SUSITNA HYDROELECTRIC PROJECT

1984 ANNUAL REPORT

MOOSE UPSTREAM

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Submitted to the

Alaska Power Authority

October, 1985

PREFACE

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

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

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

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

SUMMARY

During late winter 1985, the proposed Bureau of Land Management experimental burn was surveyed to estimate numbers of moose utilizing the area prior to burning. Four hundred forty-three moose were estimated in the area in 1985. Similar counts in 1982 and 1983 were much lower; 287 and 253 moose, respectively. Annual winter moose usage of the proposed burn area is highly variable.

During this reporting period radio-collared moose were monitored at low intensity in an effort to maintain contact for proposed severe winter studies. Nineteen moose were recollared in 1984. A number of criteria were developed and described for refining estimation of moose annual and seasonal home ranges.

During late March 1985, a low intensity moose distribution survey was conducted in the moose primary impact zone in an effort to identify wintering areas. Late winter distribution surveys (low intensity) conducted in 1980 and 1985 were compared with fall moose distributions in 1980 and 1983 (based on high intensity surveys). Several areas immediately adjacent to the Susitna River are lightly used by moose in the fall but are heavily used in late winter. Within the moose primary impact zone both the

Watana and Devil Canyon impoundment areas were intensively counted from fixed-wing aircraft in March 1985 to estimate numbers of moose in those areas. A total of 295 and 22 moose were estimated for each impoundment area, respectively. From 1980 to 1985, winter estimates of the numbers of moose utilizing the proposed Watana impoundment area during mild or moderate winters has ranged from 42 to 580 moose while the Devil Canyon impoundment estimates have varied from 14 to 30 moose. A method for predicting winter severity by January in the Watana impoundment area is described.

Causes of moose calf mortality in the impoundment areas were studied during late spring and summer 1984. The study was conducted to determine the importance of black bear predation on moose. Black bears will be impacted by the proposed projects and if the population is reduced there may be potential benefits to moose calf survival. Of 52 radio-collared calves only 15% survived from birth to November. Brown bears killed 46% of the calves while black bears and wolves killed 8% and 6%, respectively. Black bears were a secondary source of moose calf mortality.

Three types of project impacts are proposed and defined. All identified impacts to moose were categorized by impact type.

Timing of when maximum impact from a particular impact mechanism might occur is hypothesized and types of studies needed to refine impact magnitude are proposed.

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INTRODUCTION

Background and objectives of Phase I and II studies were described by Ballard et al. (1984). As a result of earlier studies, project objectives for FY85 were as follows:

(1) To determine the number of moose inhabiting the primary impact zone.

(2) To determine habitat selectivity of moose inhabiting the primary impact zone.

(3) To determine causes and rates of moose calf mortality.

This report updates the findings of earlier reports and presents additional data collected from January 1984 through mid-March 1985. Because the information contained in this report treats only portions of continuing studies, it should not be used in scientific technical publications without the written approval of the investigators.

STUDY AREA

Boundaries and descriptions of the study area were provided by Ballard et al. (1984).

SECTION I. PROPOSED EXPERIMENTAL BURN

Introduction and Methods

Background and methods used for this portion of the study were identical to those presented by Ballard et al. (1984).

Results

During 1984 the 10 radio-collared moose were located on only a few occasions. These data were placed on computer and added to those collected in earlier segments. Final analyses will be presented in next year's report depending upon availability of computer programmer and biometrical support.

On 19 and 20 March 1985, the number of moose within a 145 mi^2 area encompassing the proposed Bureau of Land Management Alphabet Hills Burn were counted from fixed-wing aircraft at an average survey intensity of 5.2 minutes per $mile^2$. Areas within five subunits were intensively flown at approximately 12 min/mi^2 to obtain a sightability correction factor (SCF) which is used to estimate total numbers of moose inhabiting the area (Gasaway et al. 1981). A total of 308 moose were observed, and utilizing an SCF of 1.44 (46 moose observed at 12 min/mi^2 divided by 32 moose observed @5.2 min/mi^2 for the same sample areas), an estimate of 443 moose was derived (Figure 1).

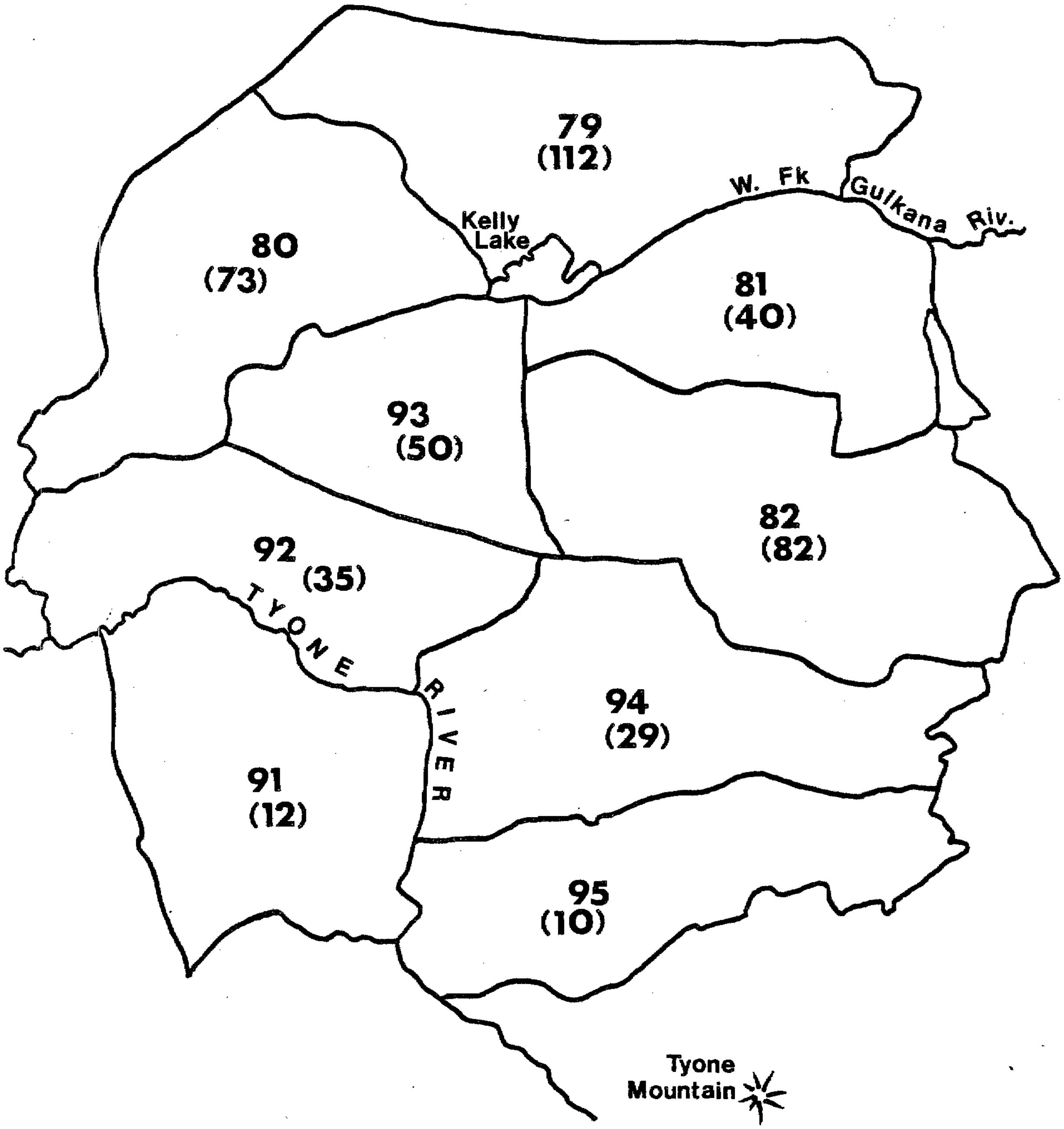

Figure 1. Map of Alphabet Hills burn area sample units and moose estimates (in parentheses) from 19 and 20 March 1985 moose census.

Identical counts were conducted in this area in 1982 and 1983 (Table 1). There was no ($P > 0.05$) difference in average number of moose observed between 1982 and 1983 (t-test). Average number of moose observed in 1985 was greater than in 1983 ($P < 0.05$). Comparison of individual estimates within the nine sample units suggested that areas which had relatively few moose in 1983 also had low densities in 1985, while areas having relatively high densities in 1983 (2-3 moose/mi^2) had high densities in 1985 (>5 moose/mi^2, Table 2). Reasons for the 75% increase in 1985 estimates are not known; SCFs were comparable, actual counting conditions and flight intensity were similar, and dates of the two surveys were within 5 days of each other. Winter severity as indicated by snow surveys conducted in the area by the Soil Conservation Service was not noticeably different. Comparable censuses conducted in the Watana and Devil Canyon impoundment areas did not suggest this increase. Because moose censuses reflect moose numbers for a limited period of time, such differences may just reflect normal annual variation.

