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The Influence of Seasonal Spatial Distribution on Growth and Age of First Reproduction of Nelchina Caribou with Comparisons to the Mentasta Herd

Bruce Dale

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Wayne L. Regelin, Director

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Mary V Hicks
Publications Specialist II
ADF&G, Wildlife Conservation
P.O. Box 25526
Juneau, AK 99802
(907) 465-4176

Mary V Hicks@fishgame.state.ak.us

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RESEARCH PERFORMANCE REPORT

STATE: Alaska **STUDY:** 3.44

GRANT: W-27-3

TITLE: The Influence of Seasonal Spatial Distribution on Growth and Age of First Reproduction of Nelchina Caribou with Comparisons to the Mentasta Herd

COOPERATOR: US Geological Survey-Alaska Biological Science Center

AUTHOR: Bruce Dale

PERIOD: 1 July 1999–30 June 2000

SUMMARY

In July 1999 the Alaska Department of Fish and Game, Division of Wildlife Conservation, (ADF&G) and the US Geological Survey-Alaska Biological Science Center (USGS) began a 5-year investigation of the impact of boreal forest fires on the Nelchina Caribou Herd (NCH) in Southcentral and Interior Alaska. This collaborative effort will evaluate relationships between fire history and lichen abundance; caribou habitat selection relative to lichen abundance; and caribou nutritional performance relative to habitat selection, lichen abundance, and spatial distribution. Results of this study will provide information directly applicable to caribou and fire management in Alaska.

This report reflects the expansion of study objectives and substantial field efforts and data collection accomplished during the first year. ADF&G and USGS cooperators generated a comprehensive proposal and secured review by several agency and university scientists. In addition, we captured, weighed and measured body size parameters of 83 caribou in early October 1999 and deployed 40 conventional and 20 GPS radio collars. We estimated survival rates and habitat use patterns by obtaining 1242 relocations of these animals by aerial radio telemetry and approximately 10,000 relocations from GPS telemetry. We evaluated stand age, lichen cover, and lichen biomass at more than 80 of those caribou locations and 25 random points. In addition, we estimated lichen cover at 86 of those caribou locations and 48 random points by aerial videography. In April 2000 we recaptured 39 of surviving caribou (first captured in October 1999) and again estimated parameters reflecting growth and condition.

Key words: boreal forest succession, caribou, habitat selection, lichen, nutritional performance, survival, wildland fire.

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BACKGROUND

Caribou wintering in boreal forest ecosystems of Alaska forage primarily on "climax" stage fruticose lichens. Wildland fires, however, chronically burn boreal forests, reducing the availability of forage lichens for decades. In addition, prescribed fires have been implemented to reduce fire hazards, restore biodiversity or enhance moose habitat.

Since the early 1900s, wildland fire has been implicated in caribou population declines. Numerous studies reveal reduced lichen availability, long lichen recovery periods, and caribou avoidance of recently burned winter ranges. However, direct evidence for fire-induced population declines is notably lacking. Moreover, researchers have long debated the importance of lichens to caribou. Although lichens dominate winter diets when available, examples of robust caribou populations utilizing lichen-poor ranges indicate that high-quality summer range or alternate winter forages can supplant lichen-rich winter range.

In addition, numerous investigators suggest that fire may rejuvenate older lichen ranges by favorably altering moss-lichen relationships, reducing overstory, or removing decadent lichens.

Fire may also alter caribou movement patterns, thereby allowing recovery of overgrazed lichen ranges. Lastly, fire likely enhances summer range through nutrient turnover and increased quality and abundance of vascular forages. Contrary to assertions that fire is detrimental to caribou, these mechanisms indicate that wildland fire may play a role in maintaining caribou winter range or enhancing nutritional status.

The Nelchina Caribou Herd (NCH) provides ideal opportunities to investigate effects of boreal forest fires on caribou ranges over a large portion of Southcentral Alaska that is influenced by a variety of prescribed and wildland fire management regimes. During the last 2 decades, the herd shifted its primary winter range from an area of very low fire frequency to a highly fire-influenced system north of the Alaska Range (Figure 1). This current winter range has limited vegetation diversity other than that generated by wildland fire occurrence. In addition, 2 prescribed fires to enhance moose habitat have recently been conducted on this winter range and another is scheduled for a portion of the summer range. These characteristics, along with a substantial history of research, provide unique research opportunities.

Management of the NCH generates substantial public interest because of its accessibility to a large portion of the Alaskan public for both subsistence and general uses. Understanding caribou/fire relationships on ranges of the NCH will provide information for herd management locally and for fire management throughout the boreal forest ecosystem of Alaska and Yukon.

1. Determine the relationships between fire history and forage lichen abundance and condition.

   H1. Forage lichen abundance and productivity increases with stand age to roughly 50–100 years, then declines.

   H2. Fire promotes lichen growth by reducing overstory or moss and increasing soil temperatures in declining and grazing-depleted lichen stands.

