Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Research Progress Report
1 July 1995- 30 June 1996

Population Dynamics of Moose and Predators in Game Management Unit 13

J. Ward Testa

Grant W 24-4
Study 1.49
December 1996

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STATE OF ALASKA
Tony Knowles, Governor

DEPARTMENT OF FISH AND GAME
Frank Rue, Commissioner

DIVISION OF WILDLIFE CONSERVATION
Wayne L. Regelin, Director

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RESEARCH PROGRESS REPORT

STATE:	**ALASKA**	**STUDY NO.: 1.49**
GRANT NO.:	**W-24-4**	
STUDY TITLE:	**POPULATION DYNAMICS OF MOOSE AND PREDATORS IN GAME MANAGEMENT UNIT 13**	
PERIOD:	**JULY 1, 1995 - JUNE 30, 1996**	

SUMMARY

An intensive study site in western Game Management Unit (GMU) 13A, the Nelchina Study Area (NSA) was chosen for detailed study of moose population dynamics. Mortality of adult females there is low, while calf and possibly yearling mortality is high. The low survival of calves to adult age is probably not sustainable in the long term, given the present adult age structure contains a high proportion of prime-age adults born before and during the peak of moose numbers around 1987. As these adults age, their susceptibility to mortality agents will likely increase (Peterson 1977) and increased calf recruitment will be necessary to offset increasing adult mortality. Studies in the NSA also have shown a relationship between the energy stores of adult female moose, as measured by rump fat thickness, and reproductive performance in both the year prior and year after the autumn of capture. This was especially apparent between pregnant and nonpregnant cows and was suggested by a trend ($P<0.10$) toward fewer twins among cows with low rump fat measurements. Twinning rates in the NSA (9-15%) were among the lowest known for moose. Browsing intensity appears also to be high relative to 2 other drainages in Interior Alaska.

Historical trend data indicate the moose population in GMU 13 is at generally high density. The evidence for a population decline is strongest in the northern part of the unit, where cow moose density is approximately 17% below historic highs in 1986-87 and a decline of 30% has occurred in the calf/cow ratio in fall. The rate of decline was not as great as the rate of population increase in the 1970s and early 1980s, and there is little evidence the adult female segment of the population has changed in the GMU since about 1991. With respect to trend count indices to cow moose abundance, GMU 13A is the most variable subunit in the GMU, making the detection of population trends there difficult. Because changes in the cow moose index were not accompanied by appropriate changes in calf:cow ratios, most of the variability in GMU 13A is likely related to temporary (interannual) migrations.

Key words: *Alces alces*, *Canis lupus*, Nelchina, population dynamics, population estimation, predator-prey, radiotelemetry, ultrasound,

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BACKGROUND

Ballard et al. (1991) documented the recent management and ecological history of moose in Game Management Unit (GMU) 13 from 1952-1984. Indices to moose abundance indicated the population underwent a decline from 1963-1976, then an increase through 1984. In recent years the population has stopped growing and has apparently declined since the late 1980s. This research program was undertaken in response to the perceived decline in moose numbers and a managment priority in the region of maximizing human harvest of moose and caribou in GMU 13. This annual report will summarize research results from 1993/94 and 1994/95, in addition to the current year, 1995/96.

OBJECTIVES

The objectives of this 5-year research program are to (1) more accurately track the dynamics of the moose population in GMU 13, (2) determine which causal variables (e.g., weather, predation, habitat, hunting) are driving population changes, and (3) help identify possible management strategies to anticipate or halt moose population declines and increase human harvests. In order to accomplish these objectives, I anticipated the following jobs as part of a 5-year core program:

1. Moose captures; condition and reproductive status

2. Moose mortality; temporal patterns and causes

3. Age of first reproduction; radio collars for yearlings

4. Surveys of winter browsing impact

5. Snow-course measurements

6. Wolf density estimates

7. Moose population estimate, trend-counts and composition surveys

8. Analyses of past trend-count data and population modeling

9. Preparation of annual reports and publications

The field objectives could not be met with a unitwide study, so I focused on an area that was logistically manageable, yet would encompass the important elements of the ecosystem from the moose's perspective. I selected the Nelchina study area (NSA) of approximately 4200 km^2 of moose habitat near the townsite of Nelchina in GMU 13A (Fig. 1), primarily because of its proximity to air charter operators for logistic support, relatively high moose densities, and historical importance to consumptive users in southcentral Alaska. The NSA also contains the principle calving area and wintering grounds for the Nelchina caribou herd. Vegetation characteristics of the area were described by Skoog (1968). Previous studies in GMU 13 indicated an area this size should encompass 9-45 wolves in at least 3 packs (Ballard et al.1987) and 80-120 independent brown bears (Miller 1990).

METHODS

CAPTURE AND HANDLING OF ADULT MOOSE

Forty adult female moose were captured from March 6-28, 1994, and equipped with VHF radiocollars. Twenty-four more were captured and radiocollared from November 7 to December 12, 1994 and from November 7-10, 1995. Using a helicopter, we darted and captured 20 new adult female moose on November 7-8, 1995 and recaptured 21 collared moose on November 9-10, 1995. Except for 13 moose captured by helicopter net-gun on November 16-17, 1994, we captured all moose by darting with a mixture of carfentinil-citrate and xylazine hydrochloride (Schmitt and Dalton 1987) from helicopters. Blood was collected for pregnancy determination by serum assay for pregnancy-specific protein B (PSPB) (Wood et al. 1986, Rowell et al. 1989, Stephenson et al. 1996), and assays were performed in G. Sasser's laboratory (University of Idaho, Moscow). Serum samples were archived in the Fairbanks laboratory of Alaska Department of Fish and Game (R. Zarnke, pers. commun.). In collaboration with Gregg P. Adams, theriogenologist from the University of Saskatchewan, I used ultrasonography to measure the maximum thickness of rump fat as an index to body condition in autumn of 1994 and 1995 and winter of 1996 (Stephenson et al. 1994). Transrectal ultrasonography was used in the field to diagnose pregnancy and incidence of twinning in utero in fall of 1994 and 1995 (Lenz et al. 1993, Stephenson et al. 1996). Eight moose diagnosed as pregnant with twins and 2 that had single fetuses were recaptured by helicopter darting on March 7-8, 1996 for ultrasound assessment of pregnancy and twinning status, and measurement of rump fat. Statistical tests of categorical data were made with log-linear models (Feinberg 1981), or Chi-square tests for 2 X 2 tables (Statistix, NH Analytical Software). Significance was accepted with $\alpha = 0.05$. Tests involving the effects of rump-fat thickness were one-tailed.

CAPTURE AND HANDLING OF YEARLING MOOSE

Ten female moose 10-11 months of age were captured by helicopter darting on April 19-20, 1995, and 12 more on April 14-15, 1996. These were bled for genetic and serum archive and disease assessment (R. Zarnke, Alaska Department of Fish and Game, Fairbanks). Rump fat thickness was assessed by ultrasound, and the animals were weighed from a portable tripod with a load-cell dynamometer to the nearest kilogram. Numbered, expandable radiocollars (Telenics, Mesa, AZ or Advance Telemetry Systems,Isanti, MN) were attached.

MOOSE MORTALITY AND REPRODUCTION

Radiocollared moose were tracked in a PA/18 "supercub" aircraft at least once, and usually twice each month, except from mid May to late June when they were tracked daily and July of 1995 and 1996 when they were tracked 2-3 times per week. Adult survival was estimated by the staggered entry, Kaplan-Meier estimator (Pollock et al. 1989). Animals were counted as having been alive in a given month if they were tracked after the midpoint of that month and found alive. Fatalities were assigned to the month in which the moose was found dead, unless tracks or other evidence indicated that death was likely before the 1st of that month. Animals were not included in survival analysis in the month following their captures, to avoid inclusion of capture-related mortality in the analysis. Telemetry data were pooled across years of the study to provide estimates of annual survival from May to April. Cause of mortality was attributed to a predator if surface investigation showed evidence of chase or struggle, or if sightings were obtained daily and a predator was observed eating a moose that appeared healthy on the previous flight.

Daily radiotracking flights, including visual sightings of all adult and 2-year old moose, were made from mid-May to mid-June to obtain parturition dates and reproductive rates. Survival of calves was estimated by treating calves of collared cows as if they were also radiocollared. Sightability of calves known to be alive (from subsequently being sighted) was lowest in the first 2 months after birth (97% per day), when telemetry flights took place daily (June) or twice weekly (July) and monthly sighting probability approached 1.0. Thereafter, calves were always sighted with the cows unless their disappearance was final and, again, sighting probability of 1.0 was assumed. Survival of calves was calculated from birth to the end of June (months of May and June were pooled in the Kaplan-Meier procedure), then monthly through April. Calf mortality to the end of July was also compared between years by calculating the daily mortality rate (based on the number of calves alive each day) and smoothing the data series using a 7-day running mean.

Differences in the timing of mortality between years 1995 and 1996 were statistically tested with the log-rank test (Pollock et al. 1989) with data pooled into weekly intervals. Causes of mortality of calves could not normally be determined, though in some cases a predator or freshly eaten calf carcass was found at the previous day's location of a missing calf, or dead calves were seen alongside the collared adult. Three dead calves were recovered by helicopter in each of the years 1995 and 1996, and necropsies were performed by R. Taylor (ADF&G).

Parturition rates were calculated as the proportion of radiocollared females that were sighted at least once with a calf in a given year. Twinning rate was calculated as the proportion of adult females with calves that also had twins when first sighted with a calf. Twinning rate was augmented by observations of uncollared moose with calves during the telemetry flights prior to June 2 of each year and excluding sightings made within 1 km of those made previously. Parts of the NSA not usually overflown during telemetry flights were surveyed from R-22 helicopter for twinning rate information on June 2, 1995 and May 29, 1996.

Survey of Winter Browsing Impact

The approach taken in the first year of this study was to sample riparian habitats for *Salix* sp. in late winter to estimate the proportion of that year's annual growth that had been browsed by moose. This was done in collaboration with Dr. Knut Keiland (University of Alaska, Fairbanks); his analyses, summarized in this report, are included as an appendix. The two most common willow species, *Salix pulchra* and *S. alaxensis*, were sampled in the Little Nelchina and Oshetna River drainages, on Tyone and Sanona Creeks, and near Clarence Lake wherever stands of either species could be found. Measurements were made at each site of a haphazard sample (n>200) of browsed willow twigs between 1 and 3 m in height above ground. We measured the diameter at the base of current annual growth (CAG) and diameter at the point of browse (DPB). A sample of twigs was collected from both speces for determining crude nitrogen content and *in vitro* dry matter digestibility (IVDMD) as a function of stem diameter, but reliable results were obtained only for *S. pulchra* in 1995. A more rigorous sampling procedure was developed in 1996 in collaboration with Bill Collins (ADF&G, Palmer), who assumed responsibility for vegetation assessment and reporting in GMU 13A this year. A summary of results only from 1995 will be reported here.

Snow-course Measurements

We continued to measure snow depths in GMU 13 in cooperation with the Natural Resources Conservation Service (NRCS). Five new sites in the NSA were added in 1994, and a sixth was repaired after many years of disuse. These augmented 3 sites that have been monitored since 1968. Rick McClure (NRCS) compiled and distributed those results to users. Ballard et al. (1991) used the mean snow depth (in inches) measured 3 times from late January to late March in the Susitna River Study Area, north and west of the NSA, as a "Winter Severity Index" (WSI). That index was calculated from 8 snow course sites in the NSA for 1995 and 1996 and compared with a longer record from 1980-96 from 3-4 sites in the NSA.

WOLF DENSITY ESTIMATES

Wolf density estimates were made in March, 1995, and February 1996 by Earl Becker, Biometrician for Alaska Department of Fish and Game. The NSA was divided into a grid of 101 square sample units of 42 km^2 and classified into strata of low, medium, and high probability of finding wolves or wolf tracks. Border units of uneven shape were combined to keep the area of each to approximately 42 km^2. Area pilots and Alaska Department of Fish and Game biologists familiar with wolf abundance in the area assigned sample units to strata based on habitat quality and tracks seen in previous flights in the area. Surveys were flown in randomly selected quadrats within a few days of fresh snowfall, and tracks were followed to determine both the number of quadrats containing tracks and the numbers of wolves associated with the tracks. The sampling procedure was based on the Sampling Unit Probability Estimator derived by Earl Becker (Becker, Spindler and Osborne, in prep). Earl Becker organized the wolf surveys and calculated density estimates in both years. Wolves harvested before the surveys, as determined from mandatory reporting forms submitted by trappers and hunters, were added to the survey results to estimate fall density of wolves in the NSA.

CENSUSES, TREND-COUNT AND COMPOSITION SURVEYS

From October 30 to November 5, 1994, a moose census was conducted on the western part of GMU 13A in areas under 1230 m in elevation. The area included all of the NSA, plus an area of approximately 200 km^2 in the extreme NW of GMU 13A that lies just outside the main study. The total area was approximately 4400 km^2. We drew sample units of approximately 40km^2 on a map of the area, choosing boundaries that could be easily identified from the air. The method used was a modification of Gasaway et al.(1986) that employed a probability regression procedure (J. Ver Hoef and E. Becker, in prep.) to relate low-intensity "stratification" counts made by observers in a Cessna 185 on one day to intensive counts made by pilot/observer teams in PA/18 aircraft the following day. Rather than classifying these sample units into strata of different moose densities (Gasaway et al. 1986), regression analysis was used to estimate the relationship between counts from the C-180 and more intensive (complete) counts from the PA/18, and then estimate the number of moose in sample units not surveyed by the PA/18 crews. Sightability correction factors were determined on the intensive sample units by resurveying a 2.6km^2 subunit at higher intensity (Gasaway et al.1986).

Trend-count surveys to index moose abundance and determine herd composition are routinely made for management purposes in traditional Count Areas (CAs) around GMU 13, and 2 of these occur in the NSA (Fig. 1). As part of this study, surveys from PA/18 aircraft were made in CAs 13 and 14 in October 1994, and from 14-16 November, 1995. The search procedure entailed a systematic search by a pilot and observer at 50-150 m height above ground level in a pattern chosen by the pilot for safety and efficient search coverage. When moose were spotted, the pilot would circle the group in order to identify sex and age composition. We identified and counted in each group calves, cows, yearling bulls (identified by antler size), and adult bulls. Management reports from the area commonly standardize these counts by reporting moose per unit of time searched (moose/hour), or per unit of area searched, which can be used as an index of moose abundance.

ANALYSES OF PAST TREND-COUNT DATA

This is an ongoing task of exploratory data analyses and modeling. At this time, only a preliminary summary of moose population trends in GMU 13 will be presented.

The most continuous record of moose abundance in GMU 13 is the series of counts made in autumn of traditional count areas. The boundaries for these units are shown in Fig. 1, but early surveyers (before 1980) often shifted boundaries in an effort to get larger counts and, therefore, better composition information. For this reason, only counts from 1980 onward were considered. The trend count database for GMU 13 is current, but analyses are preliminary. The traditional use of these data has focused on moose per hour of counting as an indicator of moose population size in the game management unit as a whole. Moose counted per unit area show very similar trends, but slightly higher year to year variability. Bull/cow ratios and calf/cow ratios vary substantially from year to year, due to harvest of bulls and annual changes in calf recruitment. Because these may tend to obscure multiannual trends in the demography and because cow moose are the most important segment to population growth, my approach is to emphasize the adult females in population analyses. Because they can more easily be compared to population estimates and appraised for sighting probabilities, I will present trend count data as moose or cows per km^2.

