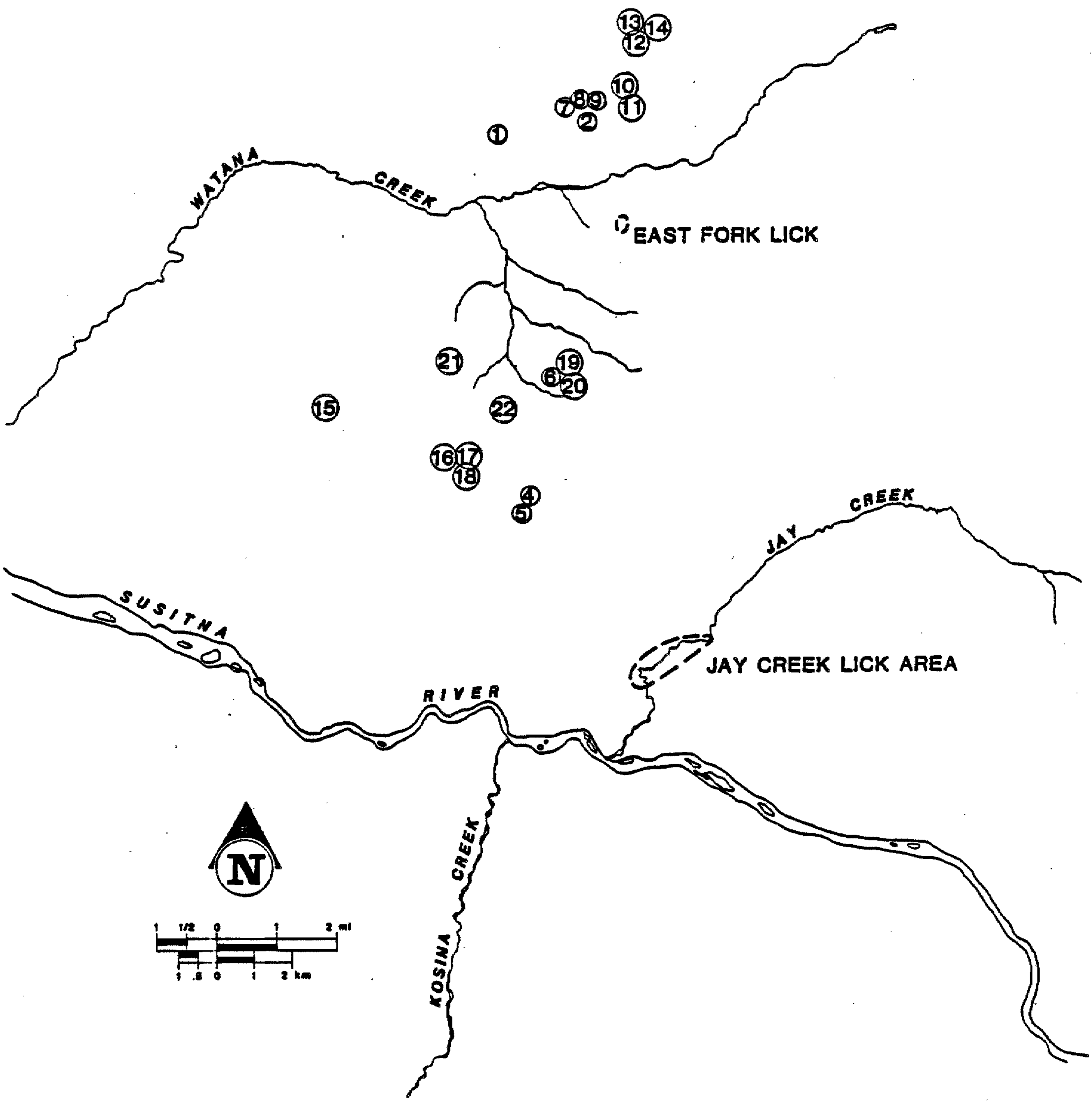

Figure 3. Locations of mineral licks and color-marked sheep in Watana Creek Hills. Circled numbers refer to data in Table 1.

METHODS

COLOR-MARKING

On 5 and 7 April 1983, a total of 21 sheep were color-marked in the Watana Creek Hills (Table 1). This was done to facilitate identification of individuals at the Jay Creek and East Fork licks, and also to determine the distance travelled to the Jay Creek licks. Ten ewes and sub-yearlings north of Watana Creek were marked with red paint, and 10 ewes and sub-yearlings and one young ram south and east of Watana Creek were marked with blue paint (Fig. 3). A CO_2-charged Nel-Spot Paint Pellet Pistol firing oil-based paint pellets and a Cap-Chur rifle type projector firing syringes (without needles) filled with oil-based paint were used for marking the sheep from a Bell 206B III helicopter. The resulting marks varied from spots about 2 in. in diameter, to streaks up to 15 in.

OBSERVATIONS - JAY CREEK

The study area was divided into zones by location (Fig. 4) and 100-foot elevational differences. Elevations in the Bluff area were estimated with a Micro M-1 surveying altimeter and markers were placed at the 2100', 2200', 2300', 2400' and 2500' levels. Marker locations and estimates of one-hundred foot elevational contours were drawn on a 9" x 13½" black and white photograph of the Bluff area.

Detailed observation of sheep in the Jay Creek lick area began 15 May 1983 and ended 11 July 1983. General notes on the number and sex and age of sheep in the area were kept during camp construction, 11-14 May. The area usually was observed from 0400 - 2100 hours daily, with a few exceptions due to rest periods, fog, helicopter logistics or lack of personnel (Fig. 5). Observations were made from or near an 8' x 8' plywood cabin (Fig. 4) with the aid of 10 x 40 binoculars and a 20-45x spotting scope. Not all

Table 1. Sheep color-marked in the Watana Creek Hills in April, 1983.

Sheep# for Fig. 3	Age-Sex	Color	Type	Comments
1	young ewe	red	pellet	
2	ewe	red	pellet	
2*	ewe	red	dart	
4	sub-yearling	blue	pellet	w/ewe #5
5	ewe	blue	pellet	w/# 4 sub-yearling
6	ewe	blue	pellet	
7	ewe	red	dart	
8	ewe	red	dart	
9	young ewe	red	dart	
10	sub-yearling	red	dart	
11	ewe	red	dart	
12	ewe	red	pellet	
13	ewe	red	pellet	
14	sub-yearling	red	pellet	
15	young ram	blue	dart	
16	ewe	blue	dart	
17	sub-yearling	blue	dart	
18	sub-yearling	blue	dart	
19	sub-yearling	blue	dart	
20	sub-yearling	blue	pellet	
21	ewe	blue	dart	
22	ewe	blue	pellet	

* Sheep #2 marked twice. No sheep #3.

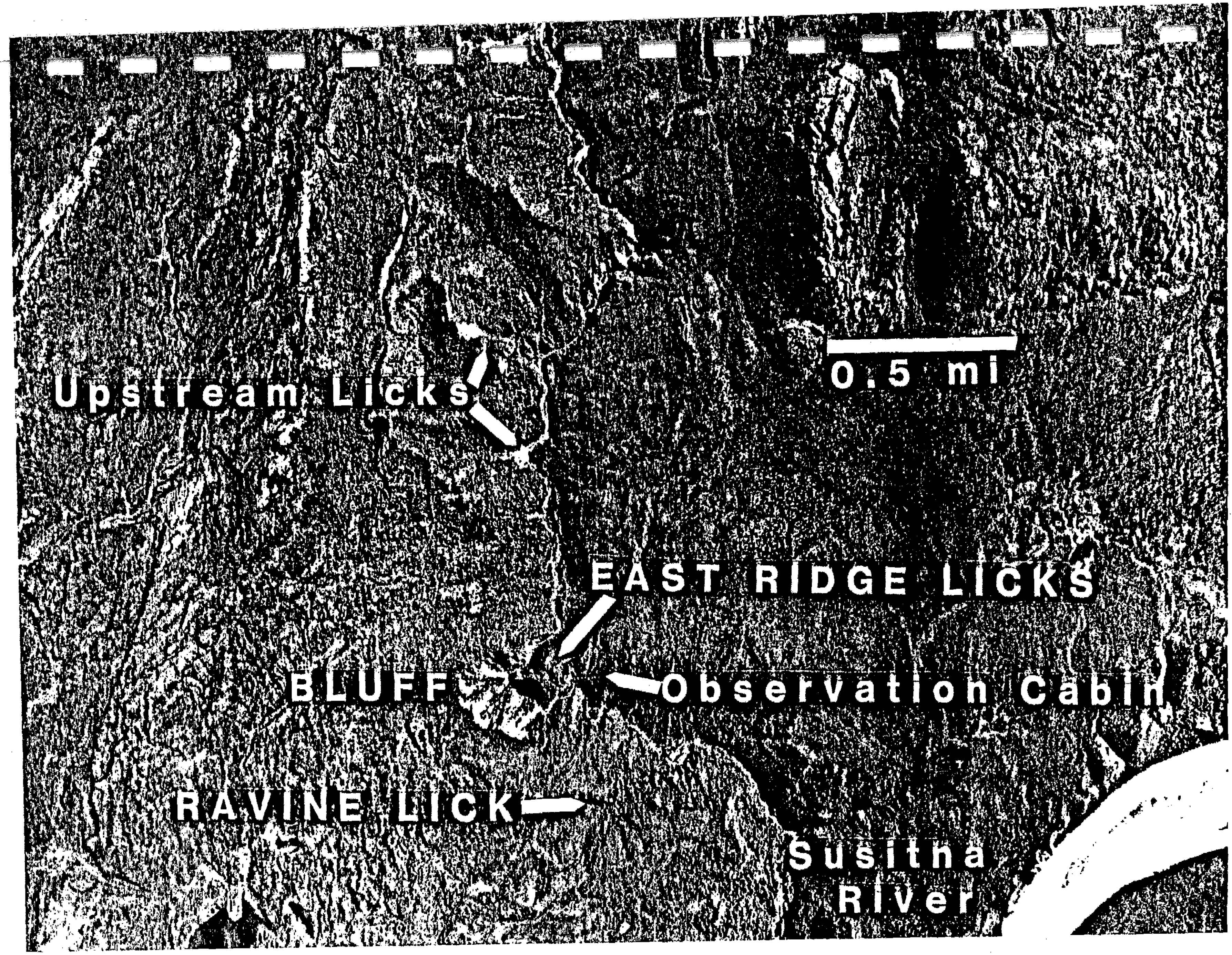

Figure 4. Aerial photograph of Jay Creek lick area.

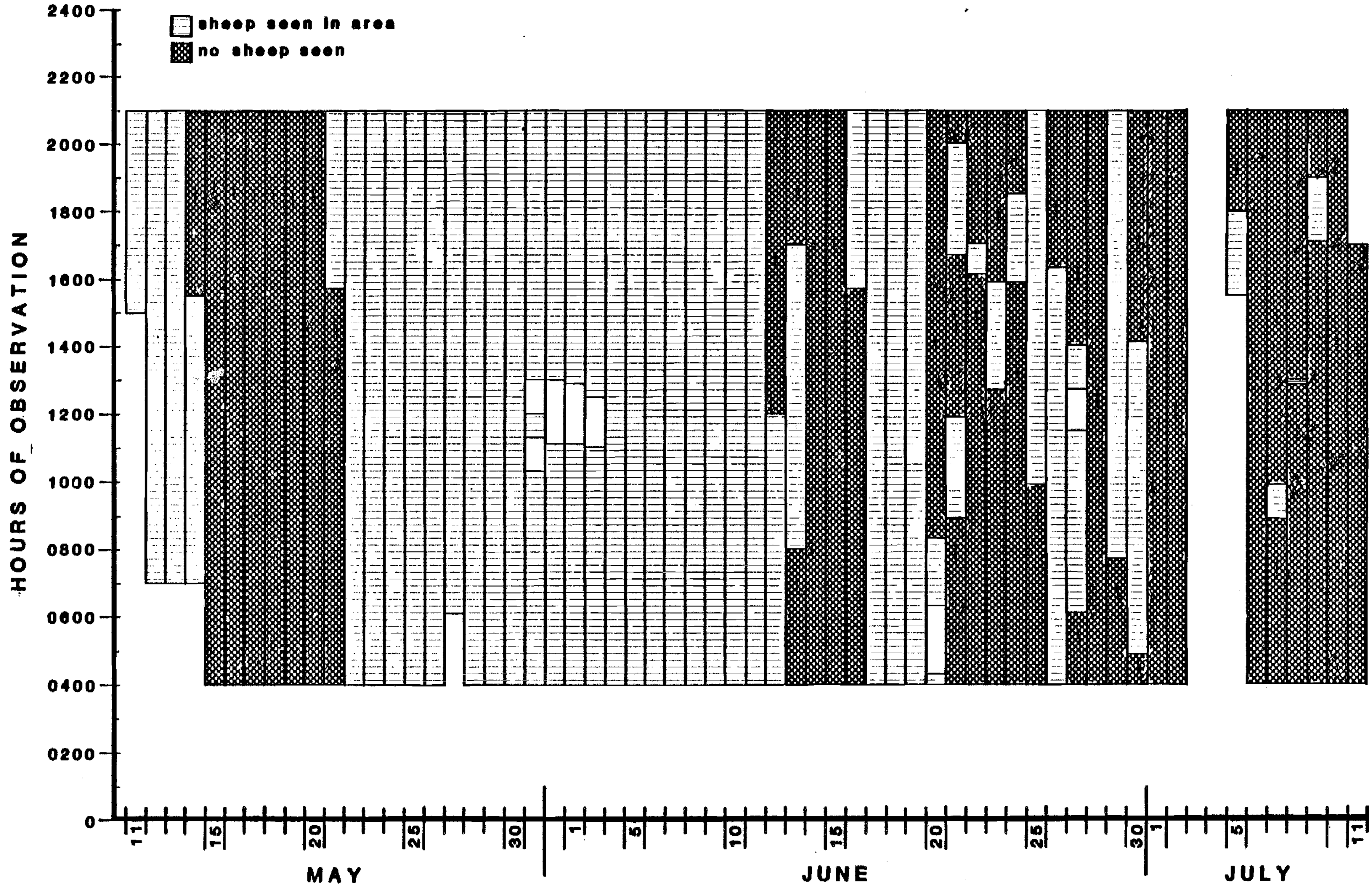

Figure 5. Hours of observation in Jay Creek lick area and hours sheep were present.

of the lower Jay Creek drainage could be seen from the observation cabin, especially the east side. Some observations of sheep on the bluff were made by observing from the East Ridge during 15-30 May until sheep were observed using the area for licking, feeding and resting. Sheep seen moving to areas out-of-view were kept track of until they returned or were assumed to have left the area.

A helicopter landing zone, about 800 ft east and 160 ft higher in elevation from the observation cabin (Fig. 4), was established to reduce the disturbance to sheep in the lick area. Also, pilots approached the zone from the east or south to reduce disturbance.

When sheep were present, the activity and number of sheep in each area and elevation were recorded every ten minutes. For analysis, these sampling observations were divided by 6 to obtain an estimate of sheep-hours spent in a location or in a certain activity. Beginning 19 June, the general weather conditions were recorded at these intervals also. The sex, age, ram horn size and time of all sheep entering or leaving the study area, as well as those present at 0400 hours, were recorded daily. Sheep in the lick area were categorized as: adult ewe, lamb, yearling, two-year old, or by the rams minimum horn curl size: 1/4-curl, 1/2-curl, 3/4-curl, 7/8-curl. Ages and curl size were assessed by referring to drawings in Nichols (1972) and the Alaska Hunting Regulations No. 23 (1982-83). Young rams were distinguished from ewes by their genitals. Color-marked sheep, or other identifiable individuals seen, were noted daily. Also, the sex, age and number of sheep crossing Jay Creek in the study area were recorded daily.

Records of elevation and activities of sheep began when they were first seen moving towards the main lick area (mostly from the north or east). Areas where sheep licked the mineral substrate on the Bluff and East Ridge were circled and numbered on 9" x 13½" black and white photograph. If a sheep was seen licking or eating soil at the 10-minute sampling period, the location of the lick spot was also recorded. Daily maximum and minimum temperatures, rainfall and general observations of sun, clouds and wind were also recorded.

OBSERVATIONS - EAST FORK LICK

Sheep using the East Fork lick were observed daily from 28 May to 16 June, and from 22-24 June from 0400 - 2100 hours with a few exceptions (Appendix I). The number of different sheep that used the lick, as well as their sex, age and curl size (rams') were recorded daily. The time of lick use, and an estimate of the number of lick visits made per individual were also recorded. (A lick visit was defined as a continuous period on the lick bluff).

LICK SAMPLING AND ANALYSES

Forty-four soil and rock samples from lick areas and comparative sites were collected in the Watana Creek Hills during June and July for mineral element analyses (Fig. 6). Some well-used lick sites (East Ridge, South Field ravine, Cabin Ridge) had obvious cavities where sheep had eaten into the soil (Fig. 7), which made locating sampling sites easy. However, sites on the Bluff, and lesser used upstream and downstream sites did not have this feature, and locating exact lick spots was much more difficult. Jay Creek control samples were taken from unused soil sites, sometimes with a different color and texture, along the creek and other areas in the hills. Lick samples from the East Fork lick were taken from two small sites on the bluff where mud was eaten. Control samples were taken from other exposed soil on the bluff which was not eaten by the sheep. Samples were collected with plastic utensils and placed in plastic bags to avoid contamination from handling.

Samples were analyzed by the inductively-coupled argon plasma (ICAP) scan method for 15 elements plus sulfate (Tables 10-13).

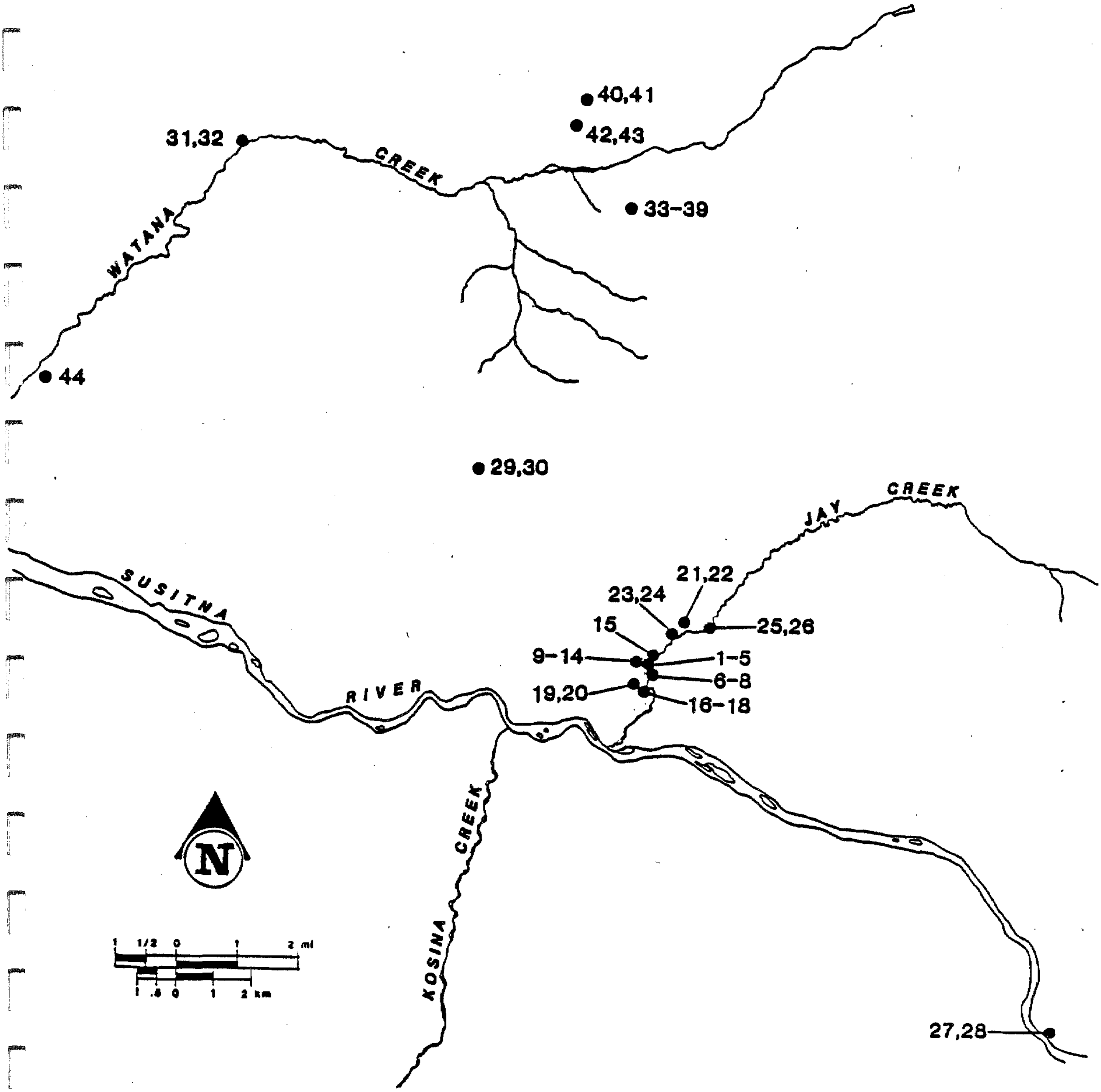

Figure 6. Lick and control sample locations.

