SURVEY OF FURBEARER POPULATIONS ON THE YUKON FLATS NATIONAL WILDLIFE REFUGE

FINAL REPORT

Cooperative Agreement Project Number 14-16-007-84-7416
Key Words: furbearers, survey techniques, trapping, habitat, interior Alaska, Yukon Flats National Wildlife Refuge

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ABSTRACT

A 2-year study was conducted from November 1984 to September 1986 to determine the distribution and relative abundance of red foxes (*Vulpes vulpes*), marten (*Martes americana*), lynx (*Lynx canadensis*), and snowshoe hares (*Lepus americanus*) on the Yukon Flats National Wildlife Refuge (YFNWR) in interior Alaska. An aerial survey technique was developed, tested, and used to count furbearer tracks in snow during late winter-early spring. Surveys were conducted along 343, 5-km transects spaced systematically across the 34,925-km^2 refuge. All transects were flown in 125 hours using Super Cub aircraft and the same observer. Correction factors were developed to account for bias in track-density indices due to differential sightability of tracks in 4 vegetation cover classes (VCC) and due to track accumulation over a variable number of days after snowfall (DAS). Sightability of tracks from the air was tested against ground counts for closed, open, woodland, and bare VCCs. Corrections for track counts of each species were derived from the sightability of carnivore and hare tracks per VCC and the percentage of each VCC length along a transect. Track accumulation differences among transects were corrected by relating DAS for each transect to 1 DAS. Corrected track densities per species were compared between transects (1) across the entire refuge, (2) in elevation strata (lowlands, benches, and hills), and (3) in 2 burned areas (Lone Mountain burn ca. 1979 and Little Black River burn ca. 1950). Relative abundance indices of tracks/km ranged from 0.0 to 1.96 for red foxes, 0.0 to 3.78 for marten, 0.0 to 0.64 for lynx, and 0.0 to 13.94 for snowshoe hares. Red foxes largely used the central lake flats of the YFNWR. Important habitat for marten seemed to be mature coniferous and coniferous-deciduous-mixed forests and the Lone Mountain burn. Lynx were most concentrated in mid-successional forests where the habitat was diverse and hare tracks were most plentiful. The Lone Mountain burn was further analyzed as a test-case for a potential approach to determine furbearer relative abundance in specific areas and at different times. Trapper harvests, use patterns, and observations of furbearers during the 1984-85 trapping season indicated that lynx numbers were near a cyclic low, and that marten were the staple catch with lynx as an important supplement due to its high pelt price. Continued development of monitoring techniques for furbearers and analysis of the status, habitat relationships, and human use of their populations are recommended.

CONTENTS

INTRODUCTION

Furbearers have ecological and economic importance on the Yukon Flats in interior Alaska, but documentation of population status is scant. Most information is derived from pelt-sealing records on harvests of lynx (Lynx canadensis), land otters (Lutra canadensis), wolverines (Gulo gulo), wolves (Canis lupus), and beavers (Castor canadensis) (Nowlin 1986a,b). Questionnaire responses from trappers in interior Alaska (Ernest 1986) provide the few records available for species such as marten (Martes americana) and red fox (Vulpes vulpes) that are not sealed. The most comprehensive review of populations in this region was done by Koontz (1968) for the proposed Rampart Dam impoundment area. Except for beavers, however, he estimated furbearer densities based only on extrapolation from available literature. Koontz stated that generally poor pelt prices resulted in low to moderate interest in fur trapping by people in the impoundment area in the early 1960's. During the 1970's, changes in the fur fashion industry and, for lynx, the tenuous status of spotted cats worldwide have made furbearers more valuable and more desirable to trappers in interior Alaska.

Since the Yukon Flats National Wildlife Refuge (YFNWR) was established in 1980, the U.S. Fish and Wildlife Service (USFWS) has been interested in determining the current status of red foxes, marten, and lynx on the refuge. The Alaska Department of Fish and Game (ADF&G) also has an interest in the status of furbearer populations statewide. To meet these mutual concerns and to further develop management strategies, the ADF&G cooperated with the USFWS to design methodology and to conduct a survey of furbearer population levels on the YFNWR. A 2-year investigation was established to address those needs, and the project began in November 1984 after a 5-month feasibility study.

Specific objectives of the investigation were as follows:

(1) to determine the distribution and relative abundance of red fox, marten, and lynx populations for the entire YFNWR and also for elevation strata and 2 burned areas within the refuge;

(2) to develop an aerial survey technique for furbearers that would be precise, efficient, and repeatable; allow extensive and expedient coverage of the entire refuge; sample several species simultaneously; and minimize sources of bias in track counts.

Snowshoe hare (Lepus americanus) populations were also studied because of their importance as prey for lynx. Observations of wolves, wolverines, and land otters were also recorded. Trapper harvests, use patterns, and observations of furbearers were recorded to initiate the assessment of trapping impacts on populations and to determine the trappers' perspectives on furbearer numbers and trends.

Acknowledgments

Funding for this cooperative agreement project (No. 14-16-007-84-7416) was provided by the USFWS. L. S. McLean and L. Swenson, YFNWR, and W. Regelin, R. Bishop, and H. Melchior, ADF&G, were instrumental in formulating and establishing this study. I am especially thankful to McLean and Regelin who generously gave their advice and support from my volunteer days through project fruition. I appreciate the help of R. Stephenson, ADG&F, who gave advice on the study design and shared his wide knowledge of furbearer ecology. The pilots were all vital components of the project, and I thank L. Peet, S. Hamilton, A. Dresselhaus, D. Miller, and especially K. Sibbitt and W. Lentsch. I was fortunate to have P. Hessing as my field assistant, whose good eyes, survey skills, and suggestions for improving survey methods and testing were much appreciated. Logistic support was aided by R. Nowlin and W. Heimer, through loans of snow machines and other equipment, and by J. Kerns and a U.S. Army helicopter crew, through an airlift of that equipment back to town just before breakup. I thank D. Reed for his substantial help in study design and data analysis and for striving to keep the vagaries of thought on course. I also thank J. Venable for his help in rapidly processing a small mountain of data, L. Nordstrom and R. O'Connor for their help with graphics, and L. McManus for typing the tables and the final draft of this report. I greatly appreciate the

comments and suggestions of those who reviewed this paper: W. Regelin, D. Reed, R. Stephenson, R. O'Connor, and D. Golden. I give special thanks to my wife, Debbie, for her interest, support, and encouragement throughout this project.

STUDY AREA

The YFNWR is located in interior Alaska (Fig. 1) and is bisected by the Arctic Circle. Its southern boundary is approximately 112 km north of Fairbanks, and the refuge extends eastward from the Trans-Alaska Pipeline Utility Corridor to within 48 km of the U.S.-Canada border and northward from the northern divide of the White Mountains to the southern foothills of the Brooks Range. Venetie Indian Reservation is the northcentral border and Arctic National Wildlife Refuge, Bureau of Land Management, and State of Alaska lands form the remaining borders. The refuge is approximately 34,925 km^2 in size, and its boundary encompasses roughly 10,927 km^2 of private lands excluded from USFWS jurisdiction and this study. These lands are mainly village and regional Native corporation property surrounding Stevens Village, Beaver, Birch Creek, Fort Yukon, Chalkyitsik, and Circle. The YFNWR is essentially a roadless wilderness with access restricted to travel by air, winter trails, and the river system.

The refuge is dissected by the Yukon and Porcupine Rivers, which meander though the middle of the poorly drained terrain in a generally southwest direction. These rivers, their numerous tributaries, and more than 36,000 lakes and ponds (USFWS, in press) make the Yukon Flats one of the largest wetland communities in Alaska. Elevation ranges from 95 to 1,804 m, averaging about 180 m. The large basin drainages in the central part of the refuge are roughly surrounded by higher bench areas and low hills. The highest hills are in the northwest corner, along the southern edge, and near the eastern boundary of the refuge. With the exception of these limited areas, the YFNWR is characterized by little topographic relief.

The Yukon Flats is an arid, subarctic environment typified by long, cold winters and short, warm summers with great extremes in temperature and

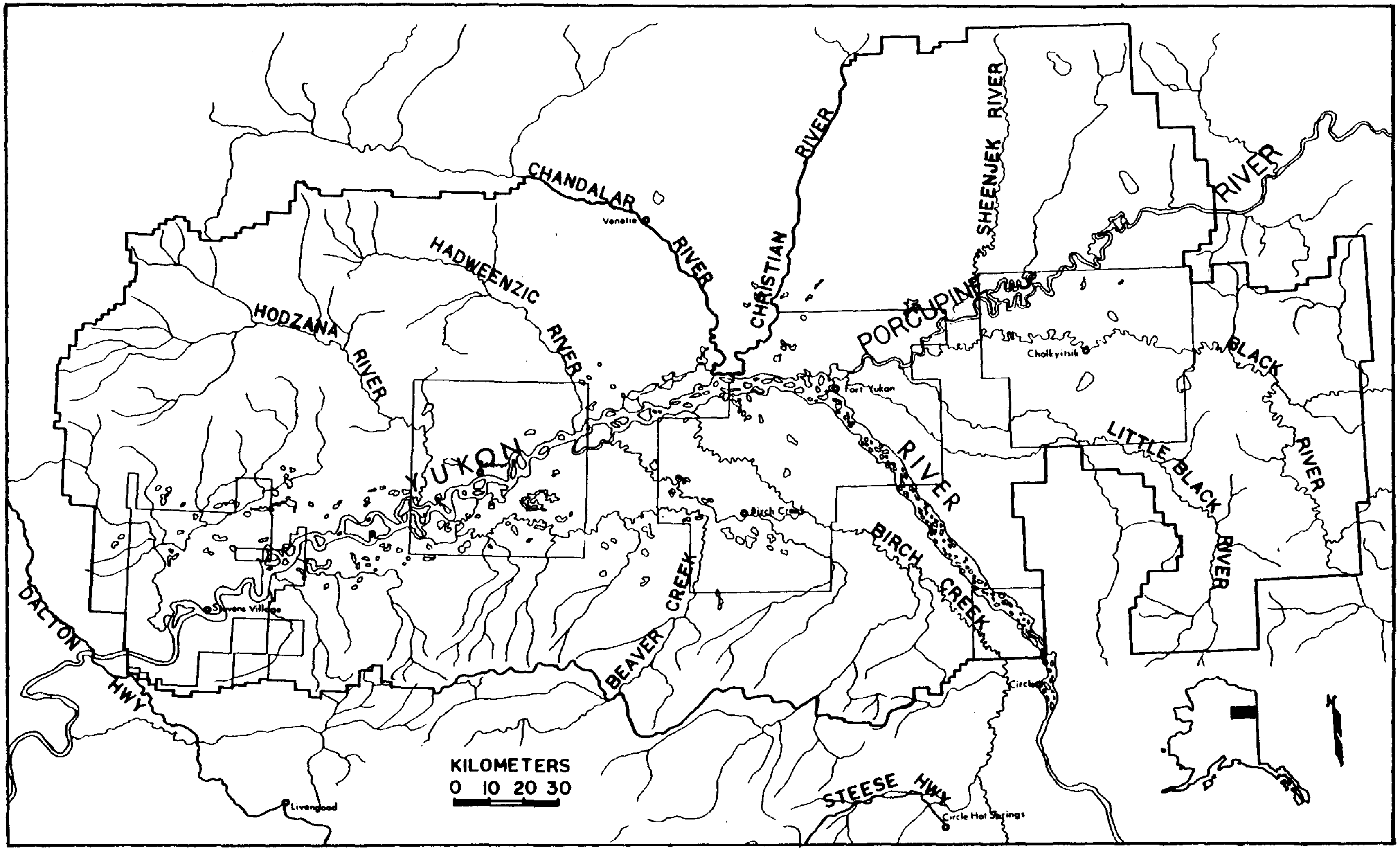

Fig. 1. Yukon Flats National Wildlife Refuge, Alaska (dark borders) and private inholdings (light) borders.

daylight (USFWS, in press). Temperatures in this continental climate have been recorded as low as -59C and as high as 38C in Fort Yukon. The same basin effect which allows summer temperatures to reach high levels also creates strong and very cold temperature inversions in winter. Continuous daylight lasts about 3 months in summer, and for a few days near winter solstice the sun remains below the horizon. The short growing season receives most of the annual precipitation, which averages only about 30 cm, in the form of scattered showers. Snowfall is normally light and accumulations are seldom more than 1 m on level ground or more than 2 m in drifts. Snow is dry and powdery because of extreme winter cold. Freezeup begins in early October and snow and ice usually persist until breakup is over in mid-May. Flooding of low areas during breakup is a major source of water for lakes and ponds (USFWS, in press). Soil moisture is high because of the long winters and widespread permafrost and contributes to the lush vegetation of the region.

Vegetation is typical of the northern boreal forest or taiga (Viereck and Little 1972). White spruce (Picea glauca), black spruce (Picea mariana), paper birch (Betula papyrifera), quaking aspen (Populus tremuloides), and balsam poplar (Populus balsamifera) are the dominant forest species. Willow (Salix spp.), alder (Alnus spp.), and ericaceous shrubs form most of the understory vegetation. The extensive open, wet meadows and bogs prevalent in lowland areas contain grasses (Calamagrostis spp.), sedges (Carex spp.), and other herbaceous species.

Although vegetation types and patterns are only generally known on the YFNWR, they are largely determined by the occurrence of wildfire. Recurring fires, with a rotation time of 50 to 100 years in interior Alaska (Viereck 1983), create mosaics of pure and mixed plant communities that result in diverse habitat for wildlife (Foote 1983). The frequent occurrence of fires over large areas of the refuge has an influence on the distribution of furbearers. Wildfires have been suggested to have a positive influence on red fox, marten, and lynx populations (Koehler and Hornocker 1977, Fox 1978, Viereck and Schandelmeier 1980, Stephenson 1984).

Efforts by man to control wildfire in this century have limited this habitat diversity and permitted forest succession to advance. The total area burned each decade in interior Alaska declined from 502.4 to 201.7 thousand hectares (ha) between the 1940's and 1970's (Foote 1983). Viereck and Schandelmeier (1980) reported that the average area burned annually since the 1950's decreased by 10% per decade due to fire suppression activities. Nevertheless, the entire region, particularly the Porcupine River area, is still highly prone to lightning and human-caused fires (J. Foote, pers. commun.). The adoption of an interagency fire plan for the Upper Yukon-Tanana area in 1984 should restore the beneficial role of wildfire and allow the use of prescribed fires on the Yukon Flats.

Besides red foxes, marten, lynx, wolves, wolverines, and land otters, other carnivorous furbearers found in the region are mink (*Mustela vison*), short-tailed weasels (*Mustela erminea*), and least weasels (*Mustela rixosa*) (Koontz 1968). Although arctic foxes (*Alopex lagopus*) are abundant north of the Brooks Range and coyotes (*Canis latrans*) are present south of the White Mountains, these species are rare in the Yukon Flats. Beavers and muskrats (*Ondatra zibethica*) are ubiquitous across the extensive wetland habitat of the region. Snowshoe hares, red squirrels (*Tamiasciurus hudsonicus*), and microtine rodents, such as red-backed voles (*Clethrionomys rutilus*), meadow voles (*Microtus pennsylvanicus*), tundra voles (*Microtus oeconomous*), yellow-cheeked voles (*Microtus xanthognathus*), and brown lemmings (*Lemmus trimucronatus*) are common, and they serve as important prey species for red foxes, marten, and lynx (McCord and Cardoza 1982, Samuel and Nelson 1982, Strickland et al. 1982). The average 1.1 million ducks and thousands of geese and swans that nest there each summer and the 3 species of grouse and 2 species of ptarmigan present year-round (USFWS, in press) also contribute to the prey base of furbearers.

Most trappers live in one of the local villages but many travel to the area by airplane or snow machine from Fairbanks and the adjacent communities of Central and Livengood. Trapper use patterns are poorly documented because people often move their traplines and there is no organized system of recording them in the region. Trapping is an important source of income, clothing, food, and recreation for people in the Yukon Flats, and it contributes to the largely subsistence-based economy of the region.

METHODS

Background

Information on population levels and the use of reliable methods to monitor the spatial and temporal differences in abundance of furbearers is essential for sound management. Animal abundance may be measured by determining the absolute number or density of a population or by providing an index of the relative abundance of the population. Caughley (1977a) promoted indices of relative abundance as generally more useful and often more precise than estimates of actual abundance. Indices of relative abundance are especially appropriate for furbearer populations except where intensive population research is desired (Clark and Andrews 1982), as in parts of the Soviet Union for sable (Martes zibellina) (Formozov 1965). The solitary, covert, and sometimes wide-ranging nature of most furbearer species makes estimates of actual abundance very difficult to obtain, especially for carnivores. Counts of tracks and other animal signs can provide an accurate index of relative abundance if the sign has an approximately linear relationship to animal numbers (Caughley 1977a).

Track counts are widely used through ground surveys to index the relative abundance of furbearers. Scent stations, which are normally established near roads, are surveyed regularly throughout North America to count tracks of a variety of furbearers (Linhart and Knowlton 1975, Hon 1979, Clark and Andrews 1982, Clark and Campbell 1983, Conner et al. 1983). Counting tracks that cross transects, trails, or roads is also a common method of indexing many furbearer populations across habitat types (Formozov 1965, Pulliainen 1981, Raine 1983, Slough and Jessup 1984, Slough and Slama 1985, Stephenson 1986).

There have been few aerial surveys for furbearers, and they employed small, fixed-wing airplanes or helicopters to count tracks along transects. Legendre et al. (1978) used a helicopter flown along a single, nonlinear 1,368-km transect to count furbearer tracks and index their abundance and habitat use across 7 bioclimatic regions in northwestern Quebec. Hechtel and Follmann (1980) conducted an aerial survey of furbearer tracks by fixed-wing aircraft along a proposed gas pipeline corridor through Alaska from the Canadian border to the Brooks Range. They determined the distribution and relative abundance of black bears (Ursus americanus), grizzly bears (Ursus arctos), wolves, coyotes, and red foxes by flying 4 or 5 linear transects per segment parallel to the corridor, which was divided into 26 segments. Buskirk (1983) also used a helicopter to count marten tracks along approximately 110 km of the Susitna River basin in south-central Alaska. He surveyed 14, 3.6-km linear transects that were oriented perpendicular to the river.

Aerial surveys in the above studies were conducted during autumn, late winter, or spring under favorable snow and light conditions. Stephenson (1986) reported on population estimation techniques for lynx in interior Alaska using ground and aerial surveys. He considered adequate snow depth and consistency and plentiful light as essential for conducting aerial track counts. He further emphasized the importance of vegetation characteristics and the accumulation of tracks following snowfall as factors that may affect the number of tracks counted.

The usefulness of ground surveys is limited by the time involved in sampling a given area and by access. They can be used under a variety of terrain and weather conditions, however, and may provide accurate data on furbearer population trends and habitat use indices. In comparison, aerial surveys must be conducted in areas with sufficient snow cover for good track visibility, and the counts are inevitably less accurate than ground counts, often requiring the use of one or more correction factors for sources of track-count bias. Aerial surveys are also much more expensive than ground surveys. Nevertheless, aerial surveys allow a biologist to quickly sample furbearer populations in large areas with poor access and provide generally adequate indices of relative abundance and habitat use.

Aerial survey was chosen as the most practical method to determine the distribution and relative abundance of red foxes, marten, lynx, and other furbearers on the refuge. I developed procedures for aerial track counts during a feasibility study from January to June 1984. Flights during this feasibility study were made to observe vegetation, terrain, snow, lighting, and weather conditions, and to experiment with aircraft routes, altitudes, and speeds. Flights were made with different pilots but I was always the observer; this allowed flexibility in the team while providing consistency in data collection. PA-18 Super Cubs were chosen as the most suitable and least expensive aircraft to use for surveys. The tandem configuration of this plane also permitted equal visibility on either side of the aircraft for both pilot and observer.

On several flights before surveying the refuge, I practiced identifying red fox, marten, lynx, and other furbearer tracks to learn to identify them from the air. Tracks were defined as a trail of animal footprints in the snow; each track comprised a separate trail of footprints, except when 2 or more trails were superimposed and appeared as 1 track. Tracks were identified to species by a combination of footprint size, stride length, straddle width, and overall travel pattern (Murie 1954, Hechtel and Follmann 1980, Halfpenny and Biesiot 1986, Stephenson 1986). Pilots skilled at aerial tracking and the use of photographs of tracks were helpful, as were frequent ground checks to compare with aerial track identifications.

Twelve linear transects, ranging from 3.2 to 29.6 km, were flown to determine the most practical way to gather data. Estimates of red fox, marten, and lynx track rates (tracks/km) in elevation strata of (1) lake flats and riparian areas, (2) benches, (3) and hills and mountains were derived from the 12 test transects (Table 1). Track-rate estimates indicated there were differences in the relative abundance of tracks between elevation strata for each species, but large sampling variances and wide confidence intervals existed. Valid comparison between areas required that sampling error

Table 1. Uncorrected furbearer tracks/km estimates (T/km)[a], sampling variances $(S_q^2/\bar{x}^2)$[b], and confidence intervals (CI ($\alpha = 0.10$)) for 3 elevation gradients[c] sampled through aerial surveys in spring 1984 on the Yukon Flats National Wildlife Refuge, Alaska.

Strata type	No. tran-sects	Red fox			Marten			Lynx		
		T/km	$S_q^2/\bar{x}^2$	CI	T/km	$S_q^2/\bar{x}^2$	CI	T/km	$S_q^2/\bar{x}^2$	CI
A	3	2.32	1.1203	0.91-3.73	1.10	0.2628	0.42-1.78	0.55	0.0409	0.28-0.82
B	6	0.28	0.0696	0.11-0.45	0.88	0.1675	0.61-1.15	0.28	0.0558	0.12-0.44
C	3	0.52	0.3863	0.31-1.35	1.90	6.1639	-1.41-5.21	0.52	0.3645	-0.29-1.33

[a] T/km = Σ tracks/Σ kilometers.

[b] $S_q^2/\bar{x}^2$ = sampling variance of track rates/squared mean of total kilometers.

[c] Strata types: A = lake flats and riparian areas, B = benches, and C = hills and mountains.

be reduced. Knowledge gained from the feasibility study led to the implementation of survey methods used in this study that were aimed at meeting that requirement.

Aerial Survey Design and Data Analysis

Survey methods were designed to determine if furbearer distribution and relative abundance was uniform across the entire YFNWR and if differences occurred between elevation strata and 2 burned areas at different successional stages. The following assumptions were made: (1) a species' track abundance was approximately proportional to its abundance; (2) species track identifications were largely correct and comparable between transects; (3) transects were flown with accuracy and consistency; (4) snowfall data were accurate across the refuge; and (5) snow conditions, such as depth and compactness, were approximately the same for each transect. Two aerial surveys were flown on the YFNWR: the first was between 14 March and 16 April 1985 to sample the entire refuge and the second was on 7 April 1986 to resample a recently burned area on the west side of the refuge encompassing Lone Mountain.

Furbearer populations were surveyed using aerial counts of tracks intersecting linear transects. Transects were 5 km in length; this provided adequate sample sizes of tracks and enabled the pilot to follow a straight route in all terrain. Transects were preselected systematically by superimposing a 10 x 10 km-scale grid on a 1:250,000-scale topographic map of the entire YFNWR. A topographic feature, recognizable from the air, that was closest to a grid-crossing and within a 2.5-km radius established one end of a transect. Transects were oriented along randomly selected compass directions; thus, the other end of a transect was the nearest topographic feature within a 2.5-km arc on either side of the random direction chosen and 5 km from the first end point. If no recognizable feature occurred within the arc, if the terrain was too rugged, or if the heading brought 2 transects within 2 km of each other, a new random direction was chosen. Transect proximity was restricted to reduce the chances of counting the same animal's track on more than 1 transect. A total of 343 transects was established to survey all parts of the refuge except private lands (Fig. 2), and no transect route was limited to one physiographic type. Each transect was assumed to represent an average area of about 100 km^2 because they were spaced approximately 10 km apart.

The survey period was in late winter-early spring to coincide with the greatest potential for track visibility (Stephenson 1986). Snow cover, light, temperature, and wind were limiting factors for the timing of track counts. Snow had to completely cover the ground for all areas sampled. An attempt was made to survey a minimum of 3 days following a snowfall of >5 cm to ensure adequate track sample sizes per transect; snowfall of <5 cm was found in the feasibility study to cause no interference with the visibility of tracks from the air. Light had to be direct or only slightly obscured by thin clouds, and daylight hours had to be long enough to permit a reasonable work period. Ambient temperatures were also required to be cold enough (<-5 C) to prevent snow from crusting and hindering track impressions, but also warm enough (>-35 C) to avoid possible restriction of aircraft operation or severe inhibition of animal activity (Buskirk 1983, Stephenson 1986). To follow a route accurately, wind speed and turbulence had to be light to moderate (<20 knots). Weather conditions on the YFNWR were frequently monitored during the survey period through National Weather Service data and field observations.