SECTION II. HOME RANGE, DISTRIBUTION AND MOVEMENTS OF MOOSE

Radio-collaring Moose

Nineteen moose originally captured in 1980 and 1981 were recollared in March 1984 to insure radio contact when a severe winter occurred. All moose were immobilized with Carfentanil (Franzmann et al. 1984).

Table 1. Comparison of moose total counts within the proposed Alphabet Hills burn area in southcentral Alaska during March of 1982, 1983, and 1985.

Year	Dates	Survey Time (Min.)	Min/ Mi^2	Observed No. Moose Observed	Observed Uncorrected Moose/mi^2	Sightability Correction Factor	Corrected Estimate Estimated No. Moose	Corrected Estimate Corrected Moose/mi^2
1982	3/24	705	4.9	167	1.2	1.72	287	2.0
1983	3/25,26	719	5.0	196	1.4	1.29	253	1.7
1985	3/19,20	751	5.2	308	2.1	1.44	443	3.1

Table 2. Comparison of estimated number of moose among years within individual sample units of the proposed Alphabet Hills burn area in 1982, 1983, and 1985, southcentral Alaska.

	Estimated Moose Numbers		
Sample Area	1982	1983	1985
79	88	48	112
80	45	34	73
81	17	13	40
82	48	52	82
91	12	15	12
92	36	19	35
93	27	40	50
94	5	23	29
95	9	9	10
Total Estimate	287	253	443

Home Range Size

No effort was made to update home range sizes described by Ballard et al. (1984). Additional data collected during 1984-85 were placed on computer file and will be reported in the final report.

During this reporting period, we analyzed movement data and developed criteria for objectively estimating home range size. The criteria should allow investigators to duplicate home range polygons. Preliminary criteria developed and tested thus far are a modification of Mohr's (1947) minimum home range method and are as follows:

1. Seasonal, annual, and total home ranges are calculated.

    a. Seasonal ranges are defined as follows.

        1) Summer - May through August.

        2) Winter - January through April.

    b. Fall home ranges (September through December) are not drawn separately, but are used in the total fall (all years combined) and total annual home ranges.

c. When less than four point locations are present for any one season, a home range for that particular season is not calculated, but the data points are used in computing total home ranges.

d. Home ranges will include some points outside of a particular season if there is a clear relationship with earlier or later points.

2. Linear lines connecting outermost point locations are used except:

a. When elevations above 3600 ft. (MSL) are transected, the home range boundary follows that contour line.

b. When chronology of location data indicates an area is not used, a concave polygon is used to exclude this unused area.

c. When macro-habitats with large areas possessing slopes in excess of 30% are encountered, those steep areas are excluded.

d. When outlying points are encountered, they should first be checked for accuracy. If they are determined to be realistic, the polygon should be drawn from the closest two perpendicular points to the outlier, reflecting this narrow exploratory movement.

e. When a major drainage is encountered, and all point locations are on one side, the home range boundary will usually follow the drainage without crossing. However, if crossings do occur, known fording areas are used to include areas on the opposite bank.

River Crossings

Crossings observed during 1983 and 1984 were computerized. These data were not analyzed for this report.

Zone of Impact

The primary impact zone was described by Ballard et al. (1984) and no further analyses for delineating boundaries are necessary.

Winter Use of the Impact Zone

Monitoring of radio-collared moose has indicated that during March and April of mild or moderate winters, most moose are relatively sedentary on the areas they have selected as winter ranges. Relative distribution of Middle Basin moose was determined from 27-29 March 1985 in the Primary Impact Zone by surveying from fixed-wing aircraft (PA-18 Super Cub). This type of survey differs considerably from other types of counts and censuses in that considerably less survey effort is used and no population estimates can be derived. A total of 2,092 minutes of survey effort (1.7 minutes/mi^2) was expended on the 1,254 mi^2 area. All moose observations were recorded on 1:63,360 scale USGS topographical maps. Similar to fall censuses, we used the winter distribution data to stratify observed moose into relative density strata. No attempt has been made to estimate population size in this large area during late winter, so only the relative differences in density are available. In-depth counts of the actual impoundment areas are described under appropriate impoundment headings. Individual sample units were assigned a relative density estimate of either high, medium or low (Table 3). Areas over 4000 ft. elevation were assumed to have no moose, so were not surveyed.

One other winter moose distribution survey was conducted in the Middle Susitna River Basin in 1980, so some comparisons are possible between 1980 and 1985 distributions even though boundaries of the two areas differed. Monitoring of instrumented moose has shown that they usually inhabit different ranges in summer and winter, and comparison of density stratification maps between fall censuses (with population estimate) and winter distribution surveys (no population estimate) depicts these differences (Figures 2 and 3 for comparison of fall 1980 with

Table 3. Relative winter moose densities in March 1985 in 114 sample units of the primary moose impact zone, Middle Susitna River Basin, Alaska.

Low Density		Medium Density		High Density	
Sample Unit	Moose Observed	Sample Unit	Moose Observed	Sample Unit	Moose Observed
9	2	7	14	8	33
11	6	10	16	14	33
26	6	12	18	17	51
30	8	13	8	19	38
31	1	15	9	20	34
32	0	16	19	21	36
33	1	18	8	22	25
36	5	24	14	23	23
37	1	27	18	25	34
38	3	29	17	28	27
41	3	34	14	42	32
43	2	35	14	47	24
44	5	39	10	48	47
45	5	40	21	50	35
46	0	49	14	51	48
58	7	54	11	52	27
86	3	55	19	53	29
122	3	56	19	60	32
126	4	57	11	123	36
131	0	72	20	128	12
132	1	76	13	139	38
133	2	88	11	153	34
137	0	89	13	168	23
138	0	104	11	186	22
140	0	125	9		
150	7	127	10		
151	1	129	13		
152	1	130	12		
157	2	134	5		
158	0	135	14		
159	1	136	5		
169	0	154	15		
170	0	155	12		
171	0	156	8		
174	1	160	10		
176	3	161	10		
177	0	172	5		
178	5	173	10		
184	1	175	8		
188	2	185	13		
191	2	187	6		
205	1	189	6		
206	4	190	6		
207	2	204	7		
218	2	219	6		
45	103	220	13		
		46	538	24	773
$\bar{x}$ = 2.3 moose/S.U.		11.7 moose/S.U.		32.2 moose/S.U.	
Range = 0-8		4-21		12-51	

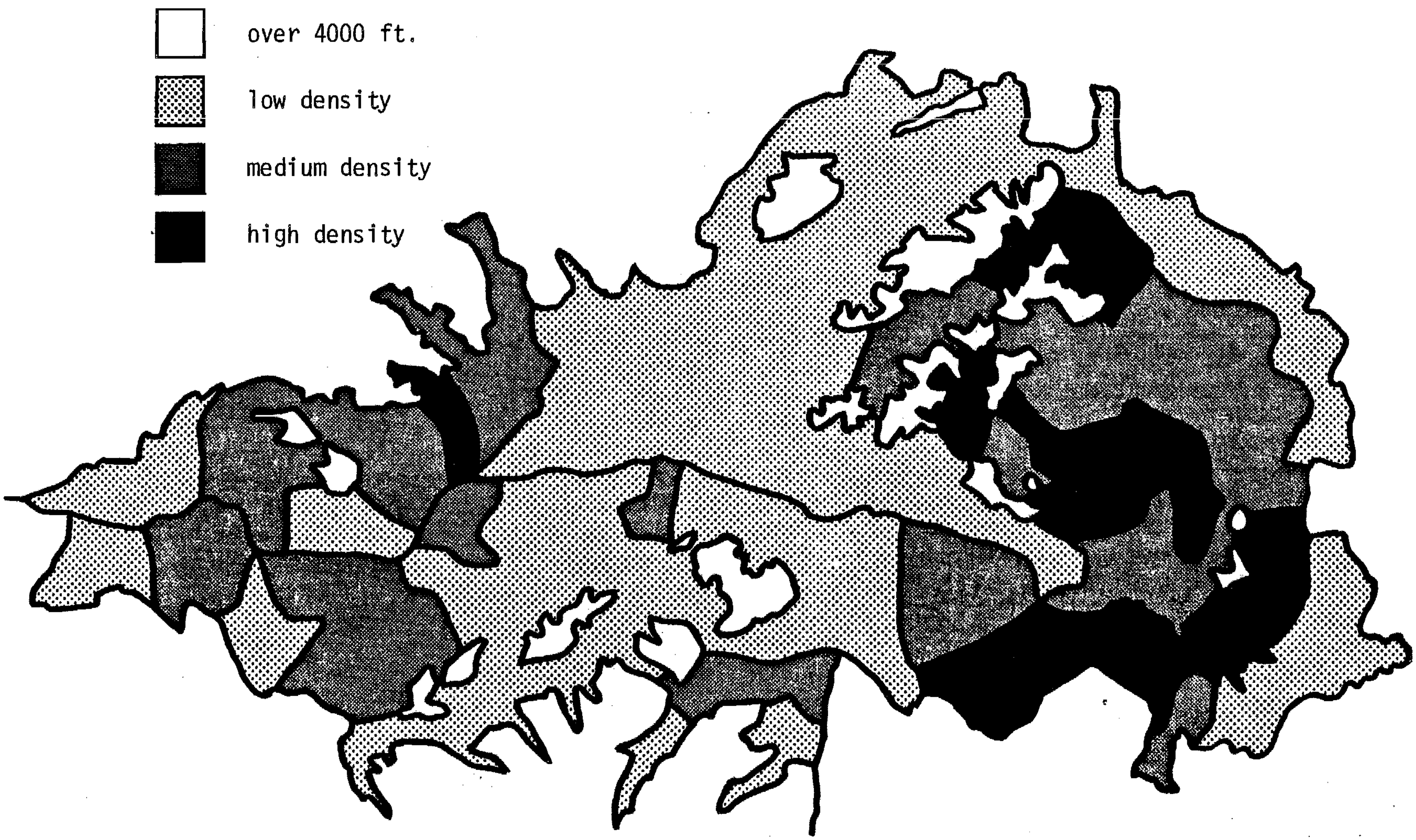

Figure 2. Relative densities of moose as determined from stratification and census flights in November 1980 in the Primary Moose Impact Zone.