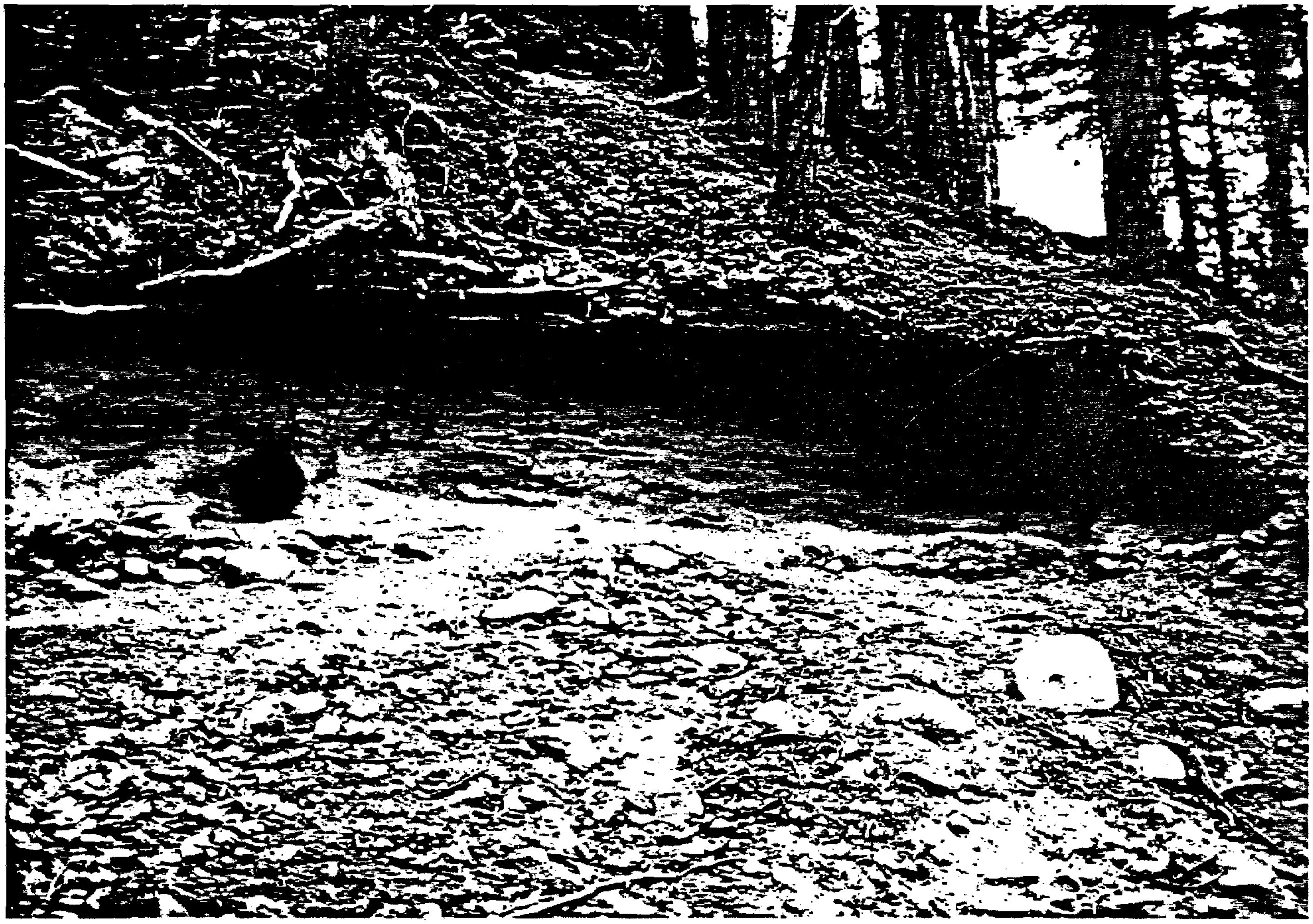

Figure 7. Photograph of lick cavity on East Ridge.

Although only 10 samples were selected for water soluble element analyses, because of confusion with the laboratory all 44 samples were analyzed for water soluble cations. Twenty-five of these were also analyzed with a 4:1 reagent grade nitric:hydrochloric acid leach for "total" elemental content, by the ICAP method. Also, 22 samples were analyzed for sulfate content. The water soluble cations would certainly be available for sheep digestive intake. However, the acid in the rumen is not as strong as what was used for "total" elemental content and not all of the elements released by aqua-regia digestion would be metabolically available to sheep.

AERIAL SURVEYS

A late winter sheep distribution survey of the Watana Hills was done with a Piper PA-18 Super Cub on 9 March 1983 by an inexperienced observer and an experienced pilot/observer. Mountainous areas were searched for sheep or tracks by flying along a mid-level contour and circling. Flatter (snow-covered) areas were searched less intensively. The temperature was about 20°F with sunshine, mostly calm skies and nearly complete snow cover (less than 1 week old) with little or no snow on south-facing and steep slopes. Another survey was flown on 20 June 1983 to look for lambing areas, new mineral licks, and to obtain a more complete population count. This survey was also done in a Piper 18 Super Cub with the same observer, but another experienced pilot/observer using the same search method. The weather was mostly sunny, about 45°F with only light turbulence. Snow remained in gulleys and patches above 3200 ft (except for south-facing and steep slopes) making observation conditions only fair to good. All sheep observed on these surveys were classified by ram horn size, or as "ewes" (mostly ewes, yearlings and 2-year olds) or lambs, counted by group, and their locations plotted on a 1:250,000 scale U.S.G.S. togographic maps.

RESULTS

JAY CREEK LICK AREA

Daily Use by Individuals

From 11 May to 11 July, the number of different sheep seen daily in the Jay Creek mineral lick area varied from 0 to 31 individuals (Fig. 8). A minimum of 46 different sheep using the Jay Creek licks was calculated (Table 2). Some recognizable individuals (color-marked and others) stayed from 2 to 15 days (Appendix II). Some of this variation was due to the seasonal nature of mineral lick use and observer or aircraft disturbance (discussed below), while other variation may have occurred due to weather-influenced travel. For example, the absence of sheep during 14-15 June (Fig. 8) may be due to severe wind and thunderstorms which occurred late on 13 and 14 June. Sheep (mostly ewe-lamb groups) were again present in the area on 16 June, which was followed by several mostly sunny and calm days.

Color-marked individuals were rarely resighted. Only two blue-marked sheep were observed in the Jay Creek lick area--ewe #6, and sub-yearling #17 on 29-31 May (Appendix II). Ewe #22 was observed about 0.5 mi southeast of her marking location on 16 May. The low level of resightings of blue color-marks was probably due to fading and molting of the color-marked area. Blue was a difficult color distinguish from grayish dirt spots and molting areas. Rams began molting in mid-May, and by early June most all sheep except pregnant ewes were molting. No red-marked sheep were resighted. The absence of red-marked sheep resightings was probably because most if not all red-marked sheep remained north of Watana Creek until at least early July. This area was a major lambing area, where a large concentration of ewes, lambs, yearlings, and two-year-olds were observed throughout June.

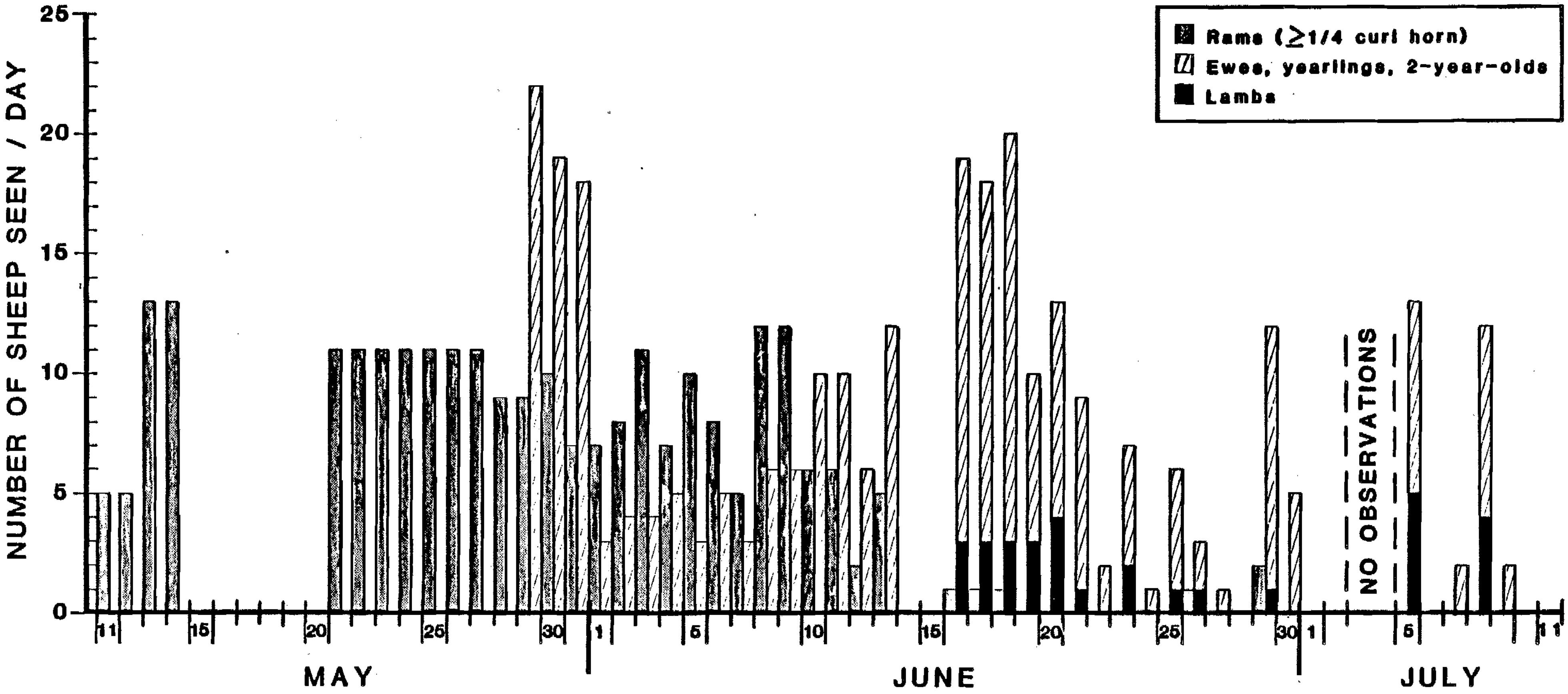

Figure 8. Sheep seen in Jay Creek lick area per day.

Table 2. Largest number of sheep seen in Jay Creek lick area in each sex-age[a] class at one time.

	E	L	Y	2-Y	RAMS $\geq 1/4$	RAMS $\geq 1/2$	RAMS $\geq 3/4$	RAMS $\geq 7/8$	TOTAL
	10	5	7	4	5	9	3	3[b]	
TOTAL	26 ewes and young				20 rams				46

[a] These codes will be used for all tables:

E = ewes
L = lambs
Y = yearlings
2Y = 2-year-olds
$\geq 1/4$ = $>1/4$ curl ram $<(1/2$ curl)
$\geq 1/2$ = $\geq 1/2$ curl ram $<(3/4$ curl)
$\geq 3/4$ = $\geq 3/4$ curl ram $<(7/8$ curl)
$\geq 7/8$ = $\geq 7/8$ curl ram

[b] This included 1 full curl ram and 2 less than full curl.

Seasonal Use

From 11 May to 11 July, sheep were frequently seen in the study area, with some exceptions (Fig. 5). From 15 May to 11 July, a collective total of 5,615 hours of sheep use time was recorded in the study area, resulting in an average of 6.1 sheep use hours per hour of observation. Sheep were continually present in the area from 21 May to 12 June (Fig. 5). Another intensive use period occurred from 16 to 20 June when ewes first brought their lambs to the lick area. The shorter use periods recorded after 20 June (Fig. 5) probably occurred because lick attraction was declining although sheep were still coming to the lick area as late as 10 August (Appendix III). Disturbance from the common late afternoon and evening wind and thunderstorms may have also contributed to shorter use periods.

Disturbance

Overall, sheep disturbance from humans in the lick area was minimal. Only three incidents provoked sheep to exit the lick area for some amount of time. On 14 May, 14 rams in Right Field exited the area to the north after seeing two of us photographing them from the Bluff area. Some of these rams returned to the Bluff area on 21 May (Appendix II). Two other times when one or two sheep travelled by the observation cabin and saw observers, they exited east (4 June and 9 July). Occasionally, sheep using East Ridge were aware of human observers in or near the cabin, but this did not cause them to leave. From 11 May to 30 May, observers were occasionally present on East Ridge when sheep were using the Bluff. This may have hindered sheep use of East Ridge during this time.

Only two out of 19 helicopter landings at the cabin or at the landing pad caused sheep to leave the area. Aircraft overflights and landings in the study area were generally discouraged, except when necessary to transport personnel or supplies. Usually radio communication aided in setting helicopter transport times when few or no sheep were present. Also, helicopter pilots approached the area from the south or east to reduce disturbance. On 20 June, a ewe and lamb group of 10 exited north from the Bluff when a helicopter landed at the pad to transport an observer for aerial fixed-wing survey work. Eight of these sheep had been in the area since 16 June, two since 18 June, and had spent most of the morning on the upper right portion of the Bluff and in Right Field. It appeared that this group was preparing to leave anyway. On 23 June, an unsolicited helicopter landing caused a ewe-lamb group of seven sheep to cross from East Ridge to the Bluff, then continue to exit north. This group was new to the area that morning, although they could have been using the area a few days earlier and spending time east of the study area.

Only one fixed-wing overflight caused sheep to exit the study area. No record was kept of the number and approximate altitude of overflights by fixed-wing aircraft, but there were approximately four overflights per week. On 8 July, a Cessna 180 flying approximately at 1,000 ft above ground level disturbed an approaching group of 12 ewes and lambs in North Field. They exited north and did not return by 11 July.

Sex and Age of Lick Users

Five rams were present in the lick area on 11 May when observations began. Rams used the area exclusively from 11-28 May and most ram use occurred before 14 June (Fig. 8). Large ewe groups appeared on 29 May. The size of ewe groups in the study area dropped on 1 June, then slowly increased with another peak during 16 to 18 June (Fig. 8). Lambs were first brought to the study area during this second peak. Appendix II has a complete list of sexes and ages of sheep using the lick area on a daily basis. The minimum number of different individuals using the Jay Creek licks in each sex and age class is listed in Table 2.

Area Use

Generally, groups of sheep entered the lick area for the first time from the mountains to the north or northwest, a distance of at least 5 mi. Often, the Bluff was visited first. Individuals or groups of sheep would commonly mix or separate and travel around the Bluff, South Field, East Ridge or upstream areas (Fig. 2) from a few days up to 2 weeks. Only one group of sheep (6 ewes and 1 lamb) were ever seen venturing south of the downstream lick (Figs. 2, 4) (for 2 hours on 17 June). Twenty-four crossings of Jay Creek by a total of 99 sheep (not all different individuals) between the Bluff area and East Ridge were documented during the study period (Table 3). Eleven of these were from the west side to the east side; 13 were from east to west. Obviously, not all crossings in the area were observed (e.g., between 2100-0359 hours) and some crossings occurred upstream out of the viewing area.

Collectively, sheep spent 57.5% of all recorded time on the Bluff, followed by 16% in Right Field and North Field (which included the main travel corridor), 11.4% on the East Ridge and nearby areas, 8.0% in the South Field area and 7.1% in Left Field. The proportions of time in the various areas varied during periods of the summer.

Four time periods between 15 May and 11 July were chosen to analyze the time spent by sheep in the lick area (Fig. 9). These were based on the sex and age groups and number of sheep seen in the area (Fig. 8). Use of the Bluff area was highest during 29 May to 13 June (Fig. 9). Early (15-28 May) and late (1-11 July) in the lick season, Right Field and North Field were used the most. The early use is high probably because observations began after rams had already used the main licking areas and were spending most of their time feeding and traveling to lesser-used upstream licking areas and back to the mountains. Late use was

Table 3. Sheep crossings between the Bluff area and East Ridge observed from 11 May to 11 July.

			*				RAMS				
DATE	TIME	# SHEEP	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	COMMENTS
5/30	0730	3						1	1	1	Bluff to East Ridge
6/1	1620	1								1	East Ridge to Bluff
6/4	1130	1								1	Bluff to East Ridge
6/5-6	overnight	3					1	1	1		Bluff to East Ridge
6/7	1230	1						1			East Ridge to Bluff
6/13	1050	12	7			2	1	2			East Ridge to Bluff
6/17	1540	8	5			2	1				Bluff to East Ridge
	1820	7	5			2					East Ridge to Bluff
6/17-18	overnight	1					1				East Ridge to Bluff
6/18	0430	5	4		1						Bluff to East Ridge
	0650	5	4		1						East Ridge to Bluff
	1250	10	5	3	2						Bluff to East Ridge
	1330	1				1					Bluff to East Ridge
	1830	10	5	3	2						East Ridge to Bluff
6/20-21	overnight	3	2	1							Bluff to East Ridge
6/23	1510	7	4	2		1					East Ridge to Bluff (probably scared by helicopter)
6/26	1110	2	1		1						Bluff to East Ridge
	1320	1						1			East Ridge to Bluff
	1440	2	1		1						East Ridge to Bluff
	1600	3	1	1	1						Bluff to East Ridge
6/29	1050	2							2		East Ridge to Bluff
	1330	3	2		1						Bluff to East Ridge
	1900	6	3	1		2					East Ridge to Bluff
	2000	2	1		1						East Ridge to Bluff

*See Footnote "a" on Table 2 for explanation of abbreviations.

proportionately high probably for similar reasons, except that it was ewe groups using the area (Fig. 8) for a relatively small amount of time (Fig. 9A). Sheep use of the East Ridge did not begin until 30 May, probably because sheep were hindered to some extent from using it by observers on the Ridge periodically until that time. East Ridge use peaked during 14-30 June and remained relatively high during 1-11 July (Fig. 9). Generally, sheep returned to the north or northwest. However, sheep frequently used the east side of Jay Creek after 30 May and it appears that some sheep spent considerable time foraging in the hills to the east of the lick area during June (see Population Surveys). On 1 or 2 June, 8 sheep (2 rams, 6 unknown) were seen at bluffs along the Susitna River southeast of the main lick area where lick samples #27 and 28 were taken (Fig. 6). Some sheep made at least two trips to the lick area from the mountains to the north (Appendix II).

