SUSITNA HYDROELECTRIC PROJECT

FINAL REPORT

BIG GAME STUDIES

VOL. IV CARIBOU

KENNETH W. PITCHER

ALASKA DEPARTMENT OF FISH AND GAME

333 RASPBERRY ROAD

ANCHORAGE, ALASKA 99502

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PREFACE

Between January 1980 and June 1986, the Alaska Power Authority (APA) contracted with the Game Division of the Alaska Department of Fish and Game (ADF&G) to provide field data and recommendations to be used for assessing potential impacts and developing options for mitigating impacts of the proposed Susitna Hydroelectric Project on moose, caribou, brown bear, black bear, Dall sheep, wolf, wolverine, and belukha whales. ADF&G was only one of many participants in this program. Information on birds, small mammals, furbearers, and vegetation was collected by the University of Alaska and private consulting firms.

Formally, ADF&G's role was to collect data which could be used to describe the baseline, pre-project conditions. This information was supplemented with data from other ADF&G studies. Baseline conditions were defined to include processes which might be sufficiently sensitive to either direct or indirect project induced impacts to alter the dynamics of the wildlife populations. The responsibility of impact assessment and mitigation planning was assigned by APA to several private consulting firms. ADF&G staff worked closely with these firms, but only in an advisory capacity.

The project was cancelled before the impact assessment and mitigation planning processes were complete. In an effort to preserve the judgements and ideas of the authors at the termination of the project, the scope of this report has been expanded to include material relating to impact assessment and mitigation planning. Statements do not necessarily represent the views of the APA or its contractors. Conjectural statements sometimes are included in the hope that they may serve as hypotheses to guide future work, should the project be reactivated.

The following list of reports completely cover all of the Game Division's contributions to the project. It should not be necessary for the reader to consult the many progress reports.

Moose

Modafferi, R. D. 1987. Susitna Hydroelectric Project, Big Game Studies, Final Report Vol. I - Moose - Downstream. Alaska Dept. of Fish and Game.

Ballard, W. B. and J. S. Whitman. 1987. Susitna Hydroelectric Project, Big Game Studies, Final Report, Vol. II - Moose - Upstream. Alaska Dept. of Fish and Game.

Becker, E. F. and W. D. Steigers. 1987. Susitna Hydroelectric Project, Big Game Studies. Final Report, Vol. III - Moose forage biomass in the middle Susitna River basin, Alaska. Alaska Dept. of Fish and Game.

Becker, E. F. 1987. Susitna Hydroelectric Project. Big Game Studies. Final Report. Vol. VI - Moose Carrying Capacity Estimate. Alaska Dept. of Fish and Game.

Caribou

Pitcher, K. W. 1987. Susitna Hydroelectric Project, Big Game Studies. Final Report. Vol. IV - Caribou. Alaska Dept. of Fish and Game. 59pp.

Black Bear and Brown Bear

Miller, S. D. 1987. Susitna Hydroelectric Project, Big Game Studies, Final Report. Vol. V - Black Bear and Brown Bear. Alaska Dept. of Fish and Game.

Wolf

Ballard, W. B., J. S. Whitman, L. D. Aumiller, and P. Hessing. 1984. Susitna Hydroelectric Project, Big Game Studies. 1983 Annual Report. Vol. V - Wolf. Alaska Dept. of Fish and Game. 44pp.

Ballard, W. B., J. S. Whitman, and C. L. Gardner. 1987. Ecology of an exploited wolf population in southcentral Alaska. Wildlife Monographs No. __ (In press).

Wolverine

Whitman, J. S. and W. B. Ballard. 1984. Susitna Hydroelectric Project, Big Game Studies. 1983 Annual Report. Vol. VII - Wolverine. Alaska Dept. of Fish and Game. 25pp.

Dall Sheep

Tankersley, N. G. 1984. Susitna Hydroelectric Project, Big Game Studies. Final Report. Vol. VIII - Dall Sheep. Alaska Dept. of Fish and Game. 91pp.

Belukha Whale

Calkins, D. 1984. Susitna Hydroelectric Project, Big Game Studies. Final Report. Vol. IX - Belukha Whale. Alaska Dept. of Fish and Game. 16pp.

SUMMARY

The Nelchina caribou herd, which ranges over a 20,000 mi^2 area in southcentral Alaska, has been particularly important because of its size and proximity to population centers. A proposal to construct a large hydroelectric project which would include two reservoirs, access roads and assorted other developments on the Susitna River in the western portion of the Nelchina range has raised concerns about the welfare of this herd. Impact studies were conducted between April 1980 and October 1985 addressing the following objectives: (1) determination of range use, movement patterns, migration routes and timing of major movements; (2) evaluation of the population status of the Nelchina herd; (3) delineation of subherds; and (4) literature review of impacts of development on caribou and reindeer populations. 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. The primary methodology for the study was the repetitive relocation of radio-collared caribou along with standardized techniques of population size estimation and composition sampling.

Distribution was more variable in winter than during other seasons. Wintering Nelchina caribou ranged from the Talkeetna Mountains foothills, across the Lake Louise Flat, through the middle portions of the Gakona and Chistochina River drainages, along the northwestern slopes of Mount Sanford in the Wrangell Mountains, northeast through the Mentasta Mountains and onto the Tetlin Flats. Most wintering Nelchina caribou were distant from the proposed impoundment sites. Historical winter ranges in the Talkeetna Mountains and to the north of the Watana impoundment area were not used during the study.

Spring migrations to the Talkeetna Mountains calving grounds from winter ranges to the east included a northwesterly movement from the Lake Louise-Susitna Lake area south of the Tyone River into the Talkeetna Mountains, generally in the area of the Oshetna River. During some years (1980-1983) substantial numbers of females traversed the upper portion of the proposed Watana impoundment enroute to the calving grounds.

During all five years of the study the female segment of the herd utilized the traditional calving grounds located in the northern Talkeetna Mountains. Core drainages used during calving included the Oshetna and Black Rivers and Kosina Creek. Relocations of females during the calving period averaged 3,742 feet elevation. During the calving period radio-collared males were mostly in transit from winter to summer range. Fidelity to a single calving ground was shown

by 59 of 60 radio-collared females that were monitored for two or more calving seasons.

Primary summer range for the female-calf segment of the Nelchina herd during the study period was the northern and eastern slopes of the Talkeetna Mountains. Two radio-collared females left the Talkeetna Mountains after calving and spent the summer north of the Susitna River in the benchlands of the Chulitna Mountains, an area historically important as both summer and winter range. During summer male radio-collared caribou were found scattered throughout the high country of the Nelchina Basin with only small numbers intermingled with the cow-calf segment.

Movements of Nelchina caribou were variable during the autumn period with many animals dispersing out of summer range onto the Lake Louise Flat. More mixing of the sexes occurred than during calving and summer.

During the rut Nelchina caribou were found from the Talkeetna Mountains east to the Wrangell Mountains foothills. Considerable west-east movement usually occurred during this period. The sexes were generally well mixed.

Relocations of radio-collared caribou during this study encompassed an area of about 16,237 mi^2. The northeastern Talkeetna Mountains are the core area of the Nelchina caribou herd, containing the calving grounds, summer range and occasional winter range. The northwestern portion of the Nelchina range received minimal use by main Nelchina herd animals during this study while historically it was important summer and winter range.

The main Nelchina herd was estimated to contain 27,528 animals in October 1985; composed of 50% females $\geq$1 year, 27% males $\geq$1 year and 23% calves. During recent years the herd has undergone: a growth phase, 1950-1960; a peak, 1961-1965; a decline, 1966-1973; and another growth phase, 1974-1985. Between 1980 and 1985 the herd grew at about 8% annually with an additional 4% harvest. Adult survival was estimated at 0.91 and 0.93 respectively for females and males from the main Nelchina herd. Between 1980 and 1983 calf survival was estimated to average 0.44 for the first 11 months of life. Hunter harvest has been limited by a permit system during recent years and the reported harvest has averaged about 883 animals annually since 1980.

The precipitous decline of the Nelchina caribou herd from 70,000+ animals in the early to mid-1960's to <10,000 animals in the early 1970's appears to have resulted from multiple factors. Primary causes probably included excessive human harvest, increased predation and decreased calf survival during several severe winters.

Three distinct subherds were identified based on relocations of radio-collared caribou. Approximately 400 caribou were estimated to reside year-round in the upper Talkeetna River. The Chunilna Hills contained a resident group of about 350 caribou. About 1,500 animals occurred year-round in the upper drainages of the Susitna, Nenana and Chulitna Rivers. Probable subherds also occurred in the western Talkeetna Mountains and along the southern slopes of the Alaska Range.

Male and female radio-collared caribou used similar habitats during the rut and winter seasons when spruce forests were primarily utilized. During spring, calving, summer and autumn, habitat use was different between sexes. Males tended to utilize lower elevation habitats such as spruce forests and shrublands to a greater extent than females which more frequently used the highland tundra-herbaceous habitats.

The proposed Devil Canyon impoundment and transportation and powerline corridors to the west appear to have little potential to adversely impact Nelchina caribou as neither currently nor historically have many caribou occurred in this region.

The Watana impoundment area has historically been crossed by large segments of the Nelchina herd both during spring migration to the calving grounds in the Talkeetna Mountains and during summer and fall movements to summer and winter ranges north of the Susitna River. Recent crossings of this nature have been infrequent; however, it is probable that large scale movements will again resume at some point in the future. Skoog (1968) considered this region to be the most important for year-round use by Nelchina caribou. The major concern with the Watana impoundment is that the female segment of the herd will try to cross the reservoir during spring migration to the calving grounds and that mortalities will result because of hazardous conditions.

The proposed Denali access road would bisect summer and winter range for about half of the upper Susitna-Nenana subherd and would run through historical summer and winter range for the main Nelchina herd. It is uncertain what impacts the road would have; however, heavy traffic could result in avoidance by caribou and perhaps some mortality through caribou-vehicle collisions.

Disturbance from increased aircraft traffic and activities associated with project construction do not appear to be of serious concern as most activities would not occur in important caribou habitats or could be mitigated through time and area restrictions. Increased access and development in remote areas of the Nelchina range resulting from project construction must be considered as potentially detrimental to the herd.

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

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INTRODUCTION

The Nelchina caribou (*Rangifer tarandus*) herd, one of 28 herds in Alaska, is found primarily in the large basin formed by the upper drainages of the Susitna and Copper Rivers and surrounded by four mountain ranges: the Alaska Range, the Wrangell Mountains, the Chugach Mountains and the Talkeetna Mountains (Fig. 1). The Nelchina range contains a variety of habitats ranging from spruce-covered lowlands to steep, barren mountains. Human developments are largely limited to the peripheries of the Nelchina range and consist primarily of the Alaska Railroad, Parks Highway, Denali Highway, Richardson Highway, Trans-Alaska Pipeline, Glenn Highway and associated settlements.

This herd has been a particularly important wildlife resource because of its proximity to the majority of the state's population and because access to the herd is provided by the highway system. Since harvest records were started in 1946 nearly 112,000 caribou have been reported taken from this herd. The popularity of hunting for animals in this herd was shown in 1984 when 12,516 people applied (including a $5.00 application fee) for 1,900 permits to hunt for Nelchina caribou.

Because of its importance and accessibility, the Nelchina herd has been the most intensively studied caribou herd in Alaska (Doerr 1979). The U.S. Fish and Wildlife Service began studying the herd in 1948 and continued through 1959. Since that time the Alaska Department of Fish and Game has been continually involved with the Nelchina herd through both research and management programs. Skoog's (1968) doctoral dissertation, a major work on caribou biology, dealt largely with the Nelchina herd.

There is currently under study a proposal to construct a large hydroelectric project on the Susitna River in the western portion of the Nelchina caribou range. Impacts on the Nelchina herd of the proposed development, which may include two dams and impoundments, access roads and railroad spurs, electrical transmission lines and settlements, were unclear. Habitat loss to inundation did not appear to be a serious consideration as less than 1% of the total Nelchina range would be flooded and Skoog (1968) concluded that caribou use of the impoundment area was largely limited to transient animals. The proposed Watana impoundment could serve as a barrier to migrating caribou. The area along the Susitna between Deadman Creek and Jay Creek has served as a migration route both during spring migration to the calving grounds and during the post-calving shift to summer range north of the Susitna (Hemming 1971). Factors associated with ice dynamics on the Watana Reservoir such as ice shelving (Hanscom and Osterkamp 1980), ice jams and glare ice sheets could be a source of mortality to migrating

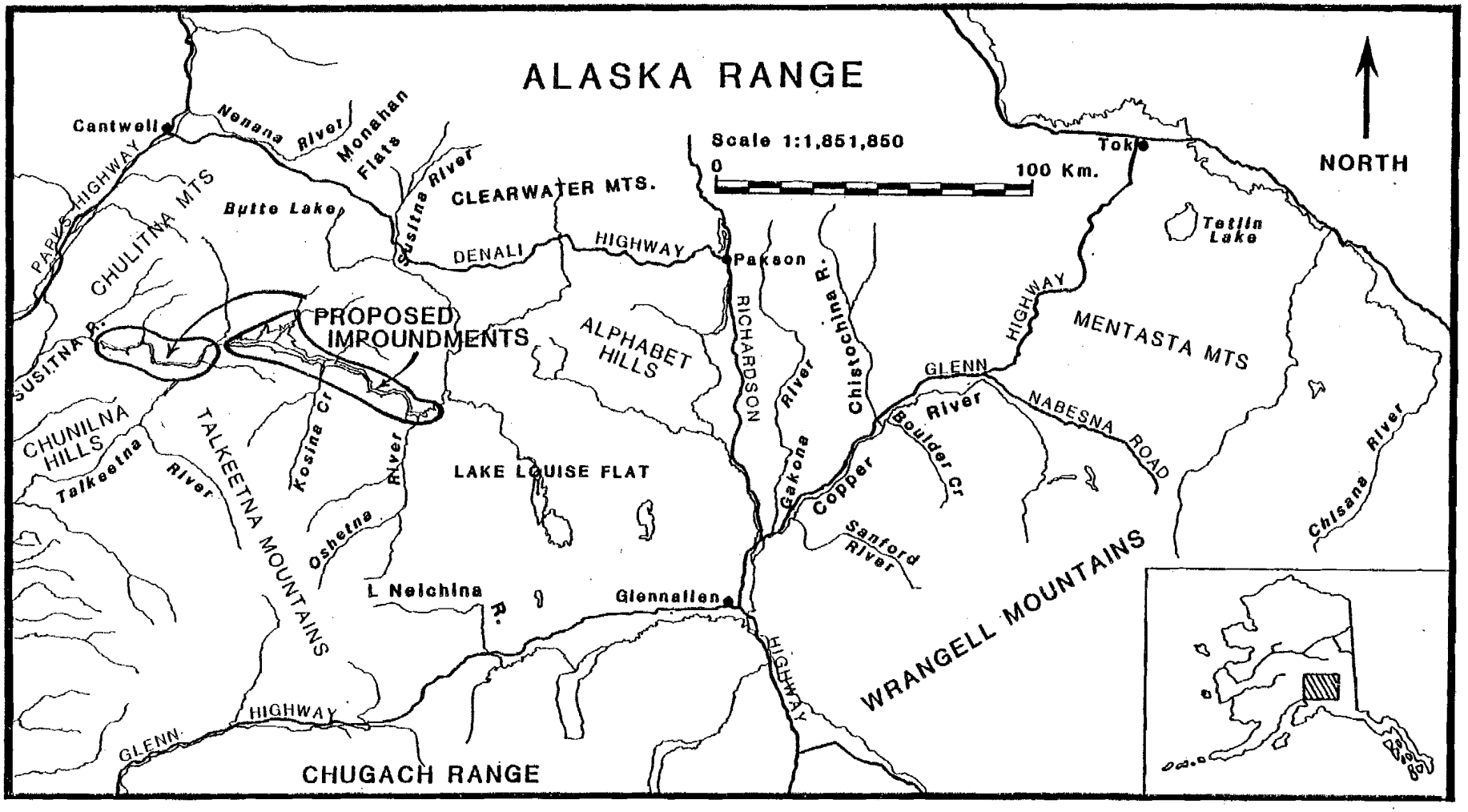

Figure 1. Neichina caribou range with basic geographic features.

caribou. Roads, railroads and electrical transmission lines have all been reported to disrupt caribou or reindeer movements (Klein 1971, Vilmo 1975, Cameron et al. 1979). Disturbances associated with construction and maintenance of hydroelectric facilities could result in reduction of caribou use of nearby areas as shown for the Prudhoe Bay oil fields (Cameron et al. 1979). The proximity of the Talkeetna Mountains calving grounds to the proposed Watana impoundment is of concern because of increased human activity associated with development in the area. Concern has been expressed that subherds in the general region of the proposed impoundments could become more isolated by construction of the Susitna hydroelectric project.

Studies to evaluate potential impacts of construction and operation of the proposed Susitna hydroelectric project and to suggest possible mitigation were begun during the spring of 1980 and continued through fall 1985. Specific objectives included: (1) determination of range use, movement patterns, migration routes and timing of major movements with emphasis on movements occurring in the vicinity of proposed development; (2) evaluation of the population status of the Nelchina herd including estimates of herd size, productivity and mortality; (3) delineation of subherds within the overall range of the main Nelchina herd; and (4) literature review of impacts of human development on caribou and reindeer populations.

Complicating the interpretation of data gathered during short-term studies of caribou range use and migratory routes is the well-recognized tendency for changes in range use, particularly winter range (Skoog 1968). Therefore the analysis of data resulting from this study must be considered in light of historical information. It is fortunate that considerable information is available on the Nelchina herd and these data were used extensively in this analysis.

METHODS

Data on range use, timing of movements, migratory routes, movement patterns and subherd status were collected by periodic relocations of radio-collared caribou. It was assumed that the behavior of radio-collared caribou was representative of the herd in general and I have no reason to suspect that this was not true. Caribou were captured by use of immobilizing drugs; etorphine (M-99), xylazine (Rompun) and acepromazine administered with projectile syringes (Cap-Chur equipment) shot from a helicopter. Radio-collars in the 152.000-153.999 MHz range, purchased from Telonics Inc., were used. Radio-collared caribou were relocated from a fixed-winged aircraft (Cessna 180, 185 or PA-18) equipped with two Yagi antennas, one attached to wing struts on each side of the aircraft. Antenna leads were

attached to a right/left switch box coupled to a radio-tracking receiver/scanner. Animals were located by balancing the transmitter signal between the two antennas through use of the left/right switch box to orient the aircraft and follow the signal. During the study period 85 radio-collared caribou were monitored between 1 and 63 months each for a total of 2,651 individual relocations.

Seasonal periods used for data analysis were: calving, 15 May-10 June; summer, 11 June-31 July; autumn dispersal, 1 August-30 September; rut 1-31 October; winter 1 November-31 March; and spring migration, 1 April-14 May.

The study area consisted of the entire range of the Nelchina caribou herd as detailed in the Introduction (Fig. 1). However we monitored radio-collared animals much more frequently when they were in the vicinity of the proposed Susitna hydroelectric development.

Radio-collared animal relocation data were initially recorded on a paper map and the associated descriptive information was entered on a field form. The descriptive data were keypunched and entered on a computerized data file. The relocation data were recorded with a computerized geoprocessor. Specifics of the data management program are detailed in the Biometrics and Data Processing report by Miller and Anctil (1981).