Only Count Areas 3, 5 and 6, in the northern part of GMU 13, and count area 13 in the western part have been surveyed each fall from 1980 to 1995. Count Areas 10 and 16 were surveyed all years except 1989, and the data series for CA 15 excluded years 1992 and 1995. Count Area 14 was surveyed in 1980, 1984-88, and 1991-95. CA 7 was surveyed in 1980-86 and 1990-92. Other parts of GMU 13 have been surveyed for moose numbers and composition, but I included only those that have been surveyed at least 10 of the past 16 years.

Summaries presented in this report were based on cow moose per km^2. Because moose density, habitat quality and size of each CA differ, and population trends are of the most interest, the moose count data from each CA were standardized by subtracting the mean value for that CA from 1980-1995. These "deviations from the mean" will be graphically illustrated. In order to pool different CAs and report subunit trends, the deviations from the mean were weighted by the size of each CA in the subunit. Because CAs 3 and 10 straddled subunit boundaries, they were weighted by half their area and included in both the subunits. Composition in the subunits was based on all moose seen in the respective CAs, except for CA 7 and CA 10, where totals were divided evenly between subunits sharing that CA.

RESULTS

REPRODUCTION

Among 40 moose captured and released in March 1994, 35 (88%) were pregnant. During daily flights, we observed only 25 of these with calves the following May and June. The apparent decline in reproductive rate from 88% to 63% in the last 2 months of gestation is unusual. The PSPB test for pregnancy in moose has not been validated, but parturition rates from 1994-1996 also differed significantly among years ($P = 0.01$), with 1994 being a negative outlier (Table 1). Subjective condition scores assigned to the animals in March 1994 (Franzmann 1977) were significantly lower ($P<0.01$) among the pregnant animals that were not subsequently seen with calves. It is not known whether the offspring were lost before or during the normal calving period. Twinning rate in the NSA was low (12.6%, SE = 1.8%). Differences in spring twinning rate among years were not significant (P = 0.44). Only 5 2-year-old moose have been observed for first reproduction, and none had a calf. One 3-year-old moose was radiotracked in 1996; it had a calf.

Among 64 moose captured in Nov/Dec of 1994 and 1995, pregnancy status was determined by ultrasound examination in 62. Of 48 pregnant females sufficiently progressed in pregnancy for fetuses to be reliably counted with ultrasound, 13 (27%) were carrying twins. Ten of these were followed the subsequent spring, and 8 gave birth to twins. One (#84) was seen only with a single calf, which died within 1 day. The following year she was not handled but gave birth to twins, both of which died within 2 days. All 3 calves were necropsied. They were of normal birth weight, but there was no discernible cause of death. The second female not seen with calves appeared pregnant in early June and made movements toward an alpine area typical of calving habitat for moose in the area but suddenly moved back to her normal home range and no longer appeared pregnant. We believe she gave birth and lost or abandoned her calf or calves within a few hours. Twinning rate determined *in utero* in fall (27%) was significantly greater ($P<0.001$) than that observed at parturition (13%, Table 1) in independent samples.

Mean rump fat thickness was significantly less among moose with 1 or more calves at heel in November ($\bar{x} = 27$ mm) than among moose without calves ($\bar{x} = 42$ mm, $P < 0.001$). Pregnant moose were also significantly fatter ($\bar{x} = 41$ mm) than nonpregnant moose ($\bar{x} = 24$ mm; $P<0.001$), excluding a single cow with a uterine pathology that prevented pregnancy. There was a trend toward greater rump fat among females with 2 fetuses ($P = 0.18$). Pregnant females that were not seen later with a calf were usually among those with the least rump fat ($\bar{x} = 35$ vs 42 mm of fat, $P = 0.10$). Moose #84 bore normal weight calves that quickly died in both years, but also had the most rump fat among the females that lost a calf or fetus before it was seen in the spring. The death of her calves may be related to some unknown pathology, rather than the amount of her energy reserves.

Of 12 yearling moose (11 months) examined in 1996, none had detectable rump fat. No difference in mass was observed among yearling moose captured in 1995 and 1996 ($P = 0.49$, $\bar{x} = 158.2$ kg, $s = 15.1$).

MORTALITY

Average annual survival after 2 years of study was 0.96 for radiocollared females (Table 2). Numbers dying in each year were too low to reliably test for statistical differences among years. Three adults were killed by brown bears during the calving season, 2 were killed by wolves in late winter, and 1 died in March, apparently from a hip injury the previous January that left her unable to stand. An additional female, not included in the survival analysis, was killed legally by a hunter in September 1994. Survival of radiocollared yearling females from May to April was 0.79, but the small sample size causes poor precision in this estimate. (Table 3). Four yearlings were found dead; brown bear predation was the cause of 2 deaths, and probably in a third. The fourth was observed dead from the air without apparent injury or attendant predator and was seen with a feeding brown bear the next day. The 4 fatalities were not unusual in weight among those radiocollared.

Most calf mortality occurred in the first month after parturition. The temporal pattern of calf mortality to the end of July, compared among years, is shown in Figure 2. Considered as a daily probability, calf mortality was highest from May 27 to about the end of June (Figure 2). The most apparent differences among years were a prolonged period of moderate (1-2% daily) mortality in the month of July in 1995, the absence of July mortality in 1994, and roughly half the normal daily rate of mortality from May to June 12 in 1996. However, a log-rank test of the difference in survival distributions (Pollock et al. 1989) for 1995 and 1996 approached, but did not exceed, statistical significance ($P = 0.07$). Average annual survival of calves (Pollock et al. 1989) was 0.28 (Table 4).

WINTER BROWSING

The current annual growth (CAG) and diameter at point of browse (DPB) measured from *S.alaxensis* and *S.pulchra* at several sites in the NSA are shown in Table 5. On the basis of stem diameter, roughly 84% of the CAG was removed per browsed stem in both species, with the heaviest browsing occurring in the Oshetna River drainage. This is higher than the proportion browsed in either the Koyukuk (approximately 75% of *S.pulchra* twigs) or Tanana (76% of *S.alaxensis* twigs) drainages in Interior Alaska (Kieland, pers.commun.). The diameter-specific concentration of crude protein (CP) in *S.pulchra* was described by $CP = 9.36*diameter^{-0.14}$. A similar relationship was found for *in vitro* dry matter digestibility: $IVDMD = 40.06*diameter^{-0.13}$. The small exponent is indicative of the relatively uniform nutritional content of *S.pulchra* at stem diameters over 3 mm. At the average DPB, IVDMD of *S.pulchra* was approximately 34%, while the protein intake per bite was in the range of 0.022-0.034g. A similar evaluation of *S.alaxensis* was not possible, due to aberrant laboratory results for that species. CP and IVDMD values of *S.alaxensis* varied significantly between studies in the Koyokuk and Tanana River drainages (Kieland, pers. commun.), so further study on these properties will be made in the NSA. K. Keiland's report is in the Appendix.

SNOW COURSE MEASUREMENTS

The winter snow index (WSI) on the NSA was 28 in the winter of 1994/95 and 17 in 1995/96. By definition (Ballard et al. 1991), the winter of 1994/95 just exceeded the threshold for a "severe" rating (WSI = >28) in the NSA, whereas 1995/96 was "mild" (WSI = <18). The longer term record from 3-4 sites on the NSA indicates that WSI in the last 16 years has occasionally exceeded 28 but never exceeded 29 (Fig.3). More extreme values were noted by Ballard et al. (1991) for GMU 13, indicating somewhat milder conditions in Subunit 13A.

Jay Ver Hoef (ADF&G, Fairbanks) is analyzing, statewide, snow course data and has produced a statistical model for data through 1993. The model output is a spatial map of snow depths for most of the state, including the NSA in GMU 13A-West. Within this framework, it should be possible to evaluate snow depth from the perspective of total habitat available below certain snow-depth thresholds. Future analyses will focus on mean snow depths and total area of moose habitat with depths < 71cm (WSI<28).

WOLF DENSITY ESTIMATES

Although late winter estimates of wolf density differed substantially from 1994/95 to 1995/96 (Table 6), the annual harvest was not imposed until very late in the winter in 1996. Effects of temporary emigration (2 packs) were greater in 1995 than in 1996, involving only 2-3 wolves/1000 km^2. Fall densities apparently differed little between years, but due to the low, late harvest in the 1995/96 winter, the impact of wolves should have been greater in that winter than in the winter of 1994/95. Several wolf-killed or injured moose calves were seen near wolves during the wolf-estimation flights of 1995/96.

MOOSE POPULATION CENSUS AND TREND-COUNTS

The moose census in November 1994 yielded an estimate of 0.81 moose/km^2 and 0.60 cows/km^2 in the NSA (Table 7). The number of moose seen per flight hour and per km^2 during trend-count surveys declined from 1994 to 1995 (Table 7). However, it is not clear that the observed difference represents a real change in population density because survey conditions were poor in 1995 due to lack of snow. There were no changes in mortality or recruitment estimates, or in composition of the counts (Table 7) that would explain a population decline. A significant (P = 0.01) increase in the proportion of cows with calves occurred in the trend-count areas, but this change was ambiguous, given the calf:cow composition during the population estimate of 1994 was higher than the trend-count composition of that year and virtually identical to the trend-count composition of 1995 (Table 7). It is expected that cows with calves, being more solitary, would be more easily missed in trend-count surveys than in the more intensive moose estimation surveys. The difference in calves/100 cows between surveys in 1994 probably reflects this bias in methods. The conclusion that the calf:cow ratio, measured by comparable methods, had improved in 1995 is valid, though the magnitude of that increase was not great.

LONG-TERM TREND-COUNT SUMMARIES

Trend-count data for CA 13 and CA 14 are summarized in Fig. 4. The extraordinary yearly variation in the index to cow moose density (cows/km^2 minus the 15-year mean) is more than is expected to result from natural dynamics of a closed population. For this reason, migration must play a substantial role in sudden changes of moose abundance in the area. This is especially apparent in the unusual counts of 1983 and, especially, 1987, which have had substantial influence on interpretations of total moose numbers in GMU 13. These sharp "spikes" in the index to moose abundance were accompanied by weak declines in calves/100 cows, a feature expected if cows with calves were less likely to move than lone cows and bulls. The sharp decline in the cow index in 1995 was strongly influenced by poor survey conditions and is an unreliable index of real population decline. On the whole, there were no indications from fall composition surveys that sharp changes in moose abundance were accompanied by appropriate changes in recruitment. Changes in bull/cow ratios have followed changes in harvest regime, which favors bulls and involved a hiatus on adult bull harvest from the late 1980s to 1992. There was limited protection for 2-3 year old bulls via selective, "spike-fork or 50 inch" antler restrictions when the season reopened in 1993, but harvest rates were high and the bull/cow ratio made a sharp decline. Calf recruitment in recent years has been below the long-term average and substantially below the highest values seen in the area. This is in accord with the high calf mortality seen in calves of radiocollared cow moose in the NSA in 1994-95, and is a possible warning of pending changes in age structure and moose abundance.

Direct estimates of moose abundance were made in CA 14 in 1983 (Ballard et al. 1991) and in the western half of GMU 13A in 1987 and 1993. The estimated density of moose in 1983 in CA 14 was nearly identical with that for the NSA in 1994, but the estimate in 1987 was 55% higher than either value. While this might be considered evidence for a peak in 1987 substantially above population levels now, the trend count data indicate that the elevated density estimate in 1987 was the result of a sharp annual influx of moose that was reversed the following year, and not a legitimate baseline on which to manage unit population.

Moose density indices and total area differ substantially among CAs (Table 8). Differences from the mean are shown graphically in Fig. 5 for each of the subunits of GMU 13 for which we have significant CA data. I have omitted Subunit 13D because the CA for which we have data (CA 15) is small (924 km^2) relative to the size of the subunit and may be misleading about the status of GMU 13D. In comparison to the rest of Unit 13, the NSA (GMU 13A in Fig. 5) showed the most yearly variation in indices to moose abundance. From 1980-86, when CA 7 was included, Subunit 13E showed a tendency to vary in an opposite direction to 13A. CA 7 lies immediately north of CA 14 in Unit 13A, probably sharing moose that change positions from year to year. There are no traditional CAs in the portion of Unit 13D that borders the CAs of 13A, so there is no way, with the present data, to test the hypothesis that yearly variation in the counts in Unit 13A result from movements of moose across that boundary. Radiotracking of moose captured in the southern part of the NSA indicate movements to Unit 13D. Current swings in the trend count index are not as pronounced as in previous years, and this may reflect a decline in migration since the moose population in other areas has declined.

Trends in population density in Units 13B and 13C show much less annual variability, and a fairly clear increasing trend until the late 1980s, followed by a small decline and relative stability for the last 5-6 years of the series. Unit 13B (Fig. 6) has the most stable series of cow density indices, possibly due to the large proportion of the subunit that lies within trend count areas. The decline from the peak in cows observed in the subunit coincided with a decline in recruitment, evidenced by the drop in the proportion of cows with calves after 1988 (28% to 20%, $P = 0.00$). In subunit 13C, the CAs comprise a small proportion of the subunit (Fig. 1), and there is more annual variation in composition and the cow density index than in Unit 13B. However, the pattern in cow moose abundance is similar to that in Unit 13B, and there was a drop in the proportion of cows with calves after 1988 (24% to 21%, $P = 0.04$). The pattern for Unit 13E is probably not reliable because only CA 3, small in area and shared with Unit 13B, was counted during the years in which the counts peaked in the other subunits. Trends in harvest density of moose in Units 13B and 13C also show a decline in those subunits since the late 1980s, while harvest density increased in Unit 13A following a hiatus on adult bull harvest.

PREPARATION OF REPORTS AND PUBLICATIONS.

The following reports were published this year.

STEPHENSON, T.R., J.W.TESTA, G.P. ADAMS, R.G. SASSER, C.C. SCHWARTZ, AND K.J. HUNDERTMARK. 1996. Diagnosis of pregnancy and twinning in moose by ultrasonography and serum assay. Alces 31: 167-172.

TESTA, J.W. 1996. Using annual approximations of birth rate in models for species with multiannual reproductive cycles. Marine Mammal Science 12(3):428-433.

DISCUSSION

The status of moose in GMU 13 is of great interest to public user groups and resource managers in the state. Historical trend data indicate the population is at generally high density. The evidence for a population decline is strongest in the northern part of the unit, where cow moose density is approximately 17% below historic highs in 1986-87 and the fall calf/cow ratio since 1988 is 30% less than that observed before 1988. The rate of decline was not as great as the rate of population increase in the 1970s and early 1980s, and there is little evidence the adult female segment of the population has changed in the GMU since 1991. With respect to trend count indices to cow moose abundance, Unit 13A is the most variable subunit in the GMU. Because changes in the cow moose index were not accompanied by appropriate changes in calf:cow ratios, this variability must be related to temporary (interannual) migrations of moose in Unit 13A. While composition data from that area appear fairly stable, and are consistent with studies of calf mortality and changes in hunter harvest, they are probably representative of an area larger than that defined by the boundaries of the NSA and GMU subunit. Similarly, the cessation of large swings in the count index since 1989 may reflect a decline in moose abundance and migration from adjacent areas.