Elevational Use

Of all the sheep that could be viewed, more of their time was spent between 2200-2299 ft (25.7%) than in any other 100-ft contour (Fig. 10A). However, these figures do not include time spent in areas not completely visible, but below a certain maximum elevation. For example, sheep spent time hidden in areas such as the South Ridge (below 2,300 ft) and on the Bluff behind the East Ridge (below 2,200 ft). When these periods of time are incorporated into the analysis, sheep spent 13.8% of the time below 2,200 ft, and 46.4% of the time below 2,300 ft (Fig. 10B).

These averages have seasonal components (Fig. 11). Sheep use of these lower elevations peaked during 29 May to 13 June, a time when total use of the area was also high (Fig. 11A).

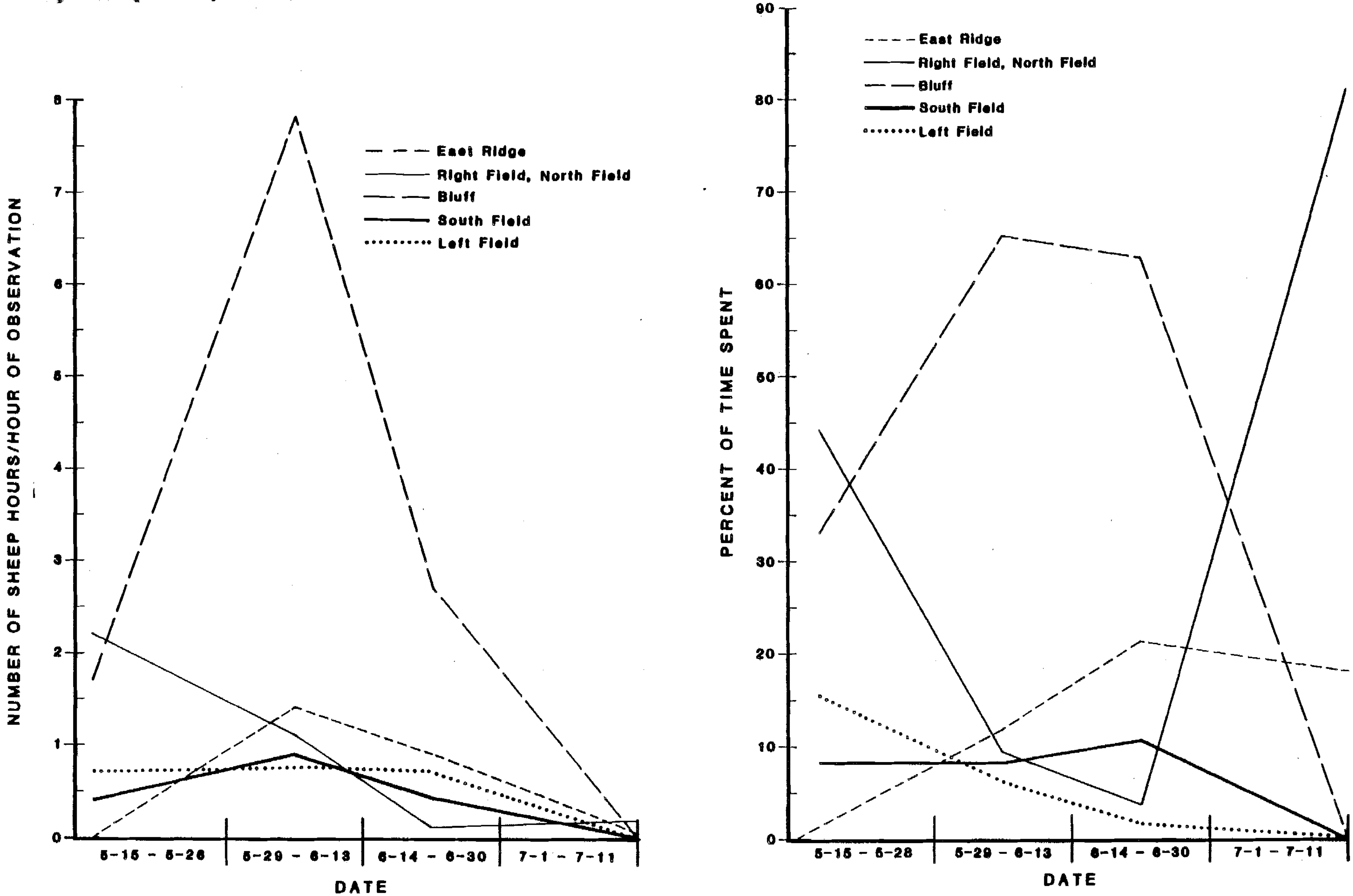

Figure 9. Time sheep spent in various locations of Jay Creek lick area during four periods of summer.

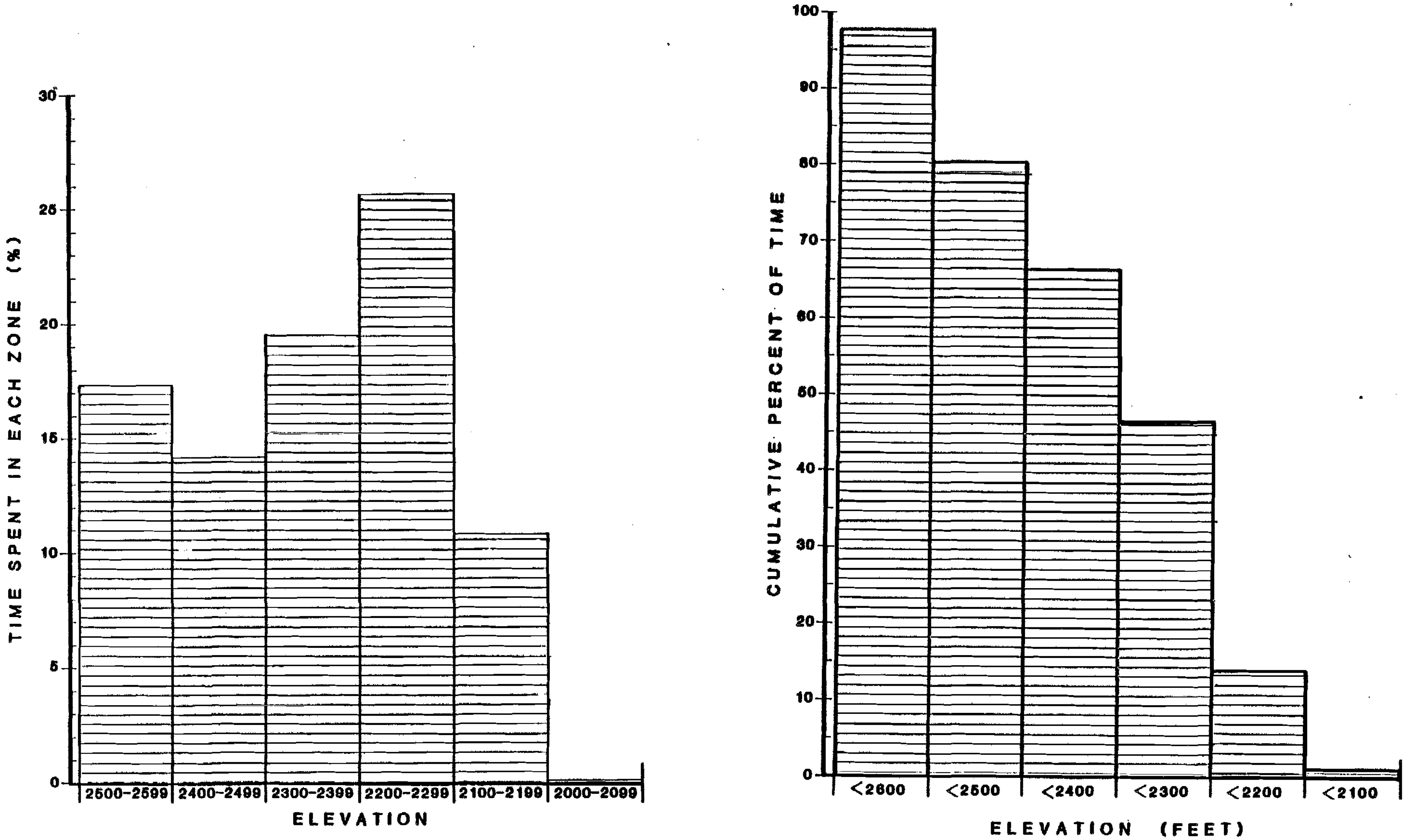

Figure 10. Time sheep spent in various elevations around Jay Creek lick area.

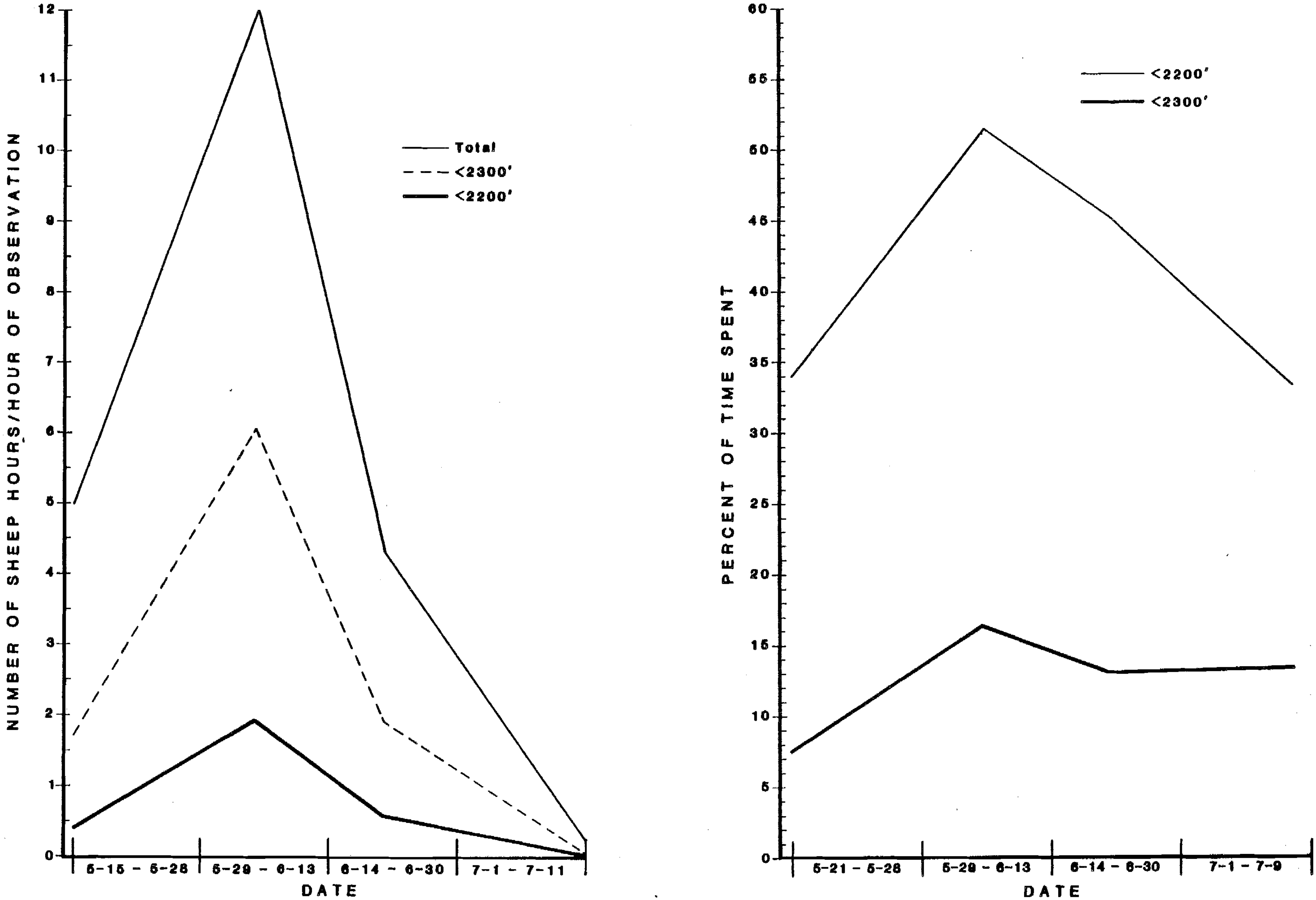

Figure 11. Time sheep spent below 2200 ft and 2300 ft during four periods of summer.

Activities

Sheep activity type was recorded every 10 minutes. An analysis of variance of activity type with four periods of the day revealed that there was no relationship between the two. So, days with some missing observation times (Fig. 5) could be included in the activity analysis. Also, there was no relationship found (P‘0.001) between activity and presence of rain, so all data was used without regard to rainy periods. However, the weather data at 10-minute intervals was only collected after 19 June and the sample size for rainy periods was low (49 out of 643 cases). Also, rain or other weather conditions may have affected the presence of sheep in the area (e.g. traveling to the study area), rather than activity once in the study area (see Daily Use by Individuals).

Of 5,615 hours of observed sheep activity, most was spent bedded (32.7%), followed by feeding (30.3%), hidden from view (25.4%), moving or standing (8.7%), and licking (3.0%). If the time spent hidden is omitted, overall sheep spent their time bedded (43.8%), feeding (40.6%), moving or standing (11.6%), and licking (4.0%). These proportions varied somewhat seasonally, with licking gradually increasing during four periods of the summer, and moving or standing and feeding showing an inverse relationship (Fig. 12A). Period 4 is somewhat anomalous, showing no feeding or bedding, probably because the time spent was very small (Fig. 12B) and only East Ridge and North Field were used at this time for brief licking and traveling bouts (Fig. 8). The total time spent licking is definitely under-represented because some known lick sites (e.g. South Field ravine and Cabin Ridge) were not visible.

A compilation of sheep-hours in various activities in 5 locales is shown in Fig. 13. Seventy-five percent of the licking observed occurred on the Bluff and the remainder was observed on

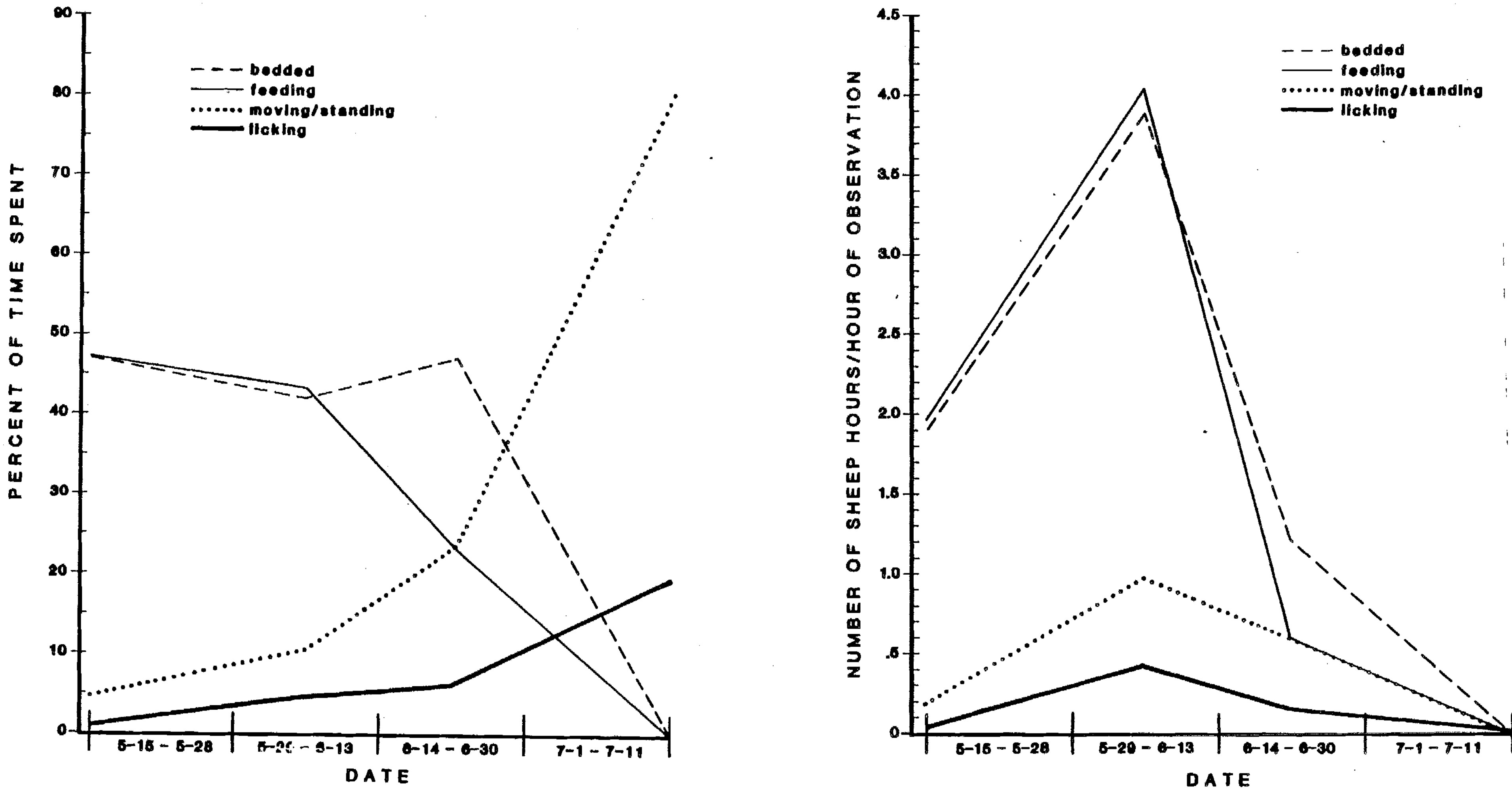

Figure 12. Time sheep spent in four activities during four periods of summer.

