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UPPER SUSITNA RIVER MOOSE POPULATION STUDY

by
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Volume I
Project Progress Report
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JOB PROGRESS REPORT (RESEARCH)

State: Alaska

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Project Nos.: W-17-9 & W-17-10 Project Title: Big Game Investigations

Job No.: 1.20R Job Title: Upper Susitna Valley Moose Population Study

Period Covered: August 1, 1976 to December 1, 1977.

SUMMARY

A total of 105 adult cow moose were marked with individually identifiable collars, which included 40 radio collars, in the upper Susitna River Basin during October 1976 and March 1977. Physical measurements, blood and hair samples, and one incisor tooth for purposes of age determination were taken from each moose. During spring tagging 59 moose, of which 52 (88 percent) were pregnant, were rectally palpated to assess pregnancy.

Mean age of marked moose was approximately 7 years. Fifty-one percent of the moose sampled were between 5 and 11 years of age. Comparison of selected blood parameters with those obtained from other moose populations indicated that upper Susitna River moose were in relatively good condition.

During the reporting period 39 radio-collared moose were located a total of 584 times. Moose tagged in the eastern half of the study area exhibited extensive migratory movements while those in other areas were much more sedentary. Most movements were from higher elevations in summer to lower elevations in winter. Fall migration was initiated in November and appeared to be somewhat correlated with the first heavy snowfall. Spring migration occurred gradually from mid-April through mid-July. Tentatively, four populations of moose were identified; their movements are discussed.

Forty-eight flights were made in late spring and summer to monitor parturition and subsequent survival of calves. Parturition was first observed on 24 May. Radio-collared cows calved between 25 May and 10 June. Thirty-eight moose produced at least 30 calves, however only 23 percent survived to 1 November. Seventy-eight percent of the calf mortality occurred prior to 24 June.

During the reporting period a report was prepared on moose movements and habitat use on the Susitna River and its relationships to the proposed Susitna River Hydroelectric Project. The report is contained in Appendix I.

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BACKGROUND

Prior to statehood, management of moose (*Alces alces*) in Alaska with its limited access and sparse human population required little more than establishing liberal seasons, conducting sex-age composition counts and keeping a gross tally of harvest. Moose numbers were increasing between 1940 and 1960 (Bishop and Rausch 1974). Within the past two decades, however, Alaska's human population has grown significantly (Yankee 1974) and there has been a manifold increase in demand for moose. Consequently, moose management has become more intensive, requiring detailed knowledge of various population and habitat parameters.

Between 1963 and 1975 over 69,000 moose were harvested in Alaska (ADF&G unpublished files). Of that total, 23 percent were from the Nelchina Basin (Game Management Unit [GMU] 13) in Southcentral Alaska. In the Nelchina Basin moose numbers began to decline after winter 1961-62 (Bishop and Rausch 1974). Deep snows were thought to have precipitated that decline and predation and hunting were thought to be preventing recovery. McIlroy (1974) suggested that low bull:cow ratios had influenced conception rates while Bishop and Rausch (1974) considered that habitat deficiencies may have been at least partially responsible for these declines.

Because of its depressed moose populations and the obvious importance of Unit 13 to the statewide moose harvest, three interrelated studies were initiated in an effort to identify both problems and possible solutions. These studies focused on both moose and wolf (*Canis lupus*) population dynamics in addition to testing the hypothesis that wolf predation was responsible for low calf survival. The latter study involved removing wolves from a portion of GMU 13 and then measuring calf survival in following years. In order to properly evaluate the effects of wolf removal on the study moose herds, it was necessary to accomplish the following: identify distinct moose populations and calving areas, and determine pregnancy rates, age structure and physical condition of these populations. The purpose of this paper is to report on the first year's results of the moose population identity and movements study.

The area selected for study is located at the head of the Susitna River almost directly between the communities of Cantwell and Paxson.

The old Denali Highway bisects the area from east to west. Its boundaries consist of the following: Alaska Mountain Range on the north; Maclaren River on the east; Maclaren and Susitna Rivers on the south; and the confluence of Deadman Creek with Susitna River northwest to headwaters of Brushkana Creek, downstream to Brushkana Creek's confluence with the Nenana River and then upstream to the Alaska Range on the west.

The area encompasses approximately 7,380 km^2. Elevations range from approximately 450 to over 2,800 m. Over 65 percent of the area is between 450 and 1,200 meters elevation. Vegetation, topography and general climate were thoroughly described by Skoog (1968) and correspond to his following units: 2 - Monahan flats, 3 - Clearwater Mountains, 5 - Deadman Lake, 6 - Tangle Lakes, and 8 - Upper Susitna bottomlands.

OBJECTIVES

To determine population identities and seasonal movement patterns of moose in the upper Susitna Valley.

PROCEDURES

Adult female moose were captured with the aid of helicopter by darting with 3 cc aluminum darts fired from a CAP-CHUR gun with appropriate dosages of succinylcholine chloride (Franzmann et al. 1974). Helicopter capture methods were identical to those used previously on other Alaskan moose movement studies (Nielson and Shaw 1967). We made no attempt to capture bull moose.

Captured cow moose were marked either with a radio collar, a colored, numbered visual collar, or both, permitting individual recognition from fixed-wing aircraft. Half of the radio collars were color-coded with canvas tape wrapped around the machine belting. Visual collars were the same type as those described by Franzmann et al. (1974). Radio collars were constructed of machine belting 1.3 cm thick by 5.4 cm wide. Collars had an inner adjustable circumference ranging from 101 cm to 111 cm. The belting surrounded the radio components which were encased in dental acrylic which theoretically made the unit waterproof. The entire unit weighed 1,133 grams. Radio frequencies were in the 150.000 MHz range. Radio collars were purchased from A.V.M. Instrument Company (810 Dennison Drive, Champaign, Illinois) and visual collars were obtained from Denver Tent and Awning Company (Denver, Colorado).

In addition to being collared, each moose was ear-tagged with numbered metal tags. Most metal tags were accompanied with 5 cm x 13 cm piece of colored polyvinyl plastic. Tags were affixed to the base of the ear.

Each captured moose was immediately fitted with a collar and, if time and/or the animal's behavior permitted, additional data were collected. We attempted to extract a lower incisor tooth from each animal for determining its age using the methods described by Sargent and Pimlott (1959).

Blood was extracted from the jugular vein into sterile evacuated containers. Upon return from the field, the blood was centrifuged to separate sera which were placed into 5 ml plastic vials and immediately frozen. One-ml samples were later sent to Alaska Medical Laboratories, Anchorage, Alaska for blood chemistry analysis (Technical Autoanalyzer SMA-12) and protein electrophoresis (Franzmann and Arneson 1973). Generally three or four 10-ml vials were filled 1/3 to 1/2 full. One of the vials contained heparin which provided whole blood for determination of percent hemoglobin (Hb) using an HB-meter (Americal Optical Corporation, Buffalo, New York) and packed cell volume (PcV) using a micro-hematocrit centrifuge (Readocrit-Clay-Adama Company, Parsippany, N.J.). Remaining sera are being stored for possible future analysis.

Hair samples were plucked from the shoulder hump area. Samples will be analyzed in conjuction with studies performed by Franzmann et al. (1975) to aid in assessing physical condition. Physical measurements of most moose included total length, heart girth, and length of hind foot. We attempted to subjectively estimate the physical condition of each moose using the index criteria developed by Franzmann and Arneson (1973). During spring tagging we rectally palpated (Greer and Hawkins 1967) each moose to determine pregnancy. Data pertaining to each individual moose were placed on numbered tagging cards.

Radio signals were received with a 4-band, 48-channel portable receiver purchased from A.V.M. Instrument Co. Radio-collared moose were tracked from either a Piper PA-18 Supercub or STOL Cessna 180 fixed-wing aircraft. Tracking methods and equipment used were similar to those described by Mech (1974). Initially, radio-collared moose were tracked every 3 to 4 weeks. From mid-May through mid-July flights were conducted every 3 to 5 days to obtain data on parturition and subsequent calf survival. Thereafter, radio-collared moose were monitored every 6-8 weeks.

No special flights were made to specifically search for visually-collared cows. All observations of these animals were made incidental to other activities. When tagged moose were located their location was recorded on U.S.G.S. maps with a scale of 1:250,000. Numbers, sex and age of associates were also recorded. Public sightings of collared adults were recorded. Beginning in March 1977 habitat descriptions for each moose sighting were recorded based upon criteria developed during the first 6 months of the study. These data will be reported in subsequent reports. Moose activity was classified and recorded for each sighting into one of four classes: standing, bedded, feeding or running.

During 1976-77 a total of 105 adult cow moose were tagged within, or close to, the Susitna River Study Area; 41 from 21 to 28 October 1976, and 64 from 18 to 23 March 1977. Forty of these moose were fitted with radio collars and the remainder were marked with visual collars. Twenty of the moose radio-collared in the spring were additionally marked with visual collars.

RESULTS

A summary of tagging location, moose numbers, physical measurements, age, and other statistics associated with tagging is presented in Tables 1 and 2. During both tagging periods we experienced considerable difficulty in sedating adult moose. Successful drug dosages in the fall ranged from 27 to 31 mg (average 28 mg) and those in the spring ranged from 23 to 29 mg (average 27 mg). During both tagging efforts several moose were darted but never responded to the drug and consequently were not collared. Dosages which did not sedate certain moose unexpectedly killed others--three in the fall and five in the spring. The length of time necessary for a moose to respond to the drug was variable, ranging from 3 to 21 minutes.

We observed considerable variation in the physical condition of collared moose. Fall index values ranged from 6 to 8 (average 6.7) and spring values ranged from 4 to 8 (average 6.4).

Considerable variation was also observed in the relative size of individual moose. Total length measurements ranged from 244 to 325 cm, while hind foot and heart girth ranged from 68 to 89 cm and from 168 to 229 cm, respectively.

The mean age of these adult cows was 84 months for fall-captured moose and 83 months for spring-captured moose. Fifty-one percent of those handled were between 5 and 11 years of age while 16 percent were 12 to 15 years of age. Calves and, in most cases, yearlings were intentionally avoided.

During spring tagging 59 moose were rectally palpated to determine pregnancy. Of that total, 52 (88%) were pregnant. Of the seven which were not pregnant, two were 13 years old, two were 4 years old, one was 3 years old, one was 8 years old, and the age of one was not determined.

Tables 3 and 4 contain means and standard deviations by tagging sites for both seasons of blood parameters tested during this reporting segment. All fall Hb values exceeded 20 gm/100 ml and were so high that precise figures could not be obtained with the instrument utilized. Fall PCV mean values likewise were high, ranging from 51.4 to 56.0 percent and averaging 53.3 percent. Other selected mean fall blood values had the following ranges and total means (expressed as mg/100 ml unless otherwise indicated): Calcium; 10.40 to 12.27 with mean of 11.33; phosphorus, 4.54 to 6.18 averaging 5.07; glucose, 153.00 to 195.75 averaging 180.3; and total protein, 7.63 to 8.24 g/100 ml with a mean of 7.98 g/100 ml.

Spring blood values as expected (Franzmann, pers. comm.) were lower than fall values for nearly all parameters tested. Hemoglobin ranged from 17.0 to 19.7 g/100 ml (average 18.8 g/100 ml) and PCV ranged from 46.4 to 51.3 percent (average 50.2%). For both Hb and PCV the lowest values were from moose sampled in the Devil Mountain area on the middle Susitna River. Other selected mean values by tagging site had the

Table 1. Location, physical measurements, ages, and statistics associated with capturing and marking of 44 adult cow moose in the Susitna River Study area from 21 through 28 October 1976.

Moose #	Date	Location	Collar color-#	L. ear tag color and #	R. ear tag color and #	Age (months)	Measurements (CM) Total length	Hind foot	Shoulder height	Heart girth	Cond. index	Heart Rate (BAM)	Body Temp. (°F)	Drug dosage (mg)	Drug reaction time	Drug placement
8017	10/27/76	S. McClaren Bend	Radio-Yellow	G16258	G16259	77	-	-	-	-	7	-	-	30	7 min	left leg
8018	10/27/76	Butte Creed	Radio-Green	B16240	B16237	17	270	79	-	184	6	-	100.4	29	7 min	lower leg
8019	10/21/76	Gracious House	Radio-Black	G16228	G16229	77	325	89	-	-	8	-	-	-	-	left rump
8020	10/22/76	Gracious House	Radio-Yellow	B16222	G16221	113	319	-	-	198	8	96	103.4	27	6 min	right rump
8021	10/22/76	Brushkana Crk.	Radio-Red	16252	16253	-	-	-	-	-	-	-	-	28	12 min	left hip
8022	10/28/76	Upper Watana	Radio-Red	W16285	W16284	101	299	81	-	214	7	-	-	29	6 min	-
8029	10/26/76	S. McClaren S.E. knob	Radio-Red	G16255	G16256	-	-	79	-	-	8	-	-	30	16 min	-
8030	10/22/76	Across from Ballard Lk. at 3400'	Radio-Black	B16202	B16201	77	306	80	-	46	6	116	100.8	25	9 min	leg
8031	10/22/76	South Bend Susitna	Radio and Blue 3	B16223	B16224	41	280	79	-	198	7	88	101.2	27	3 min	-
8032	10/23/76	Upper Clear-water Crk.	Radio-Red	G16233	G16234	89	318	81	-	266	8	-	101.8	28	10 min	top rump
8033	10/28/76	Valdez Crk.	Radio-Green	B16299	B16254	65	315	78	-	214	8	88	103.2	30	-	left flank
8034	10/23/76	Brushkana Crk.	Radio-Yellow	G10673	G10673	41	296	79	-	196	7	-	-	29	13 min	top back
8035	10/27/76	S. McClaren Flats	Radio-Blue	W16066	W16067	-	290	-	-	203	7	-	-	-	5 min	lower left hip
8036	10/28/76	West Fork Glacier	Radio-Blue	B16266	B16265	77	302	77	-	183	-	-	-	29	5 min	high left t hip
8037	10/28/76	Just below West Fork Glacier	Radio-Blue	W16243	W16244	77	308	-	-	193	7	-	-	27	9 min	left hip
8038	10/27/76	Watana Creek	Radio-Red	G16239	G16263	101	303	-	-	193	-	-	-	-	-	-

8039	10/28/76	West Fork Glacier	Radio-Yellow	B16298	B16296	77	-	-	-	-	-	-	-	30	-	top left rump
8040	10/28/76	Upper Watana Creek	Radio-Green	W16061	W16062	-	305	-	-	193	7	-	-	29	9 min	-
8042	10/28/76	West Fork Susitna	Radio-Blue	16241	W16242	53	305	-	-	203	-	-	-	29	10 min	left flank
8044	10/23/76	Upper Little Clearwater	Radio-Black	G16074	G16075	41	302	81	-	-	8	-	102.6	29	-	high tail
1	10/21/76	Gracious House	Blue 1	Y16232	Y16231	149	300	74	-	183	-	-	102.2	-	-	left rump
2	10/22/76	South Bend	Blue 2	G16248	G16247	101	297	68	-	193	-	-	-	-	6 min	-
4	10/22/76	across from Spraker Lake	Blue 4	G16250	G16249	53	312	-	-	193	-	-	-	-	-	high on left hip
5	10/22/76	across from Spraker Lake el 3400'	Blue 5	B16206	B15205	65	176	81	-	118	7	88	102.2	27	10 min	left hind
6	10/22/76	across from Spraker Lake el 3400'	Blue 6	B16277	B162776	65	317	-	-	213	-	-	-	27	4 min	left hip
7	10/22/76	Sue R - S of Coal River	Blue 7	G16226	G16227	53	-	-	-	-	-	-	-	25	9 min	left hind quarters.
8	10/27/76	South McClaren SE Knob	Blue 8	W16216	W16217	161	291	72	-	200	6	-	--	30	5 min	left hip
9	10/27/76	Butte Creek	Blue 9	G16262	G16275	65	287	79	175	206	6	120	102.2	27	-	left rump
10	10/27/76	Butte Creek	Blue 10	G16281	G16279	89	301	82	-	188	-	-	-	27	12 min	rump-left leg
11	10/27/76	South McClaren Flats	Blue 11	G16260	G16273	77	305	-	-	204	6	-	-	31	5 min	top left rump
12	10/23/76	Brushkana Creek	Blue 12	G16070	G16071	41	-	-	-	-	7	-	-	27	-	-
14	10/23/76	Brushkana Creek	Blue 14	16235	16236	41	311	-	-	-	8	-	104	29	-	inside rear left leg
15	-	West Fork Gl	Blue 15	B16269	B16267	113	301	-	-	206	-	-	-	29	10 min	high left leg
16	10/23/76	Valdez Creek	Blue 16	G16068	G16069	-	-	-	-	-	-	-	-	28	6 min	tail
17	10/21/76	Gracious House	Blue 17	Y16246	16245	173	320	74	-	224	6	78	101.1	27	5 min	low left hip
18	10/22/76	Gracous House	Blue 18	G16219	G16207	137	190	-	-	-	7	-	-	-	7 min	top of rump
19	10/27/76	Butte Creek	Blue 19	W16055	W16054	89	310	83	-	226	-	-	-	27	20 min	top rump
25	10/27/76	Butte Creek	Blue 25	W16053	W16052	125	308	88	-	210	7	-	102.8	30	7 min	lower leg
38	10/28/76	West Fork McClaren	Blue 38	B15282	B16283	173	-	-	-	-	6	-	-	29	5 min	-
42	10/28/76	West Fork Gl.	Blue 42	W16063	W16064	17	267	77	-	180	6	-	-	29	10 min	left flank
1-71	10/28/76	Upper Watana	Blue 71	B16270	B16271	41	-	-	-	-	-	-	-	29	11 min	left side rump
M-1	10/27/76	Butte	-	-	-	65	-	-	-	-	-	-	-	27	12 min	flank
M-2	10/27/76	Butte	-	-	-	137	298	84	186	212	-	-	-	27 29-3day	5 min	left low leg
M-3	10/27/76	Watana	-	-	-	101	274	81	-	118	7	-	-	30	10 min	genitals
Totals	-	Mean ($\bar{x}$)				83.46	294.4	79.39	180.50	190.45	6.7	96.29	102.15	28.3	8.4	
		Standard Deviation (S.A.)				40.16	31.47	4.66	7.78	31.21	1.35	15.77	1.07	1.45	3.64	
		Sample size (m)				39	34	23	2	31	27	7	13	37	34	

Table 2. Location, physical measurements, ages, pregnancy status, and statistics associated with capturing and marking 69 adult cow moose in the Susitna River Study area from 18 through 23 March 1977.

