MINERAL LICK USE BY DALL SHEEP IN THE WATANA CREEK HILLS, ALASKA

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ABSTRACT

A small isolated Dall sheep population in the Watana Creek Hills, Alaska, uses a mineral lick area in lower Jay Creek. This study was done in 1983 to document this lick use because the proposed Susitna River Hydroelectric Project would flood the lower reaches of Jay Creek. A minimum of 31% (at least 46 rams, ewes and young) of the estimated 1983 sheep population travelled 8 km (5 mi) or more from typical alpine range to the licks in the lower 6.5 km (4 mi) of Jay Creek. Sheep travelled through flatlands of shrubland and forest to this area even though another smaller lick with similar chemical anomalies was used within their alpine range. Lower Jay Creek contains a large rock bluff used for resting, feeding and licking, and several exposures of fine-grained soil in the creek valley which was eaten by the sheep. Soil samples from well-used lick cavities contained large ($\geq$ 1740 ppm) and significantly higher ($P < 0.05$) amounts of sodium, the suspected lick attractant, than did soil collected away from lick sites.

INTRODUCTION

Studies of big game species near the proposed Susitna River hydroelectric development were begun in 1980 by the Alaska Department of Fish and Game (ADF&G). During preliminary surveys from 1980-1982, Dall sheep (Ovis dalli) were observed using mineral licks in a forested area of lower Jay Creek in the Watana Creek Hills, several km from typical alpine habitat (Tobey 1981, Ballard et al. 1982, Tankersley 1983). The lick area is adjacent to the proposed Watana impoundment which would flood lower Jay Creek up to 670.6 m (2200 ft). The hills contain a small (usually less than 200 individuals), relatively isolated, sheep population. Detailed studies on the use and importance of this area to sheep were begun in 1983.

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 about 19 km (12 mi) to visit a lick before moving to summer range (Heimer 1973). Use of mineral licks occurs mostly in spring and early summer (mid-May through mid-July in interior Alaska) (Fraser and Tankersley, in prep). Because of the apparent importance of mineral licks to Dall sheep in Alaska, Heimer (1973) recommended that licks be designated critical habitat areas.

Although various elements have been suggested as the one sought by ungulates at mineral licks, sodium is the most likely candidate (Stockstad et al. 1953, Hebert and Cowan 1971, Weeks and Kirkpatrick 1976, Weeks 1978, Fraser and Reardon 1980, Tankersley and Gasaway 1983).

The goal of this study was to document the use and importance of the Jay Creek lick to the Watana Creek Hills sheep population. 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 sheep use of the East Fork slide lick, also in the Watana Creek Hills about 12 km (7.4 mi) north.

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STUDY AREA

WATANA CREEK HILLS

The Watana Creek Hills in the northeastern Talkeetna Mountains (Fig. 1) are approximately 52 km^2 (20 mi^2) in size and are roughly bisected by Watana Creek and an unnamed drainage. Elevations range from 914-1797 m (3000-5896 ft). The vegetation is predominantly black spruce (Picea mariana) with birch (Betula glandulosa) and willow (Salix spp) shrubs in the lower elevations, and alpine tundra in the higher elevations. Steep rocky cliffs are common in the central hills. Wolves (Canis lupus), brown bears (Ursus arctos), and in lower elevations, black bears (Ursus americanus) inhabit the area.

The Jay Creek mineral lick area occurs in the lower 6.5 km (4 mi) of the creek where elevations range from 579-914 m (1900-3000 ft). The vegetation is predominantly spruce woodland with scattered stands of deciduous trees, and birch/willow shrubland. About 3.2 km (2 mi) from the mouth on the west side is a large bluff with rock outcrops (Fig. 2). The Bluff extends along the creek for about 0.3 km (0.2 mi) rising to 777 m (2550 ft). The Bluff rock is mostly quartz biotite schist with feldspar inclusions in fracture zones and veins. Some soil occurs between the rock crevices and coats some rock surfaces and was

