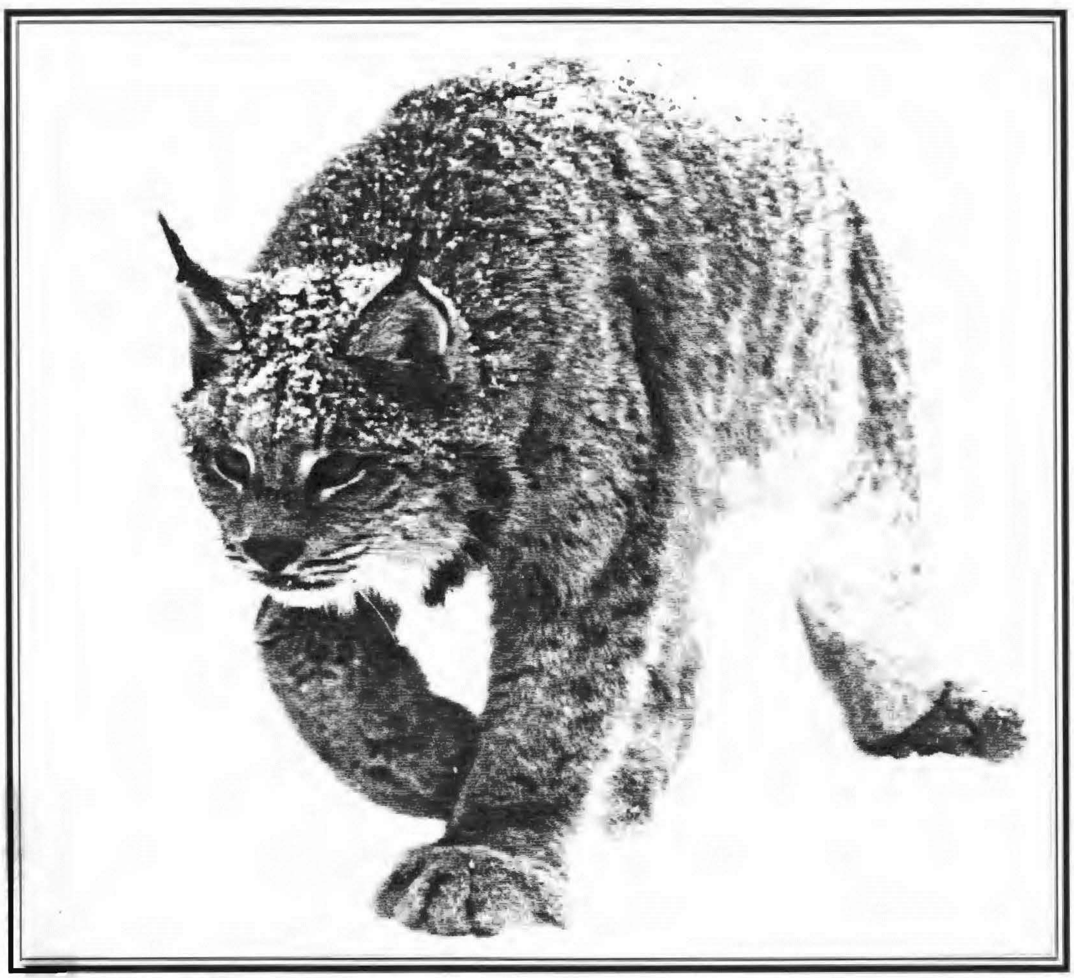
Alaska Department of Fish and Game
Division of Wildlife Conservation

Federal Aid in Wildlife Restoration
Research Final Report

Furbearer Track Count Index Testing and Development

by
Howard N. Golden



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SUMMARY

Indices of abundance can be useful in monitoring furbearer populations where actual counts of individual animals are difficult. Winter counts of tracks in snow have been used as indices of distribution and relative abundance, habitat use, and population abundance in a variety of areas. However, the ability of track counts to reliably document population trend has not been shown. Revised objectives for this study were to (1) measure and compare the deposition and retention of marten (*Martes americana*), lynx (*Felis lynx*), and snowshoe hare (*Lepus americanus*) tracks counted along ground transects in different areas of Alaska, (2) evaluate the reliability of winter track counts as indicators of furbearer abundance, (3) evaluate the use of harvest data in the interpretation of population trends relative to track count data, and (4) establish initial track-count procedures to monitor trends in the relative abundance of marten, lynx, and snowshoe hares.

I sampled marten and snowshoe hare tracks along a 21-km transect near the Klutina Lake trail (KLT) on the west side of the Copper River basin in Southcentral Alaska in February and April 1992 and along the first 7 km of that transect in March 1994. I also examined marten, lynx, and snowshoe hare track count data, through cooperative efforts, in the Wrangell-St. Elias National Park and Preserve (WRST), the Koyukuk/Nowitna Refuge Complex (KNRC), and the Tetlin National Wildlife Refuge (TNWR) in Alaska. I compared the deposition and retention of tracks, measured in tracks/km, between survey periods, among vegetation cover classes, and among the areas sampled. I examined harvest data through harvest records, trapper observations, and carcasses purchased from trappers.

Variability in track counts was often high among the species and areas examined in this study. The greatest variability was found among daily track counts. There were few differences between cumulative track deposition and retention rates that were statistically significant, although retention rates were usually lower than deposition rates and there were often differences in patterns of the 2 types of counts plotted over time. One of the most frequent

patterns was the leveling out or decline in the retention of tracks after 3-4 days after snowfall (DAS). Cumulative track deposition and retention rates were remarkably linear and showed moderate to strong correlations with DAS in most of the situations examined. Although variability was often high, rates of track retention adjusted for DAS were usually within 10% of the desired rate of change of zero. These results indicate that any positive or negative bias resulting from equating track counts to 1 DAS if pooled over several days should not prevent the use of track counts as indices of relative abundance. However, other factors, such as habitat preferences and activity patterns of furbearers relative to resource availability, that affect the deposition and retention of tracks must also be considered when interpreting trend through track counts.

Martens used the more heavily wooded vegetation types most, and their track densities tended to increase over time in the KLT and KNRC areas. Marten tracks were virtually absent in the lighter vegetation cover types, but they were most numerous in an area of KNRC burned in 1985, probably in response to a relatively high density of microtines there. Lynx and snowshoe hares tended to use the more densely forested communities. Lynx tracks were especially numerous in a moderately-aged forest that had been burned in 1966. Track densities of lynx were higher on average in the mixed boreal forest of the TNWR than in KNRC and were highest in April 1992.

Harvest data are perhaps most useful in enhancing broad interpretations of population trends, because there is often a lack of detailed or complete harvest reporting. Because marten pelts are not required to be sealed, reliable means to determine marten population or harvest levels in GMUs 11 and 13 have been unavailable. Relative to marten, lynx harvests are far easier to track because pelts of harvested cats must be sealed by Alaska Department of Fish and Game (ADF&G). Trappers reported through questionnaires that marten were stable in number after their increase during the mid-1980s which peaked in 1988 (Tobey 1993). A sample of over 800 marten carcasses indicated there was a relatively low ratio of juveniles per adult females (37:100) in 1991-92. During that same year, there was also a low proportion of lynx kittens (10%) out of a sample of over 140 carcasses. The poor representation of kittens in the sample reflected the 1991-92 pelt sealing data. Those data and the increasing median age of lynx in subsequent years indicated the population passed through its 10-year peak and was declining to its cyclic low.

Despite the variability inherent in them, track counts of furbearers can be used as indices of relative abundance. However, their reliability depends upon the rigor with which they are collected. To minimize variability, track count methods must be consistent over time, among areas, and among observers. Additionally, track counts should be conducted for several consecutive days and the results pooled to increase precision and improve the reliability of trend data. If possible, counts should also be replicated at least twice during the winter. Track counts may be one of the better methods to monitor furbearer trends objectively in much of

Interior and Southcentral Alaska, but they must be used with other indicators of a species' status. Recommended procedures for counting furbearer tracks along ground transects are provided.

Key Words: *Felis lynx*, Interior Alaska, *Lepus americanus*, lynx, marten, *Martes americana*, population index, Southcentral Alaska, snowshoe hare, survey, tracks, winter track counts.

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BACKGROUND

Marten (*Martes americana*) and lynx (*Felis lynx*) are 2 of the most important furbearers taken by trappers in Alaska. The snowshoe hare (*Lepus americanus*) is an important prey item for both species, with the cyclic oscillations of lynx populations closely tied to those of hares. Management of these species requires reliable population trend information. However, few methods are available, independent of harvest data, for monitoring populations, and it is uncertain how accurately harvest data reflect population changes. Harvest statistics derive from pelt sealing certificates, fur dealer acquisition reports, trapper export reports, trapper questionnaires, and carcass collections. The collection of more direct population data for furbearers would supplement harvest-related information and improve interpretation of perceived changes in population abundance.

The measure of relative abundance over time is especially appropriate for monitoring furbearer trend except where more rigorous population data are required (Clark and Andrews 1982). Furbearers are some of the most difficult species to monitor because of their small body size and secretive, wide-ranging behaviors. When animals cannot actually be counted, some type of animal sign may be used to assess relative abundance if the sign has a direct relationship to animal numbers (Caughley 1977, Raphael 1994). Winter track counts have the most potential as measurable animal sign in areas with good persistent snow conditions, such as Interior and much of Southcentral Alaska.

Winter track counts, normally expressed as tracks/km/day or tracks/km×day, have been used for a variety of furbearers to measure the number of tracks intersected per kilometer of roads, trails, or transects (both ground and aerial) since last snowfall. Biologists have used track counts to (1) document furbearer distribution and relative abundance across large areas (Hechtel and Follmann 1980; Slough and Jessup 1984; Slough and Slama 1985; Golden 1987, 1988), (2) measure habitat use patterns and preferences (Legendre et al. 1978, Buskirk 1983, Raine 1983, Theberge and Wedeles 1989, Thompson et al. 1989, Koehler 1990, Thompson 1994, Thompson and Colgan 1994), (3) monitor population trends (Slough and Jessup 1984, Slough and Slama 1985, Stephenson 1986, Thompson and Colgan 1987, Slough and Ward 1990, Poole 1994), and (4) estimate actual abundance (Van Dyke et al. 1986, Schwartz and Becker 1988, Becker 1991).

Track counts in snow are attractive measures of relative abundance because of they are (1) repeatable, (2) easy to conduct, (3) independent of harvest data, and (4) applicable to more than 1 species. Track counts require minimal observer training, e.g., 1-2 days for ground counts and 2-4 days for aerial counts. Track counts from the ground are less expensive and are more accurate than counts from the air. However, the latter provide indices over much larger areas and, therefore, may be most useful for scarce or particularly wide-ranging species.

Winter track counts should meet several criteria to be useful as indices of furbearer population trends:

1. Reflect actual changes in animal abundance (i.e., track density must vary in proportion to animal density).

2. Indicate reliably where a population is in its oscillation.

3. Be accurate enough to guide important management decisions (e.g., ± 10% with 80% confidence intervals).

4. Result in comparable counts among different observers.

5. Sample a variety of habitat types.

These criteria are difficult to meet considering the relationships that exist between the abundance of furbearers and the number of tracks counted. A track count index model of these relationships is shown in Figure 1, which depicts the functional responses of furbearers to an array of extrinsic and intrinsic factors that affect track deposition and retention rates and by sampling biases that affect counts. This model is summarized in the following hypothesis:

The number of marten, lynx, or snowshoe hare tracks (T) intersecting transects, trails, or roads in an area at a given time (i) is equal to the number of animals (N) present times a function (f) of track deposition (D) times a function of track retention (R); i.e.,

$$T_i = N \times f\mathrm{D} \times f\mathrm{R}$$

where D includes track overlap by a given animal or another of the same species and the number of days after snowfall (DAS), and R includes track overlap by animals of a different species (e.g., the establishment of trails by hares that overlap other animals or that other animals use as pathways) and the number of DAS.

Because furbearer movement is affected by a variety of factors, track deposition and retention rates are unlikely to be equitable among areas and over time. An example of this problem is illustrated in Figure 2, where plotting a constant track count of 10 tracks/km, adjusted for DAS, over 1-10 DAS would result in a negative curvilinear relationship. To equate track counts at 1 DAS with the measurement tracks/km×day, it is normally assumed tracks are being deposited and retained at a constant daily rate of 1X, where X = day after snowfall. This assumption may be valid for a short period of time after snowfall but is problematic as factors limiting track deposition and retention increase.

Instability in track deposition and retention rates will result in irregular track accumulation. An increase of tracks in an area may mean there are more animals present or that the same animals are more active. Ward and Krebs (1985) found the daily straight-line travel of lynx in southwestern Yukon was inversely related to hare density. It was fairly constant at 2.2-2.7 km/day when hare densities were > 1.0/ha but increased rapidly when hare densities fell below 1.0/ha, rising to 5.5 km/day at 0.2 hares/ha. Stephenson and Karczmarczyk (1989) reported significant differences in cumulative track-deposition rates of lynx between years in the Wood River area south of Fairbanks. They concluded their T-1 track surveys (of track intersects along trails) should be able to indicate population changes of >50%. However, this may be too imprecise to allow for responsive management decisions, despite Stephenson and Karczmarczyk's (1989) assertion that the population amplitudes of more than 400% reported in the literature for lynx were wide enough for >50% precision to be useful. At this point there are no standard criteria for making a management decision.

OBJECTIVES

The objectives for this study were revised in 1994 as follows:

1. To measure and compare the deposition and retention of marten, lynx, and snowshoe hare tracks counted along ground transects in different areas of Alaska relative to (1) sampling period, (2) time since snowfall, (3) vegetation cover and composition, and (4) snow conditions and temperature.

2. To evaluate the reliability of winter track counts as indicators of furbearer abundance.

3. To evaluate the use of harvest data in the interpretation of population trends relative to track count data.

4. To establish initial track-count procedures to monitor trends in the relative abundance of marten, lynx, and snowshoe hares.

STUDY AREAS

I counted tracks near the Klutina Lake trail (KLT), approximately 20 km south of Glennallen (Fig. 3). The transect I used was a seismic line running east to west perpendicular to the Copper River basin in eastern Southcentral Alaska. The Copper River basin separates Game Management Unit (GMU) 13 to the west from GMU 11 to the east. Vegetation along the transect varies from closed canopy cover predominated by white spruce (*Picea glauca*), black spruce (*P. mariana*), birch (*Betula papyrifera*), aspen (*Populus tremuloides*), balsam poplar (*Populus balsamifera*), willow (*Salix* spp.), and alder (*Alnus* spp.). The area is composed largely of mature forest with some small areas burned within the last 15 years.

In February 1992 temperatures in the KLT area ranged from -26°C to -18°C, cloud cover was scattered to broken, and the wind was calm. Snow consistency was generally dry and lightly packed, and the depth averaged 63 cm along the transect. In April 1992, the temperature hovered around 0°C, skies were generally clear, and wind ranged from calm to 25 kph. Snow consistency became grainy and fairly hard-packed during the April survey. Snow depth, though not measured, was reduced to approximately 30-40 cm along the transect. In March 1994, the temperature averaged -8°C, skies were clear to partly cloudy, and wind was 5-25 kph. Snow depth averaged 61 cm along the 7-km transect.

Cooperators collected track data in the Koyukuk/Nowitna Refuge Complex (KNRC) in west-central Alaska, Wrangell-St. Elias National Park and Preserve (WRST) between the Copper

River Basin and Canada to the east, and Tetlin National Wildlife Refuge (TNWR) just north of WRST in eastern Alaska (Appendix A). Three post-fire seral communities were surveyed in KNRC: (1) 1985 burn in the tall shrub-sapling stage, (2) 1966 burn in the dense tree stage, and (3) mature coniferous forest (Johnson et al. 1994). Habitat in WRST is similar to the KLT area, but the park has more rugged and higher-elevation terrain. TNWR is characterized by mixed forest of moderate to dense cover in foothill to lowlands terrain.

METHODS

Track Deposition and Retention

I used snow machines to count daily deposition and retention of lynx, marten, and snowshoe hare tracks along the KLT transect. I sampled the full length of the 21-km transect in 1992 but reduced the transect length to its first 7 km in 1994. Counts were conducted from 1 to 5 DAS during 1-5 February 1992, from 1 to 4 DAS during 5-8 April 1992, and from 1 to 5 DAS during 15-19 March 1994. The February 1992 count period actually began 6 DAS. I counted the number of each species' tracks deposited over each 24-hour period. All of those tracks were erased once they were counted. Daily track deposition was measured along only the north side of the transect. I measured track retention along the south side of the KLT transect. Tracks on that side were left intact to determine how well tracks were retained over time. During the February 1992 period, tracks used to measure retention were left intact at the 6-DAS level. It was recognized that tracks counted along one side of the transect may not have been deposited by the same animals or at the same rate as tracks on the other side.

The KLT transect was divided into segments based on vegetation cover classes (VCC) similar to classifications by Viereck et al. (1992). In 1992 cover types were classified into 5 levels of percent cover: (1) bare = 0%, (2) light = 1-25%, (3) medium = 26-50%, (4) dense = 51-75%, and (5) closed = 76-100%. Vegetation composition was classified for future reference into conifer, deciduous, and mixed types with major species documented. I reclassified vegetation into 4 cover classes (scarce = 0-9%, light = 10-24%, moderate = 25-59%, and dense = 60-100%) in 1994 to follow the standardized track-monitoring procedures shown in Appendix B. In addition, I extracted track count data from the 1992 sample periods for the first 7 km of transect to allow comparisons with 1994 data.

Cooperators used similar sampling methods to those I used in the KLT area. Johnson and Paragi (1993) and Johnson et al. (1994) sampled marten, lynx, and hare tracks in KNRC during 1-5 March 1992, 9-14 March 1993, and 24-28 January 1994 along trail transects of 8.2-17 km in length. Marten and hare tracks were counted in WRST along the 15.5-km Kotsina Creek trail during 3-7 February 1992 (W. Route, pers. commun.). Lynx tracks were counted in

TNWR along 25.6 km of the Stuver Creek trail during 19 February-10 April 1992 and along its full length of 86.4 km during 25 March-2 April 1993 (T. Doyle, pers. commun.).

