APPENDIX A

A FURBEARER SURVEY TECHNIQUE USING AERIAL TRACK COUNTS

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Abstract: I developed and tested an aerial survey technique that used counts of tracks to determine the distribution and relative abundance of furbearers across a 35,000-km^2 area characterized by poor access and diverse habitat in northeast interior Alaska. Red fox (*Vulpes vulpes*), marten (*Martes americana*), lynx (*Felis lynx*), and snowshoe hare (*Lepus americanus*) tracks in snow were counted and vegetation cover was classified from the air along systematically spaced, linear transects in March and April 1985 and 1986. A strict survey protocol ensured uniformity of sampling among transects. Tests of aerial:ground track counts revealed that track sightability decreased as vegetation canopy cover increased, and that sightability ratios between 2 observers were the same for carnivore tracks ($P > 0.10$) but different for hare tracks ($P < 0.10$). Track densities (tracks/km) for all transects were corrected for differential track sightability and accumulation over time to derive indices of relative abundance. Indices were compared among all transects area wide, among 3 elevation strata, and between years for 2 areas that were resurveyed. Aerial observations of relative abundance and patterns of distribution generally correlated with ground counts, observations by trappers, and each species' habitat preferences.

The sound management of furbearers requires reliable methods to measure changes in abundance. Estimates of actual abundance are difficult to obtain, because furbearers are often solitary, covert, and wide-ranging. Counts of tracks and other animal signs can provide accurate indices of relative abundance. They are generally more useful and often more precise than estimates of actual abundance, assuming that the amount of sign has an approximately linear relationship to animal numbers (Caughley 1977*a*).

Ground surveys of tracks have been widely used to index the relative abundance of furbearers at scent stations (Linhart and Knowlton 1975, Hon 1979, Clark and Andrews 1982, Clark and Campbell 1983, Conner et al. 1983) and along transects, trails, or roads (Formozov 1965, Pulliainen 1981, Raine 1983, Slough and Jessup 1984, Stephenson 1986). Although accurate, ground surveys are time-consuming and difficult to conduct over large

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areas. In contrast, aerial surveys of tracks enable rapid sampling across large areas with poor access (Legendre et al. 1978). However, aerial surveys are costly, less accurate than ground counts, and require sufficient snow cover for good track visibility.

This paper discusses an aerial survey technique I developed and tested that used counts of tracks along linear transects to assess and monitor the distribution and relative abundance of furbearers in the Yukon Flats National Wildlife Refuge (YFNWR) in interior Alaska. The technique had to be precise, time- and cost-effective, allow repeated sampling of extensive areas with diverse habitat, and sample several species simultaneously. Furthermore, it needed to minimize sources of bias resulting from the accumulation of tracks over time, the visibility of tracks among various vegetation cover types, and different observers. Furbearer species of interest were red foxes, marten, lynx, and snowshoe hares.

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STUDY AREA

This study was conducted in northwestern interior Alaska in the YFNWR, its southern border about 120 km north of Fairbanks. The refuge is approximately 35,000 km^2 and encompasses roughly 11,000 km^2 of private lands that were excluded from this study. The refuge contains most of the extensive wetlands of the upper Yukon River and Porcupine River basins within the Yukon Flats. Elevation ranges from 95 m in the flats to 1,804 m in the surrounding hills and mountains. The Yukon Flats is an arid, subarctic environment with long, cold winters and short, warm summers. Temperatures have ranged from 38°C in summer to -59°C in winter. Vegetation is typical of the northern boreal forest, or taiga (Viereck and Little 1972). White spruce (*Picea glauca*), black spruce (*P. mariana*), paper birch (*Betula papyrifera*), quaking aspen (*Populus tremuloides*), balsam poplar (*P. balsamifera*), willow (*Salix* spp.), and alder (*Alnus* spp.) are the dominant forest species, and ericaceous shrubs comprise most of the understory vegetation. Grasses (*Calamagrostis* spp.), sedges

(*Carex* spp.), and other herbaceous species are prevalent in the open, wet meadows and bogs.

