

## Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands

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Received May 30, 1988

THOMPSON, I. D., DAVIDSON, I. J., O'DONNELL, S., and BRAZEAU, F. 1989. Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. *Can. J. Zool.* **67**: 1816–1823.

Tracks of marten (*Martes americana*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), ermine (*Mustela erminea*), snowshoe hare (*Lepus americanus*), and red squirrel (*Tamiasciurus hudsonicus*) were censused from 1980 to 1985 on 1-km transects in uncut stands and on eight sites that had been clear-cut between 1 and 33 years ago, in boreal mixedwood habitat near Manitowadge, Ontario. Marten tracks were more common in uncut areas than in younger stands. Lynx tracks were most abundant on sites that were logged 20–30 years ago and were absent in uncut areas and stands less than 5 years old. Counts of red fox tracks were lowest in uncut stands and showed no consistent pattern among years of our survey with respect to stand age in second-growth forest. Hare tracks were most abundant in 20- and 30-year-old stands, and least abundant in stands less than 5 years old. Red squirrels were most common in uncut areas, but similar high values were also found in 20- and 30-year-old sites during 3 years when populations in the area were depressed. No selection of stands by age was seen for ermine. Numbers of tracks were significantly correlated with live captures of marten, hare, and red squirrels. Our results suggested that track abundance can be used as an index of habitat preferences and population trends. Highest counts were achieved in December for marten, red squirrel, and ermine, likely as a result of several types of over-winter mortality and inactivity in cold weather, which may have reduced counts in January and March. As a result of high and nonhomogeneous variance among transects and years, nonparametric statistical analysis was required. Transect length for fox and lynx should be substantially longer than 1 km (probably 3–5 km) to avoid numerous zero results.

THOMPSON, I. D., DAVIDSON, I. J., O'DONNELL, S., et BRAZEAU, F. 1989. Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. *Can. J. Zool.* **67** : 1816–1823.

Les pistes de Martres (*Martes americana*), de Lynx du Canada (*Felis lynx*), de Renards roux (*Vulpes vulpes*), d'Hermine (*Mustela erminea*), de Lièvres d'Amérique (*Lepus americanus*) et d'Écureuils roux (*Tamiasciurus hudsonicus*) ont été recensées de 1980 à 1985 le long de transects de 1 km dans des forêts intactes et en huit sites soumis à la coupe à blanc de 1 à 33 ans plus tôt, dans un habitat boréal de bois mixtes, près de Manitowadge en Ontario. Les pistes des martres étaient plus fréquentes dans les forêts intactes que dans les forêts jeunes. Les pistes des lynx abondaient surtout aux endroits déboisés depuis 20 ou 30 ans et elles étaient absentes dans les régions intactes et dans les forêts de moins de 5 ans. C'est dans les forêts intactes que les pistes de renards étaient le moins abondantes et leur présence dans les forêts régénérées ne suivait pas de tendance particulière d'une année à l'autre quant à l'âge de la forêt. Les pistes de lièvres étaient abondantes surtout dans les forêts de 20 à 30 ans et c'est dans les forêts de moins de 5 ans qu'elles étaient le moins fréquentes. Les écureuils étaient communs surtout dans les bois intacts, mais des fréquences élevées ont aussi été enregistrées dans les forêts de 20 à 30 ans durant une période de 3 ans où la densité des populations de la région était faible. Les hermines n'ont manifesté aucune tendance particulière. Il y avait une corrélation significative entre le nombre de pistes et le nombre d'animaux capturés vivants dans le cas des martres, des lièvres et des écureuils. Nos résultats indiquent que la fréquence des pistes peut servir d'indice des préférences d'habitat et des tendances démographiques. La fréquence des pistes était maximale en décembre dans le cas des martres, des écureuils et des hermines, probablement parce que plusieurs types de mortalité hivernale et l'inactivité au froid ont contribué à réduire le nombre de pistes en janvier et en mars. La variance élevée et non homogène entre les transects et entre les années d'échantillonnage nous a obligés à utiliser une méthode d'analyse statistique non paramétrique. L'étude des pistes des renards et des lynx devrait se faire sur des transects beaucoup plus longs que 1 km (probablement de 3 à 5 km) de façon à contourner le problème des nombreuses valeurs nulles.