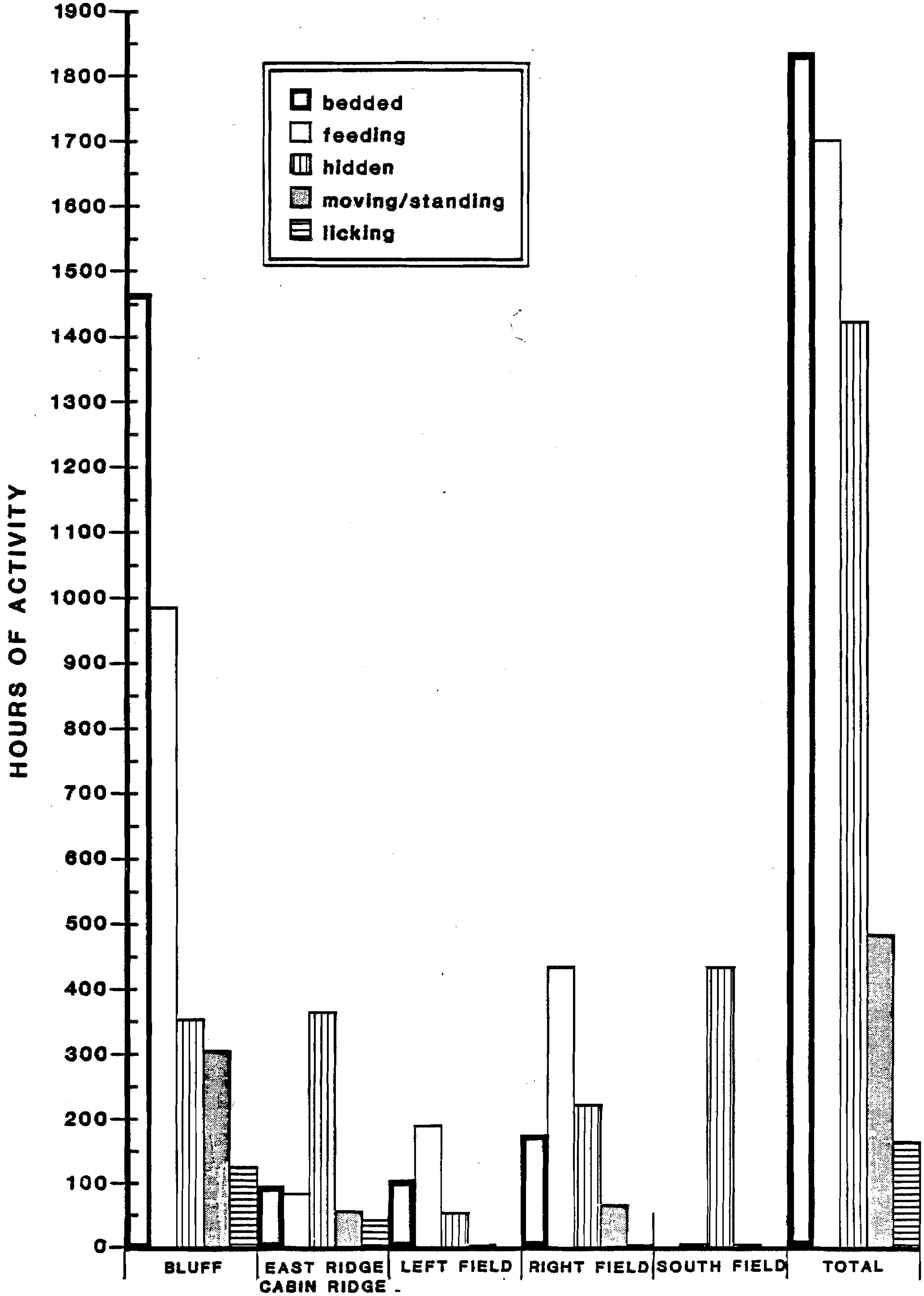

Figure 13. Time sheep spent in various activities at five locations.

East Ridge. The two known licking sites on East Ridge (Fig. 14) ranked second and fourth out of all sites observed (Table 4). However, this is not an accurate indication of the true distribution of licking intensity in Jay Creek because not all downstream and upstream lick sites were not completely visible. Because moving or standing was usually a transitional activity between bedding, feeding or licking, only bedding and feeding activities were statistically analyzed. The Bluff was used more than expected for bedding than feeding ($P<0.001$), whereas the Left and Right Field areas were used more than expected for feeding than bedding ($P<0.001$) (Table 5). No statistical difference was found between these two activities in the East Ridge vicinity, but these activities constituted only 27.4% of the sheep-hours observed there (57.1% of the time the sheep activities were hidden from view) (Fig. 13). South Field had too little activity data (97% was hidden) to analyze. Most likely a large proportion of the time sheep spent hidden in South Field (435 sheep-hours) was at the lick.

A compilation of sheep-hours in various activities at 9 different elevational zones is shown in Fig. 15. Licking, of course, occurred more between 2200-2399 ft ($P<0.001$) with 85% of the licking observed there. The areas below 2200 ft and 2400-2499 ft were used more than expected for feeding than licking or bedding ($P<0.001$)(Table 6). Bedding occurred more than expected at 2200-2299 ft and 2500-2599 ft ($P<0.001$).

Sheep-hours of activities only on the Bluff at 6 elevations are shown in Fig. 16. Again, most of the licking (82%) occurred between 2200-2399 ft ($P<0.001$) (Table 7). Twenty-seven different licking sites on the Bluff were generally located; only four of these occurred below 2200 ft and six between 2400-2499 ft. The five most used Bluff sites are identified in Fig. 14. Feeding occurred more than expected below 2200 ft ($P<0.001$)

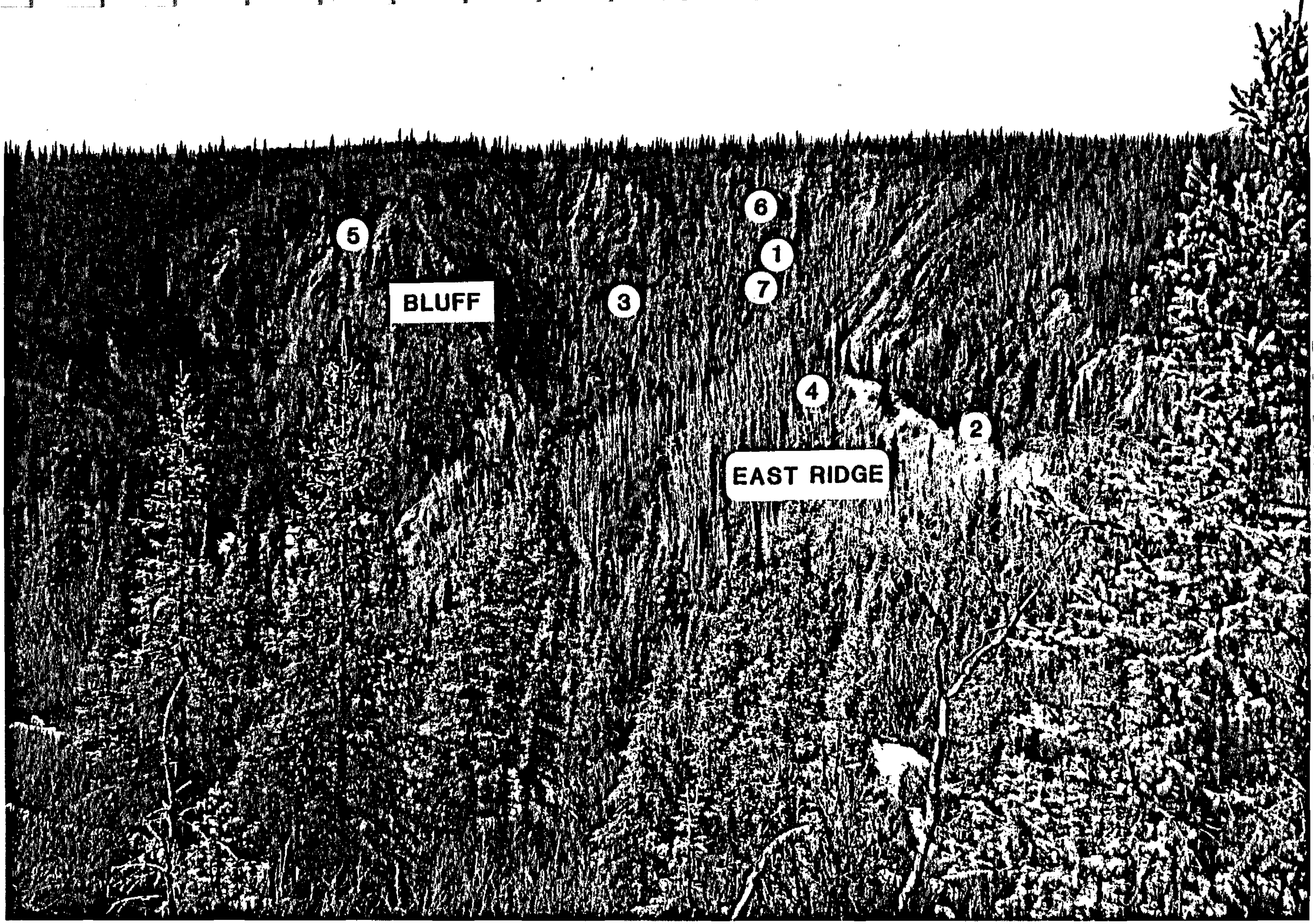

Figure 14. Photograph of Bluff and East Ridge lick locations. Circled numbers refer to data in Table 14.

Table 4. Sheep-hours of use at observed licking sites on the Bluff and East Ridge. This does not include popular lick sites in South Field ravine and other downstream and upstream areas.

LICK # FROM FIG. 14	APPROXIMATE ELEVATION (FT)	SHEEP-HOURS
1	2320-2350	36.2
2	2285	28.0
3	2250-2290	20.3
4	2260	12.7[a]
5	2380-2400	8.5
6	2400-2500	8.0
7	2280-2300	7.7

[a] Observation of this lick became difficult after leaf-out mid-June.

Table 5. Adjusted standardized deviates for sheep-hours spent feeding and bedded in four locations of study area. All locations except East Ridge and Cabin Ridge show significant differences (P<0.001). Licking was not included in the analysis because it was only observed on the Bluff and East Ridge.

Location	Bluff	Left Field	East Ridge Cabin Ridge	Right Field North Field
Feeding	-34.3	14.6	-0.5	31.5
Beeded	34.3	-14.6	0.5	-31.5

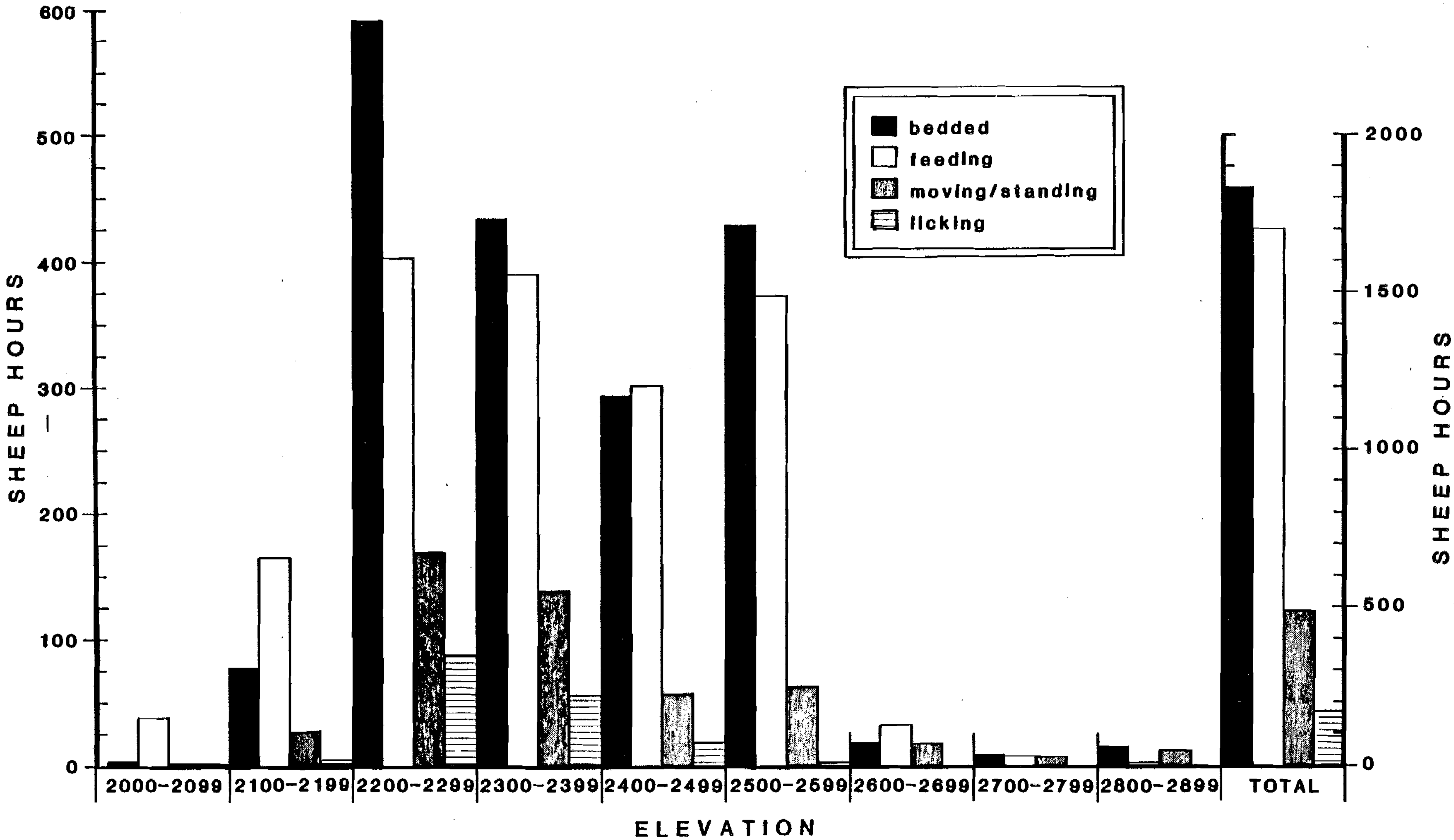

Figure 15. Time sheep spent in activities by elevational zone.

Table 6. Adjusted standardized deviates for sheep-hours spent licking, feeding and bedded in 6 elevational zones in entire viewing area. All scores were significantly different than expected (at least $\underline{P} < 0.05$) except feeding at 2500-2599 and bedded at 2300-2399.

Elevation	2000-2099	2100-2199	2200-2299	2300-2399	2400-2499	2500-2599
Licking	- 2.6	- 5.0	16.4	6.6	-5.5	-16.1
Feeding	14.1	16.9	-14.7	-2.5	4.5	0.8
Bedded	-13.0	-14.8	7.8	-0.3	-2.2	6.0

NOTE: Activities at elevations above 2600 ft were not analyzed because no licking occurred there, and the activity data collected comprised only 2% of the total. Also, the "moving or standing" activity category was not analyzed because this was only a transitional activity among licking, feeding and bedding.

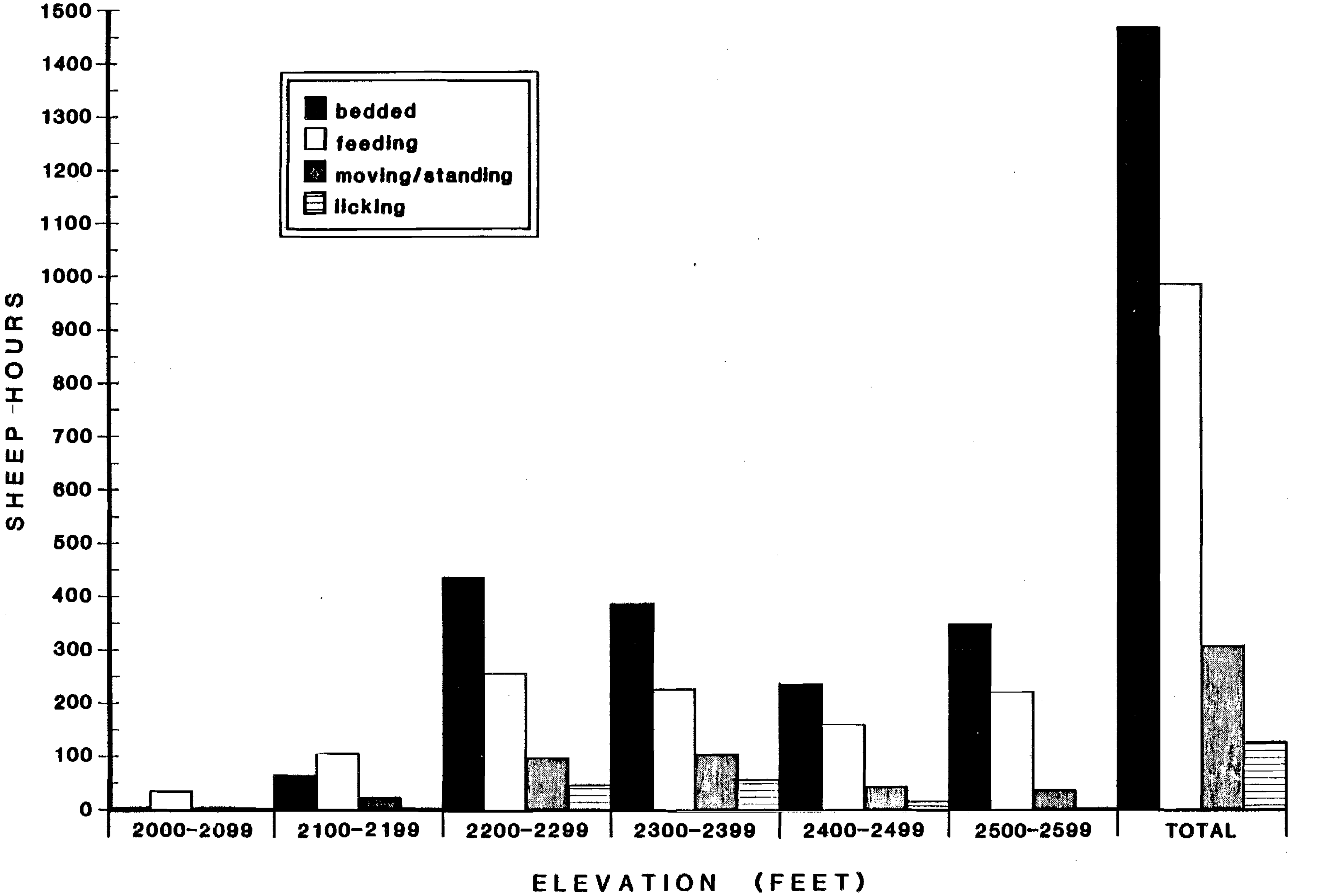

Figure 16. Time sheep spent in activities on Bluff by elevation zone.

Table 7. Adjusted standardized deviates of time spent licking, feeding and bedding on the Bluff in six elevational zones. All but those with * are significantly different than expected (P <0.05).

Elevation	2000-2099	2100-2199	2200-2299	2300-2399	2400-2499	2500-2599
Licking	-2.4	-4.9	5.6	11.8	-1.5*	-13.6
Feeding	15.7	14.5	-5.7	-8.2	1.1*	0.7*
Bedded	-14.4	-12.1	3.1	2.9	-0.4*	5.3

Note: The "moving or standing" activity category was not analyzed because this was only a transitional activity among licking, feeding and bedding.

while bedding occurred more than expected between 2200-2399 ft and 2500-2599 ft ($P<0.001$) (Table 7). Sheep often rested on the rock outcrops at the Bluff lick sites.

Other Species

Caribou, mostly bulls, were common the in area during May. However, none were seen using the licks. Cow and bull moose were observed occasionally, however, none were seen on the Bluff or using any licks in the area during the study period.

EAST FORK LICK

Daily Use by Individuals

Because this lick is within the typical alpine summer range of these sheep, the use patterns were not like those at Jay Creek. Individuals or groups of sheep would visit the East Fork lick usually for hours rather than days at a time. Even though some sheep made repeated lick visits in a day, individuals (or groups) could usually be recognized throughout the day. The number of different sheep observed at the lick per day varied from 0 to 37 from 28 May to 16 June and 22 to 24 June (Fig. 17, Appendix I). The variation was probably due to weather-influenced movements, human and aircraft disturbance, and other factors. A minimum of 47 different sheep using the East Fork lick was calculated (Table 8).

