SUSITNA HYDROELECTRIC PROJECT
1983 ANNUAL REPORT

BIG GAME STUDIES

VOLUME I BIG GAME SUMMARY REPORT

ALASKA DEPARTMENT OF FISH AND GAME

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PREFACE

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

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

This is the second annual report after the final Phase I reports (1982). In some cases, objectives of Phase I were continued to provide a more complete data base. Therefore, this report is not intended as a complete assessment of the impacts of the Susitna Hydroelectric Project on the selected wildlife species.

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

The reports are organized into the following 9 volumes:

Volume I.	Big Game Summary Report
Volume II.	Moose - Downstream
Volume III.	Moose - Upstream
Volume IV.	Caribou
Volume V.	Wolf
Volume VI.	Black Bear and Brown Bear
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DOWNSTREAM MOOSE

Objectives of this study were to determine the probable nature and approximate magnitude of impacts of the proposed Susitna River hydroelectric project on moose (*Alces alces gigas* Miller) in areas along the Susitna River downstream from the prospective Devil Canyon dam site to Cook Inlet. To accomplish this objective, one must thoroughly understand how moose utilize habitats on the Susitna River floodplain.

This report is primarily based on data from relocations of radio-collared moose collected between 15 October 1983 and 6 October 1984, and from supplemental moose censuses and surveys conducted through March 1984, but also includes pertinent findings from the Phase I study progress report (Arneson 1981) and final report (Modafferi 1982) and a Phase II study progress report (Modafferi 1983).

Since magnitude of use of winter range by Susitna River Valley subpopulations of moose is partly related to severity of climatic conditions, findings presented in this report must be considered as preliminary since sampling occurred and data were accumulated during the relatively mild to average winters between 1979 and 1984. Though not severe, the variable nature of weather conditions in the later two winters exhibited the influence snowfall can have on moose behavior and winter use of the Susitna River floodplain, and further substantiated the importance of this concern. The 1982-83 winter was characterized by large amounts of snowfall through December, followed by mild conditions and a recession of snowcover by mid-January. The 1983-84 winter was characterized by an early snowfall, continued extensive accumulations of snowcover through February, and an abrupt amelioration of conditions in early March.

In the mild winter of 1981-82, a maximum of 369 moose were observed in 6 censuses of floodplain habitats. Maxima of 934 and

819 moose were observed in 11 and 7 similar censuses conducted in winters of 1982-83 and 1983-84, respectively. Though within and between year variation in moose use of floodplain habitats were primarily associated with effects of winter weather conditions on moose behavior, possible effects of winter mortality in 1982-83 on subsequent population levels in winter of 1983-84 and of other factors, which historically may affect long term population levels, should not be overlooked.

Data on patterns of movement, habitat use, productivity, survival and identity of moose subpopulations ecologically affiliated with the Susitna River, presented in this report, were primarily synthesized from 3,184 relocations obtained from 10, 29 and 18 moose captured and radio-collared on 17 April 1980, 10-12 March 1981 and 24 February to 10 March 1982, respectively, in floodplain habitats along the Susitna River between Devil Canyon and Cook Inlet and subsequently radio-relocated through 3 October 1983. Five moose initially captured 17 April 1980, were recaptured 27 March 1983 and collared with new radio-transmitters.

Radio-collared moose, were relocated at about biweekly intervals through 16 March 1981 and about 10-day intervals from that time through 3 October 1983. This schedule provided 11, 16, 14, 9, and 9 relocation sites for most individuals monitored during the winter (1 January thru 28 February), calving (10 May thru 17 June), summer (1 July thru 31 August), "hunting season" (1 September thru 30 September) and breeding (14 September thru 15 October) periods, respectively. These data illustrate where impacts to subpopulations of moose which winter on the Susitna River floodplain will be realized during other seasonal periods.

Most data collected from radio-collared individuals were analyzed relative to these periods in moose life history. Variation due to sex of the individual, subpopulation and year were considered in interpretive analyses. Radio-relocations from dates not included in the life history periods above were grouped within spring, summer, autumn and post-breeding transitory intervals.

To assess magnitude of seasonal and regional moose use of riparian habitats along the Susitna River from to Devil Canyon to Cook Inlet radio-relocation data were integrated with information collected on 6, 11 and 7 aerial censuses for moose conducted on the floodplain between 9 December 1981 and 12 April 1982 and between 29 October 1982 and 22 February 1983, and between 17 November 1983 and 15 March 1984, respectively.

During the study period, a maximum of 934 moose were observed on the lower Susitna River floodplain, but other data, which demonstrated that moose do not use the floodplain everyday within a winter and that some moose do not use the floodplain every year, suggested that this value may underestimate the true value by a minimum of 41 percent.

Winter use of the Susitna River floodplain was greatest south of Talkeetna. Highest moose densities were recorded for large island areas near Cook Inlet. Age composition of observed moose appeared related to habitat type; calves were most commonly observed in low relief, relatively open floodplain habitats. For the third consecutive year, female moose north of Talkeetna exhibited an affinity for riparian habitats near the time of parturition. Hypothetical explanations for these observations are provided.

Radio-collared moose north of Talkeetna seldom ranged farther than 8 km from riparian habitats; moose south of Talkeetna commonly ranged farther than 8 km from the Susitna River and relocations up to 40 km from floodplain areas were not uncommon for the later area. Though moose north of Talkeetna did not range far from riparian habitats, some did travel great distances, parallel to the river, during each annual cycle.

Large variation between individuals and sexes within years and within individuals and sexes between years was observed in movements and sizes of ranges for radio-collared moose. Males generally ranged over greater distances and larger areas than females. Though many individual moose were found to range over similar areas throughout three years of study, some individuals continued to add different areas to their annual range each year.

Some data collected from radio-collared individuals suggested that several moose subpopulations which may choose to winter in the foothills of the Talkeetna Mountains, only seek winter range on the Susitna River floodplain when confronted with severe winter conditions in those alpine areas.

To more completely assess the relative importance of Susitna River floodplain habitats (vs. adjacent nonfloodplain habitats) as winter range for moose subpopulations in the Susitna River Valley downstream from Devil Canyon, studies on sites where "natural" vegetation had been altered by activities of man ("disturbed" sites) were intensified. Winter moose surveys were conducted in forested and riparian habitats adjacent to the Susitna River floodplain. These types of studies are of importance since mitigation actions may potentially involve selection and procurement of lands (primarily nonfloodplain) and alteration (enhancement) of habitats on those lands for the benefit of moose populations.

Like the Susitna River floodplain, other riparian areas appeared to be the most heavily used, nonfloodplain, winter range. However, some nonriparian, relatively open mixed forest habitats also appeared to support substantial numbers of wintering moose. Dense extensive homogeneous forest habitats contained few moose. Because of early spring movements of moose from floodplain areas in 1984, it was not known if moose had occupied those habitats all winter. These preliminary observations require further study before nonfloodplain, forested habitats are altered as a mitigation action for moose habitat enhancement.

Very dense concentrations of moose were observed at "disturbed" sites. Data on timing and magnitude of their use by moose is provided and their roles in interacting with Susitna River floodplain winter range and in moose winter ecology are evaluated.

One nonfloodplain alpine area in the southwestern foothills of the Talkeetna Mountains, which contained high densities of wintering moose, was visited to determine what food sources were attracting moose to the area. It was found that moose wintering in this alpine area were "cratering" to feed on rhizomes and immature fronds of ferns. Chemical composition of these nonbrowse food items indicated they contained higher concentrations of essential nutrients and lower concentrations of the less digestible components than apical shoots of browsed willows which occurred in the same area. Ferns may be a critical food item for moose which winter in similar alpine areas.

To understand factors which may limit growth of moose subpopulations associated with the lower Susitna River floodplain, data on productivity and calf survival were collected from radiocollared moose. The latter data when supplemented with information gathered during river censuses indicated that the moose subpopulations studied had very high rates of productivity, the calves probably sustained early summer predation by black bears and that winter weather conditions affected both productivity and calf survival.

Data available on present and historic moose population levels were provided for areas along the Susitna River downstream from Devil Canyon. Similar data must be considered in assessing the <u>potential</u> value of the Susitna River floodplain habitats to moose, since numbers of moose using those habitats are probably relative to moose population levels and the latter can vary over time. Likewise, mitigation plans should not be limited to the present status or use of habitats but more appropriately, they should be based on the potential value of those habitats to moose.

Probable and potential inadequacies of moose sampling effort in this study are listed and discussed.

Preliminary considerations for reviewing, selecting, creating and/or maintaining "enhanced" land areas for the benefit of moose populations are summarized.

An annotated summary of potential impact mechanisms and their associated effects is provided. General mechanisms considered were the following: 1) altered seasonal river flow patterns and loss of annual variation in river flow, 2) altered water temperature, 3) alteration of habitat, 4) increased access, 5) human encroachment, 6) increased railway and vehicular traffic, 7) loss of habitat at impoundment, 8) salt water encroachment at Cook Inlet, 9) altered turbidity and 10) altered ecosystem.

It was recommendated that research studies investigating: 1) moose use of "disturbed" sites; 2) moose subpopulations north of Talkeetna; 3) moose use of nonfloodplain habitats; 4) ecology of floodplain areas where high moose densities occurred; 5) annual variation in moose movements and productivity; and 6) effects of "severe" winter weather conditions on moose use of the Susitna River floodplain, be continued.

UPSTREAM MOOSE

Analyses of movements of 10 adult cow moose radio-collared in a proposed experimental burn area near the Alphabet Hill revealed the presence of 3 subpopulations occupying the area--2 wintering and 1 resident. An estimated 279 and 252 moose occupied the proposed 47,000 acre burn area in 1982 and 1983, respectively.

In fall 1982, 22 adult radio-collared moose within the Susitna Hydroelectric Study area were recaptured and recollared in an effort to continue movement and habitat use studies during Phase II. Home range sizes and movements of moose during the reporting period were presented. During 1982, 20 radio-collared moose crossed the Susitna River in the vicinity of the impoundments a minimum of 42 occasions. Forty-nine percent of the crossings were initiated during the months of January, February, May and September.