2. Investigate the importance of lichen, and therefore fire history, in determining caribou habitat selection.

   H3. Historic winter ranges in the Nelchina Basin have lower lichen abundance than currently used winter ranges north of the Alaska Range.

   H4. Caribou avoid burned areas for decades postfire and select for older stands with abundant forage lichens.

   H5. Winter movement patterns within winter range are influenced by lichen abundance.

3. Evaluate relationships between habitat selection of caribou and their nutritional performance.

   H6. Caribou utilizing lichen-rich winter ranges gain more or lose less weight than caribou utilizing lichen-poor ranges.

   H7. Caribou weight gain on preferred winter ranges is independent of caribou density on those ranges.

H8. Weight change is related to the proportion of lichen in the winter diet of caribou calves.

H9. Winter weight change is independent of summer weight gain.

4. Evaluate survival and nutritional tradeoffs associated with various spatial distributions on seasonal ranges of caribou.

H10. Nutritional performance is negatively correlated with local density of caribou, but survival rates are positively correlated with local density.

METHODS

FIRE AND ABUNDANCE OF FORAGE LICHENS

We conducted ground-based sampling of vegetation characteristics to evaluate relationships between stand age and lichen abundance and to develop a technique employing fine-scale aerial videography for rapidly and remotely assessing lichen abundance. Initially, ground-based sampling was conducted in accessible areas along the portion of the Taylor Highway that roughly bisects winter ranges north of the Alaska Highway. Subsequent ground-based sampling occurred at caribou locations and random points within the current winter range north of the Alaska Highway.

Development of Digital Imagery Techniques

We evaluated aerial videography to determine which image size (altitude and camera focal length) and airspeeds best allowed estimation of forage lichen coverage. This work was in conjunction with determining lichen abundance–stand age relationships in road-accessible stands and at caribou locations and random points throughout the current winter range. To evaluate the technique, we collected estimates of lichen cover from aerial images to lichen cover estimates from ground sampling (see below). The 9 adjacent 10x10 m quadrats provided a nested series of 10x10, 20x20, and 30x30 m plots for efficient evaluation of aerial images at different scales.

The corners of the center quadrat of each cluster were marked with surveyor's section flagging to be distinguished from the air. Lichen cover and biomass were estimated as described above. The center 10x10 m quadrat, 20x20 m and 30x30 m nested clusters were then recorded by videography 500, 1200, and 2000 feet from a DHC-2 fixed-wing aircraft. Altitudes above ground level were determined by radar altimeter. Images were geo-referenced by ADF&G software (Photoman) and videoclock times.

Total coverage from imagery was estimated by the noting the presence or absence of caribou forage lichens at each intersection of a 50-point grid superimposed over the image. Total coverage and variability of estimates from imagery were compared with those of ground samples to determine the highest altitude and means by which a minimum coverage of about 10–15% can be estimated. We collected data for ground-truthing the aerial imagery at a subset of conventional caribou locations and random points throughout the current winter range. Ground-truthing employed the ground-based methods described above; however, 2 60-meter line transects were used to estimate lichen cover.

Lichen Abundance vs Stand Age

A square block of 9 adjacent 10x10-m quadrats was established in 5 stands representing a broad range of lichen abundance. This sampling scheme provided a nested cluster of quadrats for development of aerial imagery (see above). Age of each stand was determined from sections of spruce trees and Alaska Fire Service (AFS) maps and databases. Lichen cover within quadrats was estimated from 25 systematically spaced 2-m line intercepts, with coverage classified as either open to the sky or covered by taller vegetation.

Once a suitable aerial imagery technique was developed, we collected additional lichen abundance–stand age data from a subsample of caribou locations and random points throughout the current winter range. Two 60-meter point-intercept line transects were used to estimate lichen cover at ground-truthing sites.

Depth of forage lichen mats was determined in all sites by collecting and later measuring 5-cm diameter plugs of forage lichens taken closest to the midpoint of each line intercept. Length and age of living and dead thalli from the *Cladina* spp. lichens were measured and related to the ages of stands.

Fire History Mapping

Substantial fire history information was already available from AFS as digital map products and databases. We began fine-tuning existing GIS coverage by searching AFS files for additional fires and adding them to digital coverages. An effort to map all fires greater than 0.405 km^2 (100 acres) was made. However, information about numerous fires has been lost over the years and fires under 4.05 km^2 (1000 acres) in size were often not recorded. Almost no information is available for fires dating before 1950.

LICHEN ABUNDANCE AND CARIBOU HABITAT SELECTION

We employed GPS telemetry and conventional telemetry to gather information on seasonal distribution and movements of caribou. That data, in concert with GIS coverages described above and additional sampling of forage lichen abundance utilizing fine-scale aerial imagery, allowed us to evaluate habitat selection by caribou on a variety of spatial scales.

Capture and Handling

Caribou were captured by standard helicopter chemical immobilization techniques. Caribou were weighed by electronic load cell and skeletal measurements were taken. Blood samples were collected for disease screening, analysis of stable isotopes, and pregnancy determination. Each individual was fitted with a conventional or GPS radio collar.