I compared deposition and retention for martens, lynx, and hares among vegetation types within sample areas, using Kruskal-Wallis and Mann-Whitney U tests through SYSTAT (Wilkinson et al. 1992). I measured differences between deposition and retention rates among areas and sample periods and to make comparisons between periods within each area using t-tests through Microsoft Excel Analysis ToolPak (Microsoft Corporation 1994). Probabilities less than 0.10 were considered significant.

Harvest Analysis

I examined harvest data for martens and lynx through harvest records and trapper questionnaires. I analyzed the sex and age of carcasses of marten caught by trappers in GMUs 11 and 13 during the 1991-92 trapping season and of lynx taken during the 1990-91 through 1992-93 trapping seasons. I classified marten carcasses first as adults or juveniles (<1.5 years old) by measuring temporal muscle coalescence (Poole et al. 1994). Canine or premolar teeth from a subsample of 50 male and 50 female adults from each GMU were then aged through counts of cementum annuli. Lynx canine teeth were initially radiographed to separate adults from kittens (<1.5 years old), which have an open apical foramen, and then adult lynx teeth were aged from cementum annuli. Matson's Laboratory (Milltown, MT) conducted all cementum annuli analysis.

RESULTS

Track Deposition and Retention

Marten

Marten track deposition and retention results for the KLT, KNRC, and WRST areas are summarized in Table 1.

KLT Area. Mean daily track depositions along the 21-km transect did not differ significantly between February and April 1992 ($P = 0.174$). Along the shortened KLT transect, daily depositions in April 1992 were lower than those of February 1992 ($P = 0.001$) and March 1994 ($P < 0.001$), but the latter two were not significantly different from each other ($P = 0.882$). Cumulative track deposition rates for martens were higher than retention rates in February 1992 ($P = 0.024$) and March 1994 ($P = 0.068$) but were not significantly different in April 1992 ($P = 0.704$) (Figs. 4-6). Cumulative track retention rates along the entire transect were significantly different among all VCCs in both February ($P = 0.001$) (Fig. 4) and in April 1992 ($P = 0.003$)

(Fig. 5) but not between moderate and dense VCCs along the shortened KLT transect in March 1994 ($P = 0.192$) (Fig. 6). Rates of track retention adjusted for DAS were highest in moderate and dense VCCs in February 1992 (Fig. 7) but in dense and closed VCCs in April 1992 (Fig. 8). Adjusted track retention was higher for the entire transect in April than in February 1992 ($P = 0.014$), but along the shortened KLT transect it was highest in February 1992 ($P \leq 0.108$) (Fig. 9).

KNRC Area. Mean daily track-deposition was higher in the 1985 burn in 1994 than in the 2 previous years ($P \leq 0.002$), and it was lower in the mature forest in 1992 than in 1993 ($P = 0.013$) or 1994 ($P = 0.001$). Cumulative track deposition rates for martens in the 3 seral types differed significantly from retention rates only in the mature forest in March 1993, when deposition was higher ($P = 0.078$) (Figs. 10-12). Cumulative track-retention rates were not significantly different between seres in 1992 ($P = 0.60$) (Fig. 10) but they differed among types in 1993 ($P = 0.001$) (Fig. 11) and 1994 ($P = 0.005$) (Fig. 12), with the highest rates in the 1985 burn and the lowest in the 1966 burn. Track retention adjusted for DAS in both 1993 and 1994 was highest in the 1985 burn ($P \leq 0.076$) and lowest in the 1966 burn ($P \leq 0.003$), but there was no significant difference between seres in 1992 ($P = 0.47$) (Figs. 13-15). Adjusted track retention was significantly different from other years only in 1994, when it was higher in the 1985 burn and mature forest ($P \leq 0.007$).

WRST Area. The mature forest of predominately moderate vegetation cover along the Kotsina Creek trail was sampled once, during 3-7 February 1992, to record marten track deposition. Cumulative track deposition (Fig. 16) and mean daily deposition were comparable to those values in the KLT area (Table 1).

Lynx

Lynx track deposition and retention results for the KNRC and TNWR are summarized in Table 2.

KNRC Area. During 9-14 March 1993, lynx showed substantial use only of the 1966 burn (Fig. 17), and cumulative deposition and retention rates were not statistically different in that seres ($P = 0.379$).

TNWR Area. The cumulative track deposition rate of lynx (between 1 and 9 DAS) was higher in April 1992 than in either February 1992 ($P = 0.068$) or March 1993 ($P = 0.061$), but it was not significantly different between the latter 2 periods ($P = 0.560$) (Fig. 18). Cumulative track deposition and track retention were also not significantly different during 25 March-2 April 1993 (P 0.126) (Fig. 19).

Snowshoe Hare

Snowshoe hare track deposition and retention results for the KLT, KNRC, and WRST areas are summarized in Table 3.

KLT Area. Mean daily track-depositions along the entire transect were significantly higher in February than in April ($P = 0.027$). This downward trend continued along the first 7 km of the KLT transect where the track count declined between each of the 3 sample periods ($P \leq 0.014$) from 6.63 (±1.25) tracks/km in February 1992 to 1.06 (±0.59) in March 1994. Cumulative track deposition rates of snowshoe hares were not significantly different from retention rates among the 3 sample periods ($P \geq 0.143$) (Figs. 20-22). However, cumulative track retention rates differed significantly among all VCCs in each sample period ($P \leq 0.021$), with higher rates in denser VCCs. Track retention adjusted for DAS along the entire transect was highest in dense and closed VCCs in February 1992 (Fig. 23) and April 1992 (Fig. 24). Adjusted track retention rates were not significantly different between those sample periods ($P = 0.176$), but, as with mean daily depositions, they declined between each sample period along the shortened transect ($P \leq 0.013$) (Fig. 25).

KNRC Area. Mean daily track-deposition was higher in the 1966 burn in 1993 than in 1994 ($P < 0.001$), but it was not significantly different between years in the 1985 burn nor in the mature forest ($P \geq 0.243$). Cumulative track deposition rates of snowshoe hares were not significantly different from retention rates among post-fire seres or between years ($P \geq 0.195$) (Figs. 26 and 27). Cumulative track retention rates differed among seres in 1993 ($P = 0.005$), when track counts were by far the highest in the 1966 burn (Fig. 26), but retention rates were not significantly different among seres in 1994 ($P = 0.826$) (Fig. 27). As with mean daily deposition, track retention rates adjusted for DAS for the 1966 burn were higher in 1993 than in 1994 ($P = 0.038$) but were not significantly different between years for the other seres ($P \geq 0.111$) (Figs. 28 and 29).

WRST Area. The mature forest of predominately moderate vegetation cover along the Kotsina Creek trail was sampled once, during 3-7 February 1992, to record snowshoe hare track deposition. Cumulative track deposition (Fig. 30) and mean daily deposition were approximately an order of magnitude higher in WRST than in either the KLT or KNRC areas (Table 3).

Harvest Analysis

Marten

Trappers harvested marten in GMUs 11 and 13 in 1991-92 from 10 November through 31 January, with no bag limit. Sex and age class percentages and ratios of marten carcasses collected from trappers in GMUs 11 and 13 during the 1991-92 trapping season are summarized in Table 4. Males:females were just above 150:100. There were 37 juveniles:100 adults and an equal ratio of juveniles:adult females for both GMUs. The age distribution during the 1991-92 trapping season indicates a median age of 2.5 years for females, 2.07 years for males, and 2.25 years for all marten (Fig. 31). The maximum age was 13.5 years for a female and 7.5 years for a male.

Lynx

Trappers harvested lynx in GMUs 11 and 13 in 1991-92 from 15 December through 15 January with no bag limit. Pelt sealing records for GMU 11 showed a lynx take of 38 in 1990-91, 107 in 1991-92, and 42 in 1992-93. The percentage of kittens in the harvest declined from 20% to 11% to 5% between seasons. Concurrent harvests in GMU 13 were 110 in 1990-91, 122 in 1991-92, and 125 in 1992-93, with a similar decline in the percentage of kittens from 35% to 14% to 11% between seasons.

Sex and age percentages and ratios of over 140 lynx carcasses from GMUs 11 and 13 during the 1991-92 trapping season are summarized in Table 5. Males:females were nearly equal in GMU 11 but were 150:100 in GMU 13. No kittens were in the GMU 13 sample, and they composed only 10% of the GMU 11 sample. Age distributions of lynx carcasses from the Nelchina River and Copper River basins during the 1990-91 (n = 14), 1991-92 (n = 144), and 1992-93 (n = 21) trapping seasons indicated median ages of 1.5, 1.23, and 2.18 years, respectively (Fig. 32). Female median ages were slightly lower than male ages in 1990-91 (1.5:1.67 years) and 1991-92 (1.15:1.28 years) but were slightly higher in 1992-93 (2.14:2.00 years). The maximum age for a female was 11.5 years in 1991-92 and for a male was 7.5 years in 1990-91.

DISCUSSION

Variability in track counts was often high among the species and areas examined in this study. This was expected considering the number of factors influencing track deposition and retention (Fig. 1) (Raphael 1994). The greatest variability was found among mean daily track counts. The erratic movements of 1 or 2 individuals responding to local food and weather conditions could greatly influence daily track deposition, producing low track counts one day and high counts the next. Therefore, comparisons of track counts collected in only 1 day could lead to inaccurate interpretations about the relative abundance of furbearers across areas or over time. Pooling daily track counts over several days into cumulative deposition and retention rates reduces the effect of any particular day's track count on such interpretations. There were few differences between cumulative track deposition and retention rates that were statistically significant, although retention rates were usually lower than deposition rates and there were often differences in patterns of the 2 types of counts plotted over time. One of the most frequent patterns was the leveling out or decline in the retention of tracks after 3-4 DAS (e.g., Figs. 10 and 11). Occasionally such a decline did not begin until 7 or more DAS (e.g., Fig. 19) or there was no decline during the periods sampled (e.g., Fig. 27).

Cumulative track deposition and retention rates were remarkably linear and showed moderate to strong correlations with DAS in most of the situations examined. Although variability was often high among them, rates of track retention adjusted for DAS were usually within 10% of the desired rate of change of zero. These results indicate that any positive or negative bias resulting from equating track counts to 1 DAS if pooled over several days should not prevent the use of track counts as indices of relative abundance. However, other factors, such as habitat preferences and activity patterns of furbearers relative to resource availability, that affect the deposition and retention of tracks must also be considered when interpreting trend through track counts.

Martens used the more heavily wooded vegetation types most, and their track densities tended to increase over time in the KLT and KNRC areas. Marten use of denser vegetation types in these areas reflected their preference across most of their range for mature coniferous forests that provide ample cover (Buskirk 1983, Strickland and Douglas 1987, Sherburne and Bissonette 1994, Thompson 1994). Martens were virtually absent in the light VCC along the KLT trail and they were relatively scarce in the 1966 burn of the KNRC, which Johnson et al. (1994) concluded was the lowest quality marten habitat in the area. However, marten track densities were highest in the KNRC in the 1985 burn, which were higher than those counted in the KLT area. Largely because of the increased abundance of microtine rodents that follow them, recent burns have been shown to provide excellent habitat for martens provided the burned areas contain adequate deadfall trees for cover and for subnivian movement (Magoun and Vernam 1986, Golden 1987, Sherburne and Bissonette 1994). Marten preferred upland forests and ridges in the KNRC over lowland areas and drainages (Johnson et al. 1994). Thompson and Colgan (1987) reported that marten track counts declined along with prey abundance in northcentral Ontario. In contrast, marten track counts increased each year in all habitat types in KNRC while microtine populations seemed to decline from a high in 1992 (Johnson et al. 1994). It is unlikely marten populations were increasing in KNRC during prey declines, but increased activity to search for scarcer prey may have masked a small to moderate decline in marten abundance. This situation may also have occurred in the KLT area between February and April 1992, when marten track counts were higher as small mammals and snowshoe hares were near their annual low at the end of winter. There were higher track counts in April despite the poorer tracking conditions.

Lynx and snowshoe hares tended to use the more densely forested communities. The relatively higher track densities of lynx observed in the 1966 burn of the KNRC were consistent with lynx use of 25-40-year-old forests in eastern Interior Alaska (Golden 1987). A preference for denser forest communities was also reported for hares in the middle Susitna River basin in Southcentral Alaska (MacCracken et al. 1988). Track densities of lynx were higher on average in the mixed boreal forest of the TNWR than in KNRC and were highest in April 1992. Perham (in press) conducted a multilinear regression analysis of several environmental factors that may affect lynx track densities in TNWR. After comparing among 4 parameters, mean temperature, barometric pressure change, snowfall, and time since snowfall (days), he found mean temperature was the most important predictor of track deposition and that lynx movements diminish significantly below -24°C. The higher track counts in TNWR in April 1992 may be related to warmer temperatures or to activities associated with the peak of breeding season (Quinn and Parker 1987). Lynx track counts in TNWR declined after 1992. That was around the beginning of the cyclic decline in lynx abundance across most of Alaska. While trends in snowshoe hare track counts were ambiguous in the KNRC between 1993 and 1994, track counts along the 7-km section of the KLT transect and hare pellet counts in WRST (W. Route, pers. commun.) indicated hares were in the declining phase of their 9-11-year cycle.

Harvest data can supplement track counts to indicate population trends. They are perhaps most useful in enhancing broad interpretations, because there is often a lack of detailed or complete harvest reporting. Reliable means to determine marten population or harvest levels in GMUs 11 and 13 have been unavailable. There is no requirement for trappers to have marten pelts sealed, and trapper export and fur buyer acquisition data are believed to chronically underestimate harvest. Trappers reported through questionnaires that marten were stable in number after their increase during the mid-1980s which peaked in 1988 (Tobey 1993). The purchase of over 800 marten carcasses from trappers during the 1991-92 trapping season indicated a sizable harvest was possible. However, the purchase of only 39 marten skulls during the 1992-93 trapping season revealed that trapper harvest was variable. In this case, it was attributed mainly to poor pelt prices and, subsequently, low trapper effort (R. Tobey, pers. commun.). The proportion of juveniles to adult females (37:100) in the carcass sample for GMUs 11 and 13 was substantially below the 3:1 ratio that Strickland and Douglas (1987) suggested represents a healthy marten population. Relative to marten, lynx harvests are far easier to track because pelts of harvested cats must be sealed by Alaska Department of Fish and Game (ADF&G). Lynx populations in GMUs 11 and 13 were in their 9-11-year cyclic low from about 1985 to 1987. They began increasing in 1988 and peaked in 1991 or 1992 (Tobey 1993, unpubl. ADF&G data). Trapping was prohibited from 1987 through 1989, due to low lynx numbers, and was reopened in 1990. The poor representation of kittens in the sample reflected the 1991-92 pelt sealing data. Those data and the increasing median age of lynx in subsequent years indicated the population passed through its 10-year peak and was declining to its cyclic low.

MANAGEMENT IMPLICATIONS

Despite the variability inherent in them, track counts of furbearers can be used as indices of relative abundance. However, their reliability depends upon the rigor with which they are collected. To minimize variability, track count methods must be consistent over time, among areas, and among observers. Additionally, track counts should be conducted for several consecutive days soon after a snowfall, and the results should be pooled to increase precision and improve the reliability of trend data (Harris 1986). If possible, counts should also be replicated at least twice during the winter. Recommended procedures for counting furbearer tracks along ground transects are given in Appendix B. Track counts may be one of the better methods to monitor furbearer trends objectively in much of Interior and Southcentral Alaska, but it would be risky to use track counts as the only type of index. They must be used with other indicators of a species' status. Harvest data from pelt sealing records and fur buyer/export reports, results from trapper questionnaires, observations of prey abundance, and other incidental observations should also be considered in interpreting furbearer population trends.

Research on the objectives in this study should be continued to better understand the sources and levels of variability in track deposition and retention and to improve methods for collecting precise data.. Two additional objectives should be to (1) estimate observer track-count biases, particularly in sightability between aerial and ground counts, among broad classifications of vegetation cover and composition, and (2) develop techniques for aerial track counts as indices of furbearer abundance over large areas.

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I thank Bob Tobey, Jim Woolington, and Kathy Adler for their help with field equipment and carcass collections. Jim Woolington and Jeff Cain assisted with track counts. Kiana Koenen, Ken Holt, Suzan Bowen, and King Career Center students Eric Mullen, Shane Jolly, Tom McCormick, and Aaron Hill assisted in processing carcasses, tissue samples, and teeth. Earl Becker consulted on hypothesis development and statistical analysis. Karl Schneider, David Anderson, and Charles Schwartz provided funding support and editorial review.