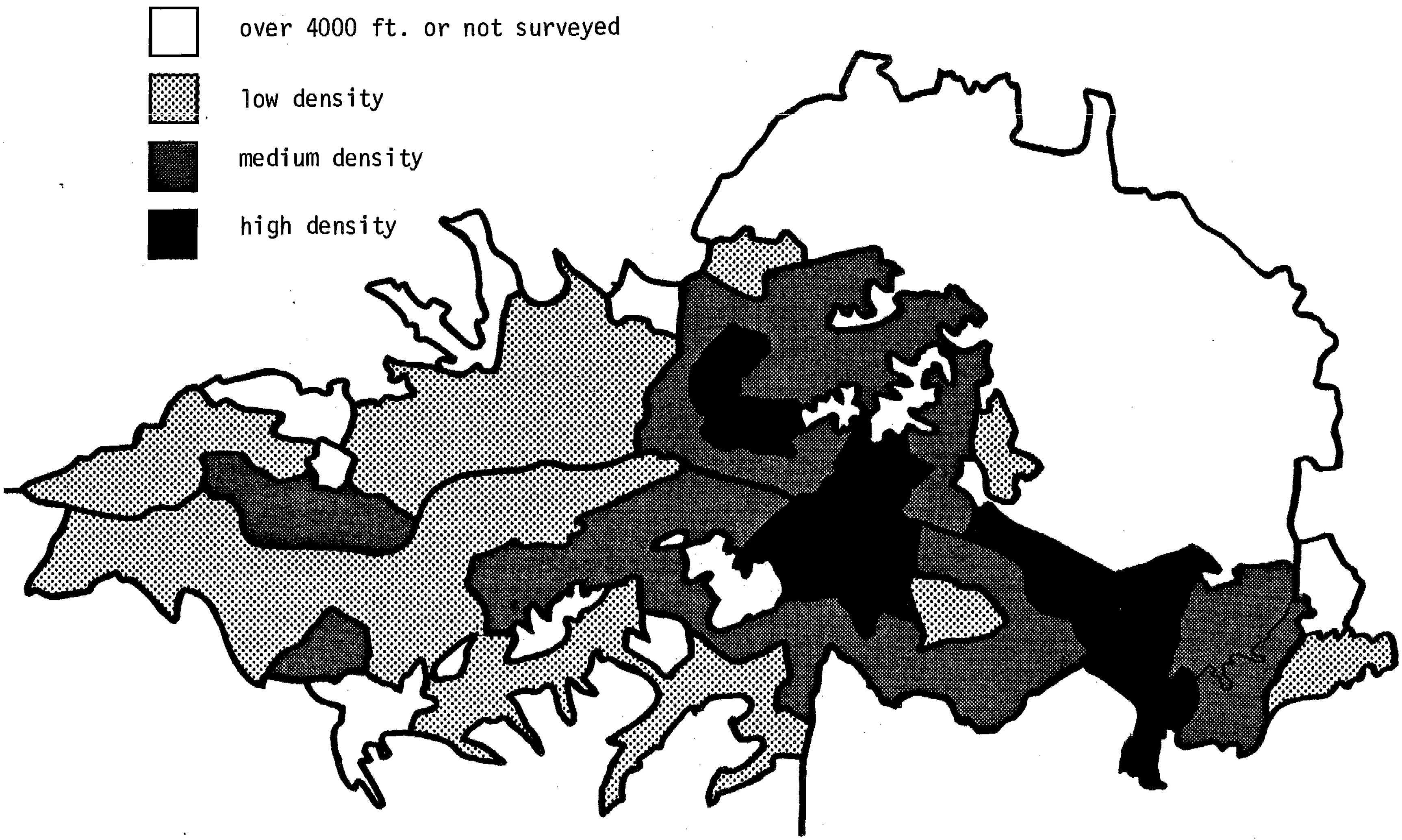

Figure 3. Relative densities of moose as determined from a stratification flight in March 1980 in portions of the Primary Moose Impact Zone.

winter 1980 distribution, and Figures 4 and 5 for comparison of fall 1983 with winter 1985 distributions). Clearly, the greatest distribution shift between fall and winter moose distributions occurs in the Watana Creek-Fog Creek areas, the Watana Lake-Jay Creek areas, and the big bend of the Susitna River. Relatively low densities are found in these areas in fall, with a graphic increase in apparent densities in winter. Overall, the stratified density maps display a shift from high elevations in fall to lower elevations adjacent to the Susitna River in the winter, mimicking the data gathered from telemetry investigations.

Watana Impoundment

On 20 and 21 March 1985, the Watana Impoundment Zone (below 2,200 ft. elevation plus an additional 0.25 mi adjacent area) was counted from a fixed-wing aircraft at a survey intensity of 4.5 min/mi^2. A total of 173 moose was observed. Three subsegments were randomly selected and more intensive searches were conducted. Following these 12.5 min/mi^2 intensive searches, a SCF of 1.703 was calculated (63 divided by 37), yielding a total population estimate of 295 moose (Table 4).

In winters 1981, 1982, 1983, and 1985, similar types of moose counts were conducted within the Watana Impoundment Zone (Table 4). Comparison of annual moose population estimates reveals that late winter use during moderate or mild winters is

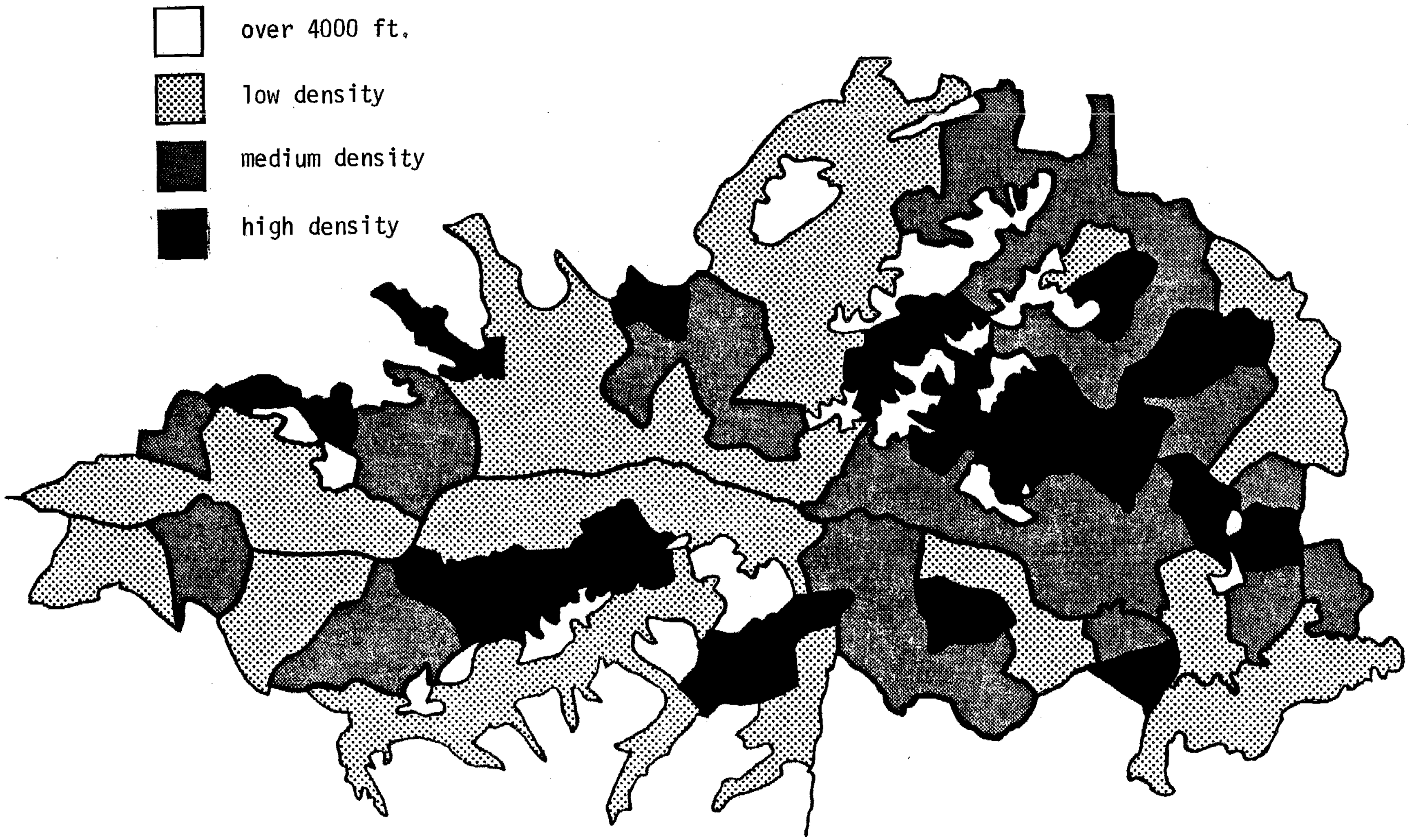

Figure 4. Relative densities of moose as determined from stratification and census flights in November 1983 in the Primary Moose Impact Zone.