Documentation of furbearer populations in the Yukon Flats has been scant and limited to recent harvest data derived primarily from pelt-sealing records for lynx, river otters (*Lutra canadensis*), wolverines (*Gulo gulo*), wolves (*Canis lupus*), and beavers (*Castor canadensis*) (Nowlin 1986) and to responses to an annual trapper questionnaire (Ernest 1986). 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

Survey Design

General assumptions of this technique were that: (1) the abundance of tracks was approximately proportional to the actual abundance of a species; (2) the ratio of correct versus incorrect track identifications was high and uniform among transects; (3) transects were flown with accuracy and consistency; (4) snowfall data were accurate for the refuge area; and (5) snow conditions, such as depth and compactness, were approximately the same for each transect.

Aerial surveys were conducted between 14 March and 16 April 1985 over the entire YFNWR. Survey aircraft were Super Cubs because of their slow-speed, low cost, and tandem seating that permitted equal visibility for observer and pilot. Tracks in snow were counted along 343 5-km linear transects that were systematically spaced approximately 10 km apart; this resulted in about 1 transect per 100 km^2 (Fig. 1). Transects were oriented along random compass directions, subject to the requirements that they avoid extremely rugged terrain and that end points be at least 2 km apart and located at topographic features identifiable from the air. If these requirements could not be met, a new random direction was chosen. Methodology ensured that no transect was limited to 1 terrain type.

Abilities to resurvey transects and to document changes in furbearer distribution and relative abundance over time were examined in 2 areas. On 7 April 1986, 27 transects were resurveyed across an area encompassing the 1,140-km^2 Lone Mountain burn in western YFNWR. A separate survey of 25 transects was flown on 16 April 1985 and repeated on 1 April 1986 across a 260-km^2 area that included the Old Lost Creek prescribed burn site in southwestern YFNWR. The latter area was surveyed using 2-km transects that were systematically spaced about 2 km apart. Methods of orienting and establishing transects were the same as described above.