Moose #	Date	Location	Collar color and #	L. ear tag color and #	R. ear tag color and #	Age (months)	Pregnancy status	Measurements (cm) Total length	Hind foot	Heart girth	Cond. index	Drug dosage (mg)	Drug reaction time (min)	Drug placement
8570	3/20/77	Lower Brushkana	Radio-Orange 12	W-15904	W-15903	82	yes	302	-	193	6	28	-	tail (genitals)
8571	3/20/77	opposite & above Spraker Lake	Radio-Blue 62	W-15910	W-15909	46	yes	292	-	183	6	25 plus & 1/2 dose	9 min	tail
8572	3/22/77	Lower McClaren	Radio-Orange 2	16124	16125	142	yes	-	-	-	7	27	10 min	left hip
8573	3/19/77	Lower Susitna near Watana	Radio-Orange 5	-	-		yes	295	-	203	7	27	26 min	tail
8574	3/20/77	between east & middle fork of Sue River	Radio-Orange 15	O-15920	O-15921	34	yes	284	-	193	6	28	6 min	lower flank
8575	3/21/77	Lower McClaren	Radio-Orange 3	G-16095	G-16096	154	yes	310	-	229	7	27	5 min	left leg
8576	3/19/77	between Sue and Watana Creek	Radio-Orange 6	G-16030	G-16029	94	-	293	-	218	7	28	9 min	top rump
8577	3/20/77	opposite & above Spraker Lake	Radio-Orange 8	O-16045	O-16045	154	yes	282	-	198	6	27	4 min	flank
8578	3/20/77	Sue Bend	Radio-Orange 10	W-15912	W-15905	46	no	262	-	168	5	27	-	-
8579	3/20/77	Sue Bend	Radio-Orange 14	O-16099	O-16100	22	yes	257	-	168	6	25	-	inside leg
8580	3/18/77	Devil Mountain	Radio-No collar	-	-		-	-	-	-	-	23	-	top hip
8581	3/18/77	mouth Valdez Crk.	Radio-Blue 13	-	-		yes	298	-	193	7	-	12 min	left leg
8582	3/22/77	Lower McClaren	Radio-Orange 4	G-16122	G-16123	82	yes	-	-	-	7	27	-	high left leg
8583	3/18/77	E. Devil Mountain	Radio-Orange 7	R-16293	R-16294	46	no	258	-	188	6	27	7 min	rib cage
8584	3/18/77	E. Devil Mountain	Radio-Orange 9	W-16003	W-16004	130	yes	290	-	198	6	25	-	top rump
8585	3/22/77	lower McClaren	Radio-Orange 1	G-16079	O-16080		yes	305	-	206	7	27 plus & 1/3 dose	18 min 5 min	left hip

8586	3/18/77	Devil Mountain	Radio-Orange 11	W-16001	W-16002	118	yes	309	80	198	4	23	10 min	top loin
8587	3/20/77	lower Brushkana	Radio-Orange 13	0-15917	0-15916	34	yes	290	-	183	5	27	9 min	top rump
8588	3/19/77	upper Jay Creek	Radio-Orange 16	-	-	94	-	274	-	208	7	29	12 min	tail
8589	3/18/77	E. Devil Mountain	Radio-White 82	R-16028	R-16027	154	no	-	-	-	-	27	-	top rump
20	3/18/77	mouth Valdez Crk	Blue 20	R-16005	R-16006		yes	-	-	-	6	27	-	top rump
21	3/20/77	between east and middle fork of Sue	Blue 21	0-15918	0-15919	46	yes	310	-	193	6	28	-	rump
22	3/23/77	Valdez Creek	Blue 22	16187	16186	82	yes	274	-	-	7	27	-	left leg
23	3/20/77	between east and middle fork of Sue	Blue 23	G-16035	G-16034	22	yes	259	-	183	-	28	10 min	lower flank
27	3/20/77	upper Brushkana	Blue 27	R-16042	R-16041	34	no	-	-	-	-	27	7 min	rump
28	3/20/77	between east and middle fork of Sue	Blue 28	G-16037	G-16036	46	yes	-	-	-	-	28	9 min	-
30	3/23/77	upper Sue	Blue 30	0-16126	0-16127	94	yes	320	-	208	7	-	4 min	-
31	3/23/77	upper Sue	Blue 31	-	-		yes	-	-	-	7	27	-	lower right leg
32	3/23/77	upper Sue	Blue 32	0-R-16128	0-R-16129		yes	-	-	-	7	27	-	left leg
33	3/23/77	upper Sue	Blue 33	R-16199	16200	22	yes	244	-	-	5	25	8 min	left hip
34	3/23/77	upper Sue	Blue 34	-	-		-	-	-	-	7	27	-	left high
35	3/23/77	upper Sue	Blue 35	0-16132	0-16133	34	yes	-	-	-	6	27	-	left hip
36	3/23/77	upper Sue	Blue 36	R-16180	R-16181	70	yes	279	-	-	-	-	-	-
37	3/23/77	middle fork	Blue 37	Y-16176	Y-16177	34	yes	-	-	-	-	27	6 min	left lower leg
39	3/20/77	lower Brushkana	Blue 39	R-16038	R-16039	34	yes	264	-	188	-	28	9 min	top rump
40	3/23/77	Valdez Creek	Blue 40	0-15875	W-15874	94	no	284	-	208	-	27	-	left rump
44	3/23/77	Valdez Creek	Blue 44	B-16192	B-16193		yes	-	-	-	-	25	-	rump
45	3/23/77	Valdez Creek	Blue 45	W-16147	W-16148	94	yes	302	-	208	6	27	-	left rump
46	3/23/77	Valdez Creek	Blue 46	0-16191	0-16190	34	yes	-	-	-	5	27	7 min	right rump
47	3/23/77	Valdez Creek	Blue 47	W-16149	W-16150	94	yes	297	-	193	7	27	-	-
48	3/23/77	Valdez Creek	Blue 48	W-15851	W-15852	154	yes	318	-	206	7	27	-	left leg
49	3/23/77	Valdez Creek	Blue 49	0-15872	W-15873	154	yes	-	-	-	6	27	-	-
50	3/22/77	lower McClaren	Blue 50	G-16120	G-16125	94	yes	-	-	-	6	27	-	left rump side
51	3/22/77	lower McClaren	Blue 51	G-16118	G-16119	34	yes	-	-	-	6	25	-	left rump
52	3/22/77	lower McClaren	Blue 52	G-16093	G-16094	82	yes	290	-	188	7	27	14 min	high on butt near spine

53	3/22/77	lower McClaren	Blue 53	16102	16103		yes	-	-	-	6	27	-	high left
54	3/22/77	lower McClaren	Blue 54	W-16116	W-16117	46	yes	-	-	-	-	25	8 min	left rear
55	3/23/77	upper Sue	Blue 55	-	-		-	-	-	-	-	27	13 min	left leg
56	3/22/77	lower McClaren	Blue 56	G-16081	G-16082	82	yes	292	-	193	7	27	5 min	left leg rear
57	3/23/77	upper Sue	Blue 57	B-15188	B-16189		yes	-	-	-	8.0	27	17 min	left rump
58	3/22/77	lower McClaren	Blue 58	G-16091	G-16092	142	yes	287	-	-	6	27	-	left leg
60	3/20/77	across from Spraker Lake	Blue 60	-	-	154	-	-	-	-	-	28	21 min	left tail
61	3/20/77	opposite & above Spraker Lake	Blue 61	W-15907	W-15908		yes	295	-	193	7	25	-	center of rump
63	3/20/77	Sue Bend	Blue 63	W-15913	W-15914	58	yes	290	-	193	7	27	7 min	flank
64	3/20/77	Sue Bend	Blue 64	O-16097	O-16098	130	yes	305	-	183	7	27	13 min	middle back
66	3/23/77	Sue River below	Blue 66	R-16088	R-16089	94	yes	302	-	198	6	27	6 min	-
67	3/23/77	SE Sue Lodge (5 mi on road)	Blue 67	G-15853	G-15854	-	-	-	-	-	6	27	15 min	ribs
68	3/23/77	Hatchet Lake	Blue 68	R-16085	R-16086	154	no	-	-	-	-	25	-	rectum
70	3/23/77	Hatchet Lake	Blue 70	-	-		no	-	-	-	-	27	10 min	left hip
75	3/19/77	between Jay and Watana	White 75	G-16033	G-16032		yes	-	-	-	-	28	-	hind end tail
												1/2/of 25		
79	3/19/77	between Jay and Watana Creek	White 79	R-15922	R-15923		-	-	-	-	-	28	20 min	right hind qrts.
80	3/18/77	E. Devil Mountain	White 80	R-16286	R-16287	46	yes	274	-	188	-	25	-	top of rump
81	3/18/77	E. Devil Mountain	White 81	-	-		yes	-	-	-	7	27	-	left rump
84	3/23/77	Hatchet Lake	White 84	-	-	-	-	-	-	-	-	27	-	top leg left
												1/3/of 27		
M-1	3/20/77	between East & Middle Fork Sue	-	-	-	70	yes	283	-	183	-	27	-	top of back
M-2	3/20/77	lower Brushkana	-	-	-	154	yes	310	-	203	5	28	10 min	high left rump
M-3	3/20/77	opposite Spraker Lk.	-	-	-		yes	284	84	208	8	27	19 min	left rump
												1/3 25	6 min	
M-4	3/23/77	upper Sue	-	-	-	84	yes	-	-	-	-	27	4 min	left hip
M-5	3/23/77	-	-	-	-	22	-	-	-	-	-	-	-	-
Total -	Mean ($\bar{x}$)					82.00		288.53	82.00	195.41	6.38	26.77	10.69	
	Standard Deviation (SD)					45.30		18.00	2.83	12.72	.82	1.14	5.34	
	Sample size (m)					49		38	2	34	47	65	36	

Table 3. Blood values from adult cow moose by tagging site in the Upper Susitna River Basin, October 1977.

	Hemoglobin g/100 ml	Packed Cell Volume %	Calcium mg/100 ml	Phosphorus mg/100 ml	Glucose mg/100 ml	B.U.N. mu/100 ml	Uric Acid mg/100 ml	Cholesterol mg/100 ml	Bilirubin mg/100 ml	Ak. Phos. mg/100 ml	L.D.H. mu/100 ml	S.G.O.T. mu/100 ml	Total Protein g/100 ml	Albumin %	Globulin %	Alpha 1 %	Alpha 2 %	Beta %	Gamma %	A/G Ratio
Susitna River Bend																				
n	8	4	3	3	3	3	-	3	3	3	3	3	3	3	3	3	3	3	3	3
$\bar{x}$	20+	52.75	12.27	5.00	166.67	3.0	-	84.67	.17	50.0	313.67	91.0	8.00	5.19	2.81	.41	.48	.88	1.04	1.85
S.D.	N/A	2.06	1.14	1.00	38.21	1.0	-	9.81	.06	2.65	20.31	18.68	.50	.32	.21	.03	.02	.03	.11	.09
Susitna Glacier																				
n	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
$\bar{x}$	20+	54.00	11.4	4.73	171.71	2.75	.07	107.00	.20	55.25	325.25	98.25	7.63	4.72	3.15	.30	.56	.91	1.14	1.64
S.D.	N/A	2.83	.95	.56	25.33	.96	.06	17.57	0.0	9.43	39.92	26.46	.32	.15	.72	.08	.14	.11	.24	.11
Maclaren River																				
n	5	5	5	5	5	5	1	5	5	5	5	5	5	5	5	5	5	5	5	5
$\bar{x}$	20+	53.20	10.94	6.18	189.2	4.4	0.2	85.8	.22	53.2	249.8	128.8	8.1	4.81	3.29	.34	.60	.87	1.36	1.49
S.D.	N/A	9.58	.83	.68	20.62	1.14	0.0	7.33	.04	13.66	53.55	78.19	.33	.49	.42	.13	.29	.12	.35	.30
Valdez Creek																				
n	2	1	1	1	1	1	-	1	1	1	1	1	1	-	-	-	-	-	-	-
$\bar{x}$	20+	56.00	10.40	4.2	185	3.00	-	82	.1	70.0	259	84	7.7	-	-	-	-	-	-	-
S.D.	N/A	0	0	0	0	0	-	0	0	0	0	0	0	-	-	-	-	-	-	-
Brushkana Creek																				
n	4	4	4	4	4	4	-	4	4	4	4	4	4	4	4	4	4	4	4	4
$\bar{x}$	20+	55.50	11.25	5.35	184.75	3.5	-	89.25	.23	56.5	316.25	112.0	8.2	5.06	3.4	.26	.55	.93	1.41	1.63
S.D.	N/A	4.04	.97	.76	34.45	1.0	-	11.3	.1	17.62	43.45	35.62	.88	.42	1.01	.03	.20	.28	.28	.18
Watana Creek																				
n	7	5	5	5	5	5	2	5	5	5	5	5	5	5	5	5	5	5	5	5
$\bar{x}$	20+	53.40	11.26	5.44	228.6	3.6	.15	46.05	.22	53.6	258	103.8	8.24	5.27	5.63	.28	.59	.93	1.18	1.78
S.D.	N/A	4.93	.92	.77	64.38	.55	.07	85.63	.11	9.07	32.88	49.71	.38	.47	3.4	.07	.2	.16	.18	.23
Middle Susitna River																				
n	10	10	11	11	11	10	4	11	10	11	11	11	11	11	11	11	11	11	11	11
$\bar{x}$	20+	51.40	12.02	4.54	153.0	2.91	.25	96.45	.29	58.82	290.55	110.2	7.91	4.86	3.05	.31	.46	1.02	1.26	1.63
S.D.	N/A	2.91	1.39	.88	29.03	.94	.06	19.85	.22	14.32	52.44	73.03	.78	.74	.43	.11	.15	.38	.47	.39

Table 3. Blood values from adult cow moose by tagging site in the Upper Susitna River Basin, October 1977.

	Hemoglobin g/100 ml	Packed Cell Volume %	Calcium mg/100 ml	Phosphorus mg/100 ml	Glucose mg/100 ml	B.U.N. mu/100 ml	Uric Acid mg/100 ml	Cholesterol mg/100 ml	Bilirubin mg/100 ml	Ak. Phos. mg/100 ml	L.D.H. mu/100 ml	S.G.O.T. mu/100 ml	Total Protein g/100 ml	Albumin %	Globulin %	Alpha 1 %	Alpha 2 %	Beta %	Gamma %	A/G Ratio
Clearwater Creek																				
n	6	5	4	4	4	4	1	4	4	4	4	4	4	4	4	4	4	4	4	4
$\bar{x}$	20+	54.60	10.63	5.0	195.75	3.5	.2	80.25	.23	52.5	271	86.5	7.9	5.03	2.87	.32	.47	.91	1.21	1.79
S.D.	N/A	1.67	.33	1.32	56.17	1.0	0.0	10.72	.05	7.0	33.68	39.23	.22	.44	.38	.08	.09	.22	.11	.43
Totals																				
n	46	38	37	37	37	37	11	37	37	37	37	37	36	36	36	36	36	36	36	36
$\bar{x}$	20+	53.29	11.33	5.07	180.3	3.32	.15	90.41	.23	55.62	286.08	134.64	7.98	4.96	3.08	.31	.52	.94	1.24	1.67
S.D.	N/A	4.39	1.01	.96	43.64	1.0	.11	15.46	.13	11.78	47.85	27.9	.57	.53	.50	.09	.17	.25	.32	.30

Table 4. Blood values from adult cow moose by tagging site in the Upper Susitna River Basin, March 1978.

	Hemoglobin g/100 ml	Packed Cell Volume %	Calcium mg/100 ml	Phosphorus mg/100 ml	Glucose mg/100 ml	B.U.N. mu/100 ml	Uric Acid mg/100 ml	Cholesterol mg/100 ml	Bilirubin mg/100 ml	Ak. Phos. mg/100 ml	L.D.H. mu/100 ml	S.G.O.T. mu/100 ml	Total Protein g/100 ml	Albumin %	Globulin %	Alpha 1 %	Alpha 2 %	Beta %	Gamma %	A/G Ratio
Susitna River Bend																				
n	5	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
x̄	18.52	49.60	11.04	4.44	153.50	2.25	.21	83.5	.10	70.4	260.1	72	6.99	5.0	1.99	.29	.35	.64	.70	2.71
S.D.	1.29	2.07	.58	.58	30.38	1.58	.10	4.93	.06	19.93	45.54	21.08	.70	.54	.38	.05	.07	.21	.20	.72
Susitna Glacier																				
n	5	13	10	10	10	10	10	10	10	10	10	10	11	11	11	11	11	11	11	10
x̄	19.70	51.23	11.45	4.78	155.3	1.7	.21	90.6	.19	59.5	211.4	71.9	7.25	5.24	2.01	.28	.39	.86	.49	3.09
S.D.	.33	2.80	.59	.90	19.18	.48	.13	11.89	.07	16.06	32.35	19.18	.68	.85	.52	.07	.20	.34	.25	.68
Maclaren River																				
n	1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
x̄	19.50	50.90	10.8	4.9	150.1	1.4	2.4	77.4	.25	66	234	77.78	6.95	4.67	2.28	.29	.35	.85	.78	2.24
S.D.	N/A	3.45	.31	.76	27.46	.52	.52	12.4	.18	18.18	22.95	25.44	.48	.55	.58	.14	.13	.33	.28	.88
Valdez Creek																				
n	0	8	8	8	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9
x̄	0	51.25	12.09	3.55	140.5	1.5	.25	89.0	.24	71.0	224.25	82.13	7.29	4.93	2.35	.31	.41	.92	.71	2.44
S.D.	N/A	2.60	1.02	.78	28.73	.53	.05	10.45	.09	14.01	24.69	40.41	.67	.51	.36	.10	.12	.25	.26	.62
Brushkana Creek																				
n	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
x̄	19.22	49.20	10.6	4.36	165.2	1.6	.14	91.0	.12	72	277.6	100.8	7.28	5.02	2.26	.32	.37	.92	.64	2.23
S.D.	.74	1.79	.86	1.96	25.81	.89	.13	16.54	.04	23.55	73.66	71.55	.7	.56	.18	.06	.10	.26	.19	.2
Watana Creek																				
n	4	4	2	2	2	2	2	2	2	2	2	2	4	4	4	4	4	4	4	4
x̄	19.25	49.50	11.45	4.85	135.00	4.5	.3	76.0	.2	62.0	251.5	97.5	7.25	5.29	1.97	.23	.32	.67	.75	2.74
S.D.	1.37	4.12	.07	.49	48.08	.71	.14	7.07	0	21.21	78.49	30.41	.82	.65	.34	.07	.09	.26	.20	.52
Middle Susitna River																				
n	0	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
x̄	0	.51	11.5	4.25	162	3.5	.2	82.0	.2	53.0	229.5	61.5	7.3	4.9	2.4	.27	.52	.99	.63	2.05
S.D.	N/A	N/A	.42	.07	28.28	2.12	0	1.41	0	2.83	48.79	7.78	.42	.24	.18	0	.16	.04	.02	.05
Devil Mth.																				
n	5	5	4	4	4	4	4	4	4	4	4	2	5	5	5	5	5	5	5	4
x̄	17.00	46.40	10.95	4.7	160.75	7.5	.3	95.5	.45	76	309.5	152.5	6.94	4.38	2.55	.28	.25	1.3	.73	1.68
S.D.	1.41	6.43	.6	1.41	29.92	2.52	.08	17.45	.31	26.5	26.29	96.87	.68	.5	.61	.15	.15	.63	.58	.53
Totals																				
n	25	51	49	49	49	49	49	49	49	49	49	47	54	54	54	54	54	54	54	52
x̄	18.75	50.20	11.23	4.48	152.43	2.35	.32	85.98	.21	70.94	243.2	82.15	7.14	4.94	2.2	.29	.37	.87	.67	2.5
S.D.	1.38	3.48	.80	1.03	26.6	2.0	.47	12.45	.15	18.26	46.86	39.13	.63	.64	.47	.09	.14	.35	.29	.74

following ranges and total means expressed as mg/100 ml unless indicated: Calcium, 10.6 to 12.1 averaging 11.2; phosphorus, 3.55 to 4.85 averaging 4.48; glucose, 135.00 to 165.2 averaging 152.43; and total protein 6.94 to 7.3 g/100 ml with a mean of 7.14 g/100 ml.

Between late October 1976 and 22 November 1977 a total of 584 location points were obtained on 39 radio-collared moose. Figures 1-9 represent the general areas encompassed by each moose and are not precise locations. The movements of 18 radio-collared moose were described in a report concerning the potential impacts of the Susitna Hydroelectric Project on Moose which was prepared under contract for the U.S. Fish and Wildlife Service (Appendix I). General movements for the remaining 21 were as follows:

Moose 8017 (Figure 1) was collared on 27 October 1976 approximately 8 km northwest of the Maclaren River bend. By 22 November she migrated approximately 40 km south to the head of West Fork of Gulkana River. She overwintered in that area and between 13 and 27 May migrated 89 km back to a site approximately 8 km SW of tagging site. She gave birth to one calf by 1 June on the Maclaren River. Between 7 and 23 July she migrated with her calf approximately 40 km north to an area approximately 11 km up from the mouth of the West Fork of the Maclaren River where they both remained through fall 1977.

Moose 8019 (Figure 2) was with a calf when collared on 21 October 1976 6 km NW of Susitna Lodge where they remained at least until 19 November. By 16 December she and the calf had moved 37 km down the Susitna River almost to the mouth of Coal Creek, but they were found 32 km back to the north to the mouth of Wickersham Creek by 19 January. They remained in that area until 10 May, after which she was not observed with the calf, but then gave birth to a new calf between 3 and 6 June some 6 km SE of her winter location. Between 6 and 7 June she was not observed with a calf and she remained in the vicinity of the tagging site until 22 August. By 5 October she had moved 8 km NW just above the mouth of Valdez Creek but then by 30 October moved back to the tagging site where she remained through fall 1977.

Moose 8020 (Figure 6) was collared on 22 October 1976, west of Susitna Lodge where she remained through 2 November. She moved 13 km by 22 November, 0.4 km north of the Denali Highway. She remained within an approximately 40 km^2 area through fall 1977: moving upland in both spring and fall and to the lowlands during summer. She was observed with twins on 7 June, then with triplets between 16 to 18 June. By 18 September she had only one calf remaining.

Moose 8021 (Figure 8) was collared approximately 6 km south of the Denali Highway along Brushkana Creek on 22 October. By 2 November she had moved 13 km to the north, crossing the Nenana River, but by 22 November she moved south 16 km to 6 km NW of Butte Lake. She continued to exhibit considerable movement until 5 June when she gave birth to one calf. They both spent the summer north of the Denali Highway on Monahan flats.

Figure 1. General area encompassed by moose 8017, 8035, 8037, and 8039 in the upper Susitna River Basin from October 1976 through November 1977.