Vegetation and track data were collected as they occurred along a transect. A transect was the flight line represented by the outside edge of the airplane ski. Two passes per transect were required: the first to document vegetation characteristics and the second to record furbearer tracks. The pilot first found one end of a transect, flew the line at about 150 m above ground level (AGL) while I recorded vegetation cover and composition, and then again flew the line at 60-90 m AGL while I recorded tracks. All pilots found the use of visual landmarks, rather than compass directions, the best for maintaining orientation along a transect route. Instead of helping with data collection, pilots concentrated on maintaining a straight

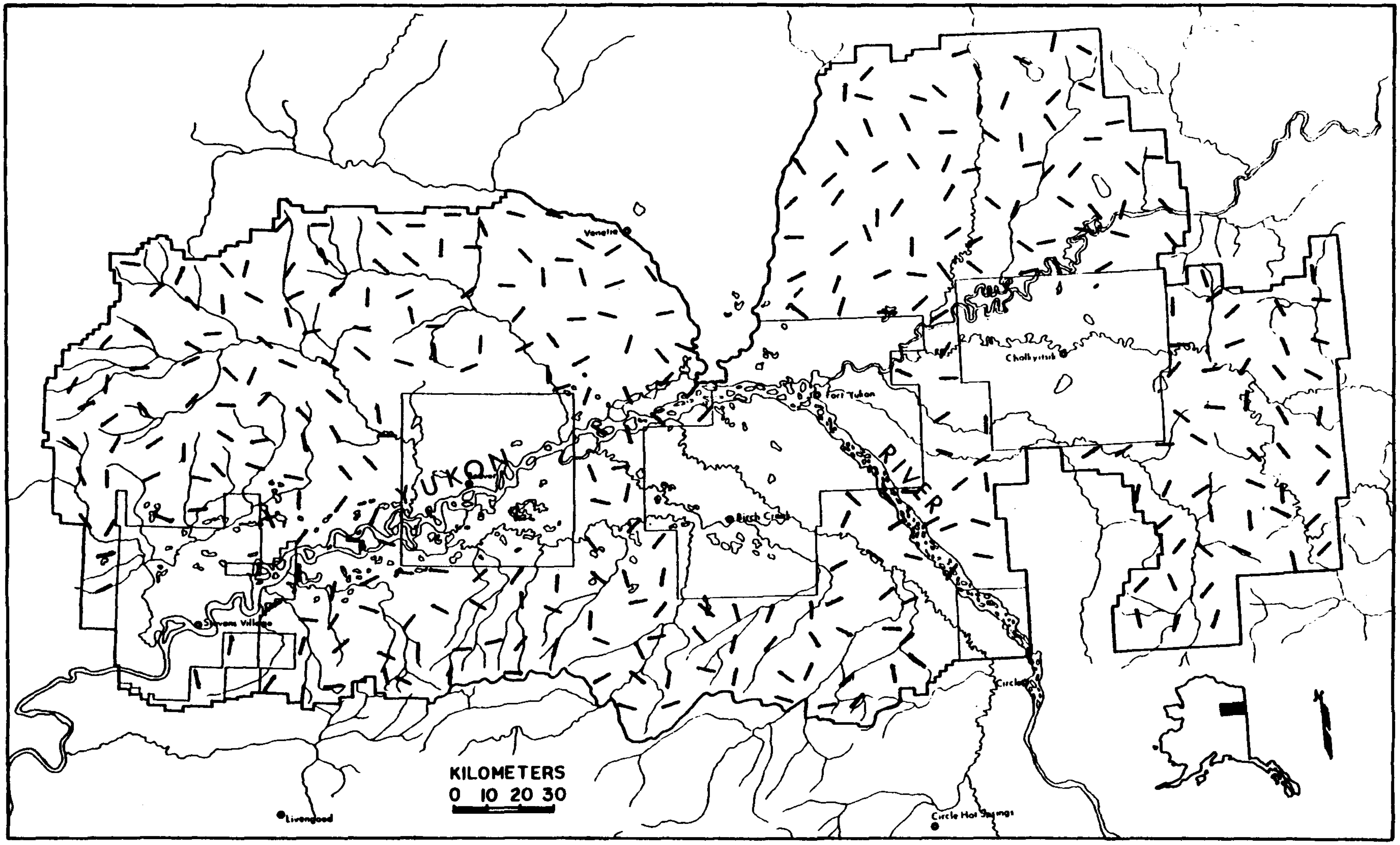

Fig. 2. Aerial transects surveyed for furbearer track counts on the Yukon Flats National Wildlife Refuge, Alaska in late winter-early spring 1985.

route and the proper speed, approximately 60 knots. The combination of altitude AGL and speed flown was consistent with that preferred in other fixed-wing aerial surveys of tracks or animals (LeResche and Rausch 1974, Caughley et al. 1976, Stephenson 1986). Transects were flown in either direction, whichever was most expedient and safe. Along each transect I also recorded snow conditions, weather, and other wildlife.

Vegetation was classified using a system modified from Viereck et al. (1981) for use in winter. Vegetation classes consisted of cover and general composition categories of trees and shrubs (Table 2). Specific composition was recorded for each general type for future reference, but these data were not analyzed for this study. Cover categories were based on estimates of vegetative cover percentage, as seen from the air, after deciduous leaf-fall (Fig. 3). Vegetation class changes were recorded into a tape recorder and their estimated locations were simultaneously marked onto a 1:63,360-scale map (Fig. 4) or 1:60,000-scale color-infrared aerial photo; they were later transcribed to data sheets. The extent of each vegetation class on each transect was measured from data sheets to the nearest 0.01-km using a computer-linked digitizing board. The percentage occurrence of various classes for each 5-km transect was calculated with a computer.

Observations of red fox, marten, lynx, and other furbearer track-intersects were recorded on tape for each transect. Track intersect data were transferred to data sheets and summed by species for each transect surveyed. Sums were then divided by 5 km to derive tracks/km.

Red fox, marten, lynx, and snowshoe hare track densities for each of the 343 transects were mapped and compared to determine their distribution and relative abundance across the YFNWR. Indices of relative abundance were defined as low, medium, and high track-density categories, each representing about one-third of the transects surveyed. This was done because there were no obvious oscillations in the frequencies of transects within the ranges of track density for any species. Comparisons were also made

Table 2. Classification system used in late winter-early spring 1985 to document vegetation along furbearer track transects on the Yukon Flats National Wildlife Refuge, Alaska.

	Composition		Vegetation class = cover x general composition
Cover	General[a]	Specific	
Closed: ≥60%	Conifer	White spruce	Closed conifer
Open: 25-59%	Deciduous	Black spruce	Closed deciduous
Woodland: 1-24%	Mixed	Standing dead spruce	Closed mixed
Bare: 0%		Birch	Open conifer
		Aspen	Open deciduous
		Poplar	Open mixed
		Tall shrub (≥1.5m)	Woodland conifer
		(willow, alder)	Woodland deciduous
		Low shrub (<1.5m)	Woodland mixed
		(willow, alder,	Bare

[a] Included trees and tall shrubs; conifer and deciduous stands were ≥75% pure and mixed stands were <75% pure.

between elevation strata including (1) lowlands (<150 m) comprising lake flats and riparian areas, (2) intermediate bench areas (150-300 m), and (3) hills and mountains (>300 m). Only those transects that lay completely within a particular stratum were included in this analysis. Sample sizes of transects were 111, 82, and 84 for lowlands, benches, and hills, respectively. Comparisons between strata were made for each species by relating the proportion of the transects surveyed in each elevation stratum to the range of track densities observed for those transects.

Track densities were compared between transects lying within 2 burned areas, the Lone Mountain burn and the Little Black River burn (Fig. 5). The Lone Mountain burn of approximately 114,000 ha resulted from a

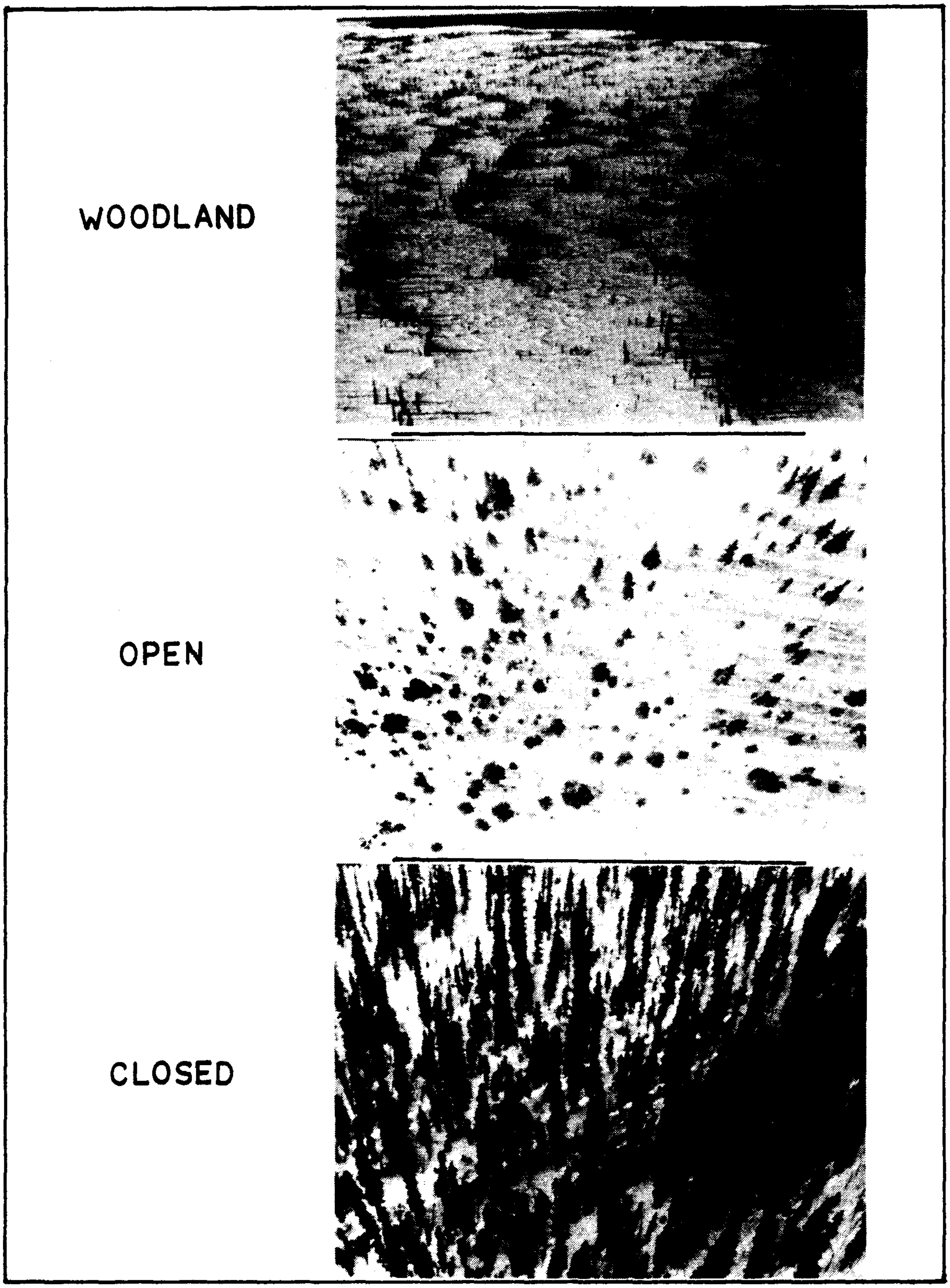

Fig. 3. Examples of woodlands, open, and closed vegetation canopy covers as seen from the air in late winter-early spring on the Yukon Flats National Wildlife Refuge, Alaska.

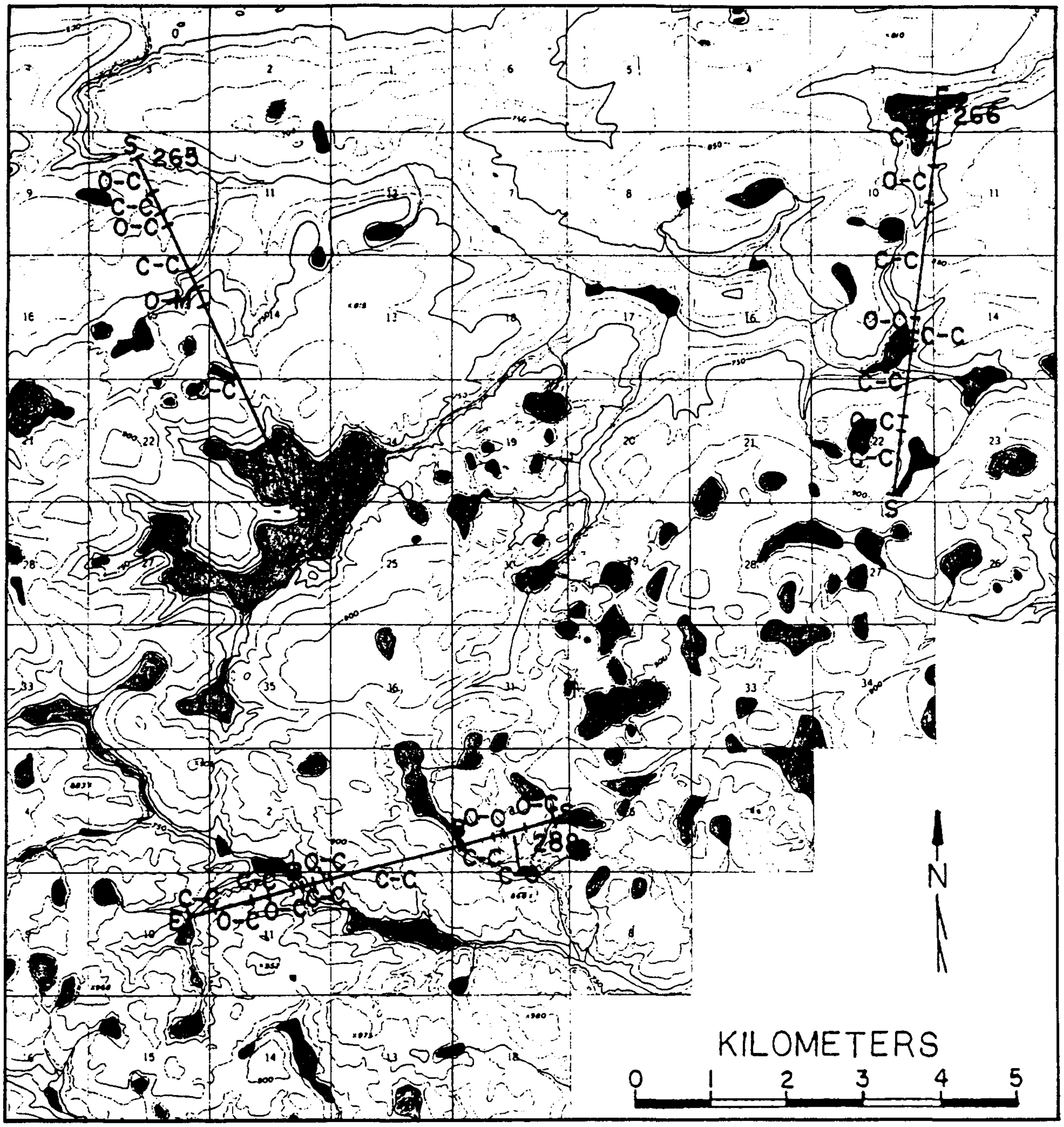

Fig. 4. Example of aerial-survey transects (265, 266, and 288) showing vegetation cover classes on Yukon Flats National Wildlife Refuge, where C-C = closed conifer, O-C = open conifer, O-M = open mixed, B = bare, S = start of transect, and E = end of transect.

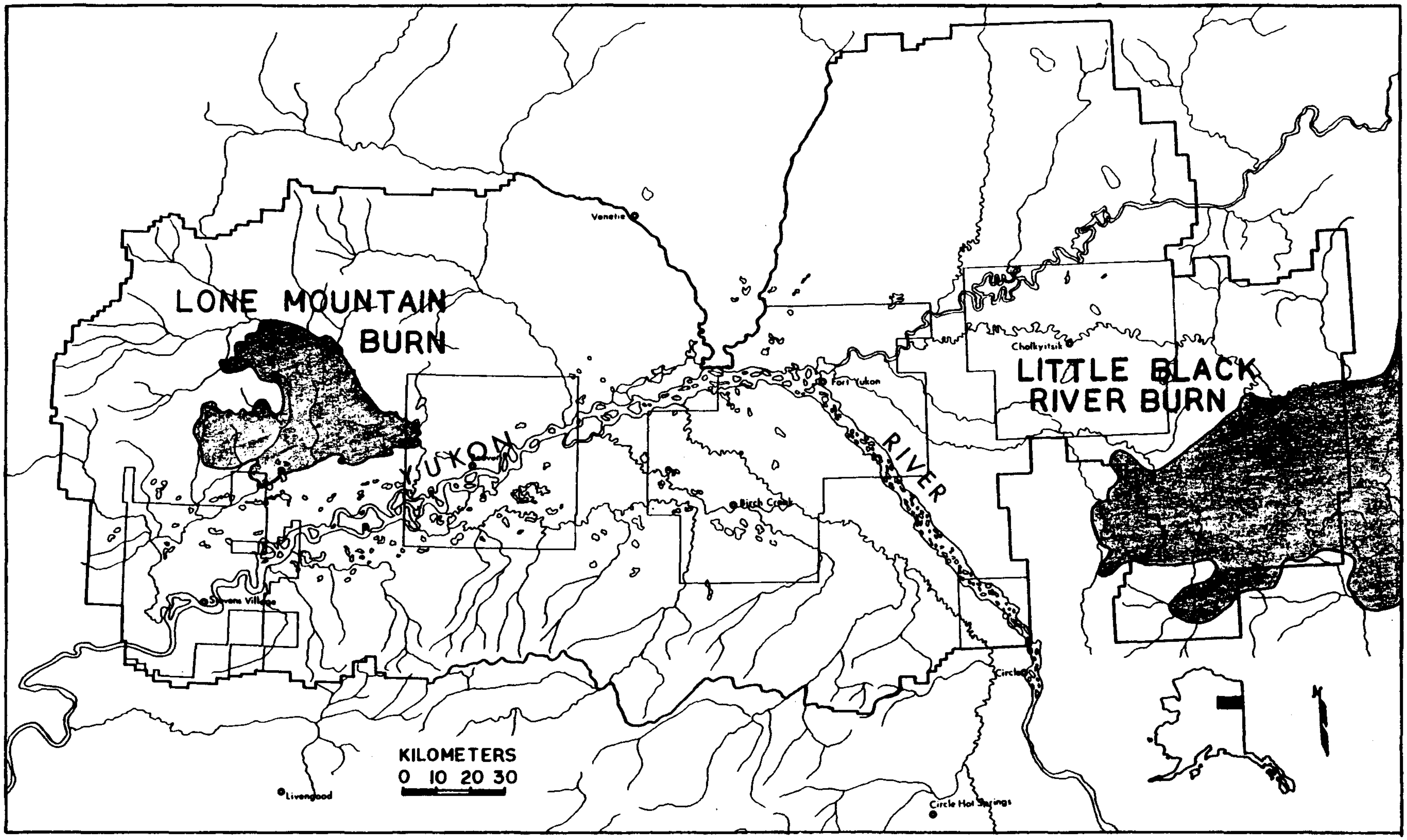

Fig. 5. Lone Mountain burn and Little Black River burn on the Yukon Flats National Wildlife Refuge, Alaska.

26,000-ha fire in 1977 and an 88,000-ha fire in 1979. Vegetation succession is in the moss-herb/tall shrub-sapling stage (Foote 1983), with grasses, fireweed (Epilobium angustifolium), paper birch, quaking aspen, and balsam poplar as the dominant species. The site is littered with fallen trees and contains abundant standing-dead spruce and many inclusions of mature live spruce and deciduous trees. The Little Black River burn resulted from an 829,900-ha fire around 1950. This area is in the dense-tree stage of forest succession (Foote 1983), with mosaics of pure and mixed stands of white spruce, quaking aspen, paper birch, balsam poplar, and willow as the dominant species. Thirteen transects were sampled in the Lone Mountain area and 20 in the Little Black River area in 1985. Comparisons between burned areas were the same as used for the elevation strata.

The Lone Mountain burn was further examined for differences between furbearer track densities inside and outside the burn and between 1985 and 1986. Vegetation outside the burn was similar to that of the Little Black River burn but had more black spruce forest on the north-facing slopes. Tests were conducted on data from 13 transects sampled inside and 14 sampled outside the burn perimeter in 1985 and 1986. Mann-Whitney U tests and Wilcoxon Matched-Pairs tests ($\alpha = 0.10$) were used to measure differences between strata.

Tests of Factors Affecting Track Counts

The problems from variables regarding observers, aircraft, and weather were circumvented prior to aerial sampling (LeResche and Rausch 1974), but vegetation characteristics and track accumulation following snowfall required further tests to determine their effects on track density indices. A study site at Canvasback Lake (Fig. 6), in the center of the YFNWR, was chosen for conducting tests on track sightability and accumulation. The habitat of the area typified the refuge in general, and the nearby winter trails on old, seismic exploration lines and the presence of a cabin owned by the refuge aided logistics. Data were collected from 14 to 24 March and on 4, 5, 7, and 8 April 1986.

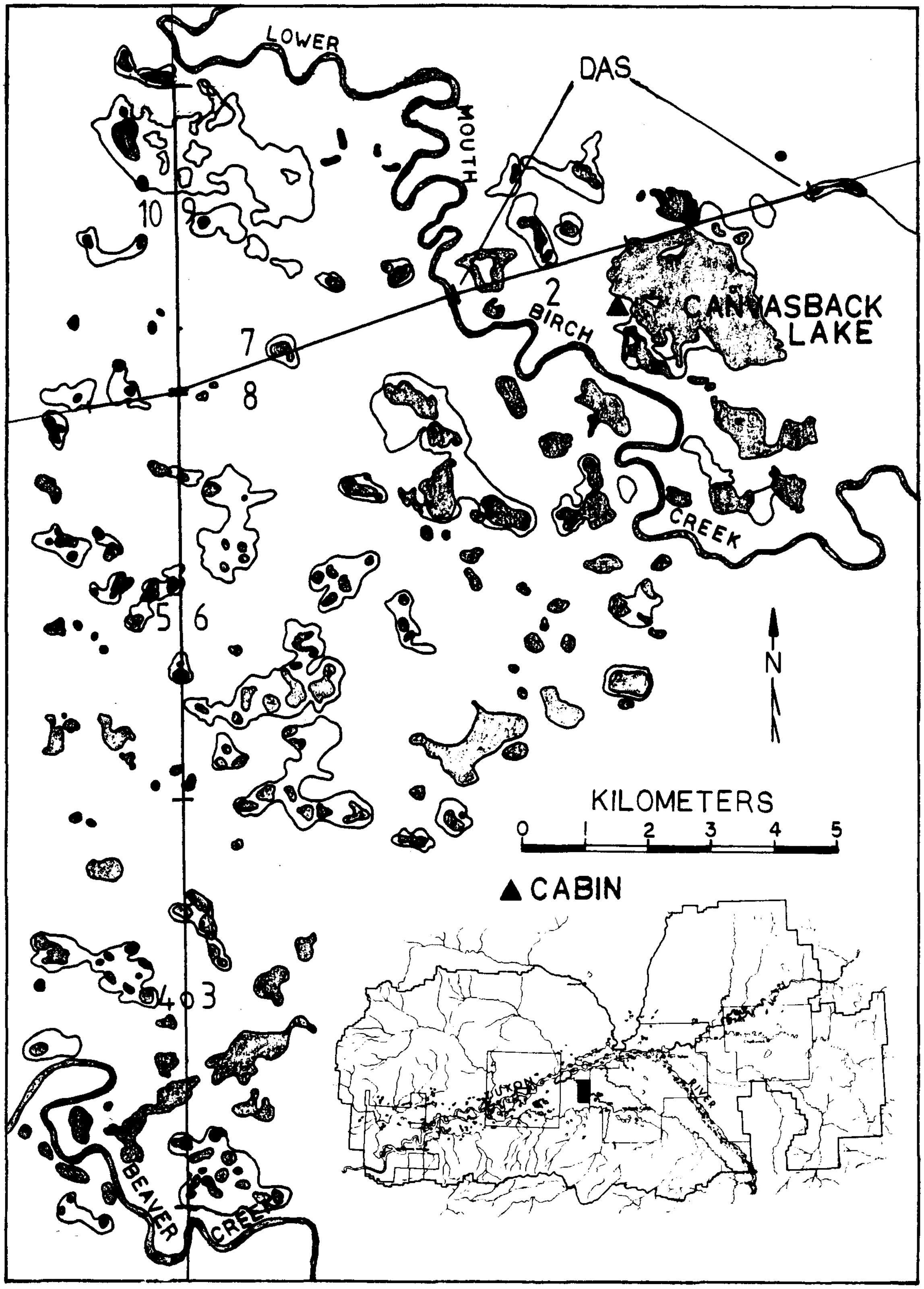

Fig. 6. Canvasback Lake study site and transects which were used for testing track sightability (1-10) and track accumulation (DAS).

Vegetation characteristics were studied because they affect the sightability of tracks from the air. Sightability was defined as the probability that animal tracks along a transect would be seen by the observer. The probability of seeing them from the air depended largely on the vegetation thickness. Track sightability was expected to be best in unvegetated areas and worst in heavily vegetated areas. Tests were conducted to determine the sightability of furbearer tracks from the air within and between vegetation classes.

Sightability was measured along 10 transects that paralleled the seismic trails about 10 m to both sides of the trails (Fig. 6). Transects ranged in length from 2.9 km to 6.5 km and totaled 53.1 km. Vegetation classes were recorded from the air for each transect prior to counting tracks. A Cessna 180 adapted for slow-speed flying was used, with both observers seated on the same side of the plane. Tracks were first counted by each observer for 1 transect and then counted for the corresponding transect on the other side of the seismic trail. Each observer was cued by the other when vegetation classes changed, thereby allowing tracks to be counted for individual classes while flying. Later on the same day, tracks were counted for the same transects from the ground. Observers walked separate transects that were reached by snow machine. Thus, each observer recorded tracks for the same 10 aerial transects but 5 different ground transects. Ground track data were shared between observers based on the assumption that all ground identifications and counts of tracks were accurate. Neither observer was aware of the other's counts until both air and ground transects had been completed.

Track counts were pooled for each vegetation class along a transect to derive tracks/km/class. Sightability was determined from ratios of ground track counts:aerial track counts, where an index value of 1.0 indicated equality. Sightability ratios were tested for carnivores and snowshoe hares as groups and between observers for those groups. It was assumed that track sightability was equal among carnivore species. Levels of significance were determined through t tests ($\alpha = 0.10$).

The number of days after snowfall (of >5 cm) that a transect was flown was recorded because of the accumulation over time of furbearer tracks on the surface of the snow. It was expected that animal activity would also influence these increases; that is, each species would have a different track-accumulation rate relative to its level of activity. Track accumulation over time was gathered for each species to determine if the length of time since snowfall had an effect on the observed number of tracks intersecting a transect.

The eastern half of the east-west seismic trail (Fig. 6) was skied to count the daily accumulation of tracks intersecting each side of the 5.9-km trail. Each observer skied half the trail and recorded tracks seen on both sides. The data were later transcribed from tape recorders and pooled for both observers using the entire 11.8-km trail to derive tracks/km/species.

Documentation of Trapping Harvest

Pelt sealing data for lynx harvested from Game Management Unit 25 (GMU 25), which includes the YFNWR, were compiled from ADF&G records. Harvest data were subdivided by 10 drainages from 1977-78 through 1982-83 and for 1984-85. Data for 1983-84 and prior to 1977-78 were unavailable. Red fox and marten pelts are not sealed, so no harvest data are available for those species.

I interviewed 23 trappers on the Yukon Flats to learn where they trapped and to record their observations on furbearer population levels and trends. Observations by trappers were tabulated for the areas trappers used in 1984-85, and summed qualitatively into high, moderate, or low population levels and with increased, unchanged, or decreased population trends.

