PROGRESS REPORT **08 MAY 2001**

PROJECT TITLE: ASSESSING WILDLAND FIRE IMPACTS ON THE WINTER HABITAT USE AND DISTRIBUTION OF CARIBOU WITHIN ALASKA'S BOREAL FOREST ECOSYSTEM

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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 south-central and interior Alaska. Wildland fire kills the late succession fruticose lichens used as winter forage by caribou and it may be decades before such lichens are again abundant. In the late 1980s the NCH shifted it's primary winter range use from the historic wintering ground in the Copper and Nelchina River basins to an area of comparatively much higher fire frequency over 150 miles to the northeast. Approximately 85% of the herd now migrates across the Alaska Range to winter in this northern study area (NSA). This collaborative research effort evaluates relationships between fire history and lichen abundance; caribou habitat selection relative to lichen abundance; and caribou nutritional performance and survival 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. During this reporting period, 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 >80 caribou in early October 1999 and 2000. We deployed 35-40 conventional radio-collars on each cohort of 4-month-old female calves and maintained a sample of >20 GPS radio-collars on adult females. We estimated survival rates and habitat use patterns by obtaining >1200 relocations of radio-collared animals by aerial radio-telemetry and >20,000 relocations from GPS telemetry each year. We evaluated the seasonal nutritional performance of individual caribou by recapturing and

handling surviving caribou in April and again the following October. Blood samples were collected at each handling for evaluating the use of stable isotopes as indicators of dietary lichen and nutritional status in collaboration with T. Stephenson (ADF&G, Kenai Moose Research Station). Weight change of calves was variable as calves gained weight over the winter of 1999-2000, but lost weight during the winter of 2000-2001. Caribou strongly avoided boreal forest stands within the NSA that had burned since 1966.

We evaluated caribou habitat selection relative to post-fire stand-age by comparing locations caribou used to random sites. We estimated stand age, forage lichen cover, lichen biomass, cover of other vegetation, and other habitat parameters within the NSA by on-site point sampling at a random subset of 120 of the conventional caribou locations and at 100 random locations. Caribou forage lichens were scarce on stands that had burned within the last 60 years for both random and used sites indicating a lengthy recovery period for burned winter range. Caribou strongly selected for older stands that had abundant primary and secondary caribou forage lichens.

Cover (%) of forage lichens correlated strongly with biomass suggesting that remote sensing of percent cover can be used to estimate winter forage availability. Because on-site sampling is expensive and time-consuming, we developed a technique for estimating forage lichen abundance using aerial digital videography. While we had proposed to evaluate various aircraft and imaging formats, our initial results employing cost effective digital videography from fixed-wing aircraft proved satisfactory. We established fixed plots on 5 stands representing a broad range of forage lichen abundance. We adjusted camera settings and flight parameters until we acquired images that provided for the detection of forage lichen cover as low as 10-15%. Digital images of 1000m x 40m transects were then acquired at all the used and random on-site sampling locations. We will estimate lichen cover from the images and compare them (via regression) to the on-site measurements of cover and biomass. Subsequently, we will use aerial videography to generate lichen abundance estimates.

We established experimental plots to evaluate the influence of fire on lichen regeneration and growth on the historic winter range. Lichen fragments were "seeded" on burned and unburned, spruce-shaded and unshaded treatments of moss and duff (or mor) substrates. In addition, lichens were marked to verify the presence of annual nodal branching for use as markers to measure annual growth of individual thalli. These experiments will be re-evaluated during the summer of 2001.

A pilot study was initiated to evaluate the feasibility of using tame caribou to conduct on-site field trials of forage selection, foraging efficiency, and nutritional performance within stands of various ages in the NSA and within the historic winter range. Four 1-day old female Nelchina caribou calves were captured and hand-raised in Palmer and at the Kenai Moose Research Station. On March 1st 2001, these animals were transported to temporary pens on the historic winter range. We collected blood and urine samples and weighed the animals immediately prior to and after each trial. After a period of adjustment to range conditions, activities of individual caribou were recorded every 15 minutes over two 24-hour periods and diets were scan sampled. At the end of two weeks, we transported the caribou to the comparatively lichen-rich areas of the NSA. Following that 2-week trail, we conducted an additional 1-week replicate trial on each range. Caribou lost weight, foraged less selectively, and ruminated longer on the historic winter range. Caribou were more selective and gained weight on the NAS. Subsequently, we plan to conduct field trails over a range of lichen availabilities and snow conditions to further evaluate caribou foraging efficiency, diet selection, and nutritional performance for different stand ages and lichen availabilities.

We established a cooperative effort with Scott Rupp and the University of Alaska to model the influence of fire frequency, as influenced by fire management or climate change, on expected availability of caribou winter range. An existing frame-based model, ALFRESCO, will be employed to estimate the total area, spatial distribution, and age distribution of black spruce stands within the NSA under various fire regimes. We will combine the output of that model with the lichen abundance – stand age relationships and caribou habitat selection for stand-age to estimate the total forage lichen biomass and total area of selected winter habitats to rank winter range under various fire regimes.

KEY WORDS: CARIBOU, WILDLAND FIRE, LICHEN, HABITAT SELECTION, NUTRITIONAL PERFORMANCE, SURVIVAL, BOREAL FOREST SUCCESSION,

CONTENTS

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 suggest 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 over-grazed 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 suggest that wildland fire may play a role in maintaining caribou winter range or enhancing nutritional status.

The NCH provides ideal opportunities to investigate many aspects of the influences of boreal forest fires on caribou. The NCH ranges over a large portion of south central 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 NSA winter range has limited vegetative 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 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 post-fire and select for older stands with abundant forage lichens.
>
> H5. Winter movement patterns 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.

The raw data, results, and conclusions presented within this report are quite preliminary and should not be cited.

METHODS

FIRE AND ABUNDANCE OF FORAGE LICHENS

Lichen abundance vs. stand age. We investigated the relationship between abundance of forage lichens and post-fire stand-age within the NSA by on-site sampling at a subset of winter caribou locations and at a similar number of random sites. Age of each stand was determined from sections of spruce trees and Alaska Fire Service (AFS) maps and databases. Lichen cover, as well as cover by other vegetation, was estimated at 0.5m point intercepts along a 60 m transect randomly oriented at each site. Our objective was to estimate lichen cover by species as well as cover of any overlying canopy that could prevent detection of forage lichens from aerial imagery. Therefore, we recorded cover at each point with a single hit in each of the following strata: ground species (lichens, mosses, *Vaccinium vitis-idaea*, *Empetrum nigrum*, etc.); low species (*Carex* spp., *Eriophorum vaginatum*, *Vaccinium uliginosum*, etc.), shrubs (*Betula nana*, *B. glandulosa*, *Salix* spp., *Alnus* spp.), and by trees (*Picea mariana*, *P. glauca*, *Populus tremuloides*, *Betula papyrifera*). Overtopping cover data will be used to generate correction factors for estimation of lichen coverage by aerial imagery.