A modified version of the aerial photo-direct count-extrapolation census procedure (Hemming and Glenn 1969, Davis et al. 1979, Doerr 1979) was used to estimate the size of the main Nelchina herd. This technique is composed of three separate procedures: (1) a complete count of all animals in the post-calving aggregation; (2) composition sampling of these same animals to determine the number of females $\geq$1 year; and (3) representative fall composition sampling to estimate the proportions of females, males and calves in the herd. Herd size is then estimated using the female estimate obtained from the post-calving aggregation count and composition sampling and the estimate of herd composition obtained in the fall. Critiques of this procedure are available from Davis et al. (1979) and Doerr (1979).

Actual counts of caribou in the post-calving aggregation were made by observers from PA-18 Super Cub aircraft. Most caribou were counted visually although when larger groups (>250 animals) were encountered they were photographed with hand-held 35 mm cameras. During the censuses conducted during this study no extremely large aggregations (>2,000) of caribou were encountered.

A helicopter (Bell 206B) was used to sample the post-calving aggregations, the herd during the rut and the herd in April

to estimate proportions of females, males and calves. Groups of animals were approached from the rear until the sex of each animal older than a calf could be determined from the external genitalia (presence or absence of the vulva).

Estimates of mean annual survival rates were made from radio-collared animals using a formula provided by Trent and Rongstad (1974). This formula is based on the number of mortalities experienced by radio-collared animals and the period of time the radio-collared animals were monitored.

Estimates of calf survival to 11 months of age were made by multiplying the calf to female ≥1 year ratio obtained in April by the estimate for annual survival of females ≥1 year, and then dividing by the ratio of calves to females ≥1 year at birth (Fuller and Keith 1981).

RESULTS AND DISCUSSION

Distribution and Movements: Main Nelchina Herd

Winter (1 November-31 March) Winter distribution was the most variable for any seasonal period ranging from the Talkeetna Mountains foothills and lower Watana Creek area in the west to the Chisana River and Tetlin Lake area in the east (Fig. 2). During the winters of 1980-81 and 1981-82 the primary wintering areas were the eastern Lake Louise Flat and the middle portions of the Gakona and Chistochina River drainages (Figs. 3&4). In winter 1982-83 Nelchina caribou ranged from the Tetlin Lake-Chisana River area, through the Mentasta Mountains, along the Wrangell Mountains foothills, throughout the Gakona and Chistochina River drainages and onto the Lake Louise Flat (Fig. 5). During winter 1983-84 the herd divided into three main concentrations (Fig. 6) with interchange among all groups. The largest concentration (about 15,000) ranged along the Wrangell Mountain foothills between the Dadina River and the headwaters of the Copper River. A smaller group of caribou (perhaps 2,500) was found along the northeastern slopes of the Mentasta Mountains. The third group (about 6,500) wintered on the Lake Louise Flat, primarily west of Lake Louise. Winter distribution in 1983-84 was the most dispersed winter distribution seen during the entire study period, with Nelchina caribou spread over an east-west range of about 150 miles. During the winter of 1984-85 most Nelchina caribou remained in the western portion of the range, primarily on the western Lake Louise Flat and in the Talkeetna Mountains foothills (Fig. 7).

During winter males tended to be segregated from females (Fig. 2) and used some of the same locations from year to

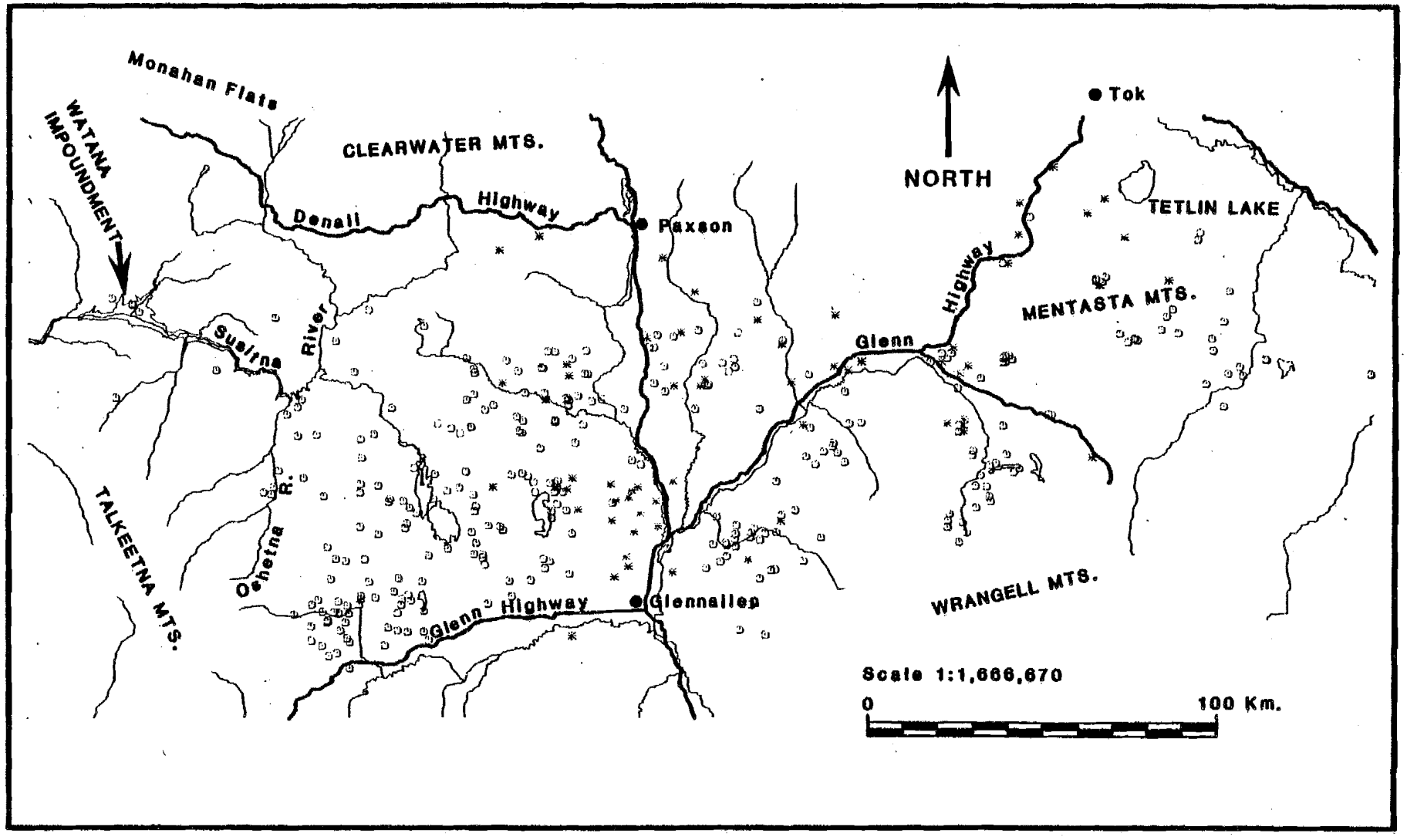

Figure 2. Distribution of Nelchina radio-collared caribou during winter, 1 November-31 March, 1980-1985. ●=females, ✱=males.

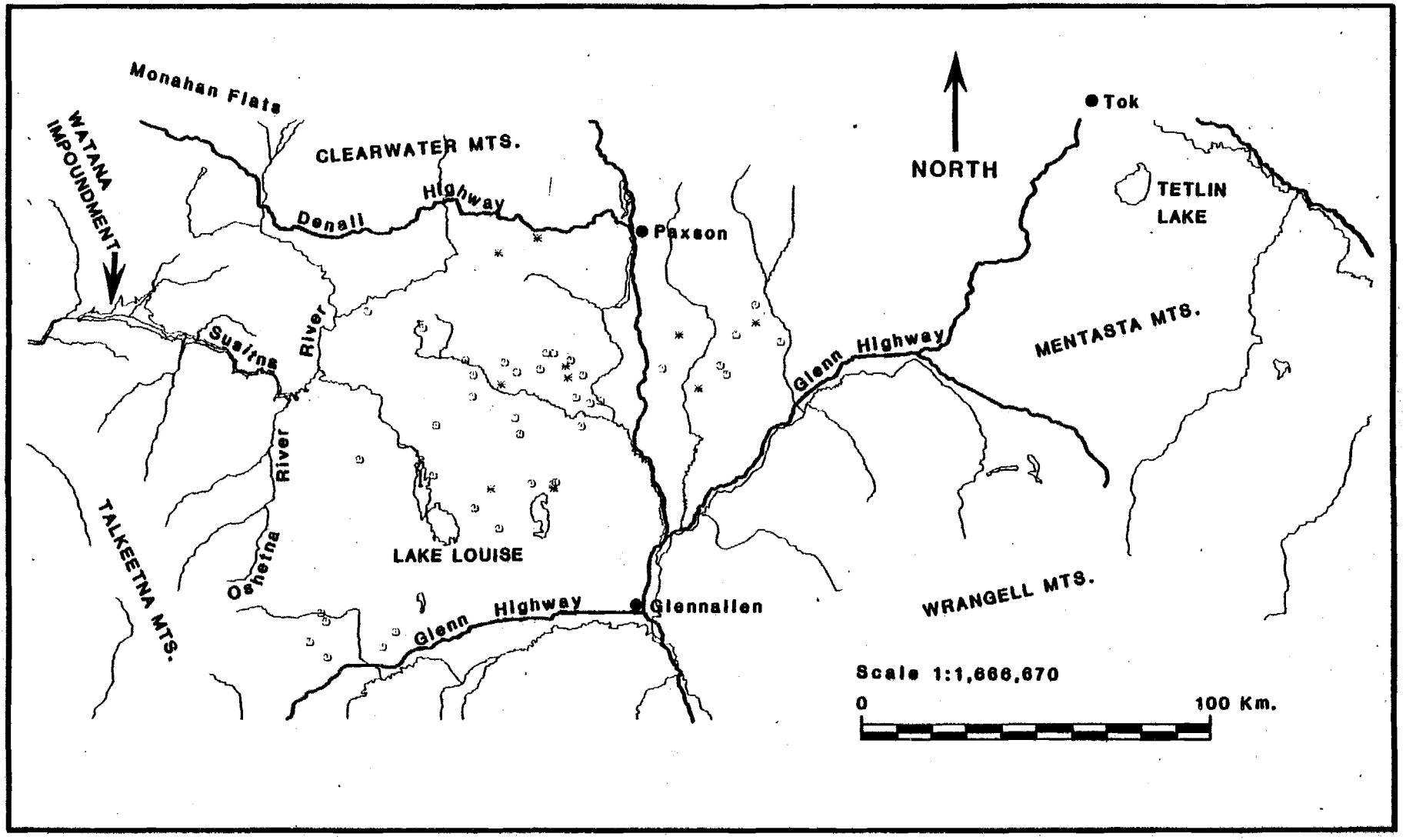

Figure 3. Distribution of Nelchina radio-collared caribou during winter, 1 November 1980-31 March 1981. ●=females, ✱=males.

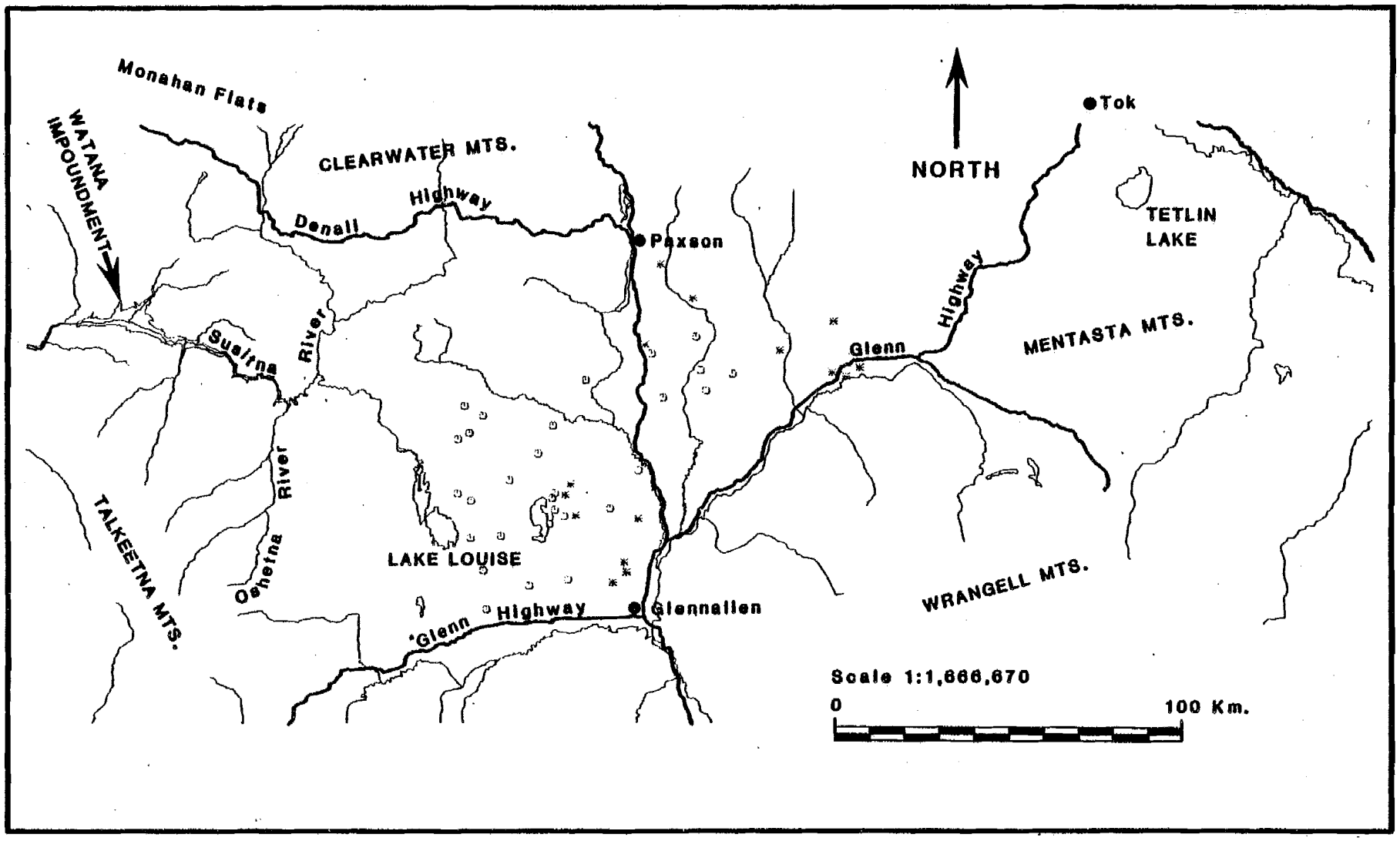

Figure 4. Distribution of Nelchina radio-collared caribou during Winter, 1 November 1981–31 March 1982. ●=females, * =males.

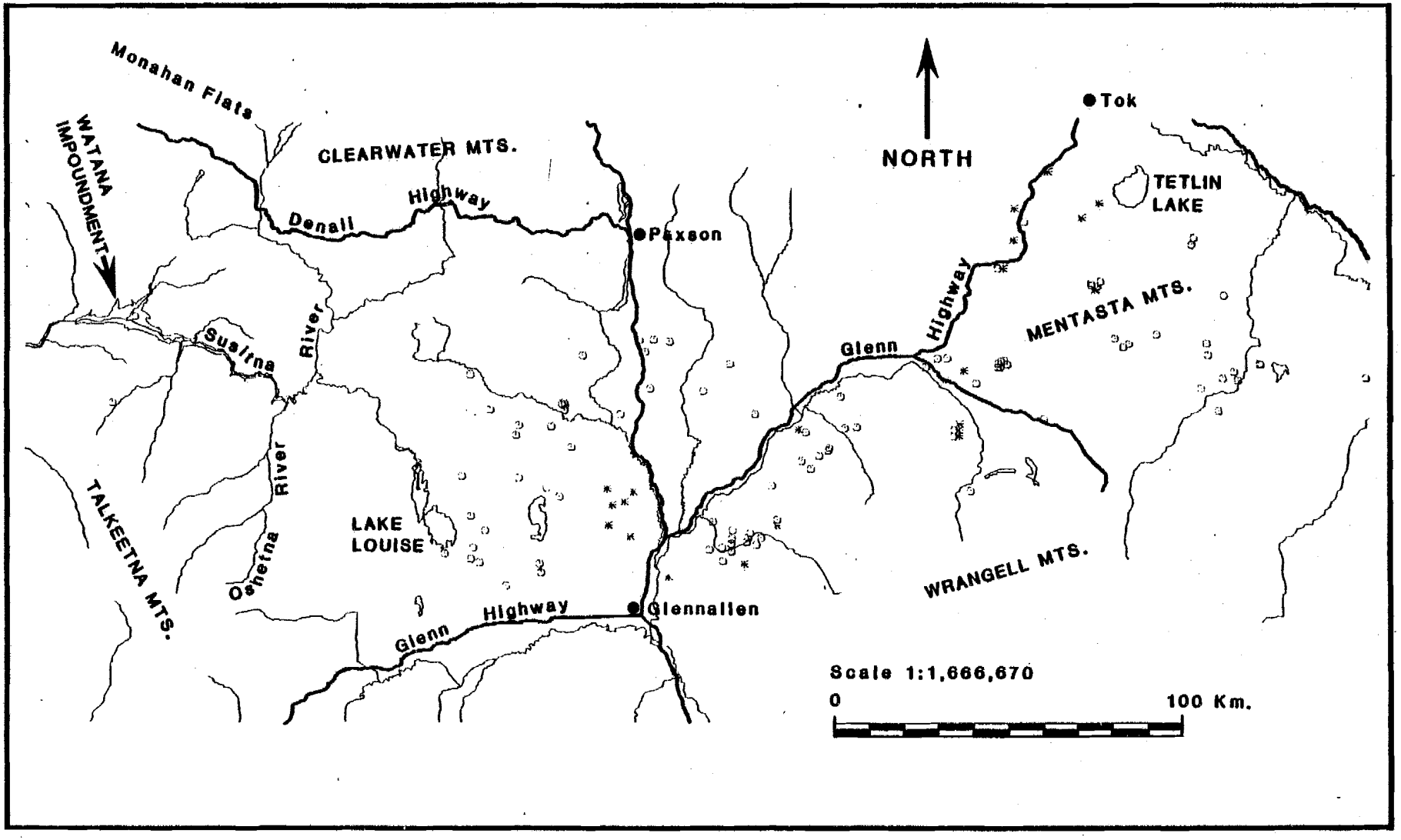

Figure 5. Distribution of Nelchina radio-collared caribou during winter, 1 November 1982-31 March 1983. ●=females, *=males.