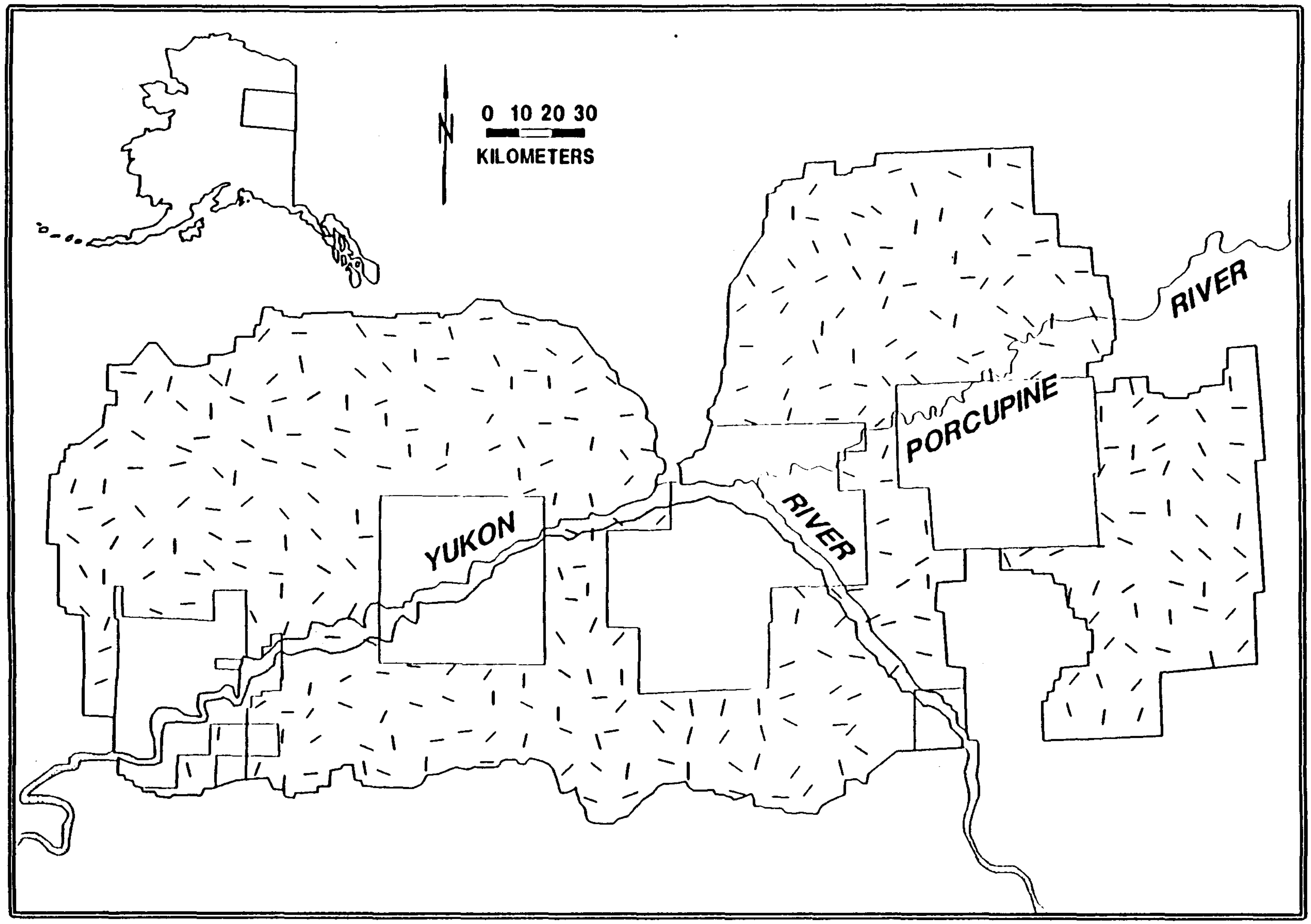

Fig. 1. Aerial transects surveyed for furbearer track counts on the Yukon Flats National Wildlife Refuge, Alaska (dark borders) in March and April 1985. Areas within light borders represent private lands that were not surveyed.

Surveys were flown in late winter-early spring when track visibility is greatest in interior Alaska (Stephenson 1986). Satisfactory surveys required complete snow cover over grass and low shrubs, direct or only slightly obscured light, winds <20 knots, and ambient temperatures of -35°C to -5°C. Warmer temperatures cause crusting, which hinders track impressions, and extremely cold temperatures may inhibit animal activity (Buskirk 1983, Stephenson 1986). Numerous ground checks indicated <5 cm of new snow did not affect the visibility of tracks from the air, but new snowfall of ≥5 cm covered tracks and made them difficult to count. Whenever possible, surveys were conducted at least 3 days following a snowfall of ≥5 cm so that adequate numbers of tracks were visible. Daily weather conditions on the YFNWR were monitored through National Weather Service data (NOAA 1985) and field observations.

For each transect, data describing vegetation and tracks were collected along a line represented by the outside edge of the airplane ski. Two passes per transect were required. On the 1st pass, flown at about 150 m above ground level (AGL), trees and tall shrubs (> 1 m) were classified into percentages of vegetation cover, where bare = 0%, woodland = 1-24%, open = 25-59%, and closed ≥ 60% (Viereck and Dyrness 1980, modified for use in winter conditions). These vegetation cover classes (VCC) were also marked on 1:63,360-scale maps or 1:60,000-scale color-infrared aerial photos to later calculate proportions of cover by each VCC. Furbearer tracks were recorded on the 2nd pass, flown at 60-70 knots and 60-90 m AGL. Tracks were defined as a trail of footprints in the snow. Those of each species were distinguished by foot size, stride length, straddle width, and overall pattern. Tracks that intersected a transect were identified and read into a tape recorder to enable rapid entry and allow the observer's eyes to remain on the survey transect at all times. It was possible for the tracks of a single animal to intersect a transect more than once, and each of those intersects was counted. Correct and rapid identification of tracks from the air was accomplished after several hours of practice.

Track intersects were used to calculate the density of tracks (tracks/km) for each transect. I corrected among transects for the differential accumulation of tracks between date of snowfall and date of survey by dividing the track density by the number of days after snowfall (DAS) (Raine 1983, Slough and Jessup 1984, Slough and Slama 1985, Stephenson 1986).