Depth of forage lichen mats and biomass were determined in all sites by collecting and later measuring and weighing 12 cm diameter plugs of forage lichens taken at 6 randomly selected points along each transect. Length and age of living and dead thalli from the *Cladina* spp. lichens were measured and related to the ages of stands.

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. To develop the technique, established nested plots at 5 sites that represented a broad range of lichen abundance. Nine adjacent 10x10m quadrats provided a nested series of 10x10, 20x20, and 30x30m 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 so as to be distinguished from the air. Lichen cover within quadrats was estimated from 25 systematically spaced 2m line intercepts, with coverage being classified as either open to the sky or covered by taller vegetation. The center 10x10m quadrat, 20x20m and 30x30m nested clusters were then imaged with a Sony PD-150 digital video camera from 200-1000 feet above ground level from a DHC-2 fixed-wing aircraft. Altitudes above ground level were determined by radar altimeter. Images were geo-referenced by synchronizing video clock times with real-time aircraft GPS locations and time recorded from a Garmin 100 GPS using a laptop computer and PHOTOMAN software (R. Delong, ADF&G Fairbanks).

Images from sampling locations were captured into JPEG computer images using Sony Dvcap software. These images were then imported into ARCView GIS and enhanced as necessary with the Image Analyst ARCView extension (ESRI). Total coverage of forage lichens 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 digital image. Total coverage and variability of estimates from imagery will be compared with those of on-site samples to further verify the validity of the technique.

Fire history mapping: Substantial fire history information was already available from AFS as digital map products and databases. We began fine tuning the 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 (1,000 acres) in size were often not recorded. Almost no information is available for fires dating before 1950.

Factors influencing lichen recovery and regeneration. Possible effects of organic substrates and nature of disturbance on early lichen recovery will be examined on lichen fragments which we "seeded" into burned and unburned sphagnum moss; burned and unburned duff or mor; and spruce-shaded and unshaded duff or mor. All plots were selected for uniformity in vegetation type, micro-topography, and exposure. Burned plots were prepared under uniform conditions and exposure to a weed burner. Portions of unburned plots were cleared of existing lichens to make room for placement of fragments. Existing mats of *Cladina* spp. were left undisturbed in a portion of each plot to provide a reference to growth rates of established lichen. Fragments of *C. rangiferina, C. mitis, C. amaurocraea, Cetraria laevigata, and C. cucullata* were prepared by cutting 1cm lengths of photosynthetically active tips and 1cm lengths of 5- to 10-year-old thallus. Fragments were spaced at 5 cm intervals in 1 m lines and protected by cages constructed of concrete reinforcement mesh. Fragments will be measured with calipers about the end of June annually. Vegetation cover in the protected plots and in adjacent unprotected, paired plots will be determined from digital imagery or by point grid sampling when lichens are measured for growth.

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 via standard helicopter chemical immobilization techniques. Caribou were weighed via 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 radiocollar.

GPS telemetry. We employed GPS telemetry for estimating habitat selection at temporal scales that were not possible with conventional telemetry and 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 radiocollars 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 radiocollars. Therefore, our sample of caribou instrumented for conventional telemetry was about 120 animals. In addition, approximately 80 instrumented caribou from the Mentasta herd, which shares winter range with the Nelchina herd, were also monitored. 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 via helicopter as soon as practical.

HABITAT SELECTION

Selectivity for post-fire age of stand. Although a complete understanding of fire history over the 68,000 sq. km 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 post-fire 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 via 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 mid- points 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 via 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 via 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 radio-collared 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.

A pilot study was initiated to evaluate the feasibility of using tame caribou to conduct on-site field trials of forage selection, foraging efficiency, and nutritional performance within stands of various ages in the NSA and within the historic winter range. Four 1-day old female Nelchina caribou calves were captured and hand-raised in Palmer and at the Kenai Moose Research Station. On March 1st 2001, these animals were transported to temporary pens on the historic winter range. We collected blood and urine samples and weighed the animals immediately prior to and after each trial. After a period of adjustment to range conditions, activities of individual caribou were recorded every 15 minutes over two 24-hour periods and diets were scan sampled. At the end of two weeks, we transported the caribou to the comparatively lichen-rich areas of the NSA. Following that 2-week trail, we conducted an additional 1-week replicate trial on each range. Caribou lost weight, foraged less selectively, and ruminated longer on the historic winter range. Caribou were more selective and gained weight on the NAS. Subsequently, we plan to conduct similar field trails over a range of lichen availabilities and snow conditions to further evaluate caribou foraging efficiency, diet selection, and nutritional performance for different lichen availabilities. These field trials would help determine the lichen biomass and distribution necessary for weight maintenance or gain thus allowing evaluation the relationship between age of stand and winter range habitat capability.

EVALUATION OF FIRE REGIMES ON CARIBOU WINTER RANGE AVAILABILITY

Appropriate models will be developed to evaluate the influence of fire management regimes on lichen abundance, suitability of boreal forest as caribou winter range, caribou movements and distribution, nutrition and survival trade-offs, seasonal range trade-offs, and caribou population dynamics. These models will incorporate data from this and other research where appropriate. The specific types of models constructed will necessarily reflect the nature and significance of relationships identified in this research effort (Starfield and Bleloch 1991).

A spatially explicit time-series model of the influence of various fire management regimes on lichen abundance will be particularly useful for managers. Fire recurrence will be varied over seasonal ranges of the NCH to simulate the effects of various fire suppression regimes. Fires will vary stochastically in size and shape within the parameters of previous fires within that locale thereby creating a complete mosaic of stand-age polygons. Lichen abundance within stands will reflect the age of the stand and the area of boreal forest within the stand as determined from AVHRR or other vegetation classification maps. Lichen removal from grazing will be simulated using rates estimated by Arseneault (*et al*. 1997) adjusted for herd size and distributed among stands following stand-age selection models developed from this study. Range-wide abundance of forage lichens in boreal forests within the range of the herd will be calculated for varying fire recurrence intervals. Caribou nutritional status and population dynamics may be incorporated into the model where appropriate.

This model will provide managers a tool to evaluate the abundance of caribou forage lichens expected under various fire regimes. In addition, because of the spatially explicit structure, it allows evaluation of variation in fire recurrence among specific portions of the NCH range. Because it is a time-series model, it allows evaluation of shorter-term temporal effects of changes in fire recurrence.

RESULTS

Progress to date entails primarily data collection. Some very limited and preliminary data analyses have been conducted and a few subjective observations were made.

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 a roughly 30x40m area (Figure 2). 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 over 100 caribou locations and 100 random points (Figure 3). Caribou forage lichens were virtually absent from stands under 60 years of age, post-fire (Figure 4). Percent cover of primary and secondary forage lichens increased with stand age after about 85 years, post- fire. Percent lichen cover was strongly correlated with biomass (Figure 5). We collected data on numerous co-variates, such as topography, to further explain variation in lichen abundance but those analyses have not been completed.