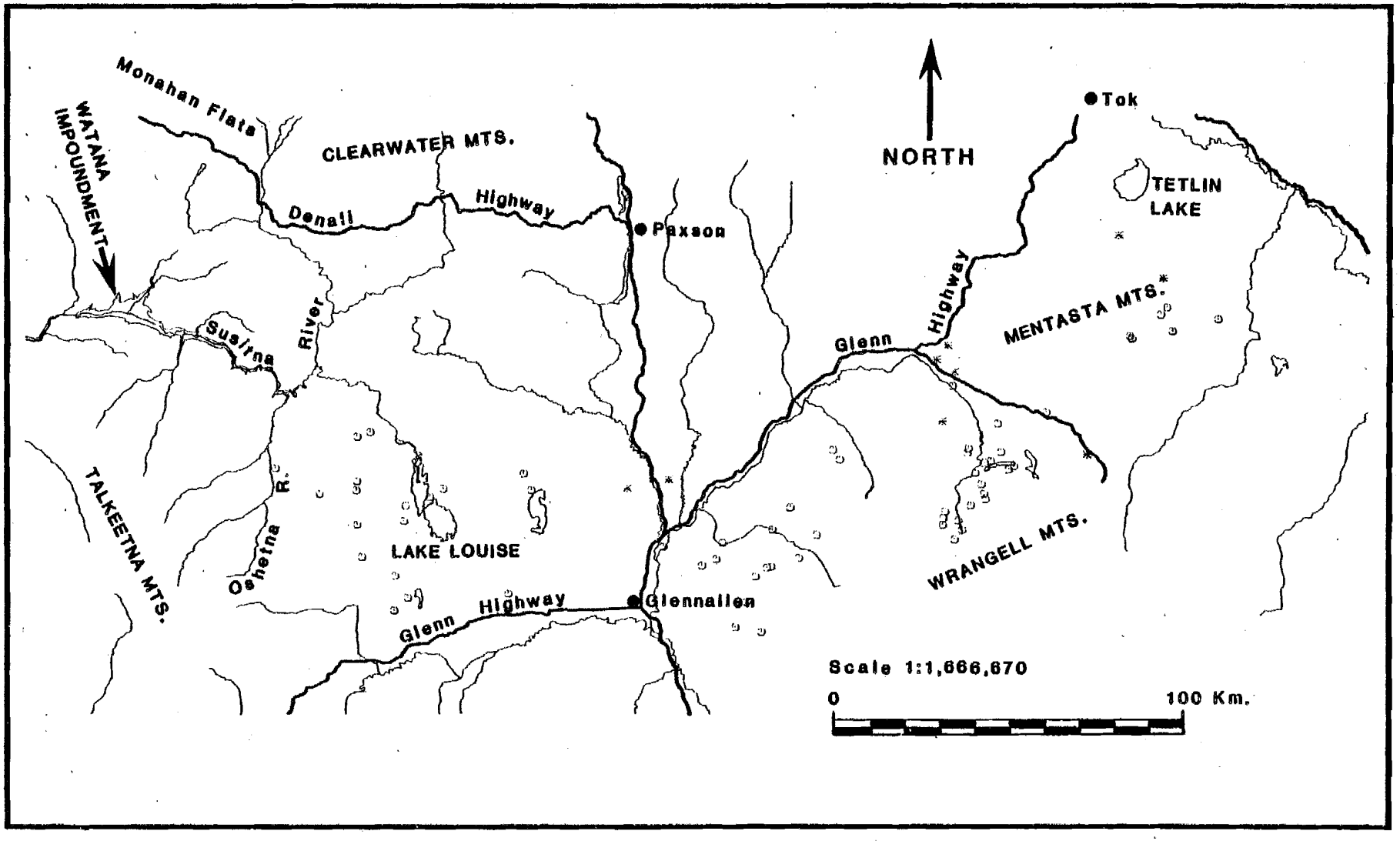

Figure 6. Distribution of Nelchina radio-collared caribou during winter, 1 November 1983-31 March 1984. o=females, *=males.

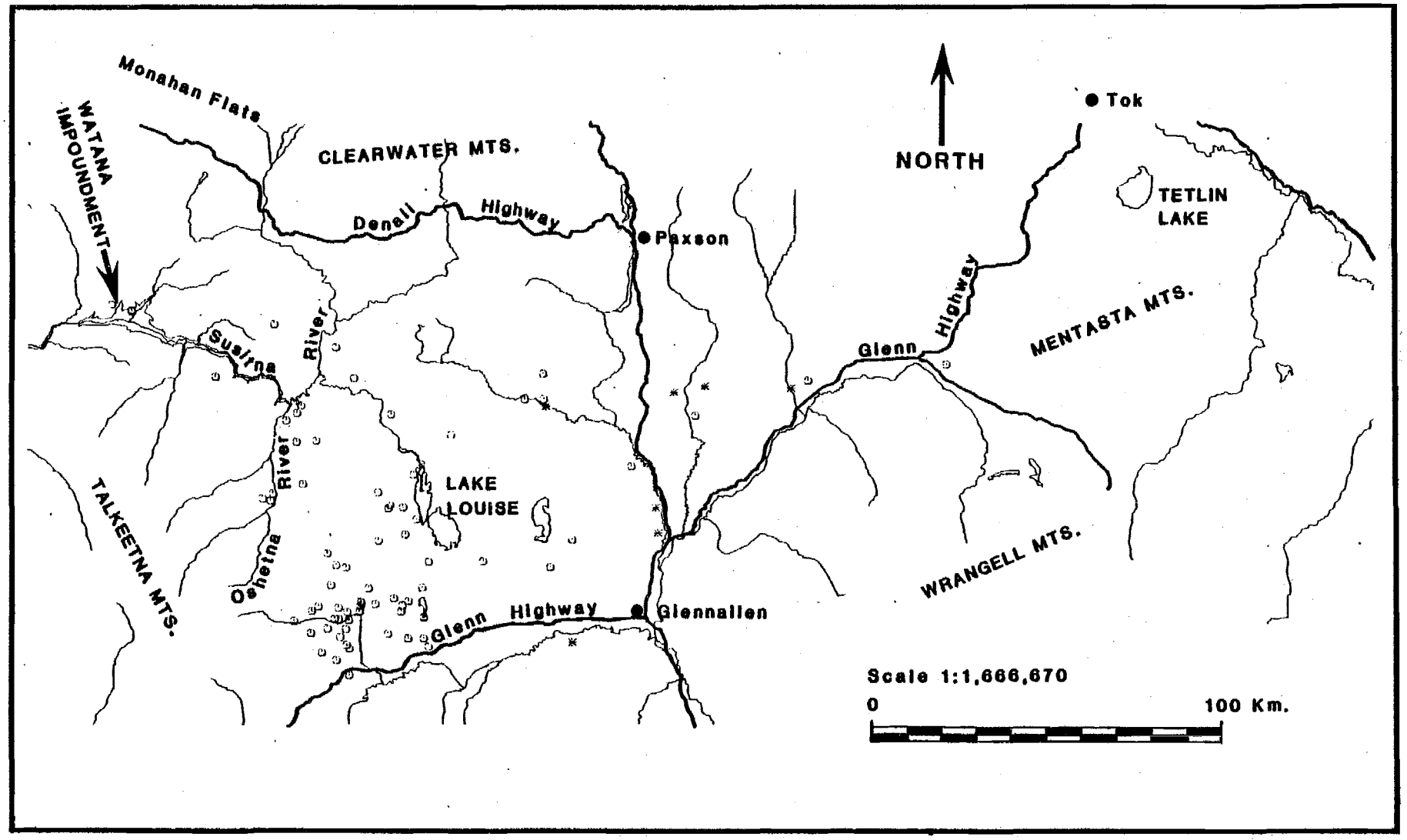

Figure 7. Distribution of Nelchina radio-collared caribou during winter, 1 November 1984-31 March 1985. e=females, *=males.

year (Figs. 3-7). Concentrations of wintering bulls were found in the area east of the Richardson Highway and north of Glennallen, the area near Slana and the Gakona and Chistochina River drainages.

Movements of Nelchina caribou, northeast of the Mentasta Mountains such as occurred during 1982-83 and to a lesser extent in 1983-84, have only rarely taken place. During the winter of 1965-66 a similar movement occurred and it was speculated that emigration of Nelchina caribou may have occurred (Glenn 1967). A similar movement may have also taken place during 1978-79 as caribou trails were seen going to the northeast through the Mentasta Mountains and caribou sightings were reported from the Tok-Tetlin area (R. Tobey, S. Eide; pers. comm.). Speculation that such movements outside of "normal" range are caused by either behavioral or food-related pressures resulting from high population densities (Skoog 1968) does not seem appropriate as only one of these movements (1965-66) occurred during a population high.

During winters that Nelchina caribou utilized the Wrangell Mountains foothills, the Mentasta Mountains and the Tetlin area, they were intermingled with Mentasta herd caribou. During the winter of 1982-83 a radio-collared Mentasta animal wintered on the Lake Louise Flat among Nelchina caribou. Despite this mixing during winter all radio-collared animals returned to their original calving grounds or summer range.

Nelchina caribou have used numerous winter ranges during the past 30 years (Table 1, Fig. 8). Important historical winter ranges not utilized between 1980 and 1985 were: range unit 5, located north of the middle portion of the Susitna River; range unit 11, primarily the Talkeetna River; range unit 12, essentially calving and summer range in the Talkeetna Mountains; and range unit 15, southeastern Talkeetna Mountains. There appears to be considerable winter range available which has not been utilized in recent years.

Spring Migration (1 April-14 May) The migratory route of the female segment of the herd from winter range to the calving grounds in the northeastern Talkeetna Mountains depends primarily on the location of the winter range. During the five winters of this study Nelchina caribou used winter ranges to the east so their general approach to the Talkeetna Mountains was similar each year, with only minor variations. This included a northwesterly movement from the Lake Louise-Susitna Lake area south of the Tyone River (Fig. 9). Entry into the foothills usually took place in the vicinity of Oshetna River and its confluence with the Susitna River. During the springs of 1980-1983 substantial numbers (exceeding 50% in 1982) of the female segment of the

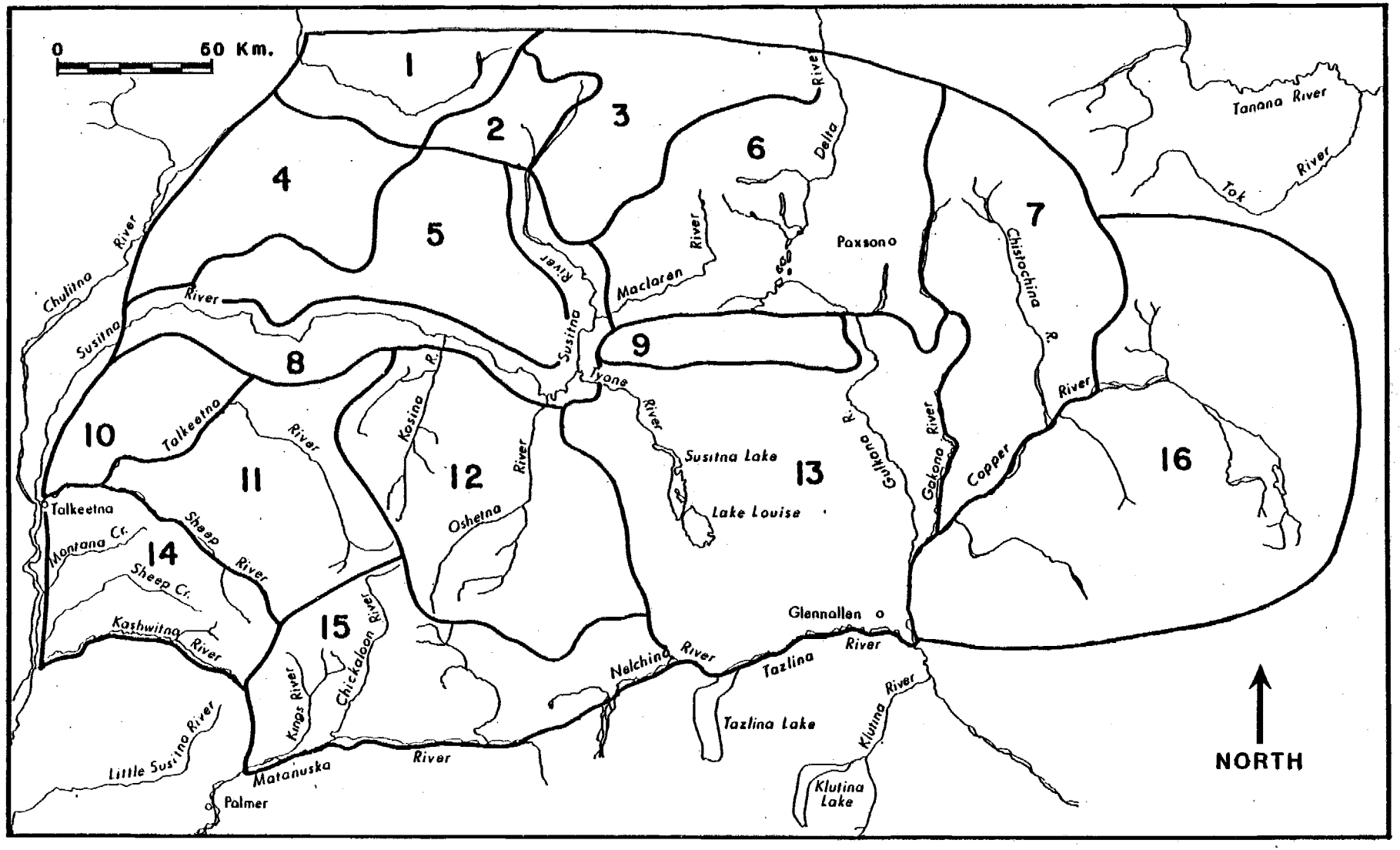

Figure 8. Division of Nelchina range into areal units based upon topography, vegetation and caribou use (modified from Skoog 1968).

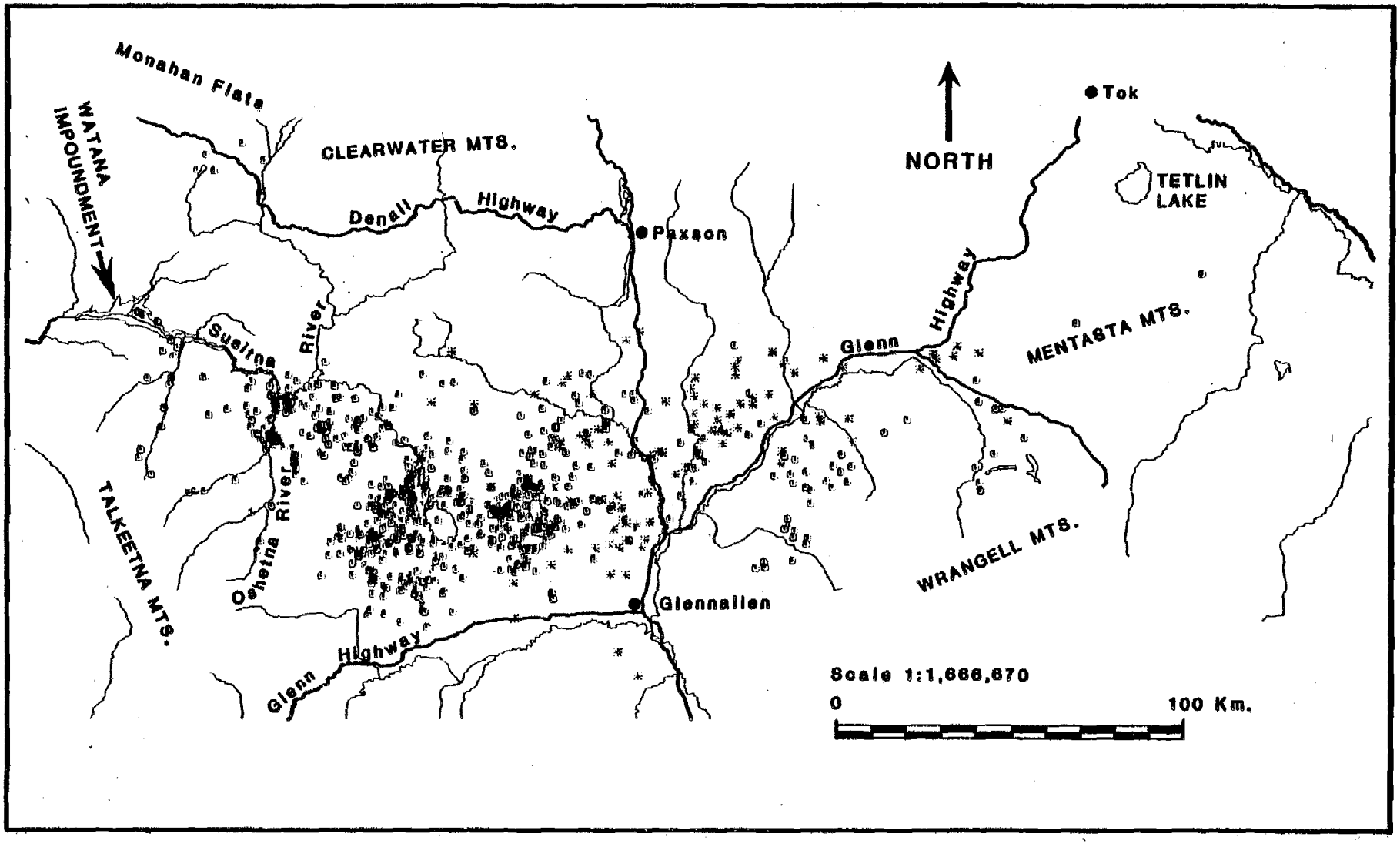

Figure 8. Distribution of Nelchina radio-collared caribou during spring migration, 1 April-14 May, 1980-1985. ●=females, *=males.

Table 1. Historical range use of the Nelchina caribou herd (modified and expanded from Skoog 1968).

Year	Calving* Grounds	Summer* Range	Rut*	Winter* Range
51-52	12	12,5	13,5,12	13,12
52-53	12	12,5,15	13,12,15	13
53-54	12	5,12	5,12,13	13
54-55	12	5	5,6	13
55-56	12	12,15	12,15,16	5,12,6,9
56-57	12	5,12,15	5,6	5,1,6,11
57-58	12	5,12	5,6,13,15	11,2,5,15
58-59	12	5,12	5,13,11,12,13	11,15,1,5,6,13
59-60	12	5,12	12,15,6	1,11,5,13
60-61	12	5,9,6,12	13,15,5,11	5,11,1,2,13
61-62	12	5,9,6,12	12,13,6,15	1,6,2,5,11
62-63	12	5,12	13,15,6,12	1,13,2,5,11,15
63-64	12	5,12	5,13,6,12	1,5,6,11
64-65	1,5,12	5,12	5,9,13,6	1,5,6
65-66	12,8,11	5	6,9,13	16,13,15
66-67	12,8,11	5,4	9,11,13	16,13,1,2
67-68	12	5,4,12	--	16,13,1,4,5
68-69	12	5,12	13	13,7,8,11,2
69-70	12	12,5	12	13
70-71	12	5,12	13	16,13
71-72	12	5,12	13	16,13,15
72-73	12	12,5	12,15	15,7,13
73-74	12	--	15,13,12	15,13,12
74-75	12	12	--	16,13
75-76	12	12	--	13
76-77	12	12,5?	12,13	13,16
77-78	12	12	12,13	13,16
78-79	12	12	13	13,16
79-80	12	12	--	13,7
80-81	12	12,15	13	13,7
81-82	12	12,15	13,7	13,7
82-83	12	12,15	13,7,8,12	16,13,7
83-84	12	12,15	7,16,13	16,13
84-85	12	12,15	13,12,8,5	13,12,8
85-86	12	12,15	7,16	

*Range units modified from Skoog (1968): see Fig. 8.

herd traversed upper portions of the proposed Watana impoundment enroute to the calving grounds. In 1981 it appeared, based on sequential relocations of radio-collared caribou and sightings of tracks and caribou, that many animals used the frozen Susitna River as a travel route between the Oshetna River and Kosina Creek. In 1982 the Susitna was ice-free during spring migration and a small

portion of the female segment crossed the river and traversed the peninsula north of the big bend and then recrossed the Susitna near the gaging station. In 1983 it appeared that only a small portion of the female segment was in the Watana impoundment area during spring migration which involved fewer animals than during the three previous years. During the springs of both 1984 and 1985 migrating females moved south of the proposed impoundment. Movements of females onto the calving grounds generally occurred during the first two weeks of May although considerable annual and individual variation took place.

In spring 1980, 1983 and 1985 three radio-collared females moved down from the Butte Lake area and crossed the Susitna in the vicinity of Watana Creek. Historically, many animals used this route to the calving grounds after wintering north of the Susitna River (Skoog 1968, Hemming 1971).