Studies in the NSA have shown a relationship between the energy stores of adult female moose, as measured by rump fat thickness, and reproductive performance in both the year prior and year after the autumn of capture. This was especially apparent in the proportion of cows with calves, and was suggested by a trend ($P<0.10$) toward fewer twins among cows with low rump fat measurements the previous fall. Franzmann and Schwartz (1985) suggested that spring twinning rate is an indication of nutritional status of a moose population, and Gasaway et al. (1992) compiled evidence that moose near a resource-dependent carrying capacity may have low twinning rates. Twinning rates in the NSA (9-15%) were among the lowest recorded for moose (Gasaway et al. 1992), while twinning rates in the rest of the GMU in recent years were higher, but not above average (23-40%: R. Tobey, pers.commun. and J.W. Testa, unpublished). In the NSA, browsing intensity appears also to be high relative to 2 other drainages in Interior Alaska (K. Keiland, pers. commun.). Two conclusions are relevant to moose in GMU 13. In the NSA, where moose densities are high and apparently stable, there is a moose-vegetation interaction that appears to have reduced moose productivity relative to that of moose in other parts of the GMU. Indications of moose nutritional status elsewhere in the GMU are no better than average.

Mortality of adult females is low, while calf and possibly yearling mortality is high. The low survival of calves to adult age is probably not sustainable long term, given present adult age structure contains a high proportion of prime-age adults born prior to and during the peak of moose numbers prior to 1988. As these adults age, their susceptibility to mortality agents will probably increase (Peterson 1977), and increased calf recruitment will be necessary to offset increasing adult mortality.

The current rate of calf mortality in the NSA has been higher that that observed by Ballard et al. (1991), though the timing of mortality (almost all in the first 60 days) has been similar. Sightings of brown bears, often on moose kills in the spring, is high and supports the contention that brown bears remain the principle cause of calf mortality in the NSA, and probably in the remainder of GMU 13 (Ballard et al. 1991). Brown bears also killed more adults than any other causative agent observed so far, though total number of adults dying was low. Assuming that no major change in moose numbers occurred from 1994 to 1995 and using the average overwinter wolf densities, moose/wolf ratios in the NSA were approximately 123 in 1994/95 and 82 in 1995/96. Both are well above the densities at which Gasaway et al. (1983) suggested that wolves can limit moose populations, but probably within the range at which all predators can limit the moose population (Gasaway et al. 1992). However, the combined effects of wolves and bears in a site where caribou are also abundant remain a matter of speculation (Gasaway et al. 1992). Bears appear to have a greater effect on moose calf survival in the NSA and GMU 13 than do wolves, and their effect on moose population dynamics would be delayed through persistently poor recruitment than directly through adult mortality. As such, the expected trajectory of a moose population preyed upon most heavily by bears may follow a slow decline, rather than a rapid one.

The management of predator numbers for the purpose of increasing human harvest of moose and caribou in Alaska is a matter of heated debate. In Unit 13 the Board of Game has modified harvest regulations to increase the take of brown bears in order to increase moose calf survival. An increase in calf survival will be necessary to increase moose in areas where that is the objective and to offset an expected increase in the mortality of aging adults, though that increase has yet to be seen. Because of the feedback loop between calving success and energy stores of adult female moose, increases in calf survival to autumn that may follow reductions in predator populations could result in compensating decreases in calving and/or twinning rates. Given the high densities and low productivity of moose in some parts of the GMU (notably 13A) and rather average productivity in areas where moose have declined, care must also be taken to ensure moose densities are not allowed to increase beyond a supportable range. Predator impact is relatively gender neutral and distributed fairly evenly over the moose population. If management actions successfully reduce predation pressure on moose, human harvest of moose "released" from predation pressure should mimic normal predator impact as much as possible to avoid local irruptions or overharvest of the moose population.

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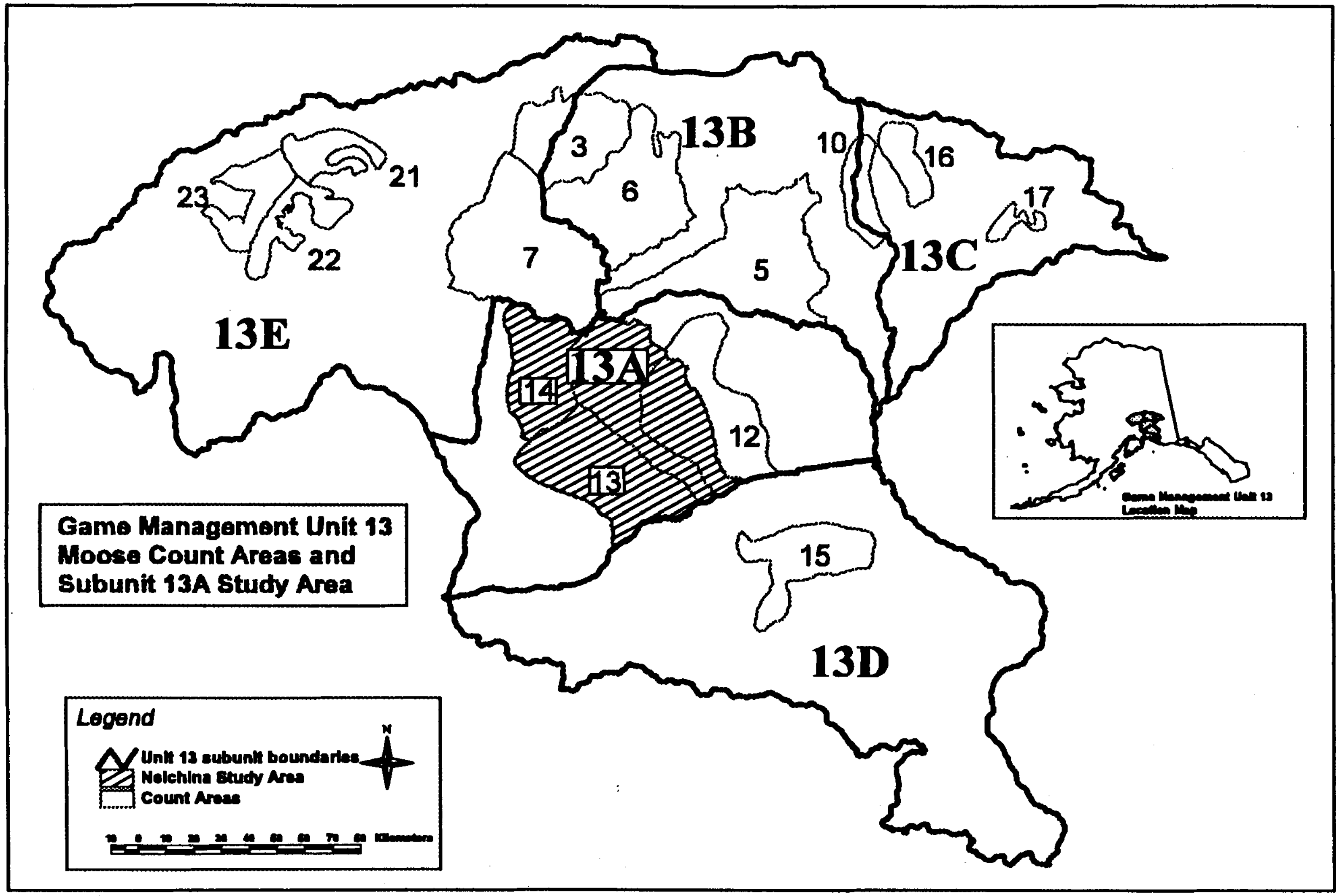


Figure 1. Game Management Unit (GMU) 13 in 5 subdivisions (A-E) in southcentral Alaska, with traditionally surveyed trend-count areas and boundary for Nelchina Study Area (NSA).

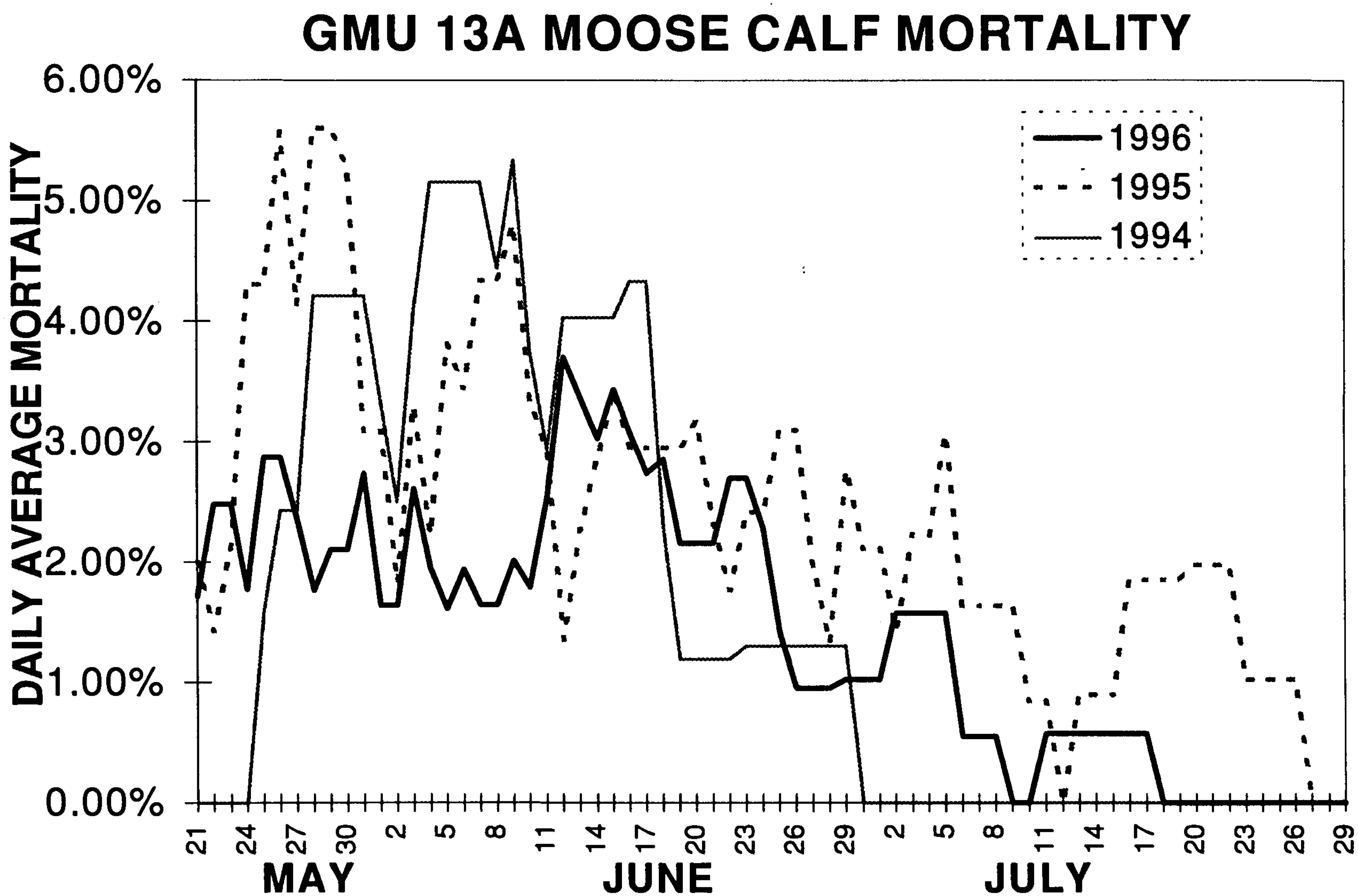


Figure 2. Seven-day running average of daily mortality rate of moose calves in the Nelchina Study Area in spring 1994-1996.

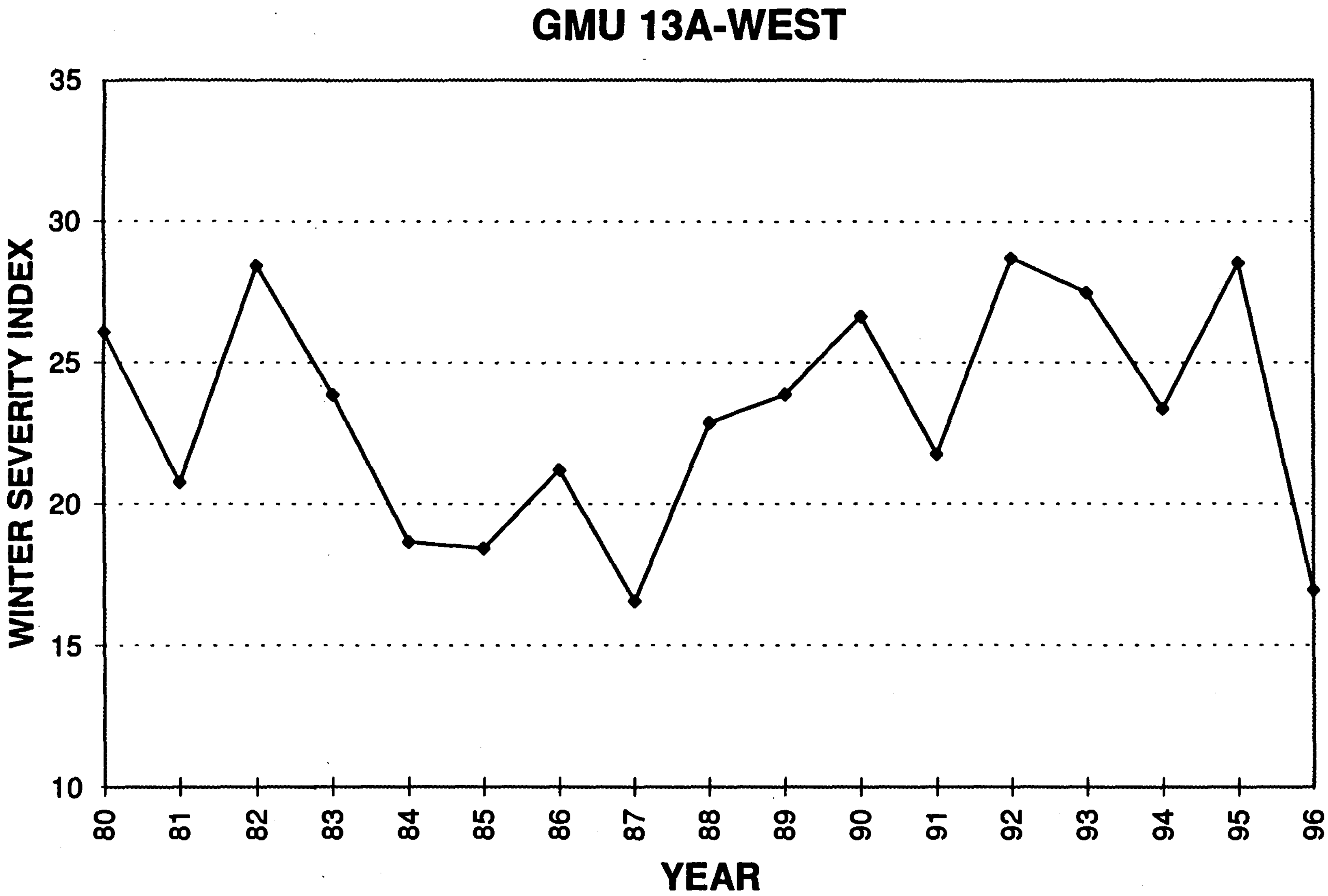


Figure 3. Winter severity index (WSI) in Nelchina Study Area from 1980-1996.