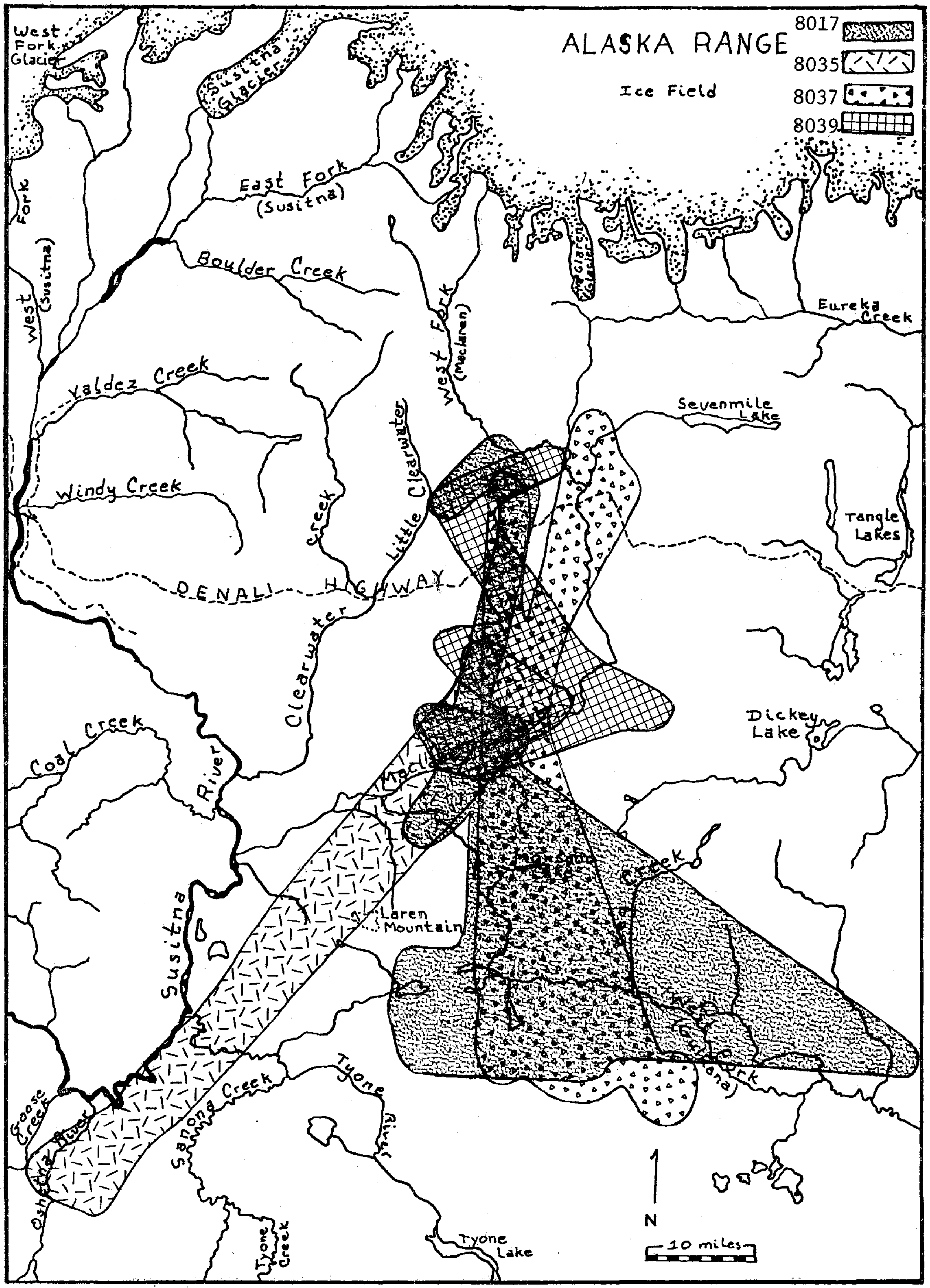


Figure 2. General area encompassed by moose 8018 and 8019 within the upper Susitna River Sasin from October 1976 through November 1977.

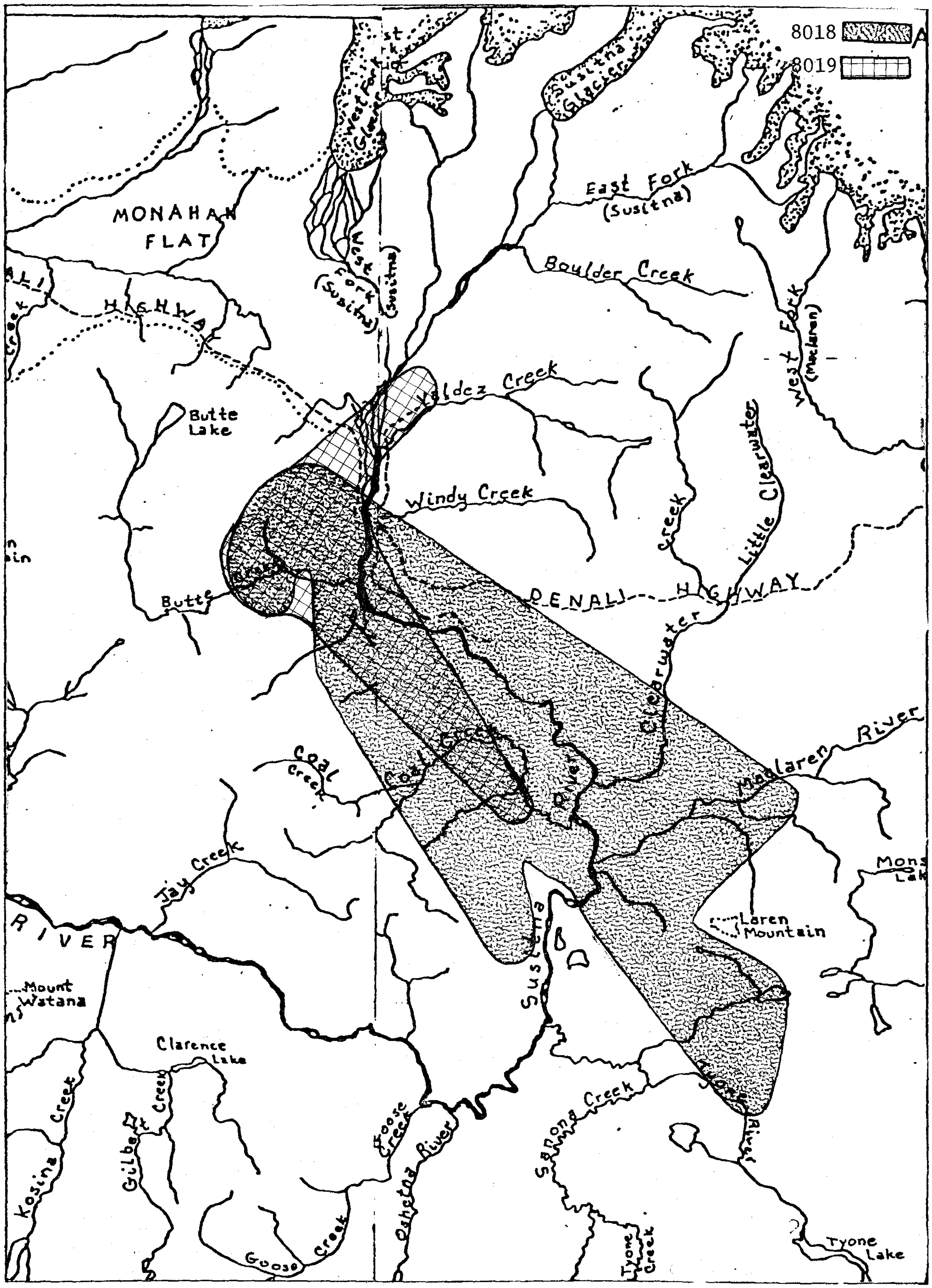


Figure 3. General area encompassed by moose 8575 and 8030 in the upper Susitna River area from October 1976 through November 1977.

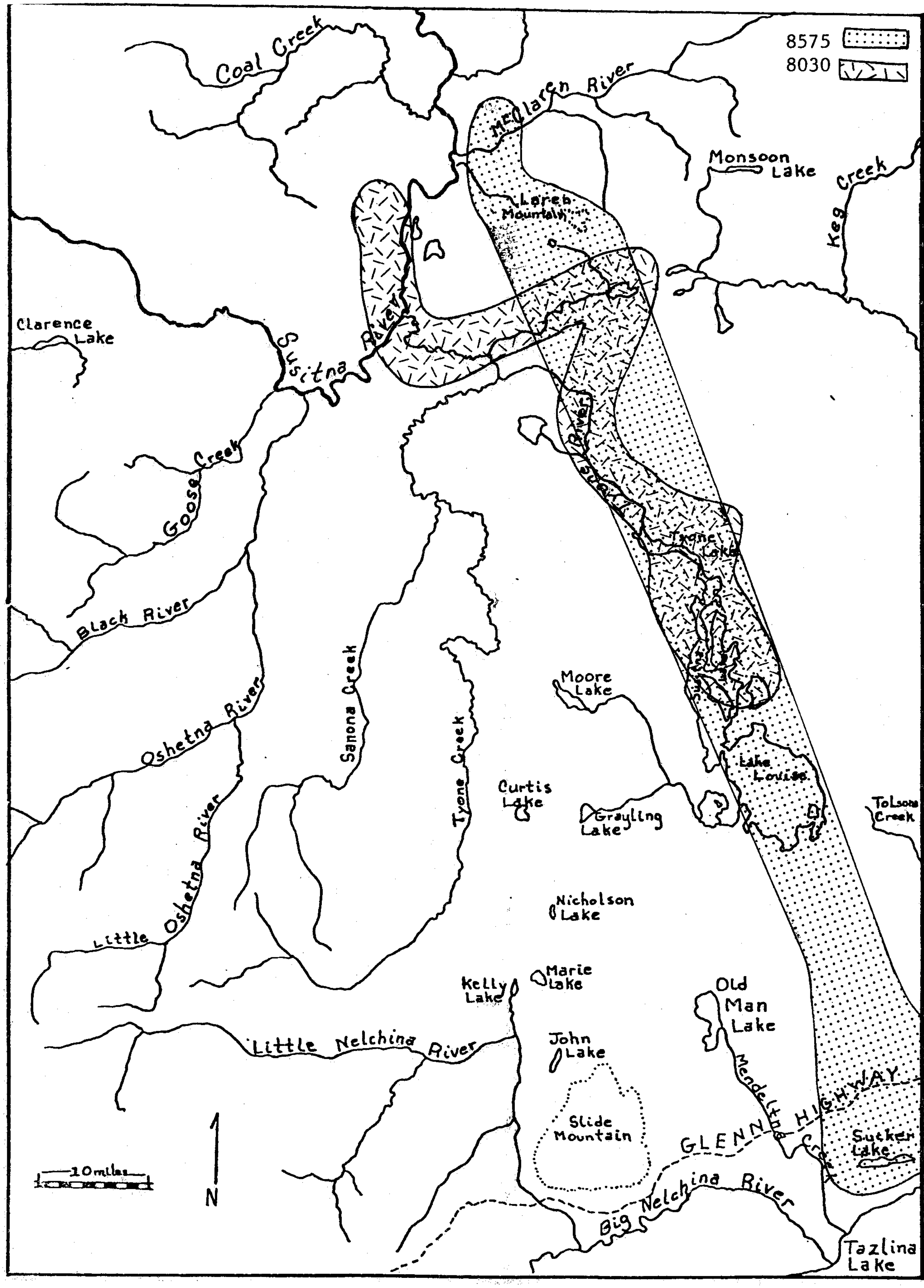


Figure 4. General area encompassed by moose 8022, 8038, 8040, 8576, 8588, and 8573 within the upper Susitna River Basin from October 1976 through November 1977.

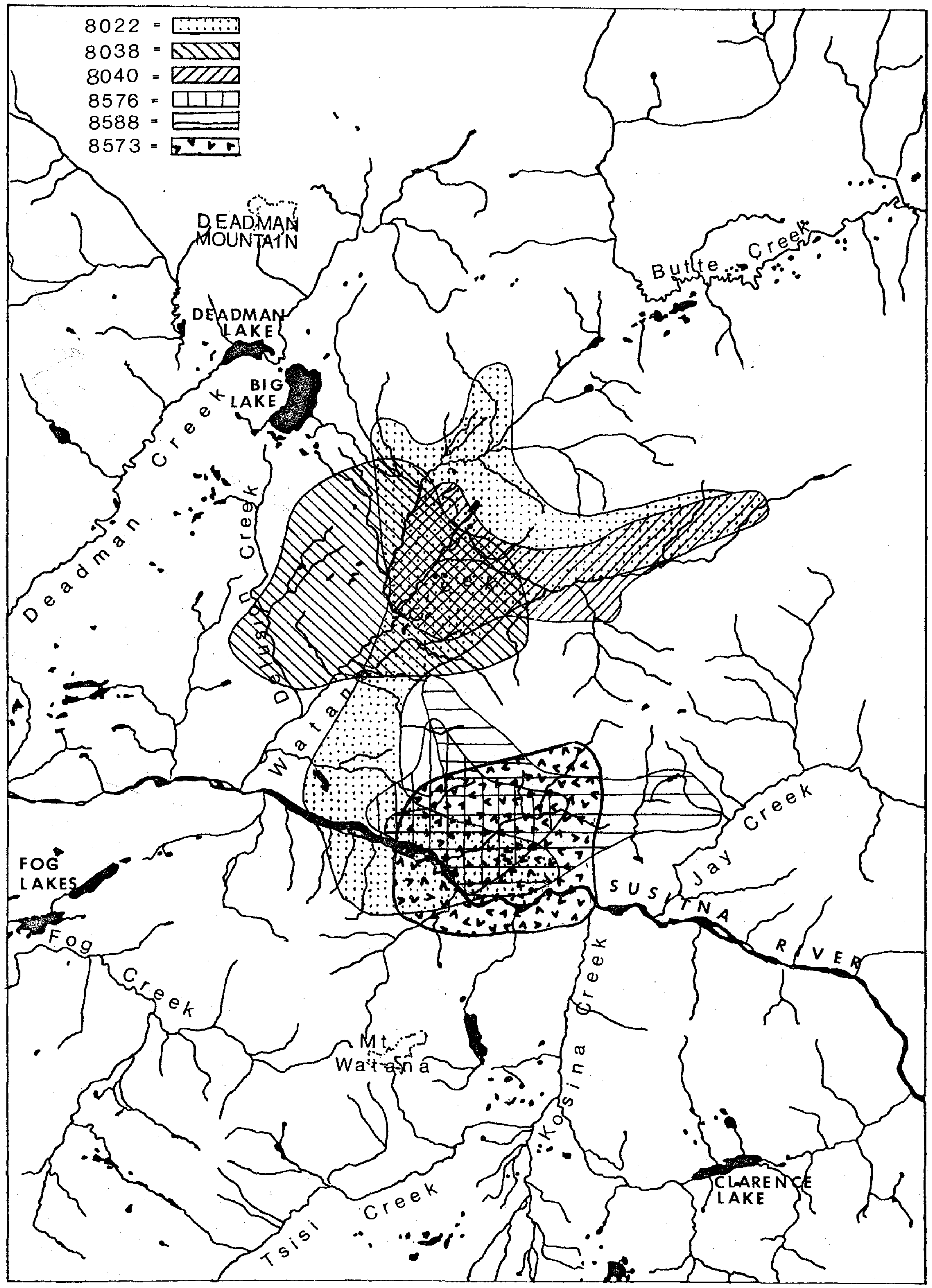


Figure 5. General area encompassed by moose 8031, 8571, 8578, and 8579 within the upper Susitna River Basin from October 1976 through November 1977.

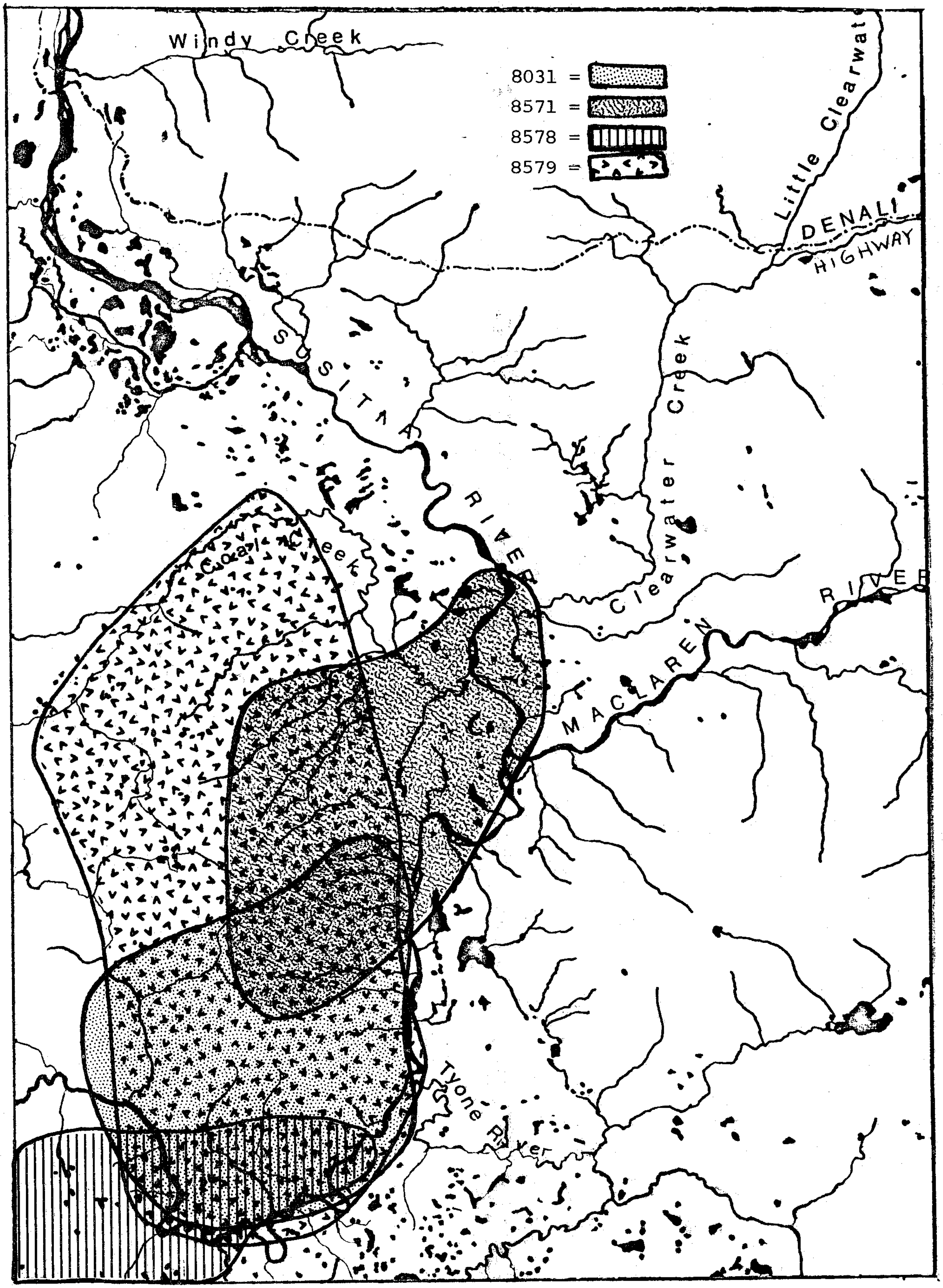


Figure 6. General area encompassed by moose 8020, 8033, 8036, 8042, 8574 and 8581 within the upper Susitna River Basin from October 1976 through November 1977.

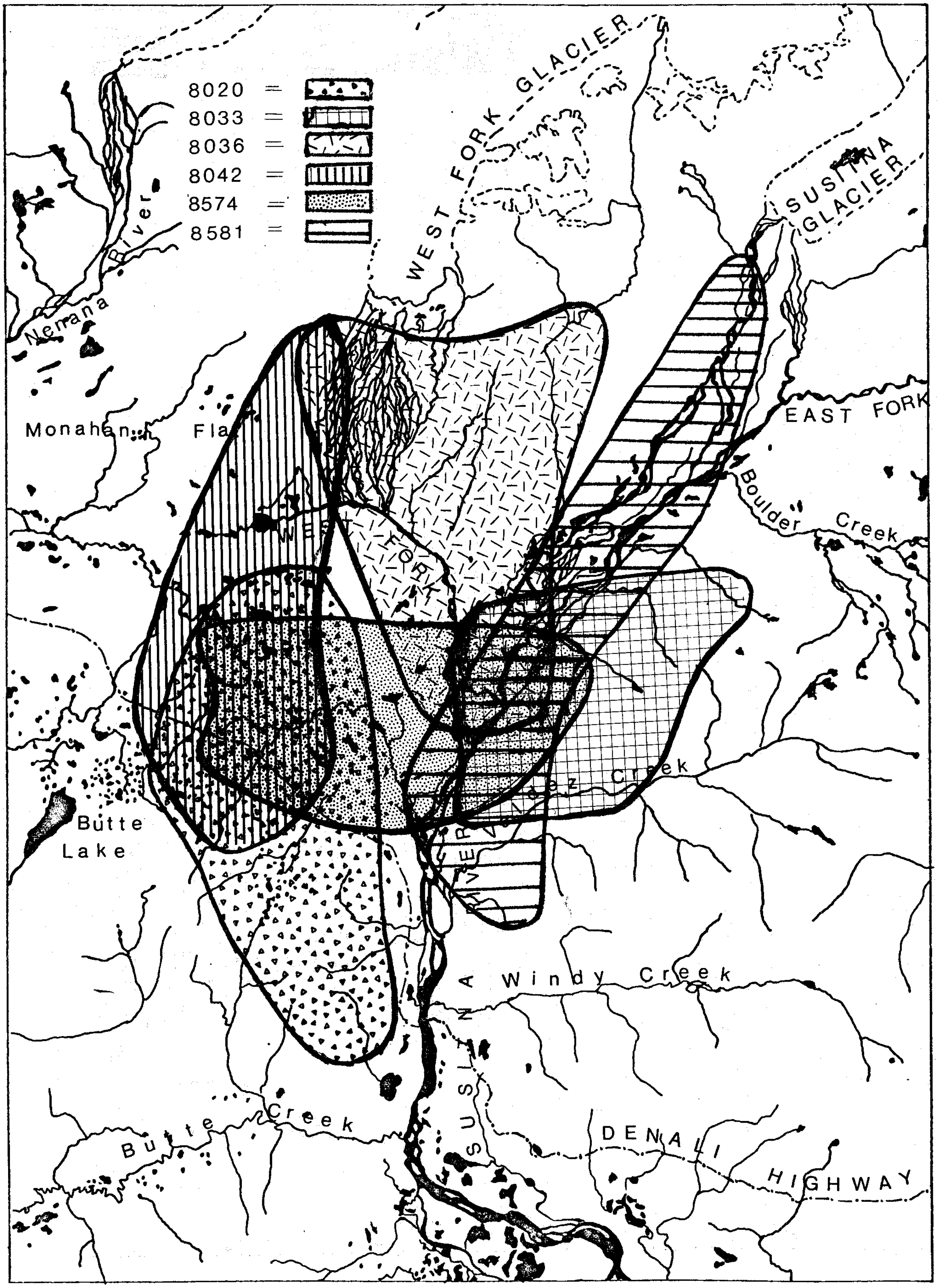


Figure 7. General area encompassed by moose 8029, 8032, 8044, 8572, 8577, 8582, and 8585 within the upper Susitna River Basin from October 1976 through November 1977.