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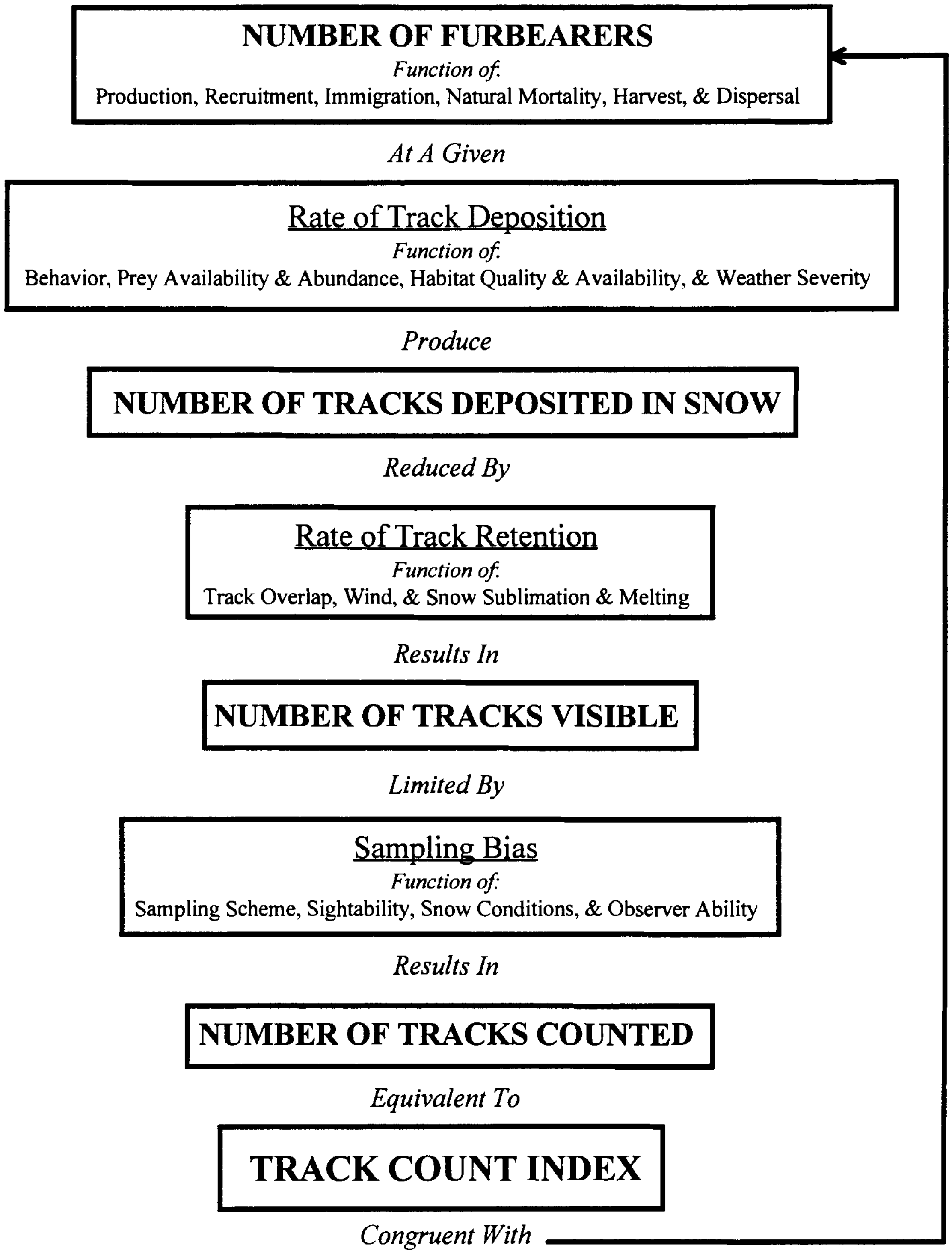


Figure 1. Track count index model based on the functional relationships between the abundance of furbearers and their tracks counted in snow.

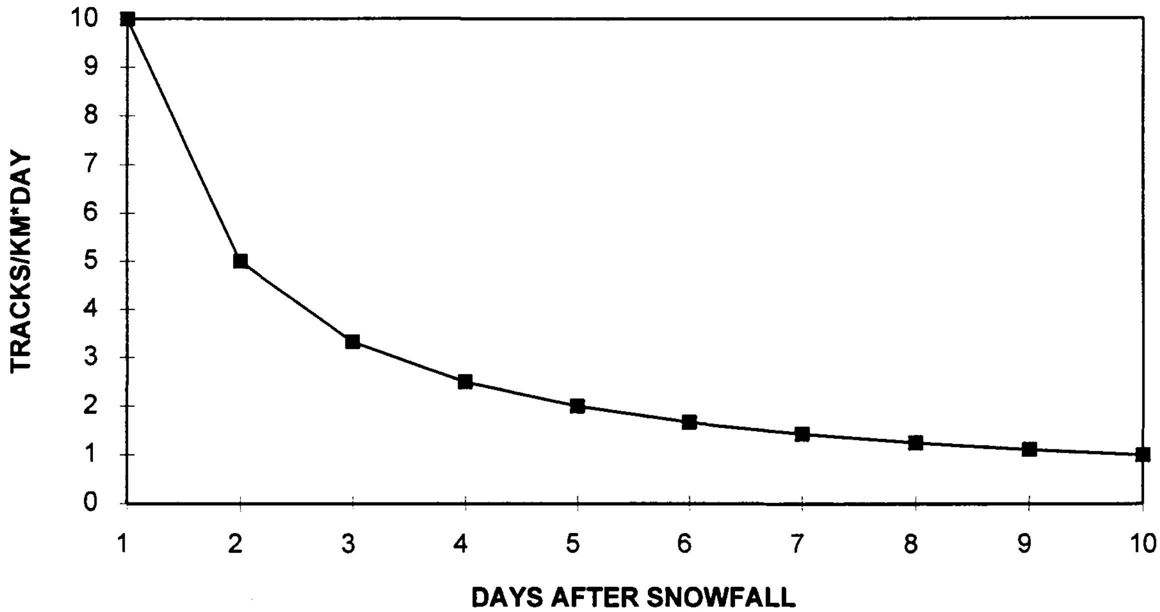


Figure 2. Illustration of a potential problem in correcting daily track counts to 1 day after snowfall (DAS). A negative curvilinear relationship results when daily track counts are held constant at 10 tracks/km and then divided by each DAS, which has been a standard procedure in equating track counts among areas and over time.

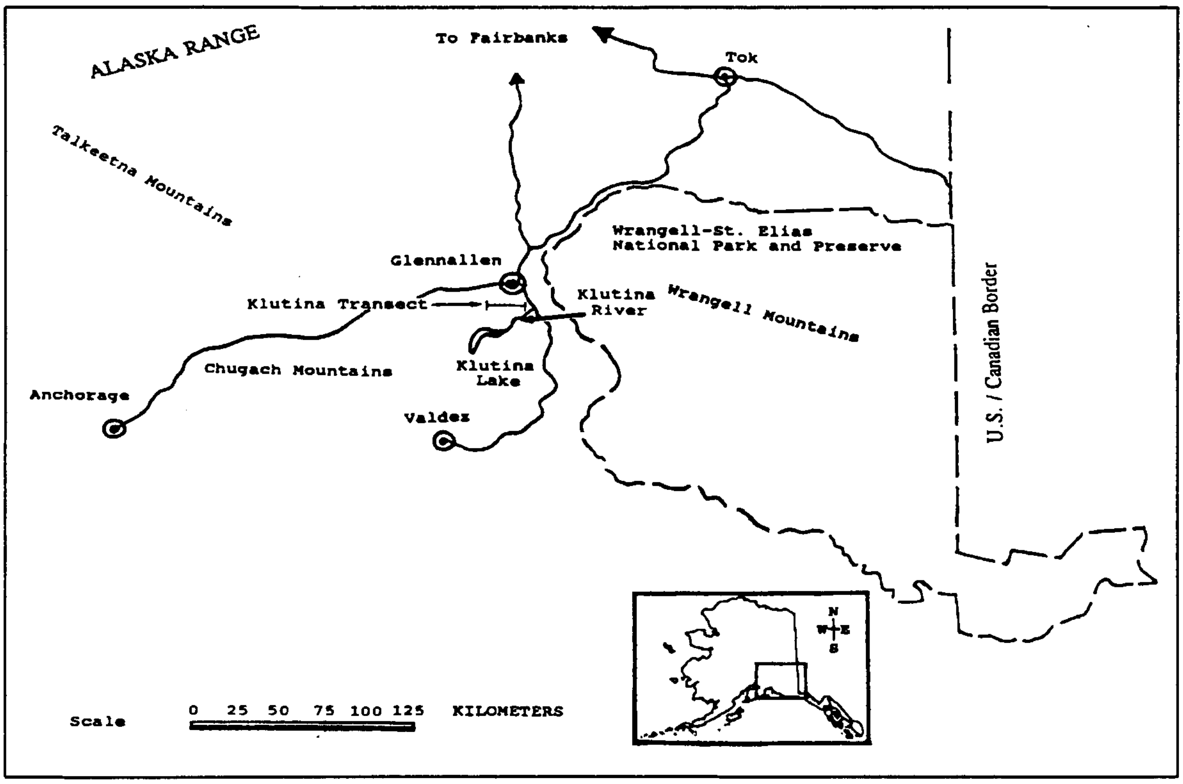


Figure 3. Location of the Klutina Lake trail transect in the Copper River basin, Alaska.

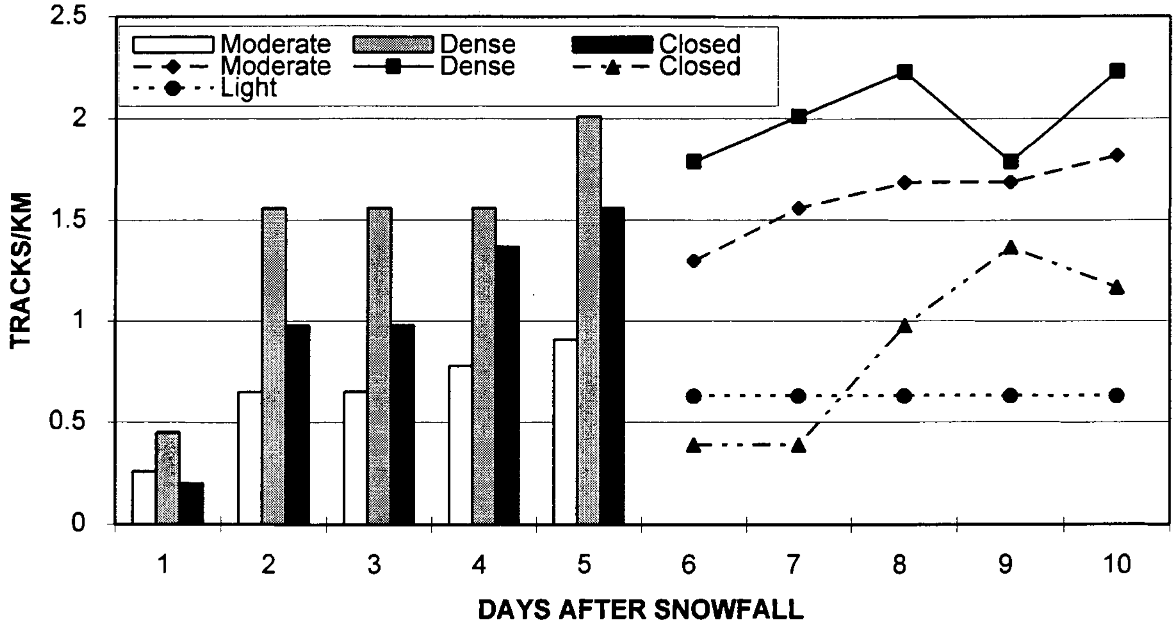


Figure 4. Cumulative deposition (bars) and retention (lines) of marten tracks counted 1-5 February 1992 among 4 vegetation cover classes (light = 1-25%, moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Tracks used for measuring retention were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

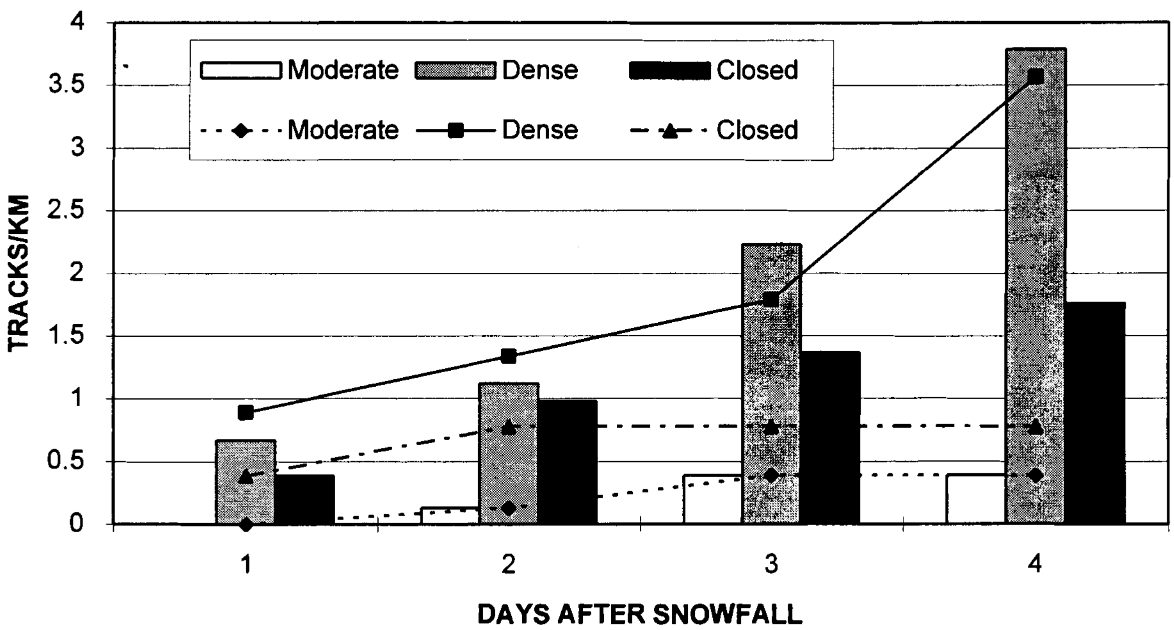


Figure 5. Cumulative deposition (bars) and retention (lines) of marten tracks counted 5-8 April 1992 among 3 vegetation cover classes (moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska.

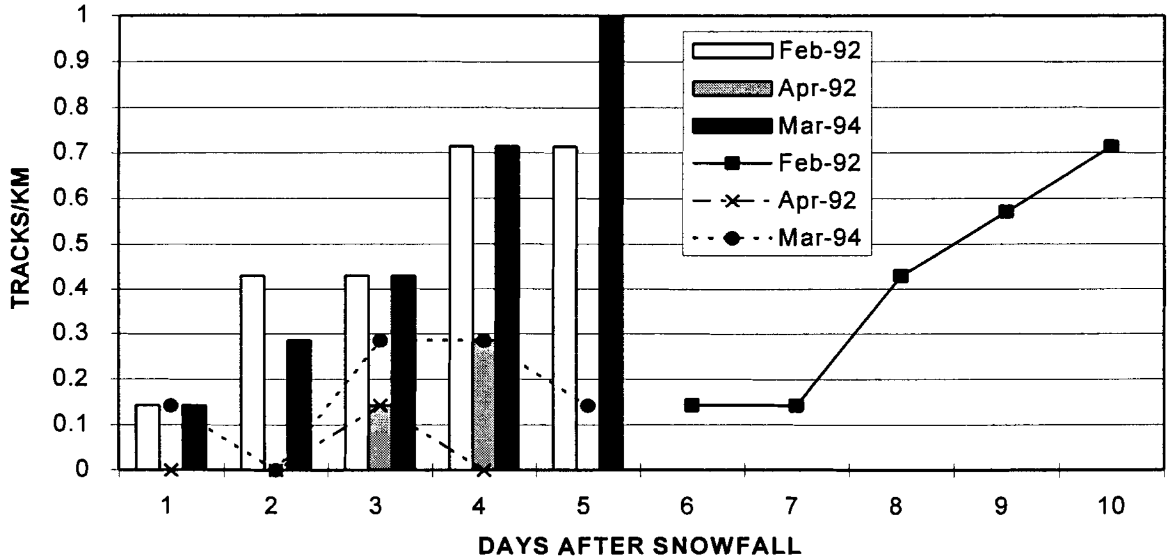


Figure 6. Cumulative deposition (bars) and retention (lines) of marten tracks counted 1-5 February and 5-8 April 1992 and 15-19 March 1994 along the first 7 km of the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Vegetation cover along this section of the trail was reclassified as moderate (26-59%) and dense (60-100%) in 1994. Tracks used for measuring retention during 1-5 February 1992 were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

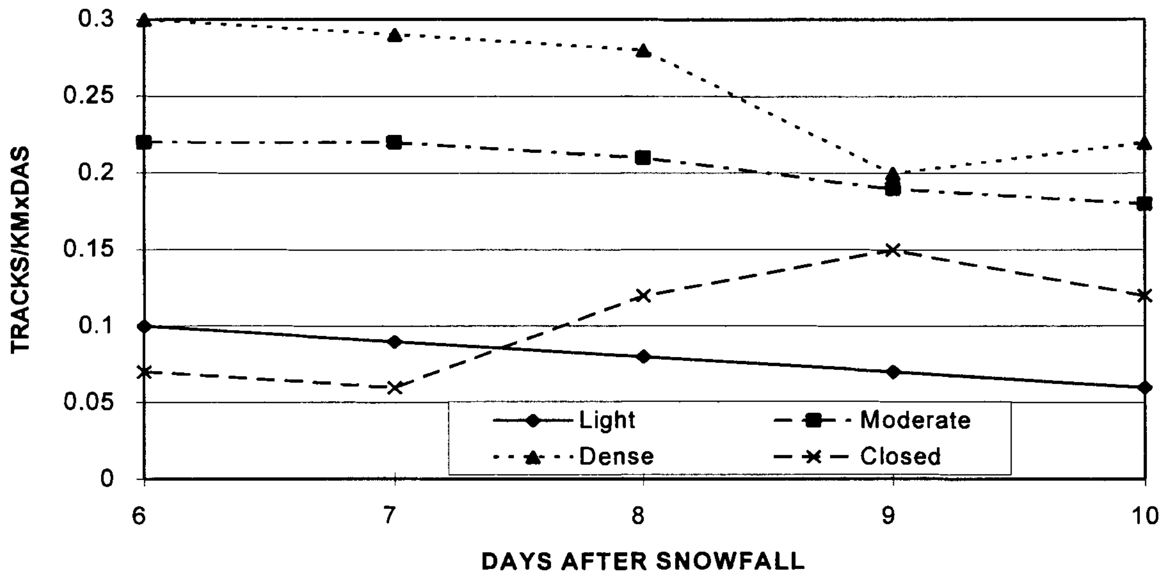


Figure 7. Counts of marten track retention adjusted for days after snowfall during 1-5 February 1992 among 4 vegetation cover classes (light = 1-25%, moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Tracks used for measuring retention were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

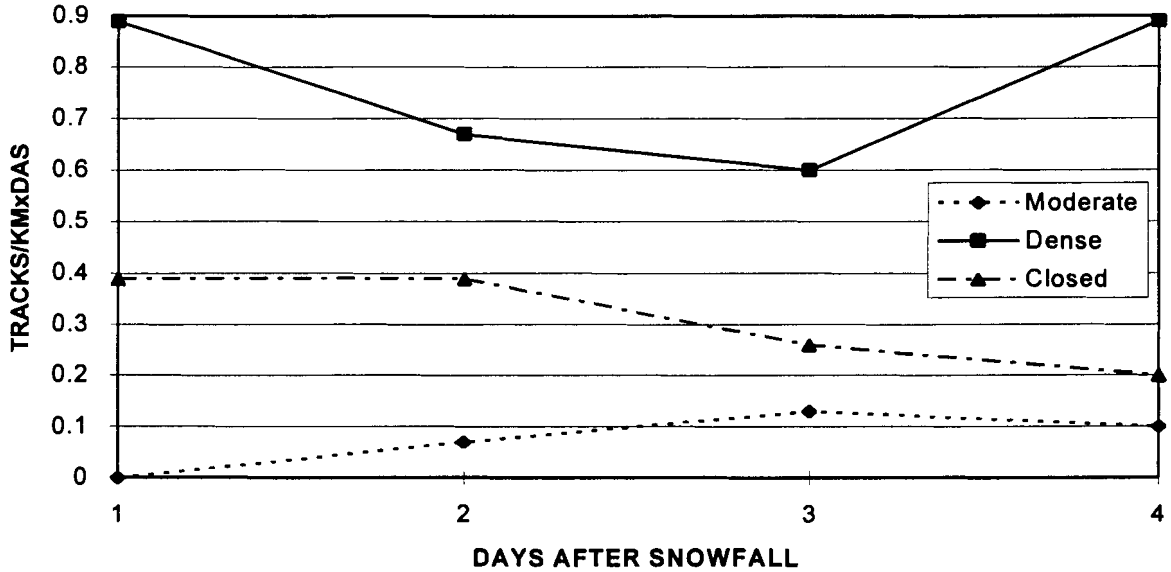


Figure 8. Counts of marten track retention adjusted for days after snowfall during 5-8 April 1992 among 3 vegetation cover classes (moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska.