Fire history mapping: We gathered fire history data and compiled a GIS layer covering the entire study area. We believe the available information represented most fires since 1950 that 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 – 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 re-captured the surviving radio-collared animals, replaced collars or batteries as required, and again estimated nutritional condition. Again in October of 2000, 87 caribou were captured. We investigated mortalities and retrieved collars as necessary.

Selectivity for post-fire 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 6). 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. The same pattern was evident in during the winter of 2000-2001 (Figure 7).

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% occurred in areas burned since 1966 (Figure 8). Lichen biomass was significantly higher at locations used by caribou than at random locations within the NSA (Figure 9). Sites older than 80 years were used disproportionately by caribou while sites younger than 80 years were avoided (Figure 10).

Nutritional performance and survival of caribou. We obtained measures of over-winter changes nutritional status (body size and weight) on 17 cows and 35 calves that survived the winter of 1999-2000. We plan to recapture survivors from the 2000 cohort in October 2001. Comparable data was collected for the 1998 and 1999 calf cohorts (Table 1). In addition, we collected data for estimating over-winter survival rates for approximately 120 Nelchina caribou (Table 2).

The pilot study to evaluate foraging efficiency and nutritional performance through field trails of tractable animals proved to be feasible. Although numerous obstacles were encountered, the animals proved tractable. Preliminary analyses indicate that the animals were less selective, increased foraging effort, and lost weight when grazed on the historic winter range. When grazed on the NSA, caribou were more selective and maintained or gained weight. We are currently evaluating a study design for an additional series of field trials on ranges with intermediate lichen abundance.

Factors influencing lichen recovery and regeneration. We established experimental plots to evaluate the influence of fire on lichen regeneration and growth on the historic winter range. Lichen fragments were "seeded" on burned and unburned, spruce-shaded and unshaded treatments of moss and duff (or mor) substrates. In addition, lichens were marked to verify the presence of annual nodal branching for use as markers to measure annual growth of individual thalli. These experiments will be re-evaluated during the summer of 2001.

Table 1. Age-specific mean (n, sd) weights of radio-collared 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)	74.8 (21, 8.4)
2000	53.5 (37, 6.6)	N/A	N/A

Table 2. October 1999 – March 2000 and October 2000 – March 2001 survival data.

Age Class	Number at risk		Number surviving		Percent surviving	
	99-00	00-01	99-00	00-01	99-00	00-01
Adults	65	76	59	72	90.8%	94.7%
Yearlings	21	13	10	11	47.6%	84.6%
Calves	34	34	22	19	64.7%	55.9%

Evaluation of fire regimes on caribou winter range availability: We established a cooperative effort with Scott Rupp and the University of Alaska to model the influence of fire frequency, as influenced by fire management or climate change, on expected availability of caribou winter range. An existing frame-based model, ALFRESCO (Rupp et. al. 2000), will be employed to estimate the total area, spatial distribution, and age distribution of black spruce stands within the NSA under various fire regimes. We will combine the output of that model with the lichen abundance – stand age relationships and caribou habitat selection for stand-age to estimate the total forage lichen biomass and total area of selected winter habitats to rank winter range under various fire regimes.

DISCUSSION

The expansion of this study to a collaborative effort between USGS and ADF&G facilitated the investigation of numerous aspects of caribou ecology. In addition, the collaboration has resulted in the assembly of an experienced research team with varied but complimentary expertise.

Data collection and analyses are just beginning. Aerial videography shows considerable promise for remote estimation of lichen cover. Caribou appear to be selecting strongly for lichen abundance, which in turn appears related to stand age. Caribou showed little use of areas known to have burned since 1966. Caribou use areas were predominately older than 60 years since fire.

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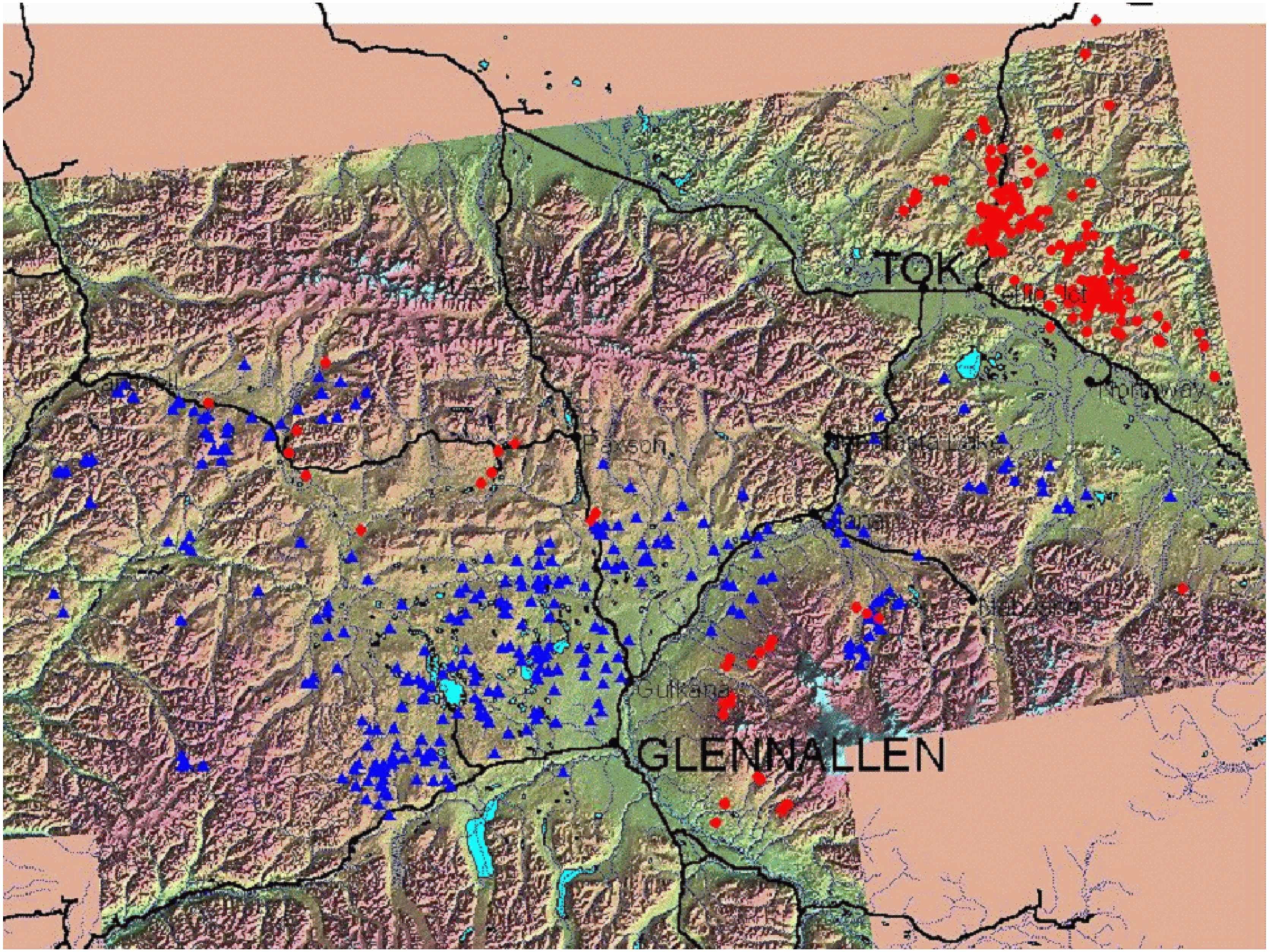
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Gulkana
GLENNALLEN