RESULTS AND DISCUSSION

Aerial Survey Technique

Survey Effort:

Transects were well distributed across the YFNWR, providing a broad picture of furbearer distribution and relative abundance. Furbearer tracks were sampled over a large area efficiently without restricting a transect to a particular habitat type. Other aerial surveys of furbearers that have been reported were restricted in scope to narrow corridors or single lines of travel (Legendre et al. 1978, Hechtel and Follmann 1980, Buskirk 1983).

The 1985 aerial survey of 343 transects on the YFNWR was completed in 125 hours of flying during 17 days, averaging 20 transects in 7 hours/day or about 3/hour. These average times included ferry time between Fort Yukon or Fairbanks and the areas surveyed daily. Five pilots were used, but only 1 pilot flew the last 13 days of the survey. Survey procedures and data collection seemed unaffected by the use of several pilots. All pilots were skilled at low-level, low-speed flying, and each was able to locate transect starts and remain oriented along the routes. Resurvey of 32 transects in the Lone Mountain burn area was completed in 4 hours, averaging 8 transects per hour. The same routes were located and flown, so it was unnecessary to resample vegetation. These results indicated that aerial survey of the YFNWR would be repeatable using the 343 established transects and that a second survey could be completed with less time and expense.

Flights were possible on only 17 days of the 34-day survey period in 1985. Storms or cloudy conditions delayed the start of work by 2 weeks and caused the cancellation of flights on 16 days of the survey period. Clear weather allowed a period of 11 consecutive days of flying in the middle of the survey. During that period and on other flight days in 1985, skies were clear or lightly overcast, winds were <20 knots, temperatures ranged from -27C to 2C, average snow depth was approximately 1 m, and average depth of drifts was 1.5 m. For the 1986 survey of the Lone Mountain area, temperatures were between -24C and -21C, winds were <5 knots, snow depth averaged 0.30-0.45 m, and drifts averaged 0.45-0.60 m.

Conditions during the late winter-early spring period in 1985 and 1986 were optimal for aerial tracking. The quality and duration of snow cover over the extensive area of the Yukon Flats and the amount of daylight provided good track visibility for a lengthy survey period in 1985. Snow was usually soft enough for track imprints and deep enough to cover low shrubs and grass. Shallow snow depth in 1986 produced an uneven surface over low vegetation, requiring more concentration and tracking experience by the observer, but sightability seemed unimpaired. Average snow depth of 0.30-0.45 m during 1986 surveys was the minimum allowable for effective observations of tracks. If snow depth had been less than 0.30 m, it is likely that reduced sightability would have precluded track counts. Windblown snow was inconsequential in most areas during both surveys; forested areas were largely unaffected by wind, and lakes, rivers, and open bogs had light wind disturbance. The highest ridgetops, particularly in the extreme northwest portion of the refuge, were often swept free of snow or covered with a thin, hard-packed layer. This condition made tracks difficult or impossible to see along parts of some transects. These effects may have been reduced if exposed areas were surveyed shortly after snowfall. Shadows along some transects in mountainous terrain made it harder to see tracks, but this problem was limited because the timing of surveys ensured maximum daylight.

The use of field guides to tracks (Murie 1954, Halfpenny and Biesiot 1986), photographs, and several hours of practice in the air and on the ground were essential to the development of an adequate level of skill in the correct and rapid identification of tracks. Stephenson (1986) described lynx track characteristics in detail. He found lynx tracks are consistently similar enough to allow their separation from other species during aerial surveys. I also found this to be true for foxes, marten, hares, wolves, wolverines, and otters. I was unable to distinguish with regularity between the tracks of foxes and coyotes or coyotes and wolves. Tracks of red foxes and arctic foxes could not be separated. These difficulties were of minimal consequence, because coyotes and arctic foxes were uncommon in the study area. Ground observations at the Canvasback Lake study site indicated that mink tracks were generally smaller than marten tracks, but they were probably often mistaken for each other from the air. Tracks of other mustelids, red squirrels, and ungulates were readily distinguished from target species by size or pattern. Hare and caribou (Rangifer tarandus) tracks sometimes overlapped tracks of other species and hampered identification, but these situations were uncommon. The incidence of other furbearers traveling on hare trails probably increased with time after snowfall. Tape recording observations of tracks increased the ability to count tracks where the track density was high, but there was an upper limit to the number of tracks that could be recorded accurately within the flight time on a transect.

Track Sightability:

Data comparing ground and aerial surveys at the Canvasback Lake study site indicated there were differences in sightability of carnivore and hare tracks between bare, woodland, open, and closed vegetation cover (Fig. 7). There were also apparent differences between deciduous, mixed, and conifer composition types, which may have been real or may have only reflected the influence of cover. For example, a closed-conifer stand may have had many trees with small canopies or fewer trees with large canopies, whereas a closed-deciduous stand in winter was characterized by many trees with small canopies. Only 7 out of 10 possible cover-composition classes were available for testing at the Canvasback Lake study site. This was an inadequate sample to differentiate between the possible effects that both cover and composition could have on sightability, so only differences due to cover were tested for statistical significance. Therefore, results and discussion of sightability are limited to the 4 vegetation cover classes (VCC); i.e., bare, woodland, open, and closed (Table 3).

Sightability ratios for carnivore tracks included the combined counts of red foxes and marten. We observed no lynx tracks at the Canvasback Lake study site, but because it was assumed that sightability of all carnivore tracks was equal, results of analyses were applicable to lynx as well. Hare tracks were often more abundant relative to any carnivore tracks in open and closed VCCs but less abundant in bare and woodland VCCs; therefore, sightability of snowshoe hare tracks was calculated separately.

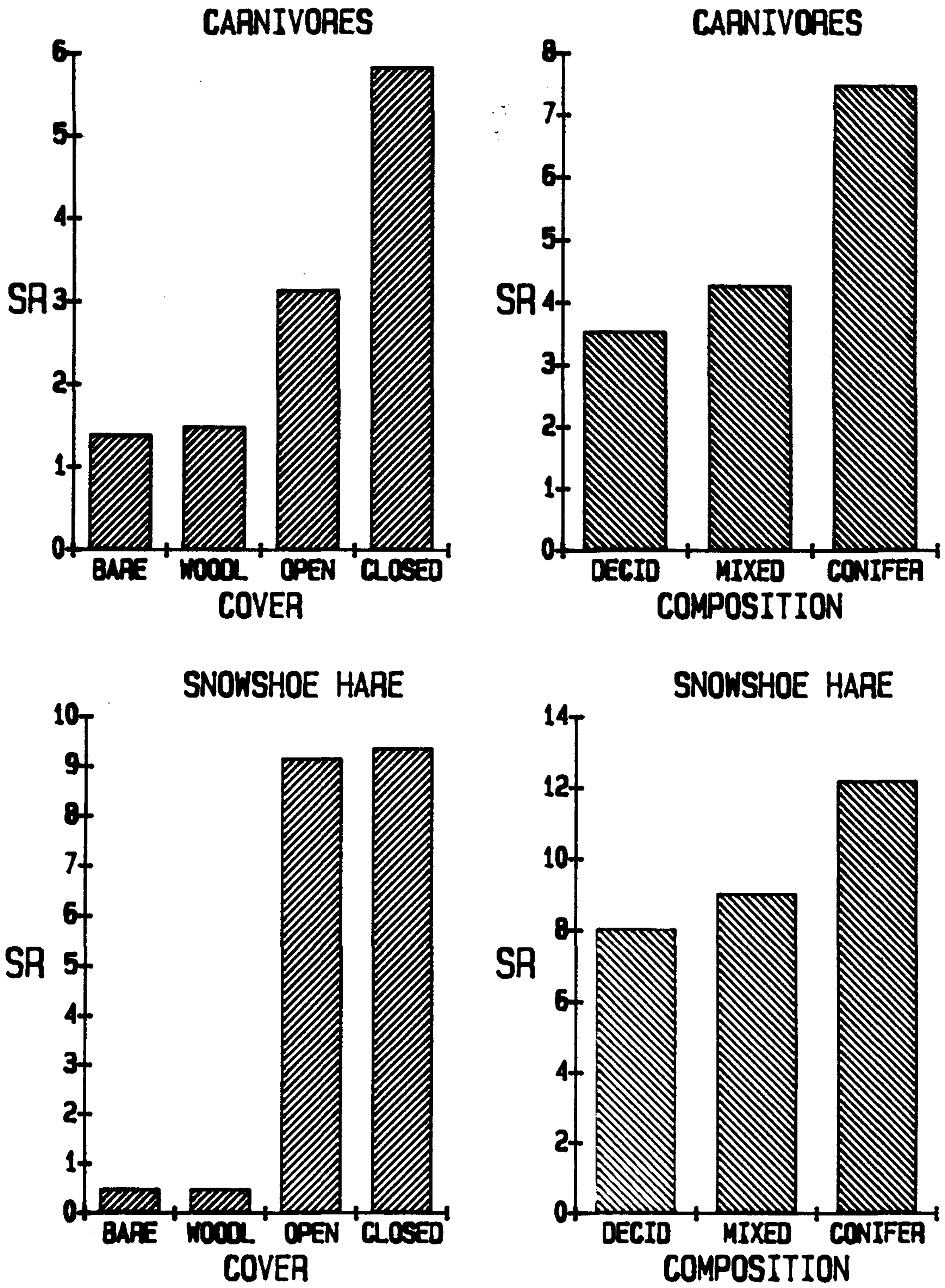

Fig. 7. Track sightability ratios (SR) for carnivores and snowshoe hares in different vegetation cover (bare, woodland, open, closed) and composition (deciduous, mixed, conifer) classes from the Canvasback Lake study site, Yukon Flats National Wildlife Refuge, Alaska, March 1986.

Table 3. Ground and aerial counts of carnivore and snowshoe hare tracks in 4 vegetation cover classes (VCC) along transects in the Canvasback Lake study area, Yukon Flats National Wildlife Refuge, March 1986.

VCC	No. of transects	VCC length (km)	Carnivore track counts		Snowshoe hare track counts	
			ground	aerial	ground	aerial
Bare	10	11.76	118	84	1	2
Woodland	5	1.10	9	6	2	4
Open	10	15.43	85	27	1394	152
Closed	10	24.84	204	35	1884	201

Track sightability ratios were tested between VCCs and between carnivores and hares for the primary observer. Sightability differences for carnivore tracks were statistically significant between all VCCs ($\underline{P} < 0.10$) except between bare and woodland and between woodland and open ($\underline{P} > 0.10$) (Table 4). Sightability of hare tracks was significantly different between all VCCs ($\underline{P} < 0.10$) except between open and closed ($\underline{P} > 0.10$) (Table 4); tests between bare and woodland VCCs were not conducted due to small sample sizes. Between carnivores and hares, there were significant differences in sightability for tracks in each VCC ($\underline{P} < 0.10$) except woodland ($\underline{P} > 0.10$). No consistent relationships were found between track sightability and track density per transect in the 4 VCCs for either carnivores (Fig. 8) or hares (Fig. 9).

Table 4. Sightability ratios (±SD) for carnivore and snowshoe hare tracks in 4 vegetation cover classes (VCC) and for the primary (1) and secondary (2) observers at Canvasback Lake study area, March 1986.

VCC	No. of transects	Carnivores		Snowshoe hares	
		Observer 1	Observer 2	Observer 1	Observer 2
Bare	10	1.40±0.53	1.55±0.80	0.50±1.18	0.00±0.00
Woodland	5	1.50±2.64	3.00±10.54	0.50±0.59	0.00±0.00
Open	10	3.15±2.21	2.83±2.77	9.17±3.63	5.18±1.28
Closed	10	5.83±3.18	4.08±3.25	9.37±5.09	5.20±2.14

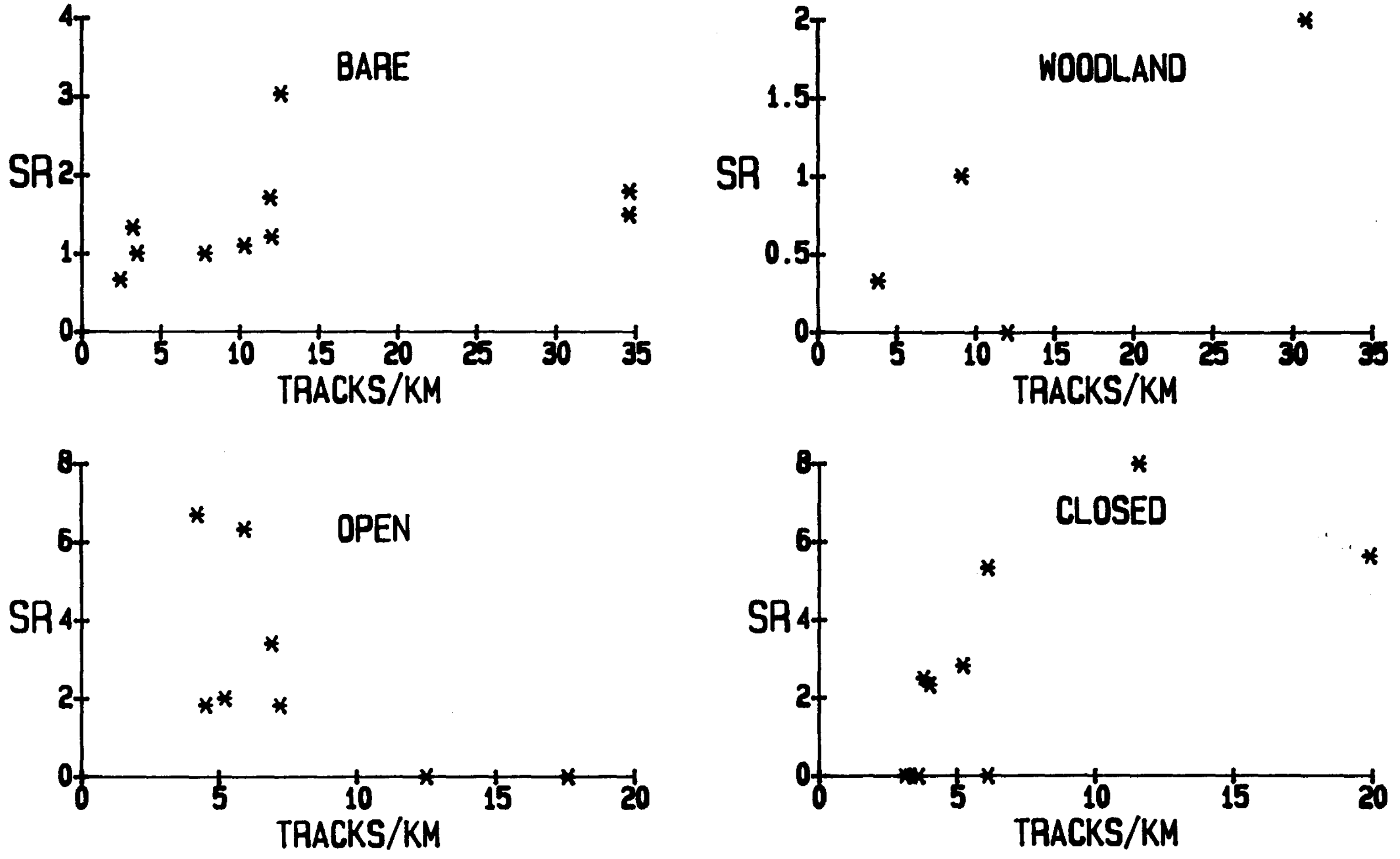

Fig. 8. Sightability ratios (SR) of carnivore tracks of various densities in bare, woodland, open, and closed vegetation cover classes from the Canvasback Lake study site, Yukon Flats National Wildlife Refuge, Alaska, March 1986.

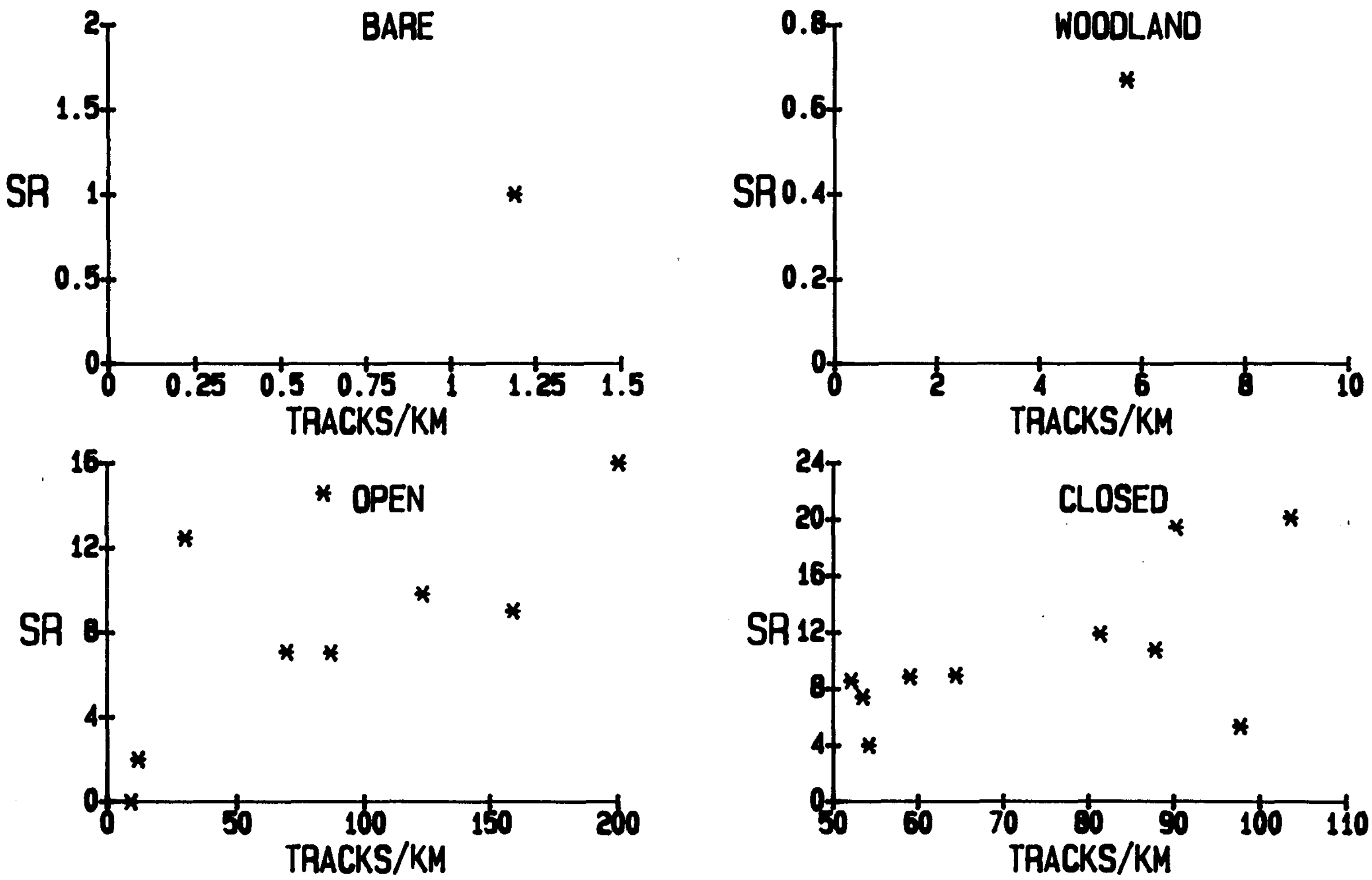

Fig. 9. Sightability ratios (SR) of snowshoe hare tracks of various densities in bare, woodland, open, and closed vegetation cover classes from the Canvasback Lake study site, Yukon Flats National Wildlife Refuge, Alaska, March 1986.

There was a sightability bias for hares in bare and woodland cover and possibly for carnivores in woodland cover. Snowshoe hare track counts, which were most affected, were relatively low in both of those VCCs during aerial-ground tests, and the small sample sizes accentuated variability. Hare, and possibly carnivore, track densities were biased in the woodland VCC, probably due to the limited amount of that VCC among test transects. Bare and woodland were lightly represented among VCCs of the 343 survey transects (Table 5), so the error associated with either VCC had relatively minor effects on overall track densities. I believe that real differences in sightability among VCCs did exist, even though data variability prevented each of the differences from being determined statistically.

Table 5. Lengths (km) and percentages of vegetation cover classes (VCC) combined for 343 transects surveyed in late winter-early spring 1985 on the Yukon Flats National Wildlife Refuge, Alaska.

	Bare	Woodland	Open	Closed	Total
Length	160.6	148.5	807.8	599.2	1716.1[a]
Percent of total length	9.4	8.6	47.1	34.9	100

[a] Rounding error <0.001%; actual total length = 1715 km.

Track sightability ratios between primary and secondary observers (Table 4) were also tested. There were no significant differences between observers in any VCC for carnivores ($\underline{P} > 0.10$), but there were differences in open and closed VCCs for hares ($\underline{P} < 0.10$). Tests were not conducted for hares in bare and woodland VCCs due to small sample sizes of transects and tracks. Discrepancies in hare track counts between observers were likely due to differences in vision acuity or search images, but no tests were made to determine the causes. Such discrepancies indicate a potential source of bias in aerial surveys of furbearer tracks if there is more than 1 observer. Observer faculties, such as eyesight, ability to identify tracks, level of concentration, and stamina, influence data collection and, therefore, results (Caughley et al. 1976, Norton-Griffiths 1976). To compare data among transects and over time, it is essential to limit variability between observers. This may be accomplished through an aerial observer training program (e.g., Dirschl et al. 1981) designed specifically for track surveys in winter, which would help equalize the abilities of observers and promote consistent data collection.

Track Accumulation:

The daily accumulation of tracks after snowfall were measured at the Canvasback Lake study site for 24 days after snowfall (DAS). The survey period from 16 to 24 March included 16-24 DAS, and the period from 4 to 8 April included 6-10 DAS. No data on track accumulation were collected for 1-5 DAS or 11-15 DAS. The minor fluctuations in tracks/km in relation to DAS for each furbearer species (Fig. 10) was likely due to track overlap. The large increase in fox tracks/km between 7 and 9 DAS was an isolated incident, the result of 1 fox repeatedly leaving and entering the seismic-line trail that it apparently used as a hunting route. I limited analysis of the effects of animal activity on species track accumulations to qualitative interpretations, because (1) DAS coverage was incomplete and represented 2 snowfall periods, (2) no lynx tracks were observed, and (3) track accumulation data appeared highly variable and nonlinear.

Tracks/km versus DAS for foxes, marten, and hares, shown in Figure 10, indicated that accumulation rates differed among species and they may have been curvilinear. The general pattern for all 3 species was the apparent rapid increase in tracks/km after 6 DAS, especially for hares, then a slower increase after 9 or 10 DAS, followed by a slight decline beginning about 21 DAS. Stephenson (1986) calculated track accumulation rates for lynx populations in 3 areas of interior Alaska, and he reported that average rates varied from 0.04 tracks/km/day to 0.15 tracks/km/day among the areas. He also noted that accumulation-rate changes within areas may have reflected changes in lynx activity, possibly due to weather conditions or food supply.

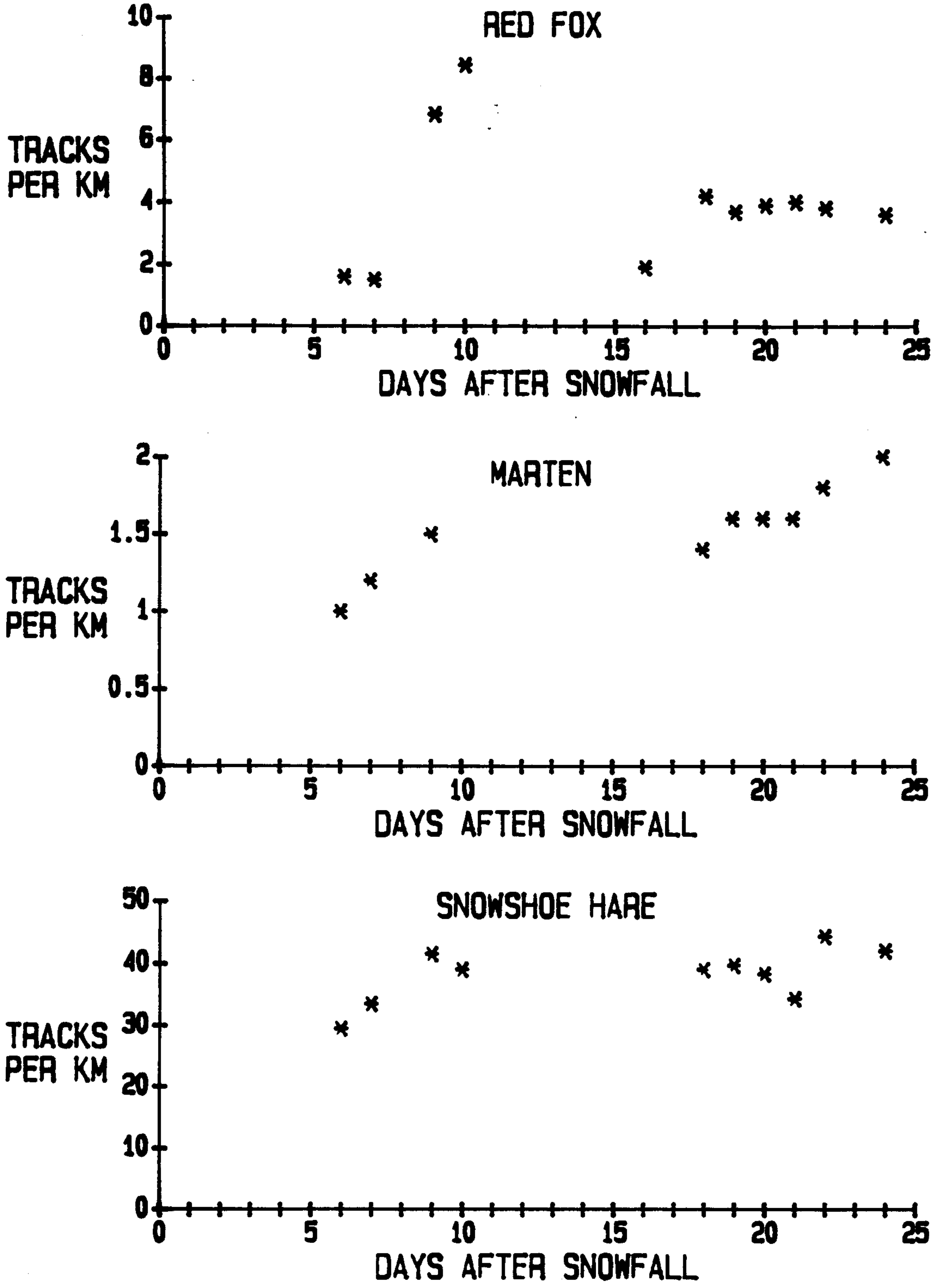

Fig. 10. Red fox, marten, and snowshoe hare tracks/km counted for days after snowfall at the Canvasback Lake study site, Yukon Flats National Wildlife Refuge, Alaska, March and April 1986.