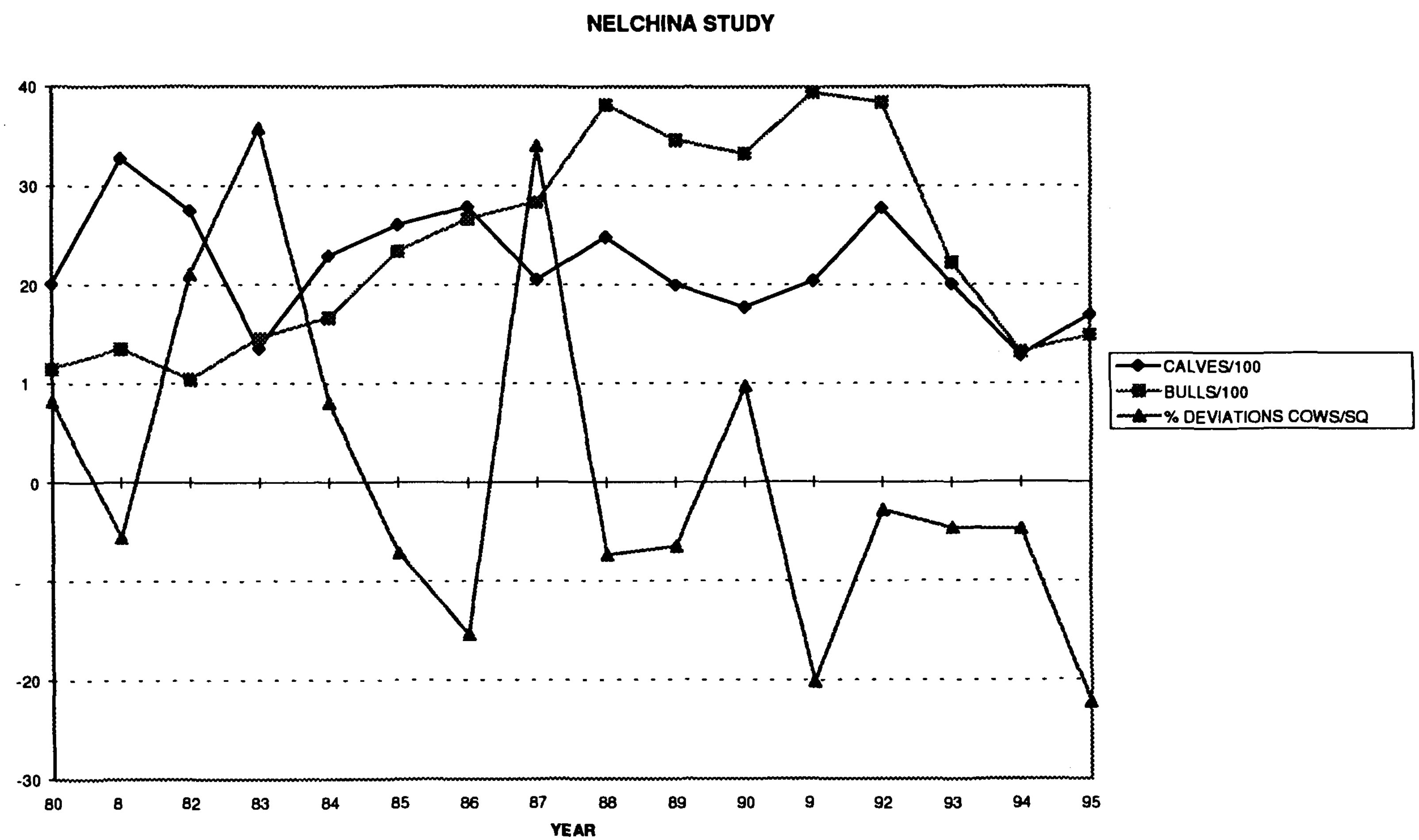


Figure 4. Fall composition and annual deviations from the mean index of cow moose/km^2 in the Nelchina Study Area from 1980-1995.

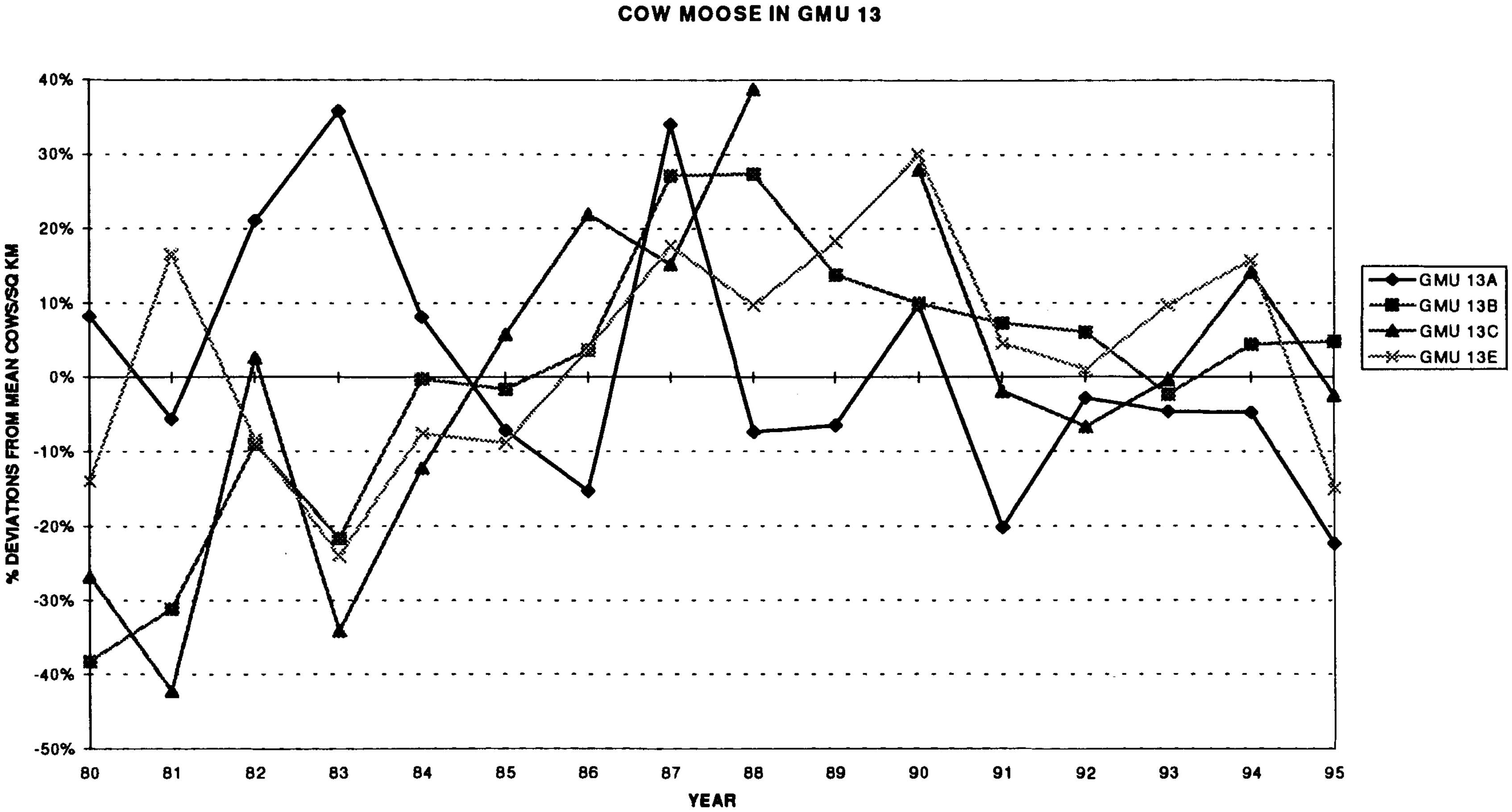


Figure 5. Annual deviations from the mean index (1980-1995) of cows/km2 in the major subunits of GMU 13.

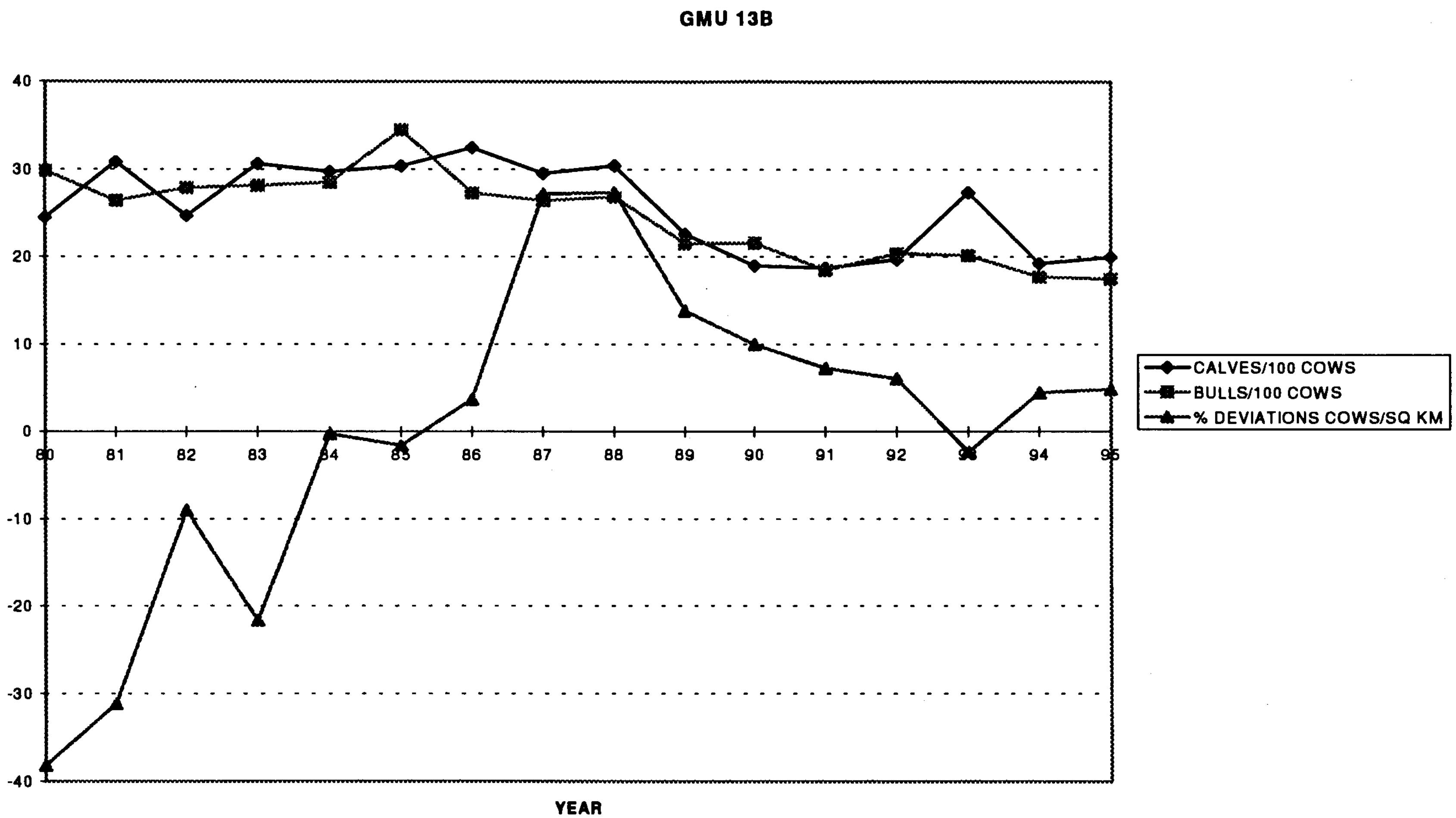


Figure 6. Fall composition and annual deviations from the mean index of cow moose/km^2 in GMU 13B from 1980-1995.

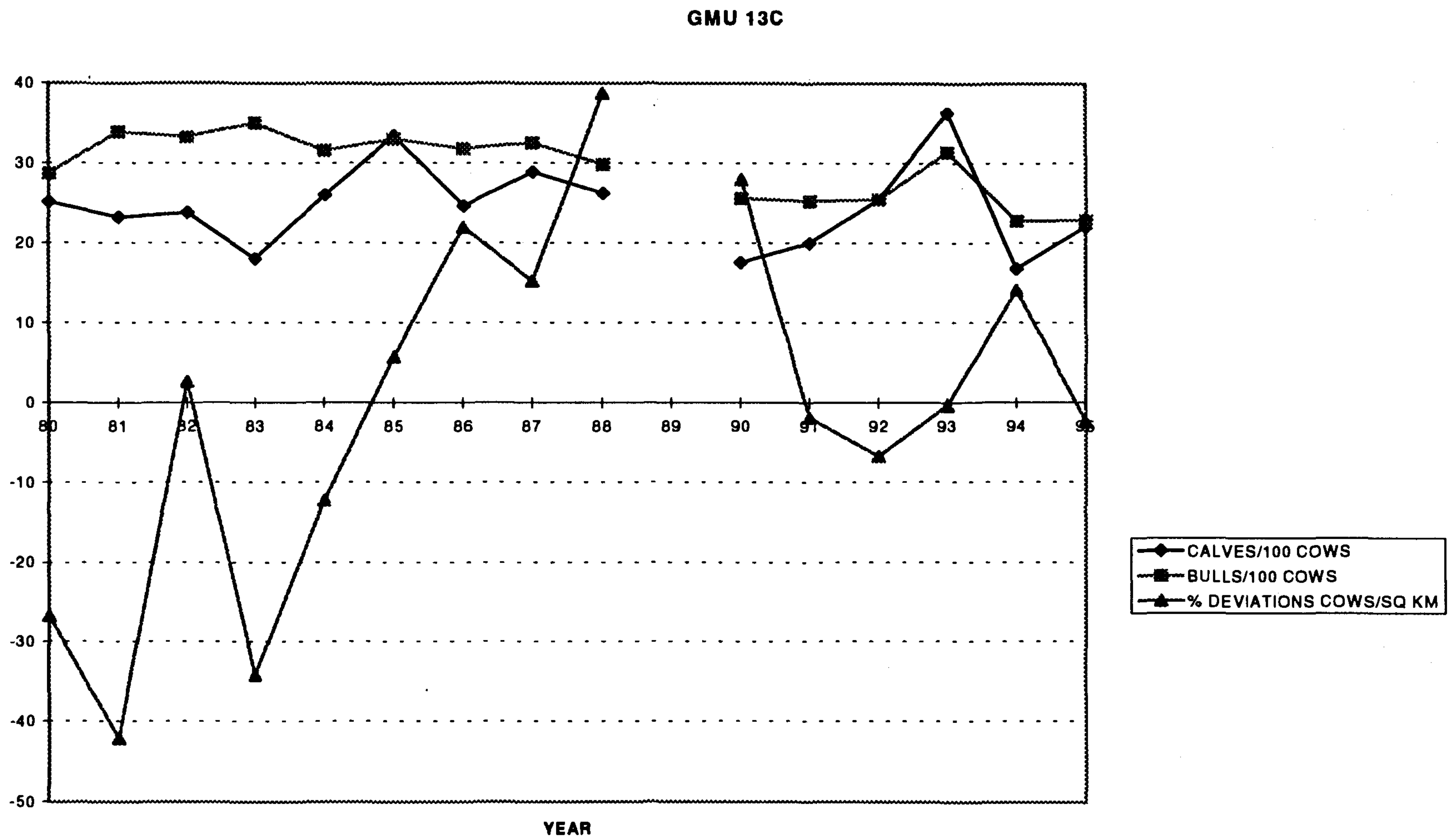


Figure 7. Fall composition and deviations from the mean index value of cow moose/km^2 in GMU 13C from 1980-1995.