Most males lagged behind the females and remained on winter range longer in the spring. Most males did not migrate to the calving grounds but moved instead to summer range in the high country throughout the Nelchina basin (Fig. 9).

Calving Period (15 May-10 July) Locations of radio-collared caribou during the broad limits of the calving period (15 May-10 June) ranged across the northern slopes of the Talkeetna Mountains from Sanona Creek to the alpine foothills east of Fog and Stephan Lakes (Fig. 10) encompassing an area of about 3,307 km^2 (1,277 mi^2). Mean elevation of female relocations during this period was 3,742 feet, ranging from 2,300 to 5,800 feet. This does not precisely portray the exact calving sites as most births occur from 20-28 May (Skoog 1968) so many of the relocations were either before or after actual calving. Core drainages used during calving were the Oshetna and Black Rivers and Kosina Creek. During the calving period, radio-collared Nelchina bulls were found generally to the east of the calving grounds (Fig. 10) mostly in transit to summer range.

Since 1949, the first year for which records are available, Nelchina caribou have utilized an area of about 1,600 km^2 (1,000 mi^2), in the northern Talkeetna Mountains, for calving (Bos 1974, Hemming 1971, Skoog 1968). While the precise areas utilized have varied, calving has taken place between about 3,000 and 4,500 feet elevation. Limited deviations of this pattern have occurred. In 1964 deep snow delayed arrival at the calving grounds (Skoog 1968) and many cows apparently gave birth to their calves north of the Susitna River (Lentfer 1965). In 1965 (McGowan 1966) and 1966 (Glenn 1967) some calving occurred in the Fog-Stephan Lakes area which is to the west of the normal calving area. In 1972, following a deep-snow winter, females were late arriving on the calving grounds and it was thought that delayed calving occurred (Bos 1973). During the spring of

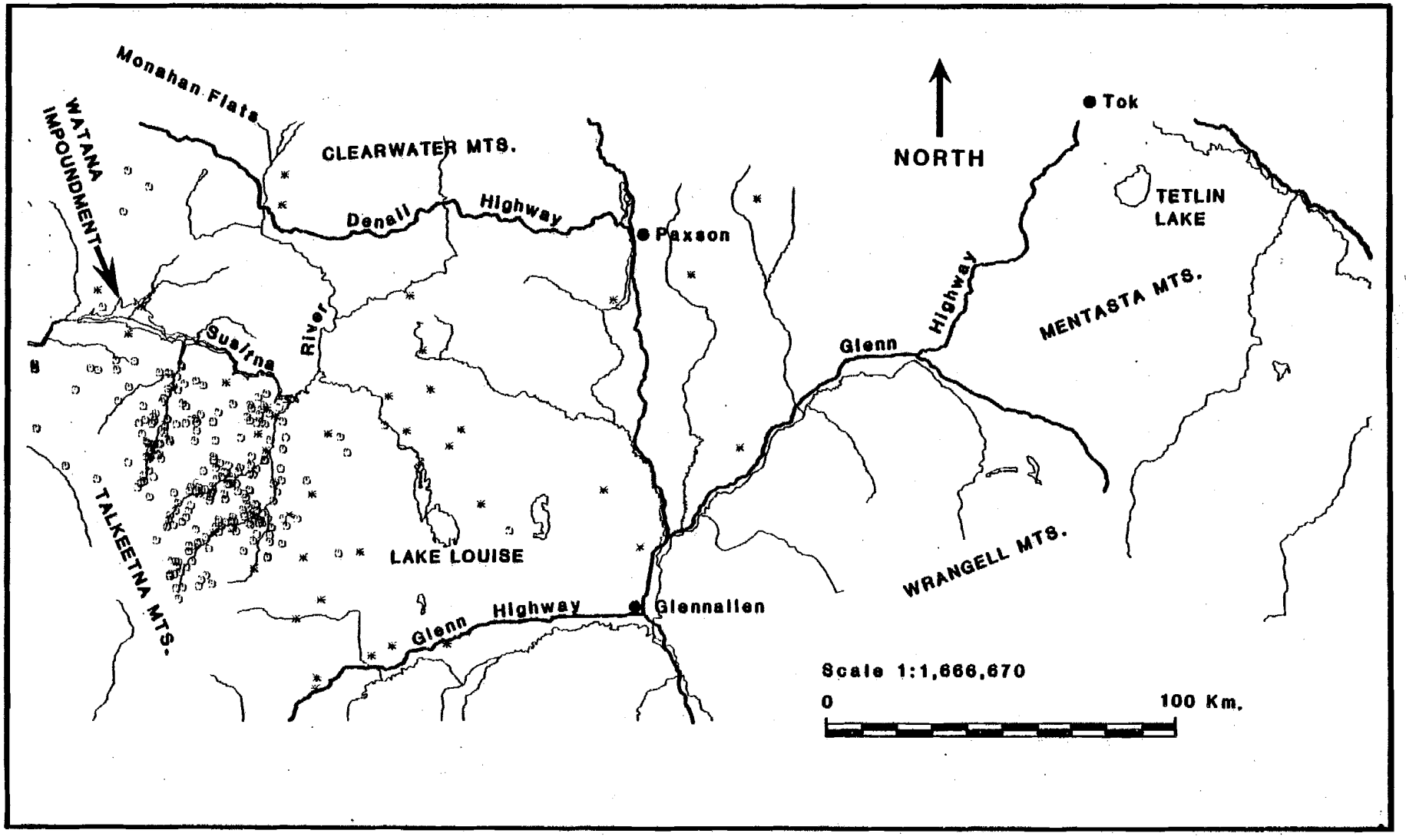

Figure 10. Distribution of Nelchina radio-collared caribou during calving, 15 May–10 June 1980–1985. •=females, *=males.

1982, a year with deep snow in the eastern Talkeetna Mountains, calving took place at lower elevations ($P < 0.05$) than during other years of the study (mean of 3,100 feet compared with 3,742 feet during all years of the study).

Shideler (1986) concluded that it is not always possible to recognize unique characteristics of heavily used geographic areas or habitats, but when disproportionately large numbers of animals select an area (such as a calving ground) over a period of years it must be assumed that this behavior confers some advantage to the animals. Therefore a loss of habitat or reduction in access is likely to disadvantage the population.

Fidelity to a single calving ground was shown by 59 of 60 radio-collared females that were monitored for two or more calving periods. The single exception was a female that calved north of the Susitna River and to the west of Deadman Mountain in 1983. The following two years she calved on the Talkeetna Mountains calving ground of the main Nelchina herd.

Summer (11 June-31 July) Primary summer range for the female-calf segment of the Nelchina herd between 1980 and 1985 was the northern and eastern slopes of the Talkeetna Mountains (Fig. 11) ranging from the Little Nelchina River to the hills east of Fog and Stephan Lakes, an area of about 3,904 km^2 (1,507 mi^2). This was basically an expansion of the calving grounds utilizing higher elevations and peripheral areas. The Oshetna River was the most heavily used portion of the summer range. At least two radio-collared females left the Talkeetna Mountains after calving and crossed the Susitna River in the proposed Watana impoundment area to summer range in the eastern benchlands of the Chulitna Mountains. Historically, movements across the Susitna River after calving were common as the Nelchina herd has used summer range in both the Talkeetna Mountains and in the Chulitna Mountains benchlands (Hemming 1971, Skoog 1968). In 1971 the female-calf segment of the herd crossed the Susitna River at least four times in May and June (Pegau and Bos 1972). To my knowledge, main Nelchina herd caribou have not used summer range north of the Susitna River to any significant degree since about 1976, although between about 1951 and 1972 it was utilized in most years (Table 1). Crossing apparently occurred between Deadman Creek and Vee Canyon (Skoog 1968).

During summer male radio-collared caribou were found scattered throughout the high country of the Nelchina Basin (Fig. 11) with only small numbers intermingled with the cow-calf segment. Summering males were found in the upper Gakona River, the Alphabet Hills, the Clearwater Mountains, the Chulitna Mountains and benchlands, and throughout the northern and eastern Talkeetna Mountains. It appeared that

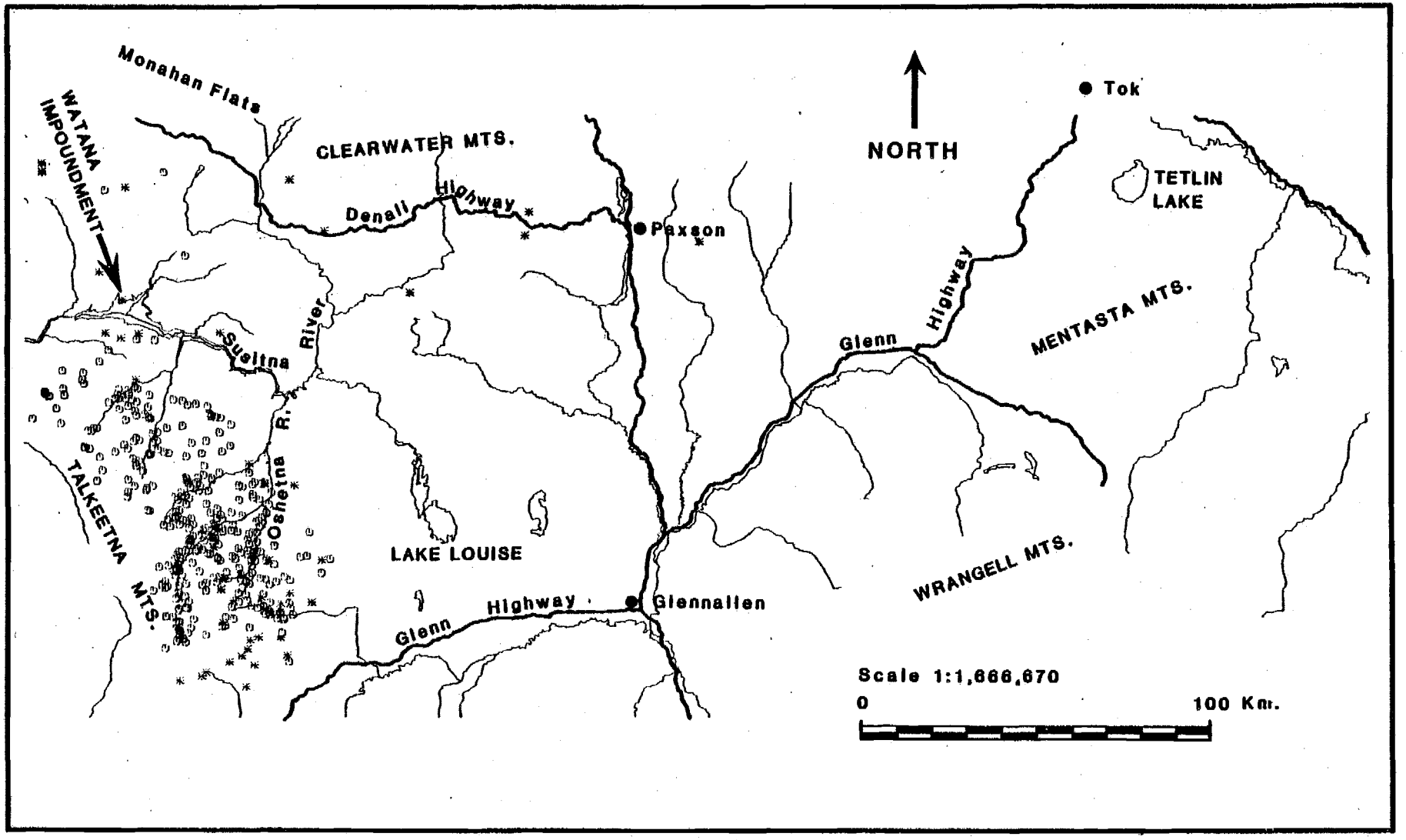

Figure 11. Distribution of Nelchina radio-collared caribou during summer, 11 June-31 July, 1980-1985. o=females, *=males.

the largest concentration of summering bulls was located in the southeastern Talkeetna Mountains in the vicinity of Caribou Creek.

Autumn (1 August-30 September) Movements of Nelchina caribou during this period were quite variable. Considerable use of summer range occurred although animals often dispersed across the Lake Louise Flat and into the Alphabet Hills (Fig. 12). Individual movements were often extensive with some individuals traversing the Lake Louise Flat between the Talkeetna Mountains and the Alphabet Hills and then returning to the Talkeetna Mountains. Some individuals moved to the north across the Susitna River in the proposed Watana impoundment area. The amount and timing of movement out of summer range varied greatly between years. More mingling of the sexes occurred during this period than during calving and summer. Movements during this period were more like dispersals or wanderings than directed migrations.

Rut (1-31 October) During the study period rutting Nelchina caribou were found from the Talkeetna Mountains north to the Butte Lake-Brushkana Creek area and east to the Wrangell Mountains foothills (Fig. 13). Historically Nelchina caribou have rutted in a wide variety of locations with the eastern Talkeetna Mountains and Lake Louise Flat being most extensively used (Table 1). The Deadman-Butte Lakes area was heavily used during years that segments of the herd wintered or summered in the area. Often, considerable movement occurs during the rut, usually from west to east. It appears that habitat type is not a critical determinant of rutting location but rather rutting occurs in virtually any area that caribou might be moving through during that period. The sexes are usually well mixed during this period (Skoog 1968) although some males may be apart from the cow-calf segment both early and late in the month.

Current Distribution (1980-1985) Use of the Nelchina range by radio-collared caribou from the main herd during the entire study period is shown in Figure 14. The area encompassed about 42,055 km^2 (16,237 mi^2). On an annual basis the area utilized was as follows: 1980-81, 18,341 km^2 (7,081 mi^2); 1981-82, 22,800 km^2 (8,803 mi^2); 1982-83, 36,193 km^2 (13,974 mi^2), 1983-84, 33,511 km^2 (12,939 mi^2); 1984-85, 32,912 km^2 (12,707 mi^2). Skoog (1968) considered the main portion of the Nelchina range to be composed of about 45,000 km^2 (17,5000 mi^2); however, he did not include the Wrangell Mountains foothills or the area to the northeast of the Mentasta Mountains in these calculations as they were not utilized to a significant extent during that period. He included areas in the western portion of the range that were not utilized during this study. Hemming (1971) considered the Nelchina range to be

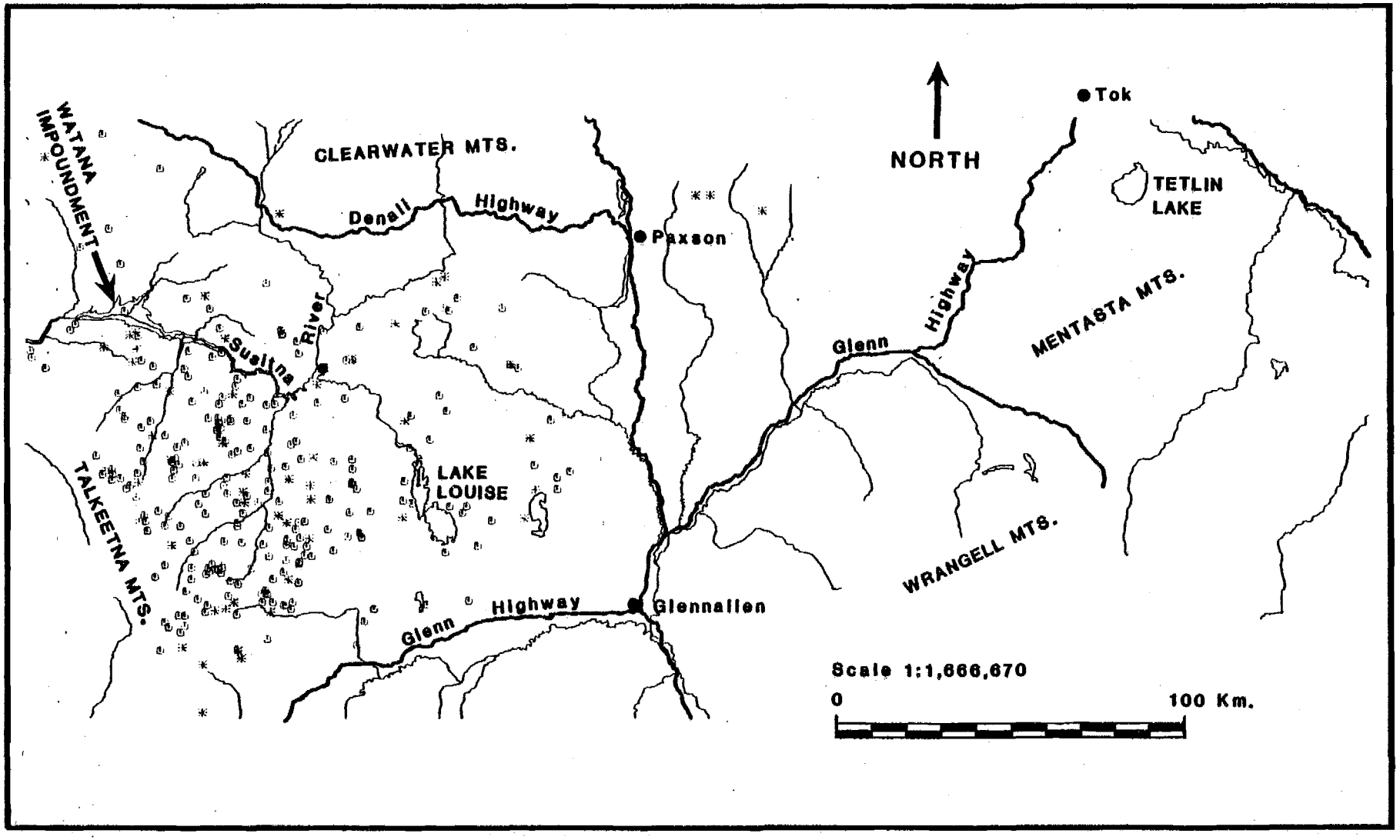

Figure 12. Distribution of Nelchina radio-collared caribou during autumn, 1 August-30 September, 1980-1984. ● = females, ✱ = males.