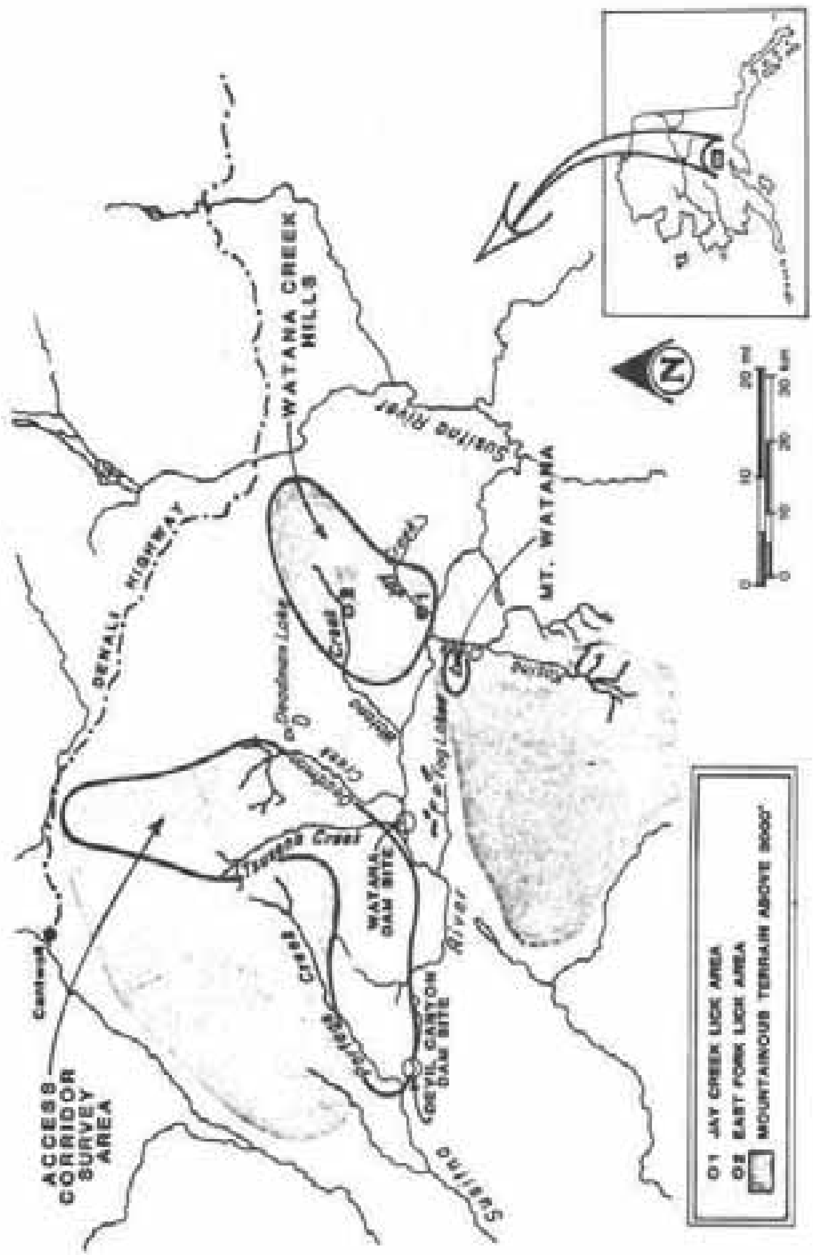

Fig. 1. Susitna River Hydroelectric study area.