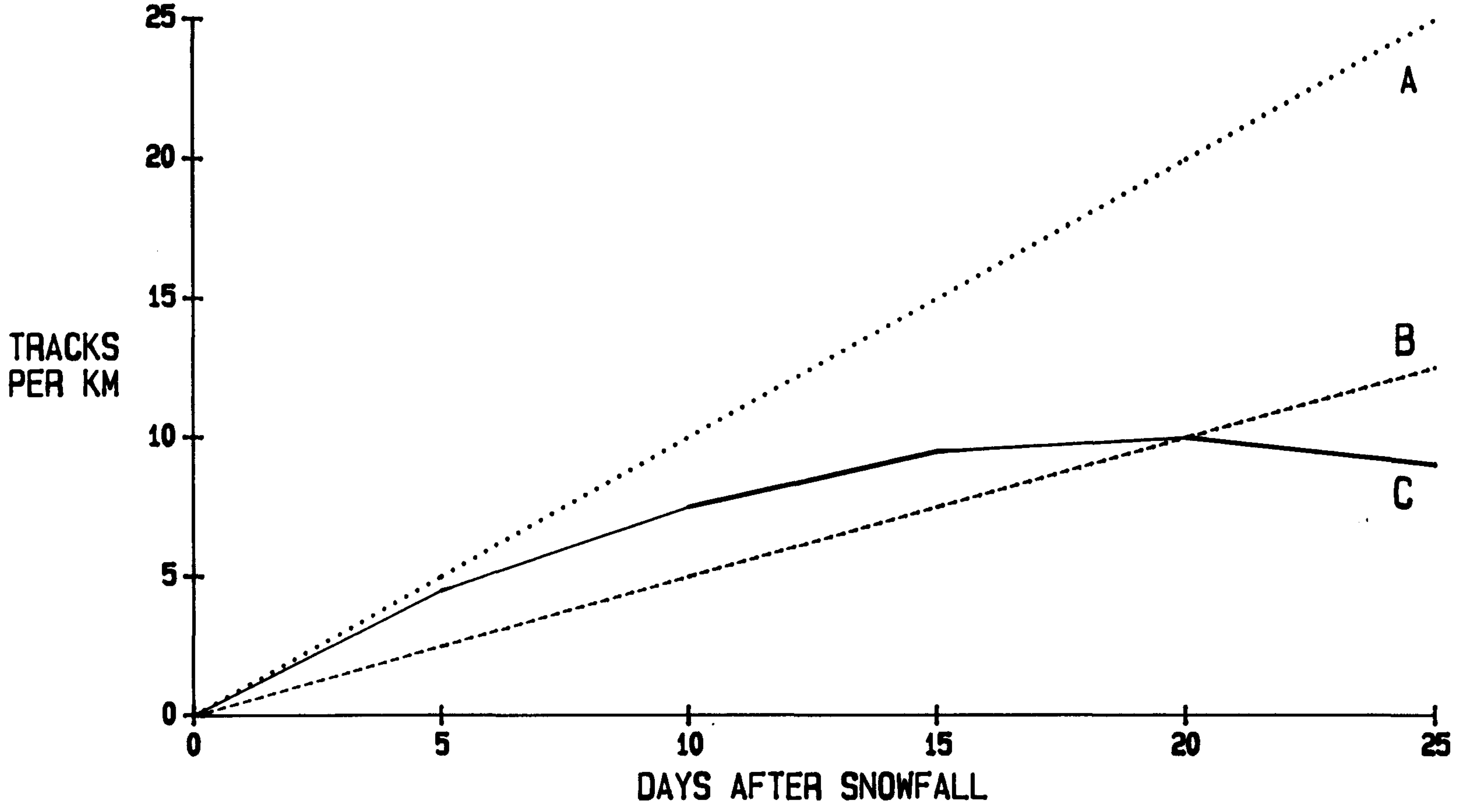

Fig. 11. Hypothetical patterns of track accumulation rates following snowfall: (A) simple linear rate regardless of activity; (B) linear rate assumes constant increase based on variable activity levels over time; and (C) curvilinear rate reflects dynamic responses to environmental and biological situations.

To demonstrate the potential effects of animal activity on track accumulation, 3 hypothetical patterns of average track-accumulation rates for furbearers are illustrated in Figure 11. Rate A defines a simple, linear accumulation of tracks regardless of animal activity. Rate B describes track accumulation that assumes a constant increase based on variable activity levels over a given period of time. Track accumulation for rate C reflects a dynamic response to a situation that affects track production or identification, such as weather, prey availability, or breeding season. It shows the effects that wind in exposed areas, track overlap, or evaporation of snow could have in reducing tracks counted, especially after more than about 20 DAS. These 2 latter rates, particularly C, probably approximate the average patterns of most furbearers. To reduce the effects of variability in accumulation rates, track counts should be restricted to a period of 3 to 20 DAS. A shorter period between snowfall and surveys should be used if tracks may be obscured due to overlap from abundant species such as hares or caribou (Stephenson 1986) or due to poor weather. Development of a model incorporating animal activity would lead to more accurate indices of relative abundance of species tracks between transects.

Correction Factors for Differential Track Sightability and Accumulation: Correction factors for track sightability and accumulation were derived to enable comparisons of track densities among transects surveyed on the YFNWR. Sightability correction factors (SCF) equalized differential sightability of tracks through the summed products of the sightability ratios (SR), which were calculated and tested for track counts of each carnivore species (C) or for snowshoe hares (H) within each VCC (V) (Table 4), and the total percentages (P) of V occurring along a transect, with $\sum_{V=1}^{4} P_V = 1$, as follows:

$$SCF_{C,H} = \sum_{V=1}^{4} SR_{V(C,H)} * P_V.$$

It was necessary to develop a SCF in this manner because simultaneous documentation of tracks and vegetation was unworkable. The accumulation of tracks counted over time was corrected, regardless of animal activity, through a linear function of DAS; e.g., tracks/km for 20 DAS were related to tracks/km for 1 DAS by dividing the former by 20. Similar methods of correcting for track accumulation have been used in other studies (Raine 1983, Slough and Jessup 1984, Slough and Slama 1985, Stephenson 1986). Combining the 2 methods, corrected track density (CTD) per transect for each carnivore species or for snowshoe hares was calculated for each original track density (OTD) per transect as follows:

$$CTD = OTD * SCF_{C,H} / DAS.$$

The use of correction factors was essential for meaningful comparisons of track densities among transects. The usefulness of the correction factors depended upon their effectiveness in reducing the bias they were intended to limit. I believe the combined use of SCFs and corrections for DAS, in conjunction with the aerial survey methods used, adequately equalized most differences among transects. Additional tests concerning track sightability versus vegetation composition and track accumulation versus the effects of animal activity, wind, and track overlap from other species would undoubtedly improve index comparisons. Corrected track densities calculated for all furbearer species and transects surveyed are listed in Appendix A and are used in the following discussion.

Furbearer Distribution and Relative Abundance

Red Fox:

Red fox track densities ranged from 0.0 to 1.96 tracks/km among all the transects, and approximately 96% of the transects surveyed had track densities below 1.0 track/km. Transects with low densities of 0.0-0.08 track/km were most common in the far northwest, southern, and eastern portions of the refuge (Fig. 12), whereas those with medium densities of 0.09-0.27 track/km were found largely for transects in the northeast and eastern regions and for scattered ones in the western half of the refuge. High densities of 0.28-1.96 tracks/km occurred mainly along river drainages,

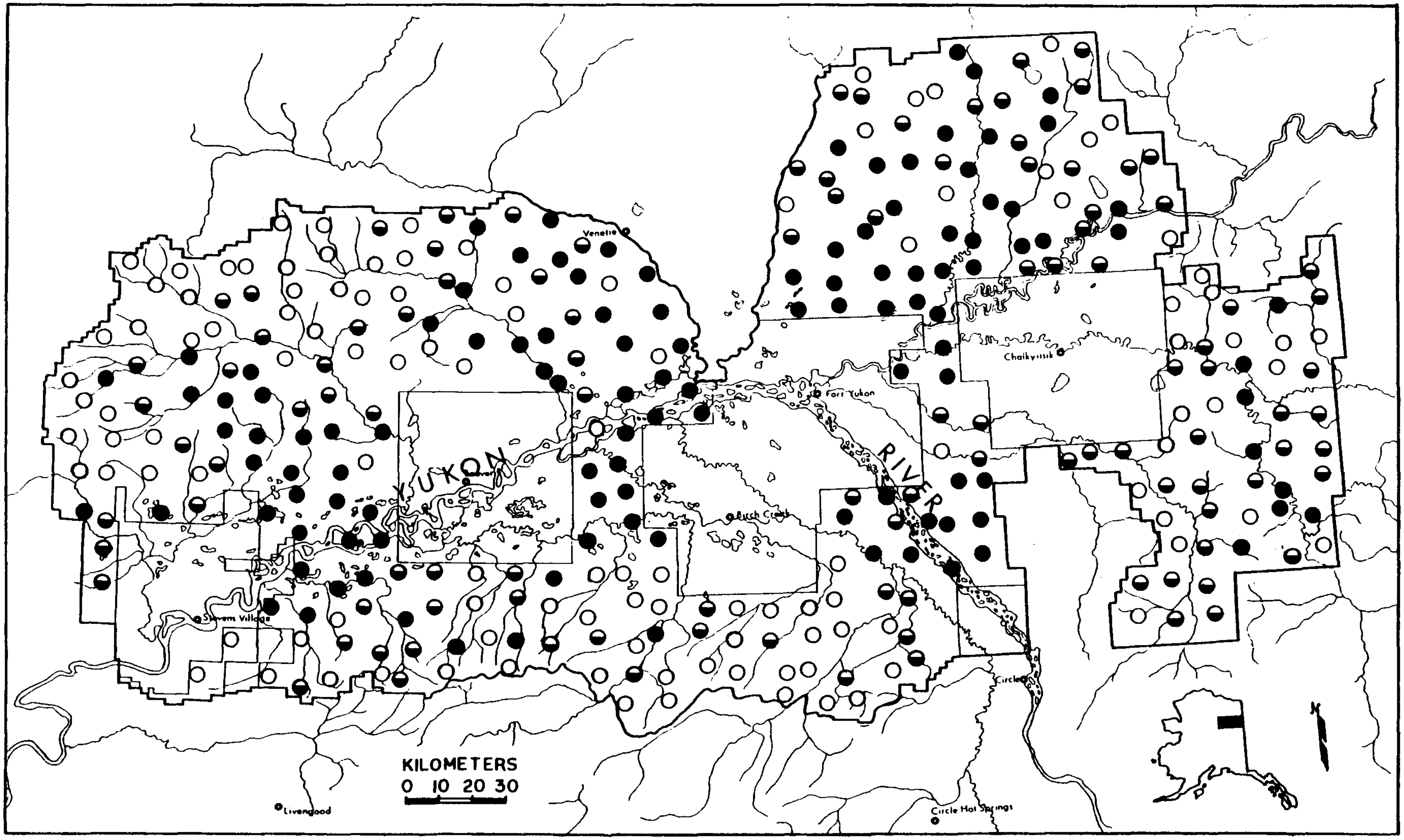

Fig. 12. Red fox distribution and relative abundance shown as low (O), moderate (◒), and high (●), track densities per transect. Each category represented approximately 33% of the 343 transects surveyed.

in the central lake flats, and in the near northwest area around Lone Mountain. Red fox track densities were higher for a larger proportion of the transects surveyed in the lowlands than for those surveyed in either benches or hills (Fig. 13). They were also higher for a larger percentage of transects in the Lone Mountain burn than in the Little Black River burn (Fig. 14).

Track densities for foxes were generally higher than the 0.01-0.12/km/day reported for the Canadian Yukon River basin, Yukon Territory (Slough and Jessup 1984) and for the 0.07/km/day reported for the Coal River Park Reserve, Yukon Territory (Slough and Slama 1985). Both of these studies were located in river and lake basins, and tracks were counted along trails. Red fox track densities along a 5,970-m trail averaged 1.5-9.9/100 m over a 13-year period in the Finnish Forest Lapland (Pulliainen 1981), and those densities were proportionately much higher overall than found on the YFNWR. The high track densities of foxes on the YFNWR in low-elevation lake flats and riparian areas reflected the general preference of foxes for diverse habitats where ecotones may be used and dense forests avoided (Samuel and Nelson 1982, Stephenson 1984).

Red foxes are omnivorous and opportunistic in their food selection and their relatively high abundance in the central flats may have reflected the abundance of breeding waterfowl in the area each summer. Sargeant et al. (1984) reported a similar relationship for the Prairie Pothole Region of North America. Although, small mammals, particularly microtine rodents, generally comprise the bulk of the fox diet (Samuel and Nelson 1982). Pulliainen (1981) stated that, in Finland, grasses preferred by microtines were most common in the mixed juniper-pine forests and open bogs. He found red fox track densities were highest in those habitats, similar to the findings in this study for the lake flats. The greater relative abundance of fox tracks inside the Lone Mountain burn compared with the Little Black River burn may have been due to the prevalence of grasses and fireweed in the former area during summer 1985. Such recently burned habitat is preferred by microtines, especially yellow-cheeked voles (West 1979, Wolff

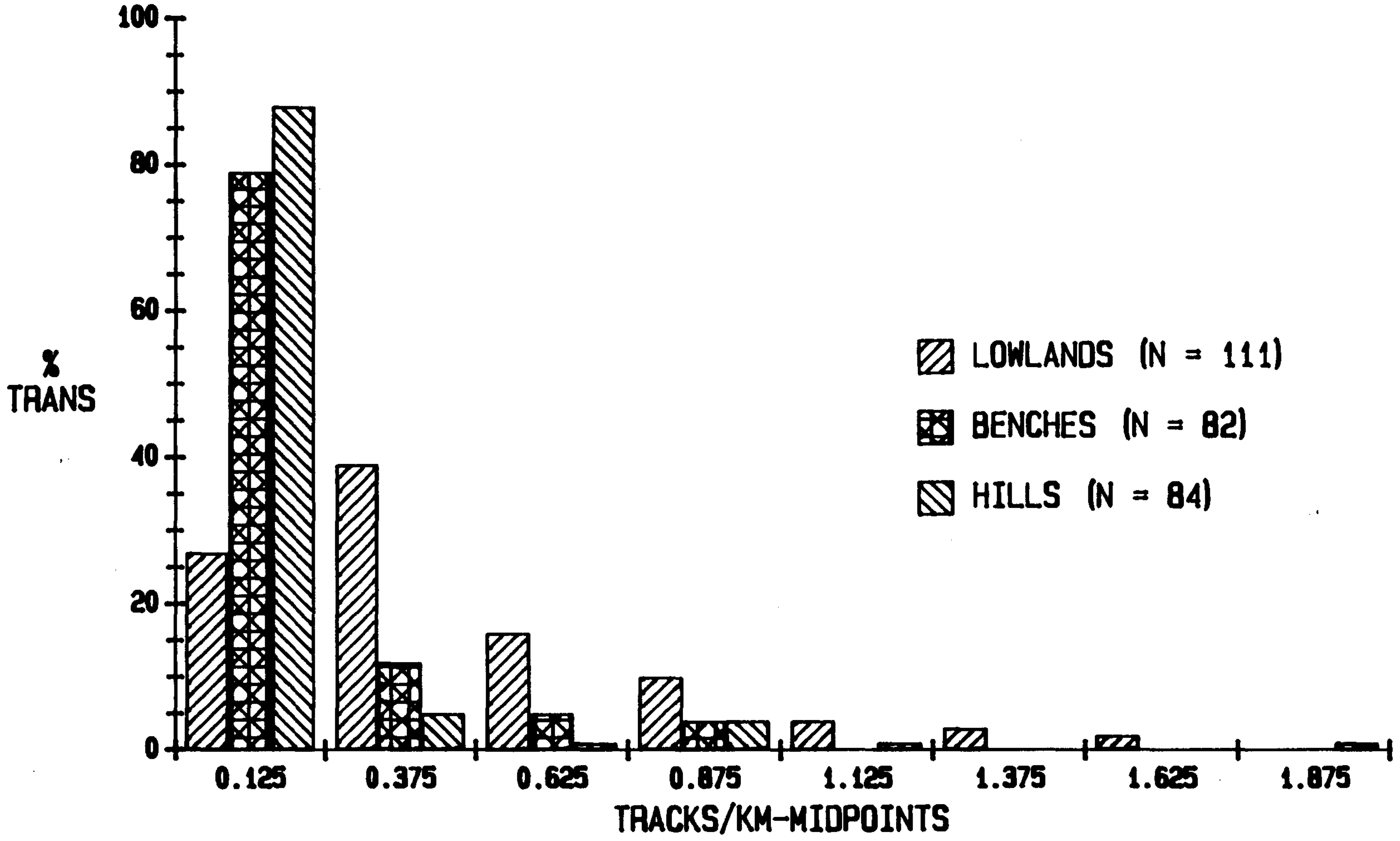

Fig. 13. Red fox relative abundance in the elevation strata of lowlands, benches, and hills on the Yukon Flats National Wildlife Refuge, Alaska shown by the proportions of transects distributed among the range of track densities observed for all strata in 1985; N = number of transects.

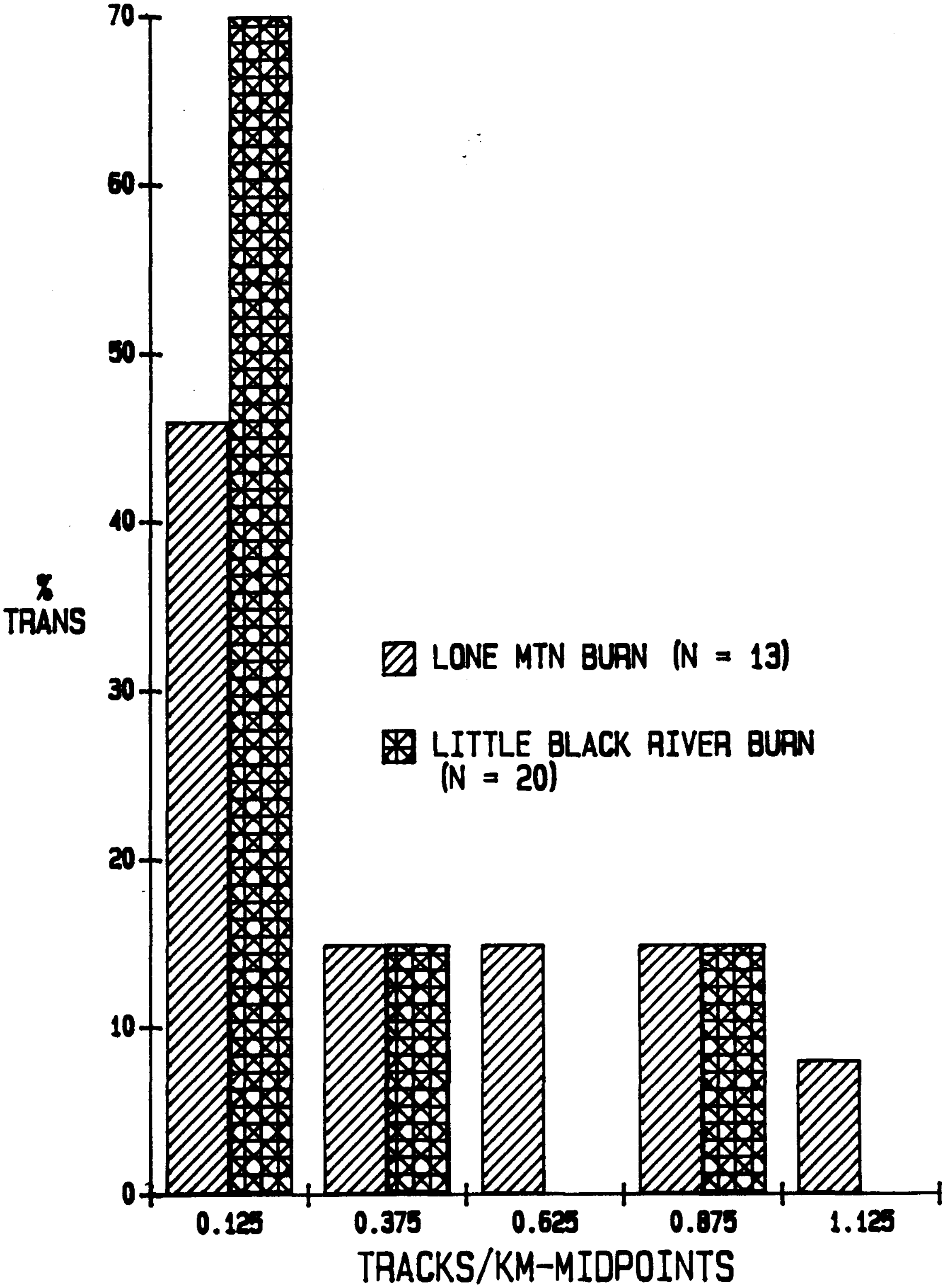

Fig. 14. Red fox relative abundance in the Lone Mountain and Little Black River burns on the Yukon Flats National Wildlife Refuge, shown by the proportions of transects distributed among the range of track densities observed for both burns in 1985; N = number of transects.

and Lidicker 1980) which I believe were abundant on the southern edge of the burn where I observed their extensive runways and heard their vocalizations (Wolff and Lidicker 1980).

Marten:

Marten track densities ranged from 0.0 to 3.78 tracks/km among all the transects, and about 78% of the transects had <1.0 track/km. Transects with low densities of 0.0-0.25 track/km were found in the lake flats of the central and northeastern areas (Fig. 15), while transects with medium densities of 0.26-0.71 track/km were seen in isolated locations outside the central lowlands. Those with high densities of 0.73-3.78 tracks/km were predominant in the general areas of Lone Mountain, the Hodzana and Hadweenzic River drainages, and the southern portion of the refuge from the west end of the White Mountains to the upper Little Black River. Marten tracks were poorly represented in the lowlands, but densities were relatively high in the benches and in the hills (Fig. 16). Compared with the Little Black River burn, marten track densities were also higher among more transects within the Lone Mountain burn (Fig. 17).

Other track surveys of marten indicated that track densities on the YFNWR were about average. Pulliainen (1981) found marten track-densities along a trail ranged from 0.10 to 1.26 tracks/100m in Finland; whereas, Slough and Jessup (1984) reported values of 0.0-0.31 track/km/day and Slough and Slama (1985) recorded 0.09-4.64 tracks/km/day. Both of the latter studies were located in Yukon Territory, Canada, and tracks were counted along trails. Marten track densities in this study were high in the northwest-central area and along the entire southern region of the refuge. These areas are typified by mature, spruce-dominated forests that may be pure or mixed with deciduous trees, which have been reported as preferred habitat for marten (Koehler and Hornocker 1977, Pulliainen 1981, Strickland et al. 1982, Buskirk 1983, Slough and Slama 1985).

Some of the highest marten track-densities were found near or inside the Lone Mountain burn. Fires have been shown in other studies to benefit

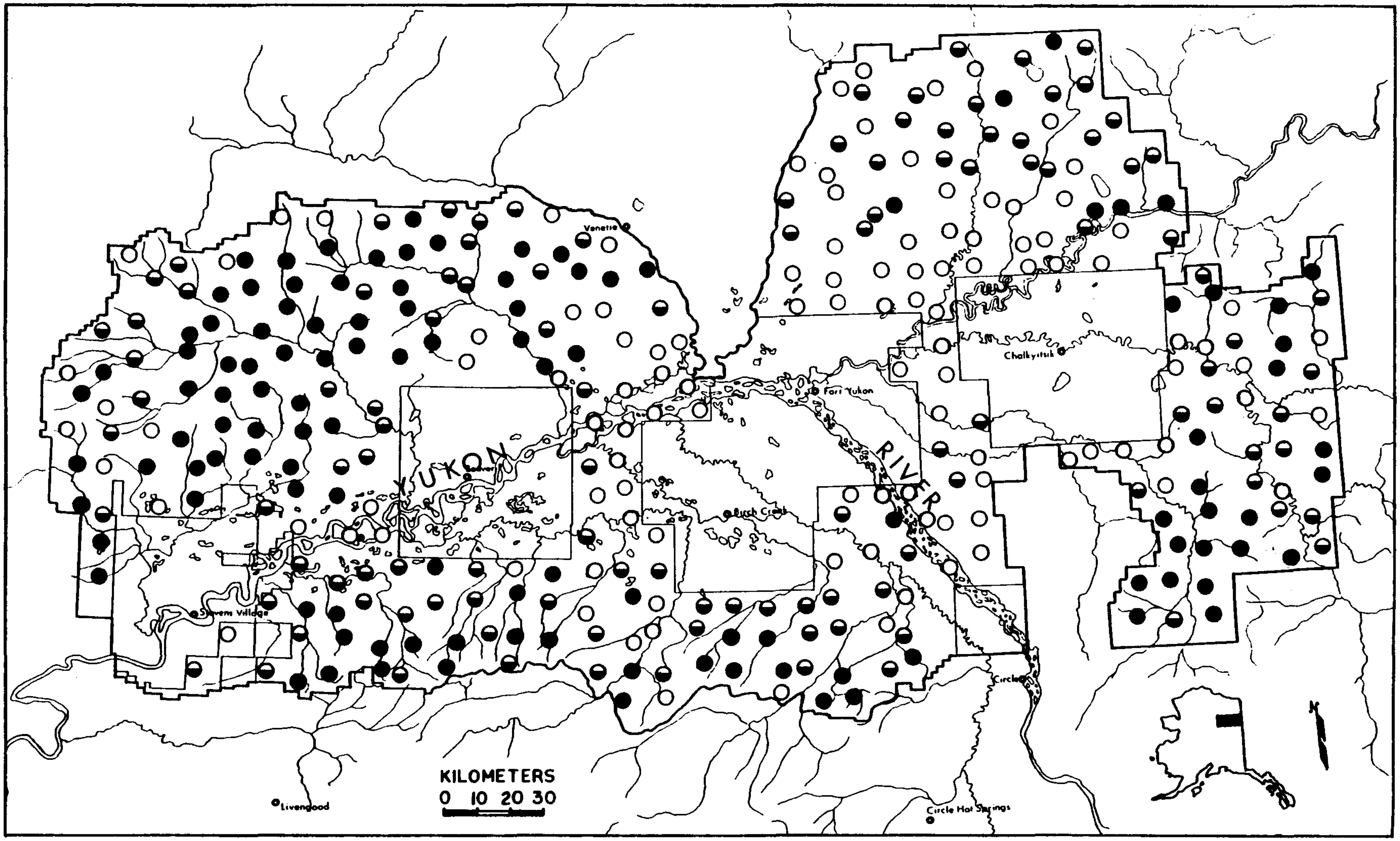

Fig. 15. Marten distribution and relative abundance shown as low (O), moderate (◓), and high (●) track densities per transect. Each category represented approximately 33% of the 343 transects surveyed.