GPS Telemetry

We employed GPS telemetry for estimating habitat selection at temporal scales not possible with conventional telemetry and for evaluating the influences of relocation frequency on our estimates of caribou distribution and habitat selection. Beginning in October 1999, we maintained a sample of 20 female caribou fitted with GPS radio collars that also had conventional mortality-sensing telemetry beacons. Onboard GPS receivers were programmed to collect locations every 7 hours and store those locations to memory included in the collar. In April, GPS-instrumented caribou were recaptured to download stored location data and to replace batteries.

Conventional Telemetry

In addition to the GPS instrumented individuals, we maintained a sample of about 100 caribou with conventional radio collars. Therefore, our sample of caribou instrumented for conventional telemetry was about 120 animals. In addition, we also monitored approximately 80 instrumented caribou from the Mentasta herd, which shares winter range with the Nelchina herd. We attempted to locate all instrumented caribou monthly by aerial radiotelemetry. Observers recorded location, as determined by aircraft-born GPS units, and group size for all observations of instrumented caribou. During winter months, evidence of cratering was also recorded. Mortalities were noted during radiotracking flights and mortalities were investigated using helicopters as soon as practical.

HABITAT SELECTION

Selectivity for Postfire Age of Stand

Although a complete understanding of fire history over the 68,000-km^2 range of the NCH is unattainable, we have substantial information on fire history, particularly in the winter ranges currently being used north of the Alaska Range. We believe the resulting GIS coverage of fire history, although incomplete, will be adequate for evaluating selectivity relative to stand age.

Both GPS and conventional telemetry data, in separate analyses, will be used to estimate use among known-age stands. To estimate the availability of various postfire age classes, we will delineate the extent of winter range north of the Alaska Range as the area enclosed by the minimum convex polygon of all locations during November–March. Selectivity relative to post-fire stand age will be estimated annually and evaluated relative to factors that may induce variability among years (e.g., snow conditions or other weather characteristics). If appropriate, analyses will be pooled over all years. Lichen abundance-stand age relationships will be estimated by aerial imagery to compare selectivity related to stand age with patterns of lichen abundance. Ultimately, a logistic regression model will be constructed to evaluate influences of lichen abundance, stand age, land cover, landform, and environmental parameters on selectivity.

Movement Patterns and Lichen Abundance

To evaluate selection for lichen abundance at a finer scale, we will explore relationships between observed caribou movement patterns and lichen abundance. We hypothesize that lichen is more abundant in areas where caribou localize. Utilizing data from the movements of GPS-instrumented caribou during winter, we categorized locations by movement pattern as reflected in relative densities of sequential point locations. Locations of individual animals were mapped and fixed-width kernel density estimates were calculated at each location. The width of the smoothing factor was adjusted so that a frequency plot of the density estimates revealed about 3 modes that described the midpoints of the movement categories. Missing point locations were estimated by interpolation from the next successful attempt. Although this introduced error into the analysis, bias in habitat or topographic-related failure of GPS satellite acquisition was reduced.

Following categorization, we randomly selected 50 locations from each movement category. Lichen abundance will be determined at each of these locations by aerial imagery. We will use ANOVA to evaluate whether arc-sine transformed lichen cover estimates vary among movement categories. In addition, we will use these data to test the hypothesis that lichen cover at a caribou location influences the distance and change in bearing traveled to the caribou's subsequent location. For this analysis we will employ multiple regression techniques, thereby facilitating the incorporation of other variables such as temperature, snow pack depth, and time of day into the model. Indicator variables will be transformed as appropriate for least-squares regression and evaluated by stepwise selection. The response variable will be a vector consisting of the distance traveled divided by the relative change in heading (0–180 degrees) from the previous movement.

NUTRITIONAL PERFORMANCE AND SURVIVAL OF CARIBOU

As part of our conventional telemetry sample, we captured and radiocollared approximately 40 5-month-old female calves using standard methods described above. These animals were weighed, measured, and blood-sampled. They were recaptured in mid-April at 11-months-old and processed similarly. Weight change of these calves, expressed as weight gain/loss or percent change over winter and arc-sine transformed for parametric statistical analyses, were the basis of our evaluations of habitat effects on nutritional performance. Weight change data will first be evaluated to detect variation among cohorts (ANOVA) or relationships between fall body weight (i.e. summer weight gain) and subsequent winter weight change (least-squares regression).

At the broadest scale, we compared nutritional performance of caribou calves that wintered in the Nelchina Basin, on lichen-depleted ranges, with those that wintered north of the Alaska Range where forage lichens are expected to be more abundant (ANOVA). At the next level, caribou calves will be grouped based on their within-season spatial distribution through hierarchical cluster analysis with average linking. Variation in weight change among clusters will be evaluated by ANOVA with arc-sine transformation of the dependent variable. In these analyses, scale can be adjusted by varying the number of clusters. If regional variation in nutritional performance is detected, then that variation will be evaluated relative to lichen abundance based on models developed from satellite imagery and/or fine-scale aerial imagery collected for selectivity analyses. At the finest scale, we hope to be able to categorize the importance of lichen in the winter diets of individual calves, based on stable isotope analyses of blood samples, and compare that to their weight change. Environmental variables were derived from weather data collected by NOAA and FAA weather stations in Tok, Northway, Paxson, Glennallen, Eureka, Palmer, Talkeetna, and Cantwell and remote fire weather stations throughout the area.