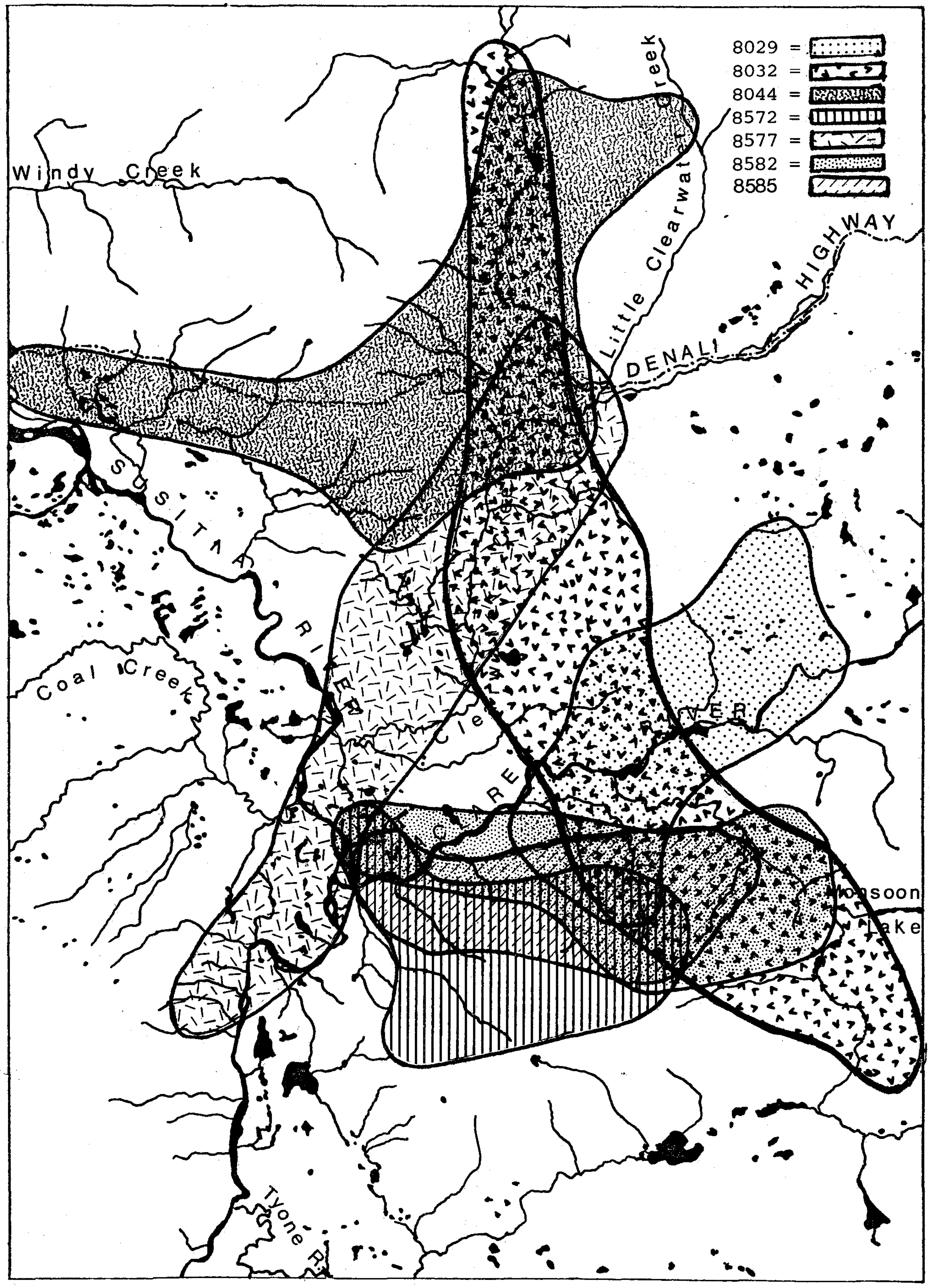


Figure 8. General area encompassed by moose 8021, 8034, 8570, and 8587 within the upper Susitna River Basin from October 1976 through November 1977.

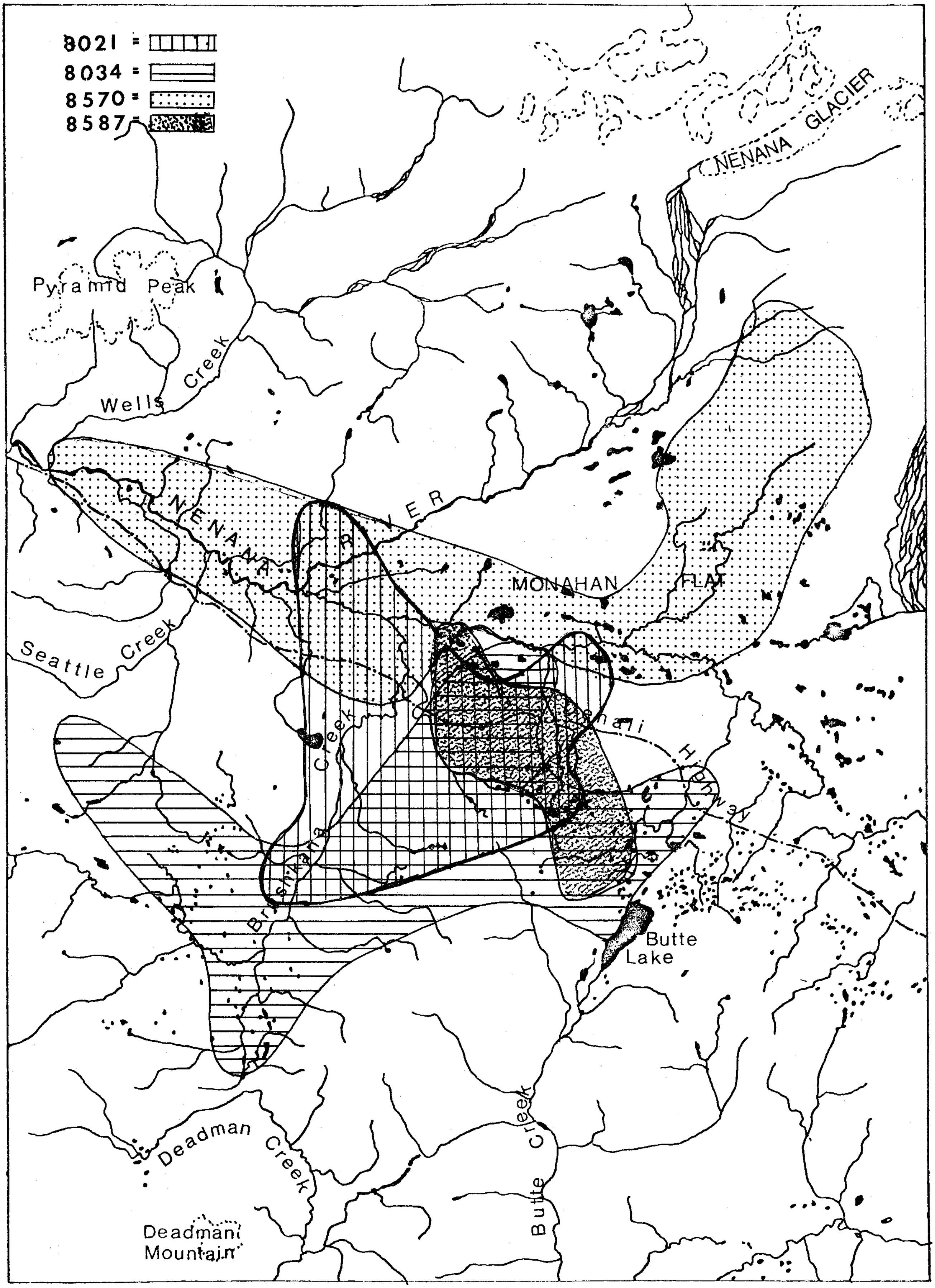
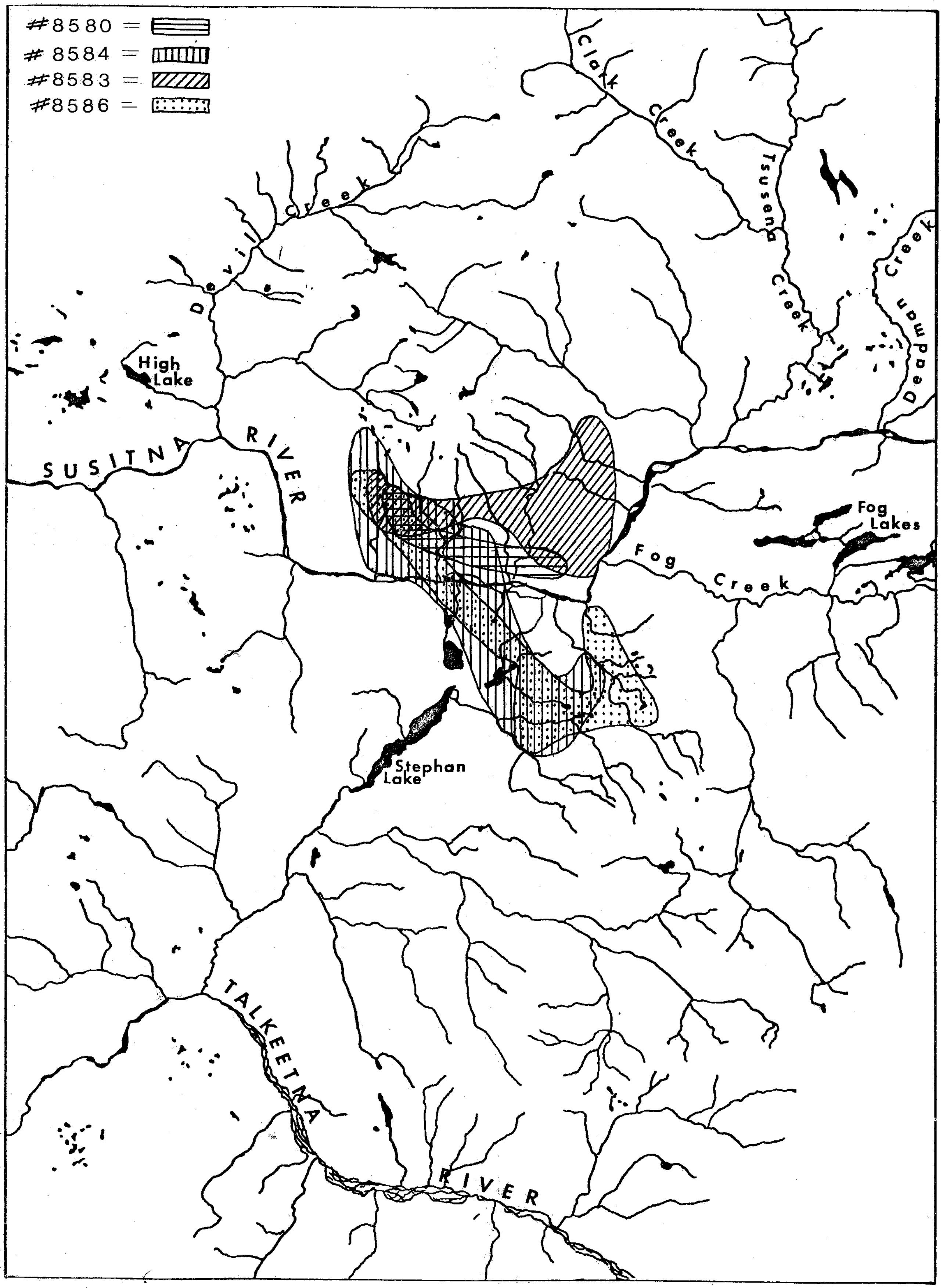


Figure 9. General area encompassed by moose 8580, 8584, 8583, and 8586 within the upper Susitna River Basin from October 1976 through November 1977.



Moose 8029 (Figure 7) was collared on 27 October 1976, 3 km east of Round Mountain. She was found along the Maclaren River 8 km south of her tagging location on 19 November. By 19 January she had moved 10 km downstream to the Maclaren cabin. She remained mostly within a 15 km^2 area through winter and spring. By 25 May she moved north of the river 3 km to higher elevation where she gave birth to twins which were missing by 1 June. She spent most of the summer along the river until 22 November when she returned to the tagging site.

Moose 8032 (Figure 7) was collared on 23 October 1977 at the mouth of Pass Creek. By 2 November she had moved 19 km down Clearwater Creek. She continued her southerly movement until 19 January; a straight line migration crossing the Maclaren and going down Monsoon Lake Creek 48 km. She overwintered along the creek and began a northward movement on 31 March reaching Clearwater Lake by 30 May where she gave birth to one calf. They moved north of the parturition site about 5 km by 11 July but did not return to the tagging site. Instead, they migrated south to a canyon area 5 km west of the wintering area where they remained through fall 1977.

Moose 8033 (Figure 6) was collared on 28 October 1976, 5 km NW of the mouth of Valdez Creek. She remained within an approximately 81 km^2 area just north of Valdez Creek through at least 5 October 1977 with movements consisting of changes in elevation ranging of up to 300 m but not coinciding with any particular season. She moved to Valdez Creek by late May and was observed with twins on 29 May. By 6 August both calves were missing. Radio failure was recorded on 6 August and our last observation was on 5 October.

Moose 8034 (Figure 8) was collared on 28 October 1976 approximately 2 km south of Seattle Creek. By 22 November she had moved approximately 16 km SE to Brushkana Creek where she remained until at least 7 February. She moved to lower elevations as winter progressed and then calved just north of the Denali Highway 5 km east of Brushkana Creek. She and this calf remained within a 6 km^2 area through June and by mid-July moved to Butte Lake where they remained through summer.

Moose 8036 (Figure 6) was collared on 28 October 1976 just below West Fork Glacier and by 2 November had moved south 18 km to a lower elevation. She remained within a 19 km^2 area through winter and spring and by 29 May had given birth to one calf. By 5 June she had moved to the Susitna River and had lost her calf. She spent the remainder of the summer and first half of fall 13 km to the north at elevations above 900 m. By 31 October she had moved back to the lowlands.

Moose 8037 (Figure 1) when collared on 28 October 1976 was accompanied by a calf above the Denali Highway between Little Clearwater Creek and the Maclaren River. By 22 November she and the calf migrated south down Monsoon Lake Creek to 16 km south of the headwaters of the West Fork of the Gulkana River; a straight line movement of

81 km. They overwintered in that area within an old spruce burn. She was last observed with her calf on 13 May. She gave birth to a new calf in the same area by 3 June. By 12 July they had migrated north 97 km to Boulder Creek above the Denali Highway and east of the Maclaren River. They remained in the area through the summer. By 5 October they had moved south to just east of Round Mountain and by 22 November had returned to the wintering area.

Moose 8039 (Figure 1) was collared on 28 October 1976 west of the Maclaren River approximately 6 km north of the Denali Highway. By 19 November she had moved south 21 km to NW of the big bend on the Maclaren River. She remained on the river through winter moving up and down the stream approximately 18 km. She gave birth to twins by 1 June. As summer progressed she moved to slightly higher elevation on Round Mountain and remained in the area through fall and was never observed back at the tagging site.

Moose 8042 (Figure 6) was collared on 28 October 1976 just below West Fork Glacier and by 19 November had moved 21 km south to the Denali Highway. She remained within an area of approximately 32 km^2 through at least 5 August. She had given birth to one calf by 31 May which was missing by 5 August. By 18 September she had moved 16 km north back to the tagging site.

Moose 8044 (Figure 7) was collared on 23 October 1976 13 km north of the Denali Highway on Little Clearwater Creek. By 23 March she had moved 13km SW to just below the Denali Highway. The radio signal from this moose shifted and therefore we lost contact with her until 10 May when she was relocated 15 km west of her last known location. By 25 May she had moved 26 km to the east on Clearwater Creek. She then moved 8 km to the SW and then in the opposite direction up to the Denali Highway by 10 June where she gave birth to one calf. By 17 June the calf was missing and she again began moving in a southwest direction but returned to same area by 5 October. Between 5 October and 2 November she had moved 15 km up Big Clearwater Creek but then returned to the Denali Highway by 22 November.

Moose 8570 (Figure 8) was collared on 20 March 1977 at the junction of Brushkana River and Monahan Flats Creek. By 10 May she had moved approximately 16 km to the junction of Wells Creek and the Nenana River. Between 10 and 25 May she moved 29 km to Monahan Flats where she gave birth to one calf. After 25 May we never observed her with a calf although she stayed in the calving area until 31 May. In early summer she moved north 15 km, spending the remainder of the summer and fall at higher elevations on the northeastern headwaters of the Nenana River.

Moose 8572 (Figure 7) was collared on 22 March 1977 approximately 1.6 km north of the mouth of Maclaren River. She crossed the river by 30 March and then moved 10km SW to higher elevations where during the summer she occupied an area of approximately 1 km^2. During October and November she remained at higher elevations south of the river. Although she was pregnant when collared she was never observed with a calf.

Moose 8574 (Figure 6) was collared 20 March 1977 at the junction of West and Middle Forks of Susitna River. By 31 March she had moved 13 km west and by 10 May had moved SW 8 km to the Denali Highway. She gave birth to one calf just below the highway but the calf was missing by 25 June. Between 25 June and 18 September she moved westward to the spruce dominated hills 6 km north of Valdez Creek where she remained through 30 October 1977.

Moose 8577 (Figure 7) was collared on 20 March 1977 approximately 10 km north of the mouth of Tyone River on west side of Susitna River. She moved 16 km NE and spent spring and summer just northeast of the mouth of Clearwater Creek. By 1 November she had moved up Clearwater Creek to the Denali Highway where she remained through the fall. Although recorded as pregnant, she was never observed with a calf.

Moose 8581 (Figure 6) was collared on 18 March 1977 approximately 3 km north of mouth of Valdez Creek. She remained in the vicinity of the junction between the middle and west forks of the Susitna River until 31 May at which time she began moving northward. By 25 June she had wandered to within 6 km of Susitna Glacier. When tagged she was determined to be pregnant; however, she was never observed with a calf through spring and summer. She remained on the upper half of the west fork through the summer, but by 18 September had begun moving downstream towards Valdez Creek.

Moose 8582 (Figure 7) was collared 22 March 1977 at the mouth of Maclaren River. By 22 April she was moving in an easterly direction and consequently moved 16 km to higher elevation just northeast of Laren Mountain. She spent summer and fall in that vicinity within a 19 km^2 area. She was pregnant in March, but was never observed with a calf.

Moose 8585 (Figure 7) Had an identical history as that described for Moose 8582.

Moose 8587 (Figure 8) was accompanied by a calf, when collared on 20 March 1977 on Monahan Flats Creek 3 km east of its junction with Brushkana Creek. After collaring they moved south to higher elevations 3 km south of the Denali Highway. Her calf remained with her until at least 25 May and by 31 May she had given birth to a new calf. She and her new calf remained above the highway within an approximately 32 km^2 area through summer and fall 1977.

The 65 visually-collared moose were observed on 107 occasions during this reporting period. Fourteen (22 percent) were never observed during the study. Only 20 percent (n = 13) of the collars were observed more than twice. Dates and locations of visually-collared moose are depicted in Appendix I. Movements data provided by the visual collars generally reflected those from radio-collared animals. One exception deserves mentioning, however: White collar #80 was tagged just above the Susitna River west of Tsusena Creek on 18 March 1977. By 6 September she was observed just east of Lone Butte near Sanona Creek, a straight line movement of 84 km. This was the second longest movement recorded during the study; surpassed only by radio-collared moose #8575 which had moved 103 km; it was the most extensive east-west migration recorded.

Eight radio-collared moose were accompanied by calves when originally collared, four in fall and three in spring. Two cows tagged in spring were never observed with calves following their tagging. The remainder stayed with their calves until at least 25 April, but most kept them until late May when parturition began. In 1977 one cow was observed with her yearling as late as 22 November.