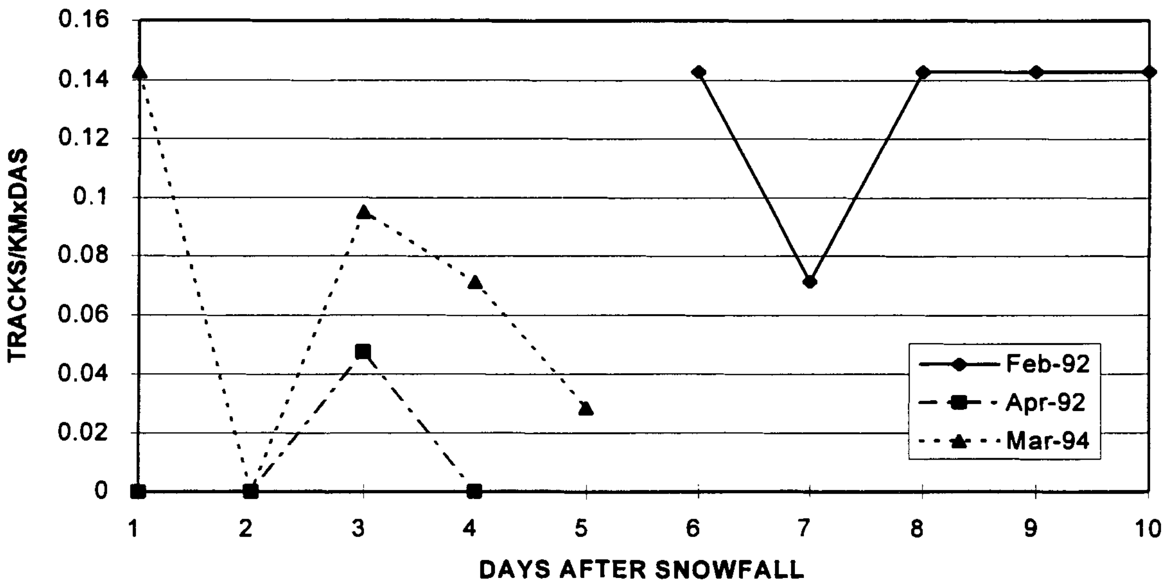


Figure 9. Counts of marten track retention adjusted for days after snowfall during 1-5 February and 5-8 April 1992 and 15-19 March 1994 along the first 7 km of the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Vegetation cover along this section of the trail was reclassified as moderate (26-59%) and dense (60-100%) in 1994. Tracks used for measuring retention during 1-5 February 1992 were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

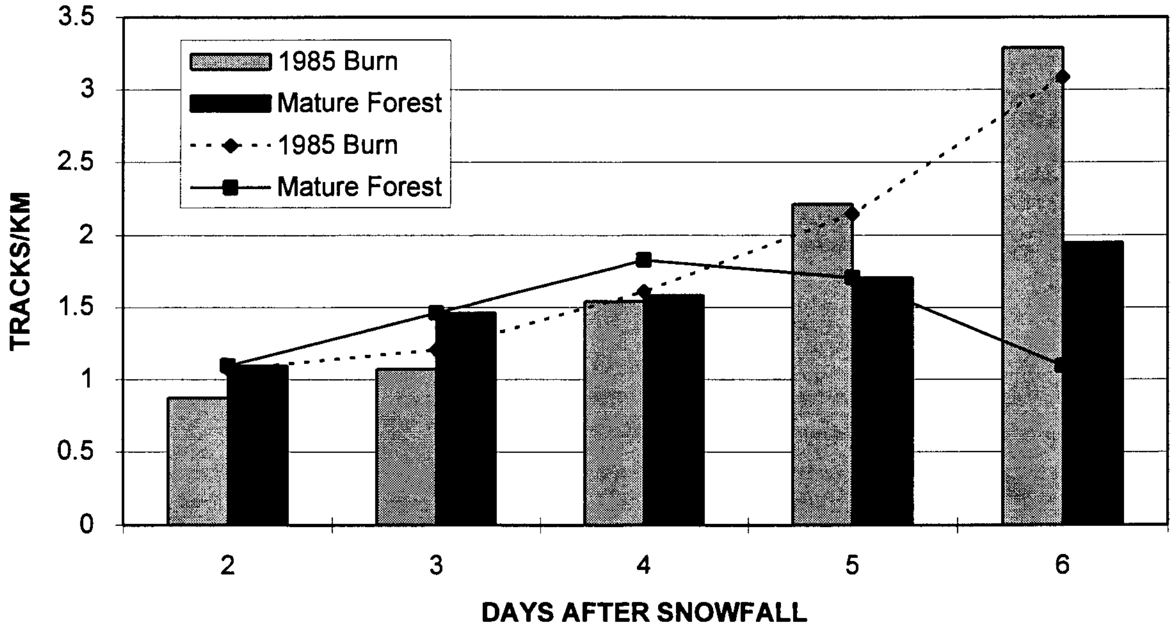


Figure 10. Cumulative deposition (bars) and retention (lines) of marten tracks counted 1-5 March 1992 in 2 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

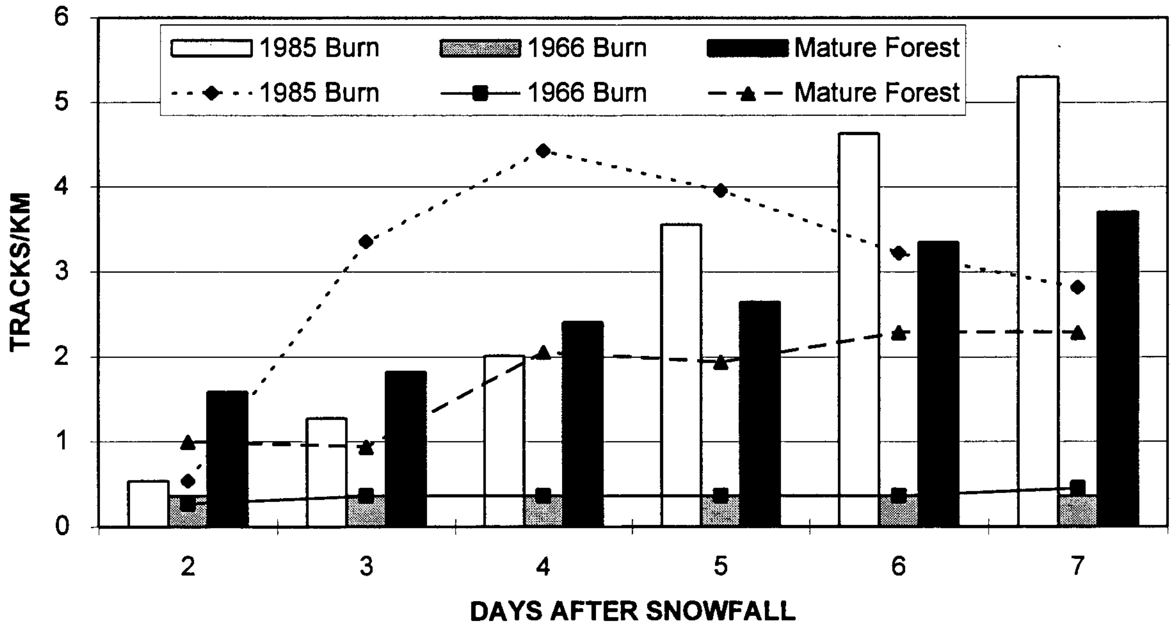


Figure 11. Cumulative deposition (bars) and retention (lines) of marten tracks counted 9-14 March 1993 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

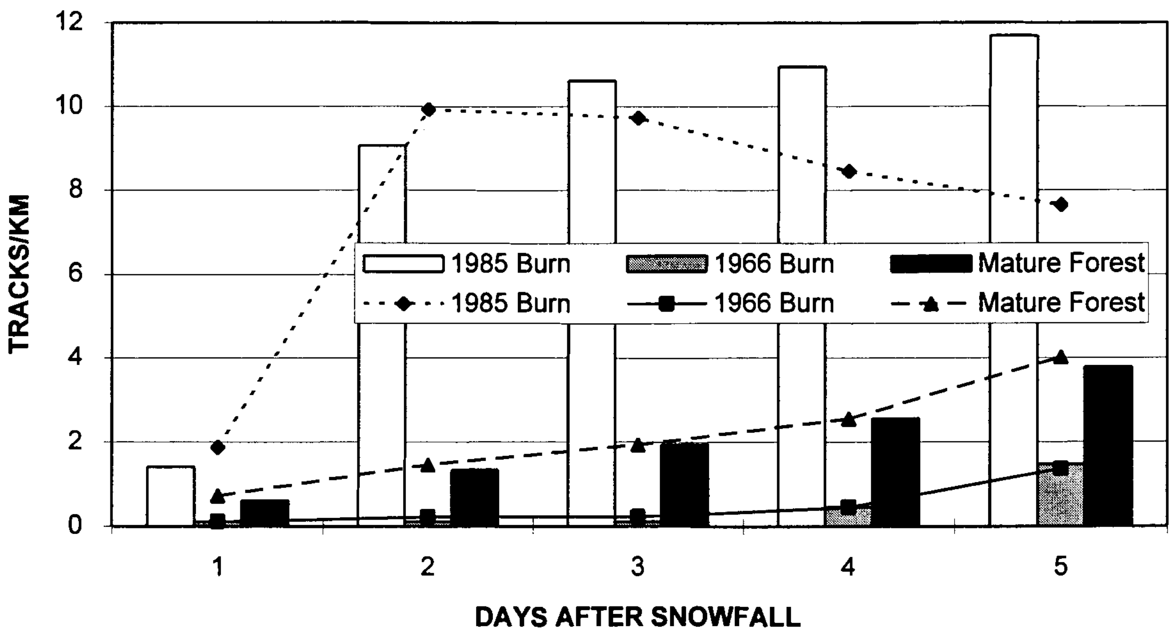


Figure 12. Cumulative deposition (bars) and retention (lines) of marten tracks counted 24-28 January 1994 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

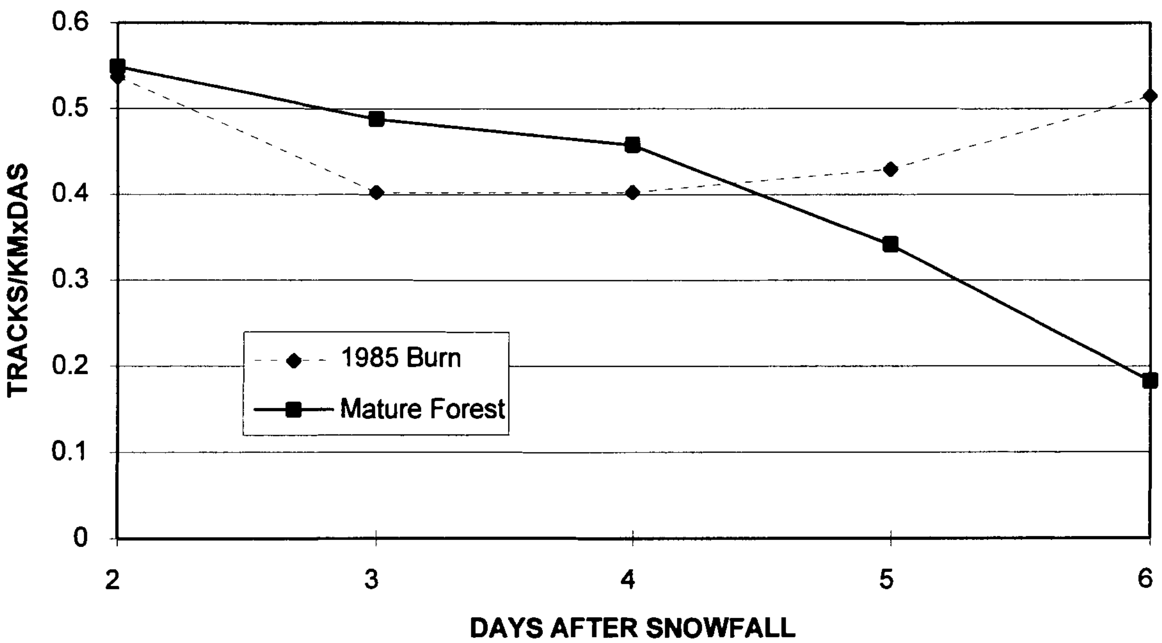


Figure 13. Counts of marten track retention adjusted for days after snowfall during 1-5 March 1992 in 2 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

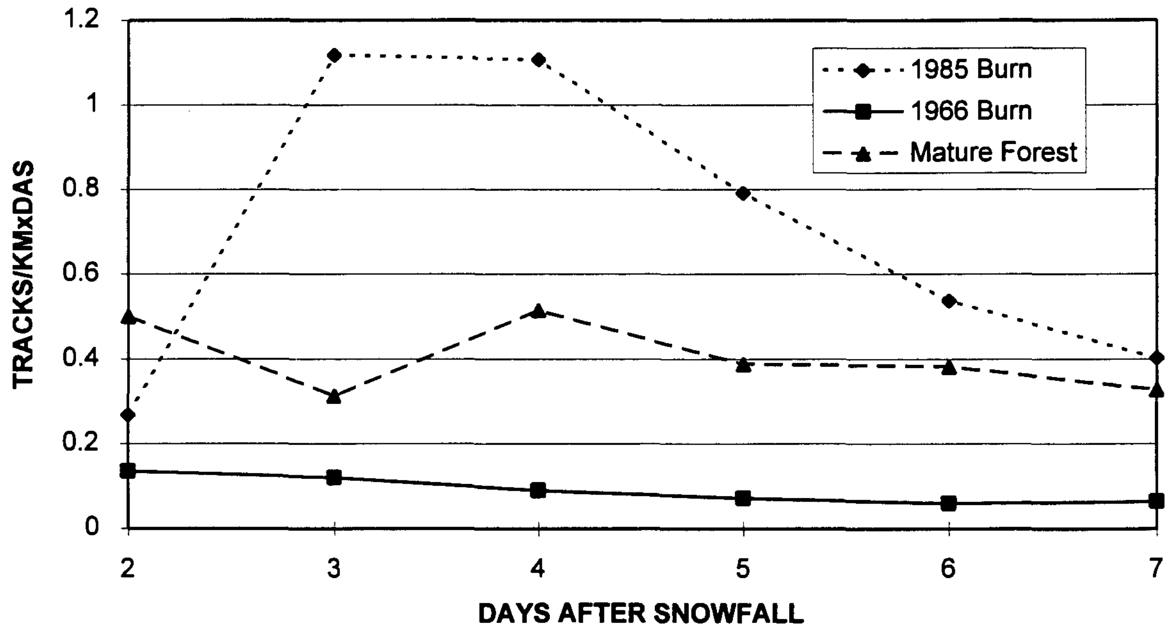


Figure 14. Counts of marten track retention adjusted for days after snowfall during 9-14 March 1993 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