Based upon locations of radio-collared moose which utilize the impoundment, boundaries of impact zones were delineated. Zones were classified as primary, secondary, and tertiary. The primary zone included radio-collared moose which would be directly impacted by the project, while the secondary and tertiary zones were comprised of moose home ranges which overlapped those in the primary zone. Population estimates based on earlier censuses ranged from approximately 1,900 to 2,600 moose which could be directly impacted by the project. A census of the area in fall 1983 provided a moose population estimate of 2,836 ± 301. Moose occupied the impoundment areas more during the months of March-May than other time periods. Two hundred and ninety, and 580 moose were estimated to inhabit the Watana impoundment area in spring 1982 and 1983, respectively. Moose usage of the Watana Impoundment zone was greatest during the month of March.

Habitat use of radio-collared moose was assessed by overlapping moose locations on preliminary vegetation maps. In relation to availability, moose preferred woodland black spruce, open black spruce, closed mixed forest, and woodland white spruce types. Lakes, rock, sedge-grass tundra, sedge-shrub tundra and mat-cushion tundra were not preferred.

For the Watana impoundment area on a year-round basis, elevations ranging from 2001-2200 and 2401-3000 ft. were used more by radio-collared moose while elevations ranging from 1201-1400 and in excess of 3200 ft. were used significantly less, in relation to availability. During winter and spring, elevations ranging from 1601-2000 and 2201-2800 ft. were used more than expected. Use of slopes and aspects were not random.

During the reporting period a moose population dynamics model was developed and tested in an effort to predict population trends under preproject conditions. Components of the preliminary model are presented and discussed. Comparison of projected moose population estimates based on modeling to those based on a 1983 census suggest that the model adequately represents moose populations dynamics under pre-project conditions. Eventually the model will be used to test hypotheses concerning the impacts of Susitna Hydroelectric development on moose.

A summary of project impacts on moose and ways they may affect basic population parameters are presented.

SECTION I. PROPOSED EXPERIMENTAL BURN

Preliminary movement analyses from 10 radio-collared moose suggest that 3 separate populations utilize the proposed burn area; (1) one population winters in the area and spends summer and early fall north of the Alphabet Hills and the Denali Highway; (2) another subpopulation also winters in the area but migrates to the Oshetna River area where they remain through spring, summer, and fall; and (3) The area is also inhabited by a year-round resident population.

During the 1982 census, a total of 167 moose in 139 mi^2 were counted. These were observed from fixed-wing aircraft at an intensity of 5.2 min./mi^2. Based upon an intensive resurvey of 1 area which was randomly selected, we estimated that approximately 40% of the moose present had not been counted. Therefore, the corrected March preburn moose population estimate in 1982 was 279 moose for a total density of 2.0 moose/mi^2. Results of the 1983 census (196 moose observed) produced comparable total estimates: 279 moose in 1982 and 252 in 1983. Although more moose were actually observed in 1983 than in 1982, the 1983 sightability correction factor was much lower (1.29 in 1983 versus 1.67 in 1982).

SECTION II. HOME RANGE, DISTRIBUTION AND MOVEMENTS OF MOOSE

ZONE OF IMPACT

Radio-collared moose which either seasonally or on a year-round basis occupy areas to be directly altered by operation and maintenance of both the Watana and Devil Canyon Impoundments were used to delineate an area where moose would be directly impacted. Home range polygons were determined for each moose which utilizes either the impoundment or its facilities, and the outermost borders of all polygons were used to delineate the border of the primary impact zone (Fig. 1). Home range polygons were computed by connecting outermost point locations (Mohr 1947) and only for those moose which had an excess of 4 location points. Similarly, secondary and tertiary zones of impact were determined by using the outer edges of moose home range polygons which overlap moose which will be directly impacted. The latter two zones were delineated on the assumption that moose displaced from the primary zone will compete with moose occupying the secondary and tertiary zones.

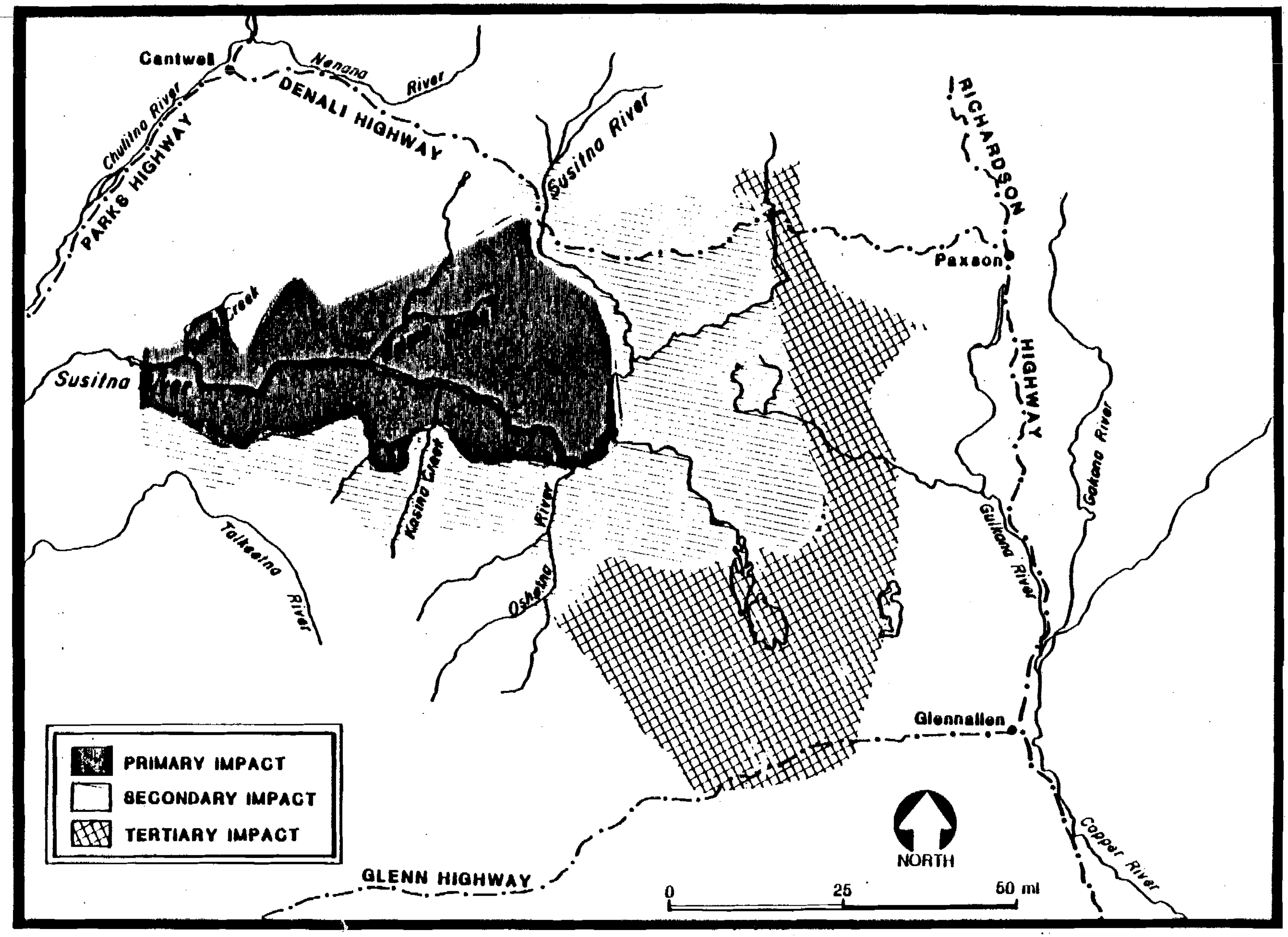

Figure 1. Boundaries of primary, secondary and tertiary zones of impact for the Susitna Hydroelectric Project based upon movements of radio-collared moose from 1976–1982 in Game Management Unit 13 of southcentral Alaska.

The primary impact zone was censused in fall 1983 using quadrant sampling techniques (Gasaway *et al*. 1982) in an effort to refine earlier moose population estimates. Boundaries of individual sample areas were identical to those used during the fall 1980 census and therefore the area censused did not conform exactly to the boundaries of the impact zone which were based on movements of radio-collared moose. Table 6 of the report summarizes the results of the fall 1983 census of the primary moose impact zone. Average moose densities in the area ranged from 0.6 moose/mi^2 in low density stratum to 3.5 moose/mi^2 in high density areas. The total fall population was estimated at 2,836 ± 301 moose.

Table 7 of the report compares 4 separate population estimates (3 based on 1980 census data and 1 based on 1983 census data) of the numbers of moose occupying the primary impact zone. The first method was similar to the preliminary analysis provided by Ballard *et al*. (1982). The proportion of radio-collared moose occurring within the impoundment zone was compared to the total number of radio-collared moose within the 1980 census boundary and was then extrapolated to the total population estimate. Although such an estimate (1,913 moose) could have potentially been biased because of capture location, over half of the radio-collared moose included in the method were captured for other studies, and thus were located away from the project area. Therefore, any biases should have been minimized. Method 2 applied the average moose density estimate derived from censusing moose count areas 7 and 14 during fall 1980 (see Ballard *et al*. 1982) to the amount of moose habitat contained within the primary zone. Method 3 utilized the actual count area boundaries used for the 1980 census. Each count area had been stratified into one of 4 moose densities (none, low, medium, and high) and its area had been determined. The moose density estimates for each stratum in 1980 were then applied to the amount of each type occurring within the primary zone. Method 4 consisted of the actual 1983 census estimate.

The most recent census provided the largest estimate of moose occupying the impact zone. This was not particularly surprising since moose modeling exercises (see Moose Population Modeling) suggest the moose population has increased since 1980. Also, the earlier estimates were based on extrapolations of 1980 census data and not direct counts of the area.

Using methods similar to those of method #2 we have estimated that there are approximately 23,000 moose in GMU-13. Therefore, over 10% of the moose in the Unit could be directly affected by the proposal project.

WINTER USE OF THE IMPACT ZONE

Winter locations of moose found within the impact zone were used to delineate the approximate boundaries of an area which should be intensively censused during severe winter conditions in future years.