[Traduit par la revue]

### Introduction

Large contiguous tracts of northern and central Canada have been logged, resulting in a direct impact on vegetation communities (Yang and Fry 1981) and associated animals (Telfer 1974; Thompson 1988). In recent years, studies of the effects of logging on birds, in particular, and mammals have become more common than in the past. Changes in small-mammal communities after logging have been published for Ontario (Martell and Radvanyi 1977; Martell 1983), Maine (Monthey and Soutiere 1985), and British Columbia (Sullivan and Krebs 1981). However, responses of other small mammalian herbivores, notably snowshoe hare (*Lepus americanus*), red squirrel (*Tamiasciurus hudsonicus*), and flying squirrel (*Glaucomys sabrinus*), to timber harvesting are not well known. All of

these species are preyed upon by small carnivores commonly found in boreal forest: marten (*Martes americana*), lynx (*Felis lynx*), red fox (*Vulpes vulpes*), and ermine (*Mustela erminea*). No studies document habitat use by these predatory species after the original boreal forest has been logged, except for a few dealing with marten (Soutiere 1979; Steventon and Major 1982; Thompson and Colgan 1987a, 1987b; Snyder and Bissonette 1987).

The objective of this paper is to report on a 5-year investigation into the occurrence of tracks of some selected mammal species in logged and uncut stands. Specifically, we wanted to know if track counts could be used to examine stand age preferences of boreal mammals, which months resulted in highest track counts, and whether track counts could be used as an index to change in abundance of individual species among years. We recommend transect lengths required to enable examination of population trends through time.

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## Study area and methods

Our study area was located approximately 40 km north of Manitowadge (49°15'N, 85°35'W), and 150 km east of Thunder Bay, in the Central Plateau section of the Boreal Forest of Ontario (Rowe 1972). Rolling topography of glacial moraines supported predominantly mixedwood stands of black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*), and white birch (*Betula papyrifera*). Lowlands were characterized by homogeneous stands of black spruce.

Logging on the area has been extensive, with individual cuts of 3–8 km<sup>2</sup> and contiguous cuts, over 10–15 years, of up to 50 km<sup>2</sup>. Early regeneration was to dense shrubs, predominantly mountain maple (*Acer spicatum*), beaked hazel (*Corylus cornuta*), and speckled alder (*Alnus rugosa*). After about 15 years, aspen and, to a lesser extent, advanced-growth balsam fir in clumps began to dominate upland sites. In uncut areas, dense mosses and herbaceous plants provided ground cover, while litter and herbaceous plants covered the ground in regenerating stands.

The area was snow covered from late October until May. Summer maximum temperatures were over 30°C, while winter minimums were below –35°C for extended periods from December to March. The study was conducted from October 1980 to February 1985.

We chose two sites in each of the following area types: logged less than 5 years ago (1980, 1981), logged 10± years ago (1972, 1973), logged 20± years ago (1957, 1961), and logged 30± years ago (1947, 1950). Two additional recently logged sites (2 years) were substituted in 1984 for the youngest sites, to keep stands of that age-class less than 5 years of age. All sites met the following criteria: less than 25% lowland, greater than 6 km<sup>2</sup> area, bordered on two sides by other logged areas of different age, and in the case of all but the most recently logged areas, regenerating naturally. The recently harvested areas were scarified and planted with spruces. Our uncut sites were 150–200 years old. Openings in the canopy of uncut areas were created by fallen old growth, and were vegetated by deciduous shrubs and young balsam fir. The latter species was also common in the understory. All of the sites were located within a 20-km radius.

We established two permanent 1-km transects more than 1 km apart at each site. The total 2-km distance covered upland and lowland habitats in proportion to their occurrence. An additional transect was walked at some sites in some years, if time permitted, to increase the number of replicates. We attempted to address the question of relative use of stand ages of originally similar stand type before logging, and the study was not designed to assess habitat preferences by use and availability techniques. We walked transects two to eight times each, depending on fresh snowfalls (which were needed to obliterate old tracks), during each of three 3-week periods from 1980–1981 to 1984–1985 in late November–December, January–February, and March. In 1980–1981 and 1984–1985, we did not conduct censuses in March. We walked the lines 12–96 h after snowfall. To standardize results, we divided the number of tracks by the number of 12-h periods since snowfall. We counted tracks if they crossed the transect. In the case of red squirrels, several tracks together were counted as one, and for hare trails an arbitrary value of four was assigned. Counts were expressed as tracks per kilometre ± standard deviation (SD). To avoid temporal pseudoreplication (Hurlbert 1984) counts from individual transects were averaged for each time period. (Use of a median value would have resulted in lost information for some species for which we often found no tracks on the transects.)