Figure 1. Winter range locations in Jan - Mar 1980-1985 (n=301, from Pitcher *et al*. unpublished data) and Jan – Mar 1999-2000 (n=271, this study).


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Figure 2. Aerial image depicting caribou forage lichens in a black spruce stand. Image was taken with a digital video camera from a fixed wing aircraft at an altitude of 300 feet.

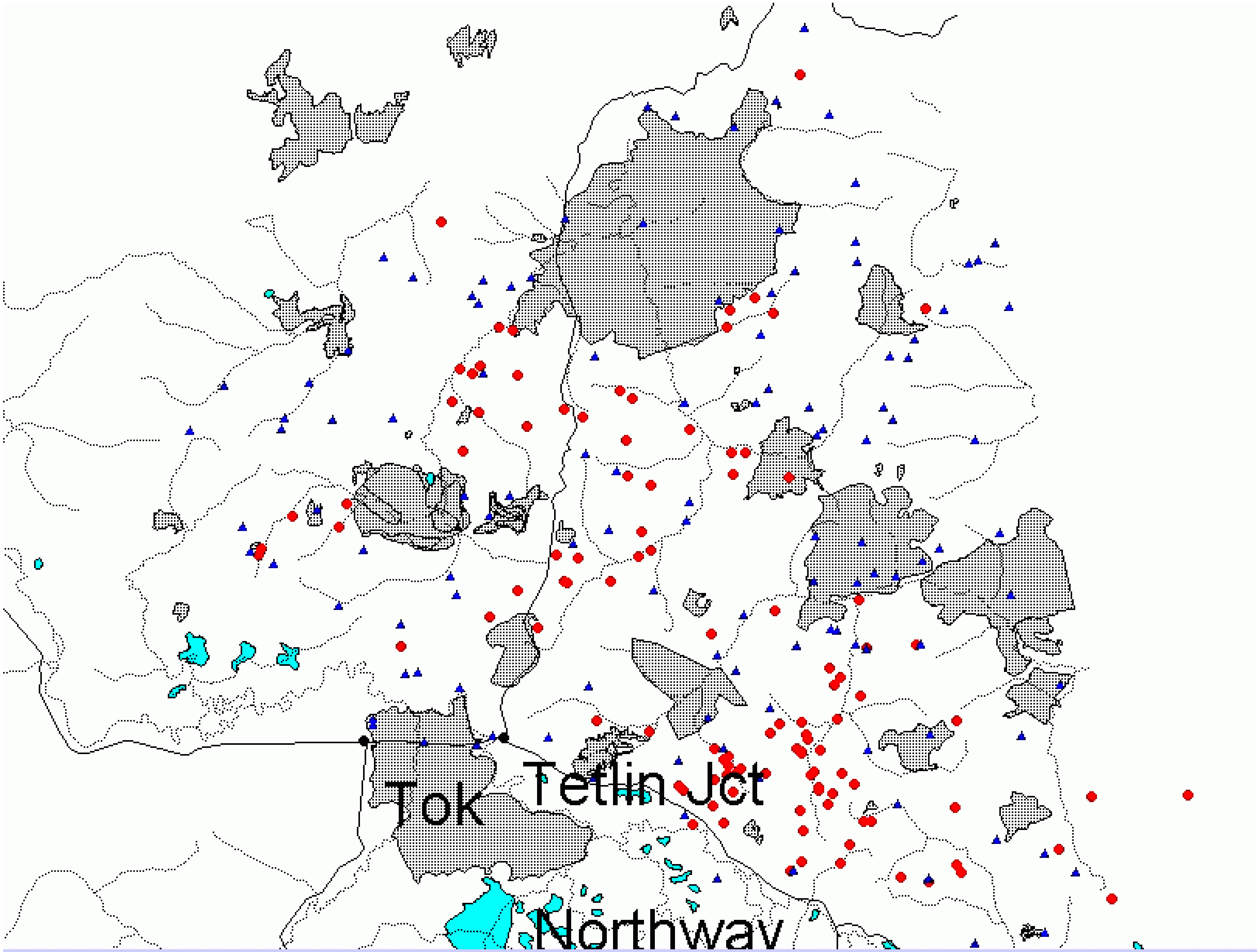
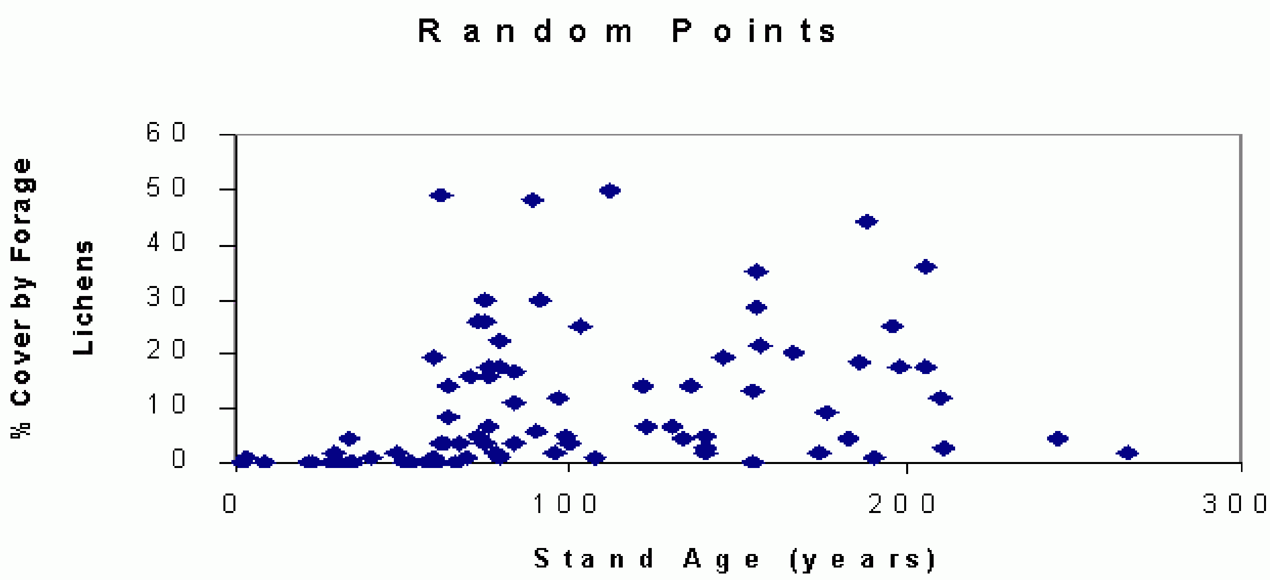
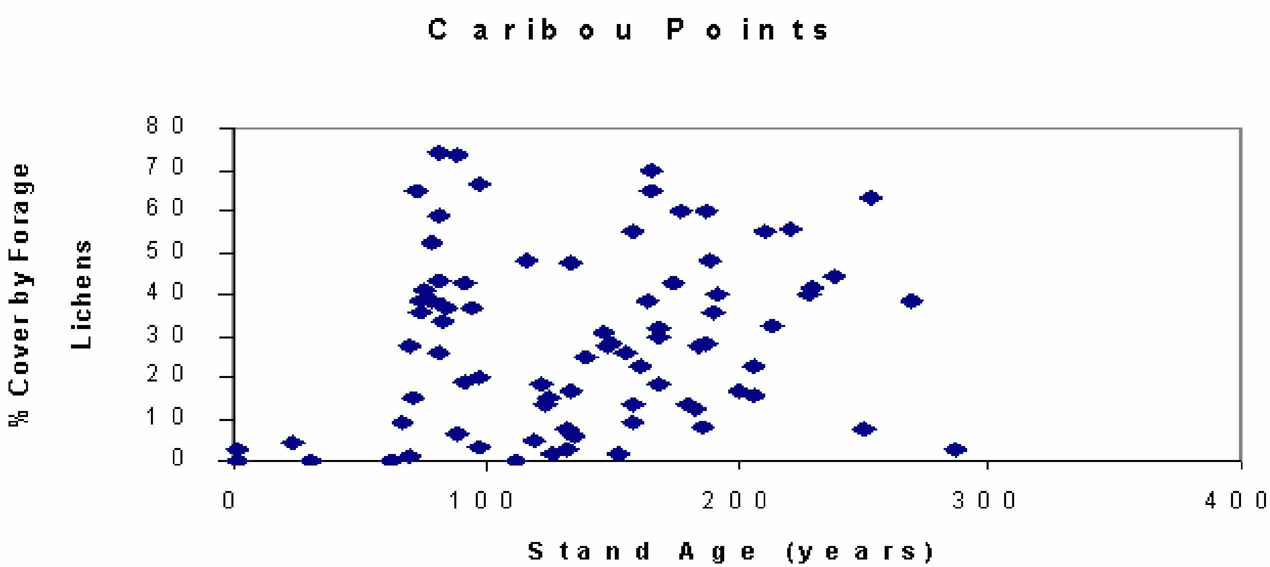