Because moose appeared to concentrate in the Watana impoundment area during March in both 1982 and 1983, an attempt was made to census the Watana impoundment area out to 1/4 mile from the 2,200 ft. high pool level. The 1982 census was conducted on 25 March and the 1983 census was conducted on 28 March. Conditions for both censuses were poor due to complete but old snow cover, overcast light conditions, and moderate air turbulence. No census was conducted in the Devil Canyon area during 1982.

Watana Impoundment

A total of 4.4 (2.73 min/mi^2) and 6.6 (4.09 min/mi^2) hours were spent surveying 96.8 mi^2 of habitat (river water area excluded) in the proposed Watana Impoundment area during 1982 and 1983, respectively. A sightability correction factor obtained from censusing the proposed Alphabet Hills burn area in 1982 was utilized which resulted in a population estimate of 290 moose in 1982. The latter estimate was 7 times greater than the number of moose which were estimated within the same area in March 1981 (Ballard *et al.* 1982). However, in 1983 3.4 mi^2 of the Impoundment area was randomly selected and recensused at an intensity of 12 minutes/mi^2 in an effort to estimate the number of moose missed during the less intensive survey. The more intensive search research resulted in a sightability correction factor of 2.6 which when applied to the numbers of moose observed during the less intensive count (161 moose) provided a total 1983 population estimate of 580 moose. The relatively high correction factor in 1983 was also substantiated by our observing only 2 of 7 radio-collared moose known to be present in the impoundment area during the count.

From 14 February through 24 May 1983, 30 radio-collared moose which have a history of utilizing the impoundment areas during some portions of the year (Ballard *et al.* 1982) were located twice weekly to determine habitat use and to estimate the proportion of time these moose utilized the area to be inundated. By 25 January 1983, 20% of the intensively monitored moose were in the impoundments. Use of the impoundment areas increased in March when approximately one-third of the intensively monitored moose were in the impoundment zone. Use declined after March and by mid-May only 7-10% of the moose were located within the impoundment.

Annual moose usage by month of the Watana impoundment zone from 1981-1983 is depicted in Figure 5 of the report. During March of each year, 33 to 48% of the locations of radio-collared moose were in areas which would be inundated by the Watana impoundment.

Devil Canyon Impoundment

On 31 March 1983, a total of 2.1 hours (4.1 min/mi^2) was spent censusing a 30 mi^2 area within ¼ of the high pool level of the Devil Canyon Impoundment. A total of 14 moose were observed. A 1.7 mi^2 area was recounted at an intensity of 12.4 min/mi^2 in an effort to generate a sightability correction factor. No additional moose were recounted, however only 1 of 2 radio-collared moose known to be within the area was observed during the less intensive count. Even if half the moose were missed however, the counts indicate that the Devil Canyon Impoundment area is poorer moose habitat than that found in the Watana Impoundment. Only 2 moose were observed in a similar census of the area in March 1981 (Ballard *et al*. 1982).

SECTION III. USE OF HABITATS, ELEVATIONS, SLOPES AND ASPECTS

Based on a preliminary assessment, the following habitat types were preferred in relation to their availability by moose both year-round and in spring: woodland black spruce, open black spruce, closed mixed forest and woodland white spruce. Willow habitat types were preferred when ecotones were included but were not selected out of proportion to their availability when ecotones were excluded. During spring, willow habitat types were used proportionally less than their availability. Also, low shrub habitat types were used year-round in excess of their availability when ecotone areas were excluded. Lakes, rock, sedge-grass tundra, sedge-shrub tundra, and mat-cushion tundra were generally used less than expected based upon their availability. Generally, the remaining vegetation types not listed above were used in proportion to their abundance. Because corrected updated vegetation maps are currently in preparation and only moose locations obtained from April 1980 to September 1981 were included, all conclusions based upon this analysis are preliminary.

There was considerable variation in the monthly and annual elevations occupied by radio-collared moose in the primary impact zone. Generally, moose in the project area move to higher elevations in October, presumably to breed, and then depending on snow conditions, begin moving downward reaching the lowest elevations occupied during the year from January through May. Moose appear to be driven to lower elevations in winter by heavy snowfall; however, we suspect that in average or mild winters, temperature inversions and high winds make foraging and traveling easier at higher elevations. Consequently, moose may occupy relatively high areas in winter and spring depending on snow depths, temperatures, and other factors. Moose occupy lower elevations in late spring and early summer during calving. This may be related to earlier snow melt, earlier growth of spring forage, and perhaps increased cover requirements during calving.

The monthly importance of elevations at or below 2,300 ft. to moose within the primary impact zone was quite variable between years except during winter and spring months. Use during at least 1 month each winter and spring exceeded 30% of the locations. As expected, use of the impoundment zone by moose was lowest during the months of October through December. Overall, 21.4% of all moose locations collected from October 1976 through May 1982 were at or less than 2,300 ft. elevation.

Watana Impoundment

Elevations ranging from 2,001-2,200 and 2,401-3,000 ft. within the primary impact zone of the Watana impoundment were used more than expected ($P < 0.05$) based upon availability, while elevations from 1,201-1,400 ft. and in excess of 3,204 ft. were used less ($P < 0.05$) than expected. Elevations ranging from 1,401-2,000, 2,201-2,400, and 3,001-3,200 ft. were used in proportion to their availability ($P > 0.05$). During winter and spring, elevations ranging from 1,601-2,000, and 2,201-2,800 ft. were used more than expected ($P < 0.05$), reflecting the downward movement of moose during these seasons. Elevations in excess of 3,001 ft. were used less than expected ($P < 0.05$) during winter and spring seasons.

Similarly, slope usage by moose was not random ($P < 0.05$), X^2 = 24.5). Flat slopes were used less than expected ($P < 0.05$) while moderate slopes were used more than expected ($P < 0.05$), both year-round and from January to May. Gentle slopes were used in proportion to their availability.

South slopes were used more than expected ($X^2 = 21.65$, $P < 0.05$) while flat slopes were used less than expected ($X^2 = 22.9$, $P < 0.05$). All other aspect categories were used in proportion to their availability ($P > 0.05$). A similar situation also existed during winter and spring months ($X^2 = 63.97$, $P < 0.005$) except that southwest slopes were used more than expected ($P < 0.05$, X^2 = 4.05).

<u>Devil Canyon</u>

Elevations ranging from 1,601 to 2,400 ft. were used relatively more by moose both year-round and during January to May ($P < 0.05$), while those in excess of 2,800 ft were used either significantly less than expected ($P < 0.05$) or in proportion to their occurrence. However, area with elevations to be inundated by the Devil Canyon impoundment were used in proportion to their availability.

Moose occupying the Devil Canyon area used both south and south-west facing slopes more than expected ($P < 0.05$) based upon availability. North facing slopes were used less than expected ($P < 0.05$), while all other slope categories were used in proportion to their occurrence.

Both year-round and during January to May flat slopes were used less than expected (P ‘0.05) while moderate slopes were used more than expected (P ‘0.05). During January to May gentle slopes were used in proportion to their occurrence (P ‘0.05), but year-round they were used more than expected (P ‘0.05).

SECTION IV. MOOSE POPULATION MODELING

In an attempt to identify additional mechanisms of project impact and to quantify impacts previously identified by Ballard *et al.* (1982), a multidisciplinary model is currently being developed for moose. This segment of the report presents our progress in developing a satisfactory moose population model for pre-project conditions. Because longer, more intense moose population studies to assess the impacts of predation on moose were previously conducted in an adjacent portion of GMU 13 (Ballard *et al.* 1981 a,b), that area was used as the basis for this particular model. Boundaries of the area were previously described by Ballard *et al.* (1981a). Briefly, the boundaries are the Alaska Range on the north, Brushkana and Deadman Creeks on the west, Susitna River on the south and the Maclaren River on the east. Although this area extends beyond the impact zones, we believe that the biological characteristics of the area are representative of the project area. Also, an attempt was made to model the entire GMU 13 moose population as well, in an effort to provide a comparison to the Susitna model and allow assessment of the percentage of the GMU 13 moose population to be impacted by the project. Both models will be published elsewhere (Ballard *et al.* In Prep.).

These population models start with an estimate of population size, and sex and age structure, and proceed through an annual cycle of reproduction and mortality factors. Population estimates are calculated for each year at calving and subsequently the population declines as mortality factors act on the population.

SECTION V. IMPACT MECHANISMS

Table 1 summarizes the major structural features associated with the construction and operation of the Susitna Hydroelectric Project and a description of their potential impact on moose. In an effort to assess the effects of these impacts on moose, they were related to the basic components of the moose model described in the report. Based upon this assessment, the proposed project will affect the population dynamics of upper Susitna moose and their predators. The exact magnitude of these effects, however, will require refinement as studies proceed and actual operation is commenced. Earlier (see section on Zone of Impact) we estimated that based upon numbers of radio-collared moose utilizing the impoundment areas in relation to the 1980 census, from 1900 to 2600 moose could be directly impacted by construction and operation of the Watana and Devil Canyon impoundments. These estimates comprised 8 to 11% of the total numbers of moose occurring in GMU-13. Including moose which could be secondarily impacted by the project through increased competition from displaced moose, etc., approximately 45% of the GMU-13 moose population could be affected to varying degrees by the proposed projects. Moose modeling efforts currently underway will be adapted to incorporate anticipated effects of the project on the individual components of the moose population.

SECTION VI. MITIGATION

Current investigation is focused on an experimental burn to improve moose habitat described in Section I.

Table 1. Susitna Hydroelectric Project actions and their potential effect on moose numbers, distribution and habitat in the Susitna River Area.