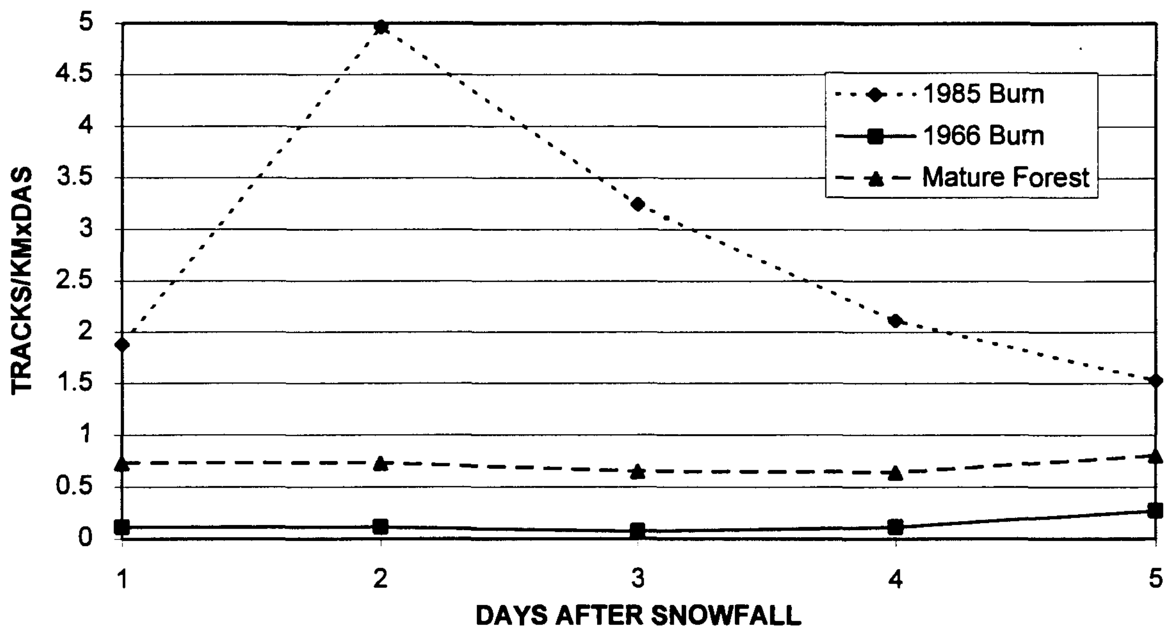


Figure 15. Counts of marten track retention adjusted for days after snowfall during 24-28 January 1994 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

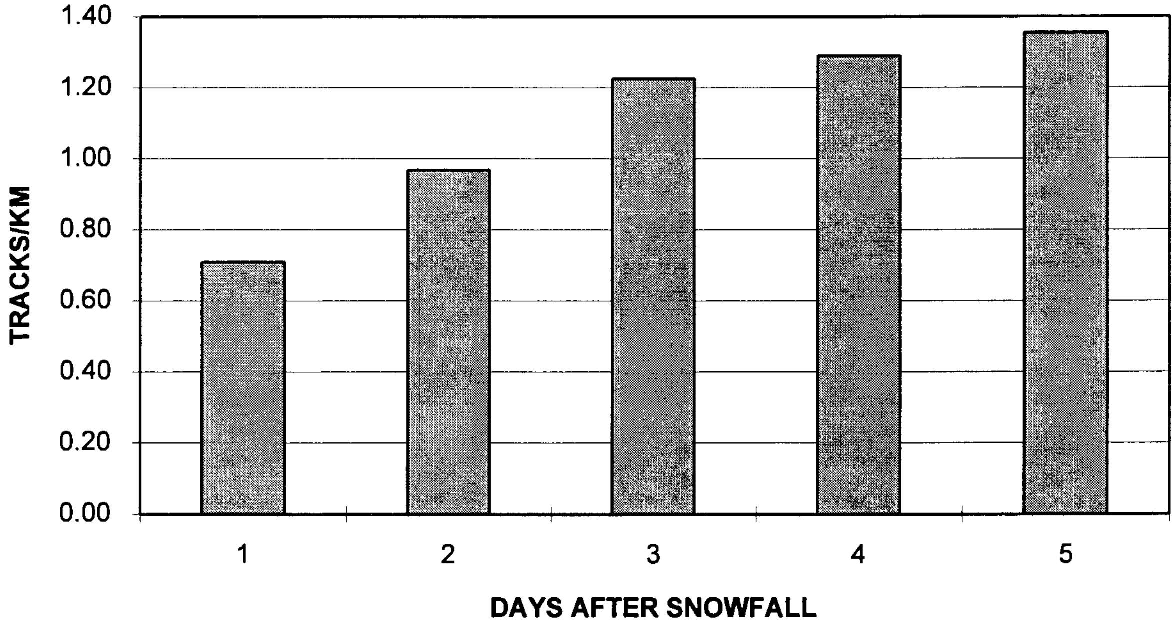


Figure 16. Cumulative deposition of marten tracks counted 3-7 February 1992 along the 15.5-km Kotsina Lake trail in the Wrangell-St. Elias National Park and Preserve, Alaska.

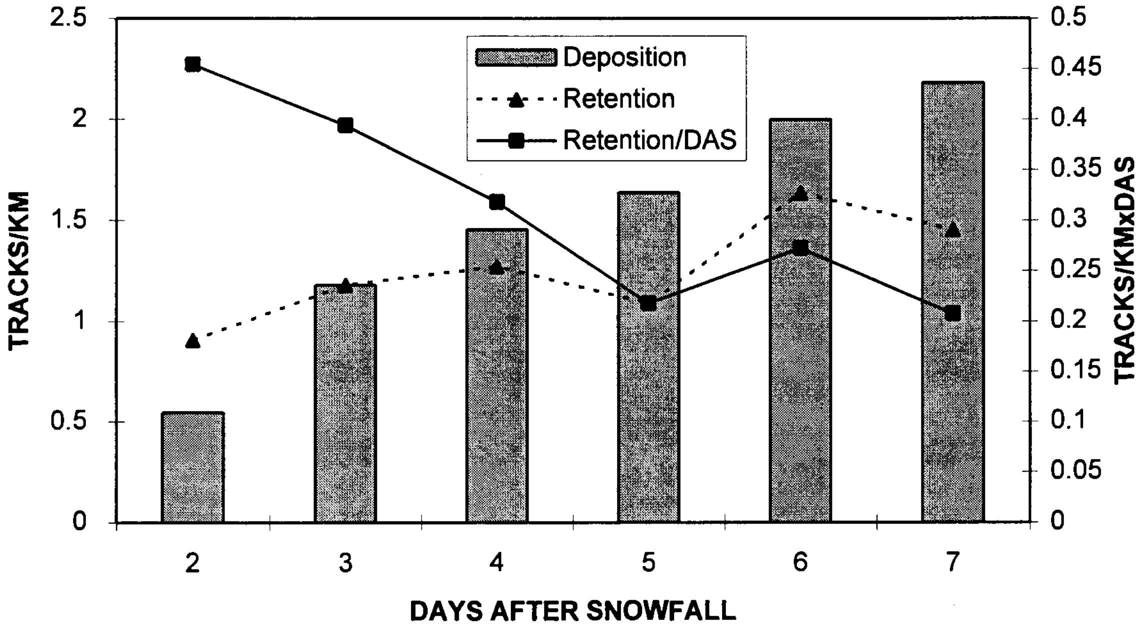


Figure 17. Cumulative deposition and retention (tracks/km) and retention adjusted for days after snowfall (tracks/km×DAS) of lynx tracks counted 9-14 March 1993 in the 1966 burn (dense tree forest) in the Koyukuk/Nowitna Refuge Complex, Alaska.

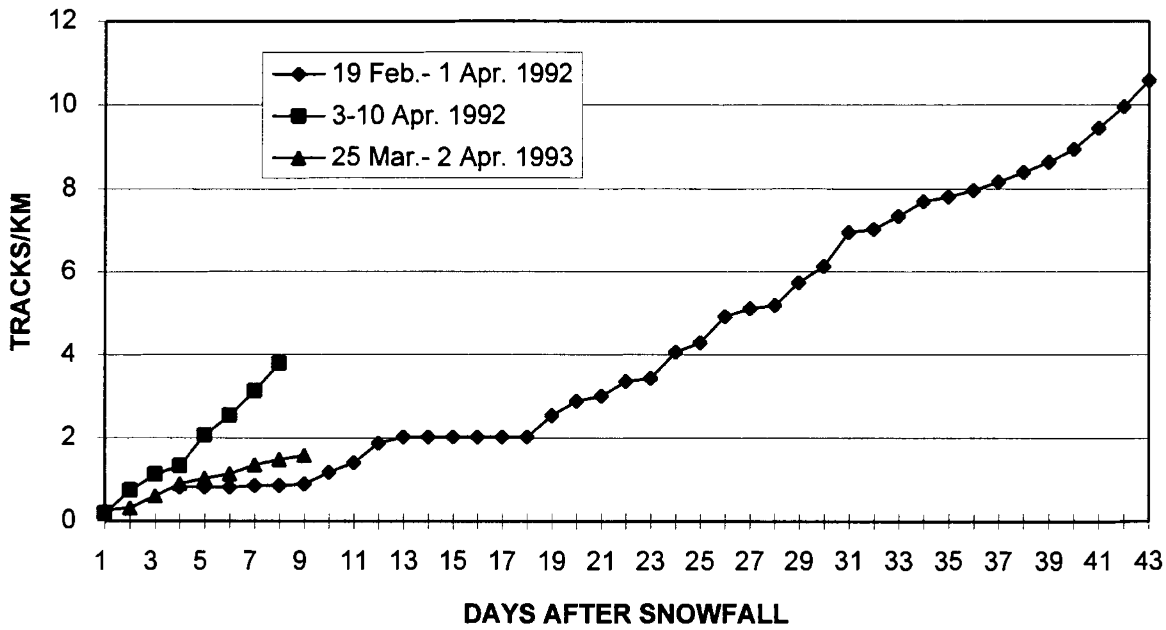


Figure 18. Cumulative deposition of lynx tracks counted 19 February-10 April 1992 (25.6 km) and 25 March-2 April 1993 (86.4 km) along Stuver Creek trail in Tetlin National Wildlife Refuge, Alaska. Tracks were erased each day after counting.

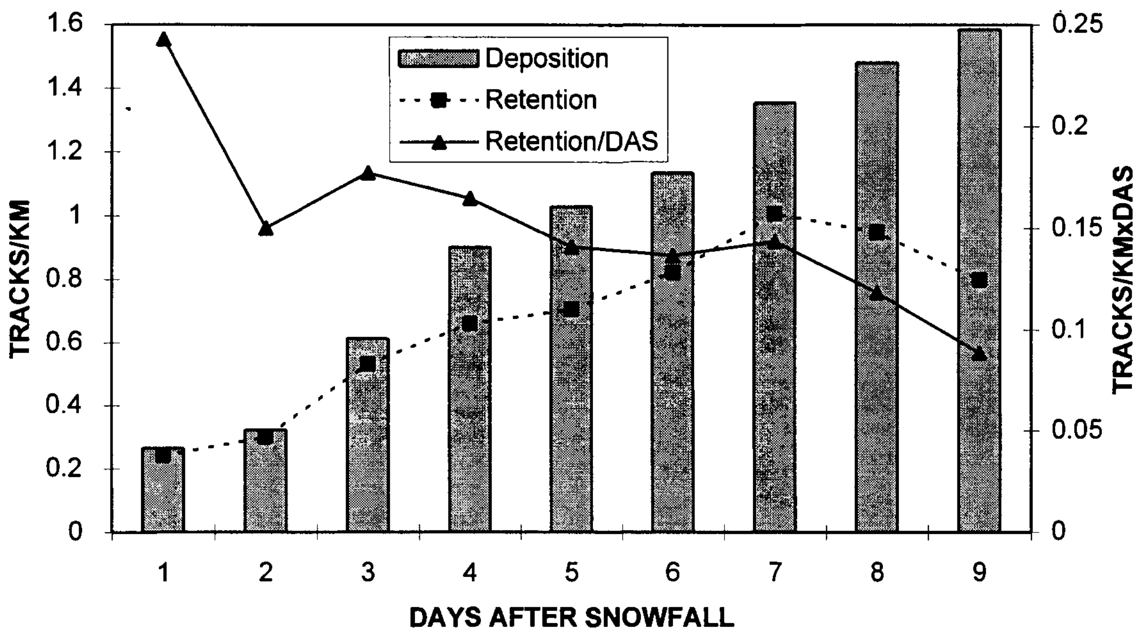


Figure 19. Cumulative deposition and retention (tracks/km) and retention adjusted for days after snowfall (tracks/km×DAS) of lynx tracks counted 25 March-2 April 1993 along the 86.4-km Stuver Creek trail in the Tetlin National Wildlife Refuge, Alaska.

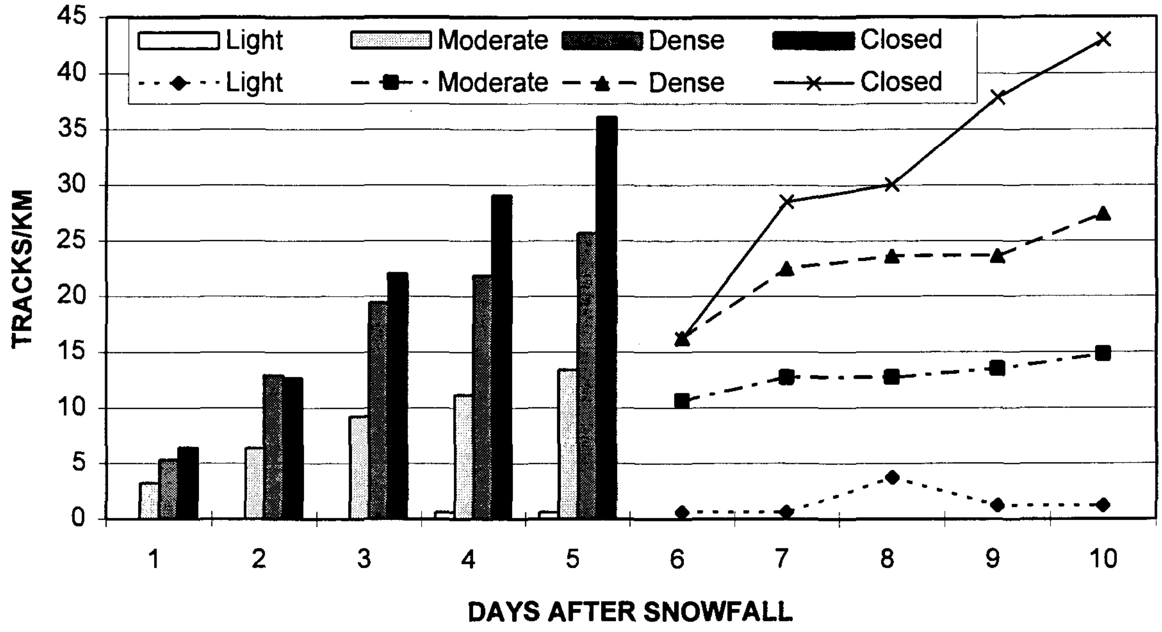


Figure 20. Cumulative deposition (bars) and retention (lines) of snowshoe hare tracks counted 1-5 February 1992 among 4 vegetation cover classes (light = 1-25%, moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Tracks used for measuring retention were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

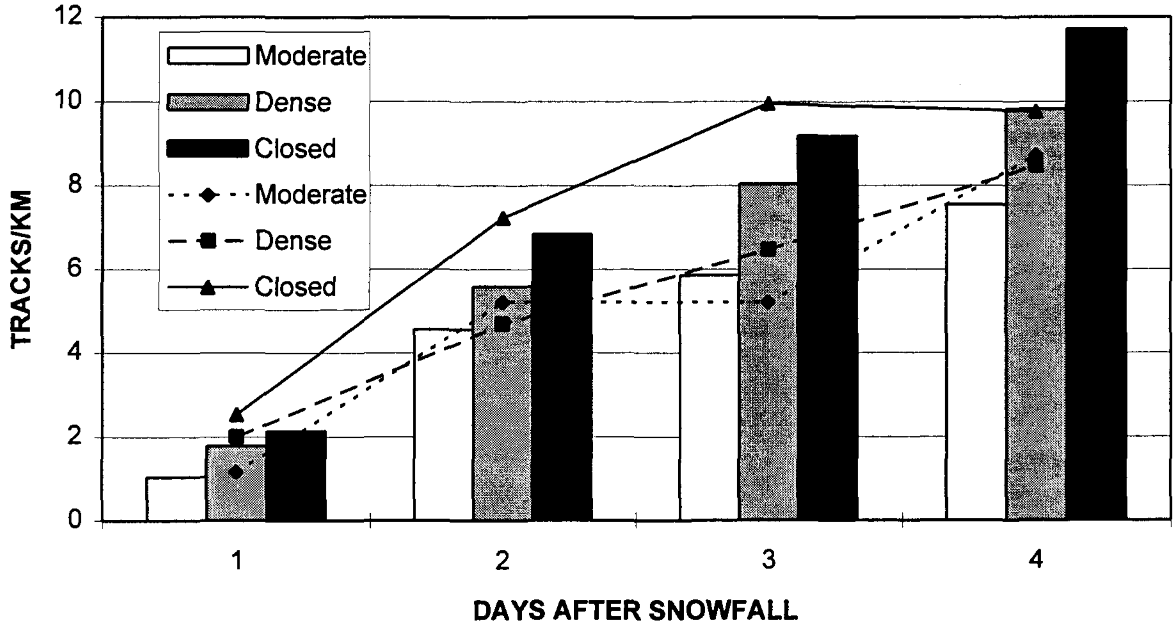


Figure 21. Cumulative deposition (bars) and retention (lines) of snowshoe hare tracks counted 5-8 April 1992 among 3 vegetation cover classes (moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska.