Although the sheep use pattern at the East Fork and Jay Creek licks were different (Fig. 18), the overall sheep visitation rates at the East Fork and Jay Creek licks were similar (Table 9). However, this comparision may not be an accurate indication of a similar <u>amount</u> of lick use because of the difference in hours vs. days of sheep presence in the two areas.

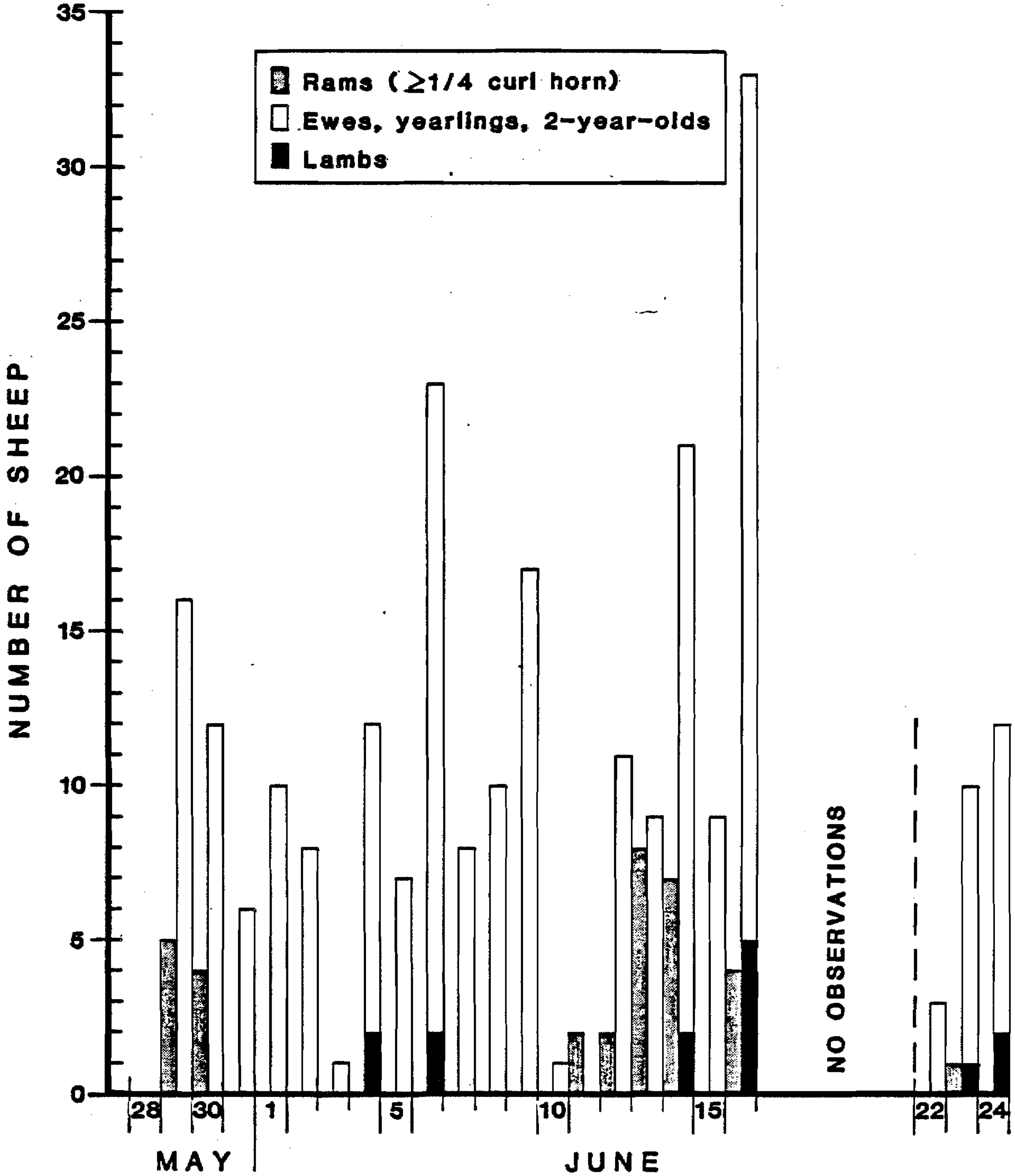

Figure 17. Sheep seen at East Fork lick per day.

Table 8. Largest number of different sheep seen in each sex and age group during one day at East Fork lick.

	E*	L	Y	2-Y	RAMS ≥ 1/4	RAMS ≥ 1/2	RAMS ≥ 3/4	RAMS ≥ 7/8	TOTAL
	19	5	9	4	3	4	2	1	
TOTAL	37 ewes and young				10 rams				47

*See Footnote "a" on Table 2 for explanation of abbreviations.

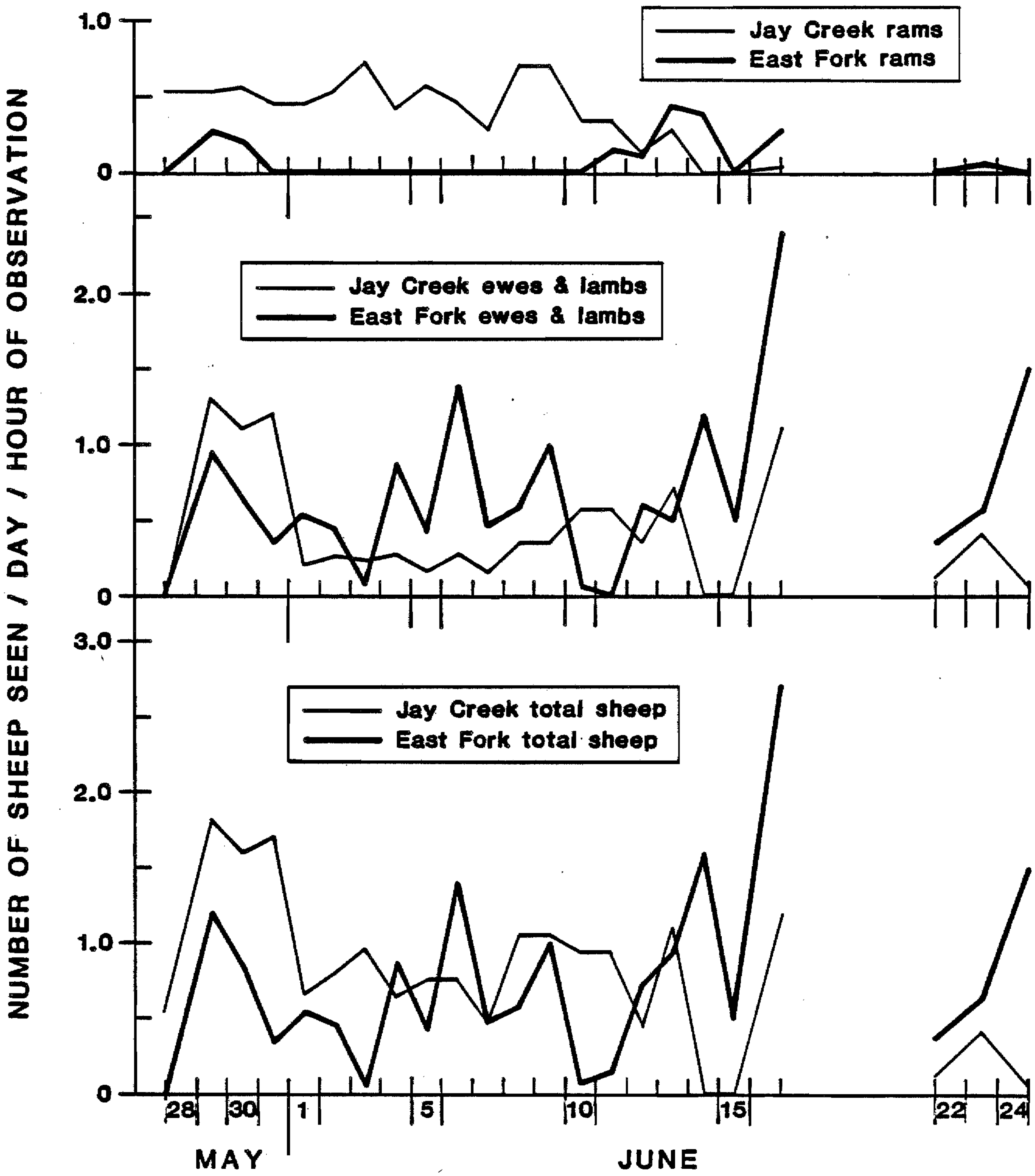

Figure 18. Rate of sheep use of Jay_ Creek and East Fork licks.

Table 9. Average number of different sheep seen per day per hour of observation for East Fork and Jay Creek licks from 28 May to 16 June and 22-24 June.

	Rams	"Ewe" Group	TOTAL
East Fork	0.09	0.67	0.76
Jay Creek	0.35	0.43	0.78

No color-marked sheep were noticed in the East Fork area. Fading dye, dirt and molting patches on the sheep may be the reason. Also, red-dyed sheep (all ewes or subyearlings marked north of Watana Creek) may not have used this area much if at all during the observation period. Only two groups (two ewes, two yearlings, one 2-year-old on 30 May; six ewes, five lambs, one 2-year-old on 16 June) were known to cross Watana Creek to visit the East Fork lick. The north side of Watana Creek seemed to be the major nursery area, and ewes may have been reluctant to cross while pregnant or with very young lambs. On the 20 June aerial survey, 55 sheep (41 "ewes" and 14 lambs) were seen on the mountainside north of Watana Creek (Fig. 20, Table 17). On 24 June, 54 sheep (36 "ewes" and 18 lambs) were seen in the same area from ground observations. A total of only 19 lambs were seen in the entire Watana Creek Hills aerial survey in June, so these lambs were the majority of lambs in the population.

No sheep were identified to use both Jay Creek and East Fork licks, although this may certainly be possible.

Sex and Age of Lick Users

A daily tally of sheep by sex and age and age class is given in Appendix I. Ram use of the East Fork licks was much lower (Table 9) and unlike at Jay Creek was nonexistent during 31 May to 10 June (Fig. 18). This may be because rams used the East Fork lick before observation began, then moved to the Jay Creek area. The majority of rams observed on the 20 June aerial survey were east of Jay Creek, and none were in the vicinity of the East Fork lick. Ewe group use was higher at the East Fork licks (Table 9) and also showed a different pattern than Jay Creek use (Fig. 18).

Other Species

Caribou (mostly bulls) were occasionally seen in the East Fork area, however, none were observed using the lick.

LICK ANALYSES

Laboratory analyses of selected lick and control samples for water soluble "total" by (aqua-regia digestion) elemental content were done for 32 elements plus sulfate. Results for 15 essential elements and sulfate are shown in Tables 10-13. To normalize the results, a log (10) transformation of ppm levels was used before testing for differences in means (T-Test). To calculate means for elements with samples containing levels below detection limits, the sample level was assigned the maximum possible level (e.g., 0.09 ppm for aqua-regia digestions results, 0.04 ppm for water soluble results, 0.9 ppm for sulfate).

Samples from lick cavities (East Ridge, Cabin Ridge and South Field Ravine) were significantly higher ($P<0.05$) in "total" sodium and chromium and somewhat higher ($0.10<P<0.05$) in copper, iron and magnesium, compared to control samples (Table 10). These samples also contained a higher ($P<0.05$) amount of water soluble sodium, magnesium, calcium and sulfate as well as the less predominant element of phosphorus (Table 11). This was in contrast to samples collected from the Bluff lick sites, which were comparatively low ($P<0.05$) in water soluble sodium, magnesium and phosphorus (Table 11). Water soluble calcium was also somewhat lower ($P = 0.56$) in the Bluff samples. Not enough Bluff samples were analyzed for "total" elemental content to compare with lick cavity results. Soil from the lick cavities was very fine-grained whereas the Bluff soil collected was much coarser (Fig. 19) and no lick cavities were found on the Bluff to accurately pinpoint licking sites. These chemical and physical differences shed doubt on the accuracy of selecting the Bluff

Table 10. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from Jay Creek lick and control sites (Fig. 6).[a]

Sample #	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Si	Sn	V	Zn
Lick Cavities														
3	10,200	20	40	100	44,000	1,300	18,700	625	2,800	30	200	5.0	110	105
4	7,500	17	30	100	35,000	410	14,600	475	1,740	25	420	0.6	84	90
7	9,470	20	40	99	38,700	640	17,370	790	3,410	30	200	<0.10	100	94
8	15,100	16	30	82	30,500	725	14,650	520	3,960	28	264	<0.10	86	79
19	11,100	16	33	77	30,100	1,110	14,560	456	1,785	27	280	<0.10	82	78
20	10,600	16	36	70	33,170	1,200	13,120	500	1,750	29	225	<0.10	88	85
$\bar{x}$	10,662	17.5	35[b]	88[c]	27,919[c]	898	15,500[c]	561	2,574[b]	28	265	0.99	91.7	88.5
Low Use Sites														
17	11,100	16	37	70	35,560	1,380	12,400	560	1,090	30	120	<0.10	92	88
18	11,230	15	31	60	32,300	1,230	11,200	520	1,000	26	175	<0.10	85	76
21	18,220	16	24	46	30,900	420	12,200	545	675	24	228	<0.10	81	58
22	19,500	13	23	45	26,940	425	11,870	464	945	21	217	<0.10	81	54
23	22,740	23	44	138	49,860	865	25,500	905	500	38	98	<0.10	108	130
24	29,700	28	52	145	18,840	645	26,630	1,050	385	42	139	<0.10	124	126
27	13,560	12	15	77	23,990	535	9,670	375	1,140	14	277	<0.10	62	45
28	11,800	12	16	65	24,200	550	9,135	420	940	12	390	<0.10	74	50
$\bar{x}$	17,231[b]	16.8	30.3	80.8[c]	30,312	756	14,826	605[b]	834	26	206	0.09	88	78
Bluff														
13	6,320	22	23	170	45,150	620	13,830	690	155	25	175	<0.10	105	74
14	10,450	15	25	84	37,200	320	9,740	429	840	22	249	<0.10	87	63

(continued on next page)

Table 10 (cont'd).

Sample #	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Si	Sn	V	Zn
							Control Sites							
16	6,200	17	24	100	33,970	230	13,460	448	180	28	215	<0.10	84	80
29	11,560	16	37	50	30,600	780	10,800	560	1,225	25	270	<0.10	95	68
31	6,190	8.9	22	28	18,980	550	5,100	280	765	16	895	<0.10	55	110
32	14,100	7.8	20	40	16,000	990	6,670	228	1,260	17	182	<0.10	42	58
44	6,685	14	27	44	28,100	1,050	10,560	515	685	22	125	<0.10	72	83
$\bar{x}$	8,947	12.7	26	52	25,530	720	9,318	406	823	21.6	337	0.09	70	80

a/ Se was not detected in any of these samples (<0.10 ppm)

b/ Means calculated from log (10) transformations were significantly higher ($P<0.05$) than means from control samples.

c/ Means calculated from log (10) transformations were somewhat higher ($0.10<P<0.05$) than means from control samples.

Table 11. Water soluble mineral elements and sulfate (ppm) from samples taken from Jay Creek lick and control sites (Fig. 6).

Sample #	Ca	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Se	Si	SO_4	V	Zn
Lick Cavities															
1	16	<0.05	<0.05	8.8	4.7	7.9	0.12	30	<0.05	0.10	<0.05	11		<0.05	<0.05
2	14	<0.05	<0.05	2.0	3.7	6.2	<0.05	30	<0.05	<0.05	<0.05	6.9		<0.05	<0.05
3	52	<0.05	0.18	3.4	2.8	34	0.06	465	<0.05	0.34	<0.05	9.3	665	<0.05	<0.05
4	530	<0.05	0.14	0.29	5.6	250	<0.05	360	<0.05	0.80	<0.05	5.0	2450	<0.05	<0.05
6	560	<0.05	0.08	0.13	5.9	101	0.07	330	<0.05	0.43	<0.05	9.0		<0.05	<0.05
7	250	<0.05	0.08	0.33	2.6	121	<0.05	760	<0.05	0.27	0.27	6.6	2600	<0.05	<0.05
8	590	<0.05	0.18	0.16	6.5	300	0.18	750	<0.05	1.0	0.22	7.1		<0.05	<0.05
19	290	<0.05	<0.05	0.13	5.2	360	<0.05	130	<0.05	0.63	<0.05	4.6	2300	<0.05	<0.05
20	360	<0.05	<0.05	0.09	5.4	190	<0.05	180	<0.05	0.50	<0.05	5.7	2050	<0.05	<0.05
$\bar{x}$	296[a/]	0.04	0.09	1.7	4.7	152[a/]	0.07	337[a/]	0.04	0.46[a/]	0.09	7.2	2013[a/]	0.04	0.04
Low Use Sites															
17	40	<0.05	<0.05	0.52	4.5	8.5	<0.05	16	<0.05	<0.05	<0.05	6.1		<0.05	<0.05
18	22	<0.05	<0.05	0.90	4.5	7.2	<0.05	11	<0.05	<0.05	<0.05	7.2		<0.05	<0.05
21	25	<0.05	<0.05	0.46	2.9	3.7	<0.05	2.4	<0.05	<0.05	<0.05	4.8	<1.0	<0.05	<0.05
22	27	<0.05	<0.05	1.0	3.0	3.9	<0.05	2.4	<0.05	<0.05	<0.05	5.3	16	<0.05	<0.05
23	465	<0.05	<0.05	0.29	7.9	125	<0.05	13	<0.05	0.25	<0.05	2.9	1000	<0.05	<0.05
24	185	<0.05	<0.05	0.24	5.0	33	<0.05	4.0	<0.05	<0.05	<0.05	2.5	800	<0.05	<0.05
25	23	<0.05	0.13	3.1	3.0	9.8	<0.05	6.3	<0.05	0.12	<0.05	9.5		<0.05	<0.05
26	26	<0.05	0.14	4.3	2.6	4.2	0.05	4.9	<0.05	<0.05	<0.05	12		<0.05	<0.05
27	480	<0.05	<0.05	0.15	11	295	<0.05	245	<0.05	0.64	<0.05	1.9	1950	<0.05	<0.05
28	48	<0.05	0.05	3.7	6.3	2.7	0.11	6.7	<0.05	0.17	<0.05	5.2		<0.05	<0.05
$\bar{x}$	134[a/]	0.04	0.06	1.5	5.1	49.3[a/]	0.05	31.2[a/]	0.04	0.14	0.04	5.7	753[a/]	0.04	0.04

(continued on next page)

Table 11 (cont'd).