Project Action	Environmental Effect
Construction and operation of dams (staging zone, camps, and structures)	Loss of winter range. Avoidance of adjacent winter range. Loss of spring-summer range. Avoidance of spring-summer range. Possible impedence to migration.
Spoil sites	Temporary loss of winter-summer range. Temporary avoidance of adjacent habitat.
Borrow areas	Permanent and temporary loss of winter habitat. Permanent and temporary loss of spring-summer habitat. Temporary avoidance of habitat.
Reservoir clearing	Loss of habitat. Temporary avoidance of adjacent areas.
Permanent village facilities	Loss of habitat. Avoidance of adjacent areas.
Main and accessory roads and railroads.	Loss of habitat. Permanent and temporary avoidance (disturbance) of adjacent habitat. Mortality from collisions. Increased human-related mortality (hunting, defense of life, etc.).
Airstrips	Increased commercial and recreational development on adjacent lands. Loss of habitat. Temporary avoidance (disturbance) of adjacent areas. Increased human access and human-related mortality.
Transmission line construction, access and operation	Temporary avoidance of habitat. Increased access. Temporary loss of habitat. Eventual summer habitat improvement. Potential for increased commercial and recreational development
Fill and operation of impoundments	Permanent inundation of winter range. Permanent inundation of spring-summer range. Increased snow depths on adjacent area. Increased snow drifting on adjacent areas. Icing on vegetation due to open water. Impedence of movements due to open water during subfreezing temperatures. Increased mortality from attempting to cross thin ice. Impedence of movements and increased mortality due to ice shelving. Increased mortality crossing mud flats. Unstable slopes causing habitat loss. Crowding on adjacent habitat. Increased human access. Decreased vegetation productivity on adjacent lands due to climatic changes.

CARIBOU

The Nelchina caribou herd, found primarily in the large basin formed by the upper drainages of the Susitna and Copper Rivers, and surrounded by four mountain ranges, the Wrangell Mountains, the Talkeetna Mountains, the Alaska Range and the Chugach Mountains, has been an important wildlife resource because of its size and proximity to the majority of the state's human population. Between 1954 and 1983 in excess of 100,000 caribou were harvested from this herd. In 1983, 9,715 people applied for 1,750 permits to hunt for Nelchina caribou.

Plans to construct a large hydroelectric project on the Susitna River within the western reaches of the Nelchina caribou range have raised concerns about impacts of the development on this important caribou herd. Impact studies were started in early 1980 and a comprehensive report on the results published in March 1982 (Pitcher 1982). Considerable background material was also presented in that report; primarily historical range use, movement patterns and population levels. In April 1983, a progress report was distributed updating research results (Pitcher 1983). Following is a summary of background material, methodology, results, possible impacts and recommendations from that report.

> Plans to construct a large hydroelectric project on the Susitna River within the western portion of the Nelchina caribou range have raised concerns about the welfare of this important caribou herd. Impact studies, which began in early 1980, continue with the basic objectives of monitoring herd status, determining range use and migratory routes and delineating subherds. The results of these studies are being used to evaluate potential impacts of project construction, to make recommendations to minimize adverse impacts and to evaluate mitigation measures. Extensive use of historical records of the Nelchina herd has been made in the analyses because of the changeable nature of caribou movement patterns.

During the winters of 1980-81 and 1981-82, the main Nelchina herd wintered primarily on the northeastern Lake Louise Flat eastward through the middle portion of the Gakona and Chistochina River drainages to Slana.

During spring migration females moved across the Lake Louise Flat onto the calving grounds in the eastern Talkeetna Mountains on a broad front from Lone Butte to Kosina Creek. Significant numbers of female caribou (probably over 50% in 1982) passed through the upper Watana impoundment area enroute to the calving grounds. Most males remained on winter range during this period.

Calving occurred primarily in drainages of Kosina Creek although some occurred along Goose Creek and the lower reaches of the Black and Oshetna Rivers. Nelchina bulls were found scattered throughout the Nelchina range during this time mostly in transit to summer range.

Summer range for Nelchina females was the northern and eastern slopes of the Talkeetna Mountains. Bulls were scattered in "bull pastures" throughout the high country of the Nelchina range.

During autumn considerable dispersal occurred from the Talkeetna Mountains across the Lake Louise Flat. In 1982, perhaps 10% of the female segment crossed the Susitna River and moved onto the Jay Creek-Coal Creek plateau.

During the rut the herd appeared to be well mixed and moved eastward across the Lake Louise Flat. In mid-October 1982 about 10% of the herd crossed the Susitna River in the area of Watana Creek, migrated across the Jay Creek-Coal Creek plateau and moved eastward to winter range.

Historically, Nelchina caribou have used the same calving grounds however considerable variation in summer and winter range use has been noted. Migratory routes, although somewhat traditional, have varied depending on the geographic relationship of the calving grounds to summer and winter ranges.

The Nelchina herd was estimated to contain 18,713 caribou in October 1980, 20,730 in 1981 and 21,162 in 1982. Herd composition in October 1982 was estimated at 47.7% females ≥1 year, 26.5% males ≥1 year and 25.8% calves.

Calf survival from birth to 10.5 months of age was estimated at 0.58. Average annual survival for caribou ≥1 year was estimated at 0.88 for females and 0.92 for males (0.89 sexes combined). Reported hunter kill of Nelchina caribou for the 1981-82 regulatory year was 863 animals.

Observations of radio-collared (and non-collared) caribou indicated the existence of a discrete subherd resident in the upper drainages of the Susitna, Nenana and Chulitna Rivers (upper Susitna-Nenana subherd). Although overlap with animals from the main Nelchina herd occurred during winter, summer and fall, females were separated during calving. An initial census (direct count) of this subherd was attempted in October 1982 and 2,077 caribou were counted. Complications in evaluating the count resulting from delays from weather and movement of mainherd animals through the area make it desirable to repeat the census.

It is apparent, even though the massive crossings of the Susitna River in the area of Watana Creek have not occurred in recent years, that significant numbers of Nelchina caribou migrate through the upper portion of the proposed Watana impoundment. This occurs during both spring and fall. While it is not possible to predict the impacts of the Watana impoundment on migrating caribou it does appear that the greatest potential for deleterious impacts occurs during spring migration to the calving grounds. Pregnant females are often in the poorest condition of the year at this time and might be particularly vulnerable to an extended migration or a hazardous reservoir crossing. The proposed Denali access road passes through the range of the upper Susitna-Nenana subherd and historical summer and winter range of the main Nelchina herd. Potential impacts include increased mortality from vehicle collisions, impeded east-west movements, increased hunter access and possibly increased predation.

The Susitna hydroelectric project should be viewed as one of a number of probable developments which will occur on the Nelchina caribou range. While no one action may have catastrophic results the cumulative impact will likely be a reduced ability for the Nelchina range to support large numbers of caribou.

It is recommended that range use and migratory routes be monitored by periodic relocations of radio-collared caribou. Population status should be monitored with annual censuses and sex and age composition sampling. Increased emphasis should be placed on studying the upper Susitna-Nenana subherd.

The remainder of this report deals, mainly, with findings obtained since preparation of the last progress report (November 1982-October 1983) and a discussion of the significance of these findings to project construction.

POTENTIAL IMPACTS OF PROJECT CONSTRUCTION

Migratory barriers: both the proposed impoundments and associated transportation corridors are potential barriers to the free migration of Nelchina caribou between components of their range. The Devil Canyon impoundment and transportation routes to the west linking with the Parks Highway or the Alaska Railroad do not appear to be of serious concern as neither currently nor historically have many caribou occurred in this region. In contrast, the Watana impoundment area was crossed regularly by the entire female-calf segment of the Nelchina herd during many years between 1950 and 1973 moving from the calving grounds to summer range north of the Susitna River (Skoog 1968, Hemming 1971, Bos 1974). This movement sometimes occurred in June after calving but more commonly took place in late July (Skoog 1968). Hemming (1971) stated that most crossings of the Susitna in the proposed impoundment area occurred between Deadman Creek and the big bend of the Susitna. Varying proportions of the herd have also wintered north of the impoundment area in drainages of the upper Susitna, Nenana and Chulitna Rivers in many years. Between 1957 and 1964 this was the major wintering area (Hemming 1971). Spring migration to the calving grounds crossed the impoundment area primarily between Deadman Creek and Jay Creek.

Massive movements of caribou across the proposed Watana impoundment have not occurred during the study period, nor have they been recorded since about 1976 (S. Eide, pers. commun.). Based on repetitive relocations of radio-collared caribou during this study it seemed that low to moderate level movements through the upper Watana impoundment area occurred during spring migration from the Lake Louise Flat to the Talkeetna Mountains. The main area utilized was the big bend of the Susitna near the confluence of the Oshetna River although some crossings took place downriver near the mouth of Watana Creek. During spring 1981 it appeared both from relocations of radio-collared animals and sightings of tracks and animals that many animals were using the frozen Susitna River as a travel route. They apparently traveled on the Susitna from the Tyone and Oshetna Rivers to Kosina Creek and Watana Lake where they moved west into the Talkeetna Mountain foothills. During autumn dispersal about 10% of the herd has annually passed through the Watana impoundment area as they moved out of summer range in the Talkeetna Mountains. In mid-October 1982 perhaps 10% of the herd crossed the Susitna (south to north) in the area of Watana Creek. It is quite clear that the proposed Watana impoundment intersects a major migratory route which was intensively used in the past and currently receives low to moderate use. It is expected that one day Nelchina caribou will again use summer and winter ranges north of the impoundment area and therefore will again resume massive crossings of the proposed Watana impoundment area.

The proposed Denali access road from the Denali Highway to the Watana dam site neatly bisects summer and winter range for up to 50% of the upper Susitna-Nenana subherd. Relocations of radio-collared caribou indicate that the Chulitna Mountains are important calving and summer range and that most animals which summer in the area move to the east for the winter. Thus perhaps up to half of this subherd would be exposed to problems associated with road crossings in a treeless area twice a year. Some calving occurs in the vicinity of the proposed access road. However, because calving females from this subherd do not congregate on a discrete calving ground but rather calve while dispersed over a large area it is probably impossible to route the Denali access road to completely avoid calving females. Conversely only a small amount of calving would occur wherever the road is constructed. Resumption of use of summer and winter range north of the proposed impoundments would put the main Nelchina herd in contact with the Denali access road and would require crossings in order to reach and return from summer range in the Chulitna Mountains.

Studies and observations on the reactions of caribou to highways and vehicles are somewhat contradictory although most biologists agree that highways particularly those in open terrain with heavy vehicular traffic inhibit to some degree the free movement of caribou (Cameron *et al*. 1979, Horejsi 1981, Klein 1971). Severity of impacts of roads and traffic on caribou are unknown but undoubtedly vary depending on the local situation. Nelchina caribou continue to cross the Richardson Highway often in large numbers, and have done so during many years since about 1960 (Hemming 1971). The area where the Richardson crossings take place is timbered in contrast to the open tundra and shrublands of the proposed Denali access route. Nelchina caribou also cross the Glenn Highway (primarily the Tok-Cutoff), Denali Highway, Lake Louise Road and Nabesna Road on occasion. The Glenn Highway and Nabesna Road are crossed twice yearly during those years (perhaps half of recent years) when the Nelchina herd winters in the Wrangell Mountains-Mentasta Mountains area. Small numbers of caribou, primarily bulls, cross the Glenn Highway west of Glennallen during winter and spring each year. Most years small numbers of caribou cross the Lake Louise Road during the autumn dispersal period.