Table 1. Rates of parturition and twinning in Unit 13A (sample size in parentheses).

Year	Parturition Rate (*n*)	Twinning Rate (*n*)
1994	63% (40)	9.1% (77)
1995	80% (59)	12.1% (116)
1996	86% (70)	15.0% (140)

Table 2. Average monthly survivorship (Pollock et al.1989) of adult female moose in Unit 13A derived from data collected from April, 1994 through June, 1996.

Month	At Risk	Deaths	Censored	Added	Survival	Lower 95%	Upper 95%
5	180	0	4	2	1.00	1.00	1.00
6	178	3	79	1	0.98	0.96	1.00
7	97	0	0	0	0.98	0.96	1.00
8	97	0	4	0	0.98	0.96	1.00
9	93	0	0	2	0.98	0.96	1.00
10	95	0	0	1	0.98	0.96	1.00
11	96	0	0	1	0.98	0.96	1.00
12	97	0	1	32	0.98	0.96	1.00
1	128	0	6	9	0.98	0.96	1.00
2	131	0	2	5	0.98	0.96	1.00
3	134	1	2	41	0.98	0.95	1.00
4	172	2	0	0	0.96	0.94	0.99

Table 3. Average monthly survivorship (Pollock et al.1989) of yearling female moose in GMU 13A derived from data collected from April 1995 through June, 1996.

Month	At Risk	Deaths	Censored	Added	Survival	Lower 95%	Upper 95%
5	20	1	1	0	0.9500	0.8569	1.0000
6	18	3	10	1	0.7917	0.6247	0.9586
7	6	0	0	0	0.7917	0.5025	1.0000
8	6	0	1	0	0.7917	0.5025	1.0000
9	5	0	0	0	0.7917	0.4749	1.1000
10	5	0	0	0	0.7917	0.4749	1.1000
11	5	0	0	0	0.7917	0.4749	1.1000
12	5	0	0	0	0.7917	0.4749	1.1000
1	5	0	1	1	0.7917	0.4749	1.1000
2	5	0	0	1	0.7917	0.4749	1.1000
3	6	0	0	0	0.7917	0.5025	1.0000
4	6	0	0	0	0.7917	0.5025	1.0000

Table 4. Average monthly survivorship (Pollock et al.1989) of calves of radiocollared moose in GMU 13A derived from data collected from May, 1994, through June, 1996. Survival in months 5-6 is an estimate from parturition to the end of June.

Month	At Risk	Deaths	Censored	Added	Survival	Lower 95%	Upper 95%
5-6	148	87	30	0	0.4122	0.3612	0.4631
7	31	7	1	0	0.3191	0.2264	0.4118
8	23	0	0	0	0.3191	0.2115	0.4267
9	23	0	0	0	0.3191	0.2115	0.4267
10	23	0	0	0	0.3191	0.2115	0.4267
11	23	0	1	6	0.3191	0.2115	0.4267
12	28	0	0	6	0.3191	0.2216	0.4166
1	34	0	2	0	0.3191	0.2306	0.4076
2	32	1	0	1	0.3091	0.2201	0.3981
3	32	1	2	1	0.2995	0.2126	0.3863
4	30	2	0	0	0.2795	0.1946	0.3644

Table 5. Summary statistics for diameter (mm) of current annual growth (CAG) and diameter (mm) at point of browse (DPB) for two browse species important to moose in the Nelchina Study Area. Data were analyzed by K. Keilland, University of Alaska, Fairbanks.

Salix pulchra	CAG (S.E.)	DPB (S.E.)
Clarence Lake	4.3 (0.08)	3.6 (0.09)
Tyone Creek	3.7 (0.06)	3.1 (0.06)
Salix alaxensis		
Oshetna River	8.2 (0.15)	7.3 (0.13)
Tyone Creek	6.1 (0.08)	4.9 (0.07)
Sanona Creek	6.8 (0.12)	5.7 (0.09)
Little Nelchina River	6.3 (0.09)	5.0 (0.07)

Table 6. Estimated density of wolves (per 1,000 km^2) in the Nelchina Study Area. In 1994/95, essentially all harvest took place prior to the population estimate in March. In 1995/96, due to unusually late snowfall, a harvest of 1.22 wolves/1,000km^2 took place after the population estimate in February.

Year	Estimate	90% C.I.	Pre-Survey Harvest	Fall Density
1994/95	4.5	(3.2-6.9)	4.2	8.7
1995/96	9.9	(9.7-11.3)	0.0	9.9

Table 7. Results of surveys during a 1994 population census of the Nelchina Study Area (top row), and during trend-count surveys in Count Areas 13 and 14 within the Nelchina Study Area. Apparent densities of the trend-count surveys (rows 2 and 3) are not corrected for moose sightability, so are minimum estimates.

Year	Moose/hr	Cows/hr	Moose/ km^2	Cows/km^2	Calves/ 100 Cows	Bulls/ 100 Cows
1994 NSA Census	-	-	0.81	0.60	17.1	16.8
1994	60.5	48.0	0.50	0.40	12.8	13.2
1995	35.0	26.5	0.43	0.32	17.0	14.9

Table 8. Area and count indices of moose observed in aerial surveys of traditional Count Areas (CAs). Indices of moose abundance are mean values obtained in survey flights for the period 1980-1995 (see methods). Survey flights were not intended to estimate actual densities, so values obtained each year were minimum moose densities.

CA	Area(km^2)	Moose/km^2	Cows/km^2	Moose/hr	Cows/hr
3	1103	0.42(0.06)	0.29(0.05)	66.8(15.6)	45.7(10.3)
5	2130	0.80(0.17)	0.53(0.10)	64.4(13.5)	42.4(6.8)
6	1677	0.46(0.11)	0.31(0.08)	71.0(12.5)	47.4(9.0)
7	2215	0.49(0.07)	0.33(0.06)	55.9(8.6)	37.8(5.8)
10	423	0.82(0.19)	0.56(0.14)	85.5(16.7)	58.4(11.9)
13	1594	0.61(0.10)	0.43(0.08)	64.6(13.0)	45.0(8.7)
14	968	0.61(0.16)	0.41(0.09)	64.8(15.0)	42.7(8.6)
15	924	0.19(0.04)	0.11(0.03)	35.5(9.0)	20.4(5.7)
16	341	0.48(0.13)	0.29(0.07)	47.4(13.6)	36.3(7.7)

APPENDIX. BROWSE RELATIONS OF MOOSE IN THE NELCHINA BASIN

Report to the Alaska Dept of Fish and Game, Anchorage

TO: Ward Testa, Research Biologist

FROM: Knut Kielland, IAB, UAF

INTRODUCTION

To assess forage relations of moose in the Nelchina Basin, browse diameters of preferred willow species, diamondleaf (*Salix pulchra*) and feltleaf willow (*Salix* alaxensis), were measured at selected sites in the Nelchina Basin during April 1995. In addition, forage samples were collected for analysis of *in vitro* dry matter digestibility and crude protein concentration. The chemical analyses were carried out on a diameter-specific basis. Thus the coupling of laboratory-determined chemistry and field measurements of browse diameter allowed for the determination of forage quality with respect to the forage species *per se* as well as an evaluation of the quality of food consumed by moose in this area.

RESULTS AND DISCUSSION

FORAGE CHEMISTRY

Because of the morphology of diamondleaf willow; thin, even taper of current annual growth (CAG; Fig. 1), diameter-specific changes in plant chemistry are not as pronounced as in other willow species. Within the hypothetical browse range of 1 to 6 mm, *in vitro* dry matter digestibility (IVDMD) varied between 39.5% to 31% (Fig. 2). The exponent in the equation describing the relationship between browse diameter and IVDMD: $Y=40.06X^{-0.13}$ indicates the relatively low depressing effect increased browse diameter has on digestibility. By contrast, the exponent, k, in the corresponding relationship for feltleaf willow along the Tanana was k=-0.40 (Kielland, unpublished data). Thus it appears that moose may crop CAG of diamondleaf willow close to the CAG bud scar, without strongly compromising the digestibility of this forage species.

Crude protein (CP) concentrations showed a similar pattern of diameter-specific relationship (Fig. 3). The equation for browse diameter vs. CP: $Y=9.36X^{-0.14}$ again indicates low sensitivity of CP to variation in bite diameter. The strong covariance of digestibility and protein concentration (Fig. 4) is similar to that found in other species (Kielland, unpublished data). Both CP and IVDMD are primarily determined by twig diameter (bark:wood ratio), but are causatively related to only a very small degree.

Whereas neither digestibility nor CP concentration is drastically reduced with increasing bite diameter, the energy and nutrient return for moose is of course, approximately, the **product** of these parameters. In light of this relationship, we see that **digestible protein,** thus estimated, is strongly reduced with increasing bite diameter (Fig. 5). The marginal return on dietary protein increases with bite diameter (Fig. 6), but this association is rather weak, as indicated by the exponent in the equation describing the relationship: $Y=60.17X^{0.07}$.

FEEDING BEHAVIOR

Average bite size (g) from the two study areas (Table 3-4) calculated from the summary statistics (Table 1-2), represented 65% of CAG at Clarence Lake and 57% at Tyone Creek. The smaller bite diameter, and thus smaller bite size, at Tyone Lake corresponds to smaller CAG twigs at this site (Table 2) compared with Clarence Lake (Table 1). Moose appears to have a propensity to take larger bites from larger twigs as indicated by the strong positive relationship between the diameter of CAG and dpb (Fig. 7-8).

Similar observations have been made in the Koyukuk region (Kielland unpublished data; Fig. 9). However, moose in the Nelchina evidently consume a much higher proportion of the CAG twig, as indicated by the slopes of the lines, compared to moose in the Koyukuk study. Despite the close statistical association between CAG diameter and dpb, moose definitely seem to focus their browsing on certain "optimal" diameter classes of twigs (Fig. 10-11). Diameter at point of browsing tends to be skewed right and mean dpb is substantially lower than the average CAG diameter as previously discussed (Table 1-2, Fig. 10-11). Thus it appears that the moose are selective in their choice of size classes of their forage.

Digestibility and protein concentration at average diameter at point of browsing (dpb) were virtually identical between sites. Average-bite protein concentrations were well in excess of those required for maintenance (cf. Schwartz et al. 1987), in contrast to digestibility. Primarily due to much greater bite size at Clarence Lake, "apparent protein intake/bite" were substantially greater here than at Tyone Creek. This observation suggests that in forage species whose morphology minimizes variation in forage quality as a function of twig diameter, moose should maximize bite size within CAG. The high slope values (equivalent to dpb as proportion of CAG) in Fig. 7-8 (0.94 and 0.86, respectively) are consistent with this hypothesis.

CONCLUSION

Preliminary data on forage quality with respect to diamondleaf willow in the Nelchina region indicate that this forage species can provide high levels of protein-rich food. In addition, feeding behavior of moose on diamondleaf willow show that the moose apparently are not overcropping this species. However, given the relatively small (morphologically-constrained) bite size in diamondleaf willow, this forage species alone probably can not provide optimal nutrition (primarily in the form of energy) for moose.

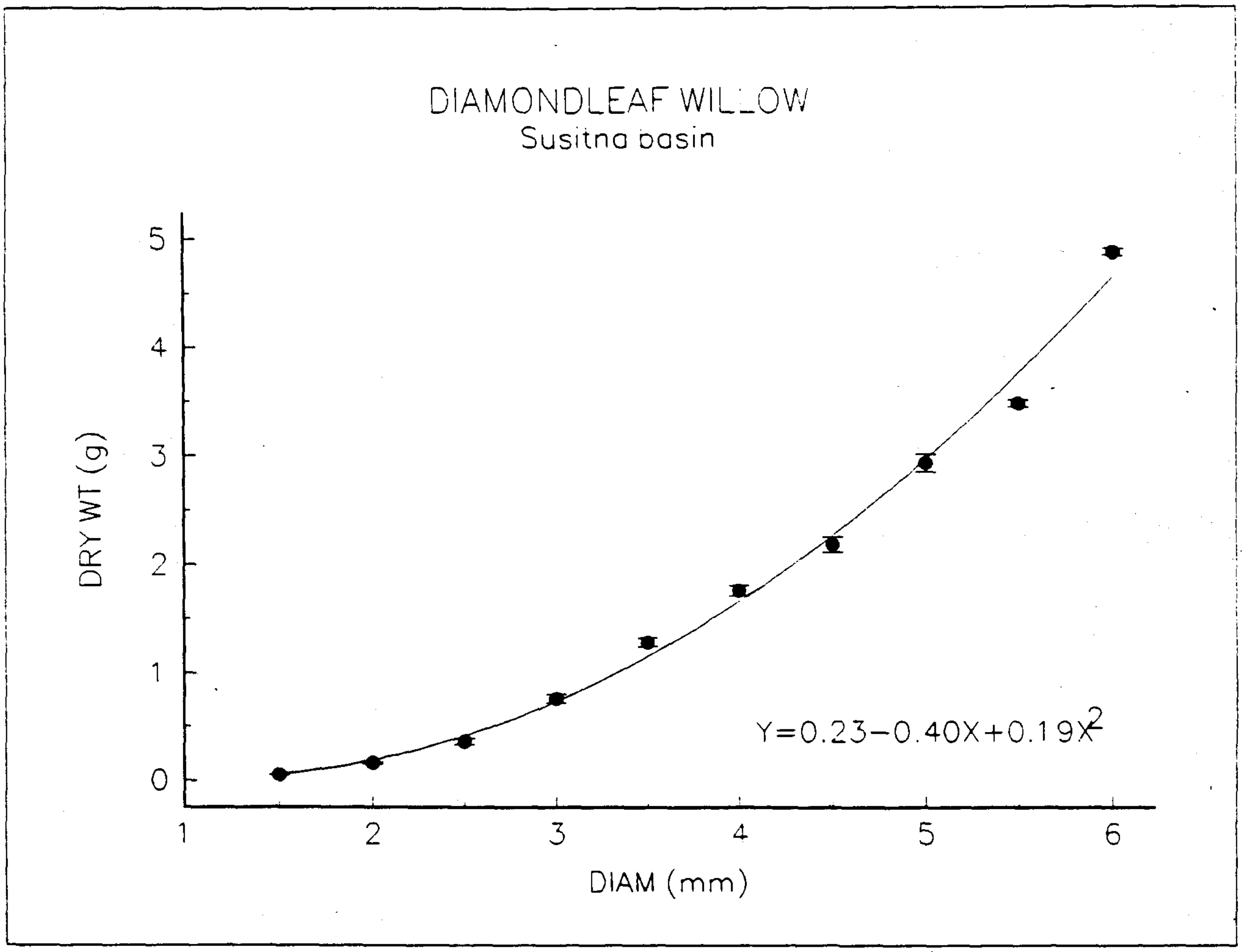


Figure 1 Relationship between dry weight and diameter of current annual growth in diamondleaf willow in Susitna Basin.