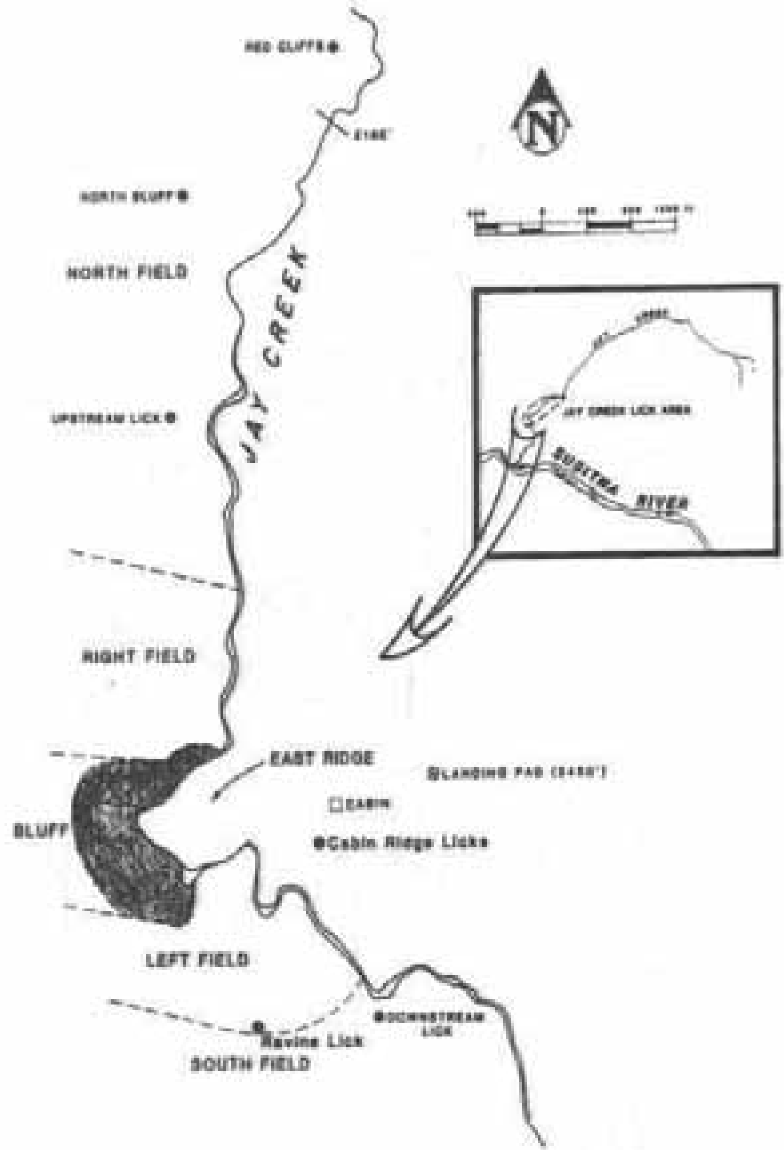

Fig. 2. Lower Jay Creek mineral lick area.

presumably the lick substrate used by sheep. At several places along the lower creek valley, soil banks are exposed. Some of these are very fine-grained deposits of glacio-lacustrine origin which were popular licking sites. Sheep had eaten so much soil at some of these exposures that they left small caves or cavities (on East Ridge, Cabin Ridge and South Field Ravine, Fig. 2). Archeological sites containing animal bones more than 4,000 years old have been discovered associated with several licks.

Another mineral lick is about 12 km (7.4 mi) north of the Jay Creek licks (Fig. 1) adjacent to the East Fork of Watana Creek. Sheep eat wet gray clay exposed in a small area on an unvegetated slide approximately 1067 m (3500 ft) in elevation. The clay probably originated in a shear/fracture zone in the bedrock. The slide is approximately 76 m (250 ft) at its base, rising 76 m (250 ft) high in a triangular shape and exposes metavolcanic rocks, predominantly metabasalts. The surrounding vegetation is predominantly alpine tundra with willows and alders (*Alnus* spp.) lining the creek slides. Steep, rocky cliffs are common in the area. Sheep live in the surrounding area year-round.

METHODS

SHEEP OBSERVATIONS

On 5 and 7 April 1983 21 sheep were color-marked on winter range in the Watana Creek Hills 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. Sheep were marked with paint-filled dart syringes fired from a Cap-Chur rifle or paint pellets fired from a Nel-Spot "007" pistol. A Bell 206 IIIB helicopter was used in the marking operation.

A detailed ground-based study of sheep in the Jay Creek lick area was begun 11 May and ended 11 July 1983. After 14 May, the area was observed from 0400-2100 hours daily, with a few exceptions due to rest periods, fog, helicopter logistics or lack of personnel. Observations were made from or near a small plywood cabin (Fig. 2) with the aid of 10 x 40 binoculars and a 20-45x spotting scope. Intermittent ground and aerial observations of the area were also made from 11 July - 10 August.