Direct Mortality: attempted movements of caribou across the Watana impoundment could result in increased mortality. Spring migration from winter range to the calving grounds in the Talkeetna Mountain foothills would occur from late April to mid-May. This would be a period of transition from an ice-covered reservoir at maximum drawdown with probable ice shelving and ice-covered shores to an open reservoir filling from spring run-off. Post-calving movements from the calving grounds to summer range north of the Susitna would occur in late June or July at which time the impoundment would be ice free and nearing maximum water level. Additional movements from August into October would likely occur but would probably involve smaller, dispersed groups of animals. At this time the impoundment would be at maximum water level and ice free.

Spring migration appears to hold the greatest potential for increased mortality. Pregnant females are in the poorest condition of the annual cycle at this time (Skoog 1968) and migratory barriers which normally would be easily circumvented could become significant mortality factors. Ice covered shores, ice sheets and steep ice shelves formed by winter drawdown of the reservoir could present hazardous obstacles to movement (Hanscom and Osterkamp 1980). Skoog (1968) mentioned several instances of injuries and death resulting from falls on or through ice. Both Klein (1971) and Vilmo (1975) mention ice shelving as a mortality factor of reindeer on reservoirs in Scandanavia.

Crossings during summer and fall when the reservoir would be ice free appear to pose considerably less hazard. Caribou are excellent swimmers and are known to cross much larger bodies of water than the proposed impoundment (Skoog 1968). Young calves might have problems with this distance if migrations occurred shortly after calving. Water crossings have been reported as mortality factors but usually involved rivers rather than more placid bodies of water such as a reservoir (Skoog 1968). Banfield and Jakimchuk (1980) suggested that open water posed a barrier, particularly during post-calving movements and mid-summer migration. Large lakes are often crossed at traditional sites, often narrow points or where islands provide interim stopping points. They state "caribou prefer to avoid open water." Rafts of floating debris could cause problems for the first few years after filling the impoundment. Mortalities of moose which could not reach shore because of floating debris have been reported in reservoirs in Canada (W. Ballard, pers. commun.).

Some mortality of caribou from collisions with vehicles along the Denali access road may occur, although caribou-vehicle collisions at other highway crossings are infrequent. Number of mortalities will largely depend on the presence or absence of the main Nelchina herd in the area. Wolf predation may increase as wolves have been found to use roads to their advantage when hunting caribou (Robey 1978).

Loss of Habitat: this is not a serious problem as the proposed developments (impoundments, access corridors, borrow pits and settlements) are a small portion of total caribou habitat in the Nelchina range and are generally of poor quality.

Increased Human Access: project development would likely increase human access to the Nelchina herd calving grounds and summer range in the Talkeetna Mountains. The calving grounds are currently in one of the most remote and inaccessible regions within the Nelchina range. Increased human activity and development would likely occur which have been shown to adversely impact caribou use of calving areas. Cameron *et al.* (1979) documented abandonment of a portion of the calving grounds of the central Arctic herd concurrent with development of the Prudhoe Bay oil fields.

The Denali access road would also increase access to important caribou habitat which is currently used primarily by the upper Susitna-Nenana subherd. The area has in the past and probably will again be an important summer and winter use area of the Nelchina herd.

Concern has been expressed that increased hunter access provided by project development could result in excessive hunter harvest. Alaska Department of Fish and Game regulatory procedures should be adequate to prevent this from happening. Illegal kills could increase with additional access.

Reduced Condition: should migratory barriers cause extended or more difficult migrations, particularly during spring migration to the calving grounds when pregnant females are in the poorest condition of their annual cycle (Skoog 1968), the population dynamics of the herd could be impacted. Mortality rates of adult animals could be increased while viability of newborn calves could be decreased.

Increased human activity particularly in the form of aircraft and vehicular traffic could result in chronic, higher levels of disturbance causing lowered physical condition. Several studies (Miller and Gunn 1979, Calef *et al.* 1976) have recorded responses of caribou to aircraft disturbance and speculated on deleterious impacts. Cows and calves were most responsive to disturbance (Miller and Gunn 1979). Caribou show the greatest sensitivity during the rut and calving (Calef *et al.* 1976).

Cumulative Impacts: perhaps the major impact of the Susitna hydroelectric development on the Nelchina caribou herd will be a contribution towards gradual, long term cumulative habitat degradation rather than immediate, severe impacts. The proposed hydroelectric project is only one (although the major one) of a number of developments which may occur on the Nelchina range. Considerable mining activity already is taking place in the southeastern Talkeetna Mountains, traditional summer range. A state oil and gas lease sale is planned for the Lake Louise Flat, a major wintering area. The Bureau of Land Management is planning to open much of the Nelchina Basin to oil exploration.

Considerable land is passing from public to private ownership through the Alaska Native Claims Settlement Act and through state land disposal programs. While no single action may have a catastrophic impact it seems likely that long-term cumulative impacts will result in a lessened ability for the Nelchina range to support large numbers of caribou. Habitat destruction, increased access and human activity, disturbance, and barriers to free movement will all probably contribute to this.

RECOMMENDATIONS FOR CONTINUING STUDIES

Herd population status should be monitored with annual censuses and sex and age composition sampling. Range use and migration routes, particularly in the general area of the proposed developments, should be documented by maintaining and monitoring a pool of radio-collared caribou from the main Nelchina herd. Up to 10 radio-collared caribou should be monitored in the upper Susitna-Nenana subherd to document range use and seasonal movements, particularly in the area of the proposed access road and proposed impoundments and associated developments. Another census of the upper Susitna-Nenana subherd should be attempted in order to generate a more reliable estimate of population size.

WOLF

During 1982 and 1983 wolf studies were continued in the Susitna River Basin to investigate potential impacts of the proposed Susitna Hydroelectric Project. Between 1 November 1981 and 31 December 1983, 42 wolves were captured and outfitted with transmitter-equipped collars to enable researchers to document movements, denning and rendezvous locations, habitat use, and food habits. Throughout the period, a total of 13 packs and 1 lone wolf were known to be using areas in or adjacent to the Devil Canyon or Watana impoundment zones. During any particular year 5-6 individual wolf packs used areas to be inundated by the proposed project. Six hundred forty-nine radio locations yielded 945 wolf sightings upon which this report is based. Individual pack histories are presented.

Territory sizes of 7 intensively monitored packs ranged from 127 mi^2 to 602 mi^2 (329 km^2 to 1559 km^2), and averaged 452 mi^2 (1,171 km^2) in 1982 and 1983. Territory sizes varied considerably among packs, probably due to pack size, prey densities, frequency of monitoring, and adjacent pack boundaries.

Distribution of wolf packs is suspected to be virtually complete in the basin, with elevational use generally restricted to less than 4,000 ft. Elevational distribution varies seasonally and is probably dependent on relative densities of major prey. Both moose and wolves used lowest annual elevations in February, with a general increase in elevational use until October with subsequent declines thereafter.

Analyses of food habits of wolves were based largely on aerial observations of wolves at kills. Moose of all age classes represented 61% of the diet, with caribou comprising 30%. Analysis of 1982 scat collections supported conclusions drawn from aerial observations.

Probably the most important impact on wolves resulting from the proposed project will be lowering of wintering densities of primary prey species (moose and caribou) in the impoundment zone, with resultant declines in wolf numbers. Secondly, loss of habitat through inundation and facilities development will undoubtedly force wolves to readjust territory boundaries resulting in intra-specific strife. This will affect not only wolf packs presently in the basin (especially the Watana pack), but also packs far removed from the area.

IMPACTS

Impacts of the proposed impoundments and their associated borrow pits, transmission corridors, work camps and facilities are difficult to quantify at this time. However, based on earlier research and that reported herein, some impacts can be estimated.

Probably the most significant impact the impoundments will have on wolves will result from a change in population density, distribution, sex and age composition and/or physical condition of moose and caribou. The majority of the wolf's diet in this area is moose, and any decrease in prey numbers will probably be reflected in both wolf density and distribution. Ballard *et al*. (1984) estimated that approximately 2,800 moose could be directly impacted by the impoundments. During the impoundment filling stage and for at least 1 year following inundation, there will probably be an increase in wolf numbers in response to higher concentrations of moose adjacent to the impoundments. There will be a high number of displaced moose which will be concentrated adjacent to the reservoirs due to the decreased availability of usable habitat. However, the duration of this relatively high moose concentration will probably be short, i.e. 2-3 years. After that, deterioration of the habitat will undoubtedly result in relatively lower moose numbers. Ultimately, remaining wolves and the area's ability to support larger numbers will be reduced, but for a short period they will remain relatively high and further depress the moose population and possibly prevent it from increasing.

Access roads and the proposed permanent village for project personnel will result in a significant increase in human use of the area. Correspondingly, there will probably be a higher incidence of hunting, trapping and accidental mortality upon wolves. Indirect effects upon wolves resulting from higher human populations will probably also occur. Activity near den and rendezvous sites in early summer will certainly disrupt, and in some cases, will probably cause wolves to abandon den and feeding sites. Den site abandonment could lead to higher pup mortality.

Inundation of den and rendezvous sites, travel corridors and hunting/feeding areas will eliminate portions of wolf territories. Loss of this habitat will force wolves to readjust territory boundaries and will probably result in increased inter-pack strife. Since present wolf mortality from some of the packs adjacent to the Susitna River are low (Watana Pack in particular) with subsequent high dispersals to surrounding areas, this area acts as a reservoir in supplying wolves to adjacent areas. Should mortality within these packs increase, there will probably be less dispersal away from the area. Consequently, the reduction of wolf numbers adjacent to the impoundments may well affect not only those packs immediately adjacent to the river, but also packs far removed from the area. Movements of over 50 miles (80 km) away from the Watana territory by wolves which either joined new packs or initiated new packs have been recorded.