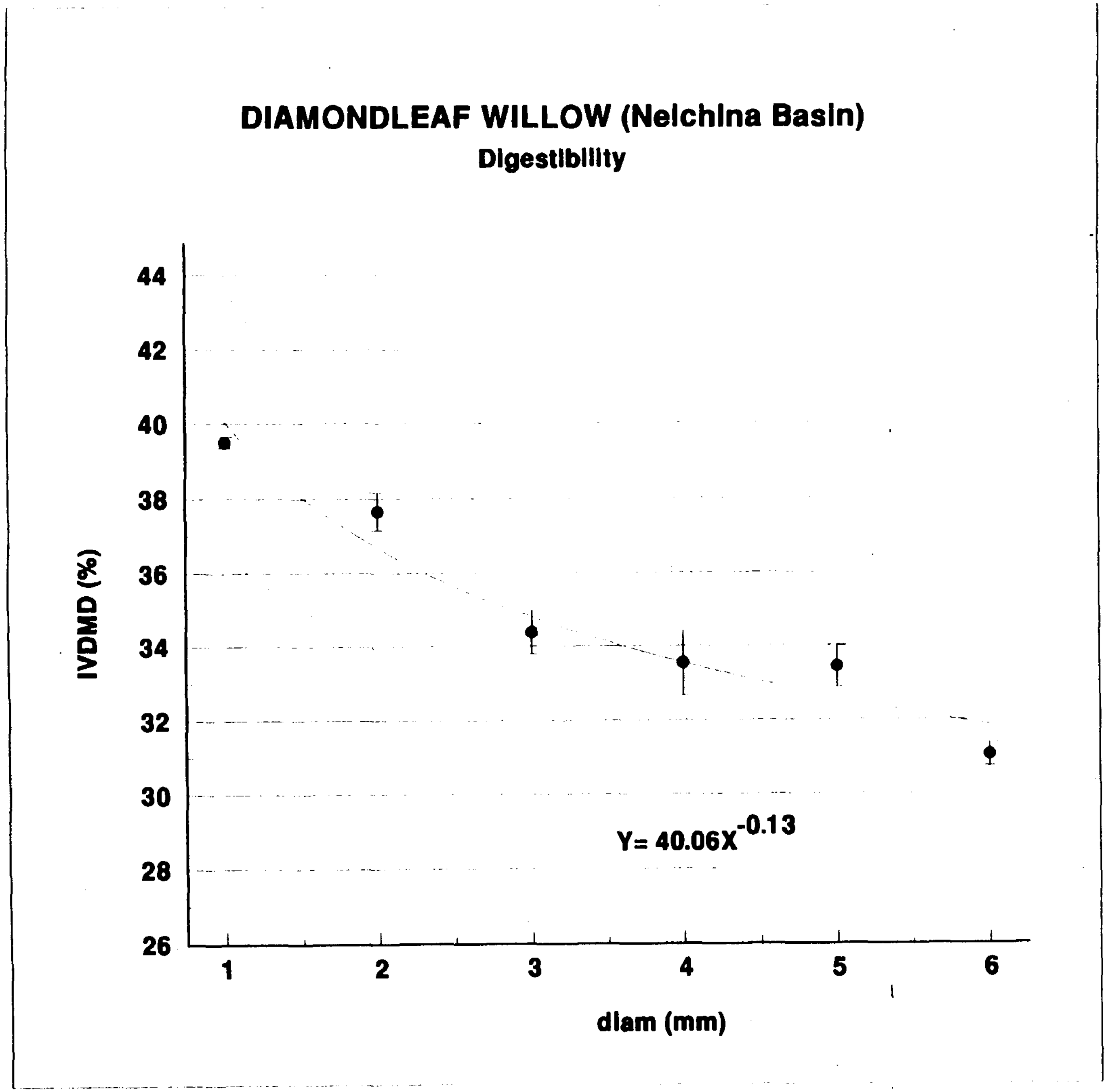


Figure 2 Relationship between in vitro dry matter digestibility (IVDMD) and diameter.

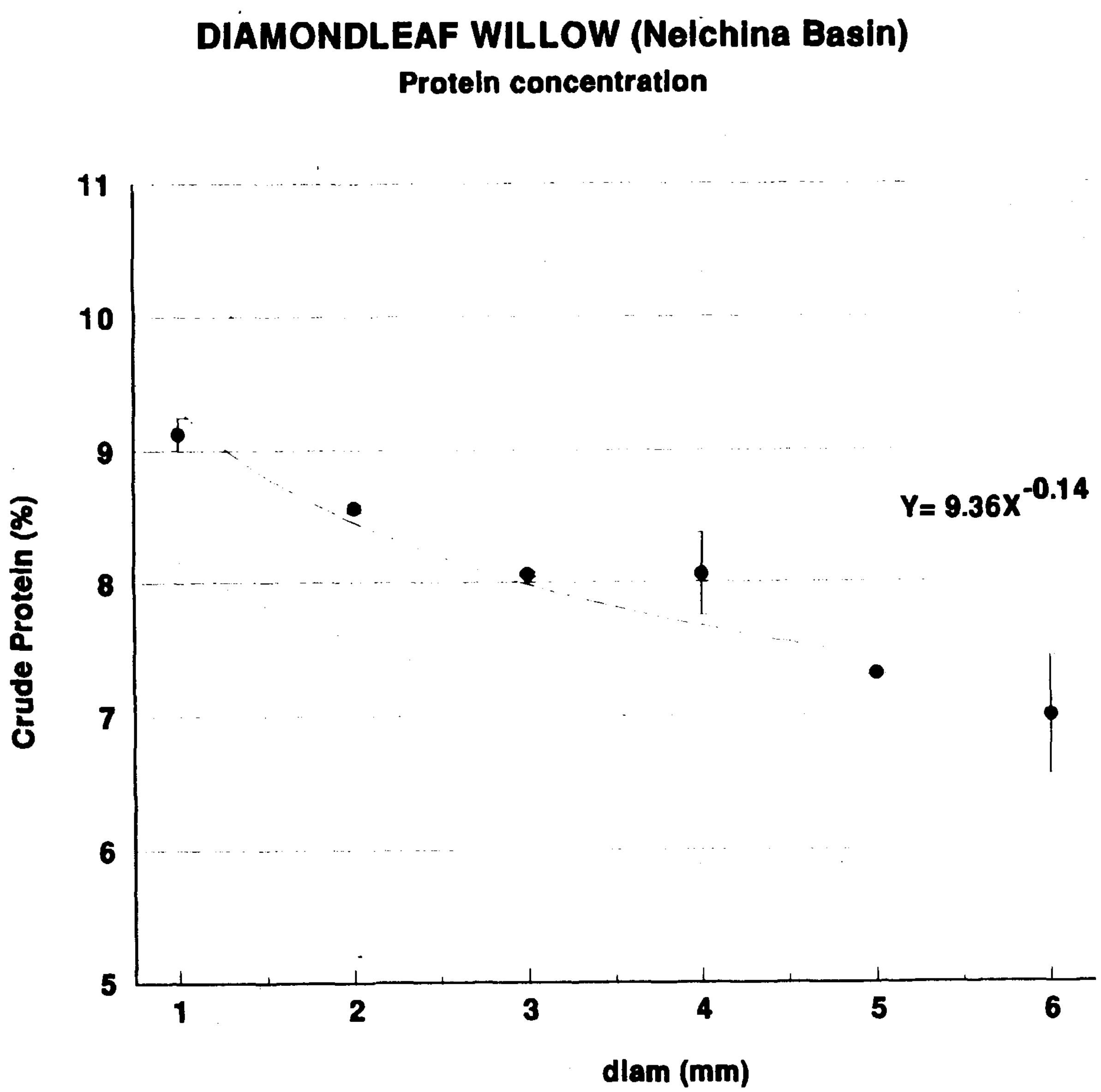


Figure 3 Relationship between crude protein and diameter of diamondleaf willow.

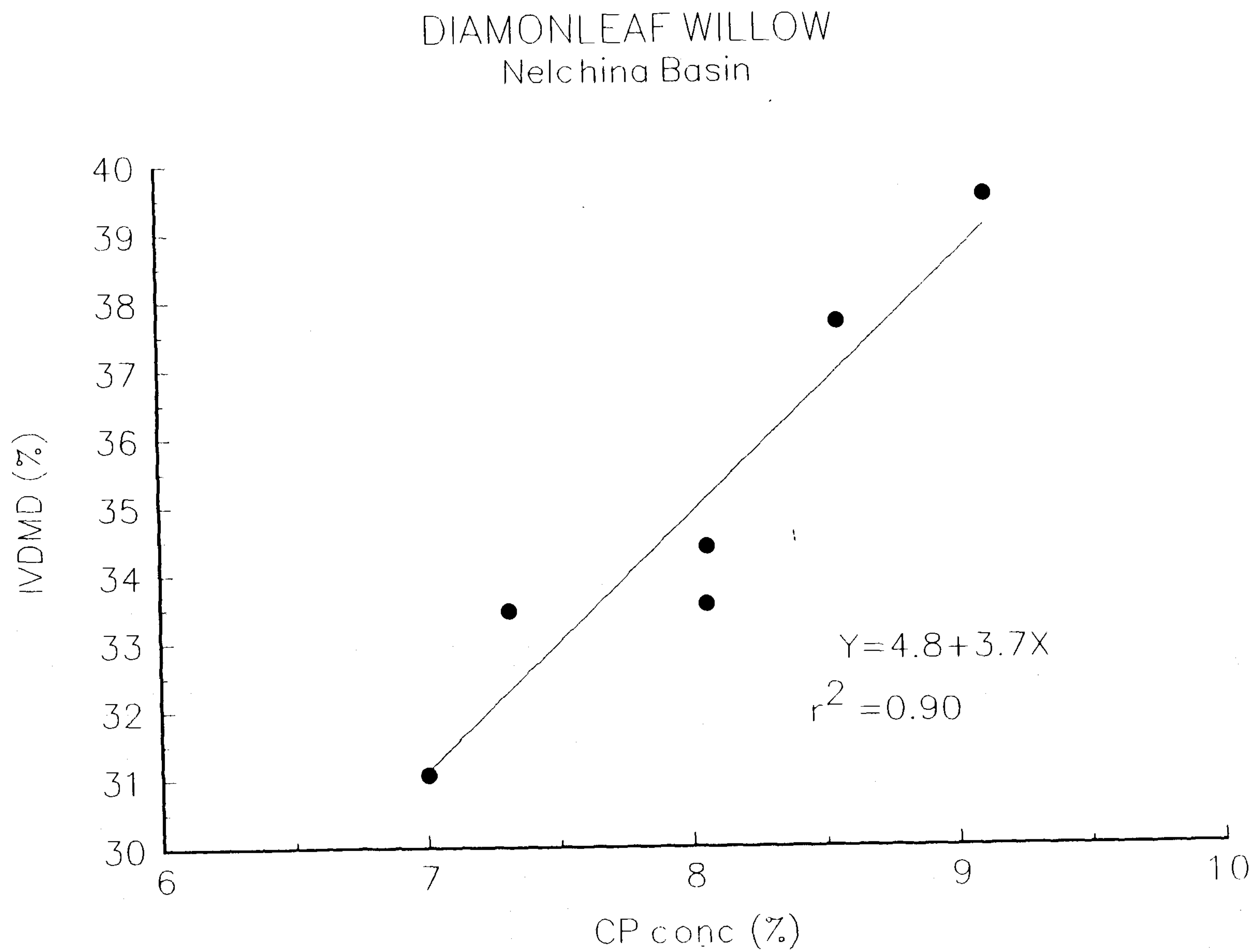


Figure 4 Relationship between in vitro dry matter digestibility and crude protein concentration in the diamondleaf willow.

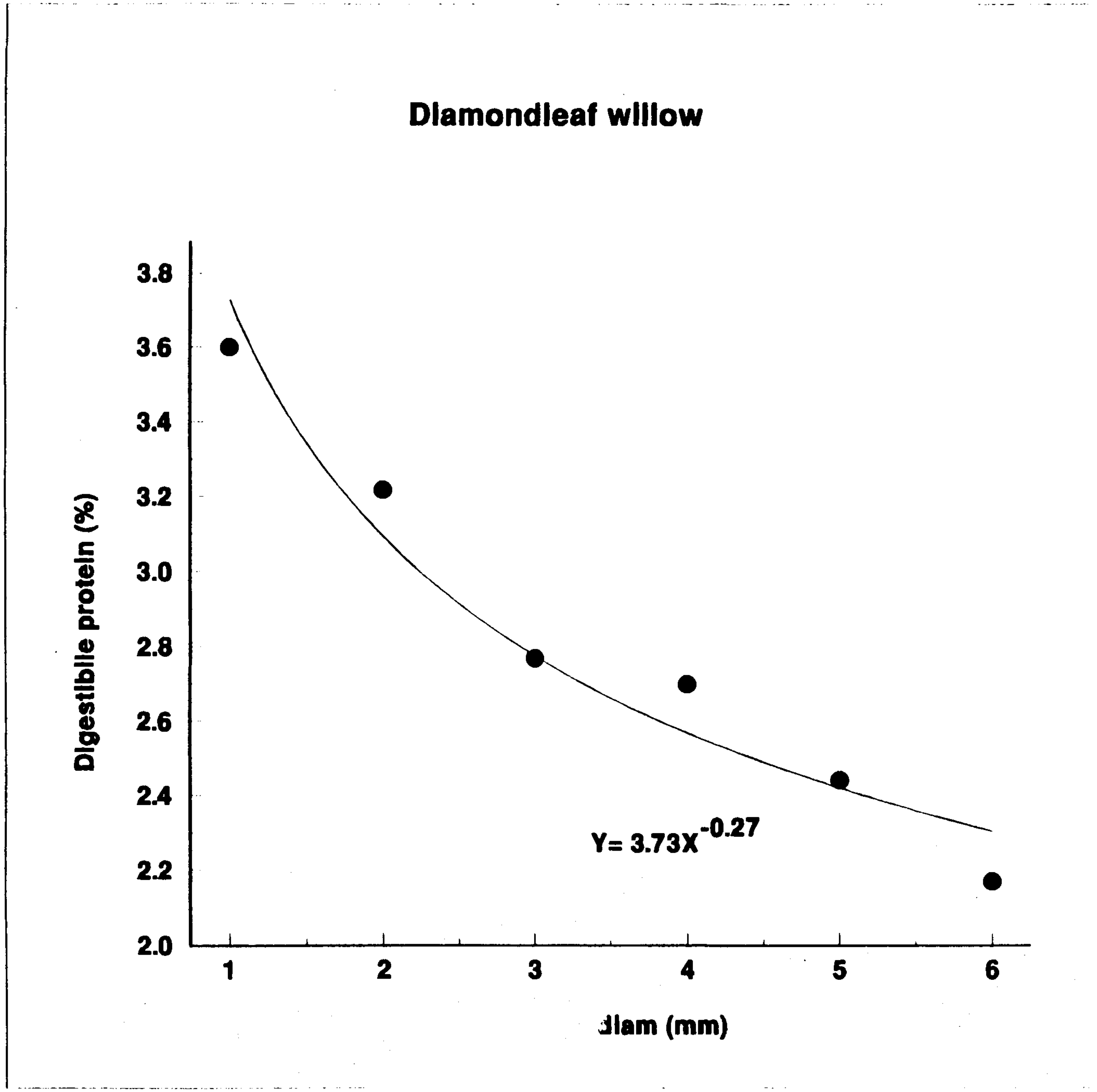


Figure 5 Relationship between digestible protein and diameter in the diamondleaf willow.