When sheep were seen in the area, the number of sheep in each location or lick site (Fig. 2) was recorded every ten minutes From these instantaneous scan samples (Altmann 1974), the location of each sheep recorded was assumed to last for 10 minutes. This provided an estimate of sheep-hours spent in certain locations. 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; $\geq$ 1/4-curl ram, $\geq$ 1/2-curl, $\geq$ 3/4-curl ram, or $\geq$ 7/8-curl ram. 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. Observations of color-marked sheep and other easily identifiable individuals were noted daily. Elevations of lick sites and other areas used by sheep were estimated with a Micro M-1 surveying altimeter.

Sheep using the East Fork slide lick were observed daily from 28 May-16 June, and from 22-24 June usually from 0400-2100 hours. The number of different sheep that used the lick, as well as their sex, age and curl size (rams') were recorded daily.

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 element analyses. Some well-used licks (East Ridge, South Field ravine, Cabin Ridge) had obvious cavities where sheep had eaten into the soil (Fig. 3), which made locating sampling sites easy. However, sites on the Bluff, and lesser used upstream and downstream sites did not have this feature, so exposed soil in the general vicinity of observed licking was taken. Jay Creek control samples were taken from exposed soil on unused sites, sometimes with a different color and texture, along the creek and other areas in the hills. Lick samples from the East Fork slide lick were taken from the two small sites where the clay was eaten. Control samples were taken from exposed soil on the slide which was not eaten by the sheep. Samples were collected with plastic utensils and placed in plastic bags to avoid contamination.

Samples were analyzed by the inductively-coupled argon plasma (ICAP) scan method for calcium, cobalt, chromium, copper, iron, potassium, magnesium, manganese, selenium, sodium, nickel, silicon, tin, vanadium, and zinc, plus 22 samples were analyzed by turbidimetric method for sulfate. All 44 samples were analyzed for water soluble cations, and 25 of these were also analyzed with a 4:1 reagent grade nitric: hydrocholoric acid leach for "total" elemental content. 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 from samples containing levels below detection limits, the sample level was assigned the maximum possible level (e.g., 0.09 ppm for aqua-regia digestion results, 0.04 ppm for water soluble results, 0.9 ppm for sulfate).

AERIAL SURVEYS

A late winter sheep distribution survey of the Watana Creek Hills was done with a Piper PA-18 Super Cub on 9 March 1983, and another survey to document summer distribution and to obtain a more complete population count was flown on 20 June 1983. All sheep observed on these surveys were classified by ram horn size, or as "ewes" (mostly ewes, yearlings and 2-year olds) or lambs, and their locations plotted on a 1:250,000 scale U.S.G.S. topographic maps.

RESULTS

AERIAL SURVEYS

Ninety-seven sheep (eleven rams and 86 ewes, sub-yearlings and two-year-olds) were recorded during the aerial survey on 9 March 1983. Most of the sheep were observed on wind-blown or south-facing slopes on the western end of the hills 11 km (7 mi) or more northwest of the Jay Creek lick area.

Fig. 3. Lick cavity in glacio-lacustrine soil.
Hole at left is 15 cm in diameter.

On the 20 June survey a total of 149 sheep (34 rams, 96 ewes, yearlings and two-year-olds, and 19 lambs) were observed. 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 in low rolling hills. The major concentration of lambs was north of Watana Creek, across from the East Fork lick.

JAY CREEK LICK AREA

Groups of sheep entered the lick area for the first time from the mountains to the north or northwest, a distance of at least 8 km (5 mi). Two color-marked sheep travelled at least that distance. Often, the Bluff was visited first, and then sheep would 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 (Fig. 2) for 2 hours on 17 June. Sheep spent 14% of the time below 671 m (2200 ft), the maximum impoundment level,1 and 46% of the time below 701 m (2300 ft). Most of the well-used lick sites are located between 671-701 m.

Most sheep were observed returning to the north or northwest. However, sheep frequently used the area east of Jay Creek after 30 May. Twenty-nine sheep were seen in the low rolling hills about 4 km (2.5 mi) east of the Bluff during the aerial survey 20 June. Observations of sheep near bluffs along the Susitna River during May and June 1982-84 indicate that additional lick sites may occur up to 20 km (12.4 mi) east of the Jay Creek area. The area east of Jay Creek is characterized by gentle topography and nearly complete snow cover from October to April and is not used as winter range.