Of the 6 packs which will be impacted by the proposed project, the Watana pack will be one of the packs to be impacted most severely. The effects of habitat inundation on the Watana wolves was selected for a further analysis because of the relatively high number of relocations. During 1982, the Watana Pack occupied a territory of 482 mi^2 (1246 km^2) within and adjacent to both the proposed Watana and Devil Canyon impoundments. Twenty-six of 58 (45%) relocations of Watana Pack members were at or below high pool level of the impoundments. During the first half of the year (January through June) over half (57%) the recorded observations were at or below maximum pool level. Fifty-one mi^2 of the 482 mi^2 territory were greater than 4,000 ft. altitude and were rarely used by the pack (‘4% of all relocations). Of the 431 mi^2 of usable habitat within the Watana pack territory, 55 mi^2 would be inundated by the two impoundments. However, the 55 mi^2 (13% of territory) accounted for 45% of the annual locations of the pack, indicating that the lower elevations are preferred by wolves in the Susitna River Basin. This was probably the result of higher concentrations of moose in these lower attitudinal areas.

At the time this report was prepared, information on exact locations and extent of area covered by encampments, borrow sites and road and transmission corridors was not available. However, preliminary site locations have been mapped, and their location will further limit the extent of the Watana territory. The exact percent of habitat loss of the Watana territory is not known. In particular, quarry sites A and B, and borrow sites D, E, F, I, J, and L will at least have portions within the Watana territory and will impact the Watana wolves during and/or after construction of Watana Dam.

The percent of various elevational strata available to the pack (calculated by random selection of 482 points within the Watana territory) compared to the percent of radio-locations at those various elevations shows that between 1,801 and 2,200 ft. were significantly preferred elevations (P ‘0.005). These elevational strata were available to Watana wolves in 13 percent of their territory, yet were used on 45 percent of the locations. The inundation of this zone will undoubtedly affect the shape and extent of wolf territories and subsequent recruitment and mortality of wolves in the Susitna Basin.

PROPOSED STUDIES

Continuation of monitoring efforts of wolves already instrumented is important. Population and individual pack boundaries are highly dynamic and documentation of denning, rendezvous, and hunting/traveling areas should be continued. Efforts should be made to instrument numbers of additional packs, especially in the area from Devil Canyon to Sherman. Of particular concern is a better representation of preferred habitat types when higher resolution vegetation mapping is finished.

In conjunction with ongoing moose and caribou studies, investigations of calf consumption by wolves should be conducted. More accurate documentation of food habits could be gathered in this way.

Mitigation of the losses of major prey species (moose and caribou) is of major importance to the continued viability of wolf populations. Evaluation of those mitigation options include their impacts on wolves.

BLACK BEARS AND BROWN BEARS

This report is an update of information presented in earlier reports (Miller and McAllister 1982, Miller 1983) and does not contain analyses of all the information available on the impacts of the proposed Susitna Dams on black and brown bear populations.

Following tagging operations in spring 1983, 43 brown bears were radio-marked including 15 subadults. Five of these were in the downstream study area. In spring 1983 40 black bears were also radio-marked, half of these were in the downstream study area between Portage Creek and Curry.

The reproductive status of marked female brown and black bears in spring 1983 was consistent with the predicted pulse in cub production expected based on the 1981 failure of the berry crop. However, this pulse was not as large as expected largely because some females expected to produce first litters failed to do so. These observations support the hypothesis that project-related reductions in food supplies would negatively impact productivity of bear populations.

Documented losses of offspring from litters of collared female brown bears was 47% for cubs and 33% for yearlings. A limited amount of data collected in 1983 suggested these losses resulted from predation by other brown bears.

Kill locations for 351 brown bears in the study area portion of GMU 13 during the period 1961-1982 were digitized based on information recorded in ADF&G sealing documents. The sex and age composition of these harvested bears are reported. These data are presented to assist subtasks undertaking socio-economic studies in the project area. Based on hunter kills of marked bears, no less than 8%/year of the brown bear population is harvested.

Telemetry studies of six 2-year old bears (5 males and 1 female) indicated that the female and 1 male remained in or near their maternal home ranges. The other 4 males dispersed distant from their maternal home ranges. These observations validate earlier hypotheses that project-related reductions in bear numbers or productivity in the study area will impact bear populations elsewhere through reduced emigration.

Continued high use of Prairie Creek during the king salmon spawning season in 1983 supported earlier conclusions that this area is a seasonally important critical habitat area for brown bears in the study area. The area documented from which bears are attracted to Prairie Creek is 7,200 km^2 and 2,200 km^2 for males and females respectively.

The brown bear density estimate of 1/41 km^2 in an adjacent study area made by Miller and Ballard (1982) remains the best available estimate for the Su-Hydro project study area. In 1983 an independent estimate was derived based on the frequency or which radio-marked bears were seen with other marked bears and with unmarked bears during the spring 1983 breeding season. This process resulted in estimates of 11-50 km^2/bear depending on the assumptions used. These calculations lend additional credence to the density estimate of Miller and Ballard (1982).

Data collected in 1983 supported earlier conclusions that few brown bears den sites would be directly affected by the proposed impoundments. Indirect effects from increased disturbance is considered to be the main impact mechanism on brown bear denning.

Overall rates of harvest by hunters of marked black bears was 14% (19% for marked males and 10% for marked females). This rate was higher in the downstream study area (29%) than in the upstream study area (13%).

Black bear litter sizes declined over time. Mean litter size in dens was 2.5, 2.2 after exit from dens and 1.9 for litters of yearlings. Forty percent of black bear cubs have been lost from litters of radio-collared females.

Efforts to replicate the summer 1982 black bear census technique in spring 1983 were unsuccessful. A tenative density estimate of 1.3 mi^2/bear based on female home range sizes and various assumptions about population composition and productivity was derived. This estimate was considered too high for 1983 populations but was considered a reasonable approximation of the maximum carrying capacity of the upstream study area (400 bears). It is anticipated that this estimate will be refined once adequate habitat maps have been prepared by the plant ecology subtask.

Analyses of scats collected along salmon spawning sloughs in the downstream study area in 1983 revealed the same pattern as seen in 1983 studies. Berries were the most abundant and common item in these scats and salmon remains were uncommon. Radio-marked bears in the downstream study area, however, moved to the vicinity of these salmon-spawning sloughs during the salmon spawning season as in previous years. Based on these results it is suggested that radio-tracking studies of downstream black bears be deemphasized in FY 1985 but that scat collections along the sloughs be continued.

Of 26 black bear den sites found in the vicinity of the Watana impoundment, 15 will be inundated. Only 1 of 21 dens found in the vicinity of the Devil Canyon impoundment will be inundated.

Results and Discussion-Black Bears

Following the May tagging effort 40 black bears were radio-collared, half of these were in the downstream study area. No cubs or yearlings were marked in 1983. Currently 27 black bears are radio-marked including 13 in the downstream study area. During 1983, 5 bears were known shot by hunters (367, 374, 410, 303, and 323), 2 bears disappeared and were suspected to have been shot (370, 372, both females with cubs), 3 bears shed transmitters (301, 318, 349), and 3 bears died (327, 379, and 365). No black bears were killed or died as a result of handling in 1983. Capture data from 1980-1983 are given in Table 2 of the report. Numbers of point location obtained are given in Table 4 of the report.

A. <u>Sex and Age Composition of Study Animals-Black Bears</u>.

The sex and age composition of the 14 remaining radio-marked black bears in the upstream study area (all ‘3 years of age) was 7 males (401, 346, 358, 359, 360, 324, 387), and 7 females (363, 354, 317, 289, 321, 329, 361). In the downstream area 2 adult males (408, 343) and 11 females (378, 376, 404, 405, 411, 409, 406, 402, 377, 369, 375) are radio-marked. Ages of these bear can be obtained from Table 2 of the report.

B. <u>Population Biology and Productivity-Black Bears</u>.

Miller (1983:68) predicted a pulse of cub production in 1983 based on the apparent berry failure in 1981. Of 19 radio-collared females, 18 (95%) could potentially have had cubs in 1983 and 14 did (70%). B364, missing at the end of 1982, was also listed as expecting cubs in 1983 but remained missing throughout 1983 so her status could not be verified. Three of the 4 bears that were expected to have cubs in 1983 but didn't were 5 years old in 1983 and were listed as expecting their first litters in 1983 (363, 367, 369), the fourth (378) was a 7 year old female in 1983. These data may indicate that mean age of first litter production is older than 5. One bear at age 5 did produce a litter in 1983 (377) but lost its cubs by 19 May. One of the 5-year old females (363) that didn't produce a litter in

1983 may also have lost an unobserved litter early, the other 2 females were examined in their dens so it is certain they did not have cubs.

The predicted 1984 reproductive status of 23 radio-marked females (including 4 missing bears) is given in Table 30 of the report. Excluding the missing bears, 9 of 13 adult (≥5) females (67%) are expected to produce cubs in 1984. Identification of a pulse in cub production in 1983 based on the 1981 berry failure is not strongly supported by these data. The data, however, may be confounded by a capture bias against females with newborn cubs. If such a bias exists, and this is considered likely, then a pulse in cub production by radio-marked females would be expected in the year following initial capture of these females, independent of any environmental factor. Additional data are needed before these hypotheses can be analyzed. Because of the initiation of the downstream study in 1982 and corresponding capture of many new females, this bias could have caused a pulse in cub production by radio-marked females in 1983. It is also possible that the blueberry failure evident in the upstream area did not affect bears in the downstream study area that are buffered by salmon and salmonberries unavailable to upstream bears.

Black bears captured in the upstream study area included slightly more males than females while much the opposite was the case in the downstream study area. This difference may reflect heavier hunting pressure in the downstream area which is accessible to riverboats out of Talkeetna and has a resident population of homesteaders. The upstream area is accessible only by plane or, in a few spots, ATVs. Comparisons of age data for these 2 populations are generally consistent with this hypothesis. Downstream males tended to be younger than upstream males although the differences were not significant and the reverse was the case for females. Heavier harvest in the downstream study area is also supported by harvest rates of marked bears, although sample sizes were small. Based on 100 marked-bears-years in the upstream area, 13% have been harvested compared to 29% in the downstream area (31 bear-years). Overall rate of harvest of marked bears in both areas was 14% (19% for marked males and 10% for marked females).