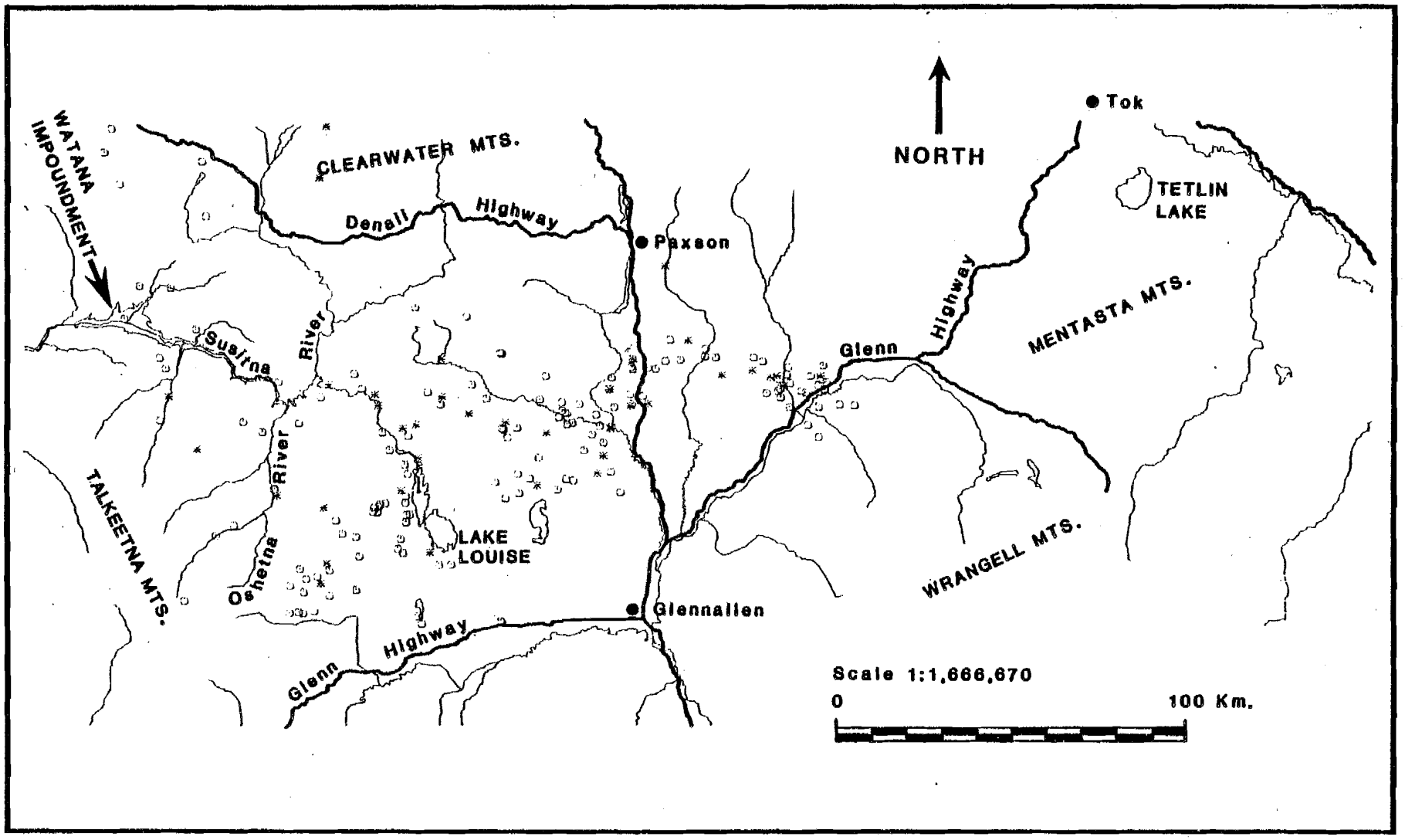

Figure 13. Distribution of Nelchina radio-collared caribou during the rut, 1-31 October 1980-1985. o=females, *=males.

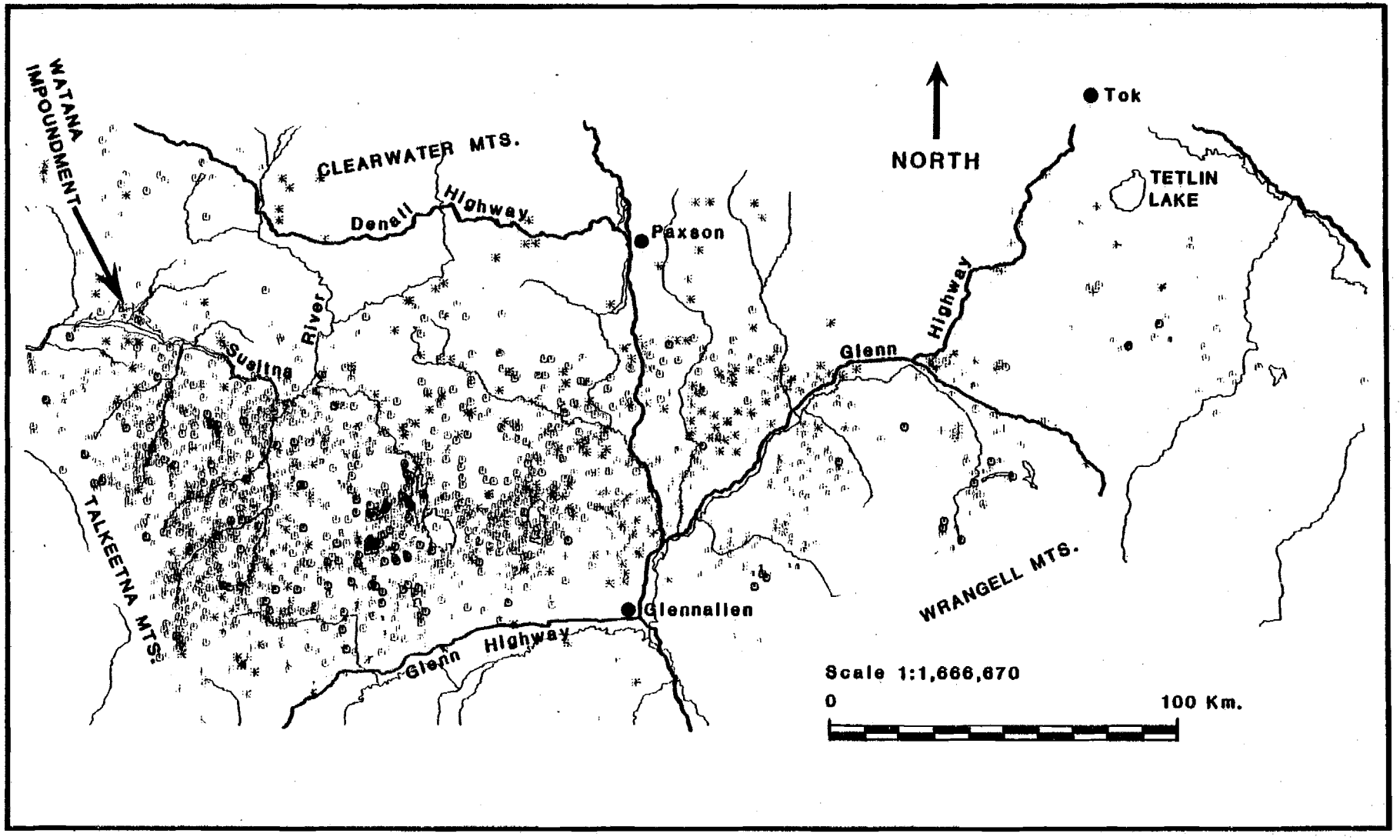

Figure 14. Distribution of main herd Nelchina radio-collared caribou during entire study period, 14 April 1980-12 October 1985. o=females, *=males.

composed of about 52,000 km^2 (20,000 mi^2) at the time of his work in the area.

The northern and eastern Talkeetna Mountains are the core of the Nelchina caribou range. The herd has shown near-perfect fidelity to the calving grounds located in this region. The Talkeetna Mountains are also the primary summer range and have been used on occasion as winter range (Skoog 1968). Locations of winter ranges are the most variable and during this study have included the Lake Louise Flat, Gakona and Chistochina River drainages, Wrangell Mountains foothills, Mentasta Mountains and area to the northeast, and the Talkeetna Mountains foothills. The northwestern portion of the Nelchina Range, including drainages of the upper Chulitna, Nenana and Susitna Rivers, received minimal use by main Nelchina herd animals during the study period while historically it was important summer and winter range.

Population Size and Composition: Main Nelchina Herd

Annual censuses of the main Nelchina herd were conducted during this study and the resulting estimates, as well as prior estimates of herd size, are presented in Table 2. These data indicate that in recent years the herd has experienced a growth phase, 1950-1960; a peak, 1961-1965; a decline, 1966-1973; and then another growth phase, 1974-1985. Census methods do not always produce precise estimates and, in retrospect, certain estimates (e.g. 1973, 1976, 1977, 1978) are likely in considerable error. Indicated growth between years is much greater than biologically possible without immigration, an unlikely possibility. The 1984 estimate was probably low, the result of nonrepresentative fall composition data. However when the complete series of estimates is examined a strong trend of herd growth since the early to mid-1970's is apparent. The observed exponential rate of annual increase (r), based on regression of natural logs of the unadjusted series of population estimates from 1972-1985 (Table 2), was 0.10. For the years 1980-1985, $r = 0.07$. During the later period an additional 4% of the herd (primarily males) was harvested annually.

Watson and Scott (1956) provided the first reasonable estimate of total population size for the Nelchina herd in 1955. Skoog (1968) concluded from fragmentary reports from early explorers that the Nelchina herd was at a high level during the mid-1800's. By 1900 the herd had declined to fairly low numbers and probably remained that way until the 1940's or 50's when herd growth began (Hemming 1975). Skoog (1968) felt that the herd probably was never below about 10,000 animals.

Composition sampling was conducted during the rutting period, in early October, of each year of the study (Table

3). The ratio of males ≥1 year to 100 females ≥1 year was relatively consistent, ranging from 54 to 62 except for 1984 (40). This was likely an erroneous estimate resulting from misclassification or nonrepresentative sampling. The ratio of calves to 100 females ≥1 year varied greatly, ranging from 27, the lowest recorded since 1962, to 54, one of the three highest values ever recorded for the Nelchina herd. The reason for the variability in calf production and/or survival to 5 months of age is unknown.

Table 2. Population estimates of the Nelchina caribou herd, 1955-1985.

Year	Total Estimate	Number of Females	Number of Males	Number of Calves
1955	40,000			
1956	36,240			
1962	71,000			
1967	61,142			
1972	8,094	4,954	1,674	1,466
1973	8,136	4,913	1,341	1,882
1974*	10,245			
1976	8,081	4,979	1,663	1,439
1977	13,936	7,509	2,868	3,559
1978	18,981	9,866	4,429	4,686
1980	18,713	9,164	5,673	3,876
1981	20,694	10,154	6,184	4,356
1982	21,356	10,199	5,650	5,507
1983	24,838	13,212	8,046	3,580
1984	24,095	13,912	5,495	4,688
1985	27,528	14,121	7,464	6,293

*Count of postcalving aggregation only, no extrapolation.

Current ADF&G management objectives for the Nelchina herd include: (1) restricting the harvest until a population level of 30,000 animals older than calves is reached, (2) maintaining a minimum sex ratio of 25 males/100 females, (3) providing for the greatest opportunity to participate in hunting caribou, and (4) providing for an optimum harvest of caribou. Management objectives are expected to be periodically reviewed as additional information on herd status, range condition and resource demand and allocation are obtained.

Currently the Nelchina herd contains about 6% of the total statewide caribou population (410,000-450,000). It is exceeded in size by the large Western Arctic and Porcupine

herds in northern Alaska and is slightly smaller than the Alaska Peninsula and Mulchatna herds in southwestern Alaska. Historically, the Fortymile herd has been much larger than the Nelchina but currently numbers about 50% as many animals.

Table 3. Nelchina caribou herd fall sex and age composition data.

Year	Cows		Calves			Bulls		
	N	%	N	%	/100 cows	N	%	/100 cows
1980	402	49	170	21	42	249	30	62
1981	797	49	342	21	43	485	30	61
1982	413	48	223	26	54	229	27	55
1983	705	53	191	14	27	429	32	61
1984	2011	58	678	20	34	794	23	40
1985	1060	50	484	23	46	574	27	54

Mortality/Survival

Natural mortality Between July 1980 and October 1985, 85 radio-collared caribou were monitored from one to 63 months, totaling 2,234 caribou-months, thereby allowing estimates of annual survival rates to be made. The radio-collared caribou included 56 females and 16 males from the main Nelchina herd and 13 females from the upper Susitna-Nenana subherd.

For females from the main Nelchina herd 12 deaths of radio-collared caribou were attributed to natural causes, 2 deaths appeared to be the result of crippling loss from hunters or abandoned hunter kills, 3 deaths were the result of legal hunter kills and there were four assumed radio failures, only one of which was confirmed. The mean annual estimated survival rate of females from the main Nelchina herd, considering only deaths attributed to natural causes, was 0.91 (0.86-0.97; 95% C.I.). If the two crippling losses or abandoned hunter kills are included, an estimate of 0.90 (0.84-0.96; 95% C.I.) is derived for mean annual survival.

Among radio-collared males from the main Nelchina herd two natural mortalities were recorded and it could not be determined if two additional deaths resulted from natural causes or were from crippling loss. Considering only the known natural mortalities the estimated mean annual survival rate was 0.93 (0.77-0.99; 95% C.I.). However, if all four deaths are considered, estimated survival was 0.86 (0.69-0.96; 95% C.I.).

Among radio-collared females from the upper Susitna-Nenana subherd three deaths occurred. All were attributed to natural causes. In addition, two radio collars were assumed to have failed. The three natural mortalities resulted in an estimated mean annual survival rate of 0.86 (0.66-0.97; 95% C.I.).

Monitoring flights were not frequent enough to always precisely determine causes of death for the mortalities which occurred among the radio-collared caribou. Among the 17 mortalities which were considered to have been from natural causes wolves (*Canis lupus*) were suspected (although not confirmed) in 14 cases. A radio-collared male was thought to have died from an antler wound inflicted by another bull during the rut. A radio-collared female died during the calving period; however, the carcass was never examined on the ground. Cause of the other mortality could not be determined, but because the animal died distant from human activities it was considered a natural mortality.

Calf survival from birth to 10.5 months of age was estimated for four cohorts (1980-1983) based on an assumed birth rate of 0.66 calves per cow $\geq$1 year (Skoog 1968, Bergerud 1978); observed ratios of calves per cows obtained during April composition sampling; and estimated survival of females between the calving season and the time composition sampling occurred (Fuller and Keith 1981). Survival estimates for the four cohorts were: 1980, 0.43; 1981, 0.58; 1982, 0.54; and 1983, 0.19.

Hunting mortality: Harvest by hunters has been an important mortality factor of Nelchina caribou. Since record keeping began in 1946 over 111,000 caribou have been reported killed by hunters (Table 4). Between 1946 and 1955 fairly restrictive regulations were in effect, limiting harvest to a single animal per hunter. From 1956 through 1971 regulations became more liberal with multi-animal bag limits (maximum of four caribou in 1964) and long seasons (nearly eight months in 1971). More restrictive regulations consisting of single animal bag limits and short seasons were in place from 1972 through 1976. Beginning in 1977 and continuing through the present, harvests have been regulated by a limited permit system.

Table 4. Reported hunter harvest of the Nelchina caribou herd, 1946-1985.

Regulatory Year	Harvest	% Females in Harvest	Permit Applications	Permits Issued
1946-47	200			
1947-48	200			
1948-49	300	3		
1949-50	350			
1950-51	500			
1951-52	525			
1952-53	450	7		
1953-54	700	15		
1954-55	2,000	72		
1955-56	4,000	27		
1956-57	3,500	28		
1957-58	2,500	25		
1958-59	3,500			
1959-60	4,000	30		
1960-61	5,500	34		
1961-62	8,000	42		
1962-63	3,500	31		
1963-64	6,300	39		
1964-65	8,000	34		
1965-66	7,100	33		
1966-67	5,500	29		
1967-68	4,000	35		
1968-69	6,000	40		
1969-70	7,800	51		
1970-71	7,247	37		
1971-72	10,131	53		
1972-73	555	28		
1973-74	810	33		
1974-75	1,036	34		
1975-76	806	31		
1976-77	822	26		
1977-78	360	22	1,383	750
1978-79	539	21	2,775	1,000
1979-80	630	14	5,600	1,300
1980-81	621	21	6,841	1,300
1981-82	901	18	6,819	1,601
1982-83	861	14	9,110	1,750
1983-84	969	14	9,720	1,750
1984-85	1,063	16	12,516	1,900
Total	111,776			

As previously mentioned, herd growth based on population estimates averaged about 8% annually (r = 0.07) between 1980 and 1985. Population projections during this period, based on estimates of calf recruitment, natural mortality and hunter kills produced annual herd growth estimates of only about 4%. It seems likely that one or more of the estimates of population vital statistics are in error. Hunter harvest estimates are undoubtedly low as they are based only on the reported harvest and do not include unreported kills, illegal kills and crippling loss. Estimates of natural mortality of adults may be high if radio-collared animals die at a higher rate than uncollared caribou. I wondered if wolves might have keyed in on collars, thereby inflating the natural mortality estimates.

Decline of the Nelchina Herd

Between the early to mid-1960's and the early 1970's the Nelchina herd declined from a high of 71,000 (Siniff and Skoog 1964) to possibly 90,000+ (Van Ballenberghe 1985) down to 10,000 animals or less (Bos 1975). Several authors have analyzed available population data to try and determine probable causes of the decline (Bergerud 1978, 1980, 1983; Bos 1975; Doerr 1979; Van Ballenberghe 1985). Bos (1975) suggested that egress of caribou to other ranges may have played a role in the decline. Bos (1975) also presented data suggesting that recruitment of calves had declined; he felt that severe weather and increased wolf predation were the most likely causes. Doerr's (1979) analyses suggested that wolf predation and human-caused mortality (hunting) played influential roles in the decline. He discounted emigration and felt that additional factors related to quality of the range, such as decreased conception rates, increased natal and post-natal mortality rates and decreased natural survival of calves also impacted population dynamics. According to Bergerud (1978, 1980, 1983), wolf predation, particularly on calves, and excessive human harvest were the primary causes of the decline. Bergerud based his argument largely on strong negative correlations between wolf abundance and calf recruitment as indicated by cohort analysis of age structure data from the harvest. Van Ballenberghe (1985) downplayed the importance of wolf predation in the decline, stating that poor survival of calves due to severe winters, and poor survival of adults because of hunting mortality were important factors in the decline.

I have reviewed available data to try and determine the most likely cause(s) of the decline. My personal experience with the Nelchina herd is limited to the period 1980-1985 and I realize that changes in wolf and caribou distribution, behavior and relationships may have occurred since the period of the decline. I also realize that the historical

data base, particularly in regard to caribou numbers, wolf numbers and harvest data, is imprecise and incomplete.

Emigration of Nelchina caribou to other ranges probably was not a cause of the decline (Doerr 1979, Van Ballenberghe 1985). Glenn (1967) reported movements of Nelchina caribou beyond established ranges; these caribou were thought not to have returned (Bos 1975). I have since seen similar movements of Nelchina caribou, documented by tracking radio-collared animals, all of which returned to the Nelchina range (Pitcher 1984, 1985).

High levels of harvest by hunters are generally acknowledged as being a contributing factor in the decline. Excessive harvest appears to have been particularly important late in the decline. About 10,000 caribou were killed by hunters in 1971-72, a figure similar to total population size in 1972. Nearly 56,000 caribou were reported killed during the approximate period of the decline (1964-1972). However, if unreported kills, illegal kills and crippling loss are considered the total becomes much higher.

Wolf numbers on the Nelchina range, which were at low levels during the 1950's because of wolf control activities, increased during the 1960's. There is some disagreement on numbers of wolves present during this period (Rausch 1967, 1969; Van Ballenberghe 1985); however, there were probably considerably more present during the decline than during the previous caribou growth phase. Bergerud (1978, 1980) provided strong correlations between wolf abundance and calf caribou recruitment, primarily based on the strength of cohorts in samples of aged individuals in the harvest. In order for this to have occurred, wolves must have strongly selected for calves over other age classes. Recent wolf studies in the Nelchina basin have not indicated selection by wolves for calves over older age classes (Ballard et al. 1981). Examination of serial composition data (July, October and April) for the Nelchina herd indicate that normally up to about 50% of the total first year mortality occurs during the first 1.5 months after birth. In recent years few wolves have been present on the calving grounds and summer range in the Talkeetna Mountains. This indicates to me that wolves have little to do with early mortality of caribou calves in the Nelchina herd, while the Ballard et al.(1981) data suggest that wolves are not highly selective for calves during other seasons. Regardless, wolf numbers during the period of the decline were considerably greater than during earlier years when the herd was growing and it is probable that predation on caribou of all age classes was a contributing factor in the decline.

Severe winters also probably contributed to the decline. Three severe winters occurred during the period of decline and one occurred shortly before the decline became

established (Van Ballenberghe 1985). The lowest values for spring calf/100 cow ratios all followed severe winters (1961-62 = 18, 1966-67 = 5, 1971-72 = 16). No spring composition data were collected in the spring of 1966, the other severe winter.