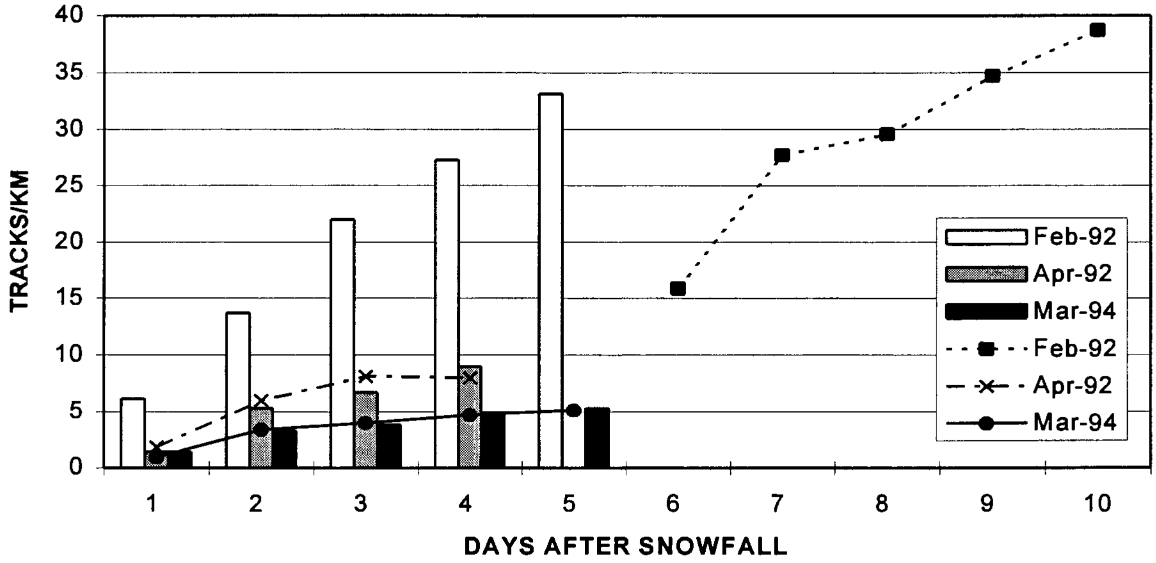


Figure 22. Cumulative deposition (bars) and retention (lines) of snowshoe hare tracks counted 1-5 February and 5-8 April 1992 and 15-19 March along the first 7 km of the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Vegetation cover along this section of the trail was reclassified as moderate (26-59%) and dense (60-100%) in 1994. Tracks used for measuring retention during 1-5 February 1992 were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

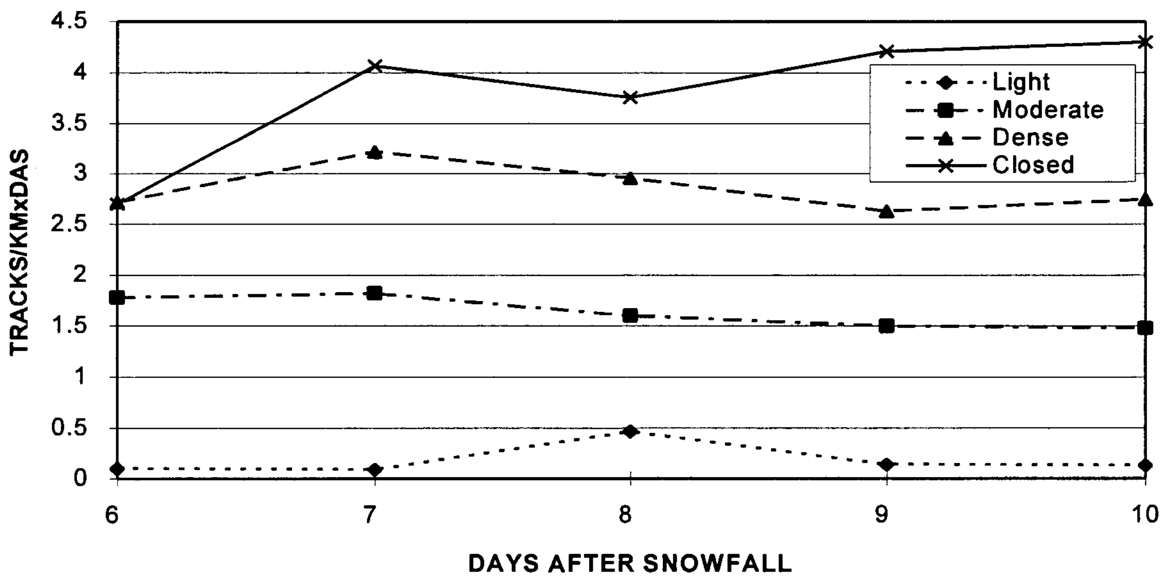


Figure 23. Counts of snowshoe hare track retention adjusted for days after snowfall during 1-5 February 1992 among 4 vegetation cover classes (light = 1-25%, moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Tracks used for measuring retention were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

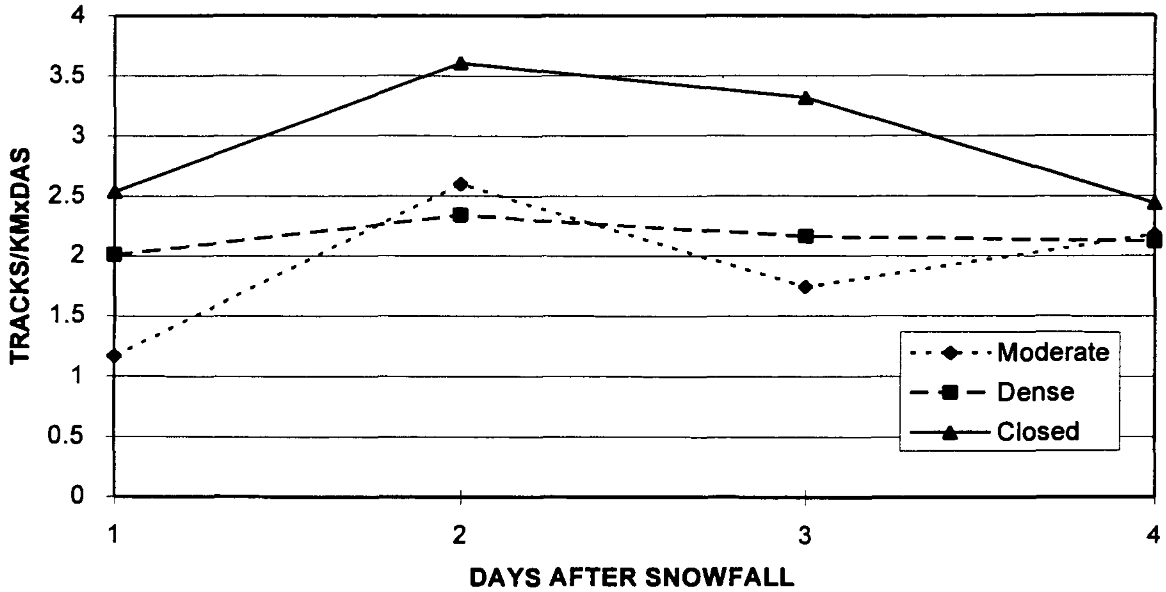


Figure 24. Counts of snowshoe hare track retention adjusted for days after snowfall during 5-8 April 1992 among 3 vegetation cover classes (moderate = 26-50%, dense = 51-75%, closed = 76-100%) along the 21-km Klutina Lake trail transect in the Copper River basin, Alaska.

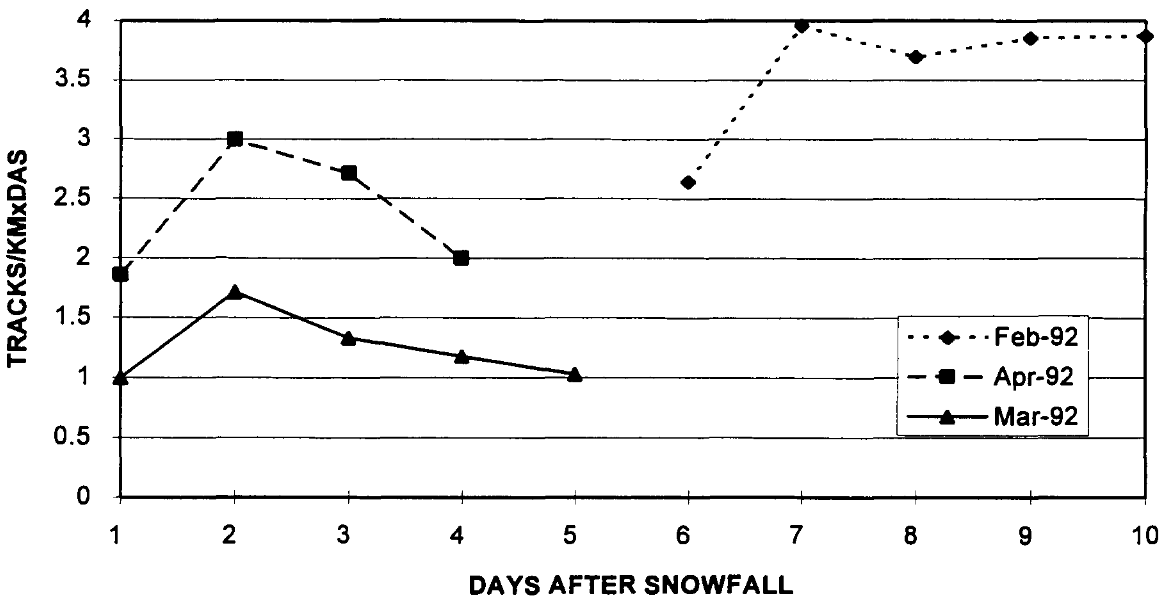


Figure 25. Counts of snowshoe hare track retention adjusted for days after snowfall during 1-5 February and 5-8 April 1992 and 15-19 March 1994 along the first 7 km of the 21-km Klutina Lake trail transect in the Copper River basin, Alaska. Vegetation cover along this section of the trail was reclassified as moderate (26-59%) and dense (60-100%) in 1994. Tracks used for measuring retention during 1-5 February 1992 were not erased prior to the first count to set DAS to 1 but were left intact at 6-10 DAS.

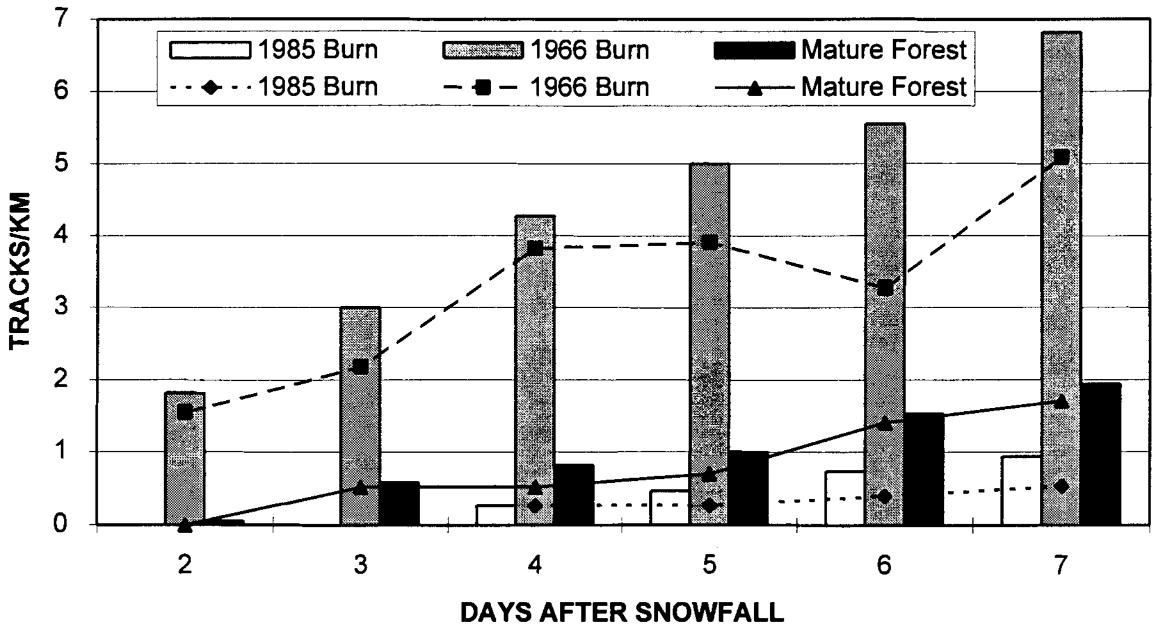


Figure 26. Cumulative deposition (bars) and retention (lines) of snowshoe hare tracks counted 9-14 March 1993 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

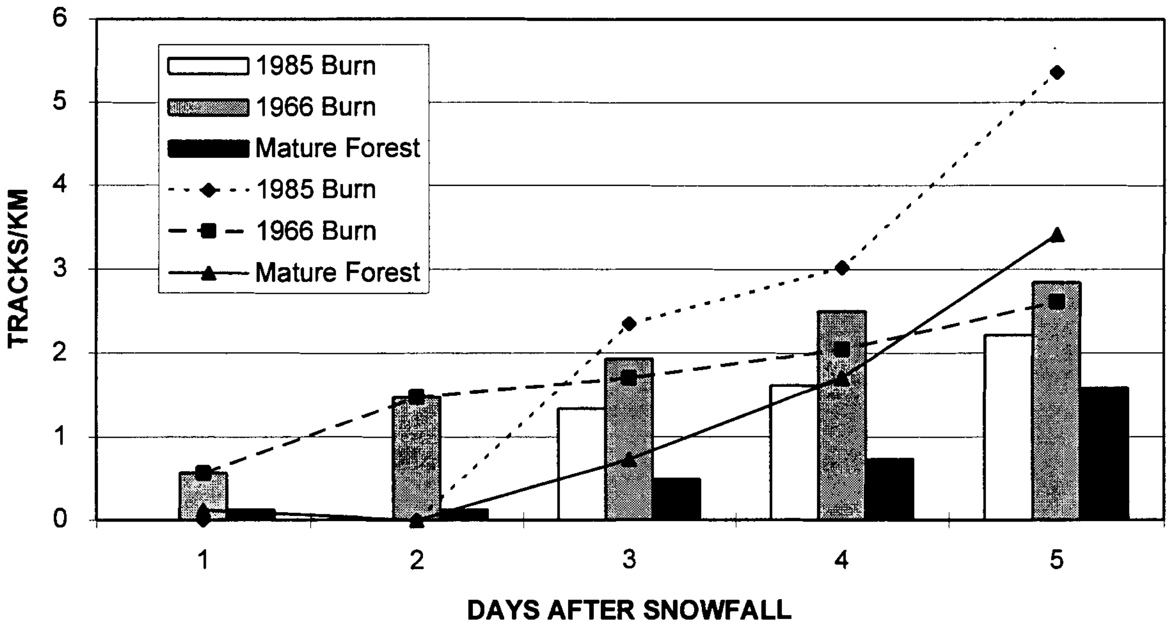


Figure 27. Cumulative deposition (bars) and retention (lines) of snowshoe hare tracks counted 24-28 January 1994 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

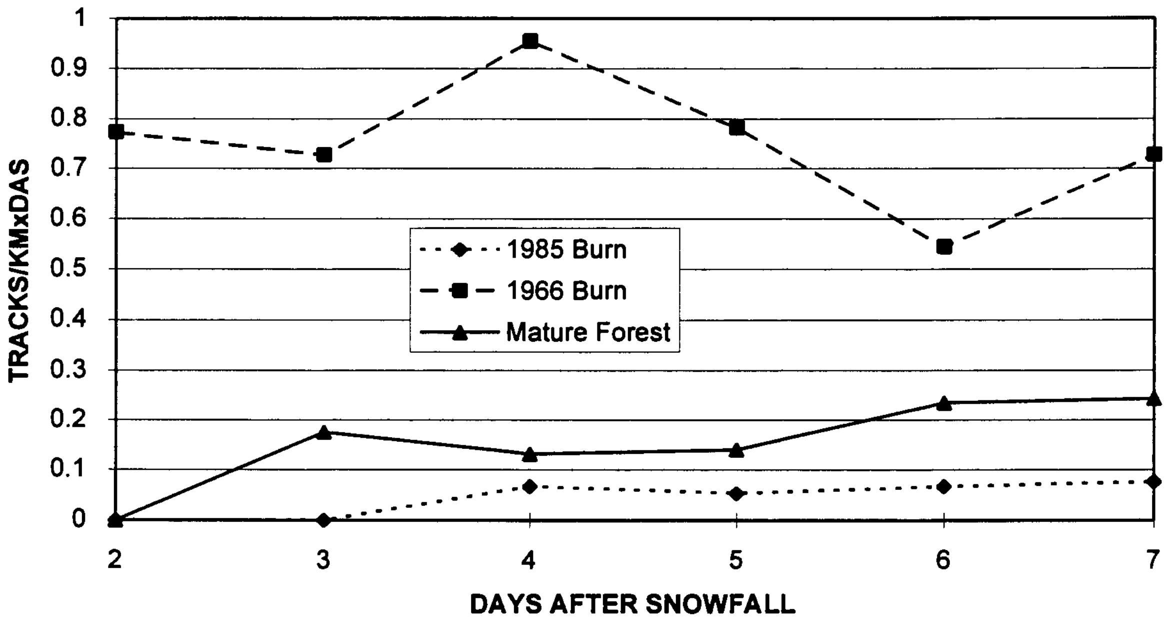


Figure 28. Counts of snowshoe hare track retention adjusted for days after snowfall during 9-14 March 1993 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

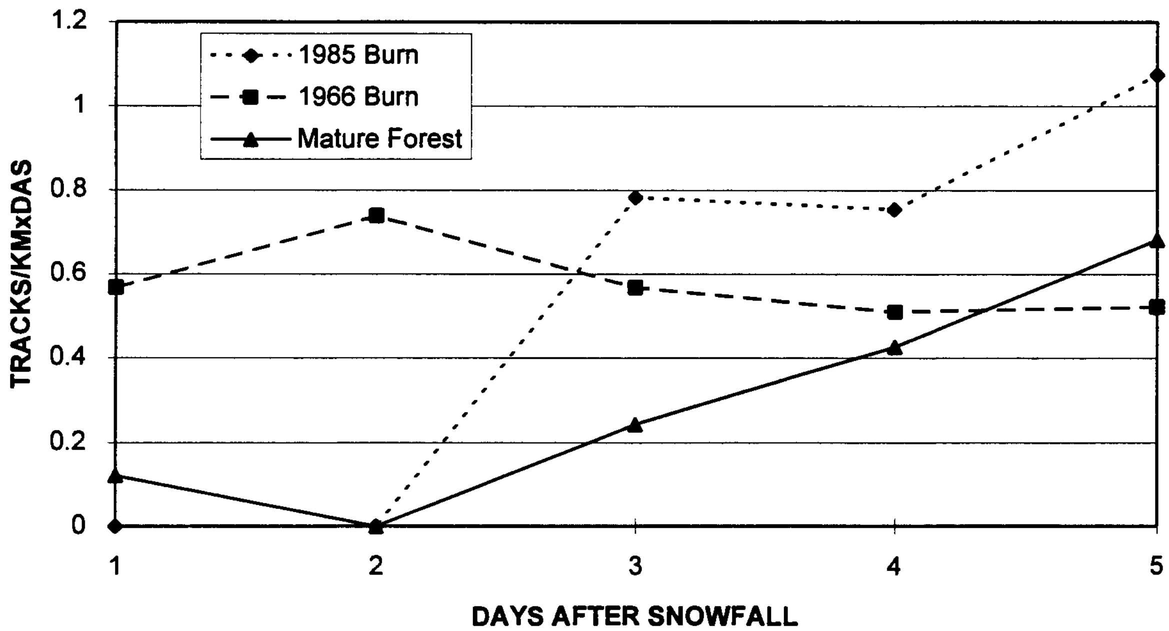


Figure 29. Counts of snowshoe hare track retention adjusted for days after snowfall during 24-28 January 1994 in 3 forest seral stages in the Koyukuk/Nowitna Refuge Complex, Alaska.