Densities of tracks were mapped and compared among transects to determine furbearer distribution and relative abundance over all areas surveyed. Track densities were arbitrarily defined as low, medium, or high with respect to the median density per species among all transects, each density category representing about 1/3 of the transects surveyed. This was done because there were no previous surveys in the YFNWR with which to compare densities and no obvious clumping within the ranges of track density for any species. Using these track-density categories, I stratified transects and made comparisons among elevations of flats (<150 m), benches (150-300 m), and uplands (>300 m) across the refuge, and compared between years for areas with replicate sampling. Only those transects that lay completely within a particular stratum were included in analyses. Aerial survey data were also generally compared with observations of local trappers obtained from interviews.

Tests of Track Sightability

The sightability of furbearer tracks from the air was tested among VCCs and between myself and another experienced observer. Sightability was defined as the probability that animal tracks along a transect would be seen by the observer from the air. Tests were conducted near Canvasback Lake in the center of the YFNWR during 5 days in March 1986 along 10 transects ranging in length from 2.9-6.5 km (53.1 km total). Two observers were seated on the same side of a Cessna 180 modified for slow speed flying. Tracks were independently counted by both observers for 2 adjacent transects per day. Observers cued one another when VCCs changed, thereby ensuring that tracks were assigned to the proper VCC. Later the same day, tracks were counted along the same transects from the ground, with each observer walking 1 transect. Thus, each observer recorded tracks for 10 aerial transects and 5 ground transects. It was assumed that all ground identifications and counts of tracks were correct for all species.

Counts of tracks were combined for each VCC along a transect to derive tracks/km/VCC. Sightability was determined from ratios of aerial:ground track counts, where an index of 1.0 indicated equality. Sightability of tracks was tested through paired-*t* tests for differences between ratios (Cochran 1977) with statistical significance considered at a = 0.10.

RESULTS AND DISCUSSION

Aerial Survey

Aerial survey protocol was strictly followed to ensure uniformity of sampling among transects. The 1985 aerial survey of 343 transects in the YFNWR was completed in 125 hours of flying during 17 days, averaging 20 transects in 7 hours/day or about 3 transects/hour. All transects were flown between 5 and 26 DAS. Five pilots were used, but only 1 pilot flew the last 13 days of the survey. All pilots were skilled at low-level, low-speed flying, and each was able to locate transect starts and follow courses accurately.

Replicate sampling of 32 transects at 9 DAS in 1986 in the Lone Mountain burn was completed in 4 hours and averaged 8 transects/hour. Sampling of the 25 2-km transects in the Old Lost Creek prescribed burn site was completed in 3 hours at 5 DAS in 1985 and replicated in 1.5 hours at 3 DAS in 1986. Results from 1986 indicated that the same transects could be flown again, and that replicate surveys could be completed with less time and expense.

The classification of vegetation into bare, woodland, open, and closed percentages of cover was easy. This likely enhanced precision in vegetation classification that may have been reduced using more than 4 cover classes. Vegetation sampling for several transects in 1986 in replicate areas resulted in identical VCC assignments along transects as were recorded in 1985. The need to resample VCCs in an area would depend upon growth rates of vegetation. Areas with rapid-growing vegetation may require resurvey every 2-3 years. Resurvey of VCCs in the Yukon Flats should be unnecessary within 3-5 years, because changes in vegetation growth stages are slow in interior Alaska (Foote 1983).

Conditions during late winter-early spring 1985 and 1986 were favorable for aerial tracking. In 1985, snow was usually soft enough for track impressions and deep enough (>1 m) to cover low shrubs and grass with an even surface. In 1986, shallow snow depth (30-45 cm) produced an uneven surface over low vegetation that required more concentration to count tracks, though they were still distinguishable. If snow depth had been <30 cm, it is likely that reduced sightability would have precluded track counts. Windblown snow was not a problem in most areas except the highest ridgetops. These were often swept free of snow or covered with a thin, hard-packed layer, which made tracks difficult or impossible to see. Observations at the Canvasback Lake test site indicated that sublimation and light winds had a cumulative effect on tracks in snow and could obscure them over time. No adjustments to track densities were made for wind, but its effect may have been reduced if transects were surveyed in high-wind areas near 3 DAS and elsewhere before about 20 DAS. Shadows generally did not affect tracking conditions, because surveys were flown during full daylight.