When the caribou population on the Nelchina range was at its peak, the density was high, perhaps approaching 4 or 5 animals/mi^2. Examination of vegetation plots in 1970 and 1971 indicated that the lichen flora had deteriorated over the previous 10 years (Pegau and Hemming 1972). Skoog (1968) felt that food was not limiting growth of the Nelchina herd when it was at high densities. Bergerud (1980) presented a convincing argument that mainland caribou herds are not food-limited, at least from a density-dependent standpoint, because they are able to utilize a wide variety of plant species and are able to move about. However I do not believe high population density and reduced availability of preferred food items should be completely dismissed as possible contributing factors in the decline of the Nelchina caribou herd.

In retrospect, it seems likely to me that the decline of the Nelchina herd from the 70,000-90,000+ level to 10,000 or less was likely due to a combination of causes, with human harvest the leading factor. Both increased wolf numbers, which probably resulted in increased mortality rates of all age classes, and extremely severe winters (three of the four most severe winters in the past 25 years occurred during the decline) likely contributed to the reduction. It does not appear possible to rank these two factors according to their importance in the decline. High population density and range deterioration should also be considered as possible contributors to the decline. Perhaps any one or two of these factors might have caused a decline of lesser magnitude but the cumulative impact of all factors during a limited time span likely caused this major population crash.

Subherds

Eide (1980) suspected that several subherds existed within the overall range of the Nelchina herd. In these subherds females calved in areas other than the Talkeetna Mountains calving grounds used by the main Nelchina herd. He based this conclusion on sightings and reports of animals, including calves, in these locations during all seasons including the calving period. Locations of these possible subherds were the Watana Creek Hills (upper Susitna-Nenana drainages), the upper Talkeetna River, Chunilna Hills and the Alaska Range. Because of their proximity to the proposed Susitna hydroelectric project, radio collars were placed on animals in three of the suspected subherds: the upper Talkeetna River, Chunilna Hills and upper Susitna-Nenana River drainages. Information on other potential

subherds within the Nelchina range was obtained from observations made during this study and from reports from other biologists and the public.

Upper Talkeetna River Two adult females and one adult male were collared in the headwaters of the Talkeetna River on 18 April 1980. These animals were relocated a total of 50 times over the next 26 months and were always found in drainages of the upper Talkeetna River or in the upper reaches of the nearby Chickaloon River (Fig. 15). One female was seen with a calf in 1980 and both were observed with calves in 1981. The male spent the summer of 1980 in the mountains west of the Talkeetna River and then shed his collar in the upper Talkeetna River in November 1980. I have seen, incidental to radio-tracking flights, small groups of caribou including cows and calves in most of the side drainages of the upper Talkeetna River. Females from this group did not appear to aggregate either during calving or post-calving as did animals from the main herd. One radio-collared female was observed with a young calf in a high (5,800 feet) snow-covered cirque far from other caribou. This appeared to be similar to predator avoidance behavior described by Bergerud et al. (1984a). No attempt was made to census this subherd; however, based on observations made during radio-tracking flights I estimated this resident group of animals at about 400. Historically (1956-57, 1961-64) major segments of the Nelchina herd wintered in the Talkeetna River area (Skoog 1968).

Chunilna Hills While only limited information (21 relocations from three radio-collared caribou) was obtained from this group it did appear to be a resident subherd as these animals remained within a local area (Fig. 16). Both radio-collared females gave birth to calves in the area. The largest group of caribou seen in the Chunilna Hills was about 125 animals although I have received unconfirmed reports of 200-300 caribou in that area. Perhaps as many as 350 animals were resident in the Chunilna Hills area. Skoog (1968) made no mention of either resident animals or significant use by Nelchina animals in the Chunilna Hills. He said that caribou use was limited to a few wandering bands. No radio-collared caribou from the main Nelchina herd were found in the Chunilna Hills during this study (Fig. 14).

Upper Susitna-Nenana This region, which is located in the northwestern corner of the Nelchina range contains the largest subherd of resident caribou. Over a 5.5-year period 14 radio-collared caribou from this area were relocated a total of 257 times (Fig. 17). Primary areas utilized included the Clearwater Mountains, the Butte Lake-Brushkana Creek area and the Chulitna Mountains.

Two attempts were made to estimate the size of this subherd.

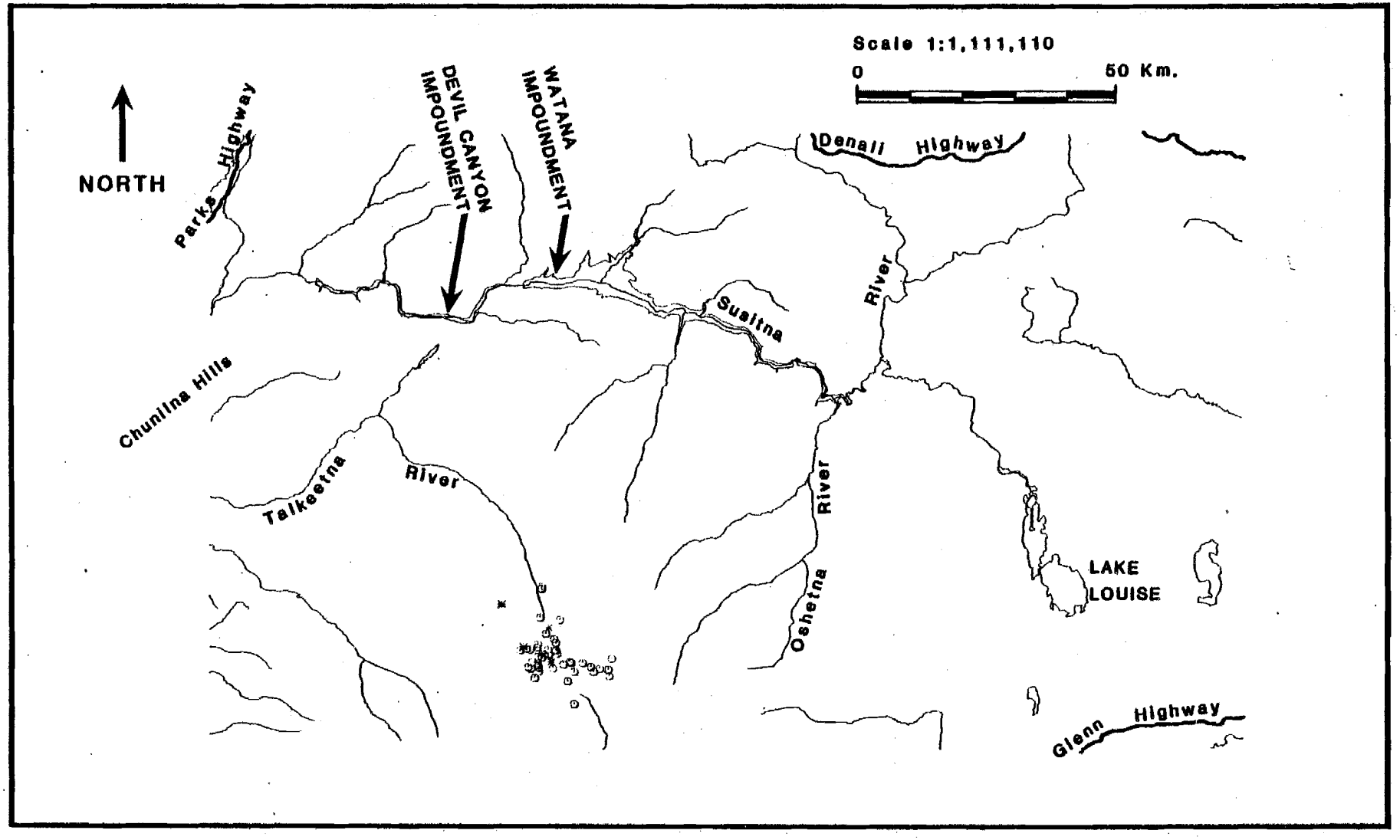

Figure 15. Distribution of upper Talkeetna River radio-collared caribou, 18 April 1980–21 June 1982. o=females, * =males.

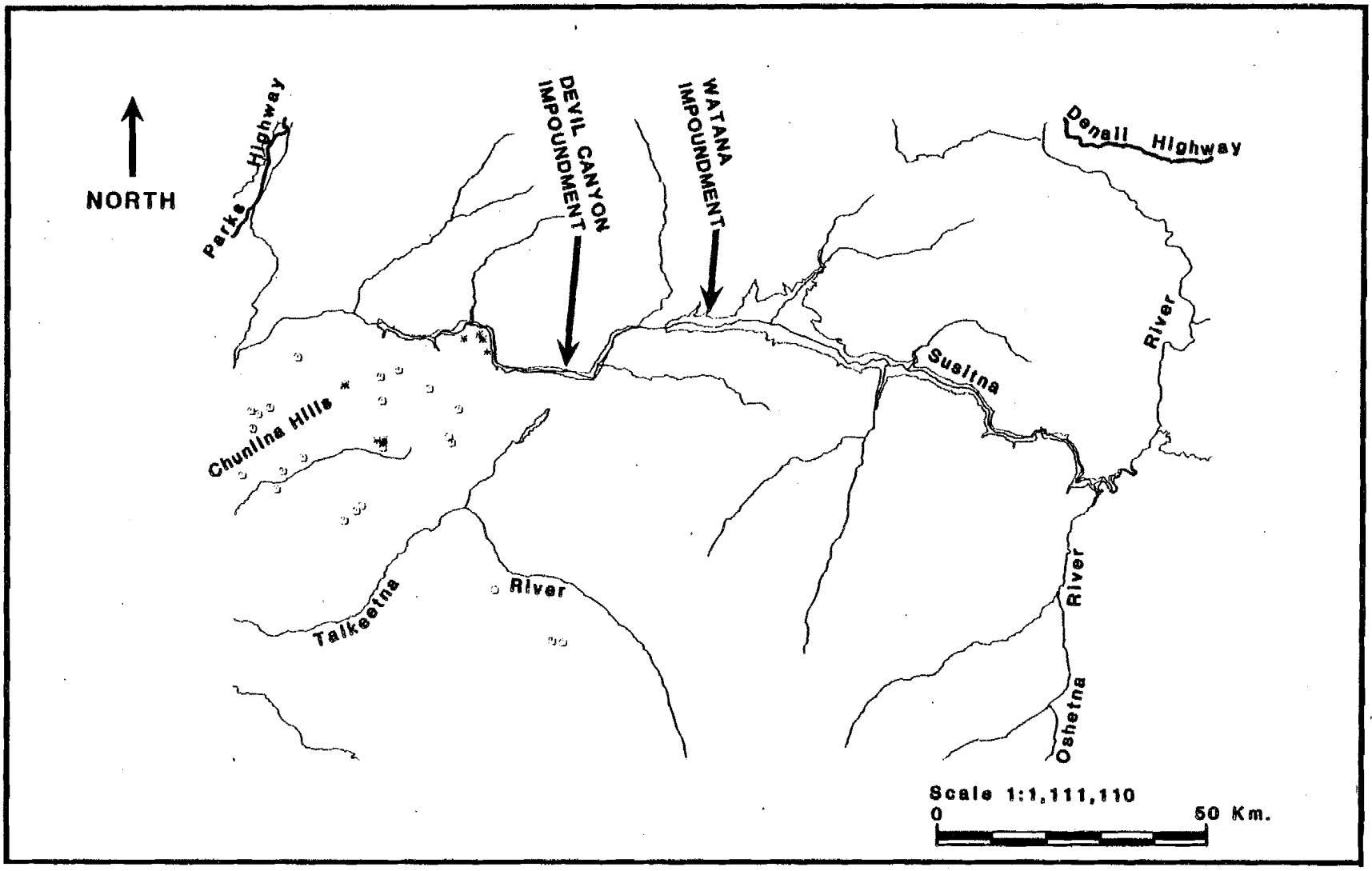

Figure 16. Distribution of Chunilna Hills radio-collared caribou, 18 April 1980-19 November 1984. •=females, *=males.

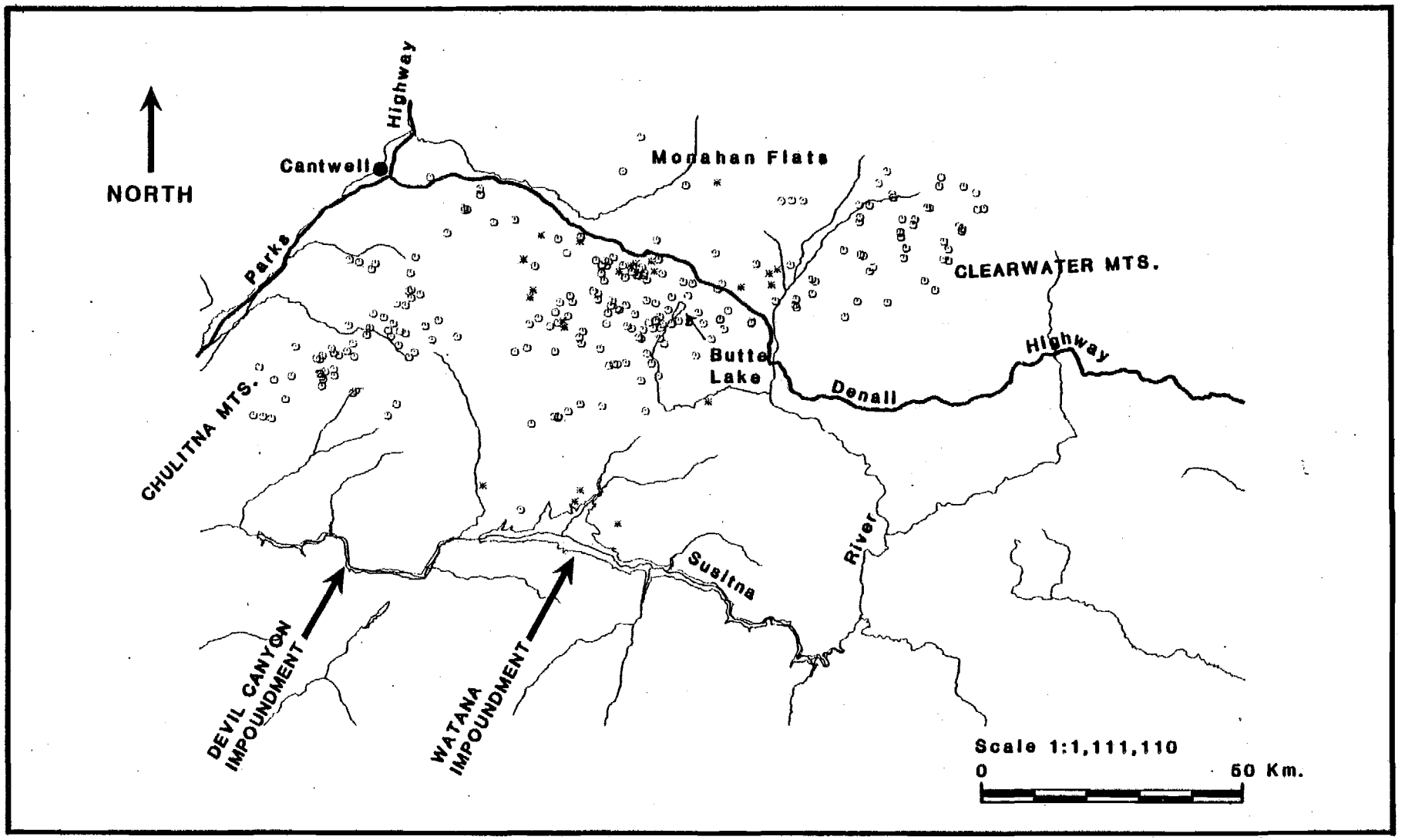

Figure 17. Distribution of upper Susitna–Nenana radio–collared caribou, 9 May 1980–12 October 1985. e=females, *=males.

From 8 through 11 October 1982 a total count of caribou in the area north and west of the Susitna River above Gold Creek and in the Clearwater Mountains was attempted. The western and northern boundaries were the Parks Highway and the Alaska Range. Reasonable snow cover allowed us to concentrate efforts in areas where tracks were present; it also increased sightability of animals. The count took place during the rut when most animals were found in groups (5-75 animals), again improving sightability. A total of 2,077 caribou was counted.

Several factors may have affected the accuracy of this census. Periods of bad weather resulted in the count being spread over a five-day period when it could have been completed in two days, thereby increasing the likelihood of movement which could have resulted in either double counting, undercounting or a combination of both. Potentially the most serious complication was the movement of perhaps 10% of the main Nelchina herd through the southeastern corner of the study area during the counts. The migratory route of these animals as they left the Talkeetna Mountains, crossed the Susitna River and moved through the study area was relatively distinct because of trailing in the snow. Animals encountered along this route were not included in the counts. Therefore, resident animals which may have been in the area were not included, which would have resulted in an underestimate. Conversely, animals from the main herd which may have dispersed from the migration route would have been counted, thereby inflating the subherd estimate. During the time the count was made two radio collars were placed on adult females within the count area. One of these radio-collared females subsequently joined the main Nelchina herd and migrated to the Talkeetna Mountains calving grounds in the spring. The next fall she again migrated through the range of the upper Susitna-Nenana subherd. Thus it appears she was actually a main herd animal that migrated through the range of the upper Susitna-Nenana subherd during at least two years. It is likely that other main herd animals also follow this pattern (another animal collared in 1980 showed a similar pattern until killed by wolves). Therefore this census attempt probably overestimated subherd size.

Another attempt at directly counting the subherd was made on 4 and 5 April 1984. Snow accumulation in the area was above normal at this time and caribou were concentrated in several locations. We counted 913 caribou in the area with major concentrations found in the following areas: hillside to the east of the middle portion of Brushkana Creek (352); foothills to the east of Butte Lake (198); Rusty Hill ridge between Valdez Creek and the Susitna River (199); and Reindeer Hills (57).

This count was probably considerably low as counting conditions were poor in places and not all animals were within the area counted. Some knolls and ridges were windblown and caribou appeared to select these areas, probably because forage was readily accessible. Animals in these windblown areas were difficult to see and count. At the time of the census seven of eight radio-collared caribou from the subherd were within the count area. None of 35 radio-collared caribou from the main herd were found within 50 miles of the count area and most were over 100 miles to the east; therefore it was unlikely that main herd animals were included in the count.

Because of the several factors that affected the count (poor counting conditions, subherd animals outside of the count area and low probability of main herd animals being included in the count), it is likely that the count was a substantial underestimate of subherd size. The previous count was likely a substantial overestimate of subherd size. It seems reasonable to assume that the two counts are likely outer bounds of the true population size. The upper Susitna-Nenana subherd probably ranged between 1,000 and 2,000 caribou with the mid-point of 1,500 being a reasonable estimate.

All observations of upper Susitna-Nenana subherd radio-collared caribou encompassed an area of about 5,525 km^2 (2,133 mi^2). Distribution of the subherd extended west from the Clearwater Mountains and headwaters of the Susitna River across Monahan Flat along the Alaska Range to Reindeer Hills, and also the Butte Lake-Brushkana Creek-upper Deadman Creek complex and the Chulitna Mountains (Fig. 17).

Calving distribution of females (Fig. 18) was quite dispersed and occurred in three general regions: headwaters of the Susitna River and Clearwater Mountains, Butte Lake-Brushkana Creek area, and the Chulitna Mountains. This dispersed calving is in contrast with that of the main Nelchina herd where females formed a relatively cohesive group and gave birth to their calves in a restricted geographic area. Summer-fall range was similar to the calving area (Fig. 19) although animals were often found at higher elevations. Primary wintering areas were in the Butte Lake-Brushkana Creek area, Monahan Flat and along and to the east of the Susitna River above the Denali Highway (Fig. 20). Some winter use of the Chulitna Mountains occurred, particularly on the northern slopes, although during deep-snow winters such as 1983-84 nearly all animals moved to the east. During deep-snow conditions caribou concentrated in the hills both east and west of Butte Lake and on Rusty Hill ridge between Valdez Creek and the Susitna River. It appeared that wind-blown areas in this higher terrain were being utilized as feeding sites.