Between 10 May and 5 October we made 48 flights to monitor parturition and subsequent survival of calves. Calving was first observed on an uncollared cow on 24 May. Radio-collared moose dropped their first calf by 25 May and their last calf on 10 June (Figure 10). Parturition appeared to be fairly evenly distributed throughout that time period. Thirty-eight radio-collared moose produced at least 30 calves; however, by 6 June calf losses began to exceed births. Timing of calf losses is shown in Figure 11. By 24 June, 78 percent of the losses had occurred and most calves which were alive at that time were alive by at least 5 November.

A comparison of the calving status of cows collared in the fall versus the spring is contained in Table 5. Of 17 radio-collared moose palpated in the spring, 14 were determined pregnant but subsequent observations only accounted for 7 calves. The 20 cow moose collared in the fall produced at least 23 calves.

DISCUSSION

Franzmann et al. (1976) developed criteria to rate the relative condition of moose populations by using several blood parameters which reflect moose physical condition. They compared five moose populations using these criteria in conjunction with other known factors concerning population density and range condition. On the basis of that comparison, the Unit 13 sample, which comprised animals from the Gakona River and eastern Alphabet Hills area, rated highest of the five populations examined. Although we did not conduct statistical analyses, we grossly compared our spring blood parameters from the upper Susitna River Basin with those reported by Franzmann et al. (1976). Our values, when compared to the five other populations sampled, were as follows: both calcium and glucose rated highest, packed cell volume rated second, both hemoglobin and total protein rated third while phosphorus rated sixth. We conclude from this simple comparison that moose from our study area were generally in relatively good condition compared to those from populations sampled elsewhere. We observed some variation in the blood parameters between tagging areas, and it is possible that some moose were not in as good condition as others, where environmental factors could be substantially different. Blood values will be more thoroughly analyzed and discussed in conjunction with other studies by Dr. Franzmann at the Kenai Moose Research Center.

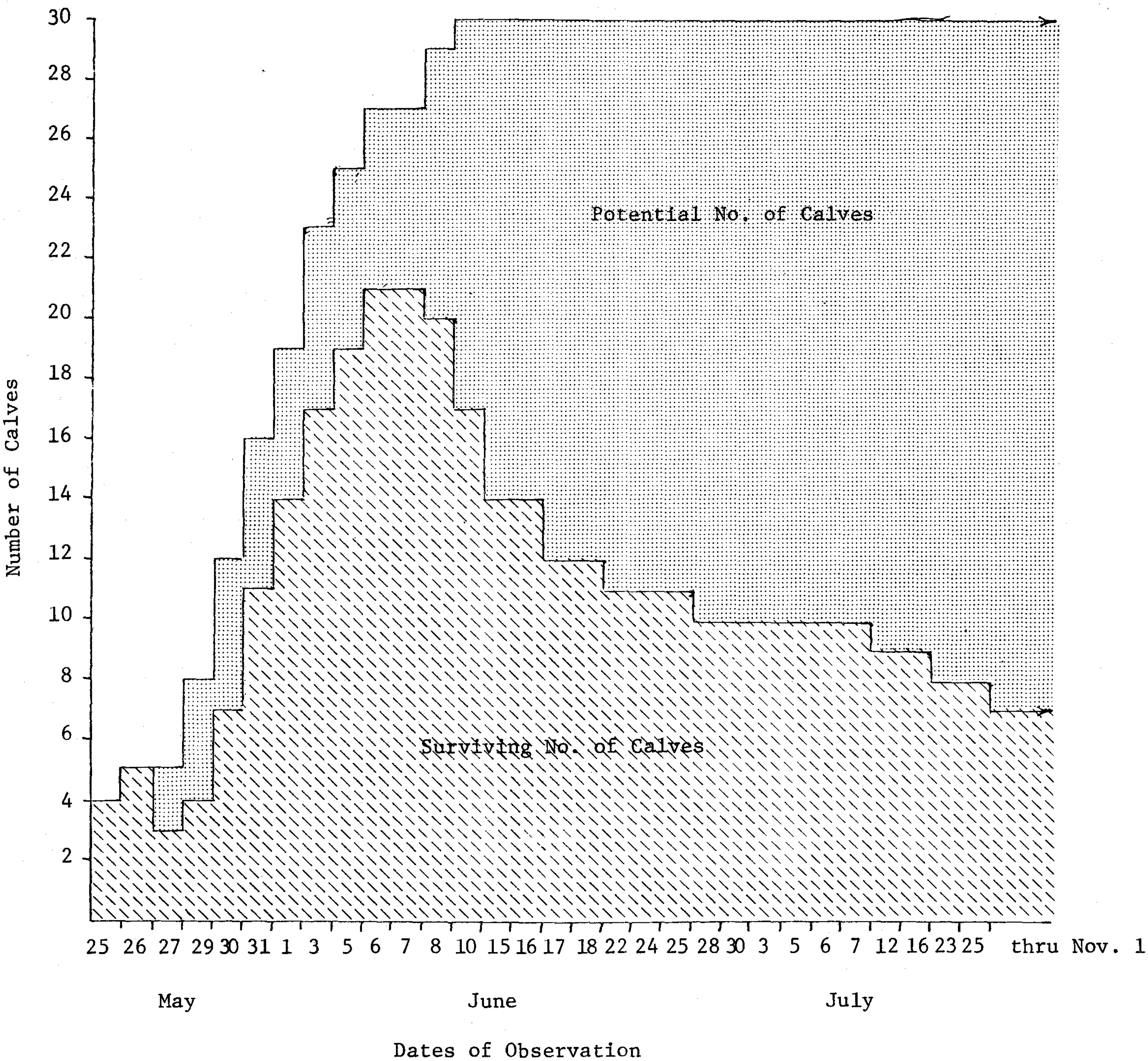


Figure 10. Comparison of known calf production with actual number of surviving calves for radio-collared moose in the Upper Susitna River Basin, Summer 1977.

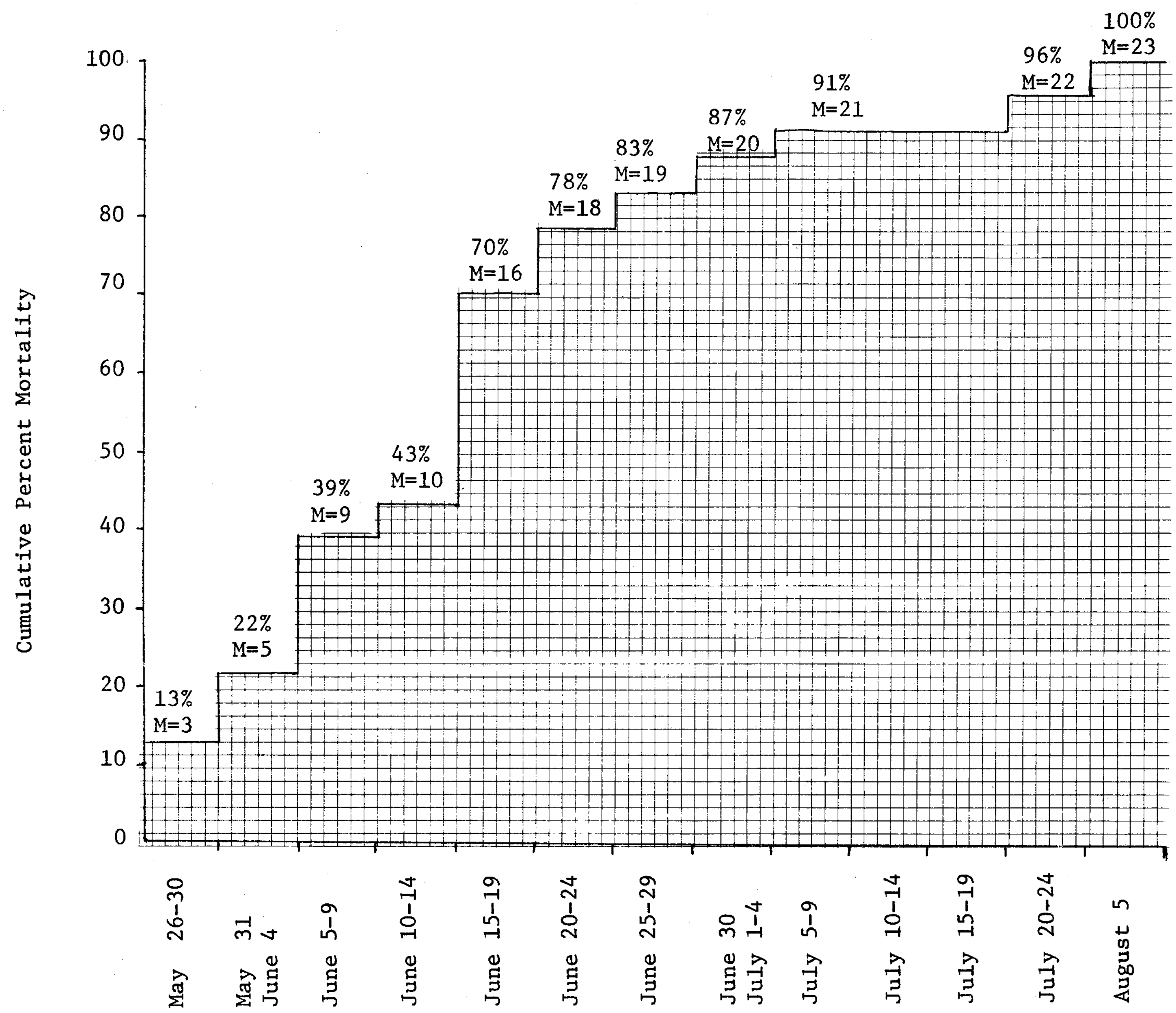


Figure 11. Cumulative percentage by 5 day increments of calf losses of radio-collared cow moose in the Upper Susitna River Basin, Summer 1977.

Table 5. A comparison of observed calf production between radio-collared moose tagged in fall, 1976 versus those tagged in spring 1977 within or close to the Susitna River Study Area.

Fall Collared		Spring Collared		
Moose #	Observed calf production	Moose #	Pregnancy status	Observed calf production
8017	1 calf	8570	Pregnant	1
8018	1 calf	8571	Pregnant	1
8019	twins	8572	Pregnant	0
8020	twins	8573	Pregnant	0
8021	1 calf	8574	Pregnant	1
8022	0	8575	Pregnant	0
8029	twins	8576	Unknown	0
8030	1 calf	8577	Pregnant	0
8031	0	8578	Not pregnant	0
8032	1 calf	8579	Pregnant	0
8033	twins	8581	Pregnant	0
8034	1 calf	8582	Pregnant	0
8035	0	8583	Not pregnant	0
8036	1 calf	8584	Pregnant	Twins
8037	1 calf	8585	Pregnant	0
8038	1 calf	8586	Pregnant	1
8039	twins	8587	Pregnant	1
8040	twins	8588	Unknown	0
8042	1 calf	8589	Not pregnant	0
8044	1 calf			
Totals 20	23	19		7

The average age of moose collared during our study was approximately 7 years. Twenty-three percent of the moose sampled were 10 years old or older. VanBallenberghe (in press) reported that 49 percent of the tagged moose in Gulkana, Gakona and Chistochina River areas were 10 years old or older. Bailey (1978) reported that for the Kenai Peninsula females 10 years old or older constituted 28 to 34 percent of the moose sampled and Didrickson and Taylor (1978) found that 9 of 24 (38 percent) cows tagged in the Peter's Hills area were 10 years old or older. We surmise from these comparisons that moose in our study area have a relatively younger age structure than other populations studied thus far in Southcentral Alaska. In Sweden Markgren (1969) concluded that moose between 6 and 11 years of age produced more twin calves than cows in other age classes. If his data are applicable to moose populations in Southcentral Alaska, half of Susitna River study area populations are currently at prime breeding age.

McIlroy (1974) expressed concern that perhaps low bull:cow ratios were influencing conception rates in portions of Unit 13. Our study revealed a pregnancy rate of 88 percent which compares closely with the 86 percent rate reported by VanBallenberghe (in press) in another portion of Unit 13. However, VanBallenberghe noted what he believed to be much variation between the relative size of fetuses. Over the years a number of biologists have speculated that low bull:cow ratios would influence conception rates (McIlroy 1974, Bailey 1978). One study in the Matanuska Valley of Southcentral Alaska, where bull:100 cow ratios have ranged from 4 to 20, demonstrated high pregnancy rates (Bishop and Rausch 1974). It is logical that at some point low bull:cow ratios would eventually influence reproduction, but the point at which that threshold level occurs has not yet been determined in North America.

During our spring tagging we determined that 14 of our radio-collared cows were pregnant. Subsequent observations in late spring and summer revealed that these animals only produced 7 calves. In contrast, 20 cows collared in the fall produced at least 23 calves. We do not know if the differences between the two groups reflect actual production since shortly after parturition most calves were lost. Nevertheless, the data were cause for concern, since we had problems with determining drug dosages. Reynolds (pers. comm.) suspected that either the drug (succinylcholine chloride) or rectal palpation was responsible for low calf production of his marked cows. We noted several instances during tagging when it became necessary to administer artificial respiration to prevent animals from dying. Unfortunately, we did not record these instances in a manner which would allow us to determine if any correlation existed between lack of calf production and the drug related problems. Perhaps those animals and others which may have been oxygen starved but did not require artificial respiration accounted for the apparent low calf production. More investigation is needed to confirm or reject this hypothesis. Regardless, there are substantial economic and biological reasons for no longer utilizing succinylcholine chloride to immobilize moose (Gasaway et al., in review). These investigators utilized M-99 Rompun on a large number of moose and had good success.

Our radio-collared moose exhibited all the types of movements described by LeResche (1974) for moose in North America. Most moose during this study were either somewhat sedentary, occupying the same drainage year around with migration consisting primarily of movements from higher to lower elevations, or highly migratory, moving from higher summer elevations to lower winter elevations with considerable distances in between.

Fall migration during 1977 and 1978 was initiated primarily during the month of November. Its occurrence appeared to be at least partially correlated with the first heavy snowfall of the year. Heavy snowfall came earlier in 1977 than in 1978 and probably accounted for the earlier dates of migration that year. LeResche (1974) reported that most investigators had reported that weather and particularly snow conditions were the mediating factor in moose migrations. Our tentative observations are supported by other studies in Alaska (Rausch 1958 and VanBallenberghe 1978). Although fall migration appeared to be initiated by most moose during the same time period, the speed at which individual moose moved to the wintering site was quite variable. Some moose arrived on wintering areas in mid-December while others continued to meander in a southward direction until early spring.

Spring migration was not as clearly defined as was fall migration. Several moose began moving in April, arriving on summer range in early May where calving took place. Other moose remained close to the wintering site where some calved and then undertook the northward migration in mid-July. Some of the summer migrators never reached the sites where they were originally tagged. These animals then turned around and began the southward migration in November. VanBallenberghe (1978) reported that moose in the eastern portion of Unit 13 departed from their wintering areas between mid-April and mid-June. Similarly, once our cow moose began spring-summer migration, the movement to summer ranges was rapid, usually taking less than 7 days.

LeResche (1974) found that home range during a given season seldom exceeded 5-10 km^2. Since this was only the first year of the study, we did not compute areas of home range. Nevertheless, it is obvious that many of the moose had small seasonal home ranges particularly those from the western half of the study area.

Based upon our one year of data it appears that four or five separate populations may exist in the study area. Obviously much of the following discussion is speculation since the study was conducted during only one winter--and a somewhat mild one at that. Further study is needed to strengthen and modify this tentative appraisal. Groups, or perhaps separate populations, of moose were as follows:

<u>Clearwater Mountains - Western Alphabet Hills Population</u> - This population apparently consists of both a highly migratory segment and a resident segment. Cows tagged in the Clearwater Mountains were extremely migratory. Most occupied the area only during late summer and fall. During November these animals migrated down the Maclaren River and Clearwater Creek to

the bottomlands along the lower Maclaren River. Some moose wintered along the lower Maclaren area where they shared winter range with other moose which resided in the area year around. Other Clearwater moose and some from the Maclaren River area continued migrating south. They either followed the Susitna River or traveled through the Alphabet Hills down Monsoon Lake Creek. They eventually wintered either in old spruce burns on the south side of the Alphabet Hills or at the mouths of the Oshetna and Tyone Rivers.

Upper Susitna River Population - Moose from this population generally were year around residents of the east, middle, and west forks of the Susitna River. Most made relatively short movements, moving from higher elevations in summer to lower elevations in winter. The mouths of Valdez and Windy Creeks and the junction of the forks of the Susitna River receive heavy moose usage through fall, winter and early spring. This population's movements appeared to correspond closely to the drainage patterns of the upper Susitna River.

Upper Nenana - Brushkana Population - Moose from this population appear to be comprised of animals which reside in the tributary drainages of the Upper Nenana. These moose are migratory in that they occupy the upper drainages in fall and summer but winter in lowland areas where they share winter range with year around residents. Evidence suggests that some individuals may make extensive fall migrations down the Nenana River. There appeared to be a noticeable distinction between animals from this area and those utilizing the adjacent upper Susitna River drainages. Obviously some exchange between these two populations occurs.

Susitna River Population - On the Susitna River from Butte Creek down to Devil's Canyon most of the study animals exhibited both relatively short movements and small home ranges. Movements were mostly altitudinal in nature with the exception of those cows tagged in upper Butte Creek. Those moose migrated either down the Susitna River or Butte Creek where they wintered either at the mouth of Watana Creek or the vicinity of the Susitna Bend. There did not appear to be much interchange of animals in an east-west direction. Some evidence exists to indicate that these resident moose share winter range with other highly migratory populations. The movement of visual-collared moose #80 may be a good example.

Perhaps one of the more significant findings of this study is that of 33 moose radio-collared within the wolf removal area, 17 spent some portion of the year outside the area. This movement outside the study area was most prevalent for the Clearwater Mountains - Western Alphabet Hills population. Obviously if substantial numbers of moose moved out of the study area and remained there, especially during calving, then those portions of the population could be subjected to wolf predation. As a consequence of these findings modifications were made in the wolf removal experiment.

During late spring and summer our observations of calves with radio-collared cows indicated that considerable neonatal mortality was occurring in this study area. We determined that 78 percent of the losses occurred prior to 24 June. After that time period the rate of loss decreased and calf survival was high at least to early November. If our observations of calves with fall radio-collared cows were any indication of survival, it would be anticipated that calves, born in spring 1977 and surviving to November 1977, should then survive through at least April or May 1978. This prediction does not consider the consequences of a severe winter, should it occur. The fate of the surviving calves from fall radio-collared cows beyond April and May is unknown.

We were unable to determine the causes of calf mortality during this study. We did, however, note the presence of grizzly bears (*Ursus arctos*) on a few occasions. The timing of calf losses from this study was nearly identical to that which occurred during the moose calf mortality study where causes were determined (Ballard and Taylor in press). In that one-year study grizzly bear predation was the single most important mortality factor.

Recommendations

1. The moose movements study should be continued for at least one additional year to acquire at least 2 years data on each radio-collared animal.

2. If funding permits, radio-collared cow production and subsequent survival of calves should be monitored intensively during 1978 and again in 1979.

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Artina Cunning and Tom Balland constructed tables and maps for this report. Charles Lucier and his staff processed and aged moose teeth.

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APPENDIX I

Moose Movements and Habitat Use Along the Upper Susitna River--A Preliminary Study of Potential Impacts of the Devils Canyon Hydroelectric Project

by
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and
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Division of Game

Robert A. Hinman, Acting Director

March 1978

CONTENTS

SUMMARY

During October 1976 and March 1977, 18 radio collars and 21 visual collars were placed on moose along the Susitna River from the mouth of the Maclaren River downstream to Devil Creek. Radio tracking flights over 13 months yielded 270 observations of radio-collared moose. Visual collars were located 43 times. Movements were slight for radio-collared moose between Jay Creek and Devil Mountain, generally within 48 km^2. One visual collar from Devil Creek was seen near Lone Butte, 84 km east of her tagging location. Movements of moose collared east of Jay Creek were substantially longer, and migrations up to 103 km were observed. Radio-collared moose were found most often (70 percent) in spruce dominated habitats during all seasons. Seven of the eight cows that produced calves gave birth in spruce vegetation. The bend of the Susitna River from Goose Creek to the mouth of Tyone River was identified as important winter habitat for moose from many areas of the Susitna River drainage. Lower elevations along the Susitna River were found to be important as both wintering and calving areas for resident populations, particularly on the south side, east of Stephan Lake. Collared moose crossed the Susitna a minimum of 26 times during this study, 15 of which were across that portion which would be inundated by dam construction.

Movement data gathered over a period of only 13 months are insufficient to accurately delineate separate moose populations. Evidence to date suggests that moose from many portions of the Susitna River drainage utilize habitats adjacent to or portions of the area which will be flooded by dam construction. Intensive vegetative studies and research on movements both upstream and downstream are needed to adequately assess the impacts of the proposed construction (Appendix II).