Difficulties in distinguishing between tracks of different species were minimal and reasonably uniform among transects. Each species' track characteristics were consistently similar to allow their separation from other species during aerial surveys, which Stephenson (1986) also reported for lynx. A potential for bias in track counts of target species may occur in areas where multiple species of similar size coexist. Lynx are the only felids present and red foxes and wolves are the only canids common in the Yukon Flats. Although usually smaller in size, mink (*Mustela vison*) tracks were probably occasionally mistaken for marten tracks in this study. Tracks of other mustelids, red squirrels (Tamiasciurus hudsonicus), and ungulates were readily distinguished from target species by size or pattern. Snowshoe hare and caribou (Rangifer tarandus) tracks occasionally overlapped tracks of other species, which hampered their identification. Hares also established runways that were often used by other furbearers. Surveys are practical after more than 20 DAS, but track identification is easier closer to 3 DAS because the problems of track overlap and runways increase with time. The methodology used was effective for identifying and counting tracks of furbearers that were solitary travelers. It would be less effective for surveying species, such as wolves, that often travel in groups because of the observers' inability to consistently distinguish between individual tracks from the air.

Track Density

Ground counts of furbearer tracks at the Canvasback Lake test site (Table 1) showed that fox tracks were most dense in bare VCC and least in open VCC. Marten and snowshoe hare tracks were relatively scarce in bare and woodland canopy cover but were more abundant, particularly hare tracks, in open and closed VCCs. No lynx tracks were observed at the test site, coincident with the cyclic low of the lynx population on the Yukon Flats since 1984-85.

Table 1. Track densities (tracks/km) of furbearers from ground count totals along the lengths (km) of 4 vegetation cover classes (VCC) among transects (N) at the Canvasback Lake test site, YFNWR, Alaska, 1986.

VCC	VCC Total Length	N	Red Fox	Marten	Snowshoe Hare
Bare	11.76	10	9.61	0.43	0.09
Woodland	1.10	5	8.18	0.00	1.82
Open	15.43	10	2.79	2.72	90.34
Closed	24.84	10	5.43	2.78	75.85

Track Sightability

Counts of red fox and marten tracks at the Canvasback Lake test site were combined and analyzed under the category carnivores. The only differences detected between their track sightability ratios for both observers were in bare cover, where sightability was higher for fox tracks ($P < 0.10$). Data were insufficient for marten in woodland cover to allow testing. I expected from these results that fox and marten track sightability would be comparable to that of other solitary-traveling carnivores, such as lynx. The sightability of snowshoe hare tracks was examined independently because of their tendency to use runways and to separate analysis of predators and prey.

The sightability ratios of carnivore and snowshoe hare tracks formed gradients with sightability highest in bare cover and lowest in closed cover for both observers (Table 2). Sightability of carnivore tracks was greater than that of hare tracks for Observer 1 in open and closed VCCs ($P < 0.10$) but was lower in woodland ($P < 0.10$) and not significantly different in bare cover ($P > 0.10$) (Table 2). However, test results for the latter 2 VCCs were confounded by low track densities of hares (Table 1) and by misidentification of their tracks that resulted in ratios of 2.0. The sightability of carnivore versus hare tracks for Observer 2 resulted in opposite conclusions of significance compared to those of Observer 1. This may have been due largely to the variability in the data, because there were no detectable differences between observers in the sightability of carnivore tracks among all VCCs nor of hare tracks in bare cover ($P > 0.10$). Sightability ratios of snowshoe hare tracks for Observer 1 were higher than those of Observer 2 in woodland VCC and lower in open and closed VCCs ($P < 0.10$) (Table 2). There was no evidence that carnivore or hare track sightability varied with track density.