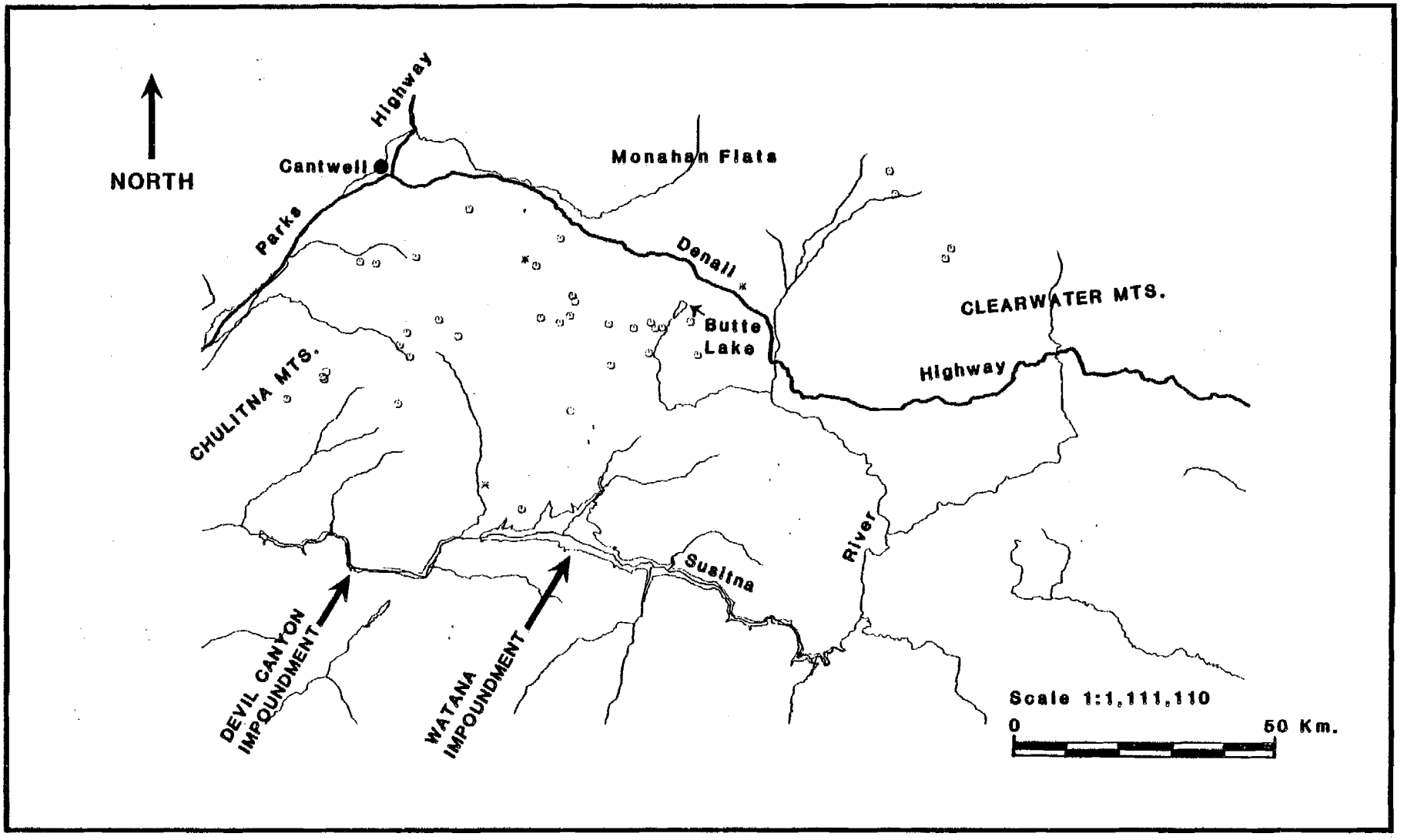

Figure 18. Distribution of upper Susitna–Nenana radio–collared caribou during calving, 15 May–10 June, 1980–1985. o=females, *=males.

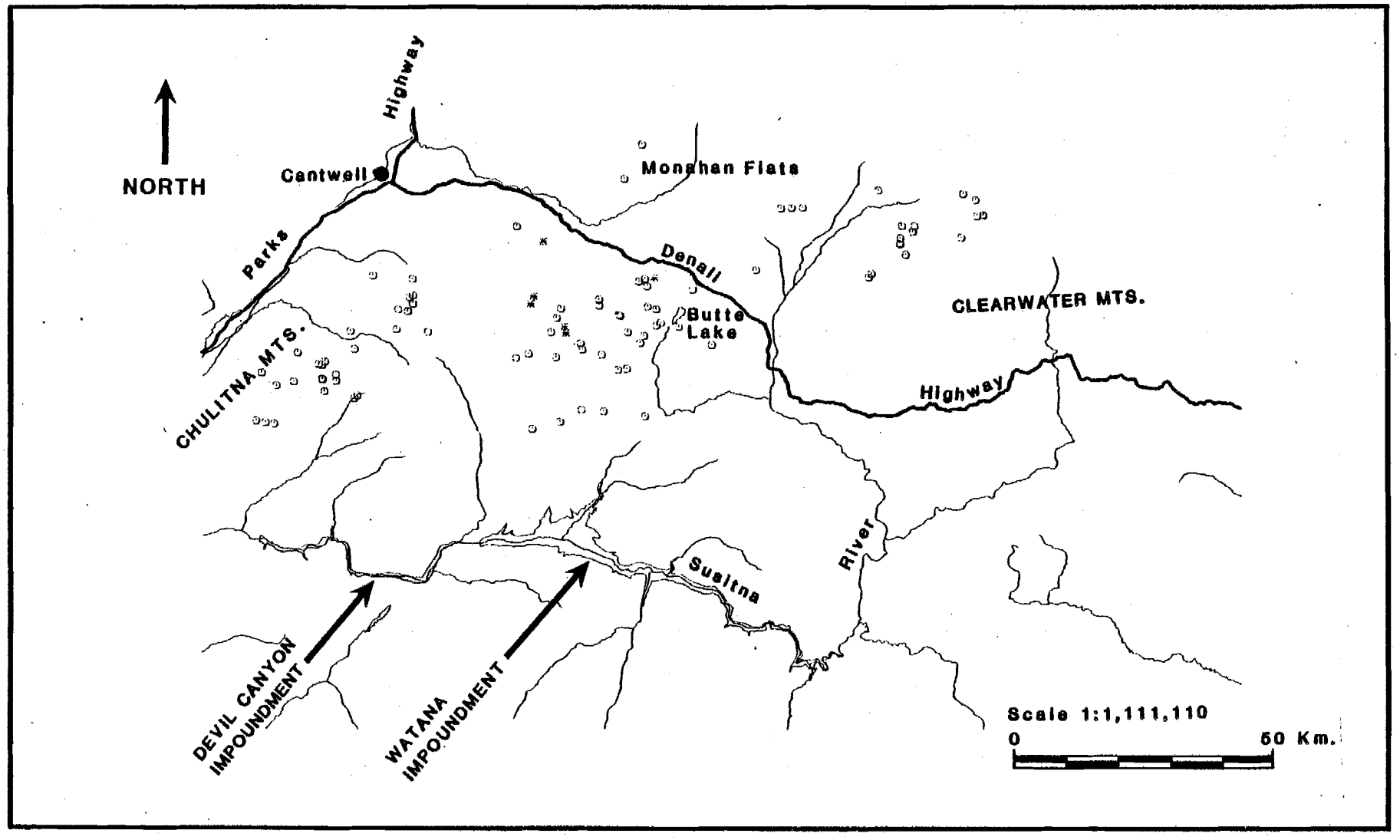

Figure 19. Distribution of upper Susitna-Nenana radio-collared caribou during summer, autumn and the rut, 11 June-31 October, 1980-1985. o=females, *=males.

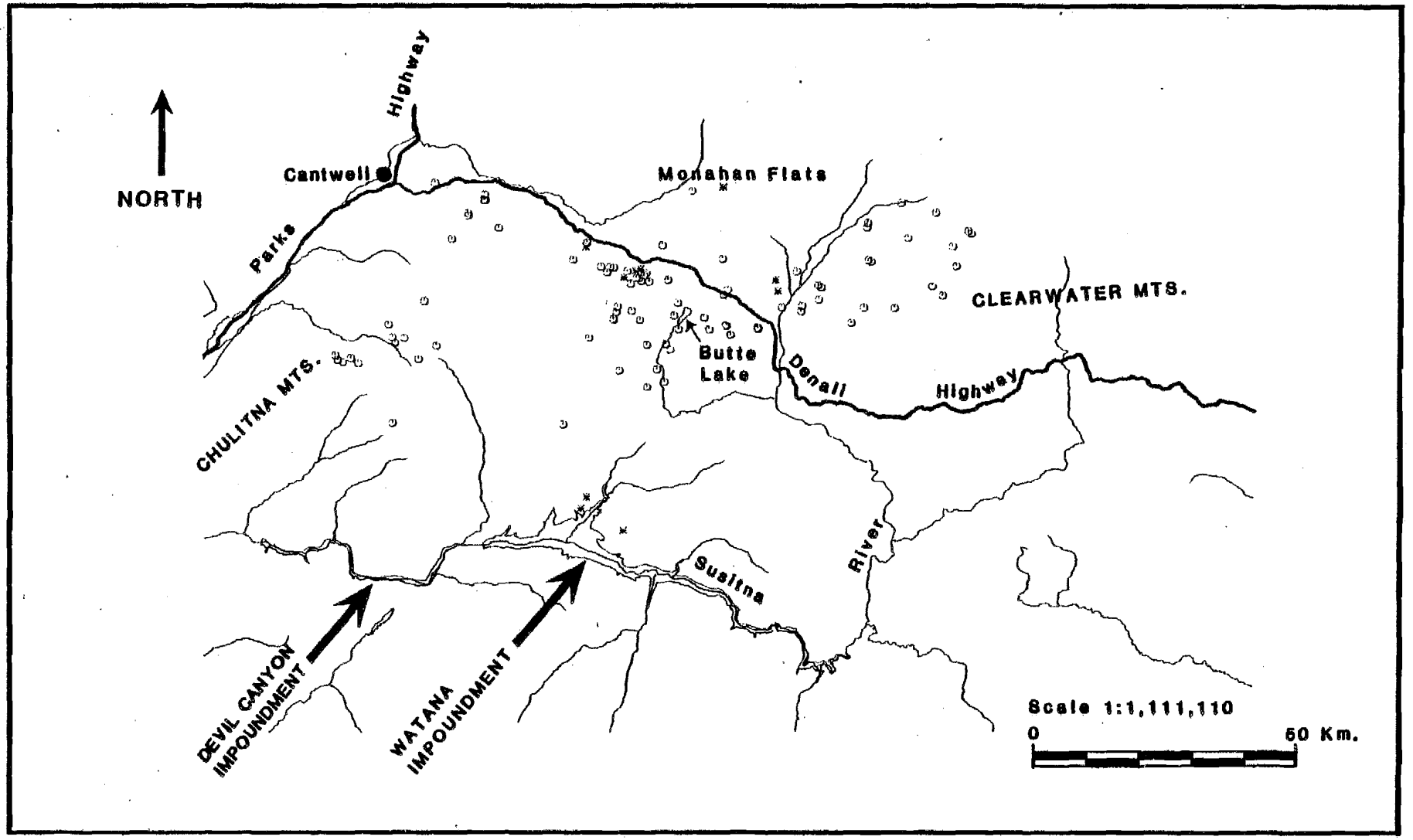

Figure 20. Distribution of upper Susitna-Nenana radio-collared caribou during winter, 1 November-30 April, 1981-1985. o=females, *=males.

The Chulitna Mountains were primarily calving and summer range although some caribou wintered there, particularly during years with moderate snow accumulation. Half of the radio-collared caribou from this subherd spent time in the Chulitna Mountains with most migrating to the east for the winter. As previously mentioned, some bulls from the main Nelchina herd also spent summers in the Chulitna Mountains (Fig. 11).

Nearly all animals using the Clearwater Mountains were residents spending the entire year in the area and could be considered a separate subherd from the rest of the upper Susitna-Nenana animals (Fig. 21). Only one radio-collared subherd animal that was not a resident of the Clearwater Mountains spent time in the area. During three years of monitoring this female spent part of one winter in the area. Bulls from the main herd also spent summers in the Clearwater Mountains. Based upon counts obtained during the two censuses it appeared that about 350-400 caribou were resident in the Clearwater Mountains.

Local resident groups of caribou likely occur in other areas of the Nelchina Basin. A subherd(s) is probably present in the western Talkeetna Mountains. A biologist flying moose (*Alces alces*) surveys has frequently seen caribou, including cows and calves, in the alpine area between Willow and Little Willow Creeks (Ron Modafferi, pers. comm.). I have also received unconfirmed reports of caribou in the Wells Mountain area, possibly the site of another subherd. After receiving reports of animals in the upper Gakona-Chistochina Rivers area a reconnaissance survey of the area was flown on 9 June 1981 during which a group of 20 cows was seen, some of which had young calves, as well as a group of 12 bulls. A radio-collared bull from the main Nelchina herd spent two summers in this area and many animals from the main herd are often present during fall and winter. This is probably a small subherd which mingles seasonally with main-herd caribou. I have also received unconfirmed reports of females with calves along the southern slopes of the Alaska Range between the Clearwater Mountains and the Richardson Highway during summer. I have only seen bulls but have not rigorously surveyed the area.

Habitat Use

I examined habitat use by recording vegetation type on each low-level relocation of radio-collared caribou during the period 1980-83. Vegetation type was that which was predominate in an area around the animal. The vegetation classifications were simplifications of Viereck and Dyrness's (1980) level I categories. My inability to precisely classify vegetative cover from aircraft plus the fact that ground vegetation was covered by snow for much of

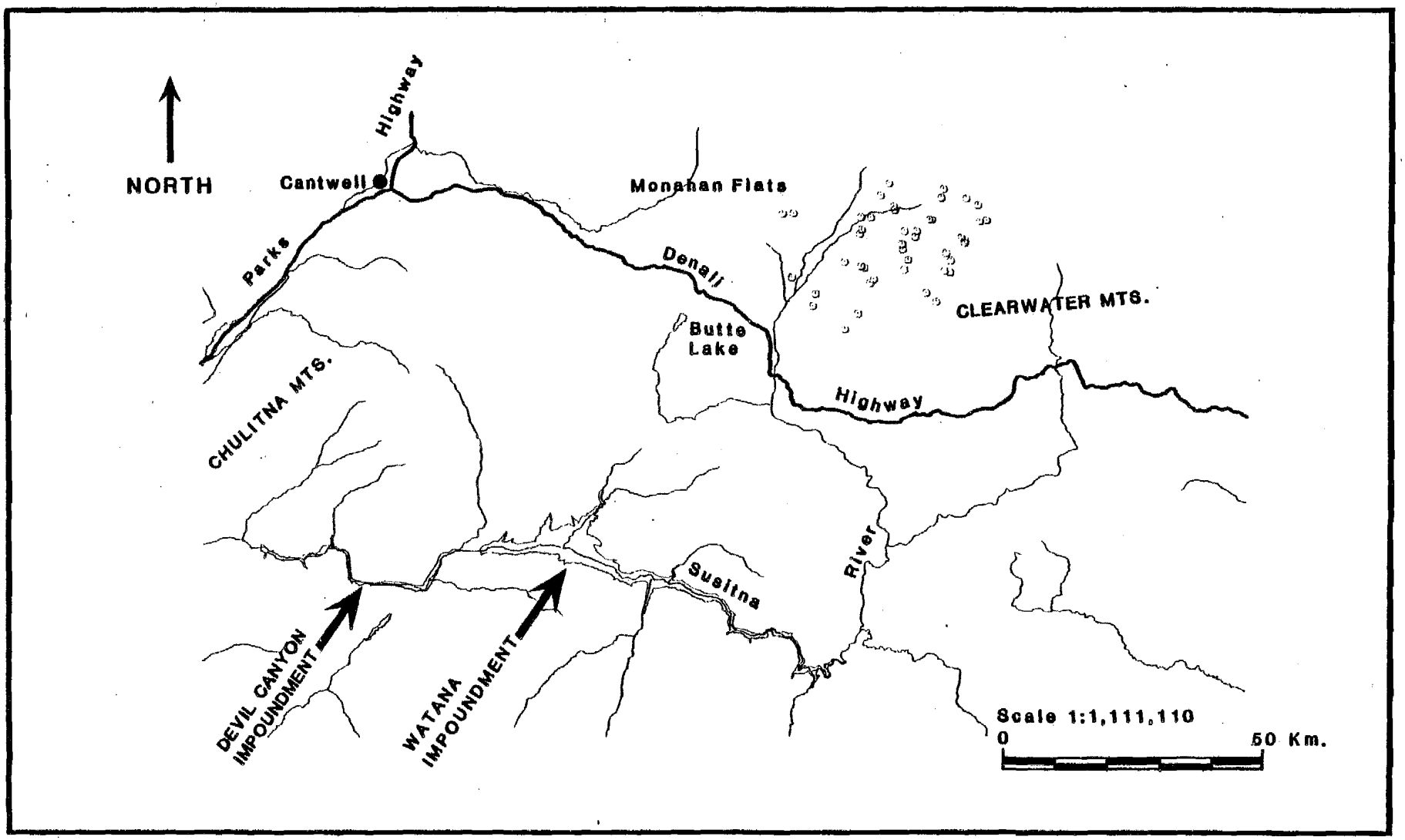

Figure 21. Distribution of upper Susitna–Nenana radio-collared caribou which were resident in the Clearwater Mountains area, 1980–1985, e=females,*=males.

the year precluded more precise classifications in most cases. Categories included: spruce forest (virtually no use of deciduous or mixed forest types was seen), tundra and herbaceous combined, shrublands and bare substrate.

Male and female radio-collared caribou from the main Nelchina herd did not utilize habitat types in similar proportions ($P = 0.002$) on an annual basis. Both sexes used similar habitats during the rut ($P = 0.763$) and winter ($P = 0.410$) but not during other seasons ($P < 0.05$). Males were found more often in spruce forest while females occurred more frequently in tundra-herbaceous and shrublands (Table 5). This largely reflects the tendency of males to remain longer on winter range in the spring (Fig. 9) and to spend spring and summer at lower elevations (Table 9). Both males and females utilized habitats differently ($P < 0.001$) by season. Males largely utilized spruce forests from the rut through the calving period while shrublands and tundra-herbaceous were the preferred habitats during summer. During autumn dispersal all habitats were utilized (Table 6). Females showed a similar seasonal pattern except they moved out of the spruce forest and into shrublands and tundra-herbaceous habitats during calving (Table 7).

Table 5. Crosstabulation of radio-collared caribou relocations from the main Nelchina herd by sex and habitat.

Sex	Spruce Forest	Tundra-Herbaceous	Shrubland	Bare Substrate
Female	296 (44%)	176 (26%)	167 (25%)	34 (5%)
Male	99 (60%)	26 (16%)	33 (20%)	8 (5%)

Chi-Square = 14.4, D.F. = 3, P = 0.002

Habitat use by animals from the main Nelchina herd differed ($P = 0.000$) from that of animals from the upper Susitna-Nenana, Talkeetna River and Chunilna Hills subherds (Table 8). Spruce forest was the major habitat utilized by main herd animals while tundra-herbaceous was the primary habitat utilized by subherd animals.