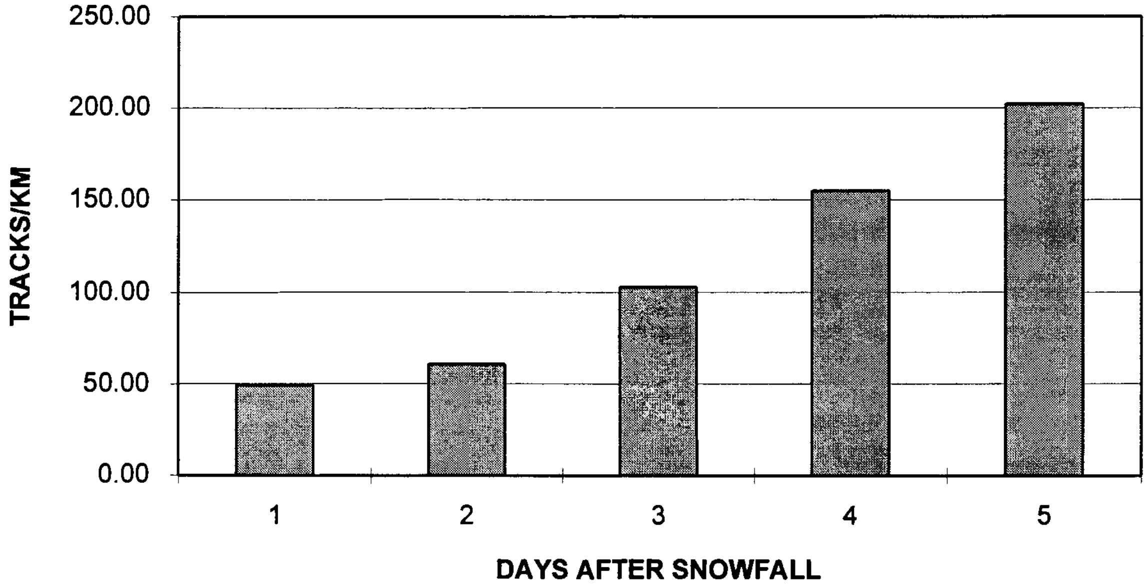


Figure 30. Cumulative deposition of snowshoe hare tracks counted 3-7 February 1992 along the 15.5-km Kotsina Lake trail in the Wrangell-St. Elias National Park and Preserve, Alaska.

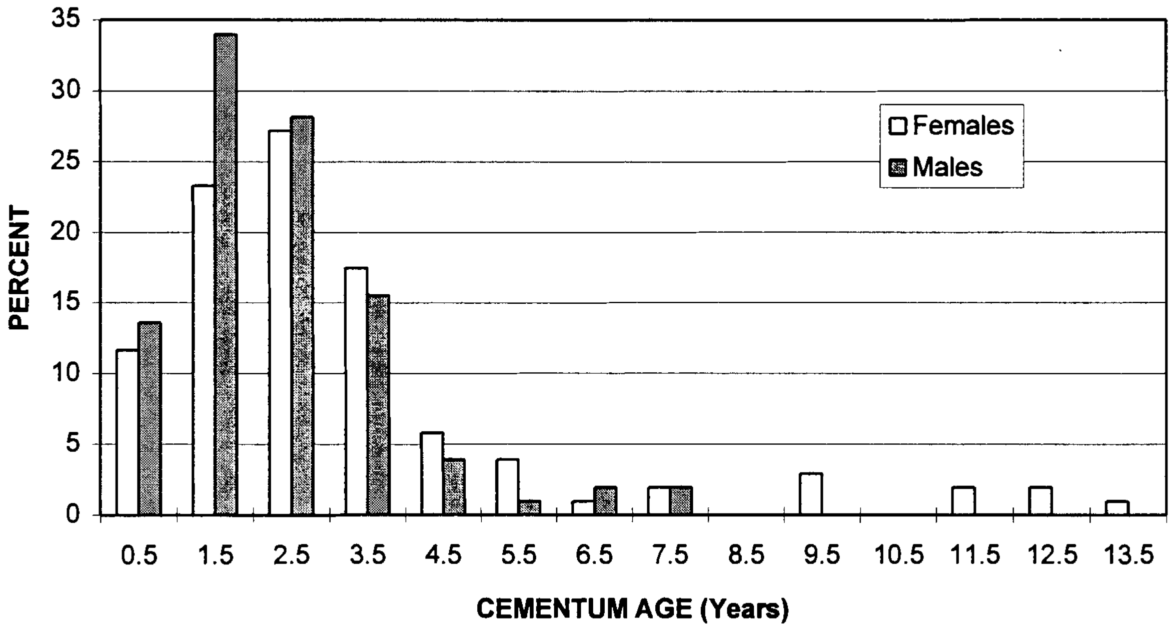


Figure 31. Age distribution of female (n = 100) and male (n = 100) marten trapped in winter 1991-92 in the Nelchina River and Copper River basins, Alaska. Samples were randomly drawn from a collection of 825 carcasses.

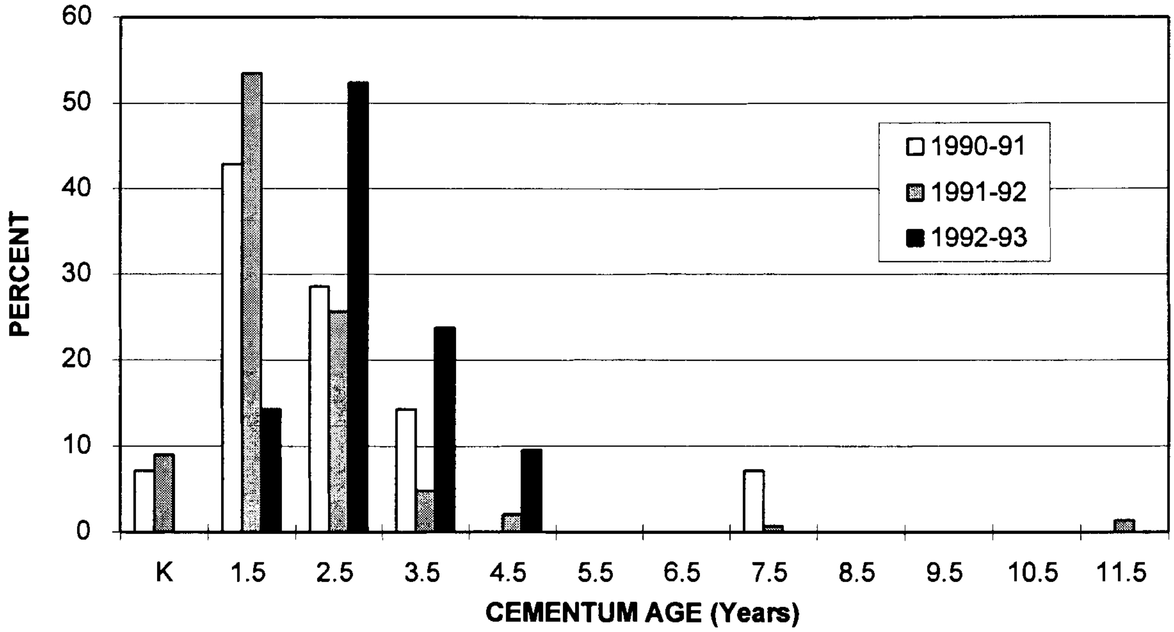


Figure 32. Age distribution of lynx trapped during the seasons 1990-91 (n = 14), 1991-92 (n = 144), and 1992-93 (n = 21) in the Nelchina River and Copper River basins, Alaska. Sample sizes represent carcasses purchased from trappers.

Table 1. Marten track deposition and retention statistics for different sample areas, vegetation cover classifications (VCCs), and time periods in Southcentral and Interior Alaska. Tracks/km were counted in snow along ground transects.

				Deposition					Retention						
		Trans.		Daily[b]		Cumulative[c]				Cumulative[d]			Adj. for DAS[e]		
Area & VCC	Mo/Yr	Length (km)	DAS[a]	Mean	(SD)	Rate	(SE)	r^2	DAS	Rate	(SE)	r^2	Rate	(SE)	r^2
KLT[f]															
Light	2/92	1.6	1-5	0.00	(0.00)	0.00	(0.00)	0.00	6-10	0.00	(0.00)	0.00	-0.01	(0.00)	1.00
	4/92	1.6	1-4	0.00	(0.00)	0.00	(0.00)	0.00	1-4	0.00	(0.00)	0.00	0.00	(0.00)	0.00
Moderate	2/92	7.7	1-5	0.18	(0.13)	0.14	(0.03)	0.86	6-10	0.11	(0.02)	0.88	-0.01	(0.00)	0.92
	4/92	7.7	1-4	0.10	(0.11)	0.14	(0.03)	0.90	1-4	0.14	(0.03)	0.90	0.04	(0.02)	0.70
Dense	2/92	4.5	1-5	0.40	(0.41)	0.31	(0.11)	0.72	6-10	0.07	(0.07)	0.22	-0.02	(0.01)	0.77
	4/92	4.5	1-4	0.95	(0.43)	1.05	(0.18)	0.95	1-4	0.85	(0.23)	0.87	-0.01	(0.08)	0.00
Closed	2/92	5.1	1-5	0.31	(0.26)	0.31	(0.06)	0.89	6-10	0.25	(0.07)	0.79	0.02	(0.01)	0.63
	4/92	5.1	1-4	0.44	(0.08)	0.45	(0.03)	0.99	1-4	0.12	(0.07)	0.60	-0.07	(0.02)	0.89
All VCCs	2/92	21.1	1-5	0.23	(0.19)	0.20	(0.05)	0.84	6-10	0.12	(0.02)	0.91	-0.01	(0.00)	0.62
	4/92	21.1	1-4	0.34	(0.08)	0.38	(0.02)	0.99	1-4	0.26	(0.03)	0.98	-0.01	(0.01)	0.14
1st 7 km of	2/92	7.0	1-5	0.14	(0.14)	0.14	(0.03)	0.89	6-10	0.16	(0.02)	0.94	0.01	(0.00)	0.92
Transect	4/92	7.0	1-4	0.07	(0.08)	0.10	(0.02)	0.89	1-4	0.01	(0.04)	0.07	0.01	(0.01)	0.07
	3/94	7.0	1-5	0.20	(0.08)	0.21	(0.02)	0.97	1-5	0.03	(0.04)	0.14	-0.02	(0.02)	0.18
KNRC[g]															
1985 Burn	3/92	14.9	2-6	0.66	(0.30)	0.60	(0.10)	0.93	2-6	0.50	(0.08)	0.92	-0.01	(0.02)	0.00
	3/93	14.9	2-7	0.88	(0.34)	1.01	(0.06)	0.98	2-7	0.30	(0.33)	0.17	-0.04	(0.09)	0.04
	1/94	14.9[h]	1-5	2.34	(3.01)	2.24	(0.83)	0.71	1-5	1.01	(1.05)	0.23	-0.36	(0.47)	0.16
1966 Burn	3/92	No data													
	3/93	11.0	2-7	0.06	(0.14)	0.00	(0.00)	0.00	2-7	0.02	(0.01)	0.71	-0.02	(0.00)	0.90
	1/94	8.8	1-5	0.29	(0.43)	0.31	(0.12)	0.67	1-5	0.27	(0.10)	0.71	0.03	(0.02)	0.42
Mature	3/92	8.2	2-6	0.39	(0.37)	0.20	(0.02)	0.96	2-6	0.02	(0.12)	0.01	-0.09	(0.01)	0.92
Forest	3/93	17.0	2-7	0.62	(0.47)	0.44	(0.03)	0.98	2-7	0.30	(0.07)	0.80	-0.02	(0.02)	0.24
	1/94	8.2	1-5	0.75	(0.26)	0.76	(0.06)	0.98	1-5	0.77	(0.10)	0.95	0.01	(0.02)	0.16
WRST[i]	2/92	15.5	1-5	0.27	(0.24)	0.16	(0.03)	0.91							

[a] Days after snowfall.
[b] Daily deposition of tracks (tracks/km).
[c-e] Rates of increase and coefficients of determination (r^2) of tracks deposited over all DAS (tracks/km), of track counts adjusted for days after snowfall, i.e. tracks/km×DAS, and of tracks retained over all DAS (tracks/km), respectively.
[f] Vegetation along the Klutina Lake trail transect (KLT) was primarily coniferous forest that was classified into 5 vegetation cover classes (VCC): bare = 0%, light = 1-25%, moderate = 26-50%, dense = 51-75%, and closed = 76-100%. No tracks were counted in the bare VCC so that category was not included in this summary. Vegetation cover was reclassified in 1994 into 4 VCCs: scarce = 0-9%, light = 10-24%, moderate = 25-59%, and dense = 60-100% cover.
[g] Vegetation in Koyukuk/Nowitna Refuge Complex (KNRC) was sampled among forests of 3 seral stages: 1985 burn = tall shrub/sapling stage, 1966 burn = dense tree stage, and mature forest stage. The 1966 burn was not sampled in 1992. Data were provided by cooperators Johnson and Paragi (1993) and Johnson et al. (1994).
[h] Transect length on 25 January 1994 was only 8.5 km due to snowmachine breakdown.
[i] Unpublished data provided by cooperator W. Route of Wrangell-St. Elias National Park and Preserve (WRST). It is characterized by predominately mixed forest of moderate VCC.

Table 2. Lynx track deposition and retention statistics for different sample areas, vegetation cover classifications (VCCs), and time periods in Southcentral and Interior Alaska. Tracks/km were counted in snow along ground transects.

Area & VCC	Mo/Yr	Trans. Length (km)	Deposition						Retention						
				Daily[b]		Cumulative[c]				Cumulative[d]			Adj. for DAS[e]		
			DAS[a]	Mean	(SD)	Rate	(SE)	r^2	DAS	Rate	(SE)	r^2	Rate	(SE)	r^2
KNRC[f]															
1985 Burn	3/93	14.9	2-7	0.07	(0.00)	0.00	(0.00)	0.00	2-7	0.00	(0.00)	0.00	0.00	(0.00)	0.00
1966 Burn	3/93	11.0	2-7	0.36	(0.17)	0.31	(0.03)	0.96	2-7	0.65	(0.11)	0.65	-0.05	(0.01)	0.85
Mature Forest	3/93	17.0	2-7	0.06	(0.00)	0.00	(0.00)	0.00	2-7	0.00	(0.00)	0.00	-0.01	(0.00)	0.14
TNWR[g]															
Stuver Cr.	2/92	25.6	4-43	0.26	(0.23)	0.26	(0.01)	0.96							
	4/92	25.6	1-8	0.47	(0.19)	0.50	(0.02)	0.99							
	3/93	86.4	1-9	0.18	(0.08)	0.17	(0.01)	0.98	1-9	0.09	(0.01)	0.90	-0.01	(0.00)	0.74

[a] Days after snowfall.

[b] Daily deposition of tracks (tracks/km).

[c-e] Rates of increase and coefficients of determination (r^2) of tracks deposited over all DAS (tracks/km), of track counts adjusted for days after snowfall, i.e. tracks/km×DAS, and of tracks retained over all DAS (tracks/km), respectively.

[f] Vegetation in Koyukuk/Nowitna Refuge Complex (KNRC) was sampled among forests of 3 seral stages: 1985 burn = tall shrub/sapling stage, 1966 burn = dense tree stage, and mature forest stage. The 1966 burn was not sampled in 1992. Data were provided by cooperators Johnson and Paragi (1993) and Johnson et al. (1994).

[g] Data were provided by cooperator T. Doyle at the Tetlin National Wildlife Refuge (TNWR) in eastern Interior Alaska near Tok. The Stuver Creek area is characterized by mixed forest of moderate to dense cover. Data shown for 2/92 represents track counts collected during 19 February-1 April 1992.

Table 3. Snowshoe hare track deposition and retention statistics for different sample areas, vegetation cover classifications (VCCs), and time periods in Southcentral and Interior Alaska. Tracks/km were counted in snow along ground transects.