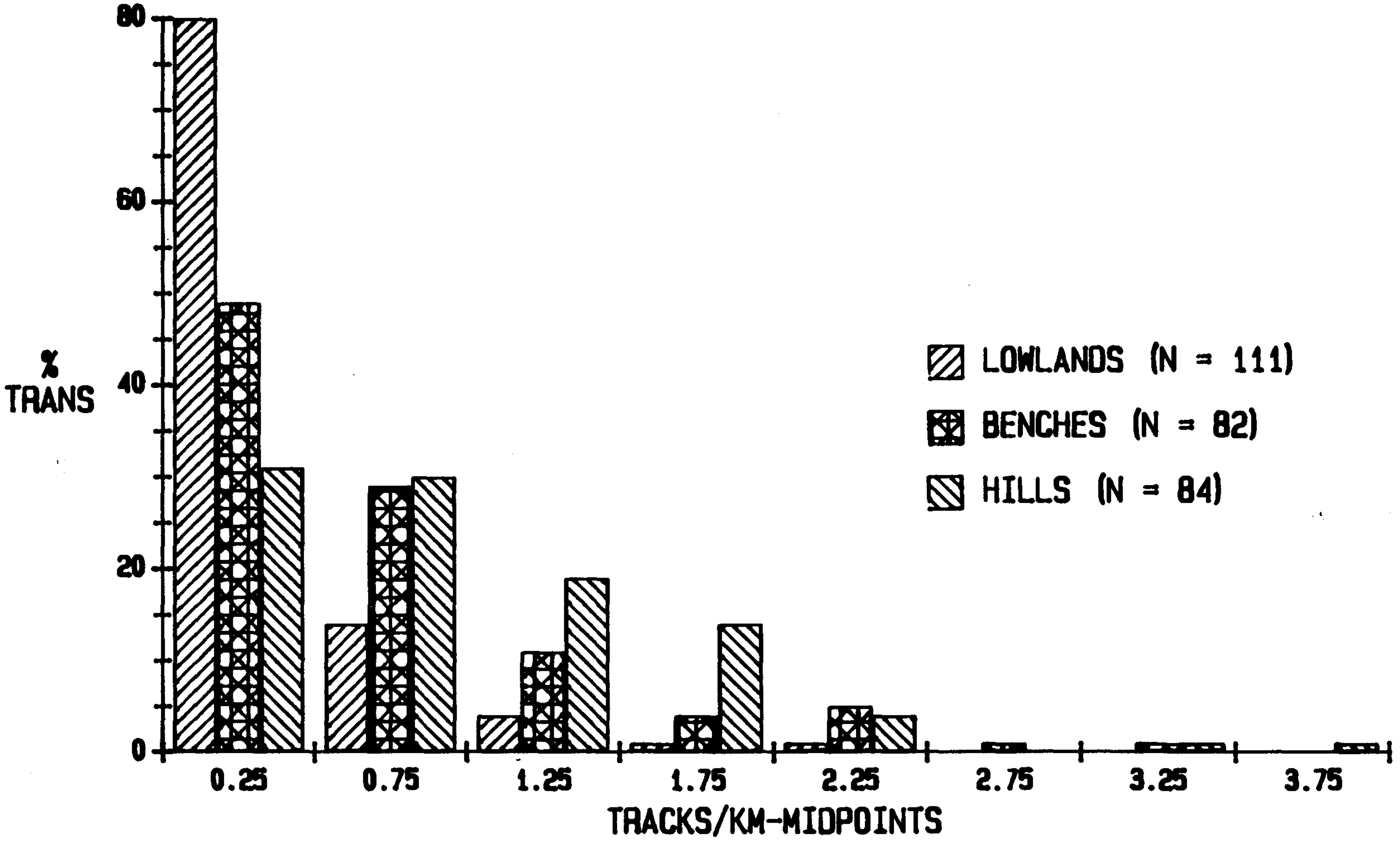

Fig. 16. Marten relative abundance in the elevation strata of lowlands, benches, and hills on the Yukon Flats National Wildlife Refuge, Alaska shown by the proportions of transects distributed among the range of track densities observed for all strata in 1985; N = number of transects.

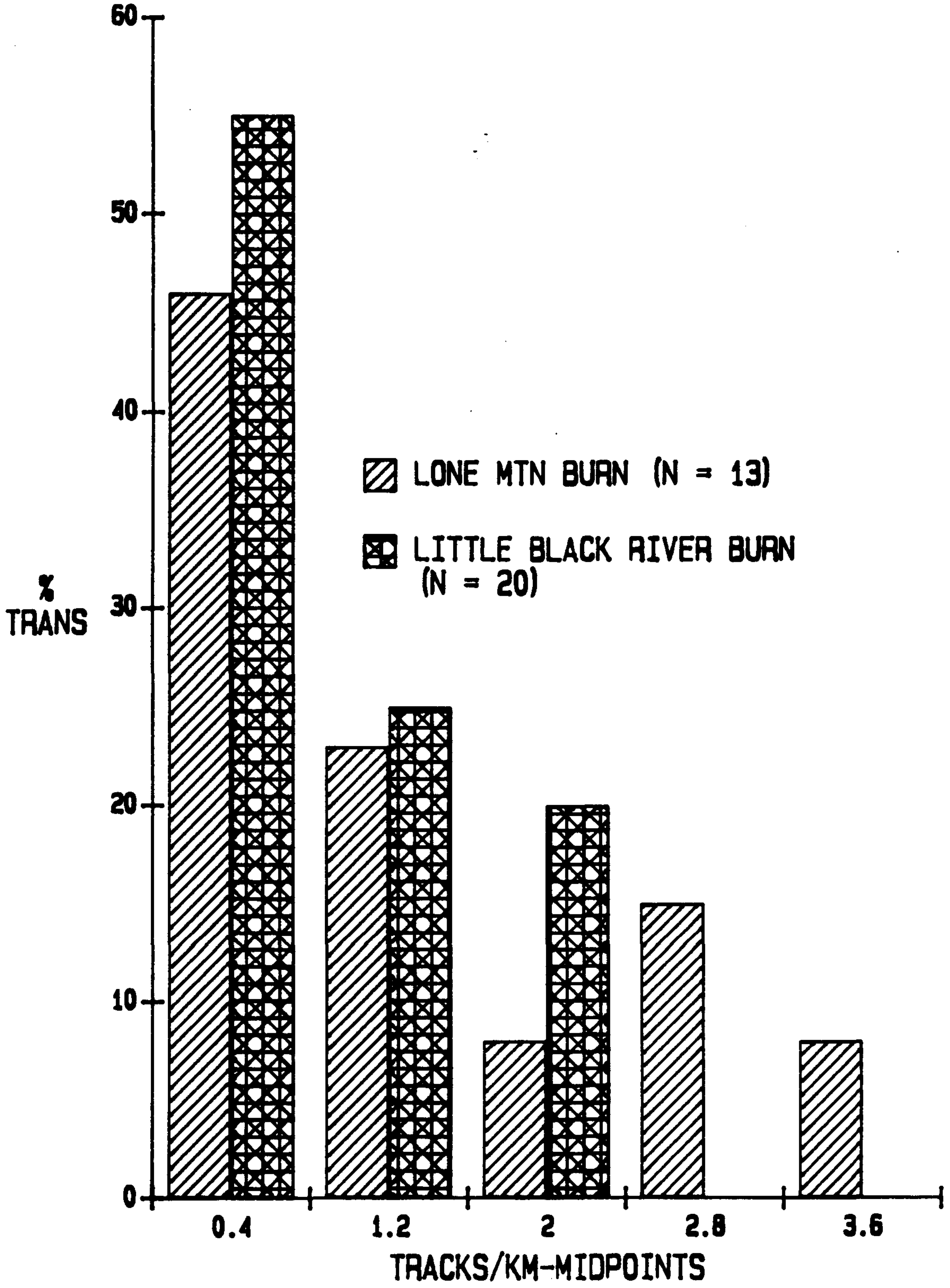

Fig. 17. Marten relative abundance in the Lone Mountain and Little Black River burns on the Yukon Flats National Wildlife Refuge, shown by the proportions of transects distributed among the range of track densities observed for both burns in 1985; N = number of transects.

marten where the food supply, primarily microtine rodents, was increased and adequate cover was available in the resulting mosaic of vegetation (Koehler and Hornocker 1977, Stephenson 1984, Slough and Slama 1985). Magoun (1986) investigated the effects of the Bear Creek burn on marten habitat in interior Alaska. She reported that marten have adapted to an ecosystem driven by fire and that an overhead canopy of vegetation may be unnecessary if alternate cover is available. She concluded the amount of deadfall timber is a key factor in determining the quality of a burn as marten habitat. The Lone Mountain burn has abundant deadfall timber and is believed to have high microtine populations. To fully evaluate a burn as marten habitat, however, Magoun (1986:33) further concluded that the presence of deadfall timber and small mammals along with the amount of unburned inclusions, potential marten predators, coniferous regrowth, and snowfall are all important and should be considered as interdependent.

Lynx:

Compared with foxes or marten, lynx generally had much lower track densities among transects on the YFNWR, ranging from 0.0 to 0.64 track/km, with nearly 80% of transects having <0.10 track/km. No lynx tracks were counted on about 46% of transects. The medium-density category for lynx included only about 21% of the transects rather than the usual 33%. Transects with low tracks/km were widely distributed on the refuge, though slightly grouped in the southcentral and extreme northwestern portions (Fig. 18). Those with medium densities of 0.02-0.06 track/km were most common in the northeastern and southeast-central regions. Concentrations of transects with high densities of 0.07-0.64 track/km were located in the upper Black River-Little Black River region, the area between the Porcupine and Christian Rivers, the Hodzana River-Hadweenzic River drainages, and the southwestern portion of the refuge between Lone Mountain and the White Mountains. There were nearly equal percentages of transects with relatively low lynx track-densities for each of the 3 elevation strata; but a slight preponderance of transects with high track densities occurred in benches and hills (Fig. 19). In contrast with foxes and marten, lynx track-density was generally higher in the Little Black River burn than the Lone Mountain burn (Fig. 20).

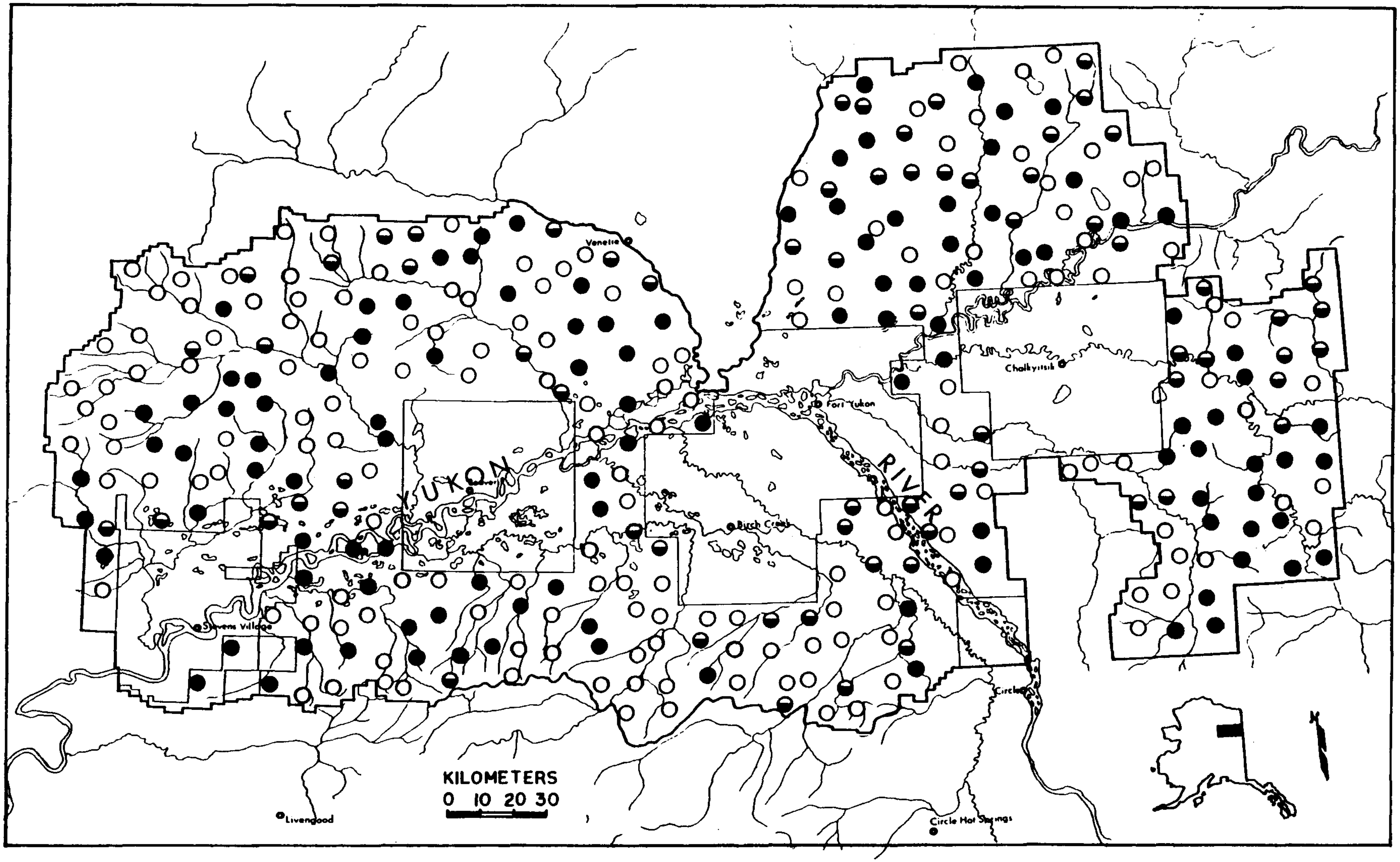

Fig. 18. Lynx distribution and relative abundance shown as low (O), moderate (◐), and high (●) track densities per transect. Each category represented approximately 33% of the 343 transects surveyed.

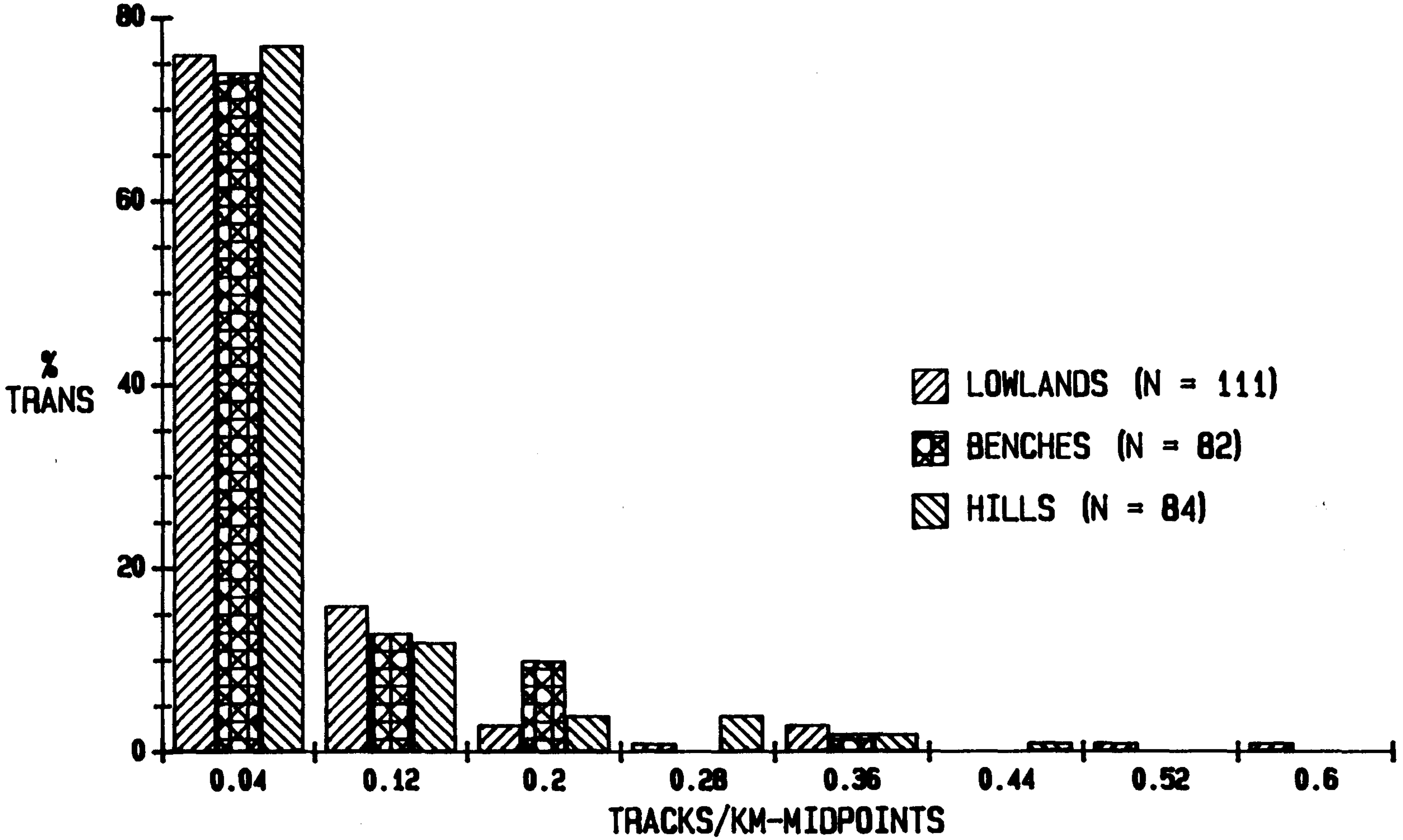

Fig. 19. Lynx relative abundance in the elevation strata of lowlands, benches, and hills on the Yukon Flats National Wildlife Refuge, Alaska shown by the proportions of transects distributed among the range of track densities observed for all strata in 1985; N = number of transects.

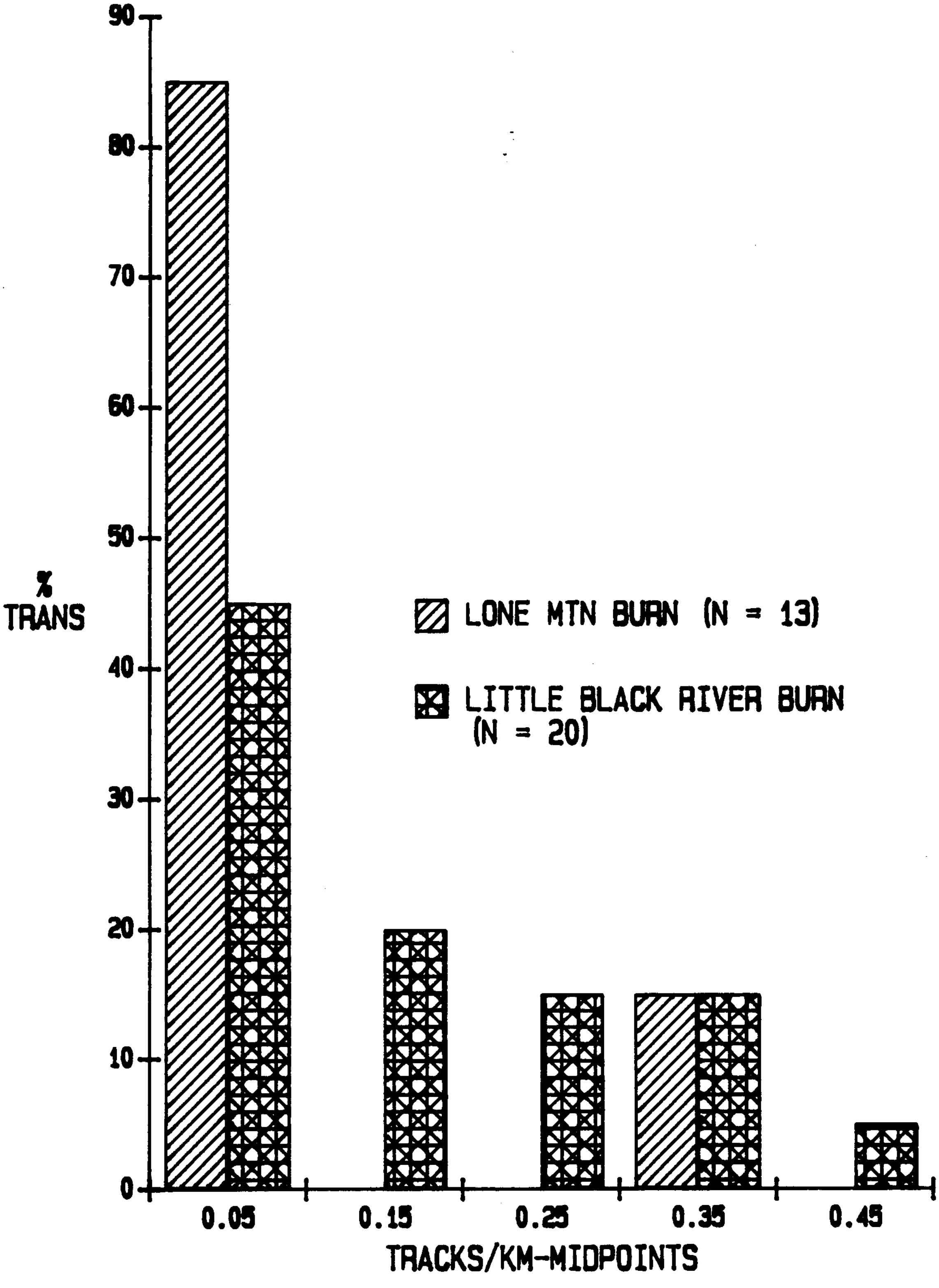

Fig. 20. Lynx relative abundance in the Lone Mountain and Little Black River burns on the Yukon Flats National Wildlife Refuge, shown by the proportions of transects distributed among the range of track densities observed for both burns in 1985; N = number of transects.

Track densities of lynx on the YFNWR were generally lower than those reported elsewhere. In the Yukon Territory, Canada, Slough and Jessup (1984) counted between 0.0 and 0.12 track/km/day along trails in 3 river drainages over 2 years; Slough and Slama (1985) counted 0.03, 0.03, and 0.13 track/km/day in forests of pine/black spruce, aspen/pine/spruce, and pine, respectively; and Ward (1985) counted tracks along 600-m lines near Kluane Lake and reported densities equivalent to 1.33-8.33 tracks/km. Stephenson (1986) studied lynx populations in eastern and central interior Alaska for 3 years. He reported track densities in the former area of 0.12-0.14 track/km in 1982 and in the latter area of 0.09-0.12 track/km in 1984 and 0.06-0.07 track/km in 1985. Stephenson counted 2 or more lynx tracks as 1 observation if determined to be from the same individual; therefore, his values may be lower compared to those of my study or the others discussed.

On the YFNWR, lynx track densities were similar among elevation strata but were more clearly differentiated between the burned areas. Lynx preferred the older Little Black River burn. The Little Black River burn is characterized by mixed coniferous-deciduous forests with understories of willow and alder. Elsewhere lynx are most often associated with dense boreal forests (McCord and Cardoza 1982). The main prey of lynx in these forest habitats is likely snowshoe hares (Saunders 1963, Nellis et al. 1972, McCord and Cardoza 1982, Parker et al. 1983, Stephenson 1986). Lynx population fluctuations have been documented to reflect hare abundance, despite shifts in diets to alternate food sources during hare population lows (Brand et al. 1976). Brand et al. (1976) and Ward (1985) found that lynx tracks were concentrated in areas of relatively high hare abundance.