Table 6. Crosstabulation of radio-collared male caribou relocations from the main Nelchina herd by habitat and season.

Season	Spruce Forest	Tundra-Herbaceous	Shrubland	Bare Substrate
Calving	12 (63%)	3 (16%)	4 (21%)	0 (0%)
Summer	0 (0%)	9 (41%)	12 (55%)	1 (4%)
Autumn	7 (23%)	5 (17%)	14 (47%)	4 (13%)
Rut	9 (90%)	0 (0%)	1 (10%)	0 (0%)
Winter	30 (88%)	2 (6%)	1 (3%)	1 (3%)
Spring	41 (80%)	7 (14%)	1 (2%)	1 (2%)

Chi-Square = 86.4, D.F. = 15, P = 0.000

Table 7. Crosstabulation of radio-collared female caribou relocations from the main Nelchina herd by habitat and season.

Season	Spruce Forest	Tundra-Herbaceous	Shrubland	Bare Substrate
Calving	3 (2%)	67 (41%)	92 (56%)	1 (1%)
Summer	0 (0%)	43 (72%)	16 (27%)	1 (2%)
Autumn	23 (25%)	46 (49%)	14 (15%)	10 (11%)
Rut	29 (76%)	1 (3%)	6 (5%)	2 (5%)
Winter	94 (80%)	4 (3%)	5 (4%)	14 (12%)
Spring	147 (73%)	15 (7%)	34 (17%)	6 (3%)

Chi-Square = 443.5, D.F. = 15, P = 0.000

Table 8. Crosstabulation of radio-collared caribou relocations by habitat and subherd.

Herd	Spruce Forest	Tundra-Herbaceous	Shrubland	Bare Substrate
Nelchina	395 (47%)	202 (24%)	200 (24%)	42 (5%)
U. Sus-Nen	2 (2%)	76 (63&)	35 (29%)	8 (7%)
Talk. R.	1 (2%)	44 (90%)	2 (4%)	2 (4%)
Chun. Hills	0 (0%)	21 (81%)	5 (19%)	0 (0%0

Chi-Square = 215.6, D.F. = 9, P = 0.000

Seasonal Elevation Patterns

Male and female radio-collared caribou from the main Nelchina herd were found at different ($P < 0.02$) elevations during all but the autumn and rut periods (Table 9). During the spring and calving periods males lagged far behind the females, remained longer on winter range, and then spent much of the summer in the lower shrublands. Maximum mixing of the sexes occurred during autumn dispersal and the rut, resulting in use of similar elevations. Males were found in low-elevation spruce forests during winter. Females were found at highest elevations during summer while males went highest during summer and autumn.

Table 9. Mean seasonal elevations (feet) for relocations of female and male radio-collared caribou from the main Nelchina herd.

Season	Females	Males	P
Calving	3,742	2,948	0.000
Summer	4,032	3,444	0.000
Autumn	3,771	3,605	0.389
Rut	2,649	2,523	0.424
Winter	2,791	2,498	0.012
Spring	2,591	2,219	0.000

POTENTIAL IMPACTS OF PROJECT CONSTRUCTION

The proposed Susitna hydroelectric project is located in the western portion of the Nelchina caribou range. The Devil Canyon impoundment, with its related developments and transportation routes and powerlines to the west does not appear to be of serious concern. Neither during this study (Fig. 14) nor historically have many caribou from the main Nelchina herd occurred in this region. No direct access routes to important caribou habitats would be created. The small Chunilna Hills subherd (Fig. 16) resides a short distance to the southwest of the Devil Canyon impoundment site. However, it does not appear that either the impoundment or associated developments would occur in habitat occupied by this group of caribou. Elevations of relocations of Chunilna Hills radio-collared caribou ranged between 2,000 and 3,800 feet which is higher than all proposed Devil Canyon developments except a quarry site.

The proposed Watana impoundment and associated developments such as access and construction roads, the project settlement and airstrip and borrow pits present a somewhat different situation. The Watana impoundment would intersect a major migratory route which was heavily utilized in the past and has been moderately used during the past five years. The Watana development would be in close proximity to important caribou habitats and would result in increased human access to these areas.

Potential adverse impacts generally fall into five broad categories with some overlap between groupings: (1) direct habitat loss, (2) harassment, (3) avoidance of development, (4) disruption of movements, (5) increased mortality, and (6) increased human access to important habitats.

Direct habitat loss does not appear to be a serious impact of project construction. Most of the area that would be altered by development such as the impoundments, borrow sites, roads, villages and the airstrip are not heavily utilized caribou habitat. Skoog (1968) stated that the area to be flooded by the Watana impoundment was used primarily by transient caribou. Occasionally they spent time in the area, particularly in spring in snow-free areas. Skoog (1968) felt that the thick spruce and wet conditions found in the area would not normally attract caribou although they did feed somewhat during migration across the area. The area lost would be <1% of the total Nelchina range and is generally considered low-quality habitat. The exception to this is the Denali access road running from the Denali Highway south to the Watana dam site. This road would traverse an area utilized by members of the upper Susitna-Nenana subherd during the entire year. Historically this area was used by the main Nelchina herd during both summer and winter and was considered by Skoog (1968) in terms of year-round use to have been the most important region in the Nelchina range. Although during the past 10 years few main herd animals have utilized this area it is expected that heavy use will again occur sometime in the future.

Harassment or disturbance of Nelchina caribou caused by increased aircraft traffic associated with the project as well as vehicular traffic along the access roads and heavy equipment in the borrow sites and the dam construction sites is certain to occur in portions of the development area although the area along the Denali access road is the only area with a history of heavy caribou use. Contradictory conclusions on the impacts of disturbance on caribou have been reported. Calef et al. (1976) reported that severe harassment could cause injury or death, increased energy expenditure and reduced condition, and abandonment or reduced use of traditional ranges. Miller and Gunn (1979) felt that helicopter harassment had the potential for causing stress in Peary caribou, leading to additional

mortality. Davis and Valkenburg (1984) reported that the Delta caribou herd has been exposed to more disturbance (including considerable civilian and military aircraft traffic) than any other Alaskan caribou herd, yet has grown at a rapid rate and is now larger than ever recorded. Bergerud et al. (1984b) felt that the available data indicated caribou could tolerate periodic severe disturbance without adverse effects on productivity and survival. Shideler (1986) concluded from his literature review that caribou were probably most sensitive to harassment during calving and post-calving and that large groups were more reactive than small groups. He also felt that caribou could adapt to some levels of harassment if no negative experiences such as hunting were associated with the disturbance. Despite the lack of conclusive evidence on impacts of harassment on individual caribou and on caribou populations it does seem prudent to minimize disturbance when possible, particularly on the calving grounds (Bergerud 1978) and during post-calving. In regard to the Susitna project the two key points appear to be restriction of activities such as low-level aircraft traffic on the Talkeetna Mountains calving grounds during calving and post-calving and close monitoring of possible harassment in the vicinity of the Denali access road which is used during calving by animals from the upper Susitna-Nenana subherd.

Developments and associated human activity may reduce the amount of habitat available to caribou by causing direct avoidance of areas nearby developments and by impeding movements of animals between segments of their range. It was concluded, based on the sex and age composition of caribou sampled along the Trans-Alaska pipeline haul road compared with region-wide surveys and based on the relocations of collared caribou, that the cow-calf segment of the Central Arctic herd tended to avoid the pipeline corridor and haul road (Cameron et al. 1979, Whitten and Cameron 1983). Carruthers et al. (1984) maintained that these conclusions were erroneous because the differences in composition were the result of differential habitat selectivity rather than avoidance of the corridor. Shideler (1986) found that a reanalysis of Carruthers et al. (1984) data supported the conclusion that the cow-calf segment avoided the pipeline corridor. Horejsi (1981) reported that caribou showed signs of anxiety and fear in the presence of fast-moving vehicles; they reacted strenuously trying to escape. Johnson and Todd (1977) concluded that a group of mountain caribou became habituated to a highway and traffic and continued to use a traditional movement route despite harassment and mortality. Klein (1971) reported that well-traveled highways and railroads have obstructed the movements of wild reindeer in Norway. Bergerud et al. (1984b) failed to find strong correlations between the construction of roads through caribou ranges and population declines except when the roads were used as access routes

for hunters, resulting in overharvests. Despite these contradictory findings on the impacts of highways on the free movement and behavior of caribou it does appear that high levels of activity along highways may affect caribou in certain situations (Klein 1971, Horejsi 1981, Smith and Cameron 1983).

Nelchina caribou cross the Richardson Highway, often in large numbers, and have done so during many years since about 1960 (Hemming 1971). The Richardson crossings take place in timbered habitat 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. In some years small numbers of caribou cross the Lake Louise Road during the autumn dispersal period and in winter.

It is not clear how the Denali access road and associated traffic will impact caribou migrating from the Chulitna Mountains to and from winter range to the east. It is likely that small amounts of habitat directly adjacent to the road will receive less use than prior to project construction. Based on the reactions of Nelchina caribou to highways in other portions of their range it is reasonable to expect that the east-west migrations from the Chulitna Mountains would continue to occur, although the open terrain found along the Denali route could cause caribou to react differently.

Other developments associated with the Susitna project, such as settlements, borrow areas and transmission lines would not be located in important caribou habitats and are not expected to cause serious impacts.

Disruption of movements, should they occur, would most likely be caused by the Watana impoundment and the Denali access road. The Watana impoundment would intersect a heavily used historical migration route between summer and winter range in the Chulitna Mountains and benchlands to the east and the calving grounds and summer range in the Talkeetna Mountains. According to Skoog (1968), Hemming (1971) and Pegau and Bos (1972) large numbers of caribou crossed the Susitna River, mainly between Deadman and Jay Creeks, during most years between 1951 and 1972. Deeply worn caribou trails are still visible in this area although the last large movement of caribou through this migratory corridor was about 1976. Several of the radio-collared caribou crossed the Susitna in this region during the study;

however, no large-scale crossings of caribou occurred. It seems highly probable that Nelchina caribou will again at some point utilize the historically important winter and summer range north of the Susitna, thereby crossing the proposed impoundment area.

During some years of this study large numbers of caribou utilized the upper portion of the proposed Watana impoundment during spring migration from eastern winter ranges to the calving grounds. Skoog (1968) mentioned that caribou used the frozen Susitna River as an avenue for travel and this was observed during the spring of 1981 when many caribou traveled on the ice of the Susitna between the confluences of the Oshetna River and Kosina Creek. Creation of the impoundment would limit options of caribou migrating through the area.

It is unclear how caribou would react to the presence of a large reservoir in the path of a traditional migratory corridor. Refusal to cross the reservoir would extend the distance traveled between the calving grounds and summer and winter range north of the impoundment by perhaps 60 miles. This might be particularly important during the spring migration to the calving grounds when pregnant females are in the poorest condition of the year. If the reservoir were a barrier to free movement it could result in reduced use of the northwestern portion of the Nelchina range, thereby reducing the long-term carrying capacity.

The Denali access road, as previously mentioned, intersects the migratory route of about 50% of the upper Susitna-Nenana subherd between calving and summer range in the Chulitna Mountains and winter range to the east. In addition, bulls from the main Nelchina herd use the Chulitna Mountains as summer range, thereby crossing the proposed access road. Historically, large numbers of main Nelchina herd caribou summered and wintered in the area of the Denali access route. It is not known how caribou would react to the access road and associated traffic; however, based on observations at other highway crossing sites within the Nelchina range and observations in other areas (Shideler 1986) it seems likely that unless heavy traffic is encountered caribou will successfully cross the road. Most crossing would likely occur during May, June, September and October and if problems with deflections were noted some system of traffic control such as periodic convoys could be instituted.

Neither the Richardson Highway nor the adjacent Trans-Alaska oil pipeline corridor appear to have had serious negative impacts on the Nelchina caribou herd (Eide et al. 1986). Caribou continue to cross these structures during migrations to and from winter range and the herd has been growing since about 1972.

Increased mortality resulting from various aspects of project construction could impact population dynamics of the main Nelchina herd and the upper Susitna-Nenana subherd. The greatest potential mortality factor is attempted crossings of the Watana impoundment under hazardous conditions. Large-scale historical crossings occurred primarily during April and May as caribou were en route to the Talkeetna Mountains calving grounds and during June and July as they moved to summer range north of the Susitna. The summer crossings, with a minimum distance of 0.75 mi, would occur during an open water period. Caribou are known to be strong swimmers. Skoog (1968) saw a band cross Lake Louise, a distance of about 5 mi. He also stated that caribou commonly crossed much larger lakes in Canada. Crossings during this period would not appear to pose a great hazard except perhaps to young calves, and Skoog (1968) noted that caribou take readily to water at an early age. During spring crossings conditions could be much more hazardous and females would be in the poorest condition of their annual cycle. This would be a period of transition from an ice-covered reservoir at low water levels to a rapidly filling open water impoundment. Potential hazards could include ice-covered shores, ice sheets, ice blocks and steep ice ramps formed by winter "drawdown" of the reservoir (Hanscom and Osterkamp 1980). Skoog (1968) mentioned several instances of injuries 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 Scandinavia. If crossing were attempted during the period of reservoir breakup and ice floes were stacked along the southern shore by a northerly wind, mortalities might result from animals being unable to exit the water.

During autumn dispersal, low to moderate rates of crossings in the Watana impoundment area have taken place during the past 5 years. Rather than large-scale migrations, movements during this period appear to be of a wandering nature. Impoundment crossings during this period would probably be relatively nonhazardous. Relatively few animals crossed during the rut and winter periods. Neither time appears to pose a serious threat because of probable reservoir conditions and the numbers of animals involved. The transitory phase of freeze-up might present increased hazards because of thin ice but would probably be similar to conditions already occurring on large lakes.

There are indications that migratory mammals will, on occasion, attempt to follow traditional routes even after changes have occurred which make them hazardous. Near Vail, Colorado mule deer (*Odocoileus hemionus*) fell from a precipice created by highway construction across migratory trails (Reed et al. 1979). Possibly more than 10,000 caribou from the George River herd were killed while

attempting to cross a river at flood stage during fall migration (Sullivan 1984, Goddard 1985). Mass drownings of elk (*Cervus canadensis*) (including about 60 animals in 1978, which were thought to have resulted from breaking through thin ice created by drawdown) have been reported from the Blue Mesa Reservoir in Colorado (Harza-Ebasco 1985). These animals were thought to have been following a traditional migration route. The Lucky Peak Reservoir in Idaho is on a number of mule deer migratory routes and during the early years following construction up to about 175 animals were lost annually. Losses were caused by falling on the ice, breaking through the ice and drowning, being unable to exit the reservoir on the opposite shore due to ice sheets on the reservoir banks, and becoming mired in the mud around the reservoir perimeter (Harza-Ebasco 1985).

It appears to me that the potential, under specific conditions, would exist at the Watana site for serious levels of mortality of females migrating to the Talkeetna Mountains calving grounds. The main Nelchina herd would need to resume use of historical winter range north of the Susitna River; this is likely to occur at some point. The spring migration to the calving grounds would need to coincide with hazardous ice conditions on the reservoir. Both of these events would likely occur during the first two weeks in May. The female segment of the herd would need to attempt a reservoir crossing rather than extend their migration around the reservoir. This might well occur as this is a traditional route and females would be "motivated" to reach the calving grounds.

Some mortality of caribou from collisions with vehicles along the Denali access road may occur, although it is not expected to be a serious problem. Caribou-vehicle collisions along the Richardson Highway, where major crossings occur, probably do not result in more than about 50 deaths per year (Tobey, pers. comm.). Vehicle-caribou collisions are reportedly uncommon along the Dalton Highway (Cameron, pers. comm.).

Increased hunter access would be provided by the Denali access road and the impoundments. This could result in increased harvest, particularly on the upper Susitna-Nenana subherd. Reductions in numbers of permits issued or area hunting restrictions could become necessary in order to prevent a local overharvest of resident subherd animals. Illegal kills could increase with additional access into remote areas.

Robey (1978) suspected that wolves used roads to their advantage when hunting caribou; this behavior might increase predation along the Denali access road. However, the Denali access road would also provide increased access for trapping

and hunting of wolves and bears which are predators on caribou.

Increased human access to important caribou habitats including the calving grounds and summer range in the northeastern Talkeetna Mountains, would likely be provided by project construction. This is currently one of the most remote and inaccessible regions within the Nelchina range and must be considered the most important single geographic area for the Nelchina herd. The Denali access road would provide access to important caribou habitat currently utilized primarily by the upper Susitna-Nenana subherd and historically important to the main Nelchina herd. While it is difficult to envision development occurring in these areas to the extent that caribou use would be impacted such as has occurred on the Prudhoe Bay oilfields, the possibility must be considered.

Shideler (1986) discussed two case histories in which linear developments appeared to disrupt and modify traditional migration patterns of wild reindeer; those of the Taimyr herd in the Soviet Union and the Snohetta herd in southern Norway. A pipeline-railroad-highway corridor within the range of the Taimyr herd disrupted movements and caused abandonment of a portion of the range, resulting in overuse of other areas. Mortalities resulted from train collisions and deflections into a river. Despite these factors the herd has continued to increase. Hydroelectric development and a transportation corridor acted as "semibarriers" to movements between seasonal habitats for the Snohetta herd. These developments and associated human activities caused avoidance of some areas and disruption of traditional migration routes. Range overuse developed and population impacts were noted; i.e., small body size, reduced reproduction and starvation.

Studies of the effects of the Upper Salmon Hydroelectric Development on the Grey River caribou herd in Newfoundland found that many animals avoided the development area during construction and that animals that migrated through the area during construction had their movements disrupted (Northcott 1984). However caribou numbers returned to preconstruction levels after the development was completed. Displacement and disrupted movements observed during construction had no measurable effect on herd productivity.

Impacts studies (Simpson 1986) were conducted on a small group of woodland caribou which periodically crossed, and seasonally used, river bottom habitat which was flooded by an impoundment on the Columbia River north of Revelstoke, British Columbia. This study was conducted for three years prior to flooding, and thus far, one year post-flooding.

Riparian meadow habitats which were used extensively during May and which were thought to be important for predator avoidance as well as providing abundant food, were lost after flooding. Caribou continued to cross the impoundment after flooding and no mortality was noted. However, crossings, both historically and after flooding, occurred during ice-free periods with minimal hazards. Mortalities of both moose and deer which tried to cross the ice-covered reservoir were noted. A decline in caribou calf recruitment was documented during the first year after flooding; however, a causal relationship was not established.

Cumulative habitat loss and degradation is probably the most serious concern of the Susitna hydroelectric project rather than any immediate, severe impacts. The proposed hydroelectric project is only one (although the major one) of a number of developments which have occurred or may occur, on the Nelchina range. Considerable mining activity already is taking place, particularly in the eastern Talkeetna Mountains and Clearwater Mountains. A State oil and gas sale is planned for the Lake Louise Flat, a major wintering area. The Bureau of Land Management plans 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. Agricultural enterprises have been attempted. While no single action may have a catastrophic impact it seems likely that long-term cumulative impacts will result in a lessened ability of the Nelchina range to support large numbers of caribou. Habitat destruction, increased access, development, increased human activities, disturbance and barriers to free movement will all probably contribute to this loss.

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PERSONAL COMMUNICATIONS

Raymond Cameron, Alaska Department of Fish and Game, Research Biologist, 26 November 1984.

Sterling Eide, Alaska Department of Fish and Game, Regional Supervisor, 21 November 1984.

Ronald Modafferi, Alaska Department of Fish and Game, Research Biologist, 25 March 1986.

Robert Tobey, Alaska Department of Fish and Game, Area Management Biologist, 21 November 1984.