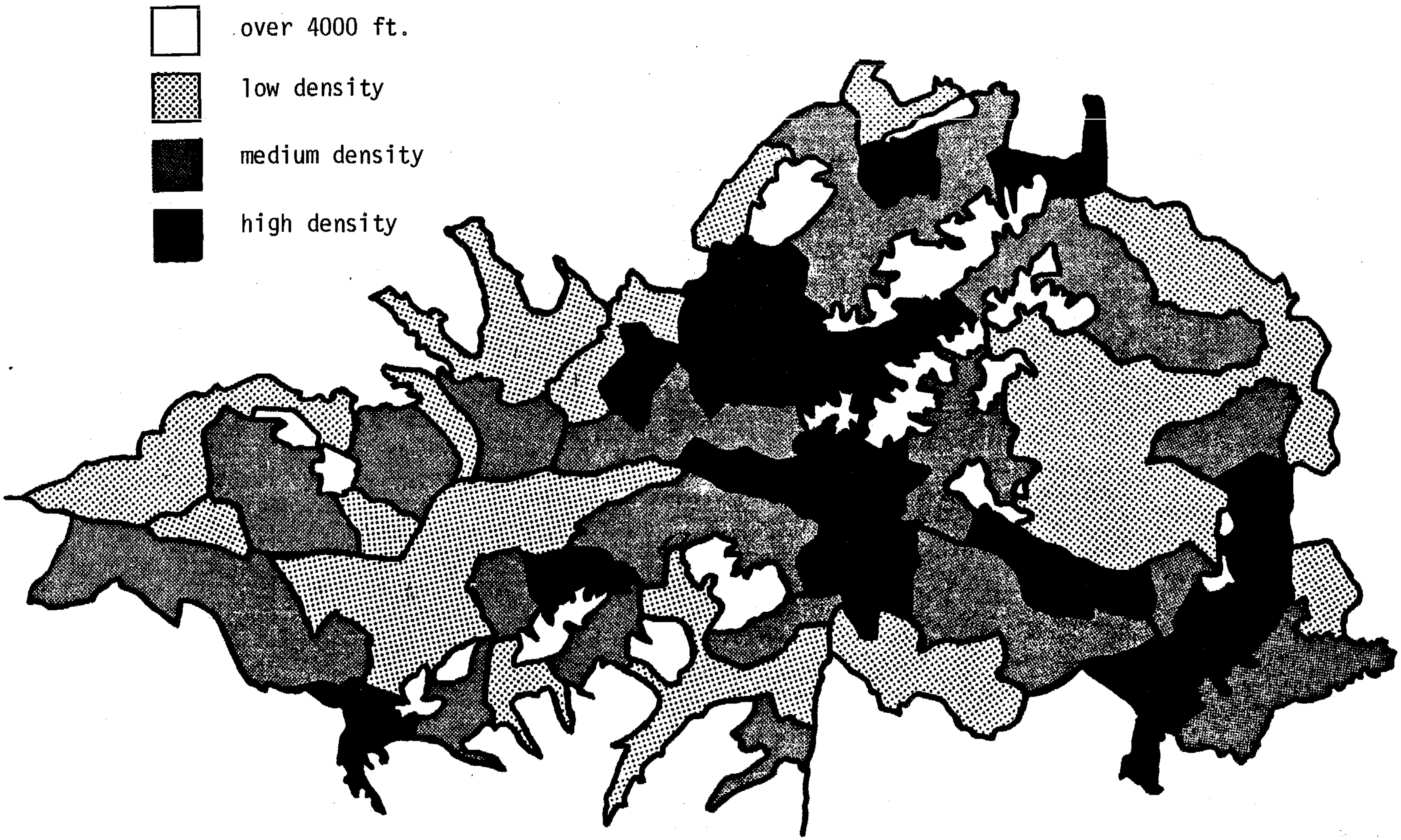

Figure 5. Relative densities of moose as determined from stratification survey in March 1985 in the Primary Moose Impact Zone.

Table 4. Comparison among years of moose counts conducted each March within the Watana Impoundment Zone 1981 through 1985.

Year	Survey time (min.)	No. moose observed	S.C.F.	Estimated no. moose	Estimated moose/mi^2
1981	374	42	1.00 1/	42	0.4
1982	264	174	1.67	290	2.9
1983	396	161	3.600	580	5.9
1984			NO SURVEY		
1985	436	173	1.703	295	3.0

1/ Fewer moose were observed on recount.

highly variable. In 1981, only 42 moose were estimated in the area. In 1982, an estimated 290 moose were within the impoundment zone. Because of the high SCF in 1983, the estimate was doubled to 580 moose. In 1985, the calculated estimate was again down to 295 animals. These data suggest that the numbers of moose within the impoundment zone are subject to high fluctuations, perhaps in response to local snow conditions. Winter moose densities in the impoundment zone during these relatively moderate winters have fluctuated from 0.4 to 6.0 moose/mi^2.

Moose observability in the Watana impoundment zone is low because of large topographical variation and in many cases dense overstory vegetation. As in previous years, count conditions in 1985 were poor because of lack of recent snowfall. However, because telemetry studies have indicated that throughout the year the largest numbers of moose occupy these lower elevations in March, the counts are conducted at that time. The calculated SCFs for the Watana counts are relatively higher than the Alphabet Hills counts and those within other areas because of this low observability. For example, in 1983 only 2 of 7 instrumented moose were observed, partially verifying the high SCF of 3.6. Similarly, in 1985, only 2 of 8 instrumented animals were observed; however, the SCF was much lower (1.7) suggesting that the SCF in

1985 may be low. Based on this gross difference, we assume that our 1985 moose estimate may be somewhat low.

Devil Canyon Impoundment

The Devil Canyon impoundment zone was counted on 21 March 1985 and similar to the Watana impoundment count, survey conditions were poor. Moose observability in the count area was extremely hampered by dense overstory vegetation. In 1983 and 1985, 14 and 16 moose were observed, respectively. Intensive searches of approximately 12 min/mi^2 were conducted, but in 1983, no additional moose were seen. In 1985, an SCF of 1.4 was calculated, yielding an estimate of 22 moose in the area. Table 5 compares Devil Canyon counts conducted during March of 1981, 1983 and 1985. In comparison to the Watana Impoundment Zone, moose densities are very low, yielding estimates from 0.5 to 1.0 moose/mi^2.

Prediction of Severe Winters

In earlier reports based upon observed moose movements, we hypothesized that more moose would utilize the impoundment zones during severe winters when deep snows would force them into lower elevations (Ballard et al. 1982, 1983, 1984). In recent years we proposed a method of determining the relative severity of previous winters (Ballard et al. 1984). However, this method

Table 5. Comparison among years of moose counts conducted each March within the Devil Canyon Impoundment Zone from 1981 through 1985.

Year	Survey time (min.)	No. moose observed	S.C.F.	Estimated no. moose	Estimated moose/mi^2
1981	190	28	1.06	30	1.0
1982	---	---	---	---	---
1983	123	14	1.0	14	.5
1984	NO SURVEY				
1985	166	16	1.40	22	.7

could only be used for graphically presenting the relative severity of any particular winter after that winter occurred. The Winter Severity Index (W.S.I.) was based upon a summary of monthly snow depths from January through March collected by the Soil Conservation Service, (S.C.S.) (Figure 6).

During the winter of 1984-85, we developed a method for predicting relative winter severity in the impoundment area by 1 February rather than waiting until early April. Increased accuracy can be obtained by 1 March. The following is a synopsis of the methodology used for predicting relative winter severity:

I. Four S.C.S. snow stations are used in the analysis. These include Lake Louise, Square Lake, Fog Lakes and Monahan Flats.