RESULTS

Progress to date entails primarily data collection. We have made some very limited and preliminary data analyses and a few subjective observations.

Development of Digital Imagery Techniques

We set up the nested plots in 5 stands along the Taylor highway. We tried various altitudes and camera settings to obtain clear images of the ground vegetation and suitable color. Altitudes of 250–400′ above ground level and airspeeds of 60–80 knots, an approximately 3x zoom setting and a shutter speed of 1/1000 of a second provided excellent resolution and color over an area roughly 30 x 40 m. By the end of this reporting period, we obtained aerial images for 86 caribou locations and 48 random points.

Lichen Abundance vs Stand Age

By the end of this reporting period, we estimated lichen abundance at 80 caribou locations and 25 random points (Figure 2). Caribou forage lichens were absent from stands under 70 years of age, postfire. Caribou forage lichen cover quickly increased with stand age after about 85 years, postfire. Analyses of forage lichen cover-biomass relationships are ongoing.

Fire History Mapping

We gathered fire history data and compiled a GIS layer covering the entire study area. We believe the available information represents most fires since 1950 that have burned more than 1000 hectares. However, no fires were reported for the current winter range north of the Alaska Highway until 1966. Given the fire frequency in the area, it is likely that significant fires from 1950 to 1965 are not yet recorded. We will attempt to delineate these and older fires during ground-truthing efforts.

Capture and Handling

We captured 83 caribou in autumn 1999 and deployed GPS or conventional transmitters, or collected body measurements and blood samples. In late April of 2000 we recaptured the surviving radiocollared animals, replaced collars or batteries as required, and again estimated nutritional condition. We investigated mortalities and retrieved collars as necessary.

Selectivity for Postfire Age of Stand

We collected 1242 conventional aerial telemetry relocations for approximately 207 Nelchina and Mentasta caribou for estimating winter habitat use. These locations included estimates of group size and presence or absence of feeding craters. We plotted these data relative to the burn history GIS layer for the current winter range north of the Alaska Highway (Figure 3). Of 585 locations on the winter range north of the Alaska Highway, 2.1% occurred in areas burned since 1966. These burns represented 16.7% of the study area.

Movement Patterns and Lichen Abundance

Approximately 10,000 GPS relocations were obtained for 20 animals fitted with GPS collars. We have just begun point density estimates for stratifying these locations into movement patterns. Of the 6687 winter locations north of the Alaska Highway, 3.9% were in areas burned since 1966 (Figure 4).

Nutritional Performance and Survival of Caribou

We obtained measures of overwinter changes in nutritional status (body size and weight) on 17 cows and 35 calves that survived the winter. We plan to recapture survivors from the 1999 cohort in October 2000. We collected comparable data for the 1998 calf cohort (Table 1). In addition, we collected data for estimating overwinter survival rates for approximately 120 Nelchina caribou.

Table 1 Age-specific mean (n, SD) weights of radiocollared individual caribou from the 1998 and 1999 cohorts.

Cohort	4 months	10 months	16 months
1998	51.0 (7, 3.8)	51.5 (7, 4.6)	75.8 (22, 11.9)
1999	51.7 (35, 4.7)	48.7 (23, 3.9)	-

Table 2 October 1999–March 2000 survival data.

Age Class	Number at risk	Number surviving	Percent surviving
Adults	65	59	90.8%
Yearlings	21	10	47.6%
Calves	34	22	64.7%

DISCUSSION

The expansion of this study to a collaborative effort between USGS and ADF&G has facilitated the investigation of numerous aspects of caribou ecology that previously was not affordable. In addition, the collaboration has resulted in the assembly of an experienced research team with varied but complementary regions of expertise.

Data collection and analyses are just beginning. Aerial videography shows considerable promise for remote estimation of lichen cover. Lichen abundance appears to be related to stand age, and caribou showed little use of areas burned since 1966.