From 11 May-11 July up to 31 different sheep were seen daily in the Jay Creek mineral lick area (Fig. 4). By adding the highest number of different sheep seen in each sex-age class at any time, a minimum of 46 different sheep using the Jay Creek licks was calculated. Some recognizable individuals (two color-marked and others) stayed 2-15 days. Some sheep made at least two trips to the lick area from the hills to the north.

Rams used the area exclusively from 11-28 May and most ram use occurred before 14 June (Fig. 4). Large groups of ewes and yearlings appeared on 29 May. The numbers of ewes and yearlings in the study area dropped on 1 June, then slowly increased with another peak during 16-18 June. Lambs first appeared in the study area during this second peak. Lick use declined by late June although a few sheep were still coming to the lick area as late as 10 August.

EAST FORK SLIDE LICK

Because this lick is within the typical alpine summer range of these sheep, they did not have to travel a long distance to use this lick. Consequently, sheep would visit the East Fork slide lick for hours rather than days at a time. No color-marked sheep were noticed in the East Fork area, but other recognizable sheep made repeated lick visits in a day. Up to 37 different sheep were observed at the lick per day from 28 May-16 June and 22-24 June (Fig. 5). By adding the highest number of sheep seen in each sex-age class per day, at least 47 different sheep used the lick during this period. No sheep were identified to use both Jay Creek and East Fork slide licks, although this may have occurred.

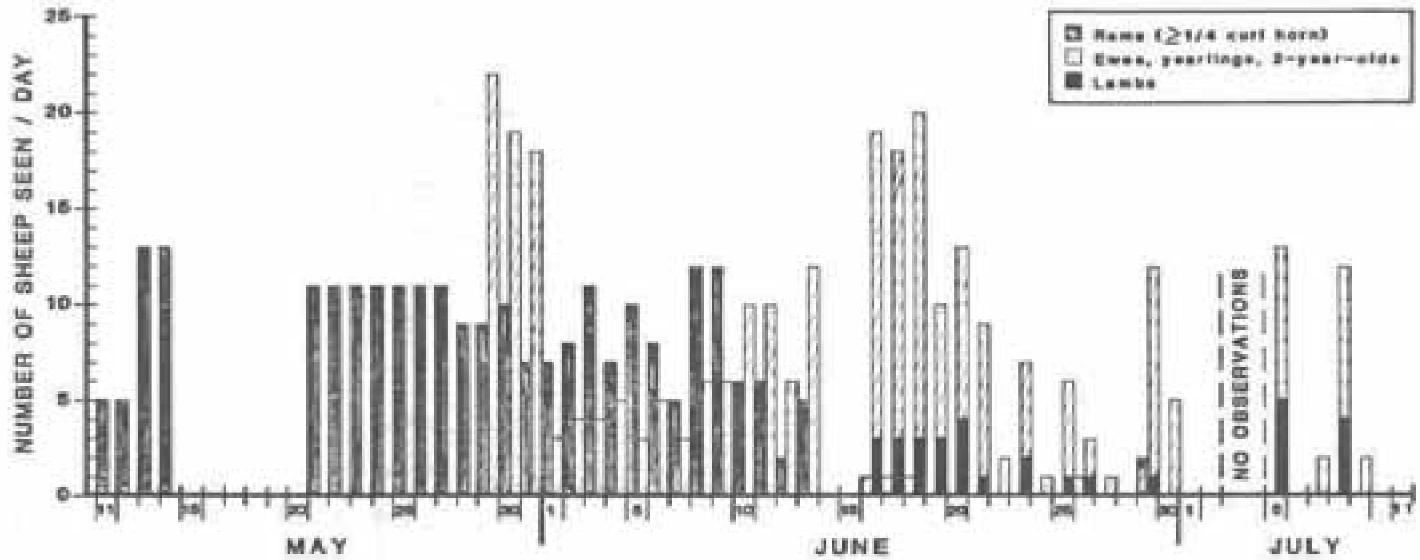

Fig. 4. Sheep seen at Jay Creek lick per day.