Tok
Tetlin Jct
Northway

Figure 3. Used and random ground sampling locations for the current winter range north of the Alaska


Random Points
% Cover by Forage Lichens
0
10
20
30
40
50
60
0
100
200
300
Stand Age (years)


Caribou Points
% Cover by Forage Lichens
0
10
20
30
40
50
60
70
80
0
100
200
300
400
Stand Age (years)

Highway.

Figure 4. Percent cover of primary caribou forage lichens plotted against age of stand.

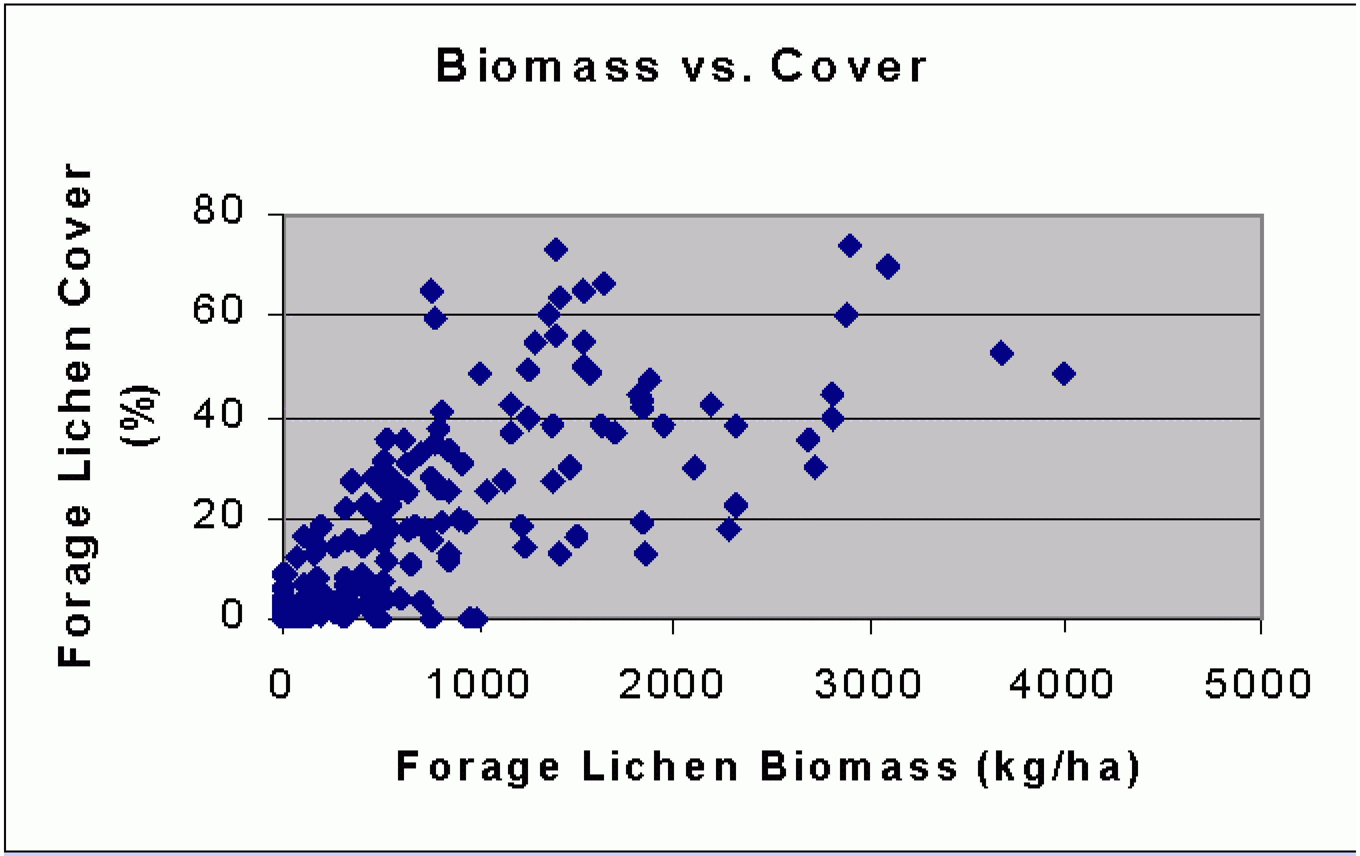
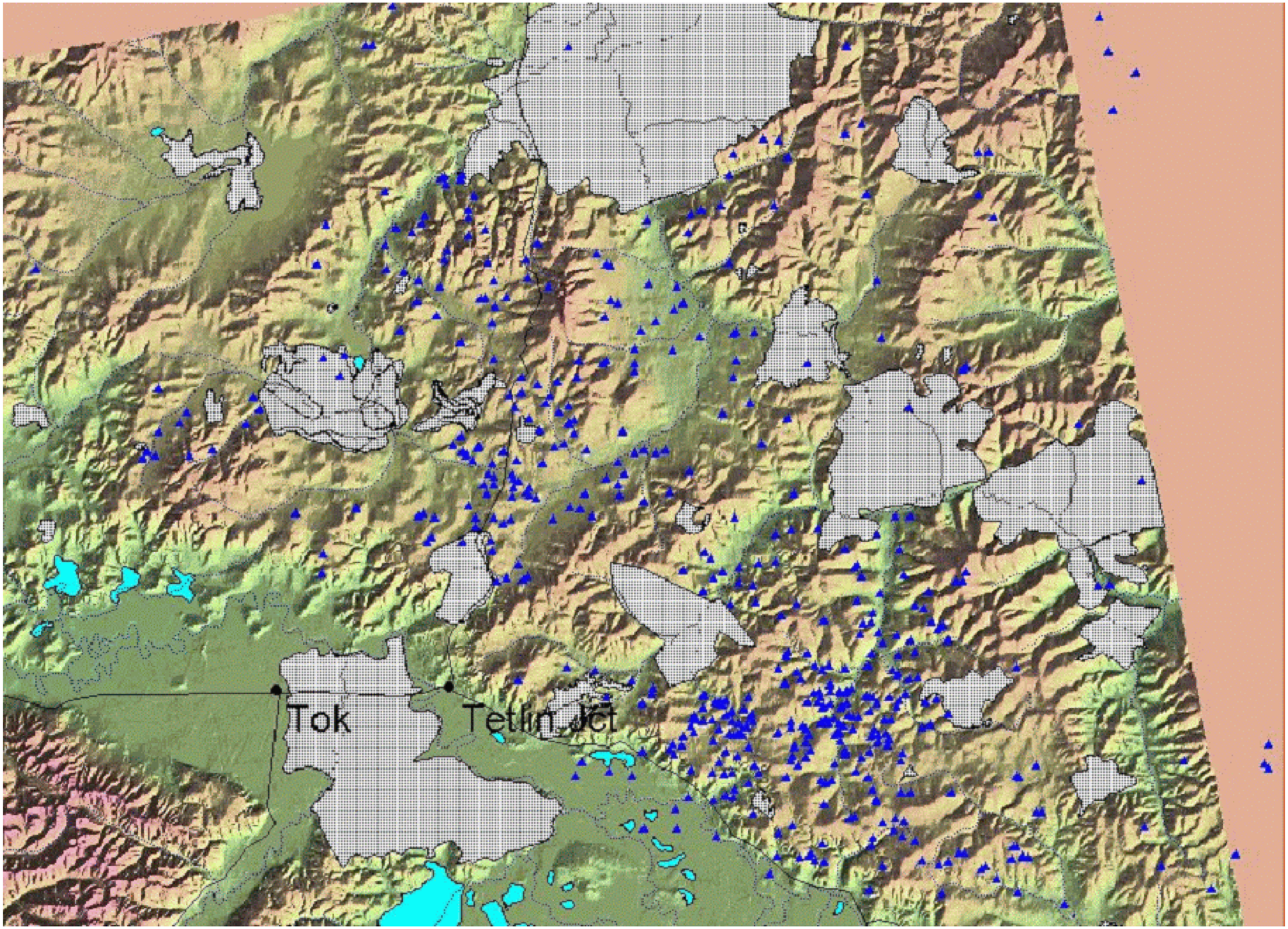


Figure 5. Relationship between percent cover and biomass of caribou forage lichens.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Tetlin Jct

Figure 6. Conventional telemetry locations within the northern study area Oct - Apr, 1999-2000 relative to fire history since 1966 (n=585).