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PREPARED BY:

Bruce Dale
Wildlife Biologist III

APPROVED BY:

Wayne L. Regelin, Director
Division of Wildlife Conservation

SUBMITTED BY:

Donald Spalinger
Research Coordinator

Steven R Peterson, Senior Staff Biologist
Division of Wildlife Conservation

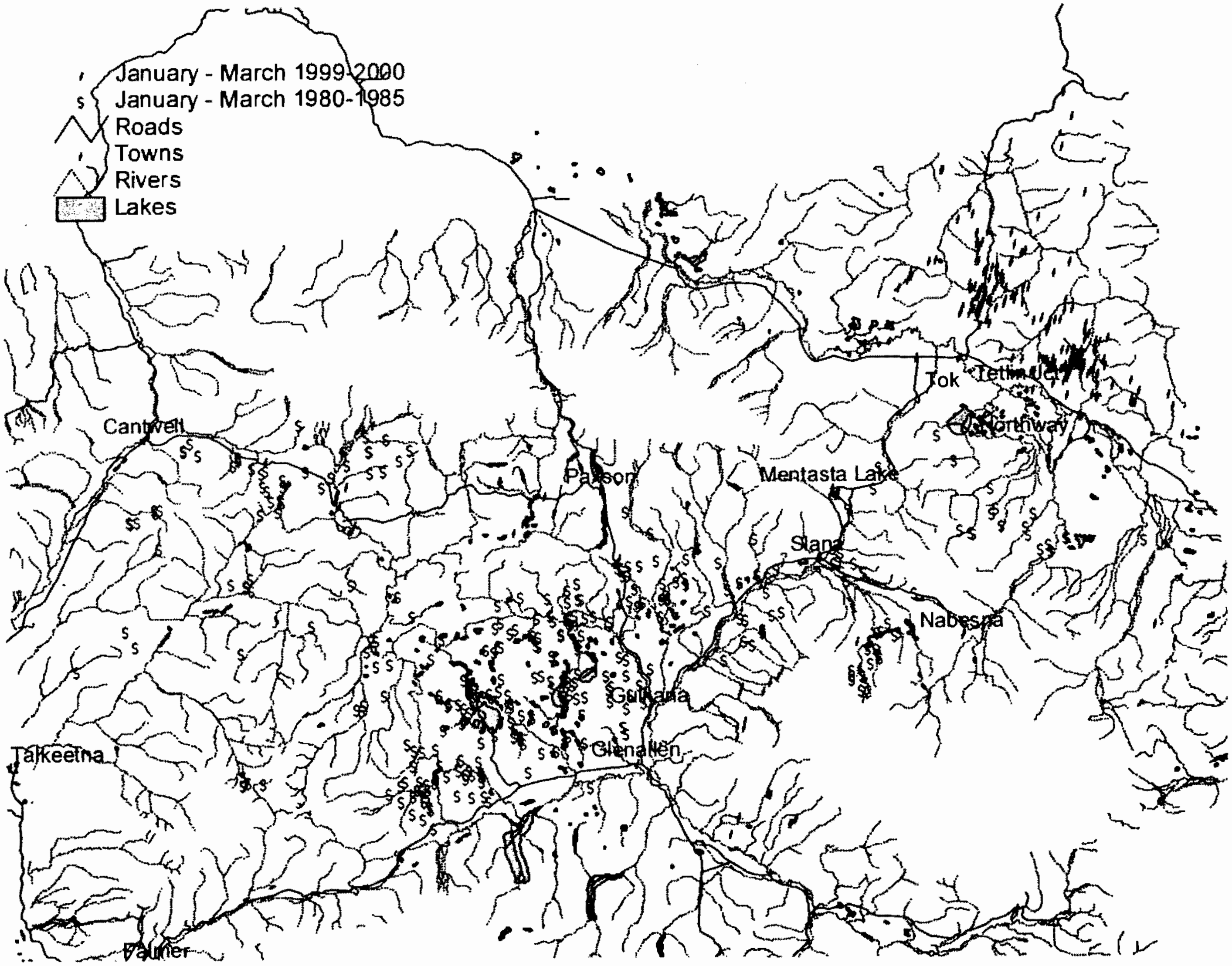


Figure 1. Winter range locations in Jan - Mar 1980-85 (Pitcher et. al. n=301) and Jan- Mar 2000 (n=271).