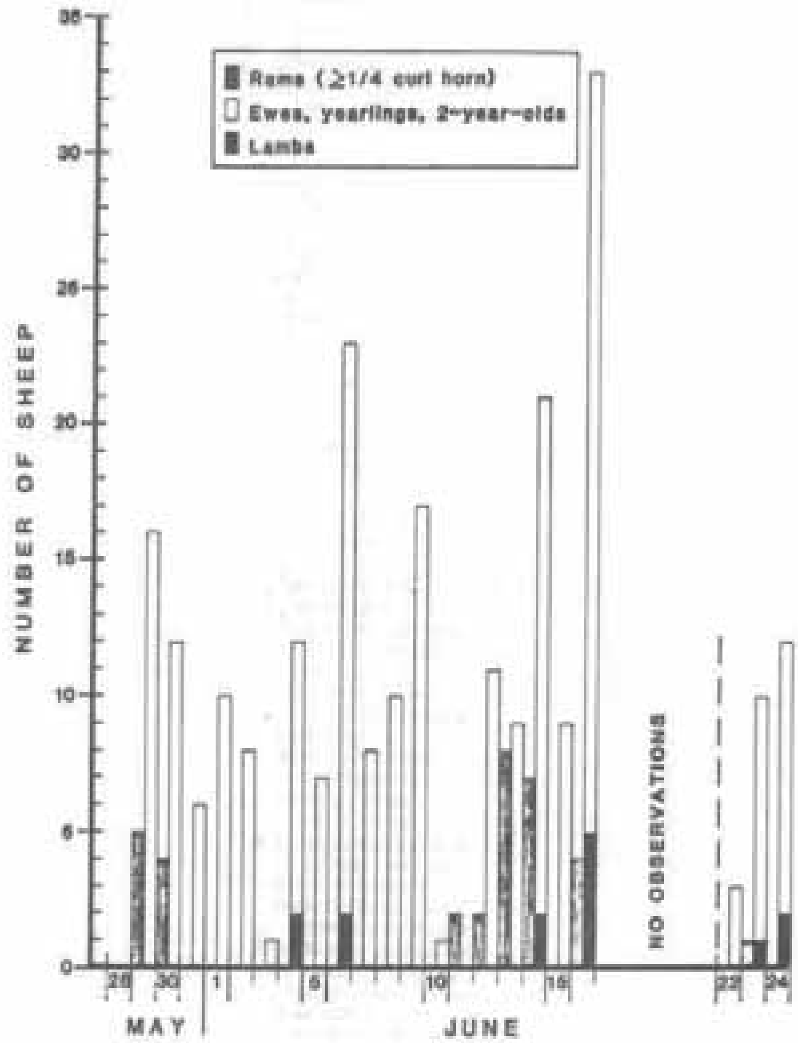

Fig. 5. Sheep seen at East Fork slide lick per day.

Possibly because observations began later, ram use of the East Fork slide licks was much lower than at Jay Creek (Table 1), and was nonexistent during 31 May-10 June (Fig. 5). 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 slide lick. Use by ewes and yearlings was higher at the East Fork slide lick (Table 1). Although the mountains north of Watana Creek were a major nursery area, only two groups (of 5 and 11 ewes, yearlings and lambs) were seen crossing Watana Creek from the north to visit the East Fork lick.

Table 1. 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

LICK ANALYSES

Samples from well-used Jay Creek 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 "total" copper, iron and magnesium, compared to control samples (Table 2). The lick samples also contained higher ($P < 0.05$) amounts of water soluble sodium, magnesium, calcium, sulfate and phosphorus (Table 3).

Samples from well-used lick cavities were also higher ($P < 0.05$) in water soluble sodium, magnesium and phosphorus than Bluff samples (Table 3). Water soluble calcium was also somewhat higher ($P = 0.56$) in the lick cavity samples compared to 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 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 lick sample locations.

Lesser used lick 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 2). Water soluble sodium, magnesium, calcium and sulfate were higher in the lesser used lick sites compared to control samples ($P < 0.05$, Table 3).