Correction for Differential Track Sightability and Accumulation

Although inconclusive statistically, the differences in sightability of carnivore and snowshoe hare tracks among VCCs indicated that correction factors were required to enable comparisons of track densities between transects. Differences in track sightability between observers determined at the Canvasback Lake test site required that only those aerial data I gathered as Observer 1 be used in analyzing refuge-wide data, because I had conducted all aerial surveys of the YFNWR.

Table 2. Sightability ratios (SE) of carnivore and snowshoe hare tracks from aerial:ground counts by 2 observers among 4 vegetation cover classes (VCC) along transects (N) at the Canvasback Lake test site, YFNWR, Alaska, 1986. Ratios within a column by VCC sharing common capital letters are not significantly different ($P > 0.10$).

		Carnivore[a]		Snowshoe Hare	
VCC	N	Observer 1	Observer 2	Observer 1	Observer 2
Bare	10	0.712 (0.085)A	0.644 (0.105)A	2.000 (1.491)AB	0.000(0.000)A
Woodland	5	0.667 (0.393)ABC	0.333 (0.393)AB	2.000 (0.790)A	0.000(0.000)A
Open	10	0.318 (0.070)B	0.322 (0.101)B	0.109 (0.014)B	0.193(0.015)B
Closed	10	0.172 (0.030)C	0.245 (0.062)B	0.107 (0.018)B	0.192(0.025)B

[a]Includes the combined track counts of red foxes and marten.

Sightability ratios were converted to their reciprocals (Table 3) to simplify the correction of track densities. Sightability correction factors (SCF) for carnivore (C) and snowshoe hare (H) tracks counted along each transect were calculated as follows:

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

where
SR = sightability reciprocals,
V = bare, woodland, open, and closed VCCs,
P = proportions of each V along a transect, and

$$\sum_{V=1}^{4} P_V = 1.0.$$

Tracks may not have been seen in a particular VCC along a transect, but SCFs were developed in this manner because simultaneous documentation of tracks and vegetation from the air was not feasible.

Track accumulations over time were equated among transects as tracks/km at 1 DAS by converting original track densities (OTD) at i DAS to estimated mean daily-track-accumulation rates:

$$\overline{TD}_{DAS} = OTD/iDAS.$$

Track sightability and accumulation adjustments were used in the following formula to determine corrected track densities (CTD) from OTDs for each furbearer species per transect:

$$CTD = \overline{TD}_{DAS} * SCF_{C,H}.$$

Table 3. Reciprocals of sightability ratios of carnivore and snowshoe hare tracks in 4 vegetation canopy covers (VCC) (for Observer 1, Table 2) used in calculating corrected track densities.

VCC	Carnivore	Snowshoe Hare
Bare	1.40	0.50[a]
Woodland	1.50	0.50
Open	3.14	9.17
Closed	5.81	9.34

[a]Values in bare and woodland VCC were uncorrected for snowshoe hare track-count errors.

The error associated with sightability ratio reciprocals of 0.50 for snowshoe hare tracks in bare and woodland VCCs (Table 3) probably had minimal effect on corrected track densities given the relatively low density of hare tracks in those cover types (Table 1). However, the high SE among sightability ratios (Table 2) precluded statistical tests among corrected track densities; thus, further tests of sightability are required to more precisely define the effects of VCCs on track sightability.

Data from the Canvasback Lake test site indicated that species track accumulations were nonlinear; i.e., tracks appeared to accumulate rapidly up to 6-10 DAS, increase gradually until about 20 DAS, and thereafter decline slightly. In addition, Stephenson (1986) reported that lynx track-accumulation rates varied from 0.04 tracks/km/day to 0.15 tracks/km/day among 3 areas in interior Alaska. Nonlinear rates of track accumulation may be due to the effects of a number of factors including track visibility and identification as well as furbearer activity changes due to weather conditions, breeding, and food supply. Further study is required to understand their individual and combined importance in a model of track accumulation rates that goes beyond the linear correction for DAS.

The causes of observer differences were not determined, but biases were minimized by using only sightability ratios developed for myself as the primary observer. However, this approach would not be practical when more than 1 observer is required. Eyesight, ability to identify tracks, level of concentration, and stamina may all influence results (Caughley et al. 1976, Norton-Griffiths 1976). It is essential to limit observer-caused variability as a potential source of bias in aerial surveys of furbearer tracks. This can be accomplished by determining track sightability ratios for each observer and by an observer training program (e.g., Dirschl et al. 1981) designed specifically for track surveys in winter.