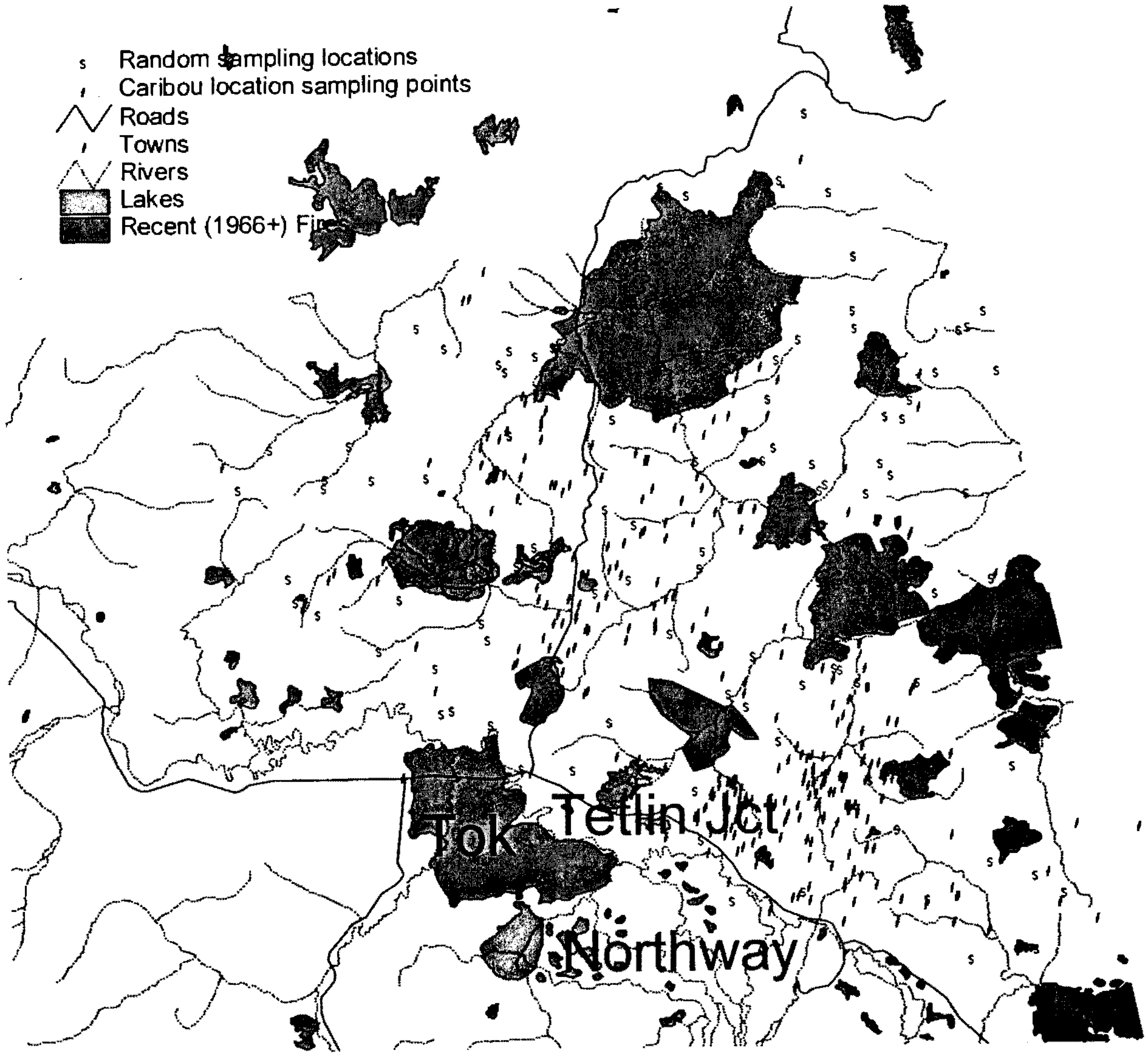


Figure [illegible]. Ground sampling locations for the current winter range north of the Alaska Highway 1999-2000.