II. January Prediction

1. End of month (Jan. 28 to 2 Feb.) snow depths for the four stations are added together and averaged.

2. Based on the previous 22 years' data, a predicted W.S.I. is calculated.

A. Average of January snow depths from four stations x 1.14.

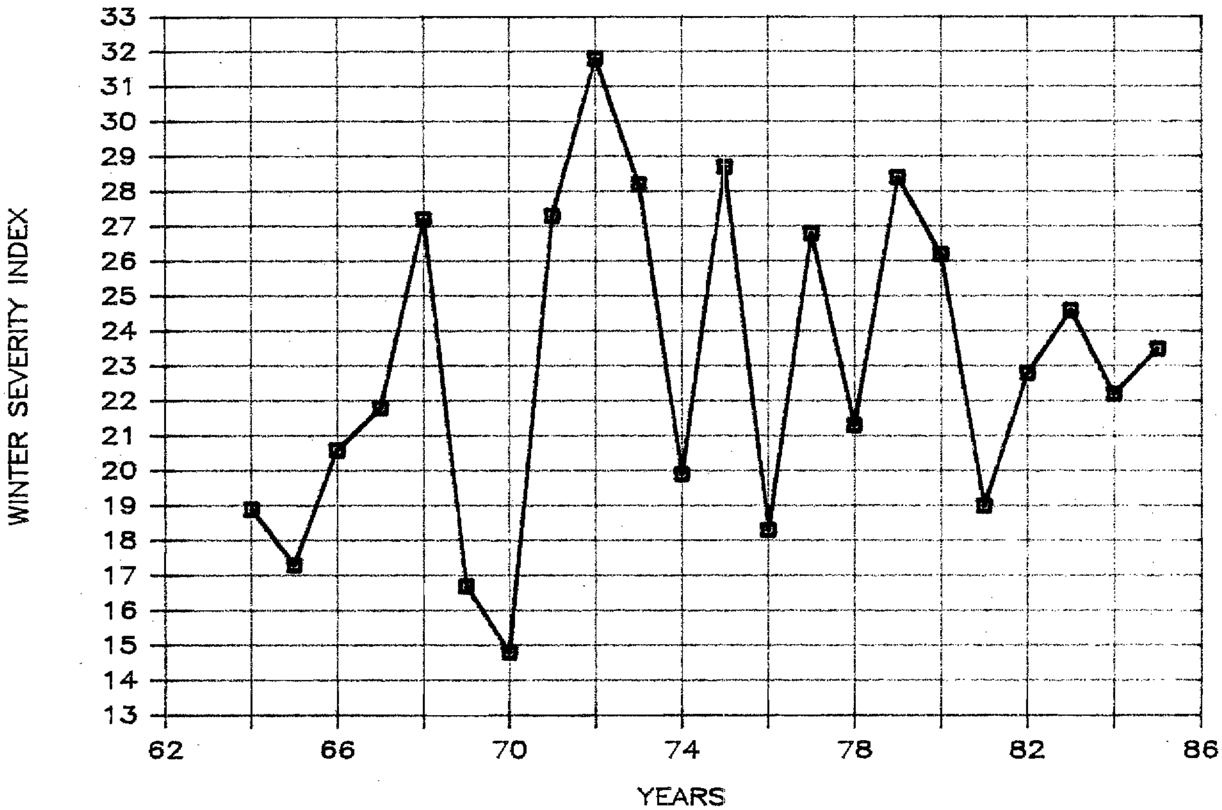

Figure 6. Winter Severity Index (WSI) in the middle Susitna River Basin from 1964 through 1985.

3. 95% confidence limits are placed around that prediction. For example, for winter 1985 the lower limit is 1.14 - 0.04. = 1.10, while the upper limit is 1.14 + 0.04. = 1.18.

III. January - February Prediction.

1. End of month (Jan. 28 - 2 Feb. and Feb. 26 - Mar. 2) are added together and averaged.

2. Based on previous 22 years' data (1964-1985), a predicted W.S.I. is calculated.

   A. Average January and February snow depths from four stations x 1.05.

3. 95% confidence limits are placed around that prediction. For example, in 1985 the lower limit is 1.05 - 0.02 = 1.03, while the upper limit is 1.05 + 0.02 = 1.07.

We have hypothesized that habitat use by moose is different depending upon severity of the winter. To test this hypothesis, monitoring of instrumented moose and winter censuses must be conducted during a severe winter. By 1 February, the winter severity prediction capabilities now enable us to prioritize our monitoring schedule at the onset of a severe winter to better document the different habitat utilization by the moose.

SECTION III. HABITAT USE

Vegetation/Habitat Selection

Use of 19 habitat types by moose which was based on preliminary vegetation maps was presented by Ballard et al. (1984). No further analyses were conducted during this reporting period; however, designs for future analyses were developed and planned for final reports in FY86. Additional moose observations were added to computer files and the final analyses depends upon completion of final vegetation maps and eventual digitization of final results.

Use of Elevations, Slopes and Aspects

Preliminary analyses were presented by Ballard et al. (1984). Moose observations obtained in 1984 and 1985 were added to computer files and no further analyses will occur until the final report.

SECTION IV. MOOSE POPULATION MODELING

Preliminary design of the moose population model which depicts moose population dynamics prior to the project was presented by Ballard et al. (1984). Additional modifications are necessary because of findings described in the next section entitled Section V. - Moose Calf Mortality Studies. Other modifications may become necessary as additional data and analyses dictate. The population model should be viewed as a continuing dynamic process.

SECTION V. MOOSE CALF MORTALITY STUDIES

Introduction

To assess the potential impacts of the proposed project on the dynamics of the study area's moose population, the population was modeled to reflect pre-project conditions (Ballard et al. 1983, 1984). Portions of the data used to estimate moose population parameters were either collected prior to initiation of Susitna investigations in 1980 or were from other areas of GMU-13 and were assumed to represent conditions in the project area. One of these basic assumptions was that black bears constituted an insignificant source of calf moose mortality.

Recently both brown (*Ursus arctos*) and black bears (*Ursus americanus*) have been identified as important predators of moose in North America (Franzmann et al. 1980, Ballard et al. 1981, Ballard and Larsen, in press). Studies in GMU-13 in the late 1970s suggested that brown/grizzly bears were responsible for 79% of calf moose mortalities during summer (Ballard et al. 1981). Black bears were scarce in areas studied earlier.

In 1980, Susitna Hydroelectric Feasibility Studies discovered that a sizable black bear population existed in the middle Susitna Basin (Miller 1984). Therefore, black bears could potentially be a significant source of moose mortality in addition to brown bear and wolf (*Canis lupus*) predation. If correct, the moose population model would have to be altered to properly reflect pre-project conditions. In other areas of North America where bears have been identified as important predators of ungulates, only one bear species was present, or when both have been present, one has been present in low densities (Ballard et al. 1981, Franzmann et al. 1980, Schlegel 1976, Larsen unpub. data). Relative magnitude of predation has been loosely correlated with predator density. Therefore the opportunity existed to investigate the relative importance of three predator species on moose calf survival. Also, if black bears were a significant source of calf moose mortality, it has been hypothesized that the proposed project could result in an increase in calf survival because of increased bear mortality due to flooding of bear dens.

The purpose of this investigation was to determine whether black bear predation on moose calves was as important a mortality factor as was predation by brown bears. We hypothesized that because black bears were more numerous than brown bears, they would be at least equally as important as a moose calf predator.

METHODS

Methods used for collaring and determining causes of calf mortality were identical to those described by Ballard et al. (1979, 1981). Brown bear densities were estimated at 1/41 km^2 according to methods described by Miller and Ballard (1982) while black bear densities were estimated at 1/3.4 km^2 (Miller 1984). Wolf densities averaged 1/361 km^2 (Ballard and Whitman, unpub. data). All calves were collared in the project area between Jay Creek and the mouth of Fog Creek below treeline.

RESULTS AND DISCUSSION

Between 25 May and 1 June 1984, a total of 52 moose calves (29 males and 23 females) ranging in age from 1 to 10 days were captured and radio-collared (Table 6). The observed twinning rate was 63%, which was twice as high as that recorded from 1977 through 1979 (Ballard et al. 1980). Of the 52 collared calves, seven (13.5%) died as a result of capture (Fig. 7). In five of

Table 6. Parameters and fates of 52 instrumented calf moose from the Watana/Susitna study area, 24 May 1984 to 1 November 1984.