BACKGROUND

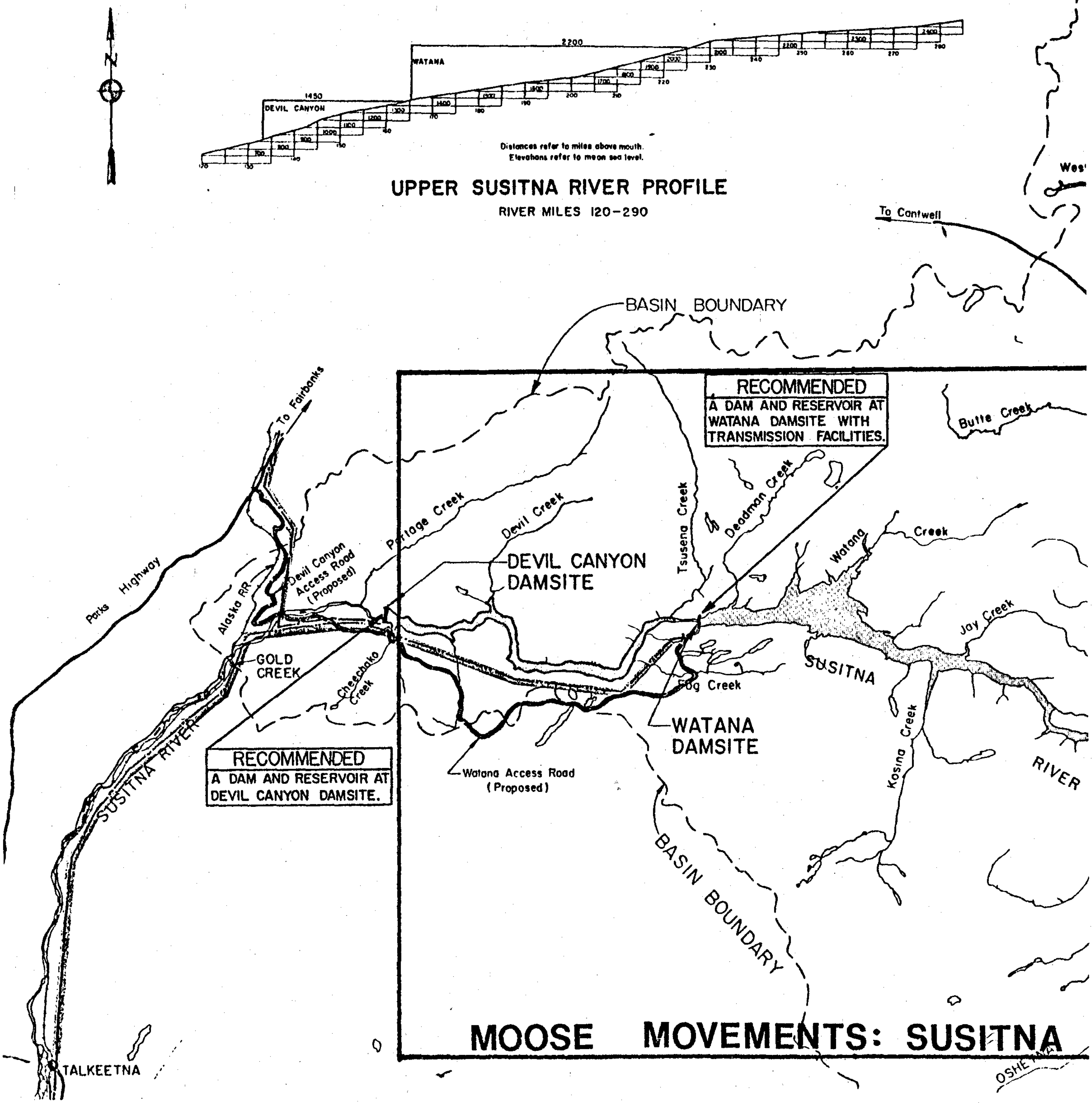
Feasibility studies on providing hydroelectric power from the Susitna River to the railbelt area of southcentral Alaska have been conducted since 1948. Potential dam sites were identified by the U.S. Bureau of Reclamation, the Alaska Power Administration and the Henry J. Kaiser Company. Proposed hydroelectric projects have included from 2 to 12 dams within the Susitna River basin, along with associated maintenance facilities and transmission lines to Anchorage and Fairbanks (Dept. of Army 1975).

The Devils Canyon-Watana dam system has been selected by the Army Corps of Engineers as the most viable of several alternatives (Fig. 1). This system would theoretically provide 6.1 billion kilowatt-hours of electrical power annually from a dependable capacity of 1,568 megawatts (Army Corps of Engineers 1975). The Devils Canyon dam would be a concrete structure 193 m high, and the Watana dam would be a rock fill impoundment rising 247 m above the river bottom. A 103-km road from Chulitna to the Watana site including a 198-m bridge across the Sustina would be constructed for transporting materials and personnel to the dam sites. Five hundred eighty-six km of transmission line corridors, 57-64 m wide, would be cut across the mountains between Anchorage and Fairbanks. Warehouses, vehicle storage buildings and permanent living quarters would be erected at the dam sites. The total projected cost of completing this project is $2,100,000,000 (Army Corps of Engineers 1977). The estimated annual cost for operation for 100 years following completion is $104,000,000. Power on the line from the Watana site is scheduled for 1986 and from the Devils Canyon dam by 1990. Construction and maintenance of this system would constitute the largest hydro-power project in North America (Gravel 1977).

Construction of both proposed dam sites would inundate 51,000 acres of the river valley, 132 km upstream to a point between the Tyone and Oshetna Rivers (Fish and Wildl. Ser. 1975). Water levels of the Devils Canyon reservoir are expected to remain almost constant but may fluctuate up to 55 m (ob. cit.). The Watana reservoir is projected to have substantial seasonal fluctuations up to 78 m. Downstream flow is expected to be maintained at a constant rate between 8,000 and 10,000 cubic feet per second, eliminating the flooding action that presently occurs each spring when downstream flows may be as high as 90,000 cfs (Army Corps of Engineers 1975).

The Susitna River Basin has long been recognized as an extremely rugged wilderness area of high esthetic appeal and as an important habitat to a wide variety of wildlife species (ADF&G, unpubl. data). Most important to sport and subsistence users are moose (*Alces alces*) and caribou (*Rangifer tarandus*). Hydroelectric development has been under consideration in this area for a number of years and some very general ungulate population assessment work was begun in 1974 (USF&W 1975). Since then no studies were conducted in the project area until 1976 when limited funds were made available to begin acquiring baseline information on moose and caribou populations within and adjacent to the project area. The purpose of this report is to present the findings of this one-year study and to discuss their implications in relation to the construction of the proposed hydroelectric project.

Figure 1. Devils Canyon Proposed Hydroelectric Project Moose Movement Study Area. Devils Canyon Project, March 1978.



DESCRIPTION OF AREA

Moose movements and habitat use were studied in that portion of the Susitna River Basin lying between latitudes 60°30' - 63°15' north and longitudes 146°30' - 149° west (Figure 1). The landscape is primarily mountainous and ranges in elevation from 300 to 1900 m. Semi-arid conditions dominate this area of the basin. Temperatures are generally cool in the summer and overcast days are common. Snowfall is usually moderate and ground accumulation does not often exceed one meter. Prevailing winds are out of the east and north. High winds are common along the river during any season.

Along the banks of the Susitna and its tributaries from the Maclaren River to Devil Creek the dominant vegetative cover is black spruce (*Picea mariana*), interspersed with muskeg bogs on the basin floor. Occasional stands of black cottonwood (*Populus trichocarpa*) are found on the islands in the river. Understory vegetation in the lower elevations includes highbush cranberry (*Viburnum edule*), devil's club (*Echinopanax horridus*), blueberry (*Vaccinium* spp.), lowbush cranberry (*Vaccinium vitis-idaea*) and several representatives of the rose and grass families. Hardwoods such as aspen (*Populus tremuloides*) and birch (*Betula papyrifera*) are often found interspersed among the spruce, predominantly on south-facing slopes. White spruce (*Picea glauca*) replaces the smaller, stunted black spruce on better drained soils. The understory above 300 m contains blueberry, lowbush cranberry, Labrador tea (*Ledum* spp.), fireweed (*Epilobium* spp.), crowberry (*Empetrum nigrum*), and several mosses and lichens.

Alder (*Alnus* spp.) dominates the reaches just above timberline, particularly along the headwaters of streams. Willow (*Salix* spp.) exists throughout the study area but occurs most frequently at timberline and on riparian sites. Alpine tundra extends above the alder-willow zone about 1200 m. A network of old caribou trails scars the tundra slopes of the mountain foothills throughout most of the area.

PROCEDURES

During October 1976 and March 1977, moose were captured along the Susitna River from its confluence with the Maclaren River downstream to Devil Creek. They were darted from a Bell Jet Ranger helicopter using standard techniques described by Franzmann et al. (1974) with doses of Anectine (Succinylcholine chloride), ranging from 23 to 29 mg. All captured moose were marked with plastic flagging affixed with metal ear tags and with either a radio collar, visual collar, or both. Radio collars were manufactured by AVM Instrument Company (Champaign, Illinois). These collars weighed 1.1 kg and were constructed of machine belting 13 mm thick and 65 mm wide with an adjustable inner circumference of 101 to 106 cm. The belting surrounded the radio components which were encased in dental acrylic, making the unit waterproof. Each radio was equipped with a SB-2 transmitter powered by cold resistant lithium batteries. All radios operated on frequencies between 150.700 and 151.875 MHz. Each visual collar (as described by Franzmann et al. 1974) had three sets of numerals, one on top and one on each side, to facilitate identification from the air. Visual collars were placed over many of the

Figure 2. Survey form used to record data during radio tracking flights along the Susitna River. Devils Canyon Project, 1978.

SUSITNA STUDY

MOOSE RADIO OBSERVATION FORM

Observer:

Time off:

Weather:

Temp.:

Time On:

Radio #	Channel	Seen	Calves	Location	Vegetation	Notes
8583	4-7-4.0					
8584	4-8-2.0					
8586	4-10-3.2					
8589	4-12-3.0					
8580	4-6-2.0					
8038	4-3-2.8					
8573	2-9-3.5					
8576	3-6-0.0					
8022	1-4-2.5					
8588	4-12-2.4					
8040	4-11-.5					
8578	4-4-3.9					
8579	4-5-1.9					
8031	3-8-2.5					
8035	3-12-1.4					
8018	1-2-3.8					
8030	3-7-1.5					
8575	2-12-4.2					

radios to enable observers to more easily pick out the radio-collared individual from a group of moose.

When conditions permitted, a lower front incisor was removed from each moose for age analysis using techniques developed by Sargent and Pimlott (1959). Blood and hair samples also were collected to aid in assessing physiological condition using methods described by Franzmann et al. (1975). Several physical measurements were taken when time permitted and general physical condition was assessed according to criteria developed by Franzmann and Arneson (1973). Cows captured in March were rectally palpated using techniques described by Greer and Hawkins (1967) to determine pregnancy.

Radio tracking flights were made monthly in a Piper PA-18 Supercub equipped with two three-element Yagi antennas connected to a four band, 12 channel portable received manufactured by AVM Instrument Company. Tracking methods were similar to those described by Mech (1974). Radio locations, vegetation type and miscellaneous notes were recorded for each observation (Fig. 2). During parturition, flights were increased to approximately every 3 to 5 days to more adequately assess initial production and survival of calves.

FINDINGS

Numbers of Moose Captured

Thirty-nine moose were captured and collared during October 1976 and March 1977 along the Susitna River in the vicinity of that portion of the river which would be inundated by the construction of the proposed dams at Devils Canyon and Watana Creek. Although the 13 moose collared in October were not originally part of this study, the data from these animals are included in this report. Collaring location and other pertinent tagging statistics are summarized in Table 1. Eighteen moose were fitted with radio transmitters and 21 wore numbered visual collars only. Twenty-seven incisor teeth were collected during the collaring operation, and cementum layer analysis indicated the average age for females was 6.7 years with a range from 2 to 13 years. Yearlings were generally avoided during the collaring operation. Of 21 females palpated, 18 were pregnant (85.7 percent).

Blood and physical measurement data were combined with those from other moose studies and were presented elsewhere (Ballard and Taylor, in prep.). Briefly, the pooled blood parameters tested were very comparable to values obtained from other studies of populations considered to be in good condition. Some parameters tested (hemoglobin and packed cell volume) from the Devil Mountain area were lower than those from the other tagging sites, but it is not known if those differences were statistically significant since no tests have as yet been performed.

A total of 270 observations were recorded for 18 radio-collared moose between late October 1975 and mid November 1977. One radio-collared moose was found dead two weeks after collaring. The cause of death was undetermined; we suspect, however, that it was drug related.

Table 1. Date, location and general information of female moose radio and visual collared along the Susitna River. Devils Canyon Project, 1978.

Collar Number	Collaring Date	Location	Anectine Dosage	Cementum Age (years)	Condition*	Pregnant**
8583	3/18/77	E. of Devil Mtn.	27 mg.	4	6	No
8584	3/18/77	E. of Devil Mtn.	25 mg.	-	6	Yes
8586	3/18/77	Devil Mtn.	23 mg.	10	4	Yes
8589	3/18/77	E. of Devil Mtn.	27 mg.	-	-	No
8580	3/18/77	Devil Mtn.	23 mg.	-	-	—
8038	10/27/76	Watana	— —	9	-	—
8573	3/19/77	Susitna-Watana	27 mg.	-	7	Yes
8576	3/19/77	Susitna-Watana	28 mg.	8	6	—
8022	10/28/76	Upper Watana	29 mg.	10	7	—
8588	3/19/77	Upper Jay Creek	29 mg.	8	7	—
8040	10/28/76	Upper Watana	29 mg.	-	7	—
8578	3/20/77	Susitna-Tyone	27 mg.	2	5	No
8579	3/20/77	Susitna-Tyone	25 mg.	3	6	Yes
8031	10/22/76	S. Bend-Susitna	27 mg.	-	7	—
8035	10/27/76	S. MacLaren Flats	— —	-	7	—
8018	10/27/76	Butte Creek	29 mg.	2	6	—
8030	10/22/76	W. of Ballard L.	25 mg.	6	6	—
8575	3/21/77	Lower Maclaren	29 mg.	11	7	Yes
2 Blue	10/22/76	N. Oshetna R.	— —	9	-	—
4 Blue	10/22/76	Susitna-Tyone	— —	4	-	—
5 Blue	10/22/76	Susitna-Tyone	27 mg.	6	7	—
6 Blue	10/22/76	Susitna-Tyone	27 mg.	5	-	—
7 Blue	10/22/76	Susitna-Tyone	25 mg.	6	-	—
71 Blue	10/28/76	Jay Creek	29 mg.	3	-	—
50 Blue	3/22/77	Lower Maclaren R.	27 mg.	8	6	Yes
51 Blue	3/22/77	Lower Maclaren R.	25 mg.	3	6	Yes
52 Blue	3/22/77	Lower Maclaren R.	27 mg.	7	7	Yes
53 Blue	3/22/77	Lower Maclaren R.	27 mg.	-	5	Yes
54 Blue	3/22/77	Lower Maclaren R.	25 mg.	4	-	Yes
56 Blue	3/22/77	Lower Maclaren R.	27 mg.	7	7	Yes
58 Blue	3/22/77	Lower Maclaren R.	27 mg.	12	7	Yes
60 Blue	3/20/77	Susitna N. of Tyone	28 mg.	13	-	—
61 Blue	3/20/77	Susitna N. of Tyone	25 mg.	-	7	Yes
63 Blue	3/20/77	Susitna Bend	27 mg.	5	7	Yes
64 Blue	3/20/77	Susitna Bend	27 mg.	11	7	Yes
75 White	3/19/77	Jay Creek	28 mg.	-	-	Yes
79 White	3/19/77	Jay Creek	28 mg.	-	-	—
80 White	3/18/77	E. Devil Mtn.	25 mg.	4	-	Yes
81 White	3/18/77	E. Devil Mtn.	27 mg.	-	7	Yes

*Condition was determined by general appearance and relative amount of fat over rump and ribs. Scale of 1-10, 10= excellent. See Franzmann et al. (1974) for criteria.

**Only cows collared in March and palpated are included in this column.

Another moose was lost from the sample when we were unable to relocate it after one month of tracking. Its loss was attributed to a faulty transmitter.

Movements

Radio-collared moose occupied areas ranging from 21 km^2 to 520 km^2 (Table 2). Significantly smaller areas were occupied in the rugged terrain between Jay Creek and Devils Canyon than east of Jay Creek where the terrain becomes more open and level. The correlation between the number of sightings and size of range for each moose was r = 0.50. Observed locations and detailed movements of each radio-collared moose are presented in Appendix I. A brief description of radio-collared moose movements follows.

Devil Mountain Area: Three moose (#s 8583, 8584 and 8586) were radio-collared on Devils Mountain on 18 March 1977, approximately 3 km north of the Susitna River (Fig. 3). All three remained in the vicinity of their tagging location until spring when #8583 moved 8 km east. Both #8584 and #8586 remained on their winter range through April. At the end of May, during the peak of calving, #8584 and #8586 were located 10-11 km to the southeast on the other side of the Susitna River within 2 km of each other. Three days later #8584 was seen with two new calves and #8586 was seen with one. Number 8583 was not pregnant when palpated in March. She remained on the north side of the river within a 3 km radius of her April location. Number 8586 lost her calf within two weeks and remained through the fall within 6 km of her calving location. Moose #8584 lost one calf within the first two weeks and the other prior to the first week in July. She was found on the north side of the river on 28 June and on the south side on 5 July where she remained through the fall. All three moose remained at elevations below 950 m during the time they were monitored. Some seasonal fluctuation in elevation occurred just prior to calving as #8584 and #8586 moved down from the south facing slope of the riverbank and crossed the river to calve. Seasonal home ranges for all three moose appeared to be small, probably not in excess of 20 km^2.

Watana Creek Area: Three radios were placed on cows along upper Watana Creek in October. Two of these females, #8040 (Fig. 4) and #8022 (Fig. 5), were collared together. Both moved to lower elevations as winter progressed and remained there until June. Number 8040 was seen with twins on 8 June but on 16 June the calves were missing and were never seen again. The cow returned to upper Watana Creek and remained within a 2 km radius throughout the fall. Number 8022 traveled considerably farther than #8040 as she crossed the Susitna sometime in February and returned in March. On 1 June she was seen in the same vicinity as #8040 on lower Watana Creek. On 16 June they were again found in close proximity. Her movements indicated no distinct migration between winter and summer ranges. Number 8022 was never seen with a calf. During the calving season she was found in four different locations.

Number 8038 was collared 5 km south of Big Lake. During all 19 observations this moose was between 600 m and 950 m elevation (Fig. 4). Although she was observed with a new calf on 26 May, when checked again

Table 2. Range size, number of locations and minimum number of river crossings of radio-collared moose along the Susitna River. Devils Canyon Project, 1978.

Collar Number	Number of Locations	Range Length km.	Range Width km.	Total Area km^2	Minimum number of river crossings
8583	12	11.6	4.8	30.9	0
8584	12	17.7	4.5	37.3	3
8586	10	17.7	5.3	30.9	1
8589	2	--	--	--	-
8580	3	--	--	--	-
8038	19	14.2	9.3	51.5	0
8573	14	14.8	7.9	47.6	2
8576	12	6.9	6.4	20.6	0
8022	18	24.8	17.2	180.2	1
8588	11	13.5	8.2	39.9	1*
8040	19	17.1	6.4	49.9	0
8578	17	14.3	5.5	32.2	1
8579	10	30.6	11.9	173.2	2
8031	26	16.1	12.1	74.7	0
8035	23	62.3	14.0	373.4	0
8018	18	65.0	18.7	520.1	2
8030	24	55.5	21.2	415.8	2
8575	20	103.0	10.5	291.4	0
	270 Total		Ave. range size 148.1 km^2		15 Total

* Cow observed on island.

Correlation between number of sightings and size of range for each moose =0.50.

Figure 3. Location and General Range Size for Radio-Collared Moose Along the Susitna River near Devil Mountain. Devils Canyon Project, March 1978.