Snowshoe Hare:

Track densities of snowshoe hares were higher than those of other furbearer species; they ranged from 0.0 to 13.94 tracks/km. Approximately 98% of the transects had <6.65 tracks/km, but 40% of them had >1.0 track/km. The distribution of track density categories was distinguishable though somewhat less defined for hares compared with other species (Fig. 21). An area

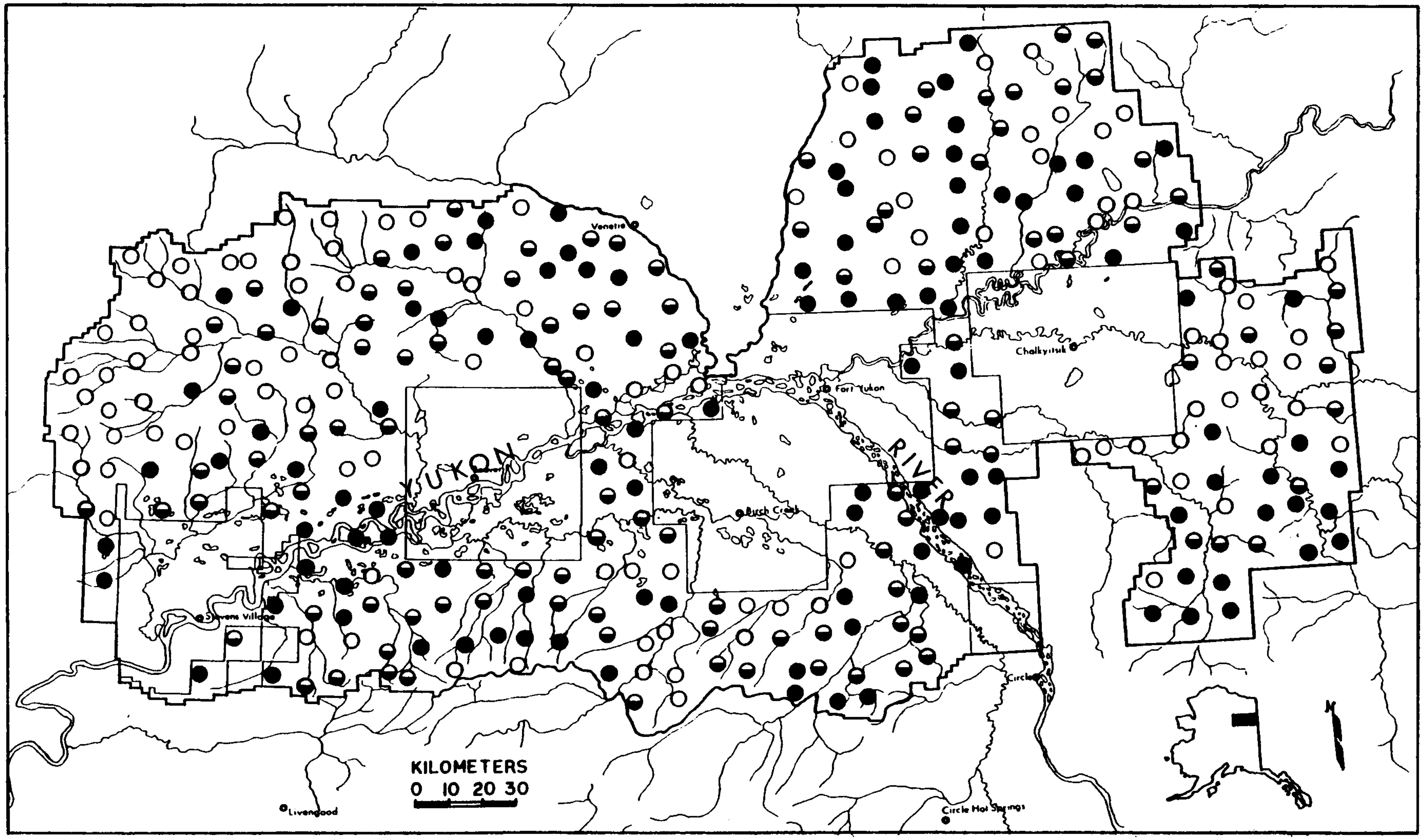

Fig. 21. Snowshoe hare distribution and relative abundance shown as low (O), moderate (◐), and high (●) track densities per transect. Each category represented approximately 33% of the 343 transects surveyed.

at the east end of the refuge around the Black River and a band of hilly terrain along the northwest border had the only obvious concentrations of transects with low densities of 0.0-0.39 track/km. Hare and lynx track densities were proportionately the same in those areas. Transects with medium densities of 0.41-1.13 tracks/km were scattered across the refuge with no definite patterns revealed. Patterns of high track densities were more clearly defined, however, and generally similar to those of lynx. The upper Black River-Little Black River area, the region between the Porcupine and Christian Rivers and south to the White Mountains, the Hodzana River-Hadweenzic River areas, and the southwestern portion of the refuge between Lone Mountain and the White Mountains had the highest concentrations of hare tracks. There were more transects with high track densities of snowshoe hares in lowlands and benches than in hills (Fig. 22). This was comparable to lynx as were the smaller differences in track density among elevation strata for lynx than for either foxes or marten. Also similar to lynx, but with slightly less magnitude, was the greater percentage of transects with high densities of hare tracks in the Little Black River burn than in the Lone Mountain burn (Fig. 23).

Track densities of hares reported for 2 studies in Canada were generally higher than those found on the YFNWR. Slough and Jessup (1984) documented between 1.84 and 28.75 tracks/km/day from 1982 through 1983 and Slough and Slama (1985) found between 2.30 and 38.40 tracks/km/day in 1984. Hare populations in those studies were in a declining phase following a peak in 1980-81. Slough and Slama (1985) considered hare runways as 7 tracks for data analysis, and they reported the highest densities in pine, aspen/pine/spruce, and pine/black spruce forests. Hares use a variety of forest habitats that have dense, brushy understories and usually avoid open areas (Pietz and Tester 1983, Keith et al. 1984, Slough and Jessup 1984, Fuller and Heisey 1986). These characteristics were evident at the Canvasback Lake study site where there was a relative absence of hare tracks in the bare and woodland vegetation cover classes compared to the open and closed classes (Table 3).

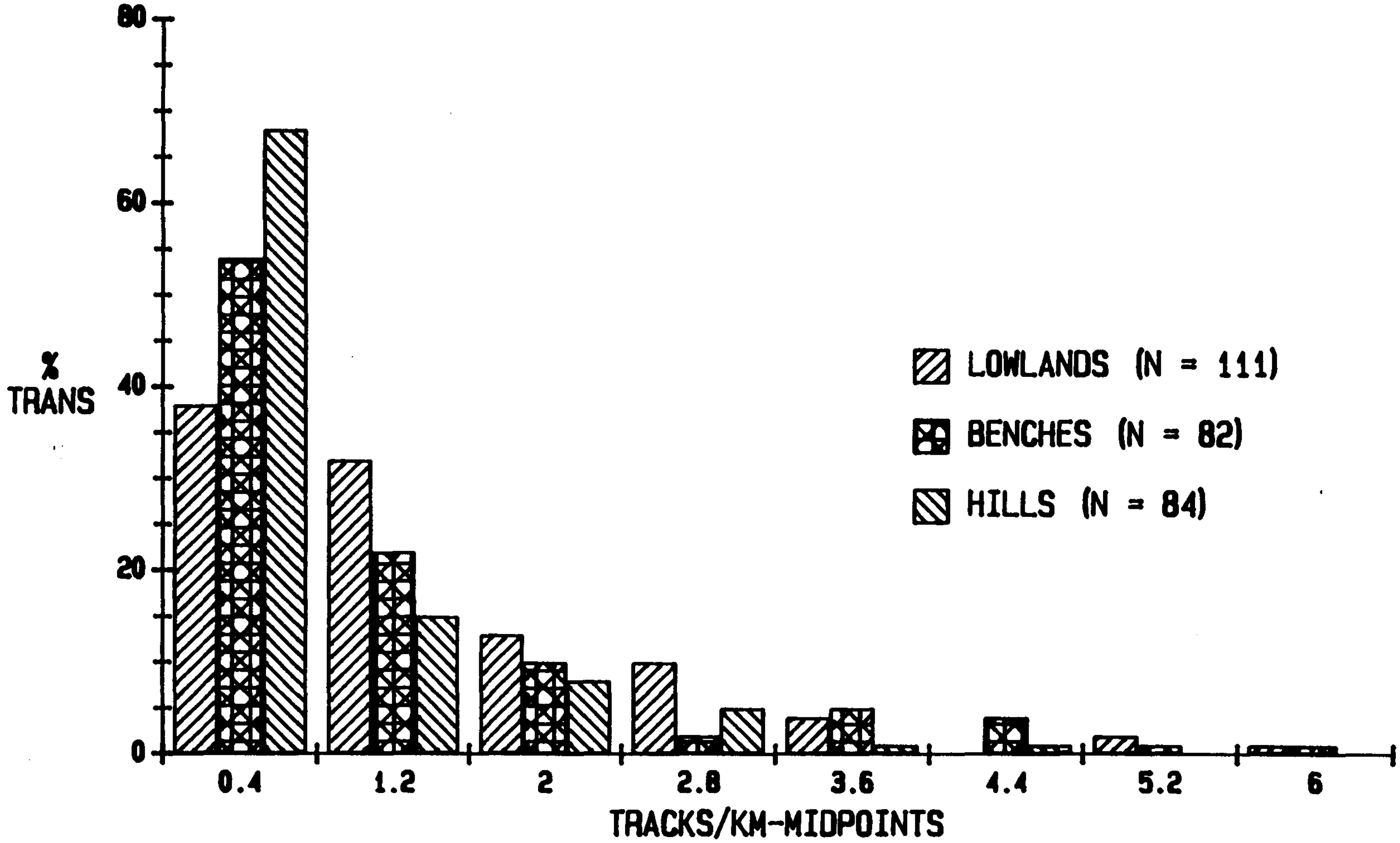

Fig. 22. Snowshoe hare relative abundance in the elevation strata of lowlands, benches, and hills on the Yukon Flats National Wildlife Refuge, Alaska shown by the proportions of transects distributed among the range of track densities observed for all strata in 1985; N = number of transects.

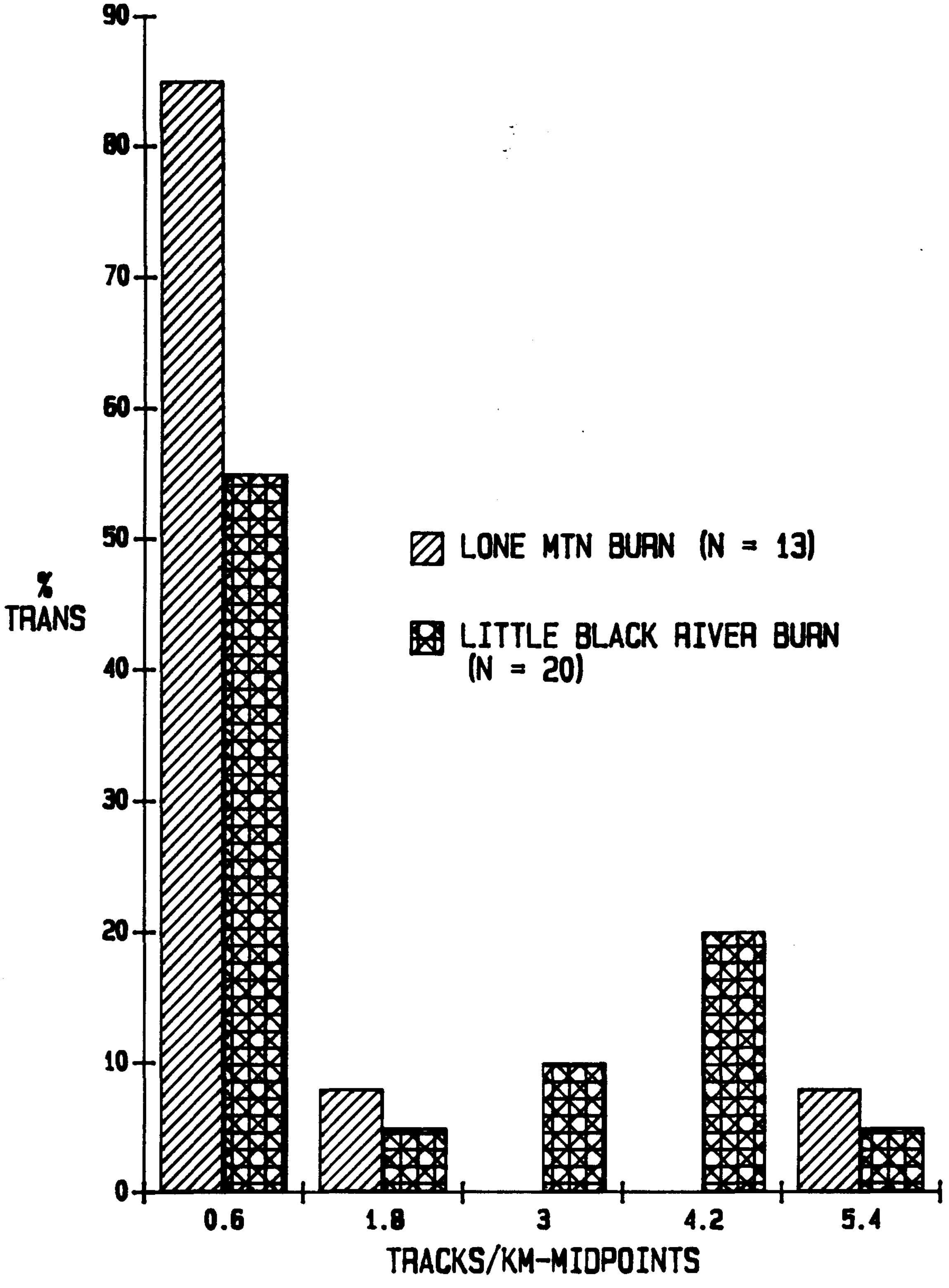

Fig. 23. Snowshoe hare relative abundance in the Lone Mountain and Little Black River burns on the Yukon Flats National Wildlife Refuge, shown by the proportions of transects distributed among the range of track densities observed for both burns in 1985; N = number of transects.

Patchy environments with mosaics of vegetation types and densities create favorable habitats for snowshoe hares by providing food and protection from predators (Wolff 1980). The areas of the YFNWR where hares appeared most abundant, particularly the Little Black River burn, typify those favored habitats. Post-fire vegetation succession probably created this optimal habitat for hares (Fox 1978) on the refuge. Areas with lower track densities may have been too recently burned or may be too near the end of succession to meet the needs of snowshoe hares. The fire-vegetation-hare relationship is complex, but wildfire patterns can at least partially explain the distribution and relative abundance of snowshoe hares.

Test-Case Analysis of a Recent Burn

Analysis of the Lone Mountain burn is presented as a test-case for a potential approach to determine relative abundance of furbearers in specific areas and at different times. The results are most meaningful for general interpretation rather than being statistically conclusive, because of the small sample sizes per stratum and the minimal strength of correction factors for track densities. Summary statistics of furbearer track densities are presented in Table 6, and results of tests of significance for strata comparisons are shown in Table 7. Appendix B lists the corrected tracks/km of red foxes, marten, lynx, and snowshoe hares for transects surveyed inside and outside the burn in 1985 and 1986.

Histograms (Fig. 24) best illustrate differences of mean tracks/km for furbearers between the year and location strata. Densities per transect of red fox tracks appeared to have declined between 1985 and 1986 both inside and outside the burn. Only values for outside the burn were significantly different between years. There were no patterns of use indicated for foxes in the Lone Mountain burn area. Marten tracks/km increased for each location stratum from 1985 to 1986, and inside densities were significantly different from those outside in 1986. My general observations were that marten track densities were highest inside the burn perimeter. Lynx track densities were not significantly different between strata for either year,

Table 6. Summary of furbearer tracks/km for survey-year and location strata for the Lone Mountain burn area.

Species	Strata Year	Strata Location	N	Tracks/km Range	Tracks/km Mean	Tracks/km Std. Dev.
Red fox	1985	Inside	13	0.0 - 1.23	0.44	0.42
		Outside	14	0.0 - 1.96	0.54	0.56
	1986	Inside	13	0.0 - 1.26	0.29	0.33
		Outside	14	0.0 - 0.81	0.17	0.21
Marten	1985	Inside	13	0.31 - 3.64	1.33	1.01
		Outside	14	0.21 - 1.75	0.90	0.45
	1986	Inside	13	0.76 - 4.16	2.11	0.85
		Outside	14	0.12 - 2.03	1.16	0.64
Lynx	1985	Inside	13	0.0 - 0.36	0.07	0.13
		Outside	14	0.0 - 0.29	0.08	0.09
	1986	Inside	13	0.0 - 0.12	0.01	0.03
		Outside	14	0.0 - 0.24	0.05	0.07
Hare	1985	Inside	13	0.02 - 4.83	0.79	1.32
		Outside	14	0.19 - 2.74	1.16	0.92
	1986	Inside	13	0.06 - 9.56	2.02	2.81
		Outside	14	0.69 - 18.54	5.02	4.83

Table 7. Tests of significance[a] between Lone Mountain burn strata for furbearer track densities inside vs. outside of the burn and 1985 vs. 1986.

Strata comparison	Red Fox	Marten	Lynx	Hare	Statistical test
1985 Inside vs. Outside	NS	NS	NS	*	Mann-Whitney U
1986 Inside vs. Outside	NS	*	NS	*	Mann-Whitney U
Inside 1985 vs. 1986	NS	*	NS	*	Wilcoxon Matched Pairs
Outside 1985 vs. 1986	*	*	NS	*	Wilcoxon Matched Pairs

[a] * = significant difference, $\underline{P} < 0.10$; NS = no significant difference.

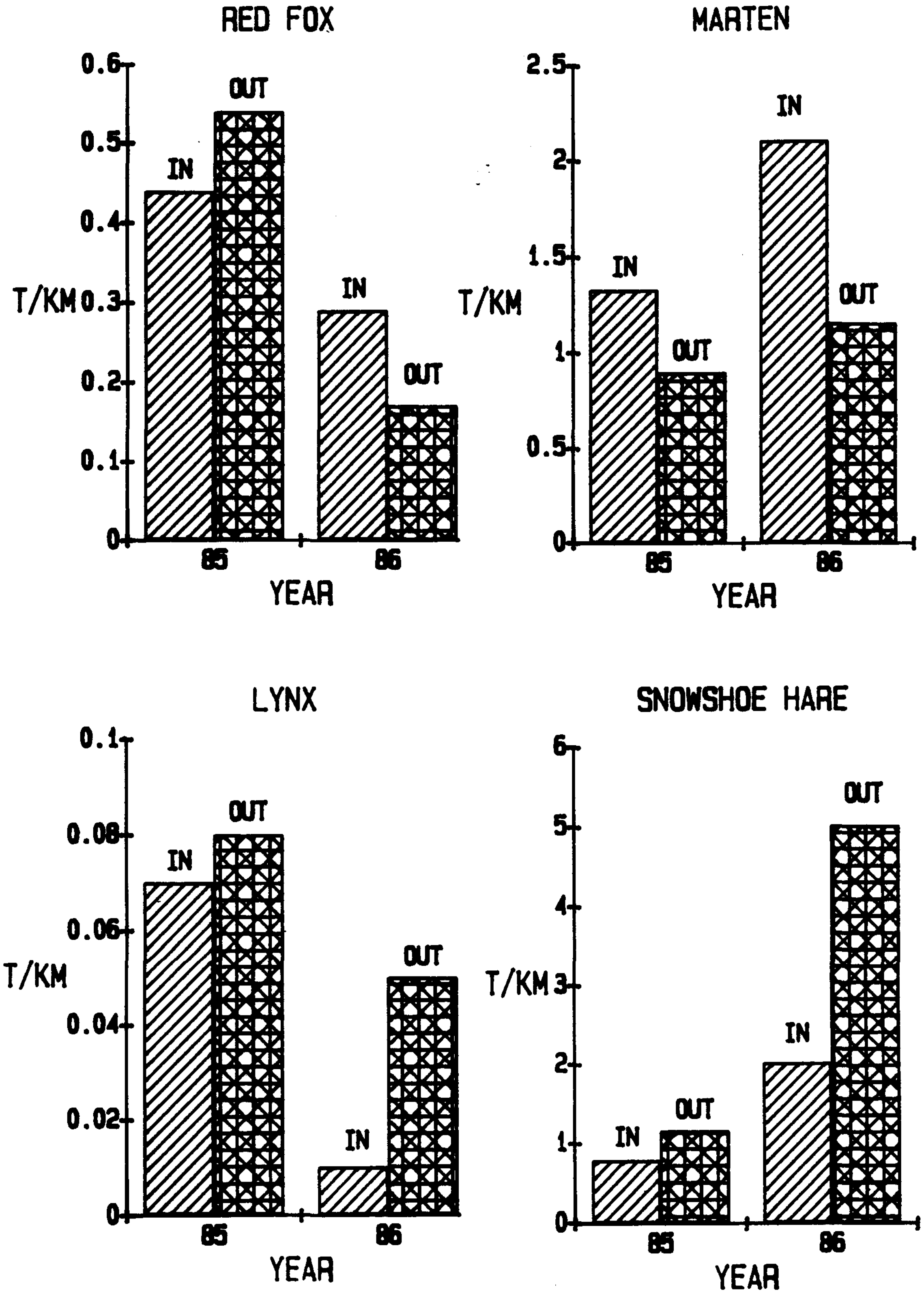

Fig. 24. Average track densities of red foxes, marten, lynx, and snowshoe hares for 13 transects inside and 14 transects outside the Lone Mountain burn, Yukon Flats National Wildlife Refuge, in 1985 and 1986.

however I think lynx did prefer the unburned areas. Track densities were different between strata both years for snowshoe hares, with a large increase in track densities outside the burn from 1985 to 1986. The greater abundance of hare tracks outside the burn than inside probably reflects the higher proportions of closed and open vegetation-cover classes in the unburned areas (Table 8). Lynx and hare track densities appeared to have had similar relationships between location strata within each year but had inverse relationships among all location strata between years. This may have been due to anomalies in sampling or to the suggested 1- to 2-year lag in the lynx cycle relative to the hare cycle in Alaska (Wolff 1980, O'Connor 1984).

Table 8. Percentages of vegetation cover classes (VCC) inside and outside the Lone Mountain burn, derived from VCC lengths during late winter-early spring 1985 on Yukon Flats National Wildlife Refuge, Alaska.

Strata	Bare	Woodland	Open	Closed
Inside	2.2	33.1	44.3	20.4
Outside	9.3	2.4	44.6	43.7

Results of these tests demonstrate the variability in track counts that may be found for a species between years or adjacent habitat strata. Transect lengths, orientations, and spacing must adequately sample each stratum to reduce sources of variability in surveys and to maximize data collection (Caughley 1977b). Differences in species track densities among strata for the Lone Mountain burn may have been more precisely measured through the use of shorter, more closely spaced transects.

Trapper Harvest Patterns and Observations

Lynx Harvests:

Harvests of lynx along drainages in the Porcupine River area tended to be higher than among those in the Yukon River area, and the Black River drainage had the highest harvests of any on the Yukon Flats for all seasons examined (Table 9). The Christian and Yukon Rivers generally had higher harvests than other drainages examined in the major Yukon drainage. Nowlin (1986a) reported that lynx populations were variable in 1983-84 with the highest populations probably occurring in the Little Black and Porcupine drainages and the area east of Fort Yukon.

Table 9. Lynx pelts sealed by Alaska Department of Fish and Game from 1977-78 through 1984-85[a] for minor drainages within the Porcupine River and Yukon River drainages in Game Management Unit 25, which includes the YFNWR.

Drainage	1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1984-85
Porcupine River							
Black River	115	150	362	631	586	478	161
Little Black River	22	14	33	100	165	295	52
Porcupine River	23	48	12	25	76	110	94
Sheenjek River	8	7	6	1	11	68	29
Yukon River							
Beaver Creek	1	5	3	3	16	37	14
Birch Creek	0	23	12	6	30	28	26
Chandalar River	13	9	55	75	50	100	44
Christian River	5	5	14	12	42	47	66
Hodzana River	2	10	10	13	9	5	21
Yukon River	89	56	62	85	58	117	98

[a] Data were unavailable for seasons prior to 1977-78 and for 1983-84.

Lynx harvests within the 2 major drainages and all drainages combined had similar patterns over time, but the trends differed substantially in magnitude (Fig. 25). Harvests in the Porcupine drainage were considerably higher and more dynamic than the Yukon's between 1978-79 and 1982-83, with a more rapid rise from 1979-80 to 1980-81 and a more precipitous decline after 1982-83. Catch per trapper was calculated for the 1984-85 season, and it revealed a 2-fold difference between the major drainages; the Porcupine River rate, of 336 lynx/63 trappers, averaged 5.33 lynx/trapper and the Yukon River rate, of 269 lynx/115 trappers, averaged 2.34 lynx/trapper.

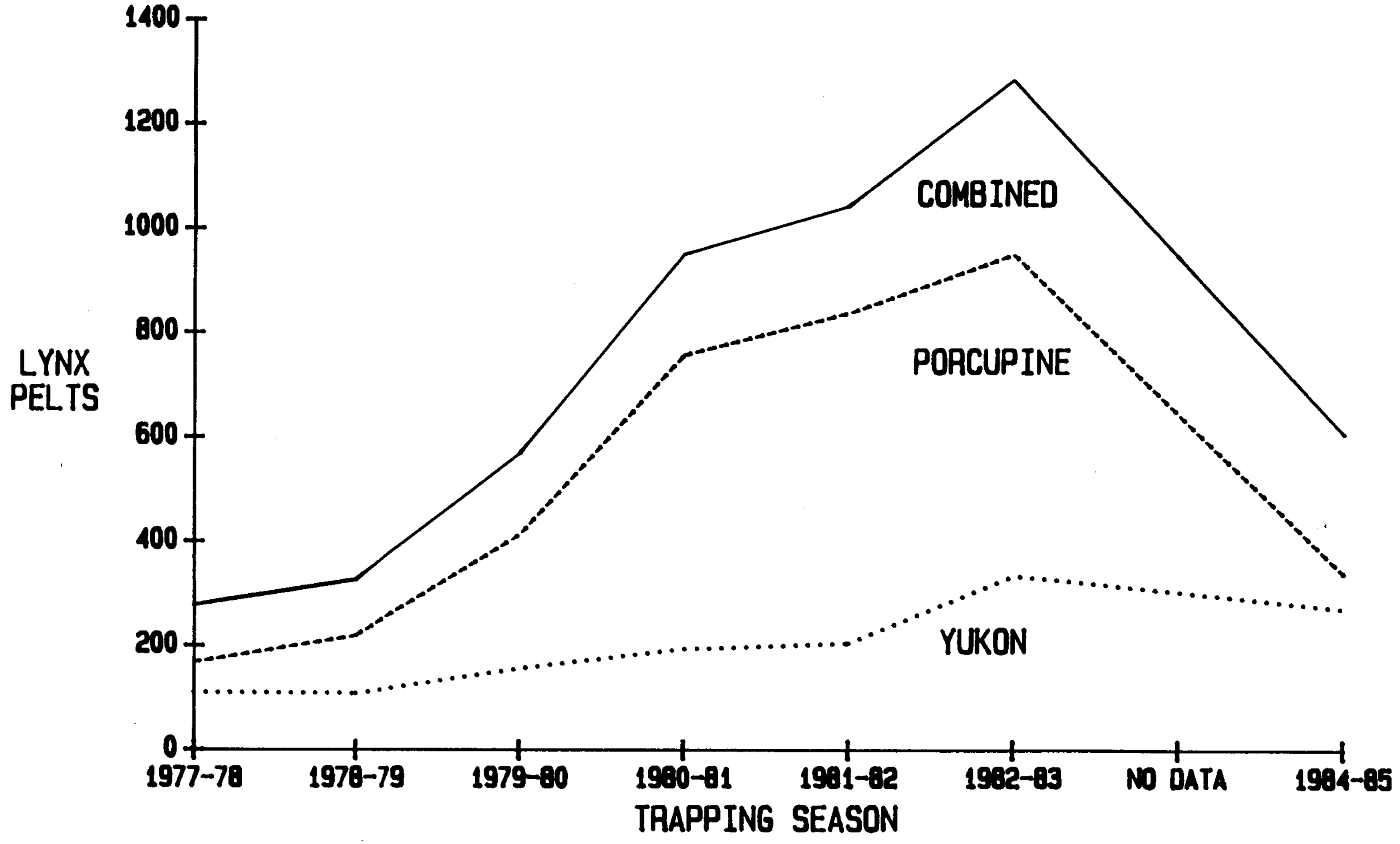

Fig. 25. Number of lynx pelts sealed by Alaska Department of Fish and Game from 1977 through 1985 for the Porcupine River drainage, the Yukon River drainage, and the 2 major drainages combined.