Sample #	Ca	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Se	Si	SO_4	V	Zn
							Bluff Soil								
9	75	<0.05	<0.05	0.38	6.6	26	<0.05	4.8	<0.05	0.08	<0.05	2.6		<0.05	<0.05
10	48	<0.05	0.07	1.0	1.8	4.5	<0.05	6.0	<0.05	0.09	<0.05	6.4		<0.05	<0.05
13	39	<0.05	0.72	35	3.2	14	1.2	3.1	0.06	0.07	<0.05	47	<1.0	<0.05	0.14
14	44	<0.05	<0.05	1.4	1.1	2.8	<0.05	9.9	<0.05	<0.05	<0.05	9.6	<1.0	<0.05	<0.05
$\bar{x}$	52	0.04	0.22	9.4	3.1	11.8	0.33	5.9	0.05	0.07	0.04	16.4		0.04	0.07
							Bluff Rock (Crushed)								
11	24	<0.05	0.07	2.7	1.9	2.5	0.08	9.6	<0.05	0.15	<0.05	5.1		<0.05	<0.05
12	30	<0.05	0.06	0.37	1.3	1.9	<0.05	3.8	<0.05	0.10	<0.05	1.3		<0.05	<0.05
							Control								
15	30	<0.05	0.08	5.5	2.6	2.8	0.10	0.85	<0.05	<0.05	<0.05	8.0		<0.05	<0.05
16	3.0	<0.05	0.09	9.1	1.6	1.1	0.44	0.50	<0.05	<0.05	<0.05	8.4	<1.0	<0.05	<0.05
29	26	<0.05	0.10	17	4.0	7.4	0.28	1.9	<0.05	0.08	<0.05	21	20	0.05	0.09
30	32	<0.05	0.12	24	6.8	10	0.43	1.4	<0.05	0.33	<0.05	31		0.08	0.14
31	15	<0.05	<0.05	3.6	3.2	1.7	0.17	2.7	<0.05	0.14	<0.05	3.8	<1.0	<0.05	<0.05
32	17	<0.05	0.06	11	6.1	4.4	0.08	0.8	<0.05	<0.05	<0.05	12	<1.0	<0.05	<0.05
40	1.9	<0.05	0.05	1.0	1.6	0.27	0.15	2.4	<0.05	0.06	<0.05	2.7		<0.05	<0.05
41	2.2	<0.05	0.05	1.0	1.3	0.29	0.06	3.4	<0.05	0.10	<0.05	2.9		<0.05	<0.05
42	11	<0.05	<0.50	0.14	8.0	2.2	0.05	3.4	<0.05	<0.05	<0.05	1.8		<0.05	<0.05
43	2.3	<0.05	<0.05	0.39	1.9	0.65	<0.05	5.1	<0.05	0.12	<0.05	2.1		<0.05	<0.05
44	150	0.19	0.88	135	14	60	5.5	4.4	0.27	0.32	<0.05	139	140	0.43	1.1
$\bar{x}$	26.4	0.05	0.18	18.9	4.6	8.3	0.67	2.4	0.06	0.12	0.04	21	32	0.08	0.15

a/ Means calculated from log (10) transformations were significantly higher ($P < 0.05$) than means from control samples.

Table 12. Water soluble mineral elements and sulfate (ppm) from soil samples taken from the East Fork lick and control sites (Fig. 6).[a]

Sample #	Ca	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Si	SO_4	V	Zn
							East Fork Lick							
33	87	4.1	1.8	645	29	510	3.3	245	0.86	0.96	315		4.0	0.46
34	90	<0.05	1.4	270	40	300	2.6	255	0.60	0.61	200	230	1.2	0.25
35	21	1.2	0.4	245	33	150	1.7	115	<0.05	0.35	820		1.9	<0.05
36	38	2.0	0.56	465	33	300	2.9	150	<0.05	0.79	1750	200	3.8	<0.05
$\bar{x}$	59	1.8	1.04[b]	406[b]	34[b]	315[b]	2.6[b]	191[b]	0.39	0.68[b]	771[b]		2.7[b]	0.20
							East Fork Control							
37	5.8	<0.05	<0.05	6.9	1.5	1.8	0.40	1.6	<0.05	<0.05	5.8		<0.05	<0.05
38	18	<0.05	<0.05	0.22	1.8	1.1	<0.05	1.2	<0.05	<0.05	1.1	<1.0	<0.05	<0.05
39	14	<0.05	<0.05	0.14	3.7	13	<0.05	0.30	<0.05	<0.05	1.7	4.0	<0.05	<0.05
$\bar{x}$	12.6	0.04	0.04	2.4	2.3	5.3	0.16	1.03	0.04	0.04	2.9		0.04	0.04

a/ Se and Sn were not detected in any of these samples (<0.05 ppm).

b/ Means calculated from log (10) transformations were significantly higher ($P<0.05$) than means from control samples.

Table 13. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from the East Fork lick and control sites (Fig. 6).[a/]

Sample #	Ca	Co	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	P	Si	V	Zn
							East Fork Lick							
34	30,200	27	90	92	40,770	510	39,100	1,050	8,150	105	135	110	97	47
36	49,000	42	115	114	64,700	590	69,500	1,440	13,400	10	140	645	155	65
							East Fork Control							
38	31,370	29	34	346	48,540	180	21,340	930	345	42	545	160	149	82
39	21,530	39	<0.10	400	58,900	385	17,400	1,960	70	42	345	610	<0.10	125

a/ Se and Sn were not detected in any of these samples (<0.10ppm).

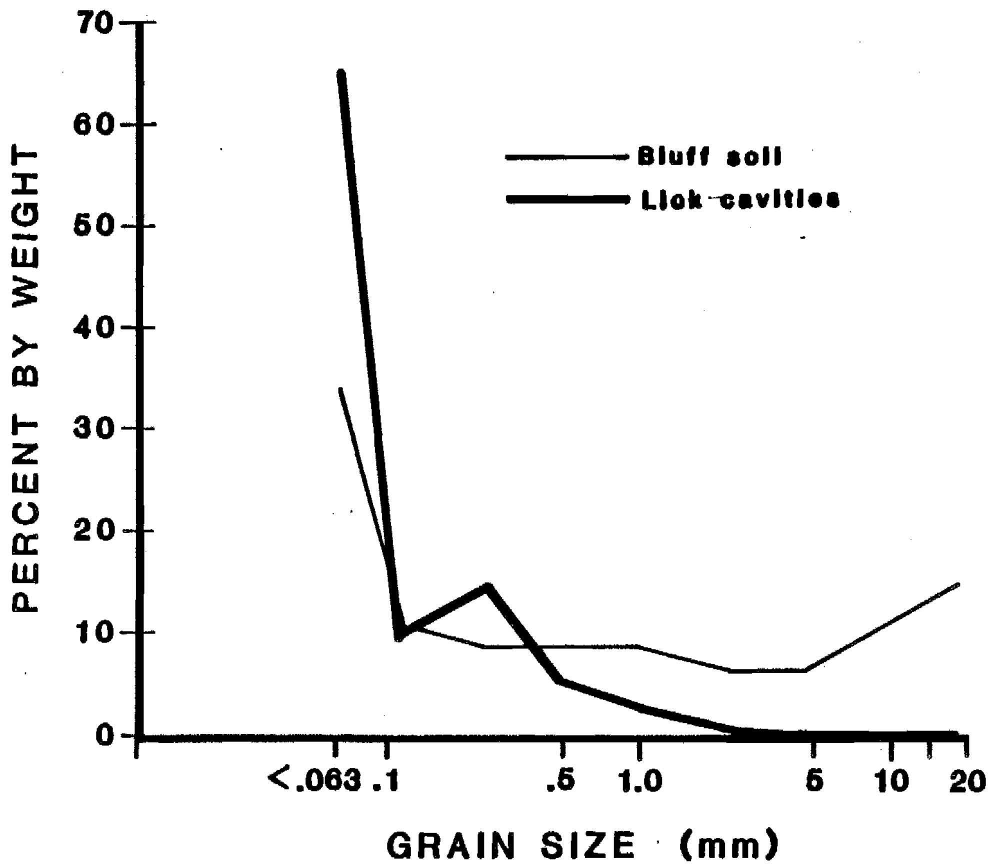

Figure 19. Percent by weight of soil with various grain sizes from Bluff, East Ridge, Cabin Ridge and South Field ravine licks.

lick sample locations. Low use sites were significantly higher ($P<0.05$) in "total" calcium and manganese (but not sodium or magnesium) than control sites and copper was somewhat higher ($0.05<P<0.10$) (Table 10). Only water soluble sodium, magnesium, calcium and sulfate were again higher in the low use lick sites ($P<0.05$) (Table 11).

Water soluble sodium, magnesium and phosphorus and several other elements were also significantly higher ($P<0.05$) in the East Fork lick samples compared to control samples (Table 12). However, unlike the Jay Creek licks, water soluble silicon and iron were the two most abundant elements in the East Fork samples. The laboratory reported that extremely high solids occurred in the water extraction of these samples and that they were unable to completely filter out or centrifuge the suspended particles. Consequently, some of the elements reported may be high because of this phenomena. Not enough samples were analyzed for "total" elemental content to compare lick and control sites statistically (Table 13).

POPULATION SURVEYS

Watana Creek Hills

Eleven rams and 86 ewes, sub-yearlings and two-year-olds were recorded during the aerial survey on 9 March 1983 (Table 14). Most of the sheep were observed on wind-blown or south-facing slopes on the western end of the hills (Fig. 20).

On the 20 June survey, 34 rams, 96 ewes, yearlings and two-year-olds, and 19 lambs were observed (Table 15). This population count (149) was less than last year's count (Table 16). Again, the majority of the sheep were found on the western end of the hills, however, one large group was observed east of the Jay Creek lick area (Fig. 21). The major concentration of lambs was north of Watana Creek, across from the East Fork lick. Ground

Table 14. Number of Dall sheep observed in the Watana Creek Hills during an aerial survey on 9 March 1983.

Obs. # for Fig. 20.	RAMS 7/8 curl	RAMS 7/8 curl	Ewes[a]	Sub-Yearlings	TOTAL
1.		2	5	2	9
2.			2	1	3
3.			9	1	10
4.			3	1	4
5.			2	2	4
6.			7	3	10
7.			2		2
8.			6	2	8
9.	1	1			2
10.			3		3
11.		3			3
12.			3	1	4
13.			3		3
14.		2	4	3	9
15.			5	2	7
16.		1	3	1	5
17.		1	1	2	4
18.			5	2	7
TOTAL	1	10	63	23	97

[a] Ewes include unidentified young rams and yearlings of both sexes.

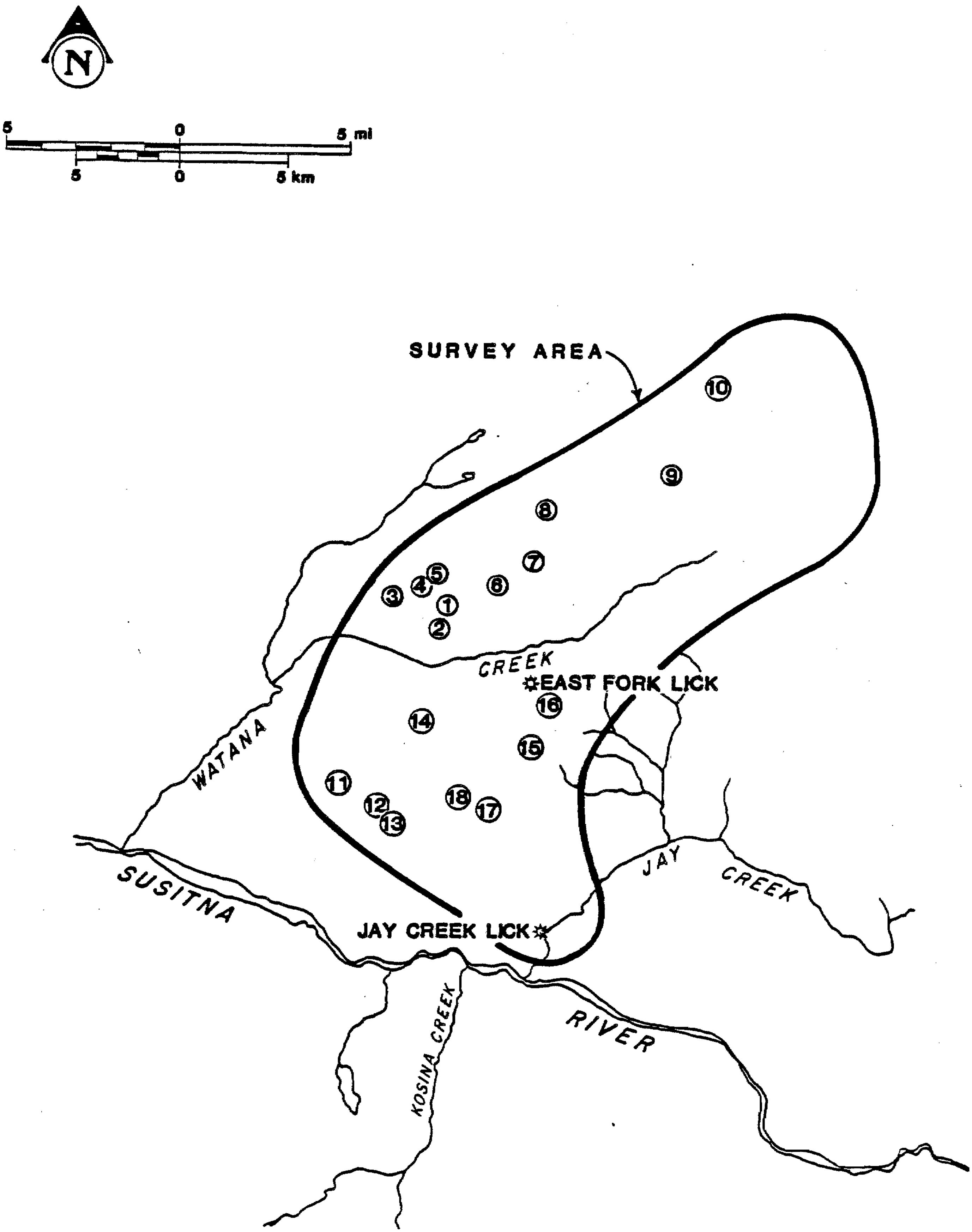

Figure 20. Location of sheep seen on äerial survey of Watana Creek Hills on 9 March 1983. Circled numbers refer to data in Table 14.

Table 15. Number of Dall sheep observed in the Watana Creek Hills during an aerial survey on 20 June 1983.

Obs. # for Fig. 21.	RAMS 3/4 curl[a]	RAMS 3/4 curl	Ewes[b]	Lambs	TOTAL	Remarks
1.			2		2	
2.			4		4	
3.			11		11	at East Fork lick
4.			11	4	15	
5.			6		6	
6.	1	7			8	
7.	2	3			5	
8.	7	14	8		29	
9.			6	1	7	
10.			10	10	20	
11.			15		15	
12.			1		1	
13.			15	4	19	
14.			4		4	
15.			3		3	
TOTALS	10	24	96[c]	19[c]	149[c]	

[a] 3/4 curl differentiation was used to lessen aerial harassment.

[b] Ewes include unidentified young rams and yearlings of both sexes.

[c] A group of 7 ewes and 3 lambs that left the Jay Ck. lick area at 0830 (moving north) may have been missed on the survey.

Table 16. Highest summer counts completed in Watana Creek Hills.

Date	Large Rams[a]	Small Rams[b]	Lambs	TOTAL	% Large Rams	% Small Rams	% Lambs	Surveyor	Survey Time (Hrs)
8 Sept. 1967	--		--	220	---		----	Nichols	---
Aug. 1968	--		--	183	---		26.6	Nichols	---
3 Aug. 1973	10		40	176	5.6		22.7	McIllroy	---
24 Aug. 1976	4		30	130	3.1		23.0	Eide	---
11 July 1977	4		33	152	2.6		21.7	Spraker	---
23 July 1978	5		34	189	2.6		18.0	Eide	1.8
22 July 1980	9	19	42	174	5.1	10.9	24.1	Tobey	2.5
28 July 1981	2	37	43	209	1.0	17.7	20.6	Westlund	3.3
3 Aug. 1982	0	19	38	200	0	9.5	19.0	Westlund	1.8
20 June 1983	10[c]	24	19	149[d]	6.7	16.0	12.7	Tankersley	4.5

[a] A large ram was one having a 7/8 curl or greater horn on the 1981 and 1982 surveys. On the rest of the surveys, a minimum of 3/4 curl was used.

[b] New category begun in 1980. Small rams associated with ewe groups (mostly yearlings and 2-year-olds) are not included.

[c] At least 3 of these were 7/8 curl or larger.

[d] A group of 7 ewes and 3 lambs may have not been counted (see Table 10).

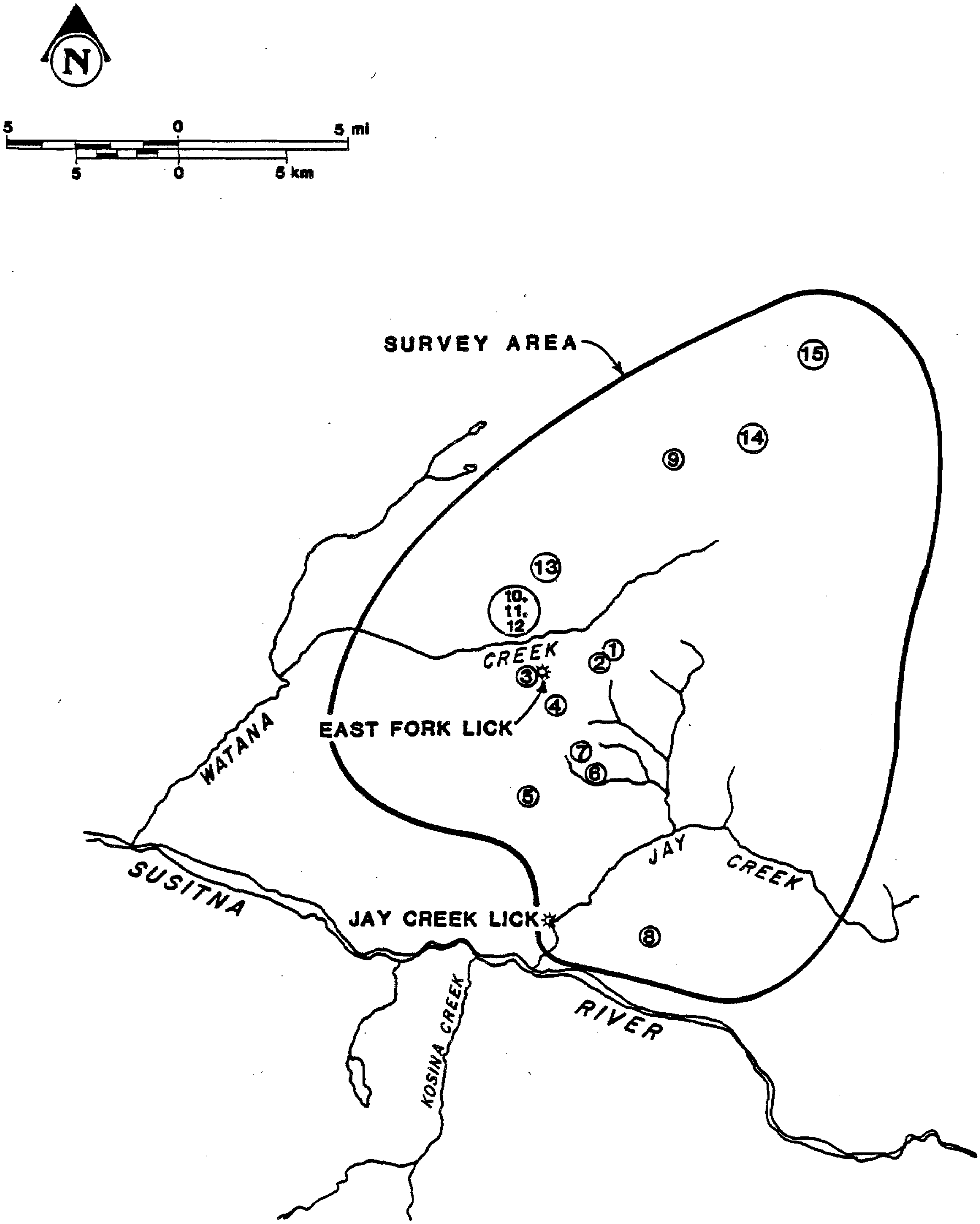

Figure 21. Location of sheep seen on aerial survey of Watana Creek Hills on 20 June 1983.

surveys from the East Fork lick on 24 June indicate there were at least 20 lambs in population. No new mineral licks were discovered on aerial or ground surveys.