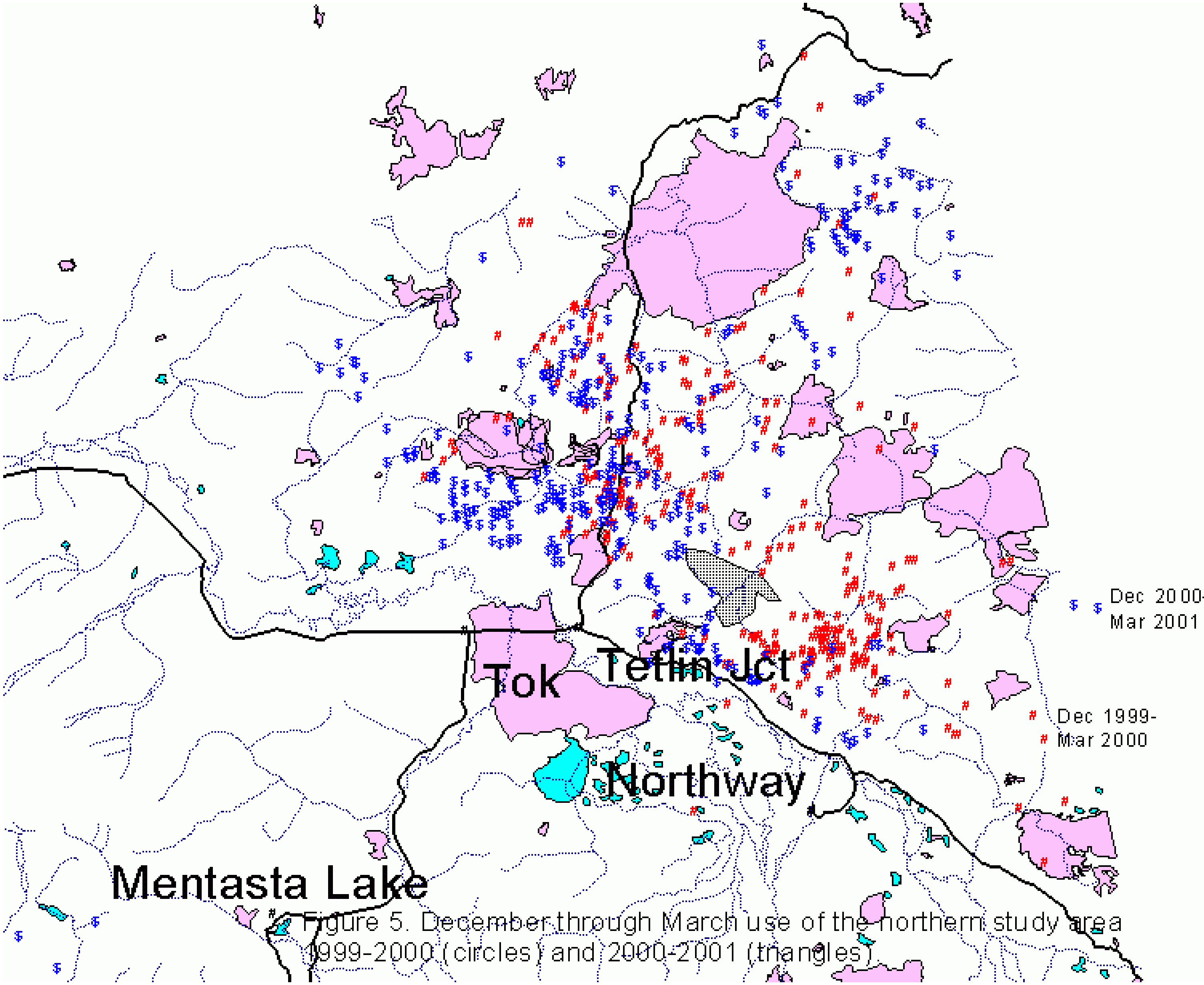
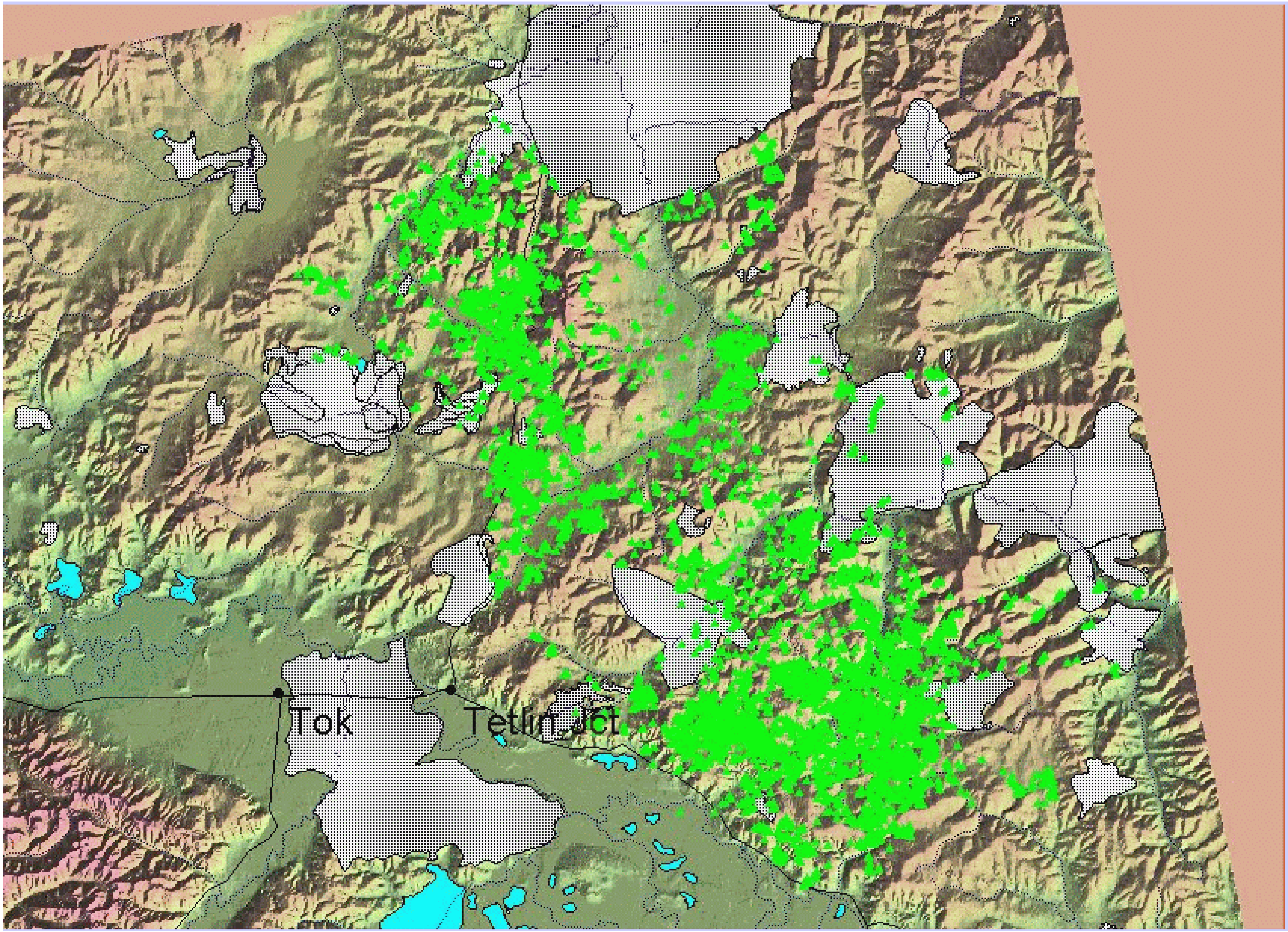


Figure 5. December through March use of the northern study area 1999-2000 (circles) and 2000-2001 (triangles).

Figure 7. Conventional telemetry locations within the northern study area during December 2000 through March 2001 (triangles) and December 1999 through March 2000 (circles).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Tetlin Jct

Figure 8. GPS telemetry locations and fire history since 1966 within the northern study area Oct – Apr, 1999 – 2000.