			Deposition						Retention						
				Daily[b]		Cumulative[c]				Cumulative[d]			Adj. for DAS[e]		
Area & VCC	Mo/Yr	Trans. Length (km)	DAS[a]	Mean	(SD)	Rate	(SE)	r^2	DAS	Rate	(SE)	r^2	Rate	(SE)	r^2
KLT[f]															
Light	2/92	1.6	1-5	0.13	(0.25)	0.19	(0.06)	0.75	6-10	0.19	(0.46)	0.05	0.01	(0.06)	0.01
	4/92	1.6	1-4	0.00	(0.00)	0.00	(0.00)	0.00	1-4	0.00	(0.00)	0.00	0.00	(0.00)	0.00
Moderate	2/92	7.7	1-5	2.68	(0.51)	2.51	(0.14)	0.99	6-10	0.91	(0.17)	0.91	-0.09	(0.02)	0.86
	4/92	7.7	1-4	1.89	(0.97)	2.08	(0.34)	0.95	1-4	2.27	(0.54)	0.90	0.22	(0.30)	0.21
Dense	2/92	4.5	1-5	5.13	(1.84)	4.96	(0.61)	0.96	6-10	2.35	(0.59)	0.84	-0.05	(0.08)	0.12
	4/92	4.5	1-4	2.46	(0.82)	2.66	(0.32)	0.97	1-4	2.12	(0.13)	0.99	0.02	(0.07)	0.02
Closed	2/92	5.1	1-5	7.23	(1.12)	7.58	(0.25)	1.00	6-10	6.29	(0.83)	0.95	0.33	(0.14)	0.66
	4/92	5.1	1-4	2.93	(1.02)	3.11	(0.38)	0.97	1-4	2.44	(0.77)	0.83	-0.66	(0.31)	0.02
All VCCs	2/92	21.1	1-5	3.83	(0.62)	4.00	(0.00)	0.99	6-10	2.37	(0.36)	0.94	0.04	(0.05)	0.12
	4/92	21.1	1-4	1.92	(0.76)	2.07	(0.28)	0.96	1-4	1.86	(0.31)	0.95	0.06	(0.18)	0.06
1st 7 km of	2/92	7.0	1-5	6.63	(1.25)	6.76	(0.35)	0.99	6-10	5.27	(0.88)	0.92	0.24	(0.15)	0.46
Transect	4/92	7.0	1-4	2.53	(1.14)	2.41	(0.34)	0.96	1-4	2.06	(0.68)	0.82	0.01	(0.30)	0.00
	3/94	7.0	1-5	1.06	(0.59)	0.93	(0.14)	0.94	1-5	0.96	(0.22)	0.87	-0.05	(0.10)	0.07
KNRC[g]															
1985 Burn	3/93	14.9	2-7	0.23	(0.03)	0.23	(0.01)	1.00	2-7	0.09	(0.02)	0.89	0.02	(0.00)	0.76
	1/94	14.9[h]	1-5	0.44	(0.56)	0.60	(0.10)	0.92	1-5	1.38	(0.22)	0.93	0.29	(0.06)	0.87
1966 Burn	3/93	11.0	2-7	1.14	(0.41)	0.95	(0.06)	0.98	2-7	0.60	(0.16)	0.78	-0.03	(0.03)	0.15
	1/94	8.8	1-5	0.57	(0.21)	0.56	(0.06)	0.97	1-5	0.46	(0.06)	0.95	-0.03	(0.03)	0.30
Mature	3/93	17.0	2-7	0.32	(0.18)	0.35	(0.03)	0.98	2-7	0.32	(0.05)	0.92	0.04	(0.01)	0.71
Forest	1/94	8.2	1-5	0.32	(0.33)	0.36	(0.08)	0.86	1-5	0.83	(0.19)	0.86	0.15	(0.04)	0.83
WRST[i]	2/92	15.5	1-5	40.43	(14.73)	40.0	(4.44)	0.96							

[a] Days after snowfall.

[b] Daily deposition of tracks (tracks/km).

[c-e] Rates of increase and coefficients of determination (r^2) of tracks deposited over all DAS (tracks/km), of track counts adjusted for days after snowfall, i.e. tracks/km×DAS, and of tracks retained over all DAS (tracks/km), respectively.

[f] Vegetation along the Klutina Lake trail transect (KLT) was primarily coniferous forest that was classified into 5 vegetation cover classes (VCC): bare = 0%, light = 1-25%, moderate = 26-50%, dense = 51-75%, and closed = 76-100%. No tracks were counted in the bare VCC so that category was not included in this summary. Vegetation cover was reclassified in 1994 into 4 VCCs: scarce = 0-9%, light = 10-24%, moderate = 25-59%, and dense = 60-100% cover.

[g] Vegetation in Koyukuk/Nowitna Refuge Complex (KNRC) was sampled among forests of 3 seral stages: 1985 burn = tall shrub/sapling stage, 1966 burn = dense tree stage, and mature forest stage. The 1966 burn was not sampled in 1992. Data were provided by cooperators Johnson and Paragi (1993) and Johnson et al. (1994).

[h] Transect length on 25 January 1994 was only 8.5 km due to snowmachine breakdown.

[i] Unpublished data provided by cooperator W. Route of Wrangell-St. Elias National Park and Preserve (WRST). It is characterized by predominately mixed forest of moderate VCC.

Table 4. Percentages and ratios (*n*) of sex and age class of marten carcasses purchased from trappers during the 1991-92 trapping season in Game Management Units (GMU) 11 and 13 in Southcentral Alaska.

GMU	Sex				Age				Sex and Age Class							
	Male		Female	*n*	Adult		Juv.[a]	*n*	Adult Male		Adult Female		Juv. Male		Juv. Female	*n*
11	63		37	359	73		27	356	49		25		14		11	354
	170	:	100		100	:	37		196	:	100	:	57	:	44	
13	62		38	340	73		27	327	47		27		15		11	325
	164	:	100		100	:	37		174	:	100	:	56	:	41	
Total	60		40	843	73		27	825	46		27		14		12	819
	150	:	100		100	:	37		170	:	100	:	52	:	44	

[a] <1.5 years old.

Table 5. Percentages and ratios (*n*) of sex and age class of lynx carcasses purchased from trappers during the 1991-92 trapping season in Game Management Units (GMU) 11 and 13 in Southcentral Alaska.

GMU	Sex				Age				Sex and Age Class							
	Male		Female	*n*	Adult		Kit.[a]	*n*	Adult Male		Adult Female		Kit. Male		Kit. Female	*n*
11	51		49	55	91		9	55	51		40		0		9	55
	104	:	100		100	:	10		128	:	100	:	0	:	22	
13	60		40	10	100		0	10	60		40		0		0	10
	150	:	100		100	:	0		150	:	100	:	0	:	0	
Total	56		44	144	90		10	146	52		38		3		6	143
	127	:	100		100	:	11		137	:	100	:	8	:	16	

[a] < 1.5 years old.

APPENDIX A. Cooperating investigators and their projects.

1. Buddy Johnson and Thomas Paragi, Koyukuk-Nowitna Refuge Complex; Relationships of wildfire to lynx and marten populations and habitat in Interior Alaska.

2. William Route, Wrangell-St. Elias National Park and Preserve; Development of techniques to monitor furbearer populations in Wrangell-St. Elias National Park and Preserve.

3. Terry Doyle and Craig Perham, Tetlin National Wildlife Refuge; Mortality factors, home range characteristics, and habitat preferences of lynx in Game Management Unit 12.

APPENDIX B. Standardized procedures recommended for monitoring furbearer tracks along ground transects in winter.

The following procedures were designed to enhance the collection of track data for marten, lynx, and snowshoe hares along ground transects in a variety of habitat types.

1. Survey Areas

   Areas should have easy access by snow machine or snowshoe, and, if possible, they should contain a variety of vegetation cover and composition (VCC) types.

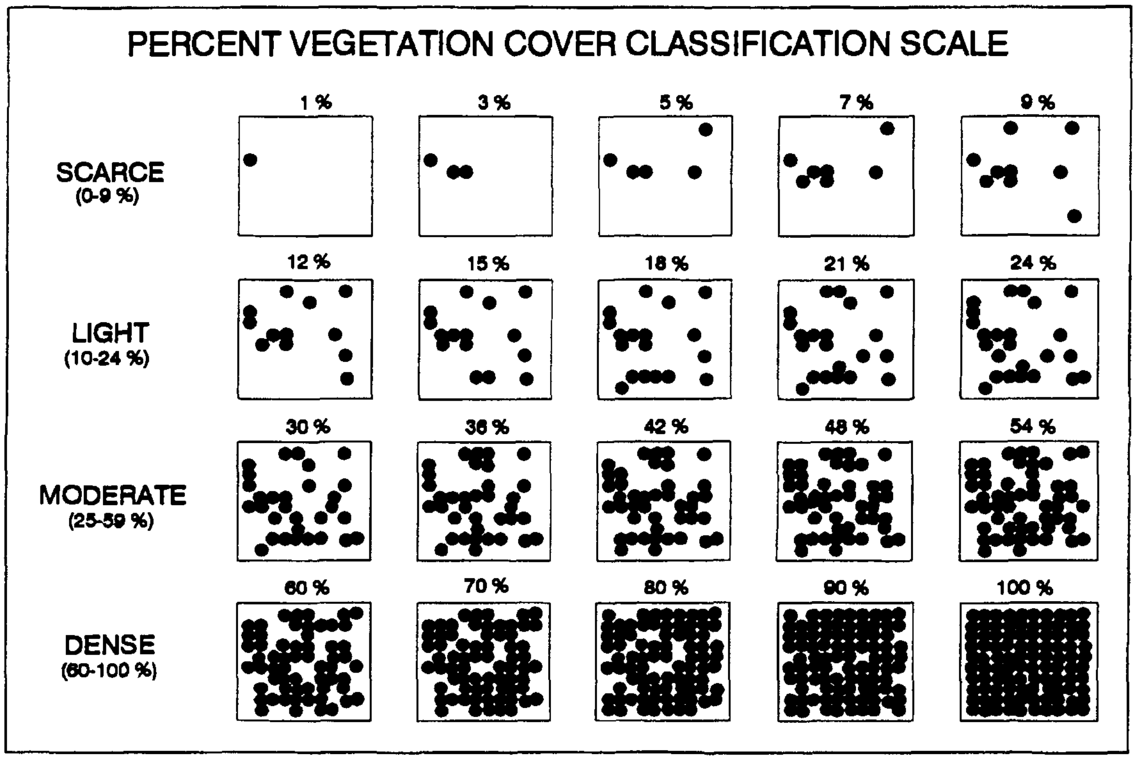
2. Vegetation Cover and Composition

   I recommend a standardized approach for classifying VCCs to enable comparisons of track data among different studies. Classifications modified from Viereck, et al. (1992) should be made for trees and tall shrubs in winter, once snow depth is sufficient to cover low shrubs and grasses.

Cover -	SCARCE: 0-9% cover; LIGHT: 10-24% cover; MODERATE: 25-59% cover; and DENSE: 60-100% cover.
Composition -	CONIFER: ≥ 75% needleleaf; DECIDUOUS: ≥ 75% broadleaf; and MIXED: needleleaf or broadleaf = 25-75%; document major species in order of canopy dominance for future analysis.
Example -	M-M-Pima, Bepa, Sasp = Moderate-Mixed-black spruce, birch, willow (spp.).

- Prior to track counts, conduct vegetation classifications from the air after leaf-fall and when there is enough snow to cover small shrubs and grasses. It is necessary to classify VCCs at this time because tracks will be counted in the winter when vegetation will look substantially different than during other seasons. The scale of percent VCC shown below may be used as a visual guide.

- It will facilitate classification to mark each VCC along a transect on a map or aerial photo and then to measure the length of that VCC. A global positioning system (GPS) receiver may be used in place of mapping VCCs by hand. Use of a GPS receiver or an observer in an aircraft in radio communication will also facilitate marking VCCs on the ground. A GPS has the added benefit of quick incorporation of VCC data into a GIS database. Lump vegetation types less than 0.5 km of a transect's length into 1 VCC.



3. Selection of Transects

- The transects used can vary from one long line that includes many VCCs to several lines with each one or a few lying within different VCCs. Measurements of variability will be improved with the latter but such a configuration may not be possible in all areas. Minimum transect length should be approximately 1 km for marten and lynx and 100 m for hares. Select transects so that all may be surveyed in 1 day.

4. Track Counts

Timing

- Conduct track counts at least twice during periods of 5 to 10 days duration after snow conditions become favorable.

- Begin counts 12-24 hours after snowfall or as soon as possible thereafter. For best results, count tracks after a fresh snowfall of ≥ 5 cm when possible, or count with 2-3 cm of new snow as long as tracks deposited before and after the fresh snowfall will not be confused.

- If there has not been a new snowfall for some time or tracks cannot be counted soon after a snowfall, erase all old tracks from both sides of each transect the day before counting tracks.

Track Deposition

- Count daily deposition of tracks on one side of a transect only.

- Erase each track after it is counted.

- Tally counts within each VCC along a transect or for the entire length of a transect if it is within 1 VCC.

Track Retention

- Count cumulative retention of tracks on the opposite side of the transect that deposition was counted. Track retention may be counted simultaneously with deposition counts or on the return trip along the transect.

- Leave all tracks intact after counting for the duration of the count period.

- Count individual hare tracks until they become indistinguishable (3-4+ tracks) and then count them as a trail; keep separate tallies of tracks and trails. If hare densities are high, it may be necessary to count their tracks along a smaller portion of a transect.

- Continue to count individual tracks until they become too difficult to decipher after degradation by wind, sublimation, or other causes.

- Tally counts within each VCC along a transect or for the entire length of a transect if it is within 1 VCC.

Additional Measurements

- Measure snow depth and depth of new tracks for each species every 0.5 km along a transect within a VCC at the beginning and end of each survey period, unless the survey period is ended by a fresh snowfall. If a survey period extends beyond 5 days, try to collect snow measurements every fifth day.

- Record ambient temperature highs and lows and wind speed and duration for each survey day.

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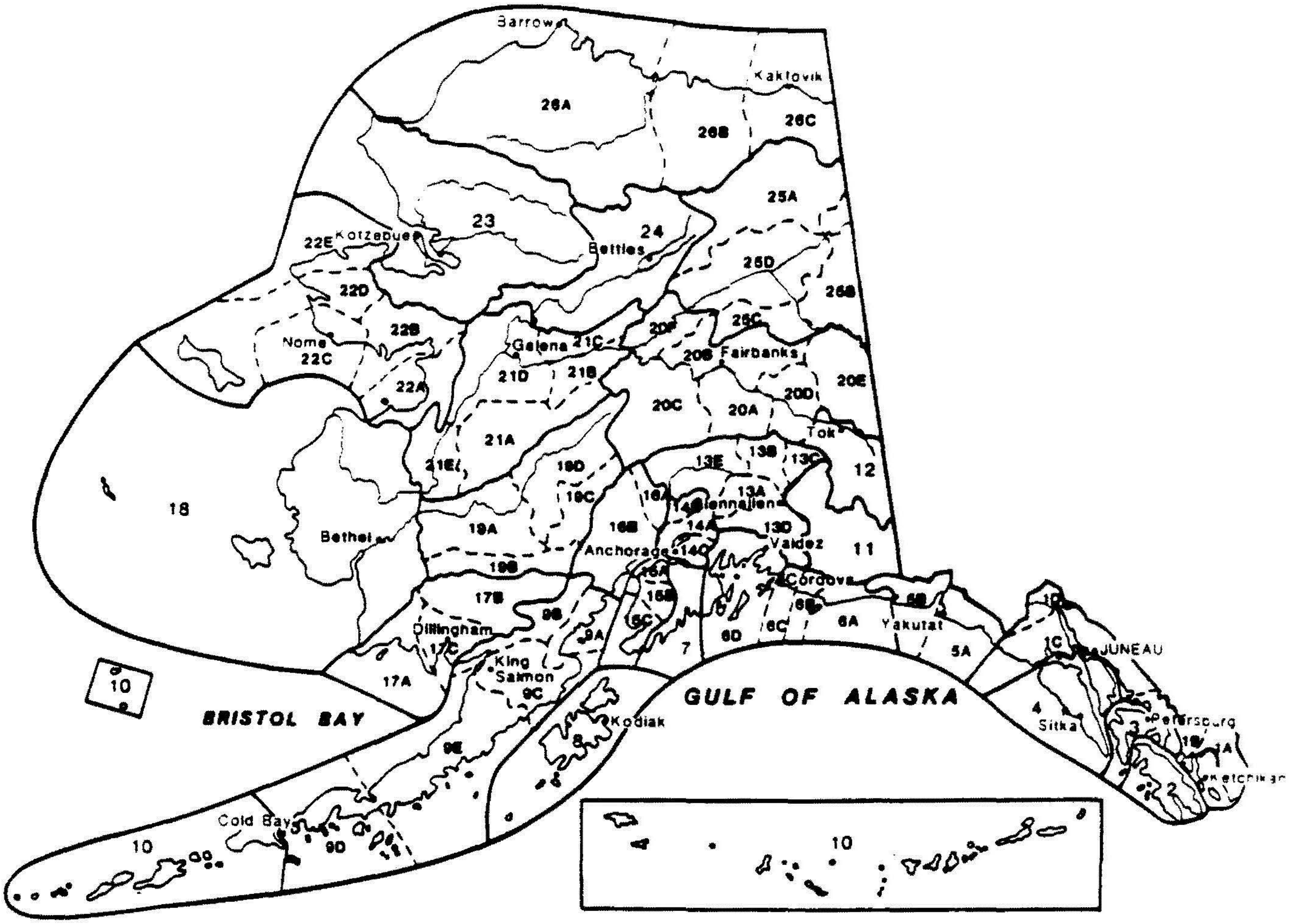
Alaska's Game Management Units



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.

LEONARD LEE RUE

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