The harvest data showed lynx were near a low phase of their population cycle in the Yukon Flats basin during 1984-85. The peak in lynx harvested was in 1982-83 (Fig. 25) but patterns of decline in harvests for that season indicated the actual population peak for most of GMU 25 occurred during 1981-82 (Nowlin 1986b). Analysis of trapper questionnaires and pelt-export data from the previous decade indicated a similar cycle but with the peak about 1970-71 (O'Connor 1984). This 11-year cycle approximated the 10-year periodicity in cycles of lynx abundance commonly reported (Archibald 1977, Keith et al. 1977, Fox 1978, Brand and Keith 1979, Bergerud 1983). Lynx cycles indicated by harvest data are often 1 or 2 years behind actual population cycles, and lynx-hare cycles in 1 region are commonly asynchronous with those of another (O'Connor 1984, Nowlin 1986b). O'Connor (1984) reported differences of 1-2 years in regional peaks in hare and lynx populations in Alaska, with the Yukon River basin cycle leading those of the Tanana and Copper Rivers to the south and southeast, respectively. She suggested that indices derived from trapper questionnaires can also provide reasonably accurate documentation of trends.

Trapper Interviews:

The 23 trappers I interviewed trapped along creeks, rivers, winter trails, or on ridges within 40 km of 1 of the 10 minor drainages listed in Table 9. Some people trapped only near their villages, and others traveled up to 150 km to their traditional trapping areas. The latter group was composed of several people from Fort Yukon who trapped in the vicinity of the Black, Little Black, and Porcupine Rivers in the eastern part of the YFNWR. Many of the areas trapped were Native lands but refuge land was also used extensively. Trappers limited themselves to specific areas and most knew who trapped near them. All trappers said marten were their staple catch, and that lynx, despite their scarcity, were an important supplement because of their high pelt price. Due to low pelt prices, trapping of foxes, beavers, or muskrats was minimal. Low abundance of wolves, wolverines, land otters, and mink was the usual reason given for trappers' incidental catch of those species.

The information from trapper interviews correlated roughly with the aerial-survey results of the distribution and relative abundance of foxes, marten, lynx, and snowshoe hares. Trappers were asked to relate their observations of several furbearer species for the 1984-85 season and, if possible, to compare them to their observations for 1983-84 (Table 10). Some people, especially in the Chalkyitsik area, thought foxes were low to moderate and unchanged or declining. According to most trappers in other areas, though, their populations were high and increasing. Trappers reported that marten populations were at high levels and generally increasing in the Beaver area and on refuge lands east of Chalkyitsik but low to moderate and generally decreasing in other areas. All trappers thought lynx numbers were low with unchanged or declining trends. A few people who trapped in the Beaver, Fort Yukon, and Chalkyitsik areas, however, said they observed a slight increase in their lynx catch or noticed more sign, particularly near rivers. Snowshoe hares were generally thought to be low in number everywhere except the Fort Yukon area, where 1 trapper said they were moderate and increasing. Several other people reported increasing trends in hare populations for the Stevens Village, Beaver, and Chalkyitsik areas. Trappers all across the refuge said numbers of wolves and mink were low and decreasing and wolverines were mainly low and unchanged, but no one had comments on land otter numbers or trends. Beaver populations were reported to be universally high and increasing.

Trapper questionnaires from this area (Ernest 1986) suggested similar patterns to my interview data for lynx and hares, but different patterns for foxes and marten. Ernest stated that trappers believed foxes were less abundant in 1984-85 than in 1983-84 and that populations were moderately low in interior Alaska. In comparison, trappers reported to me that, with the exception of the Chalkyitsik area, fox populations were high and had increased in the region since 1983-84. Trapper questionnaires also indicated the total number of marten and the catch per trapper had declined in the Beaver-Stevens Village area, whereas trappers told me that marten populations were moderate to high with trends unchanged or increasing in those areas.

Table 10. Trapper observations of furbearer population levels (H, M, L)[a] in 1984-85 and trends (+, =, -)[b] between 1983-84 and 1984-85 for areas in the Yukon Flats National Wildlife Refuge, Alaska.

Area and no. of trappers interviewed	Red Fox	Marten	Lynx	Snowshoe hare	Wolf	Wolverine	Mink	Beaver
Stevens Village n = 3	1H+ 1M-	1M= 1M- 1L-	3L=	1L+	1L-	1L=		1H+
Beaver n = 10	7H+ 1M+ 1M-	3H+ 2H= 3M+ 1L+ 1L-	1L+ 9L=	3L+ 4L=	2L-	2L=	2L-	3H+
Venetie n = 1	1H+	1L=	1L-					1H+
Birch Creek n = 1	1H+	1L-	1L-	1L-		1L=		
Fort Yukon n = 2	2H+	1M+ 1M-	2M+	1M+	1L=	1M-		2H+
Sheenjek River n = 1		1L-	1L-					
Chalkyitsik and east n = 5	1H+ 3M- 1L=	3H+ 1M- 1L=	2L+ 2L- 1L=	1L+	3L- 1L=	2M+ 1L=	4L-	3H+
Total n = 23	13H+ 1M+ 5M- 1L=	6H+ 2H= 4M+ 1M= 3M- 1L+ 2L= 4L-	2M+ 3L+ 13L= 5L-	1M+ 5L+ 4L= 1L-	2L= 6L-	2M+ 1M- 5L=	6L-	10H+

[a] Population levels: H, high; M, moderate; L, low.

[b] Population trends: +, increased; =, unchanged; -, decreased

Information derived from trapper interviews or questionnaires is useful as a supplement to other types of population information (Brand and Keith 1979, O'Connor 1984). Caution must be used by the investigator, though, to ensure that methods of gathering information are similar if 2 or more sources of information are being compared. For example, Ernest (1986) analyzed information from trapper questionnaires sent to people scattered throughout interior Alaska, whereas I obtained information from trappers through direct interviews specifically for the Yukon Flats area. Standardizing methods and consolidating data would improve the quality and usefulness of trapper information.

SUMMARY AND CONCLUSIONS

The premise underlying the aerial survey technique used in this study was that the relative abundance of furbearer species tracks was distributed in approximate proportion to the actual abundance of those species. Indices of relative abundance were used to describe furbearer distribution on the YFNWR, because indices of actual abundance were unattainable within the scope of this project. Systematic sampling of transects from the air was used to survey the sizable refuge within a short time period. Caughley (1977b) stated that systematic sampling is appropriate when indices of abundance and mapping of distribution are desired, and that using aerial transects is the most practical and efficient method of gathering data over a large area. He cautioned, however, that the utility of this method depends upon the correction of visibility biases and is limited in accuracy by the variabilities inherent in nonrandom sampling.

The systematic establishment of 343 aerial transects across the YFNWR provided the framework for determining the distribution and relative abundance of furbearers on the refuge. The selection of each transect, the logistic constraints in how those transects were selected and flown, and the assumptions made, dictated how data were gathered and, to a large extent, how they could be interpreted. Indices of relative abundance were desired, so precision between transects was important and dependent upon corrections for track sightability in different vegetation covers and for the accumulation of tracks following snowfall. Final interpretation of data required the use of correction factors to limit bias due to conditions that were unavoidable, considering the objectives and logistic constraints of this project. I believe the aerial survey technique I used, although in need of refinement, met the design objectives effectively and efficiently.

Efforts were made to determine where furbearer populations were abundant or scarce across the entire refuge, and transects were analyzed according to elevation strata and between burned areas to gain precision (Caughley 1977b). Although hypotheses regarding the reasons for apparent patterns of distribution and relative abundance were untested, comparative indices of track density per transect between strata allowed broad interpretations. Red foxes largely used the central lake flats of the YFNWR. Mature coniferous and coniferous-deciduous-mixed forests and particularly the recently burned Lone Mountain area supported the highest populations of marten. Lynx appeared to be concentrated in mid-successional forests where habitat was diverse and snowshoe hares were most plentiful. The relationship between lynx and hare relative abundance or relationships between furbearer species and habitat in general can be more decisively measured in future studies if comparisons between strata are included, as suggested by the test-case analysis I conducted for the Lone Mountain burn.

Marten and lynx were the most economically important species to trappers on the Yukon Flats. Trapping is often influenced by the changing economy of the fur market (Bergerud 1983, O'Connor 1984), and can apparently have major effects on the population dynamics of furbearers (Bailey et al. 1986). Trappers can provide valuable insight into local populations of furbearers as well as other important biological information, such as wildfire/furbearer relationships (Stephenson 1984). Therefore, it is necessary to establish a system that monitors trapping patterns and intensities. In conjunction with models of population dynamics for each species, this would allow an assessment of the effects of trapping and the development of appropriate regulatory strategies.

RECOMMENDATIONS

The sound management of furbearers on the YFNWR depends upon continued development of monitoring techniques and upon robust analysis of the status, habitat relationships, and human use of their populations. The following recommendations are made in light of those requirements.

1. Refine aerial survey techniques and analyses of furbearer populations (a) under various vegetation, terrain, snow, and weather conditions, (b) within areas of different size, and (c) for trend sampling.
2. Establish permanent trend areas by geographic boundary. Survey these areas for high, moderate, and low relative abundance of red foxes, marten, lynx, and snowshoe hares.
3. Determine furbearer distribution and relative abundance in previously unexamined areas within and near the YFNWR.
4. Analyze the ages, sexes, and reproductive history of harvested furbearers through carcass collection, and calculate population vital statistics.
5. Assess furbearer harvest patterns and levels by documenting trapper use areas and catch-per-unit effort in relation to target species and pelt prices.
6. Examine the relationships between habitat characteristics and relative furbearer abundance for trend areas and those of special interest; efforts should be emphasized in the central lake flats, the Lone Mountain area, and the Black River-Little Black River drainages for red fox, marten, and lynx, respectively, in light of their relatively high track abundance in those areas.

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Appendix A. Corrected tracks/km values for all furbearer species documented on the YFNWR in late winter-early spring 1985. Data presented include the survey year (1 = 1985, 2 = 1986), number of days after snowfall (DAS) that transect was flown, and the carnivore and hare correction factors (CarnCF and HareCF, respectively).

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
1	1	21	4.3838	9.2642	0.084	0.125	0.084	1.147	0.000	0.000	0.000
2	1	22	4.0836	9.2416	0.371	0.408	0.000	1.260	0.000	0.000	0.000
3	1	22	3.2293	5.3600	0.470	0.000	0.147	0.195	0.117	0.000	0.147
4	1	22	2.6664	3.8369	0.170	0.073	0.000	0.349	0.000	0.000	0.000
5	1	22	3.1020	8.9283	0.085	0.846	0.000	0.974	0.000	0.000	0.000
6	1	22	3.6921	8.8360	0.201	0.705	0.034	0.643	0.000	0.000	0.000
7	1	22	2.5034	5.0286	0.159	0.273	0.023	0.549	0.000	0.000	0.000
8	1	22	3.5053	4.8647	0.510	0.446	0.159	0.442	0.032	0.000	0.000
9	1	22	3.9680	8.9425	0.253	0.794	0.144	0.406	0.000	0.000	0.000
10	1	22	3.5878	7.6158	0.196	0.359	0.000	0.762	0.163	0.000	0.000
11	1	22	3.2386	5.8104	0.000	0.118	0.059	2.166	0.029	0.000	0.000
12	1	22	3.6628	9.2099	0.033	0.366	0.000	0.837	0.067	0.000	0.000
13	1	21	4.3543	9.2620	0.124	0.622	0.041	2.205	0.000	0.000	0.000
14	1	21	3.7827	7.3386	0.108	0.108	0.036	0.210	0.000	0.000	0.000
15	1	21	3.7259	7.6933	0.497	0.674	0.071	0.366	0.000	0.000	0.000
16	1	21	4.8797	9.3016	0.000	0.000	0.186	6.644	0.000	0.000	0.000
17	1	22	3.8611	9.2248	0.211	0.351	0.035	1.090	0.000	0.000	0.000
18	1	22	3.5550	6.4097	0.452	0.388	0.000	1.282	0.000	0.000	0.000
19	1	22	5.2169	9.0879	0.285	0.427	0.095	0.661	0.000	0.000	0.000
20	1	22	2.9141	7.9398	0.159	0.530	0.000	0.000	0.000	0.000	0.000
21	1	22	2.2993	4.7055	0.543	0.188	0.021	0.342	0.000	0.000	0.000
22	1	22	4.9069	7.8348	0.000	0.580	0.000	0.356	0.000	0.000	0.000
23	1	22	5.2603	9.3303	0.000	0.574	0.048	0.339	0.000	0.000	0.000
24	1	23	4.2363	8.6548	0.147	0.516	0.000	1.656	0.000	0.000	0.000
25	1	23	4.8017	8.2199	0.125	0.418	0.000	0.643	0.000	0.000	0.000
26	1	23	4.5205	9.2745	0.157	0.118	0.079	1.855	0.000	0.000	0.000
27	1	23	3.6949	9.2123	0.064	0.386	0.000	3.605	0.000	0.000	0.000
28	1	23	5.6195	9.3573	0.195	0.538	0.049	0.244	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
29	1	22	4.7579	8.5075	0.606	0.346	0.043	0.696	0.000	0.000	0.000
30	1	22	3.3036	9.1828	0.210	0.481	0.060	2.337	0.000	0.000	0.000
31	1	22	3.6538	6.7075	0.299	0.233	0.033	1.037	0.000	0.000	0.000
32	1	21	2.1428	3.8817	0.286	0.490	0.020	0.259	0.000	0.000	0.000
33	1	21	5.0287	8.6120	0.096	0.048	0.048	1.804	0.048	0.000	0.000
34	1	21	4.2197	8.6712	0.121	0.040	0.000	0.743	0.000	0.000	0.000
35	1	14	1.7709	2.3209	0.000	0.126	0.000	0.033	0.000	0.000	0.000
36	1	14	1.4244	0.5000	0.000	0.020	0.000	0.029	0.000	0.000	0.000
37	1	14	3.5936	6.2483	0.103	0.565	0.051	0.268	0.000	0.000	0.000
38	1	14	3.8125	8.6913	0.000	1.797	0.054	0.372	0.054	0.000	0.000
39	1	14	3.0525	8.6682	0.131	0.262	0.000	0.619	0.000	0.000	0.000
40	1	14	3.2446	9.1784	0.278	0.278	0.139	3.802	0.000	0.000	0.000
41	1	14	4.1542	8.9734	0.119	0.534	0.119	0.256	0.000	0.000	0.000
42	1	14	3.1481	9.1711	0.720	0.090	0.045	2.882	0.000	0.000	0.000
43	1	21	4.6853	8.8767	0.000	0.714	0.089	0.338	0.000	0.000	0.000
44	1	21	5.4319	9.3432	0.207	0.103	0.103	4.538	0.000	0.000	0.000
45	1	21	3.8668	7.2253	0.147	0.331	0.000	0.757	0.037	0.000	0.000
46	1	21	3.9598	7.5058	0.490	0.792	0.075	0.357	0.000	0.000	0.000
47	1	22	4.5962	8.6821	0.084	0.000	0.501	1.973	0.000	0.000	0.000
48	1	22	3.8973	8.5951	0.425	0.071	0.106	2.500	0.000	0.000	0.000
49	1	23	2.8284	7.4889	0.443	0.148	0.025	0.326	0.049	0.000	0.000
50	1	23	3.6855	8.9554	0.096	0.032	0.000	1.480	0.000	0.000	0.000
51	1	23	4.5156	8.3177	0.196	0.903	0.039	0.217	0.000	0.000	0.000
52	1	23	4.3800	8.4441	0.305	0.952	0.152	0.367	0.000	0.000	0.000
53	1	23	3.8507	7.0720	0.134	0.737	0.067	0.738	0.000	0.000	0.000
54	1	23	5.3622	9.3380	0.047	0.699	0.000	2.274	0.000	0.000	0.000
55	1	23	3.6961	7.9480	0.354	0.161	0.032	0.829	0.000	0.000	0.000
56	1	23	4.6085	7.7952	0.200	0.441	0.000	0.203	0.080	0.040	0.000
57	1	23	3.6788	9.2111	0.608	0.032	0.096	0.561	0.096	0.000	0.000
58	1	23	4.1137	7.3308	1.037	0.000	0.072	0.829	0.000	0.000	0.000
59	1	13	4.4047	6.8737	0.678	0.203	0.000	0.211	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
60	1	13	3.2681	6.9665	0.603	0.251	0.151	1.822	0.000	0.000	0.050
61	1	13	5.3247	9.3351	0.082	0.164	0.000	0.000	0.000	0.000	0.000
62	1	13	2.8824	6.3653	0.665	0.443	0.089	1.077	0.000	0.000	0.000
63	1	13	3.4314	9.0046	0.317	0.211	0.053	2.355	0.106	0.000	0.000
64	1	13	3.2232	9.1768	0.248	0.298	0.050	0.424	0.000	0.000	0.000
65	1	16	3.3975	7.9431	0.467	0.127	0.042	0.596	0.000	0.000	0.000
66	1	16	4.6519	9.2844	0.116	0.523	0.000	0.812	0.000	0.000	0.000
67	1	16	3.0068	7.5712	0.601	1.353	0.000	1.136	0.000	0.000	0.000
68	1	16	2.8578	6.3373	0.357	1.858	0.000	0.792	0.000	0.000	0.000
69	1	16	4.3114	9.2588	0.054	0.485	0.216	1.620	0.054	0.000	0.000
70	1	16	3.8852	9.2266	0.097	0.826	0.194	0.807	0.000	0.000	0.000
71	1	16	3.4912	9.1970	0.044	1.440	0.044	1.265	0.000	0.000	0.000
72	1	15	5.4587	9.3452	0.000	1.092	0.000	0.623	0.073	0.000	0.000
73	1	15	4.5232	9.2747	0.000	1.387	0.060	0.000	0.000	0.060	0.000
74	1	14	4.3465	8.1503	0.000	1.552	0.000	0.349	0.000	0.000	0.000
75	1	14	3.3518	5.8716	0.000	1.101	0.048	0.168	0.048	0.000	0.000
76	1	14	1.4048	0.5000	0.020	0.000	0.000	0.000	0.000	0.000	0.000
77	1	14	2.3287	5.0957	0.000	0.299	0.000	0.073	0.000	0.000	0.000
78	1	14	1.4048	0.5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
79	1	14	1.9376	2.5028	0.000	0.360	0.000	0.143	0.000	0.000	0.000
80	1	15	3.9913	8.7053	0.053	0.692	0.000	0.348	0.000	0.000	0.000
81	1	15	3.5609	9.2022	0.095	1.757	0.095	2.945	0.000	0.000	0.000
82	1	15	3.8471	7.7195	0.103	1.847	0.000	0.412	0.000	0.000	0.000
83	1	15	4.1598	7.9490	0.055	1.331	0.000	0.318	0.000	0.000	0.000
84	1	15	3.1004	8.5863	0.000	3.348	0.000	0.114	0.000	0.165	0.000
85	1	15	5.5659	9.3533	0.000	0.371	0.223	0.748	0.074	0.000	0.000
86	1	16	5.6088	9.3565	0.000	0.911	0.070	1.053	0.000	0.000	0.000
87	1	16	4.6599	9.2850	0.116	0.582	0.000	0.232	0.000	0.000	0.000
88	1	16	3.1437	4.5469	0.511	0.314	0.000	0.341	0.000	0.000	0.000
89	1	16	5.3855	8.9810	0.000	1.077	0.067	1.123	0.000	0.000	0.000
90	1	16	3.5612	6.6737	0.267	0.534	0.000	2.169	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
91	1	16	3.3737	8.1808	0.590	0.801	0.211	3.579	0.000	0.000	0.000
92	1	16	3.3357	9.1852	0.083	1.960	0.000	2.526	0.000	0.000	0.000
93	1	14	3.2925	7.2272	0.847	2.070	0.047	0.929	0.000	0.000	0.000
94	1	13	2.8169	7.5236	0.433	0.000	0.000	3.820	0.000	0.000	0.000
95	1	13	2.9157	7.6924	0.493	0.224	0.000	0.828	0.000	0.000	0.000
96	1	13	5.7535	9.3674	0.708	0.177	0.089	0.144	0.000	0.000	0.000
97	1	13	5.0938	9.0100	0.392	0.000	0.157	0.693	0.000	0.000	0.000
98	1	13	4.0004	8.5864	0.985	0.000	0.000	1.189	0.000	0.000	0.000
99	1	13	3.2544	7.0869	1.001	0.100	0.350	1.853	0.000	0.000	0.000
100	1	23	4.4092	7.2764	0.268	0.077	0.000	0.063	0.000	0.000	0.000
101	1	23	3.9508	7.4126	0.137	0.069	0.000	0.580	0.172	0.000	0.034
102	1	23	3.1086	6.7685	0.189	0.108	0.000	1.707	0.000	0.000	0.000
103	1	22	3.6638	8.8681	0.000	0.600	0.033	0.967	0.000	0.000	0.000
104	1	22	3.1884	7.9079	0.116	0.986	0.029	0.359	0.000	0.000	0.000
105	1	22	3.3561	7.8540	0.122	0.305	0.031	1.000	0.000	0.000	0.000
106	1	22	3.0000	8.1695	0.327	1.255	0.027	2.005	0.000	0.000	0.000
107	1	22	2.0373	3.3268	0.093	0.167	0.000	0.333	0.037	0.000	0.000
108	1	22	3.5341	9.2002	0.032	1.060	0.000	0.167	0.000	0.000	0.000
109	1	22	4.1040	8.3201	0.000	0.858	0.075	1.135	0.000	0.000	0.000
110	1	21	3.7169	7.0107	0.283	0.071	0.071	1.870	0.000	0.000	0.000
111	1	21	3.3659	7.4471	0.449	0.032	0.064	1.915	0.000	0.000	0.000
112	1	13	2.3303	5.0350	0.717	0.000	0.072	2.711	0.000	0.000	0.000
113	1	13	3.0652	8.2596	0.424	0.000	0.236	3.939	0.000	0.000	0.000
114	1	13	3.0684	7.6465	1.180	0.000	0.000	2.823	0.000	0.000	0.000
115	1	10	3.4031	7.8923	0.681	0.544	0.068	1.105	0.000	0.000	0.000
116	1	10	2.9576	6.6952	0.473	0.237	0.355	0.937	0.000	0.000	0.000
117	1	10	3.7760	7.7484	0.151	0.227	0.076	0.775	0.000	0.000	0.000
118	1	16	3.4054	9.1905	0.766	0.255	0.000	0.689	0.000	0.000	0.000
119	1	16	2.9535	3.8322	0.037	1.144	0.000	0.240	0.037	0.000	0.000
120	1	16	4.5071	9.2735	1.127	0.113	0.000	2.318	0.000	0.000	0.000
121	1	16	3.8316	9.2226	0.431	0.383	0.000	3.228	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
122	1	16	3.1481	9.1711	0.157	1.141	0.000	3.210	0.000	0.000	0.000
123	1	15	3.9432	8.9062	0.105	2.839	0.158	1.069	0.000	0.000	0.000
124	1	15	5.0030	9.3109	0.000	0.934	0.000	0.869	0.000	0.000	0.000
124	2	9	5.0030	9.3109	0.111	1.890	0.111	5.380	0.000	0.000	0.000
125	1	15	3.6788	9.2111	0.049	1.766	0.000	1.965	0.000	0.000	0.000
126	1	15	3.5129	6.9942	0.094	1.265	0.047	0.653	0.047	0.000	0.281
126	2	9	3.5129	6.9942	0.390	2.420	0.156	0.622	0.000	0.000	0.000
127	1	15	5.1004	8.8225	0.000	0.884	0.000	0.471	0.000	0.000	0.000
128	1	14	3.2333	8.5968	0.000	1.755	0.046	0.123	0.000	0.000	0.000
129	1	14	1.8877	2.9019	0.054	0.431	0.000	0.000	0.000	0.000	0.000
130	1	14	1.7124	1.8007	0.049	0.269	0.000	0.051	0.000	0.000	0.000
131	1	19	1.4048	0.5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
132	1	9	3.3947	9.1897	0.302	1.886	0.000	0.000	0.000	0.000	0.000
133	1	9	5.0647	9.3155	0.225	0.563	0.000	0.000	0.000	0.000	0.000
134	1	9	3.6414	8.7638	0.728	0.890	0.000	0.390	0.000	0.000	0.000
134	2	9	3.6414	8.7638	0.162	0.809	0.000	1.948	0.000	0.000	0.000
135	1	9	2.2861	4.6361	0.152	0.914	0.152	0.618	0.102	0.000	0.000
135	2	9	2.2861	4.6361	0.152	1.727	0.000	0.721	0.000	0.000	0.000
136	1	9	2.2845	4.6274	0.965	2.437	0.355	0.103	0.000	0.000	0.000
136	2	9	2.2845	4.6274	0.000	4.163	0.000	1.234	0.000	0.000	0.000
137	1	15	1.9516	2.8759	0.000	3.643	0.000	0.153	0.026	0.000	0.000
137	2	9	1.9516	2.8759	1.258	1.821	0.000	0.064	0.000	0.000	0.000
138	1	15	3.5754	7.0331	0.191	0.906	0.095	0.188	0.000	0.000	0.000
138	2	9	3.5754	7.0331	0.159	1.430	0.079	1.875	0.000	0.000	0.000
139	1	15	4.5002	8.4867	0.060	1.260	0.000	0.566	0.000	0.000	0.000
140	1	15	5.4962	9.3481	0.000	0.733	0.000	0.997	0.000	0.000	0.000
141	1	15	5.0655	8.8716	0.000	1.418	0.068	0.710	0.068	0.000	0.000
142	1	15	4.7107	7.3920	0.000	0.251	0.000	0.296	0.000	0.000	0.000
143	1	15	2.8501	7.6103	0.798	1.026	0.038	1.725	0.000	0.000	0.000
144	1	15	3.9569	7.6599	0.317	0.791	0.000	1.021	0.000	0.000	0.000
145	1	10	4.4776	9.2713	0.179	0.985	0.090	0.371	0.000	0.000	0.090