Water soluble sodium, magnesium and phosphorus were also significantly higher ($P < 0.05$) in the East Fork slide lick samples compared to control samples, along with several other elements (Table 4). However, unlike the Jay Creek licks, water soluble silicon and iron were the two most abundant elements

Table 2. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from Jay Creek lick and control sites.[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	63	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

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Table 2 (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 3. Water soluble mineral elements and sulfate (ppm) from samples taken from Jay Creek lick and control sites.

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	3.6	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	3.6	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

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Table 3 (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 4. Water soluble mineral elements and sulfate (ppm) from soil samples taken from the East Fork lick and control sites.[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.

in the East Fork samples. The laboratory staff reported that they were unable to completely filter out or centrifuge the extremely fine particles from the water leach. Consequently, some of the elements reported may be high because of this phenomenon. Not enough samples were analyzed for "total" elemental content to compare the East Fork slide lick and control sites statistically (Table 5).

DISCUSSION

The Jay Creek lick area adjacent to the proposed Watana impoundment is used by a large proportion of the sheep population in early summer. At least 31% of the observed 1983 population used the Jay Creek lick area, and up to 31 individuals (21% of the population) were seen in the lick area at one time. Rams used the licks by mid-May, followed by pregnant or barren ewes and yearlings, with ewe-lamb groups arriving after June 15. This pattern is similar to those reported for mountain goats (Hebert and Cowan 1971), Dall sheep (Heimer 1973), and moose (Tankersley and Gasaway 1983). Sheep travel some distance to use this lick as both winter and summer surveys located most of the population 11 or more km (7 mi) from the Jay Creek lick area. Two color-marked sheep travelled 8 km (5 mi) to the Jay Creek lick area between April and late May. Although Heimer (1973) reported that sheep have travelled greater distances to a lick, this travel was within typical alpine habitat which included cliffs for escape (W. Heimer, Alaska Dept. Fish and Game, pers. comm.). In contrast, the Jay Creek lick area and much of the main travel corridor is atypical sheep habitat, being relatively flat with low shrubland and trees and little escape habitat from predators.

It appears that the essential macro-elements of sodium, magnesium and calcium are the predominant components. Sulfate was also a major water soluble component. Of 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 that has been shown to be selected for by ungulates at lick sites (Stockstad et al. 1953, Fraser and Reardon 1980). Essential microelements such as copper may also be important lick elements. Indications of a copper deficiency in Alaskan moose have been reported (Flynn et al. 1977), but more studies are needed to demonstrate a link between trace element deficiency and lick attraction. Water soluble cations would certainly be available for sheep digestive intake. However, the acid in the rumen is not as strong as that used for "total" elemental content and not all of the elements released by aqua-regia digestion would be metabolically available to sheep.

While the East Fork slide lick had higher "total" sodium levels (as well as magnesium and calcium) than did the Jay Creek licks, sheep still endured the danger of travel to the Jay Creek lick and visited it at a rate similar to the East Fork slide lick. This may be because water soluble elements at Jay Creek are more important, or because of the limited size of the East Fork licking area, or due to habit, earlier spring phenology, or some other benefit of the Jay Creek area. Also, the similar visitation rates may not necessarily reflect the same amount of licking done in each area. This is because sheep visit the East Fork slide lick for hours rather than days at a time (like at Jay Creek). In any case, the significant use of the Jay Creek area in addition to the East Fork slide lick is well documented, but not well understood.

Table 5. Mineral element results (ppm) from aqua-regia digestion of soil samples taken from the East Fork lick and control sites. 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).

The proposed impoundment may affect sheep use of the Jay Creek licks. Sheep spent a large proportion of time (46%) below 701 m (2300 ft) where most of the lick sites were located. The area below 671 m (2200 ft) would be directly affected by the impoundment; erosion below 701 m may eliminate some lick sites, but may also expose new ones. Flooding and mudslides and ice shelving in the impoundment and drawdown zone (629-671 m) may inhibit sheep from crossing Jay Creek to readily use licks, escape cliffs and feeding areas on both sides. Also, disturbance from timber removal within the impoundment area and possible increased recreational use of the area may hinder sheep use. Archeological finds in the immediate vicinity should encourage caution about disturbing these licks which may have been used by sheep for a very long time.

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