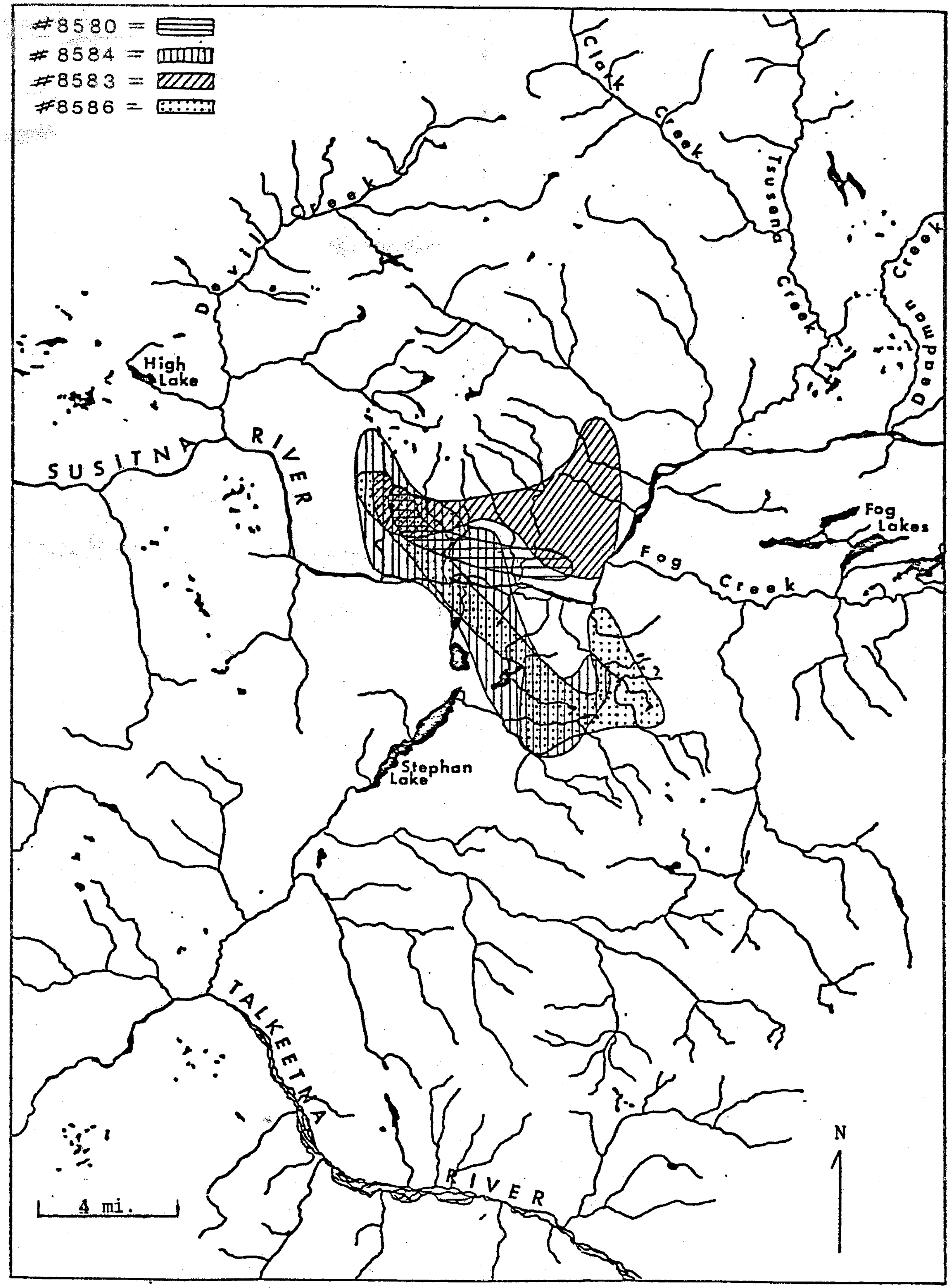


Figure 4. Location and General Range of Radio-Collared Moose Numbers 8038, 8040 and 8573 Along Watana Creek. Devils Canyon Project, March 1978.

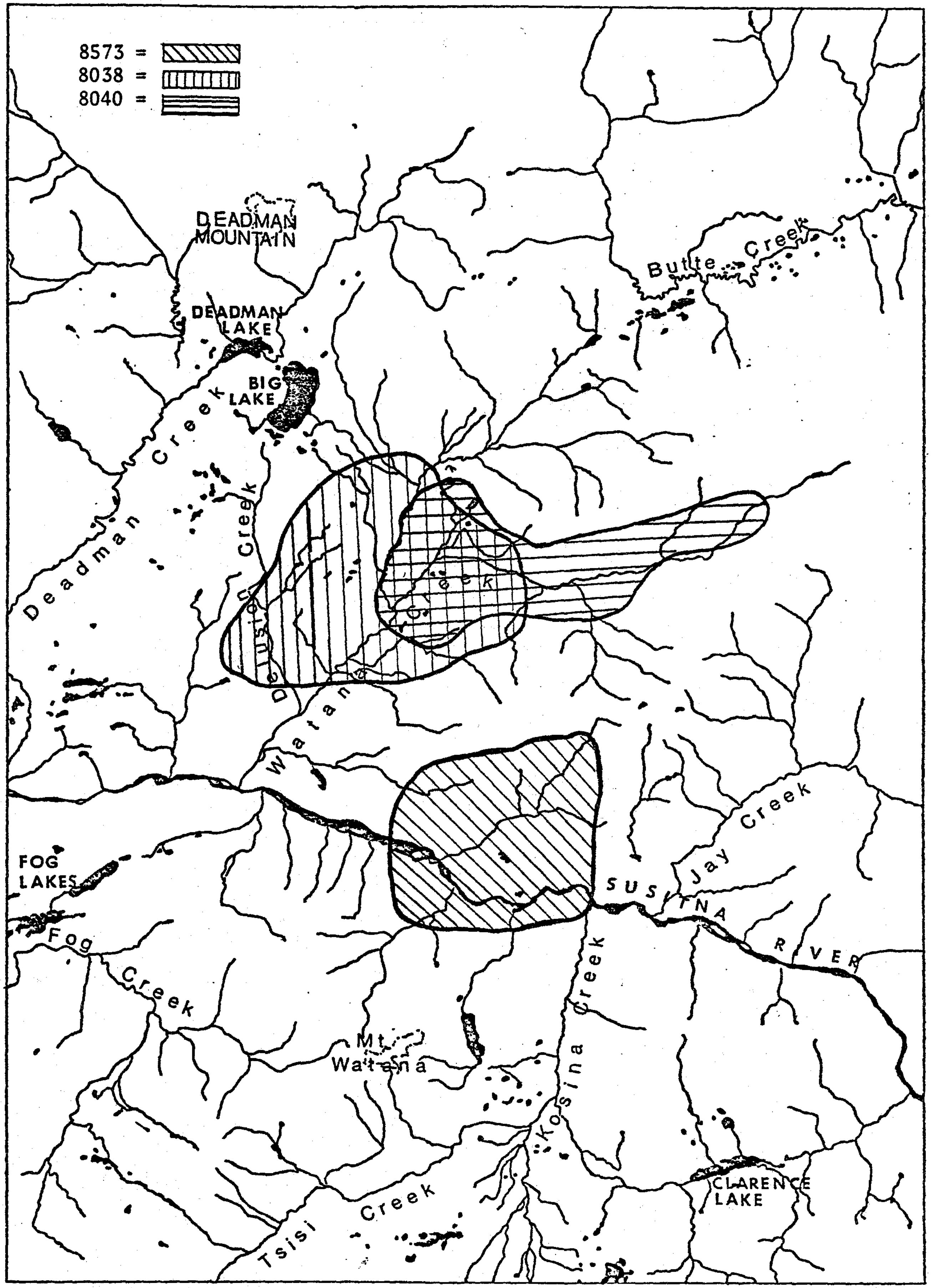
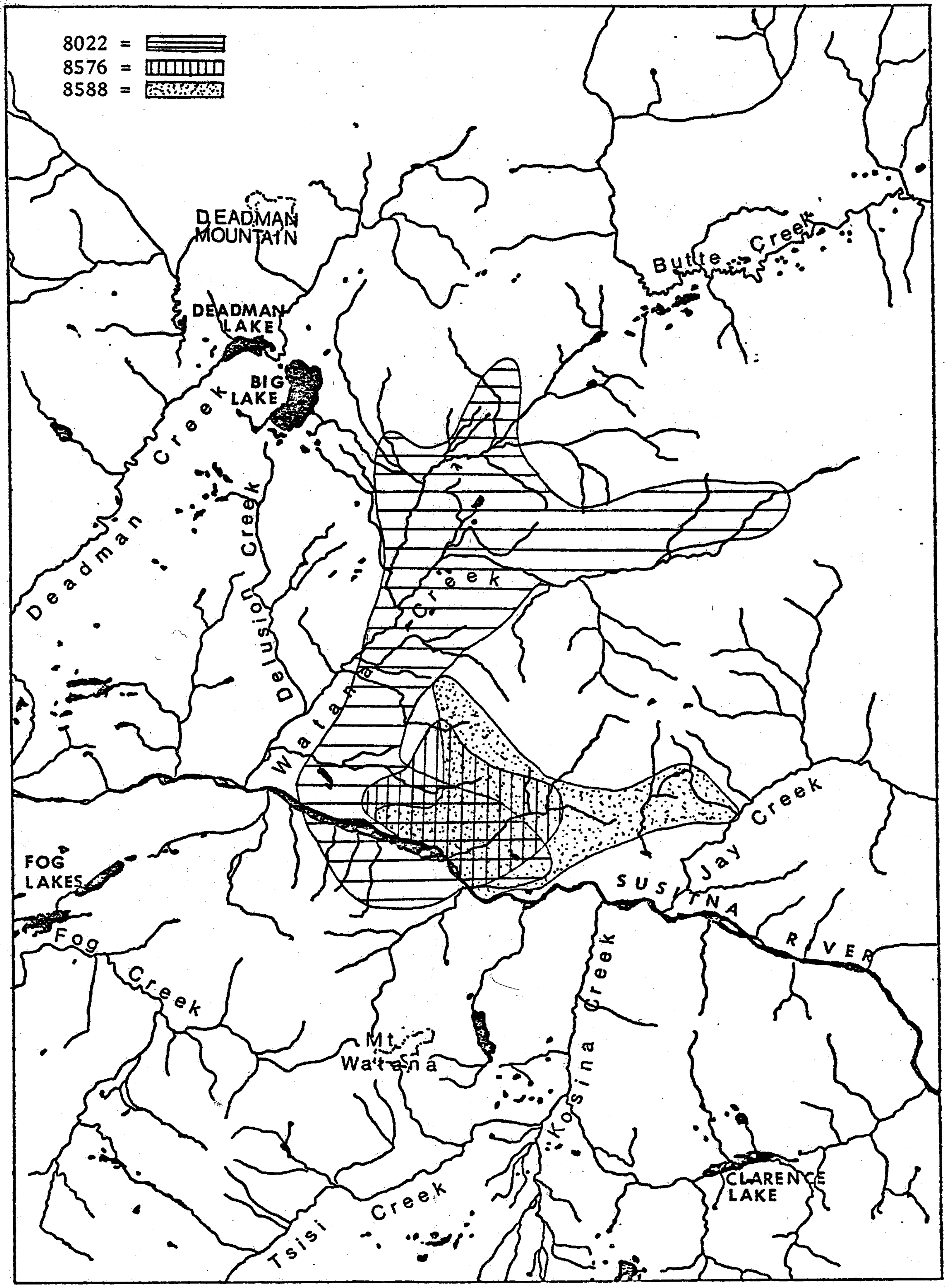


Figure 5. Location and General Range of Radio-Collared Moose Numbers 8022, 8576 and 8588 Along Watana Creek. Devils Canyon Project, March 1978.



on 31 May the calf was missing. From June through fall she appeared to move constantly, and the range used throughout this period overlapped that of winter observations.

On 19 March three females (#s 8573, 8576 and 8588) were collared on the north side of the Susitna between Watana and Jay Creeks. Number 8576 moved less extensively than any of the other radio-collared females (Fig. 5). She was observed 12 times, all on the north side of the river within an area of approximately 28 km^2. When last observed on 30 November she was within 2 km of her tagging location. Female #8588 also wintered along the north bank of the Susitna. She moved to an island in the river in early June and was observed again on the north bank on 8 June where she remained through November (Fig. 5). Number 8573 wintered along the north shore of the Susitna and crossed to the south bank during calving season (Fig. 4). She was never observed with a calf, although it was determined that she was pregnant when collared. However, she was not visually observed between 26 May and 3 June. She remained on the south side of the river until July when she returned to her collaring location. She stayed there until 30 November when, after a moderate snowfall, she moved to lower elevations near the mouth of Watana Creek.

Susitna Bend Area: Movements were more extensive for those moose collared east of Jay Creek. Number 8031 was collared in October 1976 on the north side of the Susitna near the mouth of the Tyone River. Two others, numbers 8578 and 8579, were collared in the same vicinity in March 1977. Number 8031 was observed almost exclusively between 600 m and 950 m in spruce habitats along the north and west banks of the Susitna (Fig. 6). She was never observed on the south bank of the river. She had a calf when tagged which survived the winter, but she was never observed with a calf the following spring. No seasonal range preference is discernible from her movement pattern.

Number 8579 was once found 30 km from where she was collared (Fig. 6). She wintered along the Susitna and crossed to the mouth of Goose Creek in May. She returned to the north side and moved to higher elevations near the headwaters of Coal Creek during calving where she remained through November. She was not located during June and was not observed with a calf in July, although it had been determined in March that she was pregnant. She remained in the high country through November.

Cow #8578 wintered in the same vicinity as 8579 and then crossed the Susitna to the mouth of the Oshetna River (Fig. 6). She never returned to the north side and spent the remaining summer months and fall in an area of approximately 7 km^2, west of the mouth of Goose Creek. Number 8578 was not pregnant when collared in March.

Number 8030 was collared very close to numbers 8031, 8578 and 8579, but her movement patterns were totally dissimiler (Fig. 7). She moved south across the Susitna River and wintered along the drainage of the Tyone River. By 10 May she had moved 2 km to an island in Susitna Lake and was observed there with a calf on 30 May. She remained with her calf through August in the vicinity of Tyone Village and returned on 5 October to within 1 km of her collaring location.

Figure 6. Location and General Range of Radio-Collared Moose Numbers 8031, 8578 and 8579 Downstream from the MacLaren River. Devils Canyon Project, March 1978.

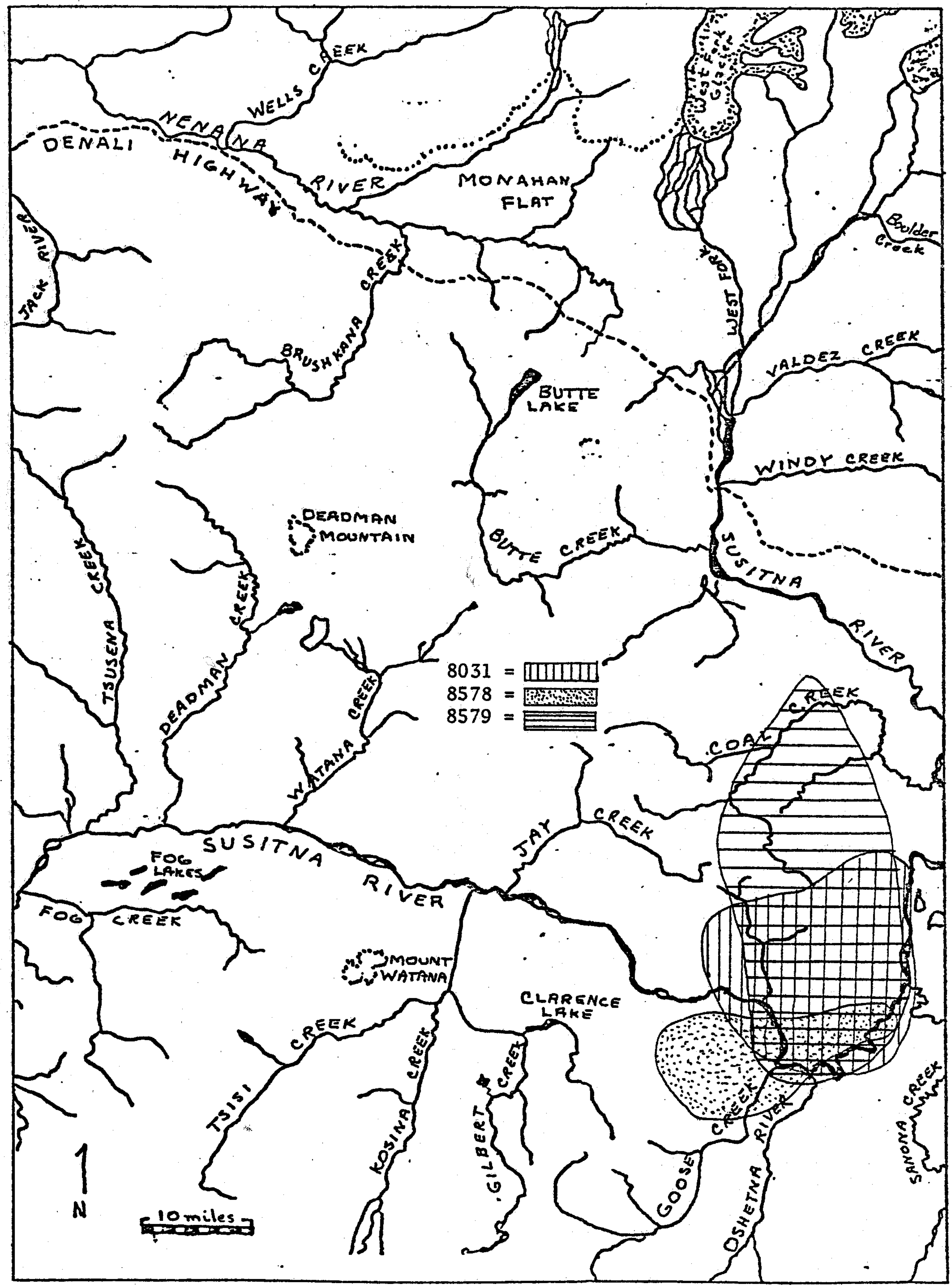
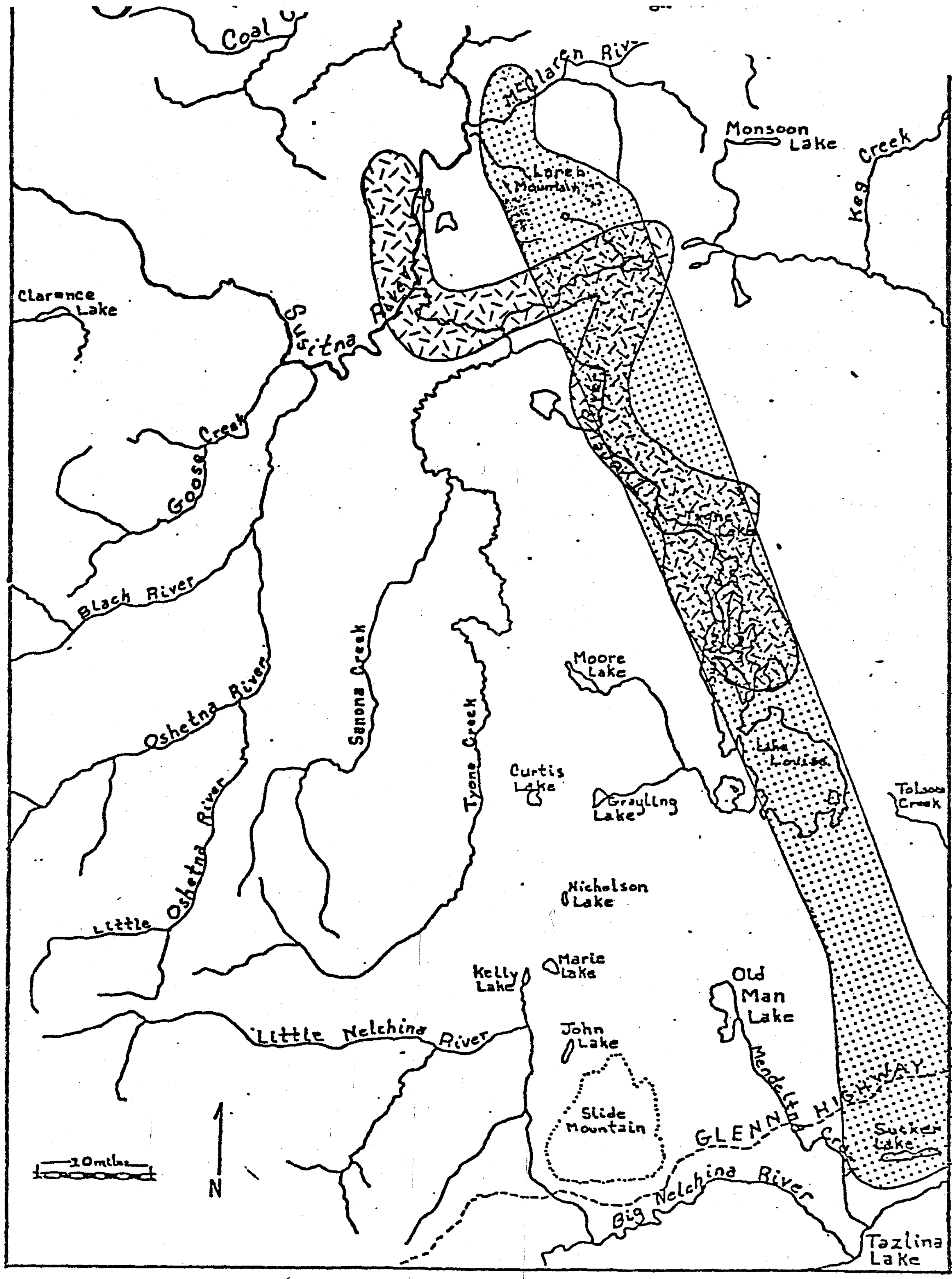


Figure 7. Location and General Range of Radio-collared Moose Numbers 8030 and 8575 Southeast from the Maclaren and Susitna Rivers. Devils Canyon Project, March 1978.