No evidence of a lick in the northeastern hills was found (reported in Tobey, 1981). The potential lick site approximately 7 mi northwest of the Jay Creek bluff reported from the August 1982 aerial survey was determined not to be used as a lick, from ground observations in May and June.

Access Corridor

On 11 March 1983, an inexperienced observer and an experienced pilot/observer in a Piper PA-18 Super Cub surveyed winter sheep distribution in the mountains west of the access route. Thirty sheep were observed in 1.5 hours (Table 17). Much of the area was not intensively flown due to heavy snow cover. Sheep were seen in the Soule Creek and Tsusena Creek drainages about 12 mi from the proposed access route (Fig. 22).

On 21-22 June 1983, the same observer and another experienced pilot/observer in the same aircraft type surveyed the area to look for mineral licks, lambing areas, and to record sheep and mountain goat distribution. Fifty-two sheep were observed in 6.2 hours (Table 18). No mineral licks were found. Most of the sheep were found in the East Fork of the Jack River, Soule Creek and upper Tsusena Creek drainages (Fig. 23). No sheep were found closer than 2.5 mi to proposed access route. No goats were observed, although other ADF&G personnel have reported small numbers of them in the upper Portage Creek area on 19 March 1983 and 3 December 1982 (L. Aumiller and W. Taylor, pers. commun). These are the furthest north observations of mountain goats in the state.

Table 17. Sheep seen on aerial survey west of proposed Denali Highway access route on 11 March 1983.

Obs. # for Fig. 22.	RAMS 7/8 curl	RAMS 7/8 curl	Ewes[a]	Lambs	Unclass.	TOTAL
1.					16	16
2.					3	3
3.		1	1			2
4.					5	5
5.		4				4
TOTALS	0	5	1	0	24	30

[a] Ewes include unidentified young rams and yearlings of both sexes.

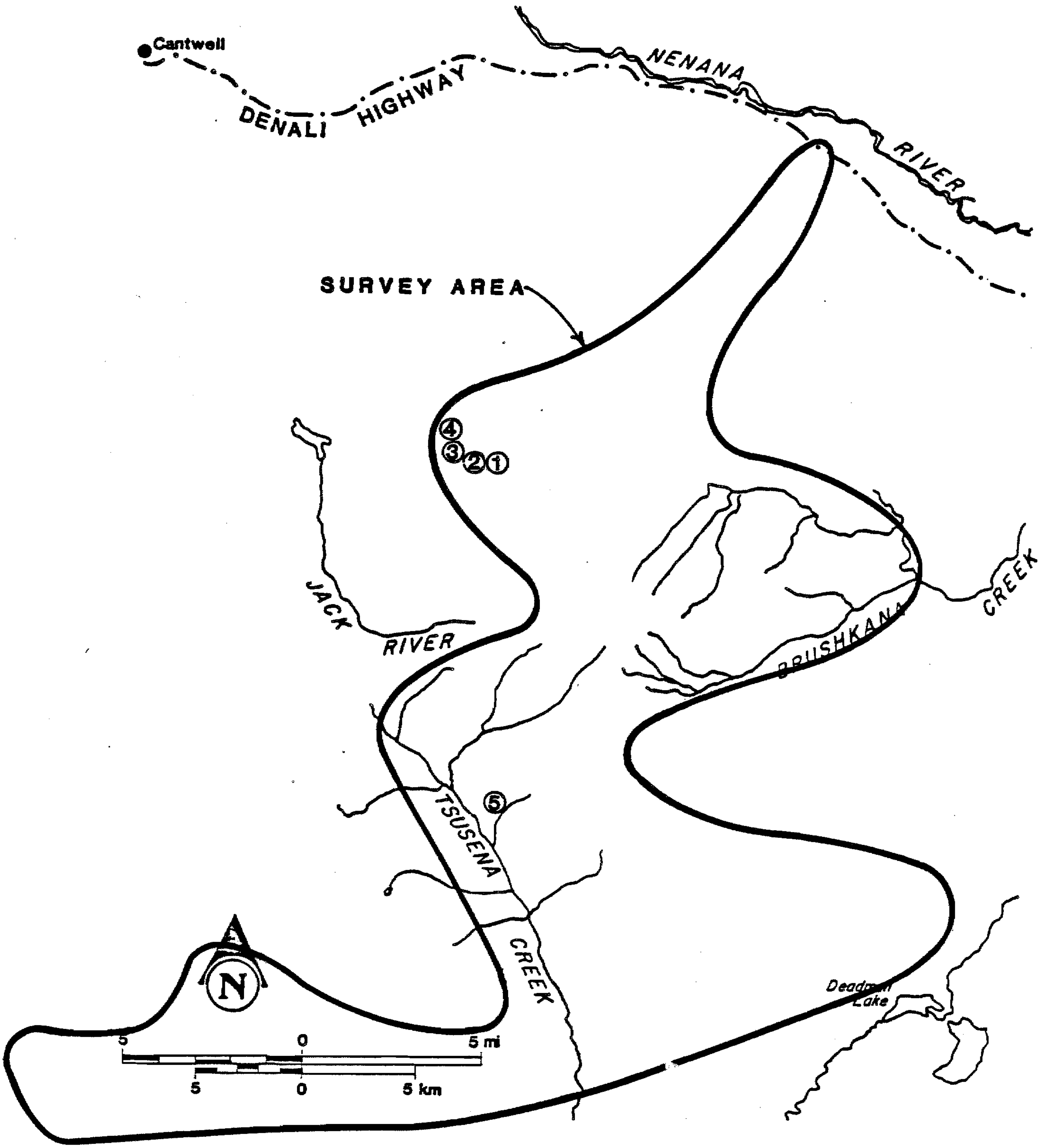

Figure 22. Location of sheep seen on aerial survey west of Denali Highway access corridor on 11 March 1983. Circled numbers refer to data in Table 17.

Table 18. Sheep seen on aerial survey west of proposed Denali Highway access route on 21-22 June 1983.

Obs. # for Fig. 23.	R A M S 3/4 curl	3/4 curl	Unclass	Ewes[a]	Lambs	TOTAL
1.				5		5
2.				14	1	15
3.	1	1				2
4.				1		1
5.				2		2
6.				6	1	7
7.		1	1			2
8.			4			4
9.			2			2
10.				1		1
11.			4			4
12.			3			3
13.	1	3				4
TOTALS	2	5	14	29	2	52

[a] Ewes include unidentified young rams and yearlings of both sexes.

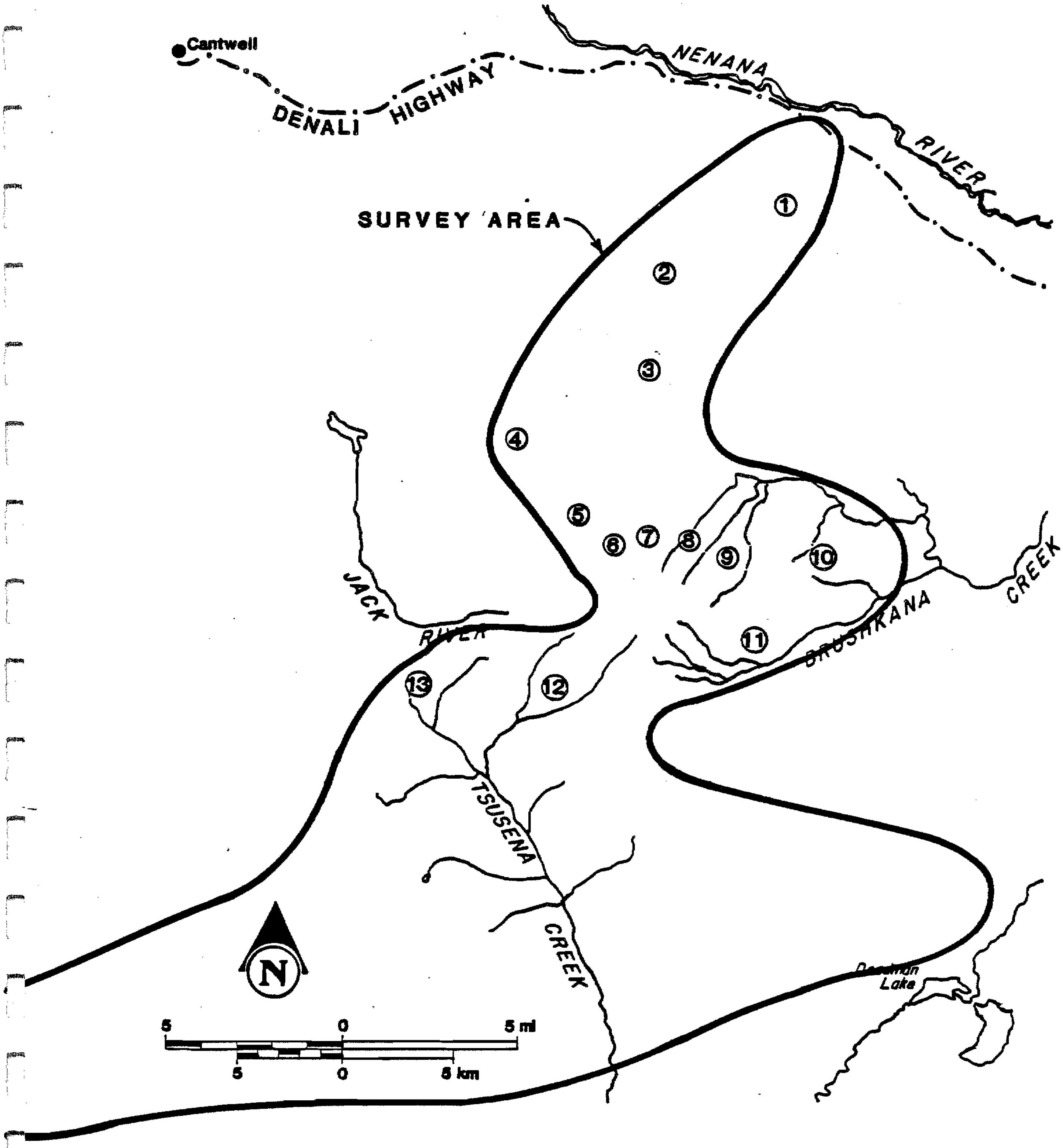

Figure 23. Location of sheep seen on aerial survey west of Denali Highway access corridor on 21-22 June 1983. Circled numbers refer to data in Table 18.

Mt. Watana

On 11 March 1983, an inexperienced observer and an experienced pilot/observer in a Piper PA-18 Super Cub looked for sheep in the Mt. Watana area (Fig. 1). No sheep or tracks were observed in 0.6 hours of survey time.

Another survey was flown with the same observer and another experienced pilot/observer in a Piper PA-18 Super Cub on 21 June 1983. Again, no sheep were seen in 0.5 hours of survey time.

HUNTER HARVEST - WATANA CREEK HILLS

No rams were shot by hunters in the Watana Creek Hills during 1983. The Alaska Department of Fish and Game has records of only four unsuccessful hunters for 1983 in this area. This was in contrast to a small harvest which has occurred in recent years (Table 19).

DISCUSSION

IMPACTS OF WATANA IMPOUNDMENT

The Watana Creek Hills sheep population could be vulnerable to severe impact from the proposed Watana impoundment because of disturbance to the Jay Creek lick area. This area, adjacent to the proposed Watana impoundment, is used by a large proportion of the sheep population in early summer. A minimum of 31% of the observed 1983 population used the Jay Creek lick area, and up to 31 individuals (21% of population) were seen in the lick area at one time (the most ever recorded). Almost half of the time sheep were in the lick area, they were below 701 m (2300 ft) which would be subjected to flooding and erosion. Rams used the licks early in the season, followed by pregnant or barren ewes and yearlings, with ewe-lamb groups not arriving until June 16. This pattern is similar to those reported for mountain goats by Hebert

Table 19. Legal ram (7/8 curl) harvest in Watana Creek Hills 1980-1983.

	1980	1981	1982	1983
Hunters	11(8)[a]	11(2)	11(4)	4(0)
Rams Killed	10	6	5	0

[a] Number in parentheses denotes the number of non-resident hunters included in total (required to hunt with a guide or close relative).

and Cowan (1971), for Dall sheep (Heimer 1973), and for moose (Tankersley and Gasaway 1983). Sheep travel some distance to use this lick as both winter and summer surveys have located most of the population 7 or more air mi from the Jay Creek lick area. Two color-marked sheep traveled 5 mi or more to the Jay Creek lick area between April and late May. Although Heimer (1973) reported that sheep have traveled greater distances to a lick site, this reported travel was within typical alpine habitat which included escape cliffs (Heimer, pers. comm.). In contrast, the Jay Creek lick area and much of the terrain traveled between observed summer and winter range is atypical sheep habitat, being relatively flat with low shrubland and trees and little rocky cliff escape habitat.

It appears that the essential macro-elements of sodium, magnesium and calcium are the predominant lick components. Sulfate was also a major water soluble lick component. Of all these elements and compounds, sodium is most likely the main attractant. High levels of sodium are often reported from natural licks (Fraser and Tankersley, in prep.) and sodium is the only element of these choices that has been shown to be selected for by ungulates at lick sites (Stockstad *et al*. 1953, Fraser and Reardon 1980). It is also possible that an essential micro-element such as copper may be an important lick element. Indications of a copper deficiency in wild Alaskan moose have been reported (Flynn *et al*. 1977), but there is no evidence that any trace element deficiency causes an appetite for that substance.

Even though the East Fork lick had higher "total" sodium levels (as well as magnesium and calcium) than Jay Creek, sheep still endure the danger of travel to the Jay Creek lick and visit it at a similar rate to the East Fork lick. This may be because water soluble elements are more important, or because of the limited size of the East Fork licking area, or due to habitat, earlier spring phenology, or some other benefit of the Jay Creek area.

Also, the similar visitation rate is not necessarily the same as the amount of licking done in each area. In any case, the significant use of the Jay Creek area in addition to the East Fork lick is well documented, but not well understood. Additionally, attraction of the Jay Creek Bluff for licking as well as resting (escape cover) needs to be clarified by additional observations and soil analyses. Archeological finds in the immediate vicinity raise intriguing questions about the history of Jay Creek lick use.

The cycle of filling and draining in the Watana impoundment will subject the lick area to flooding and erosion and possibly will leave ice shelves along the creek banks during the peak lick use season. The Watana impoundment normal maximum operating level is desginated at 2185 ft in elevation, with possible flooding levels up to 2201 ft (Alaska Power Authority 1983, Exhibit B). During the heaviest lick use season (May and June), the target minimum reservoir levels are 2092 ft (May) and 2125 ft (June). The highest annual target minimum reservoir level is 2190 ft for September (Alaska Power Authority 1983, Exhibit B). Even at the normal minimum operating level of 2065 ft, the lower portion of the creek valley will be flooded. The proposed impoundment levels will inundate a few low use licking areas (downstream 1950 ft, upstream 2190 ft, Bluff below 2200 ft), and consequent erosion and ice shelves may result in the loss of more high use licking and resting areas (especially on the Bluff and East Ridge), as well as inhibiting travel along and across Jay Creek. However, erosion may possibly expose more lick soil in new areas. This soil deposit may be widespread in lower Jay Creek and also in other areas around the Watana Hills. Similar laboratory results to high use areas were obtained about 2200 ft on similar looking exposed soil bluffs 10 mi SE on the north bank of the Susitna River (#27, #28) where sheep were observed in early June. Even some "control" samples taken from similar looking exposed soil bluffs had high sodium values (#29 4 mi NW, and #32 12 mi

NW), although no sheep use was observed there. Leaching sodium or other water soluble cations from the lick soil does not appear to be a potential impact. However, sheep attracted to the lick area may be seasonally vulnerable to disturbance and habitat degradation from timber harvest around the impoundment, and other human activities.

The Watana Creek Hills has a small isolated sheep population, used by sheep hunters and guides. The nearest additional sheep habitat occurs southwest across the Susitna River around Mt. Watana, and also farther northeast in the Clearwater Mountains across a larger valley. The Watana impoundment, with seasonal hazards of a large width of open water, ice shelving and unstable ice conditions and mud shelving may depress or eliminate any possible sheep immigration from the southwest. This could make any detrimental impacts of the project on the Watana Hills sheep population even more serious, as population recovery from a project impact could be greatly slowed or made impossible by loss of immigration opportunities.

CLIMATIC IMPACTS

A delay in spring plant growth in areas near the Watana impoundment (Alaska Power Authority 1983, Exhibit E) may degrade some of the Watana Creek Hills and Mt. Watana sheep habitat. If the Watana impoundment causes additional snow accumulation in nearby areas, important south-facing slopes in the Watana Creek Hills may become poorer winter habitat.

INCREASED HUMAN ACCESS

The project development will undoubtedly increase fixed-wing and helicopter traffic. Because precautions were usually taken, there were few observations of sheep disturbed by aircraft in this study. However, low-flying aircraft, especially helicopters, are known to disturb Dall sheep (Linderman 1972, Nichols 1972, Lenarz 1974). Groups of ewes and lambs (possibly including young rams) react most strongly to helicopters (Lenarz 1974). The dangers of aircraft disturbance include injuries sustained by sheep while fleeing (Linderman 1972), wasted metabolic energy expense (which could become critical if the disturbance is repeated during stressful winter or lambing periods) (Geist 1971b), and abandonment of habitat (Linderman 1972), which could lower the population size. However, some sheep show habituation to aircraft that maintain regular flight patterns and do not approach sheep closely (Lenarz 1974, Summerfield 1974, Reynolds 1974). MacArthur *et al*. (1982) found no cardiac or behavioral responses by unhunted adult bighorn sheep to helicopters and fixed-wing aircraft flying 400 m or more away.

Roads and reservoirs developed by the project will allow increased access by vehicles and hikers who can also disturb sheep (Tracy 1976, MacArthur *et al.* 1982). One area where the Denali National Park Road was built directly through sheep habitat receives less use by sheep now than in the early 1940's, but the exact cause of this apparent abandonment is not clear (Tracy 1976). Tracy (1976) also reported that a few Dall sheep (mostly ewe and lamb groups) in Denali National Park were disturbed while crossing a small valley with a road when vehicles were present. Tour buses stopping, people exiting and making loud noises increased (respectively) the disturbance to the sheep (observed by their behavior). Reactions of sheep to moving vehicles more than 200 m away were minimal (Tracy 1976). These sheep were habituated to traffic and not hunted. Among unhunted sheep populations, sheep may habituate more readily to human presence (Geist 1971b).

MacArthur *et al*. (1982) documented relatively few cardiac responses (8.8% of trials) and fewer behavioral responses (0.9% of trials) of bighorn sheep to vehicle passes. Most of these responses (73.7%) occurred when the vehicle passed within 25 m. Humans approaching on foot, especially accompanied by a dog, elicited stronger responses (MacArthur *et al*. 1982). These sheep were living in an unhunted sanctuary and had been regularly exposed to humans and vehicles along a nearby road. No ewes with lambs were monitored, which are more sensitive to disturbance (Murie 1944, Smith 1954, Jones *et al*. 1963).