Aerial counts of furbearer tracks have been used with nonlinear transects in Canada (Legendre et al. 1978) and with linear transects in Alaska (Hechtel and Follmann 1980, Buskirk 1983) to determine relative abundance and habitat use. These earlier studies did not examine the effects of vegetation canopy cover on track sightability nor of the accumulation of tracks over time. With the exception of Buskirk (1983), however, they did restrict survey periods to only a few DAS to minimize bias from track accumulation.

Furbearer Distribution and Relative Abundance

Refuge Wide.--Corrected track densities were used as indices of relative abundance of furbearer distribution across the YFNWR (Table 4) and among elevation strata (Table 5). Red foxes largely used the central lake flats and riparian areas as well as the Lone Mountain burn, where 260 km^2 burned in 1977 and an additional 880 km^2 burned in 1979. Vegetation in this burn was in the moss-herb/shrub-sapling stage (Foote 1983). This burn also supported some of the highest densities of marten. Marten were relatively abundant in the refuge to the northwest and south in mature coniferous and coniferous-deciduous-mixed forests, particularly in benches and uplands. Lynx and snowshoe hares appeared to be concentrated to the west, northeast, and in part of a 1950 8,300-km^2 burn in southeastern YFNWR. These areas were dominated by mid-successional forests where habitat was diverse. Neither lynx nor hares exhibited a strong elevation preference.

Results of the aerial survey data roughly coincided with observations of 23 trappers interviewed about furbearer distribution and relative abundance on the Yukon Flats. The aerial survey data were also consistent with each species' VCC use determined from ground counts at the Canvasback Lake test site (Table 1) and with their habitat preferences reported elsewhere.

Samuel and Nelson (1982) and Stephenson (1984) reported that red foxes use diverse habitats and ecotones and avoid dense forests. Pulliainen (1981) found that red foxes in Finland preferred mixed juniper-pine forests and open bogs where grasses and microtine rodents were most common, which is similar to what I observed in this study.

Table 4. Furbearer track densities shown as ranges of tracks/km for low, medium, and high categories. Each category represents approximately 1/3 of the 343 transects surveyed in the YFNWR, Alaska, March-April 1985.

Track Density Category	Tracks/Km			
	Red Fox	Marten	Lynx[a]	Snowshoe Hare
Low	0.00-0.08	0.00-0.25	All 0.00	0.00-0.39
Medium	0.09-0.27	0.26-0.71	0.01-0.06	0.40-1.13
High	0.28-1.96	0.72-3.78	0.07-0.64	1.14-13.94

[a]Lynx track-density categories represent the following approximate percentages of transects surveyed, due to the high proportion of transects with 0.00 tracks/km: Low = 46%, Medium = 21%, and High = 33%.

Table 5. Percentages of transects within track-density categories low, medium, and high for furbearer species (Table 4) in elevation strata flats, benches, and uplands in YFNWR, Alaska, 1985.

Elevation Strata[a]	N	Red Fox			Marten			Lynx			Snowshoe Hare		
		Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Flats	111	7	28	65	63	25	12	40	26	34	20	37	43
Benches	82	45	38	17	23	43	34	51	14	35	32	35	33
Uplands	84	66	24	10	17	32	51	62	12	26	46	30	24

[a]Flats <150 m, benches = 150-300 m, uplands >300 m.

Marten are mainly associated with mature conifer or coniferous-deciduous mixed forests (Koehler and Hornocker 1977, Pulliainen 1981, Strickland et al. 1982, Buskirk 1983, Slough and Slama 1985), but an overhead canopy may be unnecessary for them where alternate cover (e.g., deadfall timber) is available (Magoun and Vernam 1986). This was true on the YFNWR where marten were typically abundant in mature spruce-dominated forests but were most abundant in the Lone Mountain burn. Fires have been shown to benefit marten where the food supply, primarily microtines, was increased and adequate cover was available in the resulting mosaic of vegetation (Koehler and Hornocker 1977, Stephenson 1984, Slough and Slama 1985, Magoun and Vernam 1986).