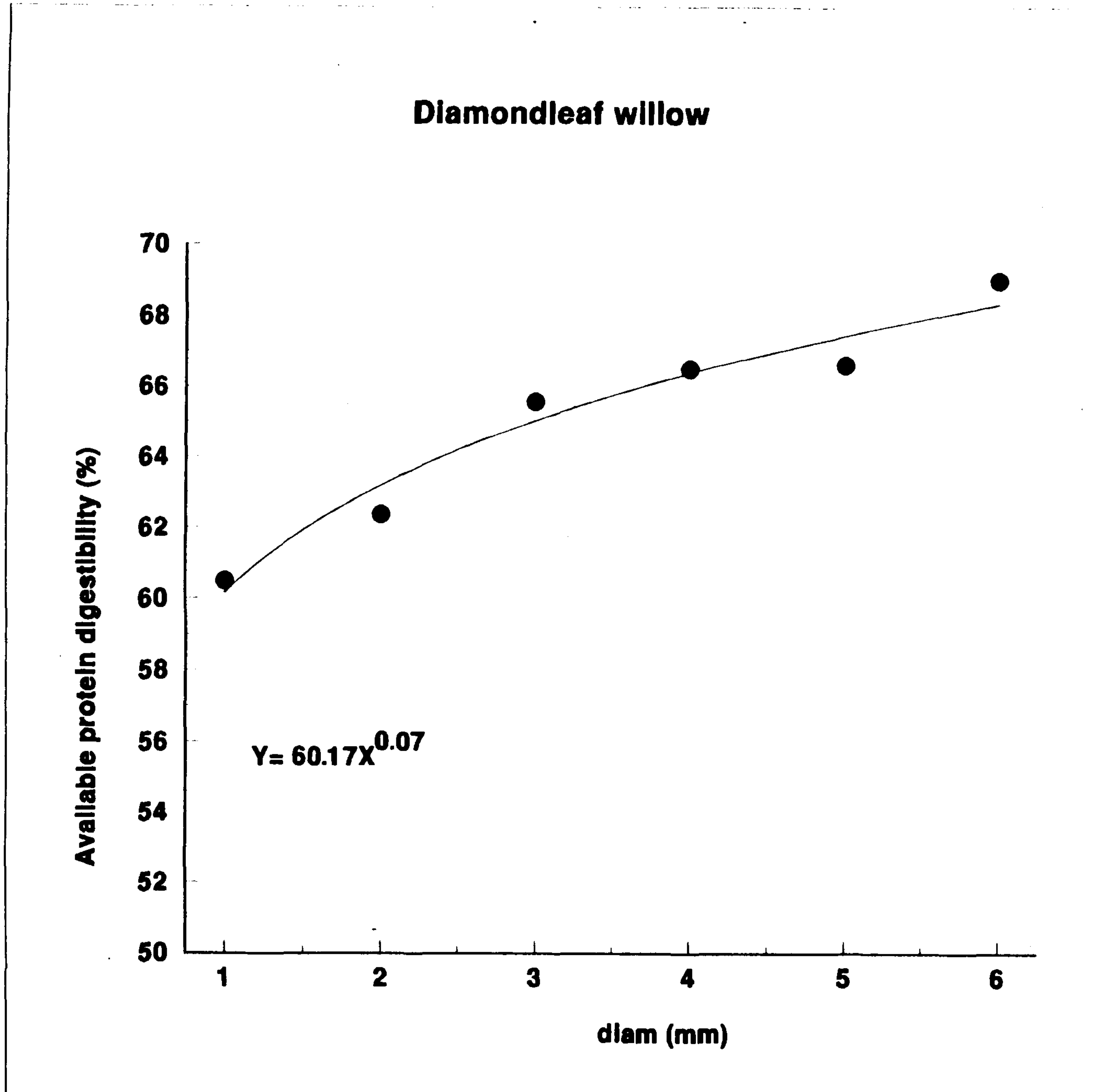


Figure 6 Relationship between protein digestibility and diameter in the diamondleaf willow.

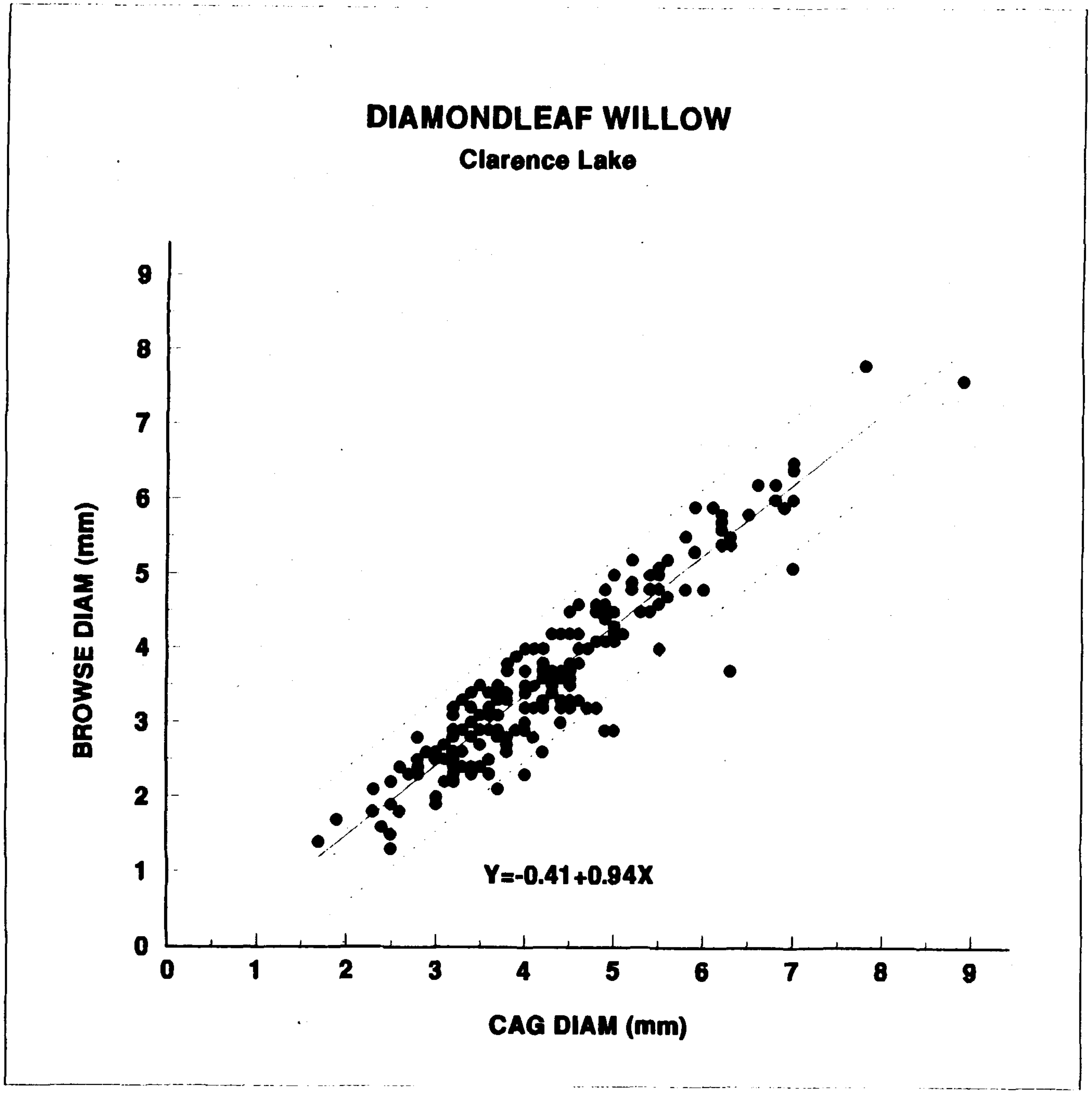


Figure 7 Relationship between diameter and current annual growth diameter in the diamondleaf willow at Clarence Lake.

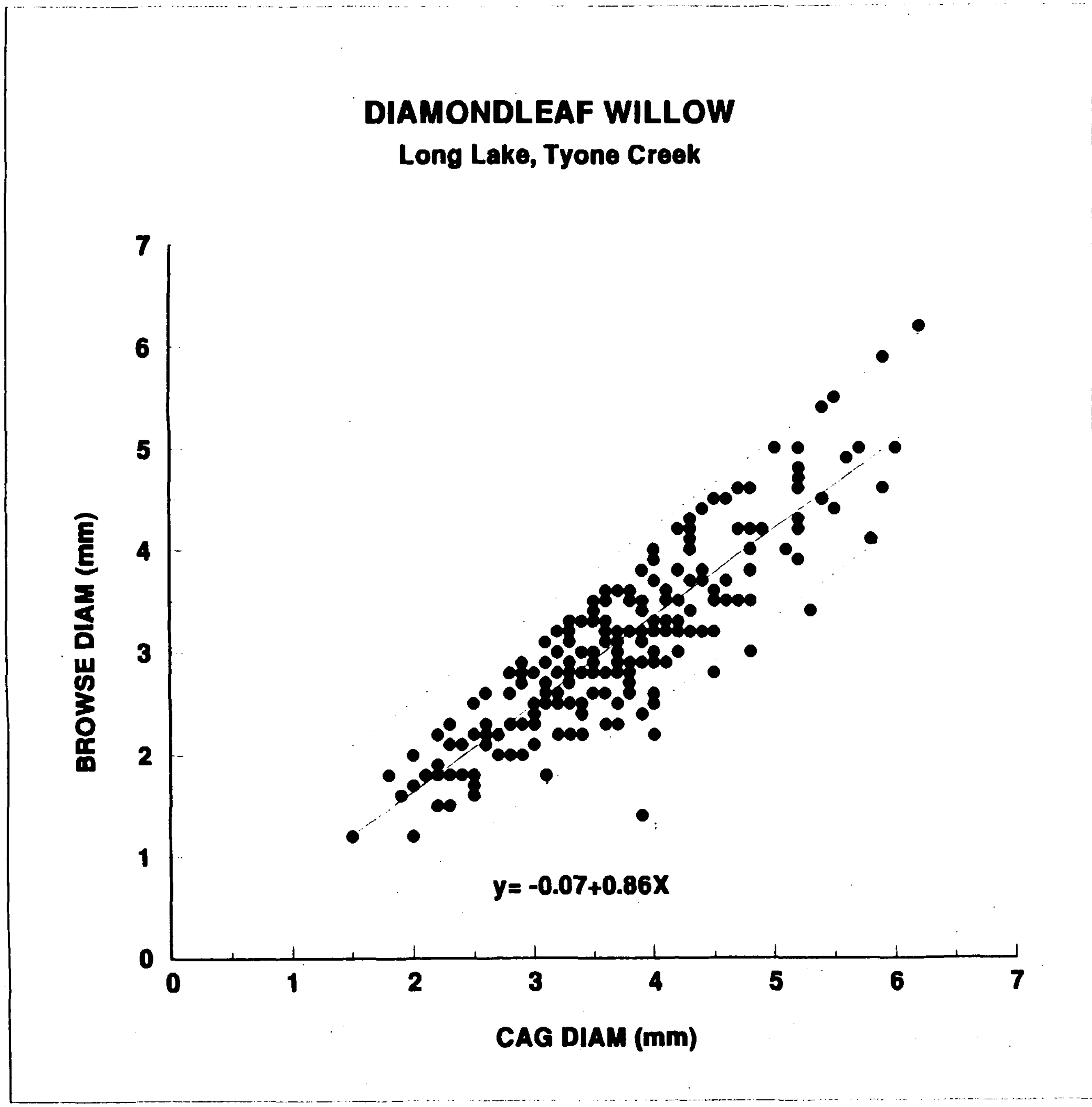


Figure 8 The relationship between browse diameter and current annual growth diameter in the diamondleaf willow at Long Lake and Tyone Creek.

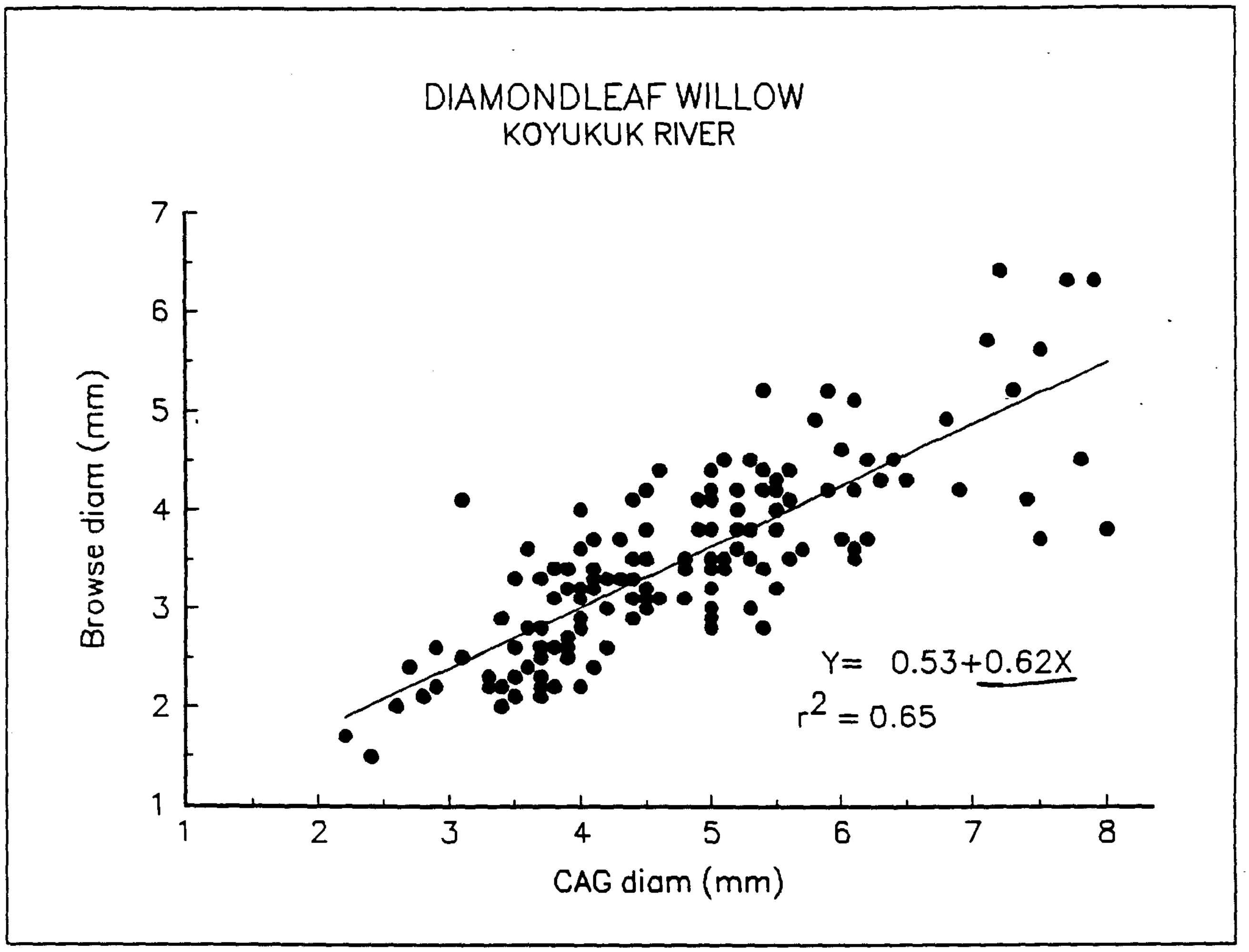


Figure 9 Relationship between browse diameter and current annual growth diameter in diamondleaf willow at Koyukuk River.