Accession Days No.	Date Instru-mented	Collar S.N.	Freq-uency	Sex	Weight (lbs)	Estimated Age (days)	% Marrow Fat	% Hb	PCV	Serum Collected	Calf Sibling Status	Date of Death	Cause of Death	No. Alive
120778	5/26	18912	8.305	F	39	2	11.95	8.7	28	yes	collared twin 120786	5/28	cow rejected	2
120779	5/26	18908	8.265	F	48	3-4	28.22	8.0	24	yes	collared twin 120797	6/02	grizzly	7
120780	5/26	18915	8.334	M	43	--	---	--	--	yes	collared twin 120790	5/29	abandonment	3
120781	5/30	18897	8.095	F	--	5-6	41.78	--	--	no	single calf	6/11	wolf	12
120782	5/27	18916	8.346	M	--	3	---	--	--	no	collared twin 120799	6/18	grizzly	22
120783	5/25	18911	8.296	M	--	2-3	---	--	--	no	with uncollared twin	6/26	unknown	32
120784	5/26	18902	8.185	F	25	1	---	--	--	no	single calf			
120785	5/29	18915	8.334	M	--	1-2	---	--	--	no	single calf	6/08	wolf	10
120786	5/26	18917	8.356	M	41	2	41.90	8.3	27	yes	collared twin 120778	5/31	grizzly	5
120787	5/26	18904	8.205	F	--	--	---	--	--	no	single calf			
120788	5/25	18916	8.346	M	54	7	---	11.5	38	yes	collared twin 120793	5/26	grizzly	1
120789	5/25	18894	8.065	M	30	--	41.44	--	--	no	collared twin 120809	6/07	grizzly	13
120790	5/26	18907	8.255	F	--	--	22.11	--	--	no	collared twin 120780	5/26	cow rejected	0
120791	5/25	18892	8.046	M	29	1-2	---	8.7	30	yes	collared twin 120800	5/25	cow rejected	0
120792	5/26	18899	8.135	F	36	3-4	---	--	--	yes	collared twin 120804	5/27	grizzly	1
120793	5/25	18902	8.185	F	--	7	42.86	--	--	no	collared twin 120788	5/26	drowned1/	1
120794	5/26	18892	8.046	M	40	2	---	--	--	yes	single calf			
120795	5/27	18901	8.175	M	65	6-7	22.55	--	--	no	with uncollared twin	5/29	wolf	2
120796	5/26	18903	8.195	F	44	2	---	8.2	28	yes	with uncollared twin	6/01	black bear	6
120797	5/26	18893	8.055	M	46	3-4	28.64	--	--	no	collared twin 120779	6/02	grizzly	7
120798	5/29	18890	8.025	F	--	3-4	---	--	--	no	with uncollared twin	6/15	grizzly	17
120799	5/27	18896	8.085	M	36	3	9.68	--	--	no	collared twin 120782	5/27	cow rejected	0
120800	5/25	18891	8.036	M	--	1-2	36.47	--	--	yes	collared twin 120791	6/03	grizzly	9
120801	5/28	18912	8.305	F	--	5	13.21	--	--	no	with uncollared twin	5/31	accidental	3
120802	5/27	18888	8.005	M	--	3-4	---	--		no	with uncollared twin			
120803	5/25	18913	8.315	M	33	--	---	9.0	31	yes	collared twin 120805	7/03	abandoned	39
120804	5/26	18890	8.025	F	34	3-4	25.25	7.5	26	yes	collared twin 120792	5/27	grizzly	1
120805	5/25	18889	8.016	F	--	--	32.34	--	--	no	collared twin 120803	6/07	grizzly	13

Table 6. (continued).

Accession No.	Date Instru- mented	Collar S.N.	Frequency	Sex	Weight	Estimated Age (days)	% Marrow Fat	% Hb	PCV	Serum Collected	Calf Sibling Status	Date of Death	Cause of Death	No. Day Alive
120806	5/29	18898	8.105	M	90	8-9	29.98	--	--	no	with uncollared twin	5/30	grizzly	1
120807	5/25	18914	8.325	M	48	4	---	10.5	34	yes	collared twin 120810			
120808	5/30	18901	8.175	F	--	1	19.60	--	--	no	single calf	6/03	grizzly	4
120809	5/25	18898	8.105	M	34	--	8.63	10.0	39	yes	collared twin 120789	5/27	cow rejected	2
120810	5/25	18909	8.276	M	54	4	11.65	10.7	33	yes	collared twin 120807	6/17	black bear	23
120811	5/25	18905	8.215	M	35	1	55.58	11.5	41	yes	collared twin 120819	6/05	grizzly	11
120812	5/25	18906	8.246	M	50	--	26.61	6.5	22	yes	single calf	6/03	grizzly	9
120813	5/25	18888	8.005	M	--	1-2	---	--	--	no	collared twin 120818	5/26	grizzly	1
120814	5/25	18896	8.085	M	--	2-3	23.48	--	--	no	single calf	5/26	drowned	1
120815	5/25	18910	8.285	M	--	--	42.11	--	--	no	single calf	6/21	grizzly	27
120816	5/24	18900	8.145	F	--	3	---	--	--	no	single calf	6/14	black bear	21
120817	5/27	18907	8.255	M	--	--	---	--	--	no	with uncollared twin			
120818	5/25	18901	8.175	M	31	1-2	10.52	--	--	no	collared twin 120813	5/26	grizzly	1
120819	5/25	18897	8.095	M	33	1	11.08	--	--	no	collared twin 120811	5/29	grizzly	4
120820	5/24	18895	8.076	F	--	3	---	--	--	no	single calf			
120821	5/27	18898	8.105	F	--	5-6	24.02	--	--	no	collared twin 120824	5/29	grizzly	2
120822	5/27	18899	8.135	F	--	4-5	20.79	--	--	no	single calf	5/29	black bear	2
120823	5/27	18896	8.085	M	--	5-6	---	--	--	no	single calf	6/04	drowned	8
120824	5/27	18890	8.025	F	--	5-6	27.00	--	--	no	collared twin 120821	5/29	grizzly	2
120825	5/31	18899	8.135	F	--	7-10	---	--	--	no	single calf	6/18	grizzly	18
120826	6/01	18912	8.306	F	--	2	---	--	--	no	collared twin 120827	6/15	grizzly	14
120827	6/01	18917	8.356	M	--	2	16.48	--	--	no	collared twin 120826	6/02	coyote	1
120832	5/30	18899	8.135	F	--	5-7	16.67	--	--	no	with uncollared twin	5/31	grizzly	1
120834	5/30	18898	8.105	F	--	3-4	---	--	--	no	with uncollared twin			

1/ Possibly complicated by either being stepped on by cow or killed by grizzly bear.

seven project-induced mortalities the cow returned to the radio-collared calf and stomped it to death, while the remaining two mortalities the cow did not return and the calves apparently starved. Although the rate of project-induced mortality was similar to that observed in 1977 and 1978 (11.1 and 9.3%, respectively) all of the earlier mortalities were the results of abandonment (Ballard et al. 1979) rather than stomping by the cow. We are unable to explain the reasons for this type of mortality, although it appeared related to odor of the collar and/or the calf from capture.

Of the 52 radio-collared calves, only 15% survived from birth to early November (Fig. 7). The largest source of mortality was due to predation by brown bears. Brown bears killed 46% of the calves, while black bears and wolves killed 8 and 6% of the calves, respectively. All other natural mortality factors such as drowning, coyote, (*Canis latrans*) predation, etc. accounted for approximately 12%. Mortality from all causes was 85%. Excluding project-related mortalities (N = 7), total natural mortality (37 of 45) was 82%.

Timing of natural mortality in 1984 (Fig. 8) was similar to earlier studies with virtually all occurring during the six weeks following birth (Ballard et al. 1981). In earlier studies predation accounted for 86% of the natural mortalities. Predation in this study also accounted for 86% of the mortality. However,

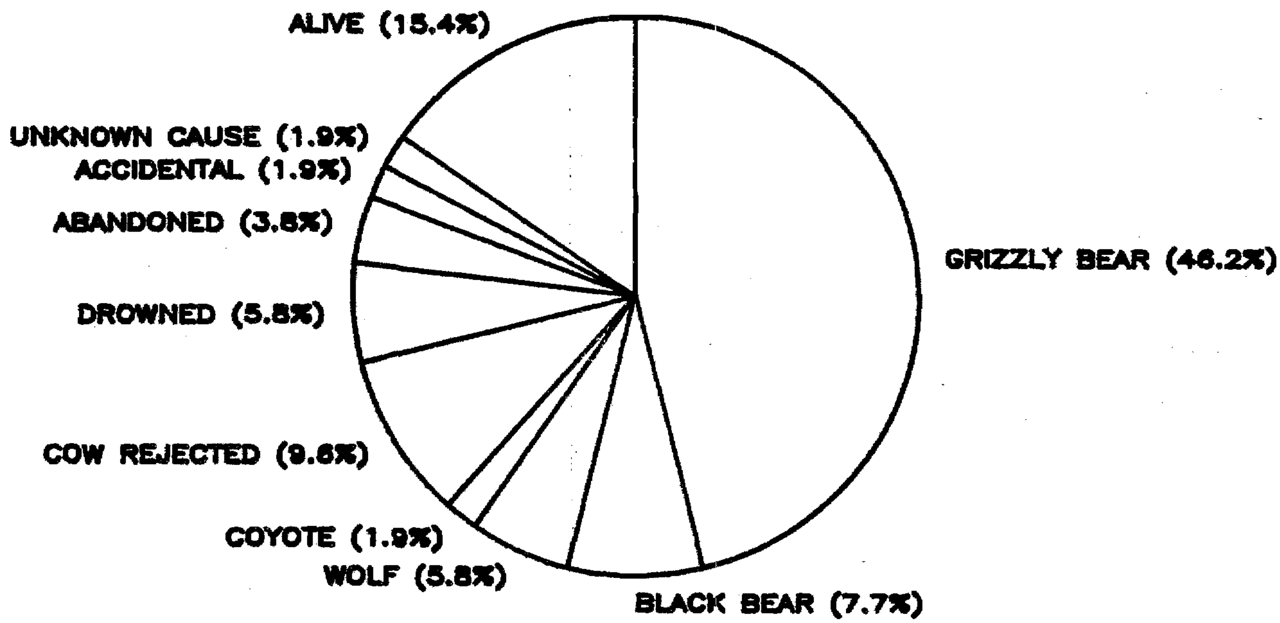

Figure 7. Fates of 52 radio-collared newborn moose calves from late May through early November 1984 along the Susitna River near Watana Creek.