Apparent natural mortalities of radio-marked black bears are presented in Table 34 of the report. Three natural mortalities of radio-marked bears were recorded in 1983. Two of these were females with cubs, both were thought to have been killed by other bears.

Black bear litter size is presented in Tables 35 and 36 of the report. As would be expected mean litter size is largest for the sample counted in dens (2.5), smaller when den data are excluded (2.2) and smaller yet for yearling litters (1.9). These data indicate a progressive loss of subadults from birth through separation from their mothers.

Overall, 40% of cubs were lost from litters of radio-collared females (excludes those cubs that were doubtless lost when their mothers' died). This percentage was higher in the upstream study area (54%) than in the downstream area (22%). This difference may reflect the marginal nature of the upstream habitat for black bears relative to the downstream habitat. This difference may also reflect the lower proportion of adult males in the more heavily hunted downstream population relative to the upstream population; adult males may cause much of the cub mortality through intraspecific predation.

Morphometrics of black bear cubs and yearlings are given in Tables 38 and 39 of the report.

C. Black Bear Density Estimates.

1. Lincoln Index method. An attempt to census the black bear population using Lincoln Index techniques on the ratio of marked to unmarked individuals observed during transect flights was made in spring 1983. A similar attempt in summer 1982 yielded a population estimate of 90 bears (47-172) ages 1 year old or older in the upstream area (Miller 1983:58). The spring 1983 effort was an attempt to replicate this previous effort during spring conditions when a different set of observability biases would exist.

   The technique was not successful in spring 1983. In the downstream study area half of the sample units were counted, these contained 76% of available marked bears but no marked bears were seen. Only 1 adult bear/hour of survey time was spotted. In the upstream area, 10 (of 37) sample units were counted, these contained 35% of available marked bears but only 1 marked bear was seen. Only 1 bear/146 minutes of flight time was seen prior to aborting this unstream census effort.

   The results of the summer 1982 census effort are given in Table 42 of the report for comparison purposes.

2. Home range of females method. In Minnesota, Rogers (1977) found that female black bears tended to occupy largely exclusive home ranges. Hugie (1982) found similar results in Maine but Lindzey and Meslow (1977) found overlapping home ranges in Washington. If home ranges do not overlap, an estimate of the number of female adult bears present could be obtained by partitioning the available habitat into parcels that correspond to mean territory size and counting these.

Annual home ranges of adult female black bears radio-collared in this study revealed overlap. This overlap was especially evident in 1981 when late summer berry crops failed and many bears made exceptional movements, apparently to compensate. Even in years of normal berry crops, however, female annual home ranges overlapped.

Overlaps between female home ranges were less marked when only spring data (1 April-5 July) were included. These data for "spring" were chosen because they precede the ripening of the berries and the corresponding movements of bears to areas of berry abundance. Figures 13-15 of the report illustrate the annual spring home ranges of radio-marked bears excluding locations at den sites. The area of these home ranges is given in Table 43a of the report. The genetic relationship between these bears was unknown except for 329 which was the 3-year old offspring of 327 and overlapped extensively with 327 in 1983. Spring home ranges defined in this manner overlapped less than did annual home ranges but even these were clearly not exclusive.

Even though annual or spring female home ranges are demonstrably not exclusive, an estimate of the number of bears the habitat could support can be obtained by assuming that the home ranges were exclusive. Annual spring home ranges of 35 upstream female black bears (≥3 years old) averaged 10.8 km^2. The amount of black bear habitat in the upstream study area can be equated with the area of the sample units delineated during the census attempt, 500 mi^2 or 1300 km^2. If this area were completely populated by black bear females with exclusive home ranges of 10.8 km^2 each, there would be space for 120 adult (≥3 years) females. Assuming equal sex ratios for adults there would also be 120 males present. Black bear females aged 3, 4, and 5 are not all reproductively mature, bears in these age classes constitute an estimated 30% of females ≥3 years old leaving 80 females of reproductive age. Based on litter size data, each of these females would annually contribute about 1.0 cubs, and 0.8 yearlings. If there is a 50% mortality of yearlings each female would also annually contribute 0.4 two-year olds. Correspondingly, each of these 80 reproductively mature females would annually contribute about 2.2 subadults (‘3 years) to the total population or an additional 175 bears. Based on these calculations, the estimated population based on these assumptions would be about 400 bears. Based on the 500 mi^2 of black bear habitat present this would be a density of 1.3 mi^2/bear or 2.1 mi^2/adult ≥3 years. This estimate would be exaggerated by the degree to which the 500 mi^2 of habitat is incompletely occupied; to the degree that the home ranges overlap this estimate would be too low.

This result can be compared with estimates obtained in other ways. Miller and McAllister (1982:93) roughly estimated a study area population of 340 black bears based on a Lincoln Index during the tagging operation in August 1980, this represented a density of 1.6 mi^2/bear. The summer 1982 Lincoln Index attempt yielded a corrected Lincoln Index and estimate of 126 bears (Miller 1983:59). My guess on the 1980 bear population in the study area was 150-200 bears (Miller 1982:59).

My subjective impression of this new estimate is that it is too high. Part of the reason for this may be that all of the 500 mi^2 is not good spring habitat. Another possible reason for an overestimate is that the current population is suboptimal, below what the habitat could support. Miller (1983:58) noted that bear population appeared to have declined in the study area since the project started, this impression has been strengthened with the addition of 1983 studies.

Possibly this decline resulted from the poor 1981 berry crop. Regardless of where this population may be at the moment, an estimate of 400 black bears is a reasonable approximation of the number of black bears the habitat in the upstream study area could potentially support.

D. Analysis of Berry Abundance.

Four transects designed to document changes in berry abundance between years were established in 1982 (Miller 1983). This procedure was replicated in 1983 although the exact same plots were not read, the plots read in 1983 were in the same general area, within 100 feet, of those read in 1982. As mentioned by Miller (1983), insufficient manpower was available to sample enough plots to provide good documentation of true variability in berry abundance. Our samples were adequate, however, to provide some support for our subject interpretations of berry abundance.

E. Food Habits.

Forty-two bear scats were collected and analyzed in 1983. Analyses of 33 scats collected previously were presented by Miller (1983, Table 11, page 45). As reported by Miller (1983) the predominant food in the scats collected on the shores of sloughs where salmon were spawning in the downstream study area were berries of Devil's club (*Oplopanax horridus*). Fish were even rarer in the 1983 scats than in the 1982 scats collected along the salmon-spawning sloughs. The difference in 1983 probably reflected the decreased availability of salmon in 1983 because 1983 had the expected low, odd year, run of pink salmon (*Oncorhynchus gorbuscha*), and very high water in the Susitna during much of the spawning period. Regardless, of the absence of abundant pink salmon in the spawning sloughs, many radio-collared black bears moved to the vicinity of these sloughs during late summer 1983 as they did in 1982. These results support our tentative conclusions that these movements are more motivated by the prevalence of devils club berries in the riparian habitats along the sloughs than by the presence of spawning salmon.

Updated records on frequency of Susitna River crossings by radio-marked black bears are given in Table 52 of the report.

Efforts to devise a technique using thin layer chromotography on bile acids to separate black bear feces from brown bear scats were unsuccessful. Results of this study are reported in Appendix 1 of the report.

F. Black Bear Den and Denning Characteristics

Characteristics of black bear dens observed during winters of 1980/81 through 1982/83 are given in Table 53 of the report. The known history of use of individual dens is presented in Table 54 of the report. In March and April 1983, 13 dens previously used by radio-marked black bears were inspected. Eight of these were vacant, 3 (numbers 10, 9, and 7) were occupied by radio-marked bears, one (#19) was occupied by an unmarked bear, and one was collapsed. Seven of the vacant dens revisited were dug dens, the other (#19) was a natural cavity. History of den use by individual marked black bears is given in Table 55 of the report.

Twenty-six dens used at least once by a radio-collared black bear have been found in the vicinity of the Watana Impoundment, 15 (58%) of these will be inundated by the impoundment. By comparison only 1 of the 21 dens found in the vicinity of the Devil Canyon impoundment will be inundated by the proposed impoundment.

Den entrance and emergence dates for radio-marked black bears are given in Tables 56 and 57 of the report for 1982/83 and 1983/84 respectively. Data for previous years was given in Miller (1983).

Locations of black bear den sites are given in Figure 16 of the report for the upstream study area and in Figure 17 of the report for the downstream study area.

WOLVERINE

From 1980 to 1983, 22 wolverine were instrumented and monitored for various lengths of time to assess the impacts of the proposed Susitna Hydroelectric Project. To gain additional information on mortality, natality and sex and age ratios, 136 additional wolverine were examined that were harvested from or adjacent to the study area.

Annual home ranges of males averaged 535 km^2 and females 105 km^2. It is suspected that there is very little overlap between home ranges of adult males, but much overlap between the sexes. Wolverine showed differential elevational and subsequent vegetation use in different seasons. In July, elevational use averaged 1,043 m with a corresponding decreased use of spruce habitat types. January elevational use averaged 818 m, with a concurrent increase in spruce forest use. Seasonal diet changes probably induce the elevational differences. The sex ratio of 158 captured and harvested wolverine was 50:50. Data indicate that approximately 30% of the harvest is comprised of juveniles.

Probably the most serious impact of Susitna Hydroelectric development on wolverine will be permanent loss of winter habitat. Forty-five percent of all instrumented wolverine had home ranges that overlapped the impoundment zone and will be displaced to some when reservoir clearing or filling begins. Also, a reduction in moose population will result in a reduction in the amount of carrion available during winter.

POTENTIAL IMPACTS

Whitman and Ballard (1983) presented 3 scenarios which may occur following inundation of the area upstream of the Watana dam site. In all scenarios, decreased moose populations will eventually (1-3 years) result in decreased carrion available to wolverine in winter. These and other changes in prey density will affect wolverine movements, densities, and population size. Improved access and a larger human population in the area will undoubtedly present the potential for higher harvests. Should this prove excessive, however, the state game regulatory process can restrict these losses.