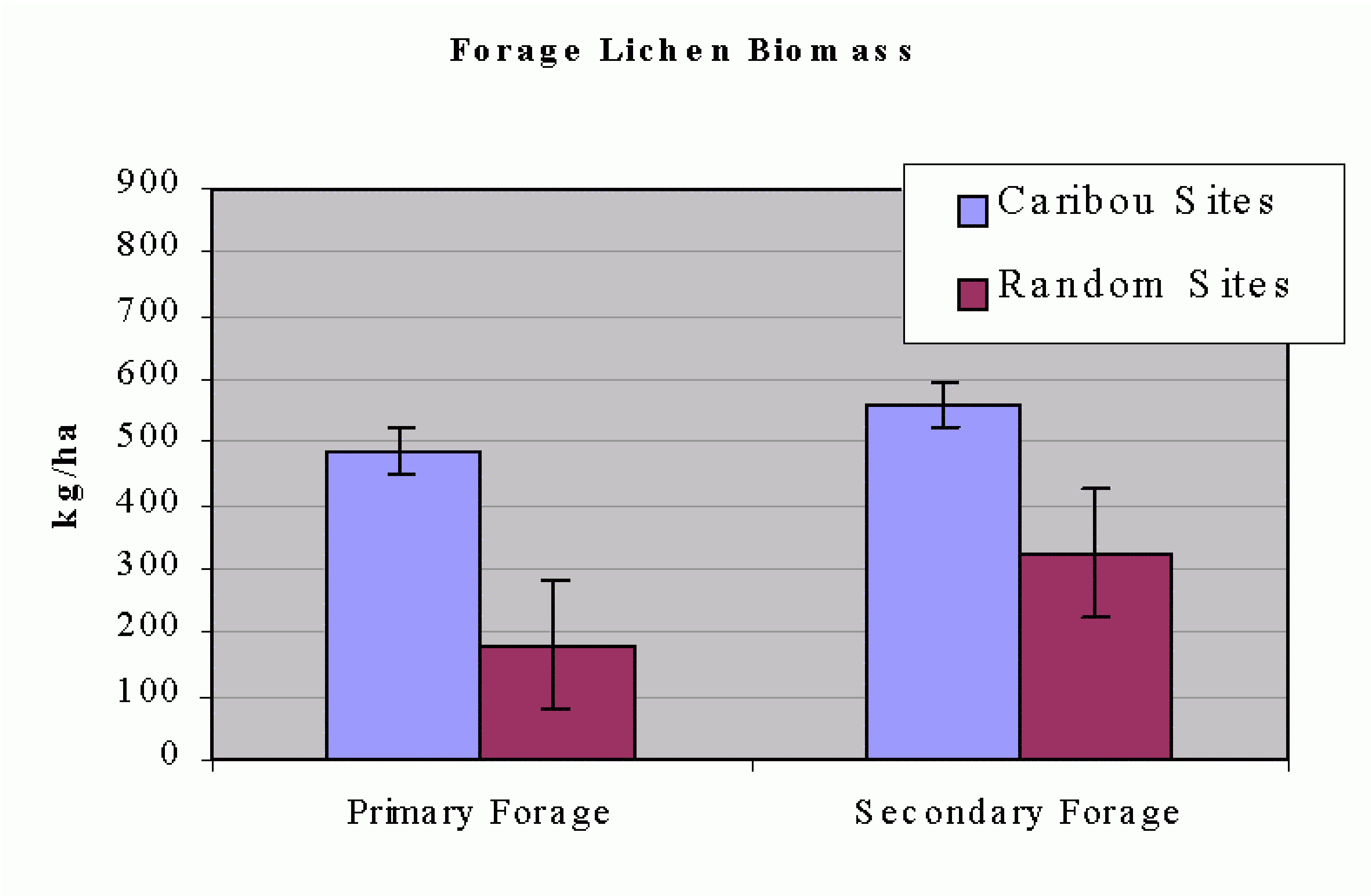

Figure 9. Lichen biomass at locations used by caribou and random locations within the northern study area.

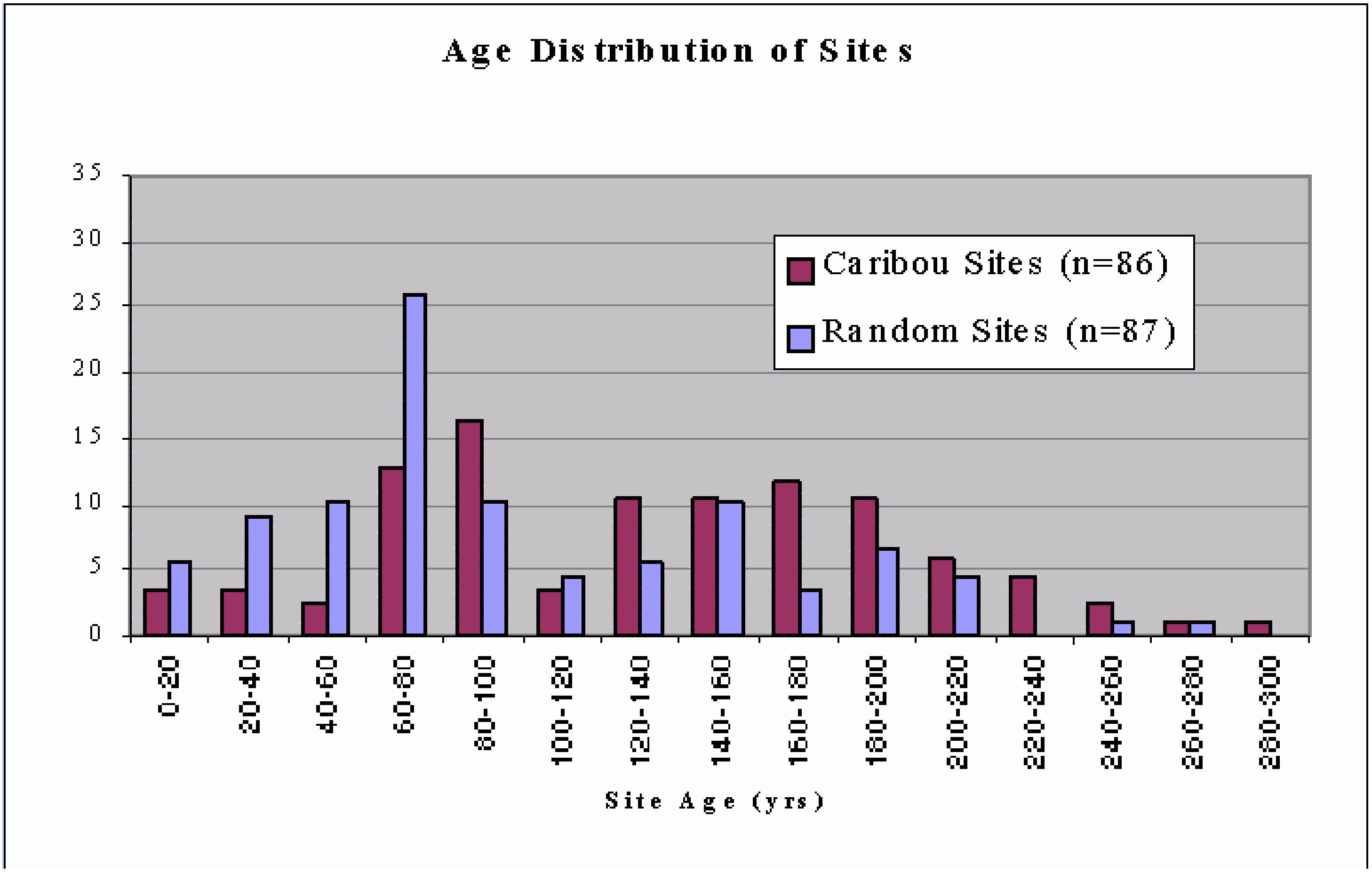

Figure 10. Age of vegetation plots; caribou locations versus random points.