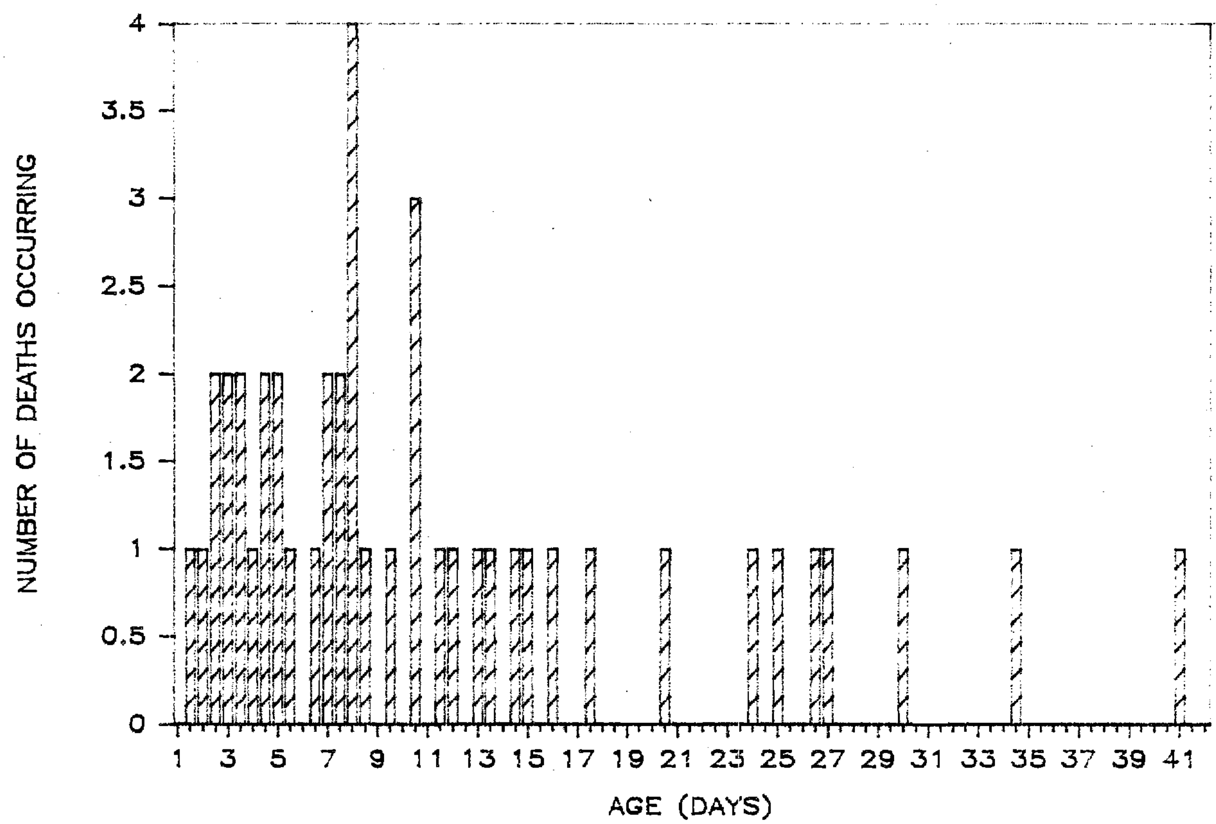

Figure 8. Timing of mortality in relation to estimated calf age for 44 calves dying between 25 May and 15 November 1984 along the Susitna River near Watana Creek.

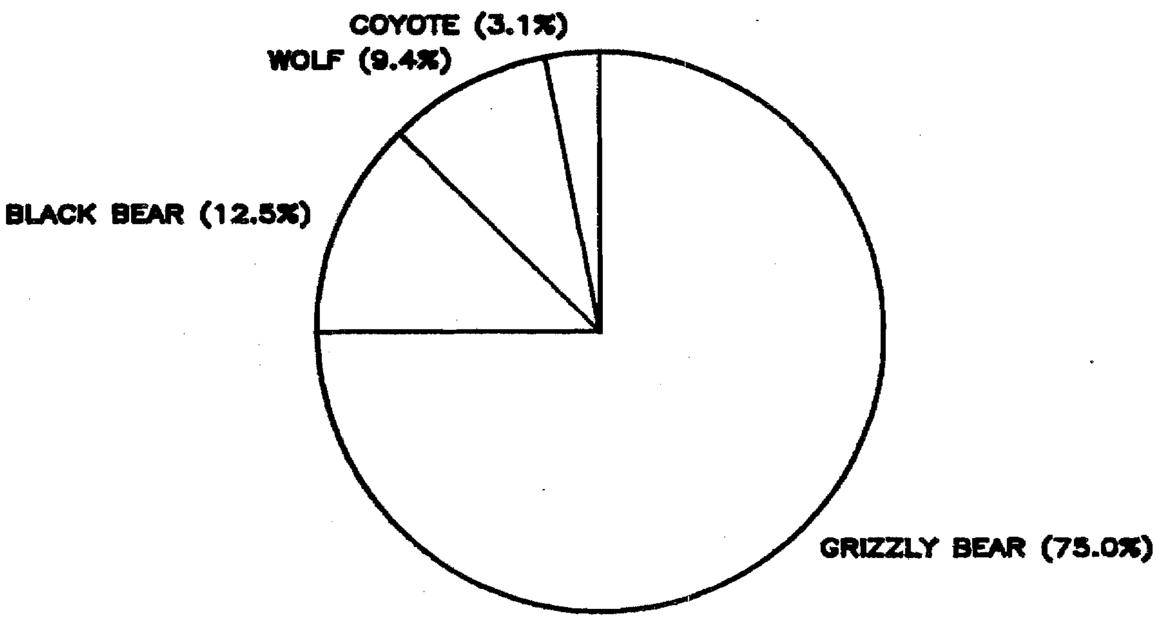

Figure 9. Relative proportion of mortality by predator species of 32 predator-killed moose calves during late spring and summer 1984 along the Susitna River near Watana Creek.

brown bears accounted for 65% of the mortality rather than 79% as in earlier studies where black bears were scarce or in very low density. Of predator-related mortalities, however, brown bear predation continued to be the largest source of predator mortality (Fig. 9, 75% in 1984 vs. 91% in 1977-78). Black bears were the second most important predator followed by wolves.

Based upon this study we reject the original hypothesis that predation by black bears was as important a mortality factor as was brown bear predation. However, because 8% of the calves were killed by black bears, the moose model presented by Ballard et al. (1984) should be slightly modified to reflect the importance of black bear predation in the study area.

SECTION IV. IMPACT MECHANISMS

Preliminary assessment of the types of impacts on moose resulting from development of a two-dam hydroelectric project on the Susitna River were presented by Ballard et al. (1984, 1985).

To aid in guiding the assessment of project impacts, we propose that the following definitions of importance be used for assessing and quantifying impacts:

(1) Important Impacts (I.I.) - Impacts which individually or in summation have high probability that a measurable change in moose population size or productivity will occur as a result of the project according to literature and available evidence.

(2) Potentially Important Impacts (P.I.) - Impacts which individually or in summation have the potential to measurably alter moose population size or productivity as a result of the project, but which either lack sufficient evidence (literature) or may be difficult to quantitatively assess individually.

(3) Not Important Impacts (N.I.) - Impacts which based on available literature and evidence have a low probability of altering moose population size or productivity.

The above definitions should be used for ranking impacts. Their use recognizes that impacts which can alter wildlife population sizes or productivity are most likely to be of importance to consumptive users (e.g., hunters, trappers) and nonconsumptive users (e.g., backpackers, photographers) of wildlife resources and to the management objectives of agencies with jurisdiction over those resources.

Based upon the above definitions of impact, we believe the following types of impacts deserve special recognition. Type of impact is also noted.

Important Impacts:

(I.I.-1) Permanent habitat loss due to the impoundments and other permanent facilities will have an adverse impact on moose populations.

(I.I.-2) Displacement of moose during reservoir filling years and alteration of movements between winter and summer range after project completion could increase predation rates, possibly driving moose populations to low levels which may be maintained there by continued predation. Adverse impact.

(I.I.-3) Open water and/or ice shelving in the impoundments may block access to traditional calving and wintering areas. Adverse impact.

(I.I.-4) Alteration of moose habitat downstream of Devil Canyon will occur due to altered seasonal and annual flow regimes of the Susitna River. Adverse impact.

(I.I.-5) Open water downstream may restrict movements across the river and to island wintering areas, and attempted crossing of open river areas may lead to mortality. Adverse impact.