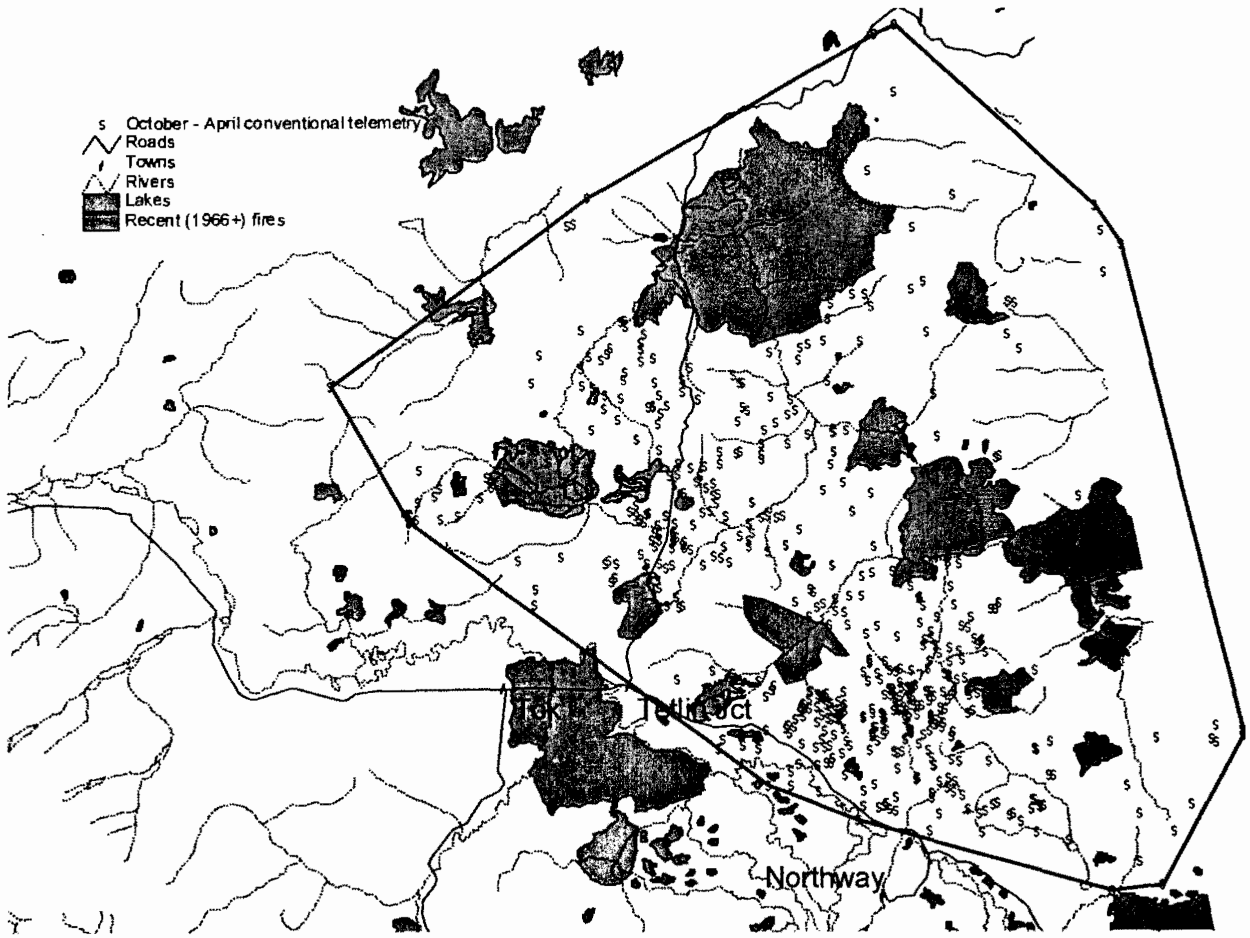


Figure 3. Conventional telemetry locations for Nelchina and Mentasta caribou within the northern study area October - April 1999 - 2000 relative to fire history since at least 1966. (n=585).