Localized avoidance of work camps and facilities will probably not significantly influence wolverine movements or productivity. However, habitat loss due to inundation and access corridors will certainly influence these parameters. The Alaska Power Authority (1983) has estimated that due to inundation and associated activities and facilities, the carrying capacity will be decreased by 2 wolverines. The reasoning behind this assumption is that since average wolverine home range size is 163 km^2 (Whitman and Ballard 1983) and a total of 206 km^2 will be affected, only 2 wolverine will be displaced. However, inundation of low-level areas will result in a permanent loss of winter habitat. We have calculated that 45% (9 of 20) of all instrumented wolverine have home ranges that overlap the impoundment zone. Assuming Whitman and Ballard's (1983) estimate is correct, at least 35 wolverine (45% of basin population) would be impacted to some degree by the impoundment alone. The additional wolverine habitat altered by transmission corridors, access roads, and work camps, will further increase the percent of wolverine affected.

DALL SHEEP

Dall sheep studies have focused on the three areas of sheep habitat nearest the proposed Watana and Devil Canyon dams - Mt. Watana, Portage Creek-Tsusena Creek-Denali Highway (access corridor) and the Watana Creek Hills. During Phase I studies, a mineral lick used by a small Dall sheep population was discovered in the Watana Creek Hills, adjacent to the proposed Watana impoundment. A minimum of 31% of the observed 1983 sheep population traveled 5 mi or more to the Jay Creek lick area, which is below alpine sheep habitat in the lower 4 mi of Jay Creek. Sheep travel to this area even though another smaller lick with similar chemical anomalies is located within their alpine range. The Jay Creek lick soil, containing significantly high levels of sodium, is exposed in several areas mostly between 2,200-2,400 ft. Sheep attracted to the area spent about 14% of the time below 2,200 ft and 46% of the time below 2,300 ft. The Watana impoundment normal maximum operating level is designated as 2,185 ft with an average annual drawdown of 120 ft. Although these proposed impoundment levels will not directly inundate any major licking areas, erosion and ice shelves may result in the loss of licking and resting areas, and inhibit travel along and across Jay Creek to well-used sites. However, erosion may possibly also expose lick soil in new areas. The lick's close proximity to the impoundment will make the sheep seasonally vulnerable to disturbance from construction, transportation and recreational activities. No sheep use of areas on Mt. Watana (directly south of Watana impoundment) or near the Denali Highway access corridor was documented.

IMPACTS OF WATANA IMPOUNDMENT

The Watana Creek Hills sheep population could be vulnerable to severe impact from the proposed Watana impoundment because of disturbance to the Jay Creek lick area. This area, adjacent to the proposed Watana impoundment, is used by a large proportion of the sheep population in early summer. A minimum of 31% of the observed 1983 population used the Jay Creek lick area, and up to 31 individuals (21% of population) were seen in the lick area at one time (the most ever recorded). Almost half of the time sheep were in the lick area, they were below 701 m (2,300 ft) which would be subjected to flooding and erosion. Rams used the licks early in the season, followed by pregnant or barren ewes and yearlings, with ewe-lamb groups not arriving until June 16. This pattern is similar to those reported for mountain goats by Hebert and Cowan (1971), for Dall sheep (Heimer 1973), and for moose (Tankersley and Gasaway 1983). Sheep travel some distance to use this lick as both winter and summer surveys have located most of the population 7 or more air mi from the Jay Creek lick area. Two color-marked sheep traveled 5 mi or more to the Jay Creek lick area between April and late May. Although Heimer (1973) reported that sheep have traveled greater distances to a lick site, this reported travel was within typical alpine habitat which included escape cliffs (Heimer, pers. comm.). In contrast, the Jay Creek lick area and much of the terrain traveled between observed summer and winter range is atypical sheep habitat, being relatively flat with low shrubland and trees and little rocky cliff escape habitat.

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

Even though the East Fork lick had higher "total" sodium levels (as well as magnesium and calcium) than Jay Creek, sheep still endure the danger of travel to the Jay Creek lick and visit it at a similar rate to the East Fork lick. This may be because water soluble elements are more important, or because of the limited size of the East Fork licking area, or due to habitat, earlier spring phenology, or some other benefit of the Jay Creek area. Also, the similar visitation rate is not necessarily the same as the amount of licking done in each area. In any case, the significant use of the Jay Creek area in addition to the East Fork lick is well documented, but not well understood. Additionally, attraction of the Jay Creek Bluff for licking as well as resting (escape cover) needs to be clarified by additional observations and soil analyses. Archeological finds in the immediate vicinity raise intriguing questions about the history of Jay Creek lick use.

The cycle of filling and draining in the Watana impoundment will subject the lick area to flooding and erosion and possibly will leave ice shelves along the creek banks during the peak lick use season. The Watana impoundment normal maximum operating level is desginated at 2,185 ft in elevation, with possible flooding levels up to 2,201 ft (Alaska Power Authority 1983, Exhibit B). During the heaviest lick use season (May and June), the target minimum reservoir levels are 2,092 ft (May) and 2125 ft (June). The highest annual target minimum reservoir level is 2190 ft for September (Alaska Power Authority 1983, Exhibit B). Even at the normal minimum operating level of 2,065 ft, the lower portion of the creek valley will be flooded. The proposed impoundment levels will inundate a few low use licking areas (downstream 1,950 ft, upstream 2,190 ft, Bluff below 2,200 ft), and consequent erosion and ice shelves may result in the loss of more high use licking and resting areas (especially on the Bluff and East Ridge), as well as inhibiting travel along and across Jay Creek. However, erosion may possibly expose more lick soil in new areas.

This soil deposit may be widespread in lower Jay Creek and also in other areas around the Watana Hills. Similar laboratory results to high use areas were obtained about 2,200 ft on similar looking exposed soil bluffs 10 mi SE on the north bank of the Susitna River (#27, #28) where sheep were observed in early June. Even some "control" samples taken from similar looking exposed soil bluffs had high sodium values (#29 4 mi NW, and #32 12 mi NW), although no sheep use was observed there. Leaching sodium or other water soluble cations from the lick soil does not appear to be a potential impact. However, sheep attracted to the lick area may be seasonally vulnerable to disturbance and habitat degradation from timber harvest around the impoundment, and other human activities.

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

CLIMATIC IMPACTS

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

INCREASED HUMAN ACCESS

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

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

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

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

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

MITIGATION RECOMMENDATIONS

Lowering Watana's maximum reservoir level to 2,000 ft in elevation would eliminate much of the physical disturbance to the main Jay Creek lick area. Also, certain methods and scheduling of construction activities and access would reduce the impacts of the Susitna Hydroelectric project on sheep.

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

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

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

RECOMMENDATIONS FOR FURTHER STUDY

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

BELUKHA WHALE

Belukha surveys were flown in upper Cook Inlet between May 17 and August 27, 1982 and April 6 to July 20, 1983. A concentration area was identified nearshore from the mouth of the Little Susitna River to the mouth of the Beluga River. Use of the area increased in late May and lasted through mid-June. It is probable that this concentration was in part associated with calving and breeding although no calves were positively identified because of generally poor viewing conditions. The concentration appeared to involve 200 to 300 animals, however accurate counts were not possible because of, again, poor viewing conditions. The Belukha concentration near the mouth of the Susitna River appeared to coincide with the arrival of large numbers of eulachon which spawned in the lower Susitna River in late May and early June. This run of eulachon was estimated to total several million fish. King salmon are probably not particularly important to this concentration of belukhas although large male belukhas probably do take some king salmon. The only other salmon species from the Susitna River system available in sufficient numbers to be considered significant prey to the belukhas concentrated in late May and early June is the sockeye. No information is presently available which would allow conclusions on belukha predation on salmon smolts from the Susitna River.

Given the present state of our knowledge, we cannot accurately predict impacts on Cook Inlet belukhas from the proposed dams on the Susitna River. It is possible that the overall population could suffer reduction in numbers both directly by alterations in the habitat, particularly the concentration area near the mouth of the Susitna River and indirectly by reduction of available food species.

POTENTIAL IMPACTS

Quantification of impacts of the Susitna hydroelectric project on belukhas at the present time is not possible. This type of development project has the potential for reducing the numbers concentrating near the mouth of the river by reducing the available food or by altering the heat budget of the river. However the overall effect on the availability of anadromous fish to belukhas is predicted to be small. There may be no alteration of the heat budget of the river realized by the belukhas at the mouth of the river, although very little data are available to prove this.

Approximately 5 to 8% of the total adult salmon returning to the Susitna River system spawn in the area from Talkeetna to Devil Canyon; the area which is predicted to be the most heavily impacted by dam construction. The slough habitat in this area is predicted to be reduced, thereby reducing the available habitat of the chum salmon from the system as well as a small number of sockeye. This means that a small amount of food in the form of adult chum and sockeye will no longer be available to the belukhas after dam construction. Since we have no quantitative measure of the importance of these species to the belukhas, no estimate of impact can be made except to guess that it will probably be slight.

Impacts on the eulachon runs which enter the Susitna River are assumed to be slight as they remain in the lower reaches of the river (Bruce Barrett ADF&G pers. comm.). This species may be extremely important to the belukhas and it is possible that <u>any</u> reduction of eulachon could severly impact the belukhas.

Although most impacts from either heat budget alteration or food reduction are likely to be slight, we cannot accurately predict the overall effect on the belukhas. If any environmental perturbations effect the belukhas in upper Cook Inlet, it is likely these effects will take the form of a reduction in the population in Cook Inlet. Given our present state of knowledge, a reduction in the belukha population of upper Cook Inlet would not be detectable unless it were greater than a 50% to 75% reduction in the entire population. Even a reduction of this magnitude could go unnoticed for several years as no systematic monitoring of the population is planned.

RECOMMENDATIONS FOR FUTURE STUDIES

The most immediate information need for the Cook Inlet belukha population with respect to the Susitna hydroelectric project is a realistic population estimate. Generation of such an estimate would require development of a systematic aerial census of the belukhas in the entire Inlet from which a statistically sound estimate could then be derived. Beyond that, future studies should involve collections of skulls in order to determine the taxonomic status of this population; food habits studies to positively identify and quantify the importance of food species; and movement studies to define the geographical range and seasonal movements of the population.

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