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
146	1	10	4.1218	8.8171	0.330	0.247	0.082	1.587	0.000	0.000	0.000
147	1	10	5.8286	9.3731	0.000	0.000	0.000	0.562	0.000	0.000	0.000
148	1	10	2.7304	6.6650	1.201	0.109	0.000	1.333	0.109	0.000	0.000
149	1	21	2.8271	6.9180	0.592	0.027	0.592	0.857	0.000	0.000	0.000
150	1	26	3.9345	7.6521	0.061	0.151	0.061	0.353	0.000	0.000	0.000
151	1	26	3.6126	7.2585	0.195	0.111	0.028	0.279	0.000	0.000	0.000
152	1	26	3.3908	8.1125	0.026	0.339	0.156	0.624	0.000	0.000	0.000
153	1	26	3.0490	7.6765	0.023	0.751	0.047	0.059	0.000	0.000	0.000
154	1	26	3.3295	8.5012	0.026	0.205	0.026	0.916	0.000	0.000	0.000
155	1	26	4.8931	9.3026	0.113	0.414	0.000	0.429	0.000	0.000	0.000
156	1	26	4.4749	9.2711	0.034	0.895	0.034	0.000	0.000	0.000	0.000
157	1	26	4.9150	8.8600	0.643	0.113	0.076	0.136	0.076	0.000	0.000
158	1	26	3.7804	8.5868	0.174	0.291	0.000	0.132	0.000	0.000	0.087
159	1	26	3.7355	7.4049	0.115	0.029	0.057	0.456	0.000	0.000	0.000
160	1	21	2.3487	4.7714	0.939	0.022	0.000	1.454	0.000	0.000	0.000
161	1	21	3.8578	8.6439	0.367	0.000	0.073	2.552	0.000	0.000	0.000
162	1	10	3.9783	6.9450	0.477	0.000	0.000	0.278	0.080	0.000	0.000
163	1	10	2.9138	5.5241	0.350	0.117	0.000	0.331	0.000	0.000	0.000
164	1	10	3.7306	6.2517	0.970	0.224	0.075	0.375	0.000	0.000	0.000
165	1	10	4.2336	8.7405	0.254	0.339	0.000	1.224	0.000	0.000	0.000
166	1	15	2.6128	5.8259	0.732	0.174	0.035	0.777	0.000	0.000	0.000
167	1	15	5.2270	8.1664	0.209	0.348	0.209	2.395	0.000	0.000	0.000
167	2	9	5.2270	8.1664	0.813	0.116	0.116	1.433	0.000	0.000	0.000
168	1	15	1.6714	1.4018	0.111	0.312	0.000	0.019	0.000	0.000	0.000
168	2	9	1.6714	1.4018	0.186	2.749	0.037	0.280	0.000	0.000	0.000
169	1	15	1.9186	2.7025	0.153	0.895	0.000	0.108	0.026	0.000	0.000
169	2	9	1.9186	2.7025	0.298	2.302	0.000	1.021	0.000	0.000	0.000
170	1	9	2.2213	4.3673	1.234	2.468	0.099	0.194	0.000	0.000	0.000
170	2	9	2.2213	4.3673	0.099	2.024	0.000	0.679	0.000	0.000	0.000
171	1	9	3.1481	9.1711	1.959	1.749	0.140	0.408	0.000	0.070	0.000
171	2	9	3.1481	9.1711	0.000	2.029	0.000	3.261	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
172	1	9	3.1252	8.0497	0.903	0.972	0.069	2.325	0.000	0.000	0.000
172	2	9	3.1252	8.0497	0.000	0.694	0.000	5.366	0.000	0.000	0.000
173	1	9	4.4830	9.2717	0.199	0.598	0.299	0.206	0.000	0.000	0.000
174	1	19	1.4048	0.5000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
175	1	19	3.6887	9.0240	0.000	1.631	0.000	0.095	0.000	0.000	0.078
176	1	19	3.1908	4.0759	0.067	0.202	0.000	0.086	0.000	0.000	0.000
177	1	19	1.9474	3.0727	0.000	0.533	0.000	0.065	0.000	0.000	0.000
178	1	9	2.4444	5.4685	0.000	0.054	0.163	0.000	0.000	0.000	0.000
179	1	9	4.3141	9.2590	0.096	1.150	0.288	0.206	0.000	0.000	0.000
179	2	9	4.3141	9.2590	0.096	1.917	0.000	2.675	0.000	0.000	0.000
180	1	9	1.6286	1.1763	0.688	1.810	0.000	0.052	0.036	0.000	0.000
180	2	9	1.6286	1.1763	0.036	1.773	0.036	0.209	0.000	0.000	0.000
181	1	9	3.1481	9.1711	1.049	3.778	0.420	1.427	0.140	0.000	0.000
181	2	9	3.1481	9.1711	0.280	2.449	0.000	4.280	0.000	0.000	0.000
182	1	17	3.0086	8.4774	0.743	1.487	0.000	0.499	0.000	0.000	0.000
182	2	9	3.0086	8.4774	0.535	1.070	0.000	0.188	0.000	0.000	0.000
183	1	15	2.6158	6.3703	0.314	0.767	0.000	0.595	0.000	0.000	0.000
183	2	9	2.6158	6.3703	0.174	0.756	0.116	0.142	0.000	0.000	0.000
184	1	17	3.8433	7.9938	0.452	0.362	0.090	0.752	0.000	0.000	0.226
184	2	9	3.8433	7.9938	0.598	1.025	0.000	4.441	0.000	0.000	0.000
185	1	10	3.1662	5.8078	0.000	0.000	0.000	0.581	0.000	0.000	0.000
186	1	10	3.6983	6.8129	1.257	0.074	0.074	2.589	0.000	0.000	0.000
187	1	10	2.6267	4.1617	0.368	0.158	0.000	0.999	0.053	0.000	0.000
188	1	10	4.0488	7.3090	0.891	0.081	0.081	2.193	0.081	0.000	0.000
189	1	21	4.1012	8.7647	0.195	0.156	0.000	0.501	0.000	0.000	0.000
190	1	21	2.8443	7.1982	0.217	0.542	0.027	0.548	0.000	0.000	0.000
191	1	26	5.1183	9.3196	0.079	0.472	0.079	0.000	0.000	0.000	0.000
192	1	26	3.3893	9.1893	0.000	0.313	0.078	0.353	0.000	0.000	0.000
193	1	26	2.7223	5.7182	0.524	0.021	0.000	0.308	0.000	0.000	0.000
194	1	26	4.9718	8.5053	0.115	0.497	0.038	0.000	0.000	0.000	0.000
195	1	26	4.1039	8.5423	0.095	0.095	0.316	0.854	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
196	1	5	2.3273	4.6055	0.186	0.838	0.372	0.000	0.000	0.000	0.000
197	1	5	3.1481	9.1711	0.252	0.378	0.252	3.940	0.000	0.000	0.000
198	1	5	3.2209	6.5773	0.773	0.515	0.258	0.000	0.000	0.000	0.000
199	1	5	3.9731	8.9942	0.159	0.795	0.636	4.317	0.000	0.000	0.000
200	1	26	5.0464	9.0241	0.039	0.194	0.078	0.208	0.000	0.000	0.000
201	1	26	3.9159	7.4687	0.241	0.120	0.060	0.057	0.000	0.000	0.000
202	1	26	3.1432	5.9849	0.193	0.097	0.097	0.230	0.000	0.000	0.000
203	1	26	3.3030	6.8429	0.102	0.152	0.025	0.263	0.000	0.000	0.000
204	1	21	5.5680	8.9436	0.159	0.053	0.053	0.852	0.000	0.000	0.000
205	1	21	4.9915	9.1221	0.048	0.333	0.000	0.782	0.000	0.000	0.000
206	1	10	2.5816	5.2746	0.413	0.207	0.000	0.316	0.000	0.000	0.000
207	1	10	4.2937	8.7448	0.687	0.429	0.086	1.749	0.000	0.000	0.000
208	1	17	2.4806	5.6593	0.029	0.700	0.000	0.067	0.000	0.000	0.000
208	2	9	2.4806	5.6593	0.055	2.260	0.000	0.503	0.000	0.000	0.000
209	1	17	3.0043	8.4427	0.954	0.353	0.035	0.199	0.000	0.000	0.000
209	2	9	3.0043	8.4427	0.534	1.402	0.000	0.188	0.000	0.000	0.000
210	1	17	4.1946	7.8654	0.592	0.790	0.099	1.851	0.000	0.000	0.000
210	2	9	4.1946	7.8654	0.186	1.771	0.000	3.671	0.000	0.000	0.000
211	1	9	4.9259	8.6035	0.438	0.547	0.328	0.574	0.000	0.000	0.000
211	2	9	4.9259	8.6035	0.109	2.408	0.000	9.559	0.000	0.109	0.000
212	1	17	5.3729	9.3388	0.126	1.960	0.000	4.834	0.000	0.000	0.000
212	2	9	5.3729	9.3388	0.119	2.149	0.000	5.188	0.000	0.000	0.000
213	1	17	4.8234	9.2973	0.000	0.908	0.000	1.094	0.000	0.000	0.000
213	2	9	4.8234	9.2973	0.214	2.572	0.000	3.512	0.000	0.000	0.000
214	1	19	5.0727	9.3161	0.053	1.282	0.000	2.452	0.000	0.000	0.000
214	2	9	5.0727	9.3161	0.000	1.353	0.000	7.867	0.000	0.000	0.000
215	1	19	1.4600	0.5000	0.000	0.031	0.000	0.000	0.000	0.000	0.000
216	1	9	3.5073	9.1982	0.078	1.169	0.078	0.000	0.000	0.000	0.000
217	1	9	3.7853	8.6037	0.421	1.346	0.084	0.765	0.000	0.000	0.000
218	1	19	3.2054	7.7571	0.101	0.439	0.034	0.245	0.000	0.067	0.034
219	1	17	2.6431	4.4533	1.368	0.249	0.031	0.576	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
219	2	9	2.6431	4.4533	0.176	0.529	0.059	0.693	0.000	0.000	0.000
220	1	17	3.5949	8.4028	0.169	1.015	0.085	0.890	0.000	0.000	0.000
220	2	9	3.5949	8.4028	0.320	0.799	0.240	2.054	0.000	0.000	0.000
221	1	17	4.1695	7.8305	0.687	0.540	0.049	1.013	0.000	0.000	0.000
221	2	9	4.1695	7.8305	0.185	0.371	0.000	2.088	0.000	0.000	0.000
222	1	17	5.1171	8.6705	0.482	0.903	0.060	0.510	0.000	0.000	0.000
222	2	9	5.1171	8.6705	0.000	1.706	0.000	2.312	0.000	0.000	0.000
223	1	17	4.5703	8.9708	0.323	1.452	0.054	1.266	0.000	0.000	0.000
223	2	9	4.5703	8.9708	0.102	1.727	0.102	4.784	0.000	0.000	0.000
224	1	17	4.4617	8.0233	0.420	0.210	0.000	2.737	0.000	0.000	0.000
224	2	9	4.4617	8.0233	0.198	0.892	0.000	8.543	0.000	0.000	0.000
225	1	10	2.8483	7.6797	0.684	0.114	0.114	1.075	0.057	0.000	0.000
226	1	10	2.9192	7.1405	0.876	0.117	0.000	1.142	0.000	0.000	0.000
227	1	20	4.2021	8.2249	0.126	0.252	0.042	1.480	0.000	0.000	0.000
228	1	20	4.6370	7.2317	0.927	0.046	0.000	1.012	0.000	0.000	0.000
229	1	20	3.7181	8.0360	0.186	0.112	0.037	1.768	0.037	0.000	0.000
230	1	20	4.9081	8.8255	0.393	0.442	0.049	1.324	0.000	0.000	0.000
231	1	21	2.9319	8.0959	0.279	0.028	0.000	1.157	0.000	0.000	0.000
232	1	26	4.4830	9.2717	0.000	0.690	0.034	0.499	0.000	0.000	0.000
233	1	26	4.5891	9.1431	0.141	0.212	0.035	0.211	0.000	0.000	0.000
234	1	5	3.1063	8.9630	0.124	2.112	0.124	4.661	0.000	0.000	0.000
235	1	5	3.4851	8.8033	0.139	0.558	0.139	5.986	0.000	0.000	0.000
236	1	5	2.5653	4.9850	0.410	0.000	0.000	0.997	0.000	0.000	0.000
237	1	5	3.0525	8.6682	0.122	1.343	0.000	3.467	0.000	0.000	0.000
238	1	5	3.8494	7.3951	0.462	0.462	0.000	1.479	0.000	0.000	0.000
239	1	5	2.9911	7.2434	0.838	0.479	0.359	4.346	0.000	0.000	0.000
240	1	5	3.8075	9.2208	0.000	1.066	0.457	4.426	0.000	0.000	0.000
241	1	5	3.3237	7.9524	0.133	2.127	0.133	0.318	0.000	0.000	0.000
242	1	5	4.0943	9.2424	0.000	0.983	0.000	2.588	0.000	0.164	0.000
243	1	21	2.8796	7.8358	0.411	0.055	0.082	5.298	0.000	0.000	0.000
244	1	21	3.1481	9.1711	0.420	0.120	0.000	1.572	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
245	1	20	3.2280	7.1788	0.387	0.032	0.032	1.938	0.000	0.000	0.000
246	1	20	3.7415	8.4297	0.262	0.973	0.000	0.843	0.000	0.000	0.000
247	1	20	3.9964	9.0470	0.400	0.320	0.040	5.247	0.000	0.000	0.000
248	1	18	3.3284	7.4443	0.444	0.185	0.037	0.827	0.000	0.000	0.000
249	1	18	3.2186	4.1380	0.715	0.000	0.036	0.598	0.000	0.000	0.000
250	1	10	4.0059	9.2357	0.401	0.320	0.000	0.924	0.240	0.000	0.000
251	1	11	3.9806	6.4840	0.941	0.000	0.072	1.533	0.000	0.000	0.000
252	1	11	4.8422	9.2988	0.440	0.000	0.352	5.748	0.000	0.000	0.000
253	1	11	5.4104	9.3416	0.787	0.197	0.098	2.548	0.098	0.000	0.000
254	1	9	3.0932	7.6625	0.206	1.443	0.137	1.873	0.069	0.000	0.000
255	1	9	3.7121	7.6068	0.247	1.485	0.000	2.198	0.000	0.000	0.000
256	1	11	4.2682	8.7256	1.707	0.388	0.155	2.856	0.000	0.000	0.000
257	1	8	3.6693	7.7586	1.559	0.459	0.000	2.716	0.000	0.000	0.000
258	1	8	2.8556	5.8606	1.356	0.500	0.071	0.293	0.143	0.000	0.000
259	1	8	3.0753	6.2877	0.154	0.461	0.000	0.472	0.000	0.000	0.000
260	1	11	5.2443	9.3291	0.191	0.763	0.000	2.035	0.000	0.000	0.000
261	1	11	5.2711	9.3311	0.000	0.288	0.192	0.848	0.000	0.000	0.000
262	1	11	5.4039	8.5213	0.098	0.000	0.000	0.775	0.000	0.000	0.000
263	1	10	4.2069	9.2509	0.421	2.103	0.337	1.110	0.000	0.000	0.084
264	1	10	5.1085	9.0970	0.000	0.204	0.000	0.364	0.000	0.000	0.000
265	1	18	4.5391	7.7388	0.050	0.353	0.000	0.172	0.000	0.000	0.000
266	1	18	5.2552	9.1079	0.058	0.350	0.000	0.202	0.000	0.000	0.000
267	1	20	4.9165	8.9112	0.049	0.049	0.000	0.267	0.000	0.000	0.000
268	1	20	4.0773	7.1425	0.408	0.082	0.041	1.071	0.041	0.000	0.000
269	1	19	3.3529	6.1837	0.318	0.635	0.035	2.148	0.000	0.000	0.000
270	1	19	3.8900	6.0331	0.819	0.082	0.000	3.429	0.000	0.000	0.000
271	1	19	2.0109	3.2141	0.275	0.127	0.127	0.338	0.000	0.000	0.000
272	1	5	4.5527	9.2769	0.000	1.821	0.000	1.113	0.000	0.000	0.000
273	1	5	4.3113	7.9275	0.172	1.725	0.000	0.634	0.000	0.000	0.000
274	1	5	2.7747	6.2288	0.999	0.777	0.222	0.498	0.111	0.000	0.000
275	1	5	4.2508	9.0492	0.170	1.020	0.170	3.258	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
276	1	5	3.1116	5.5872	0.000	0.498	0.373	2.011	0.000	0.000	0.000
277	1	5	3.4248	6.9201	0.137	1.096	0.137	3.875	0.000	0.000	0.000
278	1	5	5.1297	8.6709	0.205	1.026	0.000	1.387	0.000	0.000	0.000
279	1	5	3.0782	8.1915	0.246	2.216	0.000	0.000	0.000	0.000	0.000
280	1	19	3.1988	7.2981	0.202	0.168	0.067	1.306	0.000	0.000	0.000
281	1	20	3.0648	6.2801	0.153	0.552	0.000	1.130	0.000	0.000	0.000
282	1	20	4.5768	9.2788	0.000	0.458	0.000	1.577	0.000	0.000	0.000
283	1	20	5.1868	9.0683	0.052	0.363	0.052	0.363	0.000	0.000	0.000
284	1	19	4.2331	8.1934	0.045	0.535	0.045	0.345	0.000	0.000	0.000
285	1	19	5.0010	8.3030	0.000	0.263	0.000	0.262	0.000	0.000	0.000
286	1	18	4.0781	8.0456	0.091	0.362	0.000	0.715	0.000	0.000	0.000
287	1	18	4.3186	8.2175	0.000	0.144	0.000	1.826	0.000	0.000	0.000
288	1	18	4.7877	8.9360	0.053	1.330	0.000	1.886	0.000	0.000	0.000
289	1	11	5.6249	9.3577	0.000	0.102	0.102	1.021	0.000	0.000	0.000
290	1	11	4.6422	7.7192	0.084	0.506	0.000	0.702	0.000	0.000	0.000
291	1	11	5.1692	9.3234	0.094	0.752	0.094	1.356	0.000	0.000	0.000
292	1	11	4.6963	9.1511	0.000	0.427	0.000	0.832	0.000	0.000	0.000
293	1	8	4.1714	8.1551	0.209	0.313	0.104	0.408	0.000	0.000	0.000
294	1	8	3.9945	8.4834	0.599	0.399	0.200	0.424	0.000	0.000	0.000
295	1	8	3.9495	8.2067	0.099	0.691	0.000	0.616	0.000	0.000	0.000
296	1	8	3.8879	9.2269	0.000	0.972	0.000	1.153	0.000	0.000	0.000
297	1	5	4.0001	8.2100	0.320	2.240	0.000	0.657	0.000	0.000	0.000
298	1	11	3.5554	7.1861	0.646	0.517	0.000	3.397	0.000	0.000	0.000
299	1	11	5.6195	9.3573	0.000	0.000	0.102	0.510	0.000	0.000	0.000
300	1	8	3.3552	7.5612	0.000	0.587	0.168	0.189	0.000	0.000	0.000
301	1	8	3.4899	7.8307	0.262	1.047	0.174	0.196	0.000	0.000	0.000
302	1	8	3.8611	9.2248	0.193	0.772	0.000	0.692	0.000	0.000	0.000
303	1	8	3.1874	8.6271	0.239	2.151	0.080	2.157	0.000	0.000	0.000
304	1	8	3.3893	9.1893	0.763	1.525	0.085	1.378	0.000	0.000	0.000
305	1	11	5.0060	8.6280	0.000	0.637	0.091	2.196	0.000	0.000	0.000
306	1	11	3.1125	5.3529	0.453	1.188	0.000	1.265	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
307	1	11	4.9226	9.3048	0.090	3.043	0.000	1.523	0.000	0.000	0.000
308	1	11	5.2637	8.9032	0.096	0.479	0.096	0.486	0.000	0.000	0.000
309	1	19	4.6331	9.2830	0.000	0.049	0.000	0.293	0.000	0.000	0.000
310	1	18	4.8229	7.7098	0.322	0.054	0.000	0.171	0.000	0.000	0.000
311	1	18	4.5754	8.3393	0.102	0.356	0.051	0.927	0.000	0.000	0.000
312	1	19	4.7584	8.6771	0.000	1.352	0.000	0.000	0.000	0.000	0.000
313	1	19	3.5772	7.1525	0.151	1.130	0.000	0.602	0.000	0.000	0.000
314	1	20	4.4991	9.2729	0.045	0.585	0.000	0.464	0.000	0.000	0.000
315	1	20	5.6356	9.3586	0.000	0.338	0.000	1.497	0.000	0.000	0.000
316	1	20	5.4855	9.3472	0.000	0.055	0.000	0.561	0.000	0.000	0.000
317	1	19	4.7698	9.2933	0.151	0.452	0.050	0.587	0.000	0.000	0.000
318	1	5	3.9521	8.0353	0.000	3.320	0.000	1.928	0.000	0.000	0.000
319	1	5	2.6502	5.1340	0.106	0.530	0.106	2.464	0.000	0.000	0.000
320	1	5	3.6367	8.5584	0.145	1.309	0.291	3.081	0.000	0.000	0.000
321	1	19	2.9277	6.9753	0.092	1.140	0.154	0.808	0.000	0.000	0.000
322	1	19	4.9276	8.9975	0.000	0.622	0.000	1.042	0.000	0.000	0.000
323	1	19	4.1372	9.2456	0.087	0.827	0.044	1.071	0.000	0.000	0.000
324	1	20	4.5205	9.2745	0.000	0.678	0.000	0.185	0.000	0.000	0.000
325	1	19	4.4079	9.2660	0.000	1.114	0.000	1.366	0.000	0.000	0.000
326	1	19	3.7324	9.2151	0.000	1.061	0.000	0.873	0.000	0.000	0.000
327	1	18	3.5984	9.2050	0.000	0.800	0.080	0.614	0.000	0.000	0.000
328	1	18	4.9923	9.3101	0.000	0.277	0.000	0.310	0.000	0.000	0.000
329	1	19	4.6321	8.0525	0.195	0.731	0.000	0.170	0.000	0.000	0.000
330	1	11	5.8286	9.3731	0.000	0.636	0.000	2.045	0.000	0.000	0.000
331	1	11	2.3820	5.2518	0.000	0.476	0.000	0.000	0.000	0.000	0.000
332	1	8	2.6135	6.4164	0.000	1.895	0.065	0.160	0.000	0.000	0.000
333	1	8	2.5668	6.2085	0.128	0.578	0.000	0.621	0.000	0.000	0.000
334	1	8	2.5819	6.2952	0.000	1.355	0.000	0.472	0.000	0.000	0.000
335	1	8	2.6438	6.5177	0.066	1.190	0.000	0.489	0.000	0.000	0.000
336	1	8	2.9430	8.1132	0.147	0.809	0.000	0.406	0.000	0.000	0.000
337	1	11	4.5542	7.5335	0.083	0.662	0.083	1.644	0.000	0.000	0.000

Appendix A. Continued.

Transect	Survey	DAS	CarnCF	HareCF	Red Fox	Marten	Lynx	Hare	Wolf	Wolverine	Otter
338	1	11	3.5498	8.5694	0.065	0.516	0.194	1.246	0.000	0.000	0.000
339	1	19	3.7378	9.2155	0.000	1.102	0.000	0.485	0.000	0.000	0.000
340	1	18	3.7271	9.2147	0.000	0.124	0.000	0.000	0.000	0.000	0.000
341	1	19	3.9425	8.0686	0.083	0.042	0.042	1.359	0.290	0.000	0.000
342	1	19	3.4434	8.8344	0.000	1.124	0.000	2.976	0.000	0.000	0.000
343	1	19	3.6429	8.0631	0.000	1.380	0.000	2.631	0.000	0.000	0.000

Appendix B. Corrected tracks/km values for red foxes, marten, lynx, and snowshoe hares documented in the Lone Mountain burn area, Yukon Flats National Wildlife Refuge, Alaska, inside vs. outside in 1985 and 1986.

Location	Transect	Year	Red fox	Marten	Lynx	Snowshoe hare
Inside	136	1985	0.965	2.437	0.355	0.103
		1986	0.000	4.163	0.000	1.234
	137	1985	0.000	3.643	0.000	0.153
		1986	1.258	1.821	0.000	0.064
	168	1985	0.111	0.312	0.000	0.019
		1986	0.186	2.749	0.037	0.280
	169	1985	0.153	0.895	0.000	0.108
		1986	0.298	2.302	0.000	1.021
	170	1985	1.234	2.468	0.099	0.194
		1986	0.099	2.024	0.000	0.679
	182	1985	0.743	1.487	0.000	0.499
		1986	0.535	1.070	0.000	0.188
	183	1985	0.314	0.767	0.000	0.595
		1986	0.174	0.756	0.116	0.142
	208	1985	0.029	0.700	0.000	0.067
		1986	0.055	2.260	0.000	0.503
	209	1985	0.954	0.353	0.035	0.199
		1986	0.534	1.402	0.000	0.188
	210	1985	0.592	0.790	0.099	1.851
		1986	0.186	1.771	0.000	3.671
	211	1985	0.438	0.547	0.328	0.574
		1986	0.109	2.408	0.000	9.559
	212	1985	0.126	1.960	0.000	4.834
		1986	0.119	2.149	0.000	5.188
	213	1985	0.000	0.908	0.000	1.094
		1986	0.214	2.572	0.000	3.512
Outside	124	1985	0.000	0.934	0.000	0.869
		1986	0.111	1.890	0.111	5.380
	134	1985	0.728	0.890	0.000	0.390
		1986	0.162	0.809	0.000	1.948

Appendix B. Continued.

Transect	Year	Red fox	Marten	Lynx	Snowshoe hare
138	1985	0.191	0.906	0.095	0.188
	1986	0.159	1.430	0.079	1.875
167	1985	0.209	0.348	0.209	2.395
	1986	0.813	0.116	0.116	11.433
171	1985	1.959	1.749	0.140	0.408
	1986	0.000	2.029	0.000	3.261
172	1985	0.903	0.972	0.069	2.325
	1986	0.000	0.694	0.000	5.366
179	1985	0.096	1.150	0.288	0.206
	1986	0.096	1.917	0.000	2.675
214	1985	0.053	1.282	0.000	2.452
	1986	0.000	1.353	0.000	7.867
219	1985	1.368	0.249	0.031	0.576
	1986	0.176	0.529	0.059	0.693
220	1985	0.169	1.015	0.085	0.890
	1986	0.320	0.799	0.240	2.054
221	1985	0.687	0.540	0.049	1.013
	1986	0.185	0.371	0.000	2.088
222	1985	0.482	0.903	0.060	0.510
	1986	0.000	1.706	0.000	2.312
223	1985	0.323	1.452	0.054	1.266
	1986	0.102	1.727	0.102	4.784
224	1985	0.420	0.210	0.000	2.737
	1986	0.198	0.892	0.000	18.543