MacArthur *et al*. (1982) recommended restricting human activities to roads and established trails, and discouraging dogs in areas of sheep habitat.

A road built in the upper Portage Creek area could cause vehicular disturbance and increased hunting or poaching access which would be damaging to the small colony of mountain goats present there.

MITIGATION RECOMMENDATIONS

Lowering Watana's maximum reservoir level to 2000 ft in elevation would eliminate much of the physical disturbance to the main Jay Creek lick area. Also, certain methods and scheduling of construction activities and access would reduce the impacts of the Susitna Hydroelectric project on sheep.

Timber harvest within 2 air mi of the Jay Creek lick area should be restricted to late August through April. The area within 0.5 mi of the lick area should remain untouched by clearing activities, including roads, logging equipment and debris, except for those portions below the minimum operating level (2065 ft). Any clearing within 2 air mi of the lick area should be delayed as long as possible until just before the reservoir begins filling. This will condense the physical effects of the Watana development into a shorter time period.

Air traffic should be prohibited below 1000 ft above ground level and discouraged between 1000-1500 ft above ground level within 1.0 mi of mineral licks 1 May - 15 July. Helicopter landings within 1.0 mi of mineral licks should be prohibited during 1 May - 15 July. Boat and ground access within 1.0 mi of the Jay Creek lick area and other mineral licks should be prohibited from 1 May - 15 July.

If the project substantially reduces availability of mineralized substrate in the Jay Creek lick area, options of mining or blasting the lick area to expose additional substrate, or supplying similar mineral elements near the Jay Creek lick area or other areas with rock cliff habitat should be considered.

RECOMMENDATIONS FOR FURTHER STUDY

Impact assessment and mitigation planning is incomplete without estimating the extent and availability of the lick soil post-impoundment. Mapping and analysis of the extent of the lick soil and cliffs exposed post-project should be done by a geomorphologist or other qualified geoscientist.

ACKNOWLEDGEMENTS

I would like to express my appreciation to the following people: Polly Hessing, Bob Cassell, Enid Goodwin, Warren Ballard, SuzAnne Miller, Tammy Otto, Larry Van Daele, Hilary Van Daele (all ADF&G) and Tom Dilley (UAF) for assistance in the field; Granville Couey and Bob Lund (Frank Moolin and Assoc.) for cheerful logistical support; Vern Lofstedt (Kenai Air), Jerry Dixon, Jerry Abshire, Bill Murphy and Ken Rose (all Air Logistics) for safe and cooperative helicopter operation; Wayne Heimer for advice on field methods; Lyman Nichols (ADF&G) and Al Lee (Lee's Guiding Service) for expert fixed-wing surveying; SuzAnne Miller (ADF&G) for assistance in data analysis; Susan Lawler, and Becky Brewer

(ADF&G) for typing this report, Carol Riedner for preparing the figures; and Karl Schneider (ADF&G) for providing me with this study opportunity.

LITERATURE CITED

Alaska Power Authority. 1983. Susitna Hydroelectric Project. Application for license for major project before the Federal Energy Review Commission. 13 volumes.

Ballard, W. B., J. H. Westlund, C. L. Gardner, R. Tobey. 1982. Susitna Hydroelectric Project, Phase 1 Final Report, Big Game Studies, Vol. III Dall Sheep. Alaska Dept. Fish and Game. 21pp.

Denton, D. A. 1982. The hunger for salt. Springer-Verlag, New York.

______, and J. R. Sabine. 1961. The selective appetite for Na^+ shown by Na^+ - deficient sheep. J. Physiol. 157:97-116.

Dixon, J. S. 1939. Some biochemical aspects of deer licks. J. Mammal. 20:109.

Flynn, A., A. W. Franzmann, P. D. Arneson and J. L. Oldemeyer. 1977. Indications of a copper deficiency in a subpopulation of Alaskan moose. J. Nutr. 107:1182-1189.

Franzmann, A. W., J. L. Oldemeyer and A. Flynn. 1975. Minerals and moose. 11th North American Moose Conference and Workshop, pp.114-140.

Fraser, D., and E. Reardon. 1980. Attraction of wild ungulates to mineral-rich springs in central Canada. Holarctic Ecol. 3:36-40.

Fraser, D. and N. Tankersley. In prep. Use of natural mineral licks by wild ungulates in North America: a brief bibliographic review.

Geist, V. 1971a. Mountain sheep; a study in behavior and evolution. Univ. Chicago Press, Chicago and London. 383pp.

_____. 1971b. A behavioral approach to the management of wild ungulates. pp 413-424 <u>in</u> Duffey, E. and A. S. Watt, eds. The scientific management of animal and plant communities for conservation. 11th Symp. Brit. Ecol. Soc., Blackwell Sci. Publ.

Gill, D. 1978. Large mammals of the MacMillan Pass area: Northwest Territories and Yukon. AMAX Northwest Mining Co., Ltd., Vancouver. 58pp.

Gross, J. E. 1963. Range and use of range by Dall sheep (*Ovis dalli dalli*) on Victoria Mountain and Mount Schwatka, Alaska. M. S. Thesis. Univ. Alaska, College. 89pp.

Hanson, H. C. and R. L. Jones. 1976. The biogeochemistry of blue, snow and Ross' geese. Ill. Nat. Hist. Surv. Spec. Publ. 1.

Hebert, D., and I. McT. Cowan. 1971. Natural salt licks as a part of the ecology of the mountain goat. Can. J. Zool. 49:605-610.

Heimer, W. E. 1973. Dall sheep movements and mineral lick use. Fed. Aid Wildl. Restoration Final Rep. Proj. W-17-2, W-17-3, W-17-4, W-17-5, Job 6.1R, Juneau. 67pp.

Jones, F. F., R. F. Batchelor, H. R. Merriam, and L. A. Viereck. 1963. Sheep and goat investigations. Vol. III, Alaska Dept. Fish and Game, Ann. Proj. Seg. Rep. Fed. Aid. Wildl. Rest., Proj. W-6-R-3, Work Plan E.

Lenarz, M. 1974. The reaction of Dall sheep to an FH-1100 helicopter. Chapt. III in Jakimchuk, R. D., ed. The reaction of some mammals to aircraft and compressor station noise disturbance. Can. Arct. Gasline Stud. Biolog. Rep. Ser. Vol. 23.

Linderman, S. 1972. A report on the sheep study at the Deitrich River headwaters. Appendix III in Nichols, L. and W. Heimer. Sheep Report, Vol. XIII, Proj. Prog. Rep. Fed. Aid Wildl. Rest. Proj. W-17-3, W-17-4.

MacArthur, R. A., V. Geist, and R. H. Johnston. 1982. Cardiac and behavioral responses of mountain sheep to human disturbance. J. Wildl. Manage. 46:351-358.

Murie, A. 1944. The wolves of Mount McKinley. Fauna of the Nat. Parks of the U.S. Fauna Ser. 5 238pp.

Nichols, L. 1972. Productivity in unhunted and heavily exploited Dall sheep populations. In Nichols, L. and W. Heimer. Sheep Report, Vol. XIII, Proj. Prog. Rep., Fed. Aid Wildl. Rest. Proj. W-17-3, W-17-4, Job No. 6.4R.

Palmer, L. J. 1941. Dall sheep in the Mount Hayes region. U.S. Fish Wildl. Serv. Prog. Rep. 27pp. Typescript.

Pitzman, M. S. 1970. Birth behavior and lamb survival in mountain sheep in Alaska. M. S. Thesis. Univ. Alaska, College. 116pp.

Reynolds, P. C. 1974. The effects of simulated compressor station sounds on Dall sheep using mineral licks on the Brooks Range, Alaska. Chapt. II in Jakimchuk, R. D., ed. The reaction of some mammals to aircraft and compressor station noise disturbance. Can. Arct. Gasline Stud. Biolog. Rep. Ser. Vol. 23.

Smith, D. R. 1954. The bighorn sheep in Idaho--its status, life history, and management. Idaho Department of Fish and Game, Wildlife Bulletin No. 1, Boise, Idaho.

Stockstad, D. S., M. S. Morris, and E. C. Lory. 1953. Chemical characteristics of natural licks used by big game animals in western Montana. Trans. North Am. Wildl. Conf. 18:247-258.

Summerfield, B. L. 1974. Population dynamics and seasonal movement patterns of Dall sheep in the Atigun Canyon area, Brooks Range, Alaska. M. S. thesis, Univ. Alaska. 109pp.

Tankersley, N. G. 1983. Susitna Hydroelectric Project Phase II Progress Report. Big Game Studies, Vol. VIII Dall Sheep. Alaska Dept. of Fish and Game, Anchorage.

Tankersley, N. G. and W. C. Gasaway. Mineral lick use by moose in Alaska. Can. J. Zool:2242-2249.

Tobey, R. W. 1981. Susitna Hydroelectric Project Annual Progress Report, Big Game Studies, Part VIII Sheep. Alaska Dept. Fish and Game. 12pp.

Tracy, D. M. 1976. Reactions of wildlife to human activity along Mount McKinley National Park road. M.S. Thesis, Univ. Alaska, Fairbanks.

Weeks, H. P. Jr., and C. M. Kirkpatrick. 1976. Adaptations of white-tailed deer to naturally occurring sodium deficiencies. J. Wildl. Manage. 40:610-625.

_____. 1978. Characteristics of mineral licks and behavior of visiting white-tailed deer in southern Indiana. Am. Midl. Nat. 100:384-395.

PERSONAL COMMUNICATION

Aumiller, L., Game Technician, Alaska Department of Fish and Game, King Salmon.

Heimer, W., Game Biologist, Alaska Department of Fish and Game, Fairbanks.

Taylor, W., Game Biologist, Alaska Department of Fish and Game, Anchorage.

Appendix I. Number of different sheep in various sex and age classes using East Fork lick.

Date	Hours Observed	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	RAMS ≥1/2	RAMS ≥3/4	RAMS ≥7/8	SHEEP ID #'s
5/28	1130 - 2200	0										
5/29	0400 - 2100	21	1	9		2	4	3		1	1	
5/30	0400 - 2310	16	1	5		3	3	3		1		
5/31	0400 - 2100	6	1	3			2					
6/1	0400 - 2230	10		6		1	3					
6/2	0400 - 2100	8		6		1	1					
6/3	0400 - 1830	1		1								
6/4	0750 - 2130	12	1	6	2	2	1					
6/5	0430 - 2100	7		3		3	1					
6/6	0400 - 2100	23	1	9	2	9	2					
6/7	0400 - 2100	8		2		5	1					

Appendix I. (cont'd)

Date	Hours Observed	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	RAMS ≥1/2	RAMS ≥3/4	RAMS ≥7/8	SHEEP ID #'s
6/8	0400 - 2100	10		4		5	1					
6/9	0400 - 2010	17		7		9	1					
6/10	0400 - 1800	1		1								
6/11	0800 - 2100	2						2				
6/12	0300 - 2100	13	1	4		3	3	1	1			
6/13	0300 - 2100	17		4		1	4	3	4	1		
6/14	0300 - 2100	28		11	2	6	2	3	2	2		
6/15	0300 - 2100	9		5		3	1					
6/16	0300 - 1630	37		19	5	8	1	3	1			
6/22	1300 - 2100	3		2		1						Exit at 1300 when helicopter landed
6/23	0330 - 2100	11		5	1	2	2		1			
6/24	0330 - 1100	11		5	2	3	1					

Appendix II. Daily summary of sheep at Jay Creek mineral lick area.

										RAMS				
Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
5/11	1500			5						1	3	1		23, 24
5/12	(0400)			5						1	3	1		23, 24
5/13	(0400)			5						1	3	1		23, 24
	1615		+5	10					1	2	2			
	2100		+4	14						2	2			
5/14	(0400)			14					1	5	7	1		23, 24
		1530	-14	0					1	5	7	1		23, 24
5/15				0										
5/16				0										
5/17				0										
5/18				0										
5/19				0										
5/20				0										

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	RAMS ≥1/2	RAMS ≥3/4	RAMS ≥7/8	SHEEP ID #'s
5/21	(0400)			0										
	1545		+11	11						3	7	1		23, 24
5/22	(0400)			11						3	7	1		23, 24
5/23	(0400)			11						3	7	1		23, 24
5/24	(0400)			11						3	7	1		23, 24
5/25	(0400)			11						3	7	1		23, 24
5/26	(0400)			11						3	7	1		23, 24
5/27	(0400)			11						3	7	1		23, 24
		1950	-9	2						2	6	1		23
5/28	(0400)			2						1	1			24
	1921		+7	9							3	3	1	

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
										RAMS				
5/29	0400		+10	19		5		2	3					17, 6
	1538		+12	31		4		5	3					27, 28, 29
		1620	-4	27		1			3					
5/30	(overnight)		+1								1			
	(0400)			28		8		7	3	1	5	3	1	6,24,17,27,28,29
		1000	-3	25							1	1	1	
5/31	(0400)			25		8		7	3	1	4	2		6,24,17,27,28,29
		1300	-3	22					1	1	1			24
		1755	-14	8		7		5	2					6, 17
6/1	(0400)			8		1		2		3	2			27, 28, 29
		1420	-5	3							3	2		
	1430		+1	4									1	
	1720		+3	7							2		1	
		1755	-4	3							2		2	

Appendix II. (cont'd)

				Total										
			# Sheep	Sheep						RAMS				
Date	Time In	Time Out	Enter/Exit	Present	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
6/2	(overnight)		+4							1	2	1		
	(0400)			7		1		2		1	2	1		27, 28, 29
	1100		+5	12		1			3		1			
6/3	(overnight)		-2						1		1			
	(0400)			10		2		2		2	1	2	1	27, 28, 29
	1100		+2	12							1	1		
		1230	-1	11								1		
6/4	(0400)			11		2		2		2	1	3	1	27, 28, 29
		1040	-2	9		1						1		
		1330	-1	8									1	
	1610		+1	9		1								brok. rt. hn.
		1910	-1	8		1								brok. rt. hn.
6/5	(0400)			8		1		2		2	1	2		27, 28, 29
	1250		+5	13							3		2	
		1720	-2	11						1		1		

Appendix II. (cont'd)

				Total										
			# Sheep	Sheep						RAMS				
Date	Time In	Time Out	Enter/Exit	Present	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
6/6	(0400)			11		1		2		1	4	1	2	27, 28, 29
	1030		+2	13		1		1						#26
		1810	-7	6		1		1		1	3	1		#26
6/7	(0400)			6		1		2			1		2	27, 28, 29
	1000		+1	7								1		
	1210		+1	8							1			
		1450	-4	4							1	1	2	
		1630	-1	3							1			
6/8	(0400)			3		1		2						27, 28, 29
	0800		+5	8							4	1		
	1040		+2	10						1	1			
	1200		+4	14		2		1			1			#26
	1350		+4	18							3		1	full curl
6/9	(0400)			18		3		3		1	9	1	1	#26, 27, 28, 29
		0500	-3	15							2		1	full curl
		0930	-1	14								1		

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
6/9		1200	-4	10		2		1			1			#26
cont.		1220	-1	9							1			
	1240		+1	10							1			
		1310	-1	1							1			
6/10	(0400)			9		1		2		1	5			27, 28, 29
	1520		+7	16		2		2	3					
6/11	(0400)			16		3		4	3	1	5			27, 28, 29
		0950	-4	12							4			
		2030	-4	8		2			2					
6/12	(0400)			8		1		4	1	1	1			
		1200	-8	0		1		4	1	1	1			
6/13	(0400)			0										
	0800		+2	2							1	1		
	1020		+15	17		9		1	2	1	2			
	1220		+1	18									1	

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	RAMS ≥1/2	RAMS ≥3/4	RAMS ≥7/8	SHEEP ID #'s
6/13	1330		+1	19								1		
cont.		1350	-12	7		7			2	1	2			
		1420	-5	2		2		1			1	1		
		1700	-2	0								1	1	
6/14	(0400-2100)			0										
6/15	(0400-2100)			0										
6/16	(0400)			0										
	1540		+20	20		10	3	3	3	1				
		1730	-1	19		1								
6/17	(0400)			19		9	3	3	3	1				
6/18	(0400)			19		9	3	3	3	1				
	0930		+2	21		1		1						
		1510	-10	11		5		2	2	1				
		1630	-1	10				1						

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
6/19	(0400)			10		5	3	1	1					
6/20	(0400)			10		5	3	1	1					
		0820	-10	0		5	3	1	1					
	2050		+3	3		2	1							
6/21	(0400)			3		2	1							
		1150	-3	0		2	1							
	1640		+6	6		3		1	2					
	1720		+2	8					2					
		1820	-2	6					2					
		2000	-6	0		3		1	2					
6/22	(0400)			0										
	1610		+2	2					2					
		1700	-2	0					2					
6/23	(0400)			0										
	1240		+7	7		4	2		1					
		1550	-7	0		4	2		1					

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
6/24	(0400)			0										
	1550		+1	1		1								
		1830	-1	0		1								
6/25	(0400)			0										
	0950		+2	2		1		1						
	1030		+4	6		3	1							
		1930	-3	3		3								
6/26	(0400)			3		1	1	1						
	1100		+1	4							1			
		1520	-1	3							1			
		1620	-3	0		1	1	1						
6/27	(0400)			0										
	0610		+1	1		1								
		1400	-1	0		1								
6/28	(0400-2100)			0										

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	RAMS ≥1/2	RAMS ≥3/4	RAMS ≥7/8	SHEEP ID #'s
6/29	(0400)			0										
	0740		+7	7		2		1	2			2		
	0810		+3	10		2		1						
	0950		+2	12			1							
	1000		+2	14		1		1						
		1110	-2	12								2		
		1410	-2	10		1		1						
		2030	-2	8				2						
7/7	(0400)			0										
	0850		+2	2		1								
		0950	-2	0		1								
6/30	(overnight)		-5	3				3						
		0910	-1	2				1						
	0920		+2	4		1		1						
		1230	-2	2		1		1						
		1410	-2	0				2						

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
7/1	(0400-2100)			0										
7/2	(0400-0900)			0										
7/3	NO DATA													
7/4	NO DATA													
7/5	1530			13		5	5	1	2					
		1630	-6	7		2	2	1	1					
		1740	-2	5		1	1							
		1800	-5	0		2	2							
7/6	(0400-2100)			0										
7/8	(0400)			0										
	1250		+12	12	4	4	4							
		1300	-12	0	4	4	4							

Appendix II. (cont'd)

Date	Time In	Time Out	# Sheep Enter/Exit	Total Sheep Present	Uncl.	E	L	Y	2Y	RAMS ≥1/4	≥1/2	≥3/4	≥7/8	SHEEP ID #'s
7/9	(0400)			0										
	1710		+2	2		1		1						
		1900	-2	0		1		1						
7/10	(0400-2100)			0										
7/11	(0400-1700)			0										

Appendix III. Miscellaneous observations of sheep in Jay Creek lick areas

								RAMS					
Date	Time	# Sheep	Uncl.	E	L	Y	2Y	≥1/4	≥1/2	≥3/4	≥7/8	Location	COMMENTS
6/18	1010	5		3	1	1						North bluff upstream	Did not come to main lick area.
6/23	1350	5	2	3								North bluff upstream	
6/26	1730	2	2									North bluff	
7/12	0800	10	6	2	2							Upstream lick	
7/19	0800-2100	0										Viewing area	
7/21	0800-1800	0										Viewing area	
7/22	0800	0										Viewing area and upstream	
8/10	1700	4		2	2							Upstream below north bluff	
		4		2	2							Red cliffs, east side	
		1	1									Left field	