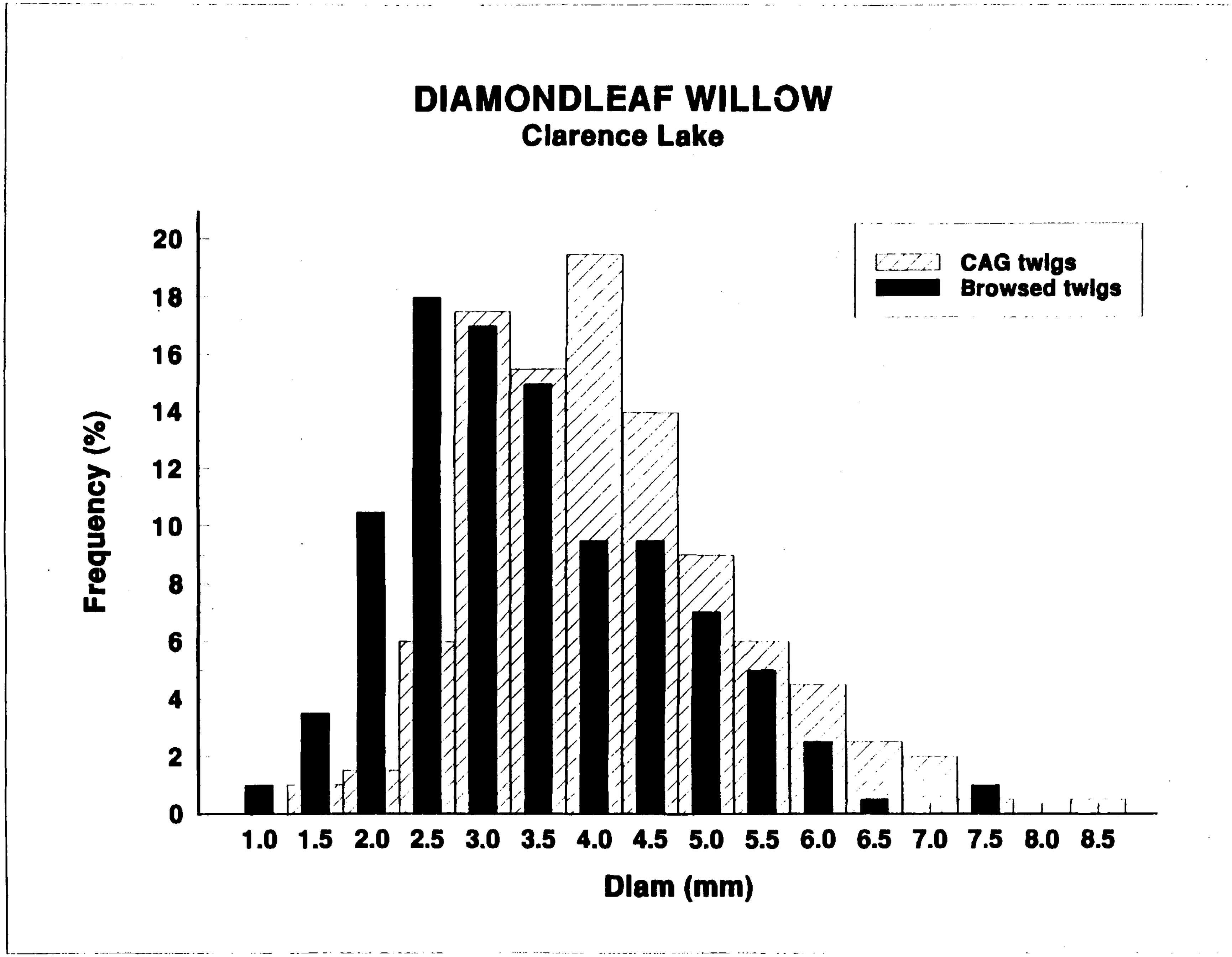


Figure 10 The frequency distribution of current annual growth and browsed twigs of diamondleaf willow at Clarence Lake.

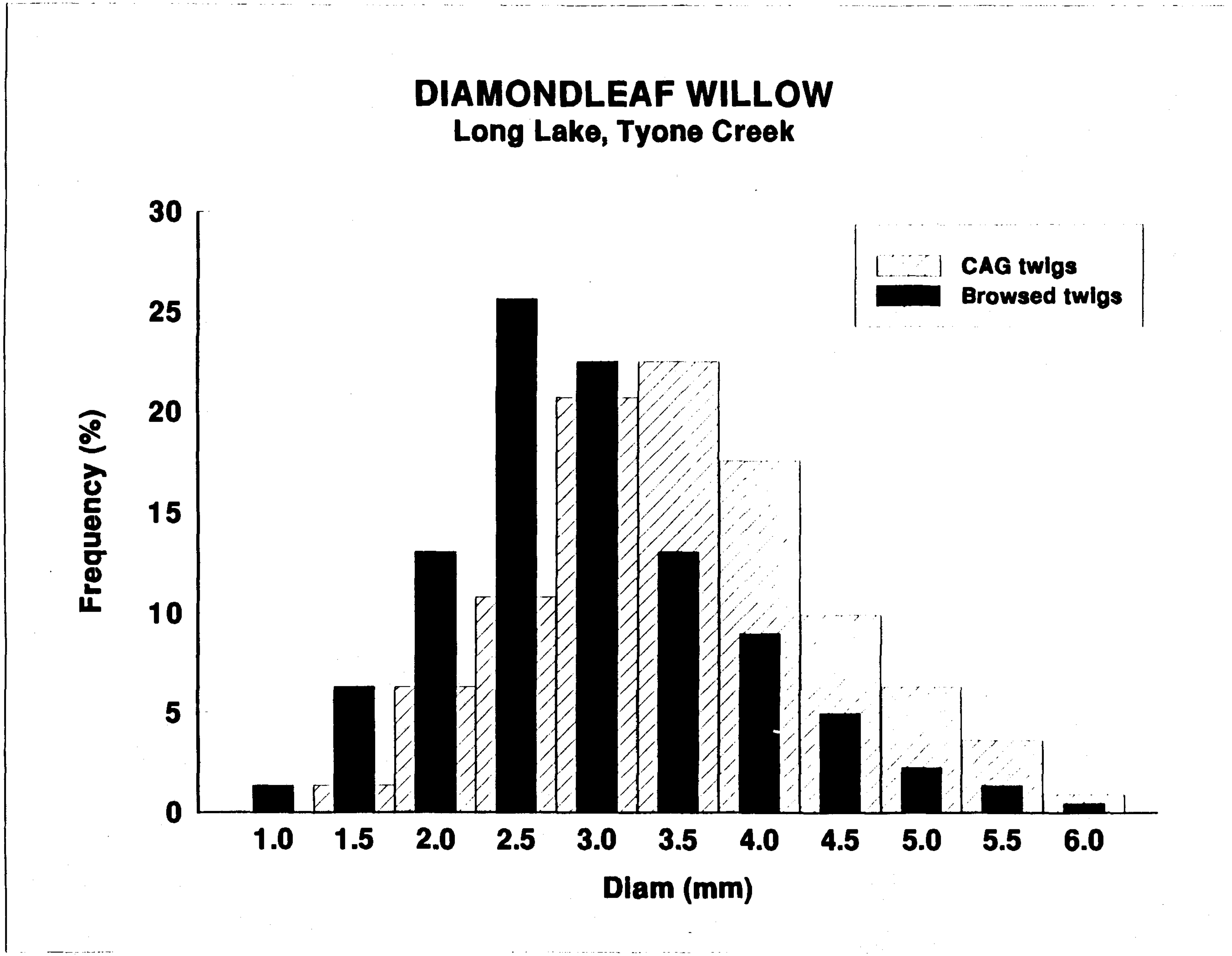


Figure 11 The frequency distribution of current annual growth and browsed twigs of diamondleaf willow at Long Lake and Tyone Creek.

Table 1. Summary statistics for diamondleaf willow at Clarence Lake, 1995.

	DPB[1]	CAG[2]
Min	1.3	1.7
Max	7.8	8.9
Median	3.5	4.2
Mean	3.6	4.3
S.E.	0.09	0.08
95% CI	0.17	0.16
n	200	200

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 2. Summary statistics for diamondleaf willow at Long Lake, Tyone Creek, 1995.

	DPB[1]	CAG[2]
Min	1.2	1.5
Max	6.2	6.2
Median	3.0	3.7
Mean	3.1	3.7
S.E.	0.06	0.06
95% CI	0.12	0.12
n	220	220

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 3. Characteristics of winter-dormant twigs of diamondleaf willow browsed by moose, Clarence Lake. (Means)

	DPB[1]	CAG[2]
Twig diameter (mm)	3.6	4.3
Twig weight (g)	1.3	2.0
Digestibility (%)	33.9	33.1
Protein conc. (%)	7.8	7.6
Apparent protein intake per bite (g)	0.034	na

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 4. Characteristics of winter-dormant twigs of diamondleaf willow browsed by moose, Long Lake, Tyone Creek. (Means)

	DPB[1]	CAG[2]
Twig diameter (mm)	3.1	3.7
Twig weight (g)	0.8	1.4
Digestibility (%)	34.6	33.8
Protein conc. (%)	8.0	7.8
Apparent protein intake per bite (g)	0.022	na

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 5. Summary statistics for feltleaf willow at Oshetna River, 1995.

	DPB[1]	CAG[2]
Min	3.1	3.6
Max	12.5	15.2
Median	7.2	8.0
Mean	7.3	8.2
S.E.	0.13	0.15
95% CI	0.25	0.30
n	200	200

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 6. Summary statistics for feltleaf willow at Tyone Creek (Daisy Creek), 1995.

	DPB[1]	CAG[2]
Min	2.2	2.8
Max	8.4	9.3
Median	4.8	6.0
Mean	4.9	6.1
S.E.	0.07	0.08
95% CI	0.14	0.16
n	210	210

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 7. Summary statistics for feltleaf willow at Sanona Creek, 1995.

	DPB[1]	CAG[2]
Min	3.0	3.4
Max	9.1	11.6
Median	5.6	6.7
Mean	5.7	6.8
S.E.	0.09	0.12
95% CI	0.18	0.23
n	190	190

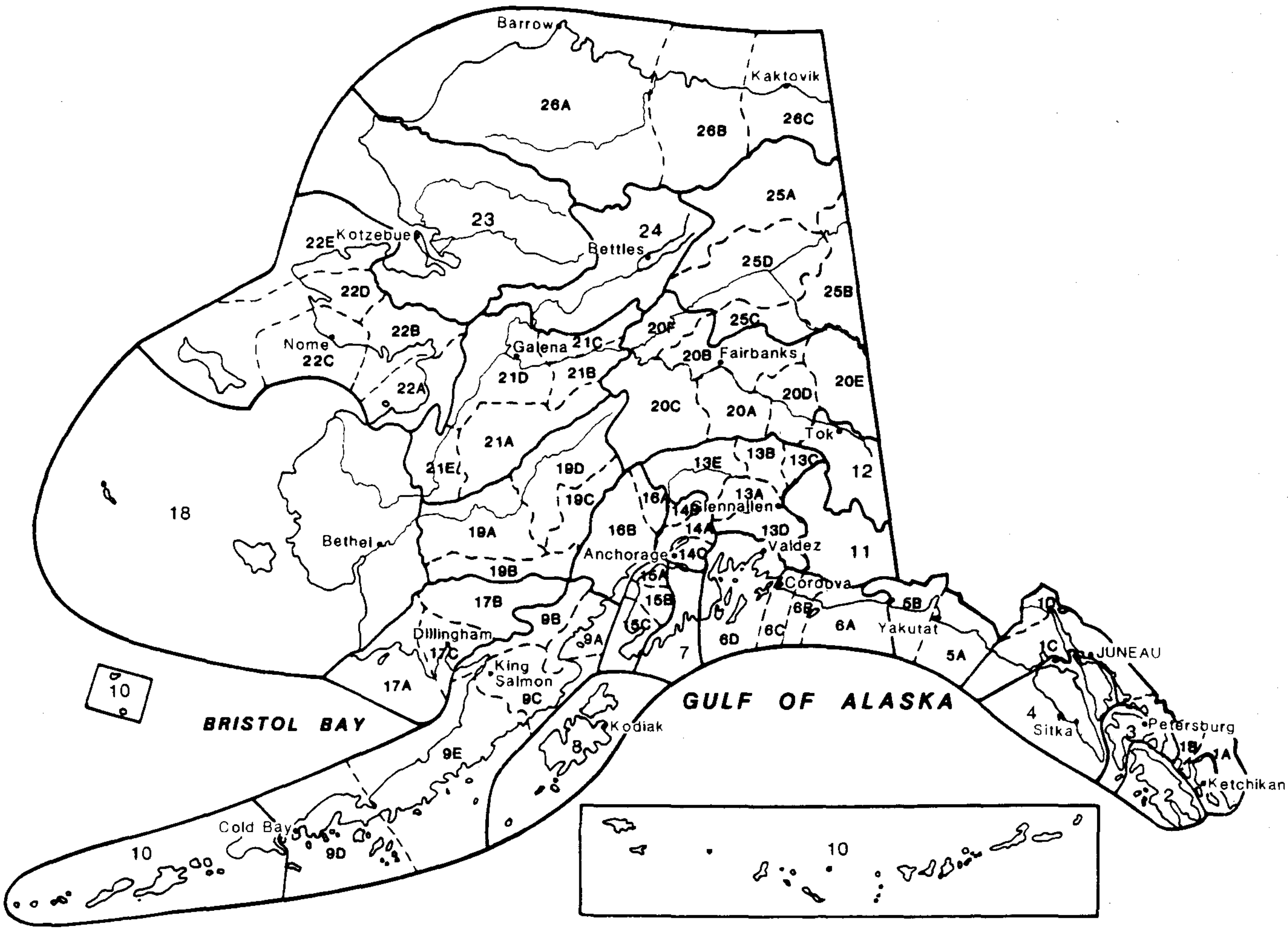
[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

Table 8. Summary statistics for feltleaf willow at Little Nelchina River (Crooked Creek), 1995.

	DPB[1]	CAG[2]
Min	2.7	3.8
Max	8.5	11.2
Median	5.0	6.1
Mean	5.0	6.3
S.E.	0.07	0.09
95% CI	0.14	0.18
n	233	233

[1]Diameter at point of browse (mm)
[2]Diameter at current annual growth (mm)

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.

KEN WHITTEN