Maclaren River Area: Two females, numbers 8035 and 8575, were collared along the Maclaren River. Number 8035, collared on 27 October 1976, moved 59 km during November and early December to the mouth of the Oshetna River where she remained through March (Fig. 8). On 22 April she was observed returning to the vicinity of her tagging location. She was observed on several occasions in this area without a calf throughout the summer and fall. By 22 November she had returned to the mouth of the Oshetna River, 50 km from her previous location. During April 1977, #8575 migrated 103 km, the longest movement recorded during this study, from the lower Maclaren River to Sucker Lake south of the Glenn Highway near Tazlina Lake (Fig. 7). She was pregnant when collared in March but was never observed with a calf. This moose remained near Sucker Lake through May and moved 11 km north to Tolsona Ridge during June where she spent most of July and August. She returned once to Sucker Lake and made one trip to Lost Cabin Lake, but both times moved back to Tolsona Ridge. On 30 September she was observed moving back towards her tagging location on the Maclaren. By 5 October she had returned 82 km and was within 9 km of her collaring location.

Female #8018 was collared in October along Butte Creek. She was accompanied by a calf and remained in the Butte Creek vicinity through January (Fig. 9). On 7 February she and her calf were observed across the Susitna, 43 km away on the north side of Kelley Lake. She wintered there with her calf and began moving up the Maclaren in April. On 30 May she was seen with a new calf which was observed until 10 June. By 12 July she had returned 30 km in the direction of her tagging location and remained in the same vicinity she had inhabited the previous fall through November.

Radio-collared moose movement data were supplemented somewhat by incidental observations of visually-collared moose. Eleven additional river crossings were documented and possible migratory directions were identified. The second longest movement during this study occurred when the moose wearing visual collar number 80 was found near Lone Butte, 84 km southeast of her tagging location at Devils Mountain. Of the moose collared west of Jay Creek, she alone showed any migratory movement of significant distance. Collar number 60 was tagged in March 1977 just north of the mouth of Tyone Creek and was found 78 km to the northwest between the Nenana River and West Fork Glacier in August. One moose, #10, collared along Butte Creek in October 1976 moved down Watana Creek to the Susitna where she was found in August. Another, #67, was collared near Susitna Lodge in March 1977 and was located in November at the headwaters of Jay Creek.

Habitat Use

Habitat types being utilized by collared moose were noted during radio-tracking flights, and observations were categorized in nine groups (Table 3). Because spruce is the dominant vegetation over much of the study area and is widely variable in density, three categories were used to describe it. One hundred and seventy-two habitat observations of radio-collared moose were noted during tracking flights. Seventy percent of all observations were in spruce dominated habitats. Moose were most

Figure 8. Location and General Range of Radio-Collared Moose Number 8035 along the Maclaren and Susitna Rivers.

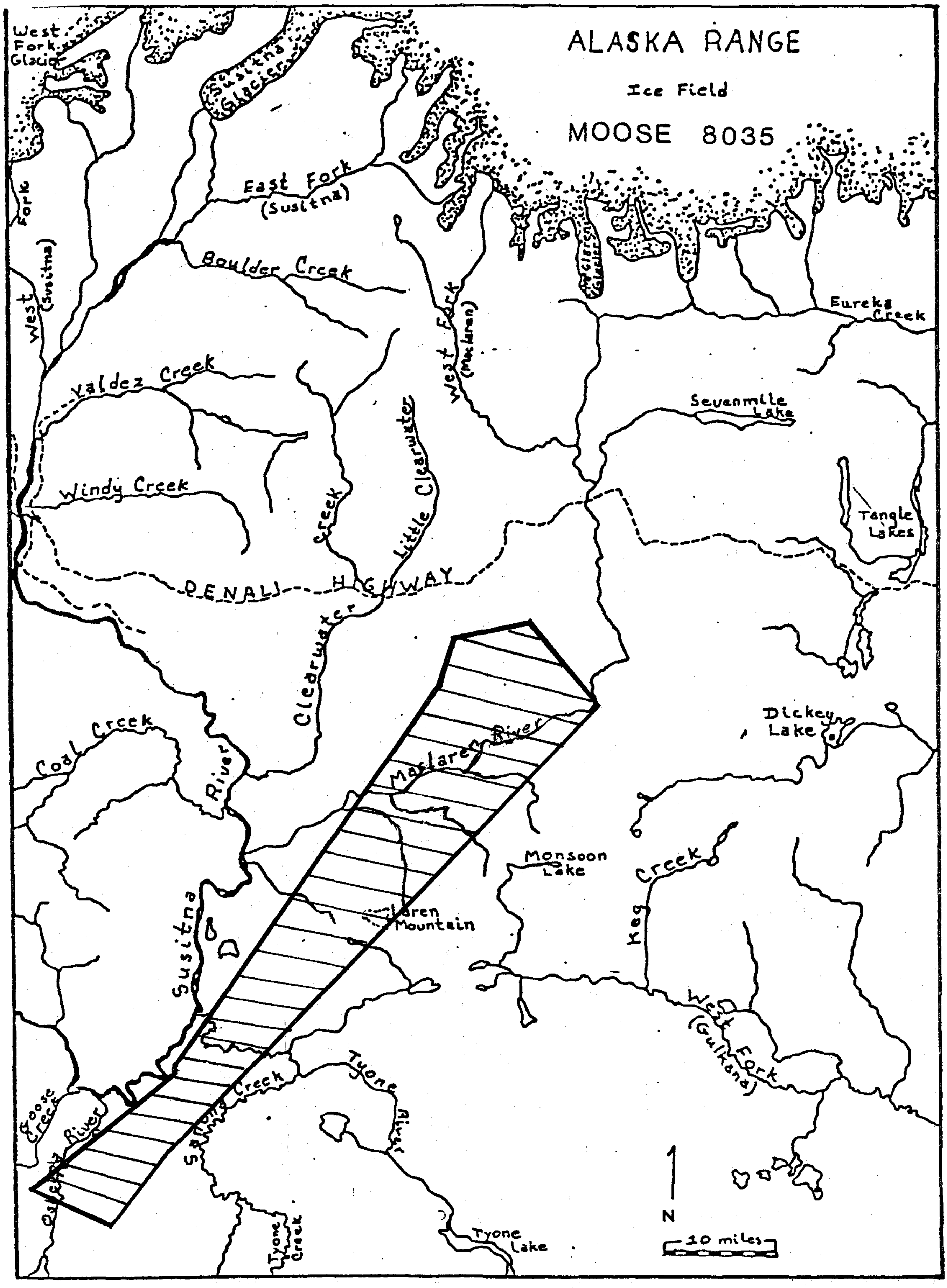
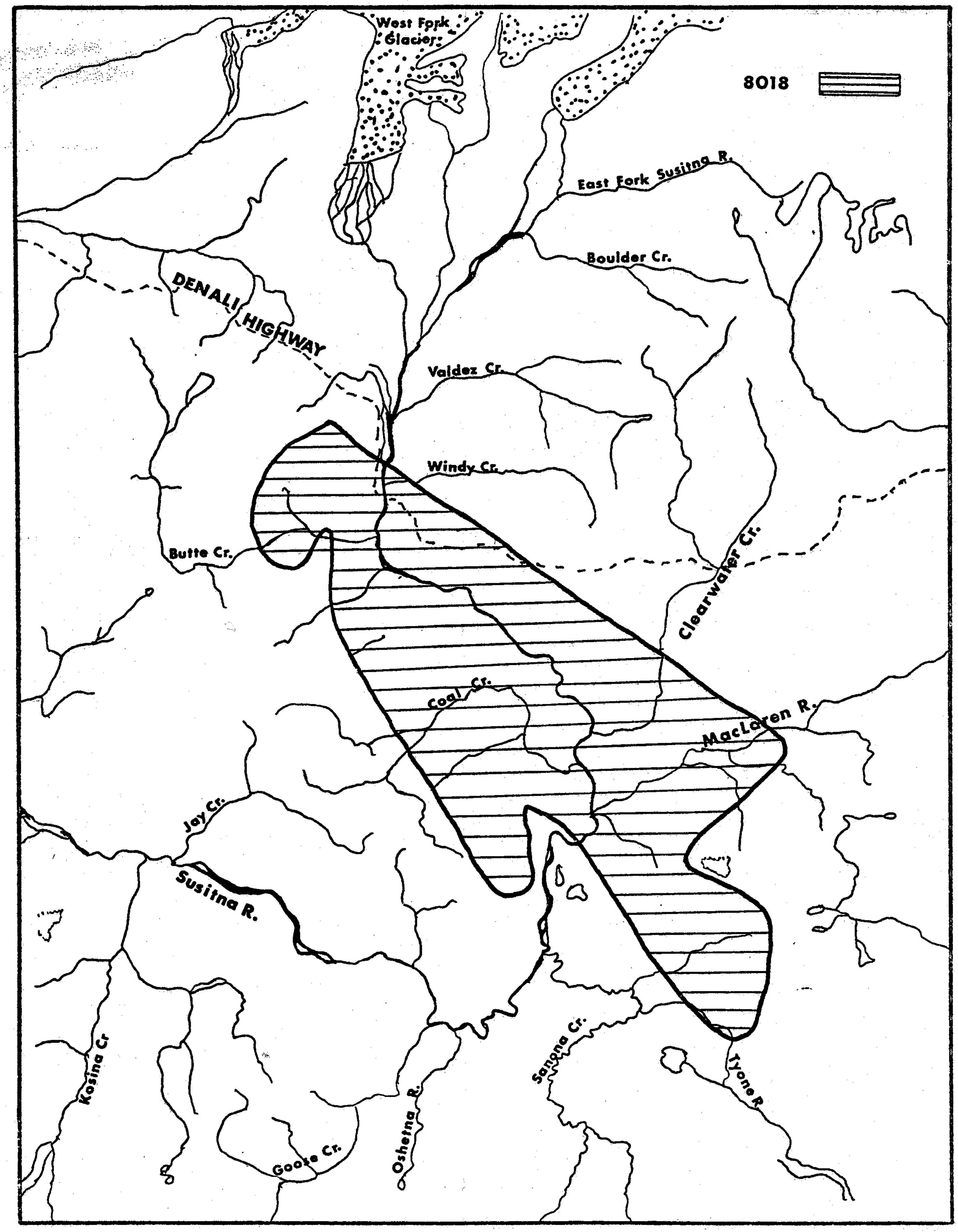


Figure 9. Location and General Range of Radio-Collared Moose Number 8018 Along the Maclaren and Susitna Rivers. Devils Canyon Project March 1978.



radio-tracking flights, and observations were categorized in nine groups (Table 3). Because spruce is the dominant vegetation over much of the study area and is widely variable in density, three categories were used to describe it. One hundred and seventy-two habitat observations of radio-collared moose were noted during tracking flights. Seventy percent of all observations were in spruce dominated habitats. Moose were most often (29.7 percent of observations) found in medium spruce areas where trees ranged from six to 15 m high in stands of moderate density.

Calving occurred primarily in open spruce areas, most often at lower elevations where stands of trees 4 to 14 m high were interspersed with openings. Eight calves, including one set of twins, were born in spruce habitats while one cow gave birth to a set of twins in alder dominated habitat. Alder and willow areas at and above timberline were utilized during the rutting season until late in the fall when snow depths approached 1 m.

Between Devil Creek and Watana Creek, radio-collared moose remained throughout the year almost exclusively at the lower spruce dominated elevations. Moose collared along upper Watana Creek were observed more often in willow-alder communities except during late winter when they were generally found in spruce habitats at lower elevations.

DISCUSSION

Movement patterns of moose are highly variable. Studies throughout North America (Edwards and Ritcey 1956, Houston 1968, Goddard 1970, LeResche 1972) support the hypothesis that movement patterns in moose may range from being sedentary to seasonal migrations of great distances. Peterson (1955) believed that many moose spend their whole lives in an area of 32-800 km^2. This appears to be true for many of the moose in the Susitna study area. Nine of the 16 moose radio-collared and tracked for 13 months along the Susitna River occupied areas smaller than 52 km^2. All but one of these were collared west of Jay Creek where the river valley is fairly narrow and is surrounded by mountains.

LeResche (1974) found that home range seldom exceeds 5-10 km^2 during a given season. Because radio-collared moose were only monitored for 8 to 13 months during this study, data were inadequate to allow computation of seasonal home range sizes. It was noticed, however, that several of the radio-collared moose were found repeatedly in areas less than 10 km^2 in extent. Others appeared to be more nomadic, particularly those collared in the eastern portion of the study area where they wandered across areas up to 50 km^2 during the spring and summer.

Areas of low elevation are often inhabited by both migratory and nonmigratory moose during winter and spring (LeResche 1972). This was apparent in the Devil Mountain area where #80 was collared. Between March and September 1977 she moved a straight line distance of 84 km to the southeast while a cow collared at the same time in the same location remained within 11 km of her collaring site throughout the year. This was also true of the wintering area between the Tyone River and Goose Creek to which many moose migrated considerable distances. Number 8031 remained in this area throughout the 13 months of this study.

Table 3. Number of observations of radio-collared moose in vegetation types along the Susitna River between October 1976 and December 1977. Devils Canyon Project, 1978.

Collar Number	Total Sightings	Open Spruce*	Medium Spruce	Dense Spruce	Spruce/ Hardwood**	Alpine Tundra	Alder	Willow	Riparian Willow	Open
8583	10	4	2	1	3					
8584	9	5	2	1	1					
8586	7	3	4							
8589	1			1						
8580	2		1	1						
8038	13	5	4	1		1			1	1
8573	10		6	1	1		1	1		
8576	12	3	8				1			
8022	8	1	2				3	1	1	
8588	9	2	3	1			1	2		
8040	10	1					6	1	2	
8578	12	6		1	1	2	1	1		
8579	9	1	1	2	1	2		1	1	
8031	11	1	7	2				1		
8035	12	3	3	1		1		1	3	
8018	11	3	2			1	2	2	1	
8030	11	2	3	6						
8575	15	3	3	7			1		1	
	172	43	51	26	7	7	16	11	10	1
Percent of Total	100.0	25.0	29.7	15.1	4.1	4.1	9.3	6.4	5.8	.6

*Spruce categories include both white spruce (*Picea glauca*) and black spruce (*Picea mariana*).
**Hardwoods in this category include aspen (*Populus tremuloides*) and birch (*Betula papyrifera*).

Edwards and Ritcey (1956) noted that increasing snow depths above timberline triggered moose migrations out of the high country to their wintering areas in the lowlands. Their observations have been supported in Alaska by Rausch (1958) and LeResche (1974), both of whom concluded that the fall migration in Interior Alaska is closely related to snow conditions. Snow depths along the Susitna River during the winter of 1976-77 were below normal until late March. They appeared to be greater along the eastern portion of the study area than west of Jay Creek. Shortly after accumulated snow reached its maximum depths, most collared moose east of Jay Creek either migrated short distances where a considerable drop in elevation was possible, or made long treks to their wintering areas, gradually moving to lower elevations. Except for #80, those west of Jay Creek showed no tendency to migrate at all. Radio-collared moose in this area may be representative of a sedentary population, but it is recognized that data collections over a 13-month period which includes subnormal snow depths are inadequate to accurately assess the migratory nature of moose along this stretch of the Susitna River. If data from this small sample are representative of the moose population currently inhabiting this stretch of the Susitna River, construction of the Devils Canyon dam would have a highly detrimental effect on the population as the dam would inundate a major portion of the winter habitat presently available. Destruction of this winter range would substantially reduce the carrying capacity of a major portion of the Devil Creek drainages.

Some of the possible migratory routes represented by data accumulated thus far are illustrated in Figures 3-9. The relative significance of each of these is unknown at this time, although it is apparent that a substantial number of moose migrate to and utilize the area near the mouth of the Tyone and the Oshetna Rivers for winter range. Coady (1974) noted that the depth, density and hardness of snow are appreciably lower in coniferous and deciduous tree communities making them more favorable to moose under stress from severe winter snow conditions. The lower, spruce-covered reaches of the Watana Creek Valley are probably critical for the majority of moose inhabiting this area during a severe winter. A major portion of this area would be inundated by construction of the Watana dam. Additional observations of moose during normal or severe winter conditions are necessary to determine the importance of this area as winter range. If this area is used as winter range during more severe winters which would normally occur in this area, construction of the Watana Dam would substantially reduce the carrying capacity of this portion of the study area.

Present information indicates moose depend heavily upon the river bottoms and adjacent areas for winter habitat both above and below the Watana and Devils Canyon damsites. Lack of adequate wintering areas in the lower Susitna Valley has been a major limiting factor to moose population growth there in the past (Chatelain 1951). Most existing winter range is along the major rivers where periodic flooding has caused rechanneling of the main stream, allowing riparian willow to colonize the dry stream beds. Regulating the flow of water from the dam at Devils Canyon could have a highly detrimental effect on growth of riparian vegetation downstream to the mouth of the Susitna. It is possible that maintaining a steady flow of 8,000 to 10,000 cu. ft./sec.

from the Devils Canyon dam would effectively prevent the flooding activity that presently occurs periodically. This could create a short-term abundance of winter range along the riverbanks that might last 30 or more years. The net long-term effect could well be a negative one, however, as it is suspected that the present natural flooding activity of the Susitna River produces favorable conditions for browse production. Without annual floods, these riparian areas could become mature stands of hardwoods after 25 or 30 years and provide little or no winter forage. Research on riparian vegetation habitat types and associated moose usage downstream of dam construction is essential to determine potential impacts on moose populations.

CONCLUSIONS

The emphasis of this telemetry study focused almost exclusively on the north side of the Susitna River upstream from the Devils Canyon dam site. Information on migratory routes and annual movement patterns was limited by the small sample of radio-collared moose (18), many of which were observed for less than nine months. Moose which were collared in October 1976 were monitored through the winter of 1976-77 which was considered to be mild. Information pertinent to identifying critical wintering areas is most appropriately obtained during winters of high to severe snow depths because moose tend to congregate in greater densities on the most vital ranges as snow depths increase. Acquisition of moose movement information downstream and on the south side of the Susitna River is essential to evaluation of the full effects of the proposed hydroelectric project. Downstream effects on moose would be expected to be significant since vegetation composition would be altered substantially as a result of regulated water flow.

Annual moose harvests within the immediate drainages along the upstream portion of the Sustina River have averaged 146 moose since 1974 (ADF&G, unpublished data). Approximately 475-500 sportsmen participate in moose hunts in this area each fall (ob. cit.). How significantly dam construction might reduce or increase this level of activity is difficult to project with the limited data available. Construction of an access road to the Watana site would substantially increase hunter pressure in the area, creating a corresponding increase in total man days spent hunting. In the long run, however, the quality of the hunting experience would probably decline, along with the rate of hunter success. Dam construction and maintenance schedules are projected on a basis of a dam life of 100 years. If impacts of the project reduced local moose populations by 50 percent this would amount to a corresponding loss of harvest of 7,300 moose during the life of the dam.

Construction of the Devils Canyon dam would flood a 45 km portion of the Susitna River having a surface area of 7,500 acres (USF&WS, 1975). The riverbanks along this portion of the river are generally steep and provide marginal habitat for moose. The low density of moose tracks in this area throughout winter 1977-78 indicates that little utilization occurs during winters of moderate snowfall. Since water levels in the Devils Canyon reservoir are expected to remain fairly constant, low mortality rates associated with ice shelving and steep mud banks would be expected.

Construction of the Watana dam would result in inundation of 43,000 acres along Watana Creek and the Susitna River. Approximately 35,000 acres sustain moderate to heavy utilization by moose during an average winter (USF&WS 1975). Much of it supports moderate moose densities during the spring and summer seasons as well. The preliminary movement data gathered thus far from radio-collared moose indicate that moose from several surrounding areas of the Susitna Basin migrate across or utilize this portion of the river during some period of the year. The Alaska Department of Fish and Game recorded observations of 2,037 moose during their fall 1977 sex and age composition counts of these areas (ADF&G, unpublished data). LeResche and Rausch (1974) concluded that an observer generally sees between 43 to 68 percent of the moose in an area during an aerial census. Using 50 percent to extrapolate roughly, the resident population utilizing this portion of the basin probably is between 4,000 and 5,000 moose. Random stratified counts weighted with an accurate sightability index are needed to accurately assess numbers of moose in this area.

Effects of the construction of the Watana dam on these moose populations could be substantial. The resident nonmigratory segment of the population could be eliminated. The immediate loss of a major portion of the winter range along Watana Creek and parts of the Susitna River to flooding would have the effect of reducing the carrying capacity of the habitat at higher elevations used only during the warm seasons and mild winters. The Watana Reservoir would be 87 km long and may during some seasons prove to be an effective barrier to migrations. The resulting disruption of movements to traditional breeding grounds may adversely impact productivity. Increased mortality of neonates during post calving movements might occur. Since water levels are expected to fluctuate as much as 78 m, ice shelving could become a significant cause of mortality as well. Calving is a common occurrence in these portions of the study area. The loss of calving habitat notwithstanding, fluctuating water levels would convert the presently timbered slopes from the Watana dam site to the Oshetna River to enormous mud banks. Calf mortality from falling down these banks or getting stuck in the mud could become a common occurrence.

RECOMMENDATIONS

Collection of baseline biological data and completion of resource assessment in the area affected by the proposed hydroelectric project in far greater depth than this study are essential prerequisites to understanding the possible impacts of the proposed action. Identification of moose populations, movement patterns, and habitat use downstream and on the south side of the Susitna River is essential to predict both negative and beneficial effects of the proposed project. Habitat studies should be conducted concurrently to determine seasonal use and degree of dependency of populations on habitat to be impacted by the project. Alternate areas suitable for habitat rehabilitation to mitigate range losses should be investigated as well as suitable methods for habitat enhancement.

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