(I.I.-6) Ice shelving, open water and thin ice during winter, or floating debris will cause a direct mortality to moose attempting to cross the impoundment. Adverse impact.

(I.I.-7) Increase in mortality will occur due to train and automobile collisions caused by increases in traffic levels. Adverse impact.

(I.I.-8) Snow drifts may impede movements south and southwest of the reservoir and reduce the value of the Fog Lakes area as winter range. Adverse impact.

(I.I.-9) Drifted snow along railroad and road access corridors and roadway berms may impede movements of moose and/or subject them to higher risk of collision mortality. Adverse impact.

(I.I.-10) Clearing of vegetation in the impoundment area will reduce carrying capacity prior to filling. Adverse impact.

(I.I.-11) Increases in mortality of moose may occur due to hunting and poaching. Adverse impact.

(I.I.-12) Temporary loss of winter habitat will occur on borrow sites. Adverse impact.

(I.I.-13) Permanent loss and alteration of moose habitat will occur as a result of access corridor construction, maintenance, and use. Adverse impact.

(I.I.-14) Habitat quality for moose will improve along the transmission line corridor because vegetation will be maintained in early successional stages. Beneficial impact.

Potentially Important Impacts:

(P.I.-1) Local climatic changes resulting from the impoundments, including increased summer rainfall, increased winds, cooler summer temperatures, increased early winter snowfall, hoar frost deposition on vegetation in winter, delayed spring plant phenology, and changes in plant species composition, may reduce habitat carrying capacity for moose. Adverse impact.

(P.I.-2) Open and warmer water in downstream areas may alter plant phenology and affect spring forage and cover for moose. Adverse impact.

(P.I.-3) Habitat quality may temporarily decrease near the reservoir as a result of locally high densities of moose dispersing from inundated areas. Adverse impact.

(P.I.-4) Drifting snow from the frozen impoundment surface may preclude use of a band of unknown width of winter browse along the impoundment shore. Adverse impact.

(P.I.-5) Delayed melting of snow drifts in a band of unknown width along both impoundment shores and the transmission corridor may reduce availability of spring forage. Adverse impact.

(P.I.-6) Loss of moose habitat due to erosion of impoundment shores will continue following flooding. Adverse impact.

(P.I.-7) Drifting snow in the transmission line corridor may preclude use of winter browse. Adverse impact.

(P.I.-8) Vegetation icing (hoar frost) downstream may render some browse unavailable and metabolic demands of moose may increase. Adverse impact.

(P.I.-9) Accidental fires resulting from human activities may temporarily renew some moose habitat. Beneficial impact.

Not Important Impacts:

(N.I.-1) Alteration of moose distribution may occur due to corridor traffic and disturbance. Not important.

(N.I.-2) Prior to filling, clearcut areas in the impoundment may inhibit movements due to slash piles and human disturbance. Not important.

(N.I.-3) Impeded drainage caused by road berms may alter moose habitat as a result of flooding of forest or shrubland areas. Not important.

(N.I.-4) Increase in ground-based human activity (road traffic, village activities, dam construction) may preclude use of some areas by moose, particularly sensitive areas such as calving sites and winter habitat. Not important.

(N.I.-5) Increase in aircraft overflights may stress animals or preclude use of some areas. Not important.

(N.I.-6) Increase in disturbance over the entire basin may occur due to increased human recreational activities. Not important.

Table 7 estimates the timing of when identified and potential impact mechanisms are hypothesized to occur as a result of the project. Also included are the general types of monitoring programs which we believe will be necessary to refine predicted impacts to allow adjustment of mitigation efforts. Because of the difficulty of precisely indentifying and measuring the path of individual impact mechanisms, quantification will require in several instances that several mechanisms be combined and measured with a combination of methods providing estimate of loss or benefit. For example, all habitat loss impact mechanisms will be combined and refinement of losses will occur through comparison of pre- and post-impoundment moose censuses.

SECTION VII. MITIGATION

Current investigations have focused on evaluating experimental burning as a method of improving moose habitat for compensation. During the reporting period project personnel have participated in planning procedures aimed at refining needed data for evaluating the potential of certain areas to serve as sites for mitigation of project losses. Table 8 summarizes moose population characteristics of several proposed moose mitigation areas. No further refinement is possible at this time.

Table 7. Preliminary summary of timing of expected impacts of Susitna hydroelectric development on moose and actions and studies necessary to refine magnitudes of impacts.

Impact I.D. #	Predicted dates of occurrence	Predicted dates occurrence first observable	Predicted dates by which maximum impact likely to occur	Actions or monitoring necessary to refine quantifications of impacts
I.I.-1	Construction and operation	1st winter	5 years after initial operation	Replication of 1980 and 1983 moose population census
I.I.-2	Construction and operation	1st winter	5 years after initial operation	Wolf and bear predation rates study, Calf mortality study, Adequate sample of radio-collared adult moose
I.I.-3	Post impoundment	1st winter of fill	10 years after initial fill	Monitor radio-collared adult moose during winter and migration.
I.I.-4	Fill and operation	5 years	25 years	Plant species composition, and browse production studies
I.I.-5	Operation	1st winter	10 years	Monitor radio-collared adult moose
I.I.-6	Fill and operation	Initiation of fill	5 years	Monitor radio-collared adult moose
I.I.-7	Construction and regular use of access routes	1st winter	Continual	Record number and frequency of collisions
I.I.-8	Operation	1st winter of fill	1st severe winter	Monitor radio-collared adult moose

Table 7. (cont'd).

Impact I.D. #	Predicted dates of occurrence	Predicted dates occurrence first observable	Predicted dates by which maximum impact likely to occur	Actions or monitoring necessary to refine quantificatons of impacts
I.I.-9	Construction and use of access routes	1st winter	Continual	Record number and frequency of collisions
I.I.-10	Construction	1st year	Pre-impoundment	Monitor radio-collared adult moose
I.I.-11	Construction and operation	1st year	Continual	Increased law enforcement effort
I.I.-12	Construction	1st year	5 years	Monitor radio-collared adult moose distribution surveys
I.I.-13	Construction and maintenance	1st year	5 years	Replication of 1980 and 1983 moose population census
I.I.-14	Construction and maintenance	3-5 years	Continual	Browse production studies
P.I.-1	Operation	1st winter	10 years	Replication of 1980 and 1983 moose population census
P.I.-2	Operation	1st year	25 years	Browse production studies
P.I.-3	At fill	At initiation of fill	25 years	Monitor radio-collared adult and browse use studies
	Fill and operation	1st winter	1st severe winter	Map snow drifts and monitor radio-collared adult moose

Table 7. (cont'd)

Impact I.D. #	Predicted dates of occurrence	Predicted dates occurrence first observable	Predicted dates by which maximum impact likely to occur	Actions or monitoring necessary to refine quantifications of impacts
P.I.-4	Operation	1st winter	1st severe winter	Map drifts, conduct moose distribution surveys and browse availability studies
P.I.-5	Operation	5 years	10-20 years	Monitor erosion and browse studies
P.I.-6	Operation	1st winter	1st severe winter	Map snow drifts
P.I.-7	Operation	1st winter	20 years	Browse availability study
P.I.-8	Unknown	5 years	25 years	Map burn and if appropriate,

Table 8. Summary of moose population characteristics for proposed mitigation areas for the Susitna Hydroelectric Project.

Area	Is the area a known wintering area?	If so, can boundaries be further defined?	How many moose sub-pop. utilize area?	Population trend	Is moose pop. limited by winter forage during mild winters?	During severe winters?	If not limited by forage, what limits population?
2	Yes	No	One 1/	stable or declining[2]	No[3]	?	Bear & wolf predation 5/
4	Yes	Yes	Two 1/	slowly increasing[2]	No[3]	?	Bear & wolf predation 5/
6	Yes	No	Three 1/	increasing[2]	No[3]	?	Bear & wolf predation 5/
6a	Yes	Yes	Three 1/	increasing[2]	No[3]	?	Bear & wolf predation 5/
7	Yes	Possibly	At least three 1/	slowly increasing[2]	No[3]	Yes 4/	Bear & wolf predation 5/
8	Yes	Yes	?	increasing[2]	?	Yes 4/	Mortality from bear predation is quite high (calf mortality studies)
9	?	?	?	?	?	?	Possibly subjected to heavy levels of bear predation
10	Yes	Yes	At least two 1/	increasing[2]	No[3]	?	Bear & wolf predation 5/
11	Yes	Yes	Several or more 1/	declining[2]	?	?	Possibly subjected to heavy levels of bear predation
12	?	?	?	declining[2]	?	?	Because area supports high bear & wolf numbers may be limited by predation
13	Yes	Possibly	At least three 1/	increasing[2]	No3	?	Probably limited by predation (wolf studies)

1/ Source: Telemetry studies
2/ Source: Moose composition counts
3/ Source: Telemetry and blood serum studies
4/ Source: Yearling mortality studies
5/ Source: Calf mortality and wolf telemetry studies

ACKNOWLEDGEMENTS

Sterling Miller and Dennis McAllister participated in several aspects of the project. Kathleen Adler provided clerical and bookkeeping services. Susan Lawler provided typing support.

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