Lynx in the refuge were most common in mixed coniferous-deciduous forests with understories of willow and alder. Lynx association with dense boreal forests was reported by McCord and Cardoza (1982), and Brand et al. (1976) and Ward (1985) found that lynx tracks were concentrated in areas of relatively high snowshoe hare abundance. Hares use a variety of forest habitats that have dense understories and they usually avoid open areas, as shown by this and other studies (Pietz and Tester 1983, Keith et al. 1984, Slough and Jessup 1984, Fuller and Heisey 1986).

Resurveyed Areas.--In the Lone Mountain burn area between 1985 and 1986, track densities of red foxes and lynx declined, whereas those of snowshoe hares increased markedly and marten track densities remained high (Table 6). Between 1985 and 1986 in the Old Lost Creek prescribed burn area, track densities changed little for all species; densities of marten and hare tracks were high both years, while those of lynx were low and those of foxes were divided between high and low (Table 6). Local trappers in the above areas commented that prior to 1986 fox numbers were moderate to high and stable or increasing slightly, marten were moderate to high and stable, lynx were low and stable, and hares were low but increasing.

Temporal changes in the relative abundance of furbearers were detectable at least for the Lone Mountain burn sampled with 5-km transects spaced 10 km apart. The Old Lost Creek area was sampled with 2-km transects spaced 2 km apart and had 0.19 km of transects/km^2 of area compared with the ratio of 0.12 used in the Lone Mountain burn. However, yearly differences in relative abundance as well as patterns of distribution of track densities of all furbearers were more pronounced in the Lone Mountain burn

Table 6. Number of transects with furbearer track densities in low, medium, and high categories (Table 4) in 1985 and 1986 in the Lone Mountain burn area (N = 27) and the Old Lost Creek prescribed burn area (N = 25), YFNWR, Alaska.

Burn Area/ Survey Year	Track Density Category	N Transects Red Fox	Marten	Lynx	Snowshoe Hare
Lone Mountain					
1985	Low	5	2	12	10
	Medium	7	6	5	10
	High	15	19	10	7
1986	Low	6	1	19	5
	Medium	15	3	2	4
	High	6	23	6	18
Old Lost Creek					
1985	Low	8	5	17	2
	Medium	1	5	0	7
	High	16	15	8	16
1986	Low	14	2	23	1
	Medium	0	7	0	0
	High	11	16	2	24

than in the Old Lost Creek area. Either few actual differences existed in the latter area or the survey technique was inadequate to detect them over the 1-year period. Short, closely spaced transects may reflect the movement patterns of a few individual animals rather than differences in the distribution and relative abundance of all animals in an area. More testing is required to determine minimum transect lengths and spacing.

CONCLUSIONS

The aerial survey technique used to survey furbearer populations on the YFNWR was the most practical and efficient method of gathering data in this large refuge. The distribution and relative abundance of a varied group of furbearers was approximated with reasonable accuracy across large areas with different types of terrain and vegetation. The technique also established a mechanism for monitoring furbearer population trends. The validity of the assumption that the relative abundance of each species' tracks was distributed in approximate proportion to the species actual abundance could not be determined directly. However, aerial observations were generally correlated with ground counts, trapper observations, and each species' habitat preferences. Such verification is important in detecting changes in population abundance measured by aerial track counts, but it is imperative that those measurements are corrected for sources of bias.

This survey technique was developed to document and compare the spatial patterns of and temporal changes in furbearer populations on the YFNWR. Tracks/km were gathered along repeatable aerial transects and served as indices of relative abundance to describe furbearer distribution. Patterns of distribution were provided by the uniform coverage of systematic sampling and enhanced through stratification (Caughley 1977b). Although precision was limited by sampling variability, differential track sightability and accumulation were accounted for as 2 important sources of bias in furbearer track counts that could not be controlled procedurally. I believe the use of correction factors, in combination with adherence to survey protocol, permitted differences in relative abundance indices among transects or strata to reflect actual differences in species abundance on the refuge.

LITERATURE CITED

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