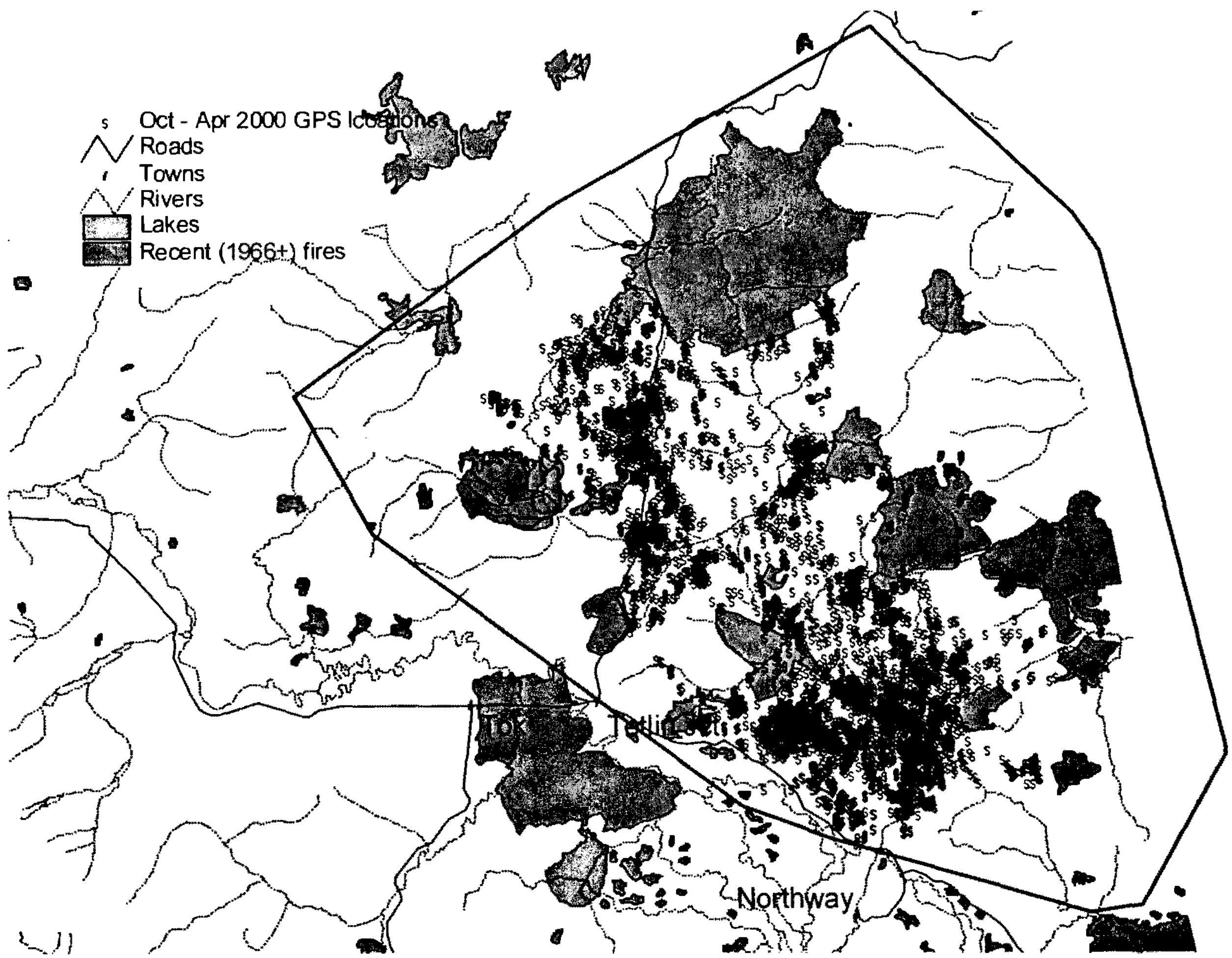
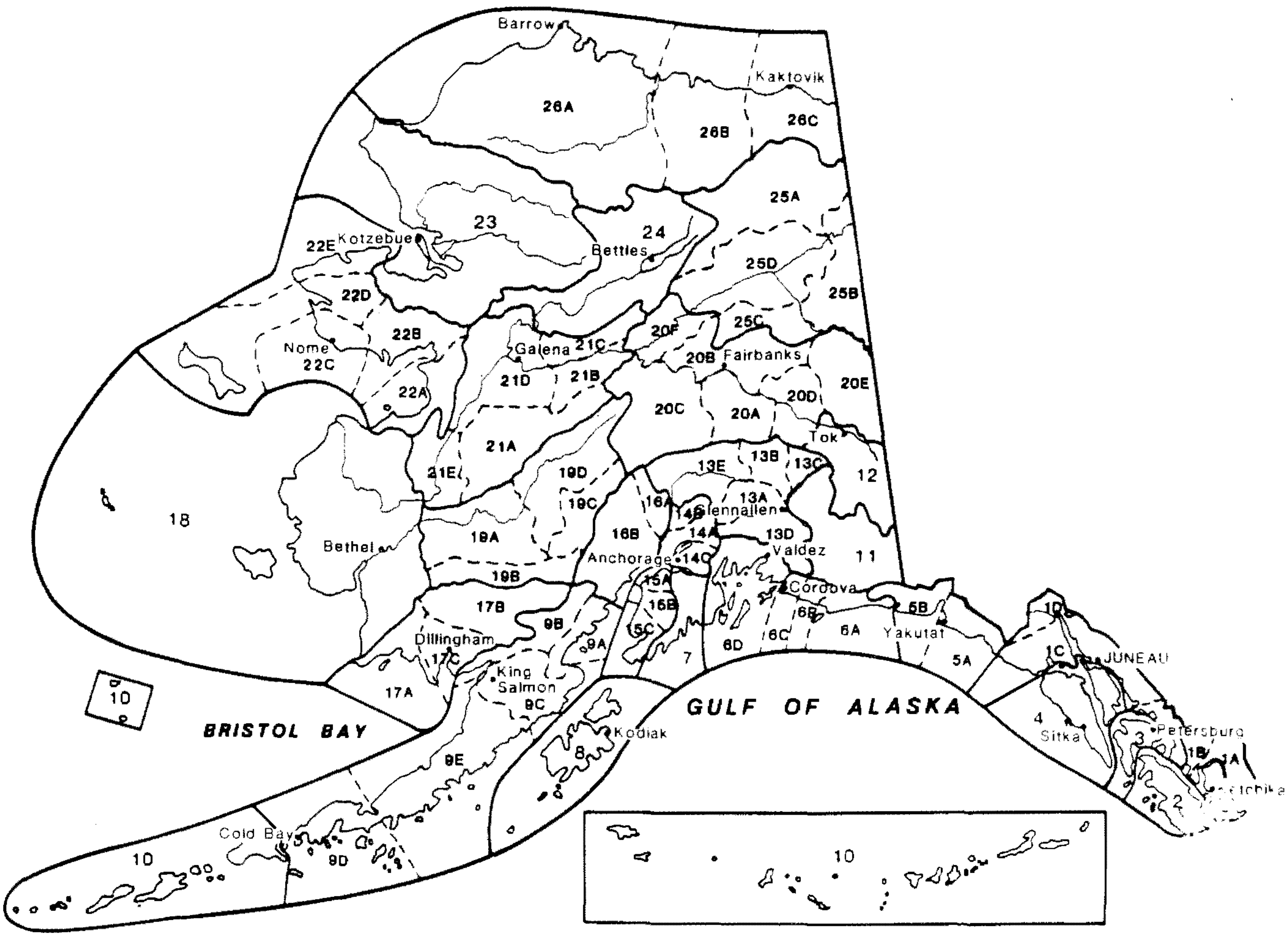


Figure 4. October - April GPS locations and fire history (since at least1966) for the primary 1999-2000 current winter range of the Nelchina caribou herd (n=6687 locations).

Alaska's Game Management Units



The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sales of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program allots funds back to states through a formula based on each state's geographic area and number of paid hunting license holders. Alaska receives a maximum 5% of revenues collected each year. The Alaska Department of Fish and Game uses federal aid funds to help restore, conserve, and manage wild birds and mammals to benefit the public. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes for responsible hunting. Seventy-five percent of the funds for this report are from Federal Aid.

ADF&G