Because of numerous zero (or near zero) counts for some species and high variance, our data did not satisfy the requirements of parametric statistical tests. Therefore, we assessed statistical differences using Kruskal–Wallis tests (Siegel 1956). We used Dunn's multiple comparison procedure (Zar 1984) to examine intergroup differences for the following: (i) track counts for each species compared among months for each stand age and for all logged areas pooled; (ii) track counts for each species in the same month compared among years, for each age of stand and with all logged areas pooled;

and (iii) track counts for each species compared among the different ages of stands. For the latter comparison, where significant changes in track counts among months were found, we made comparisons using only data from the months in which tracks were consistently most numerous. Otherwise, we pooled counts from all months.

As a comparison for population changes among years indicated by track transects for lynx, fox, and ermine, we conducted Spearman rank correlation analyses (Siegel 1956) of track counts with furbearer harvest statistics from the local area. Harvest data were supplied by L. Melnyk-Ferguson, Ontario Ministry of Natural Resources. For marten, varying hare, and red squirrels we conducted rank correlation analysis of track counts from the previous winter with live captures in traps set in May–June, and live captures in October with track counts from the following winter. Traps were set 250–500 m apart along trails and roads to assess the marten population of the study area, but incidental captures of hare and squirrels occurred regularly (Thompson 1986). We marked hare and marten for individual identification. Squirrels were not marked, so we used only captures from different traps to calculate total captures. In 1980–1983, each site was trapped for approximately 150 nights in spring and again the fall. In 1984–1985, trapping effort in all but one of the logged stands was reduced to approximately 80 nights. Acceptance of significant difference for all tests was set at  $P < 0.05$ .

## Results

The data for each species did not conform to any single frequency distribution. Mean values and standard deviations are shown in Table 1 and Fig. 1 only for purposes of conventional illustration and should not be taken as an indication of normally distributed data.

### Track counts by month

We observed that track counts were generally highest during the November–December period for marten, red squirrel, and ermine (Table 2). Red squirrel tracks were encountered least during January and approached December levels again in March. Highest values for red foxes in the logged sites <5 years old were recorded in December during two of the five winters, but no trend was seen in any of the other site-age groups. Numbers of hare and lynx tracks did not change significantly among the three winter periods ( $P > 0.2$ ). However, we found a tendency for the lowest track counts for most species to occur in January.

### Differences among years

Our track data suggest that different population levels existed for all species among the years of the study. Marten track counts were significantly higher in 1980 and 1981 compared with any of the succeeding years in uncut sites, as well as in two of the three logged sites where tracks were regularly seen (Table 3). There was a significant correlation between tracks and (i) the number of marten known to be present from livetrapping results (Table 4) and (ii) the number of marten in the known population as shown by Thompson and Colgan (1987a).

Counts of tracks of varying hare also declined significantly from 1980 and 1981 levels in the succeeding 3 years in all sites (Table 3, Fig. 1). Track counts from all logged sites and from uncut areas correlated significantly with the number of hare caught in live traps in spring and fall (Table 4).

Our data indicate that red squirrel populations were highest in 1980 (Table 3, Fig. 1). Trends in succeeding years were not so distinct. We found a significant correlation between track counts and number of red squirrels captured during fall livetrapping (Table 4); however, track data from 1984 sug-

TABLE 1. Summary statistics from 1-km track transects for December for marten, ermine, and red squirrel, and averaged Ontario,

	December												
	Marten					Red squirrel				Ermine			
	N	$\bar{x}$	SD	Range	%0	$\bar{x}$	SD	Range	%0	$\bar{x}$	SD	Range	%0
1980-1981													
Uncut	4	8.0	8.8	0.4-15.8	0	29.7	10.3	17.5-42.1	0	0.3	0.6	0-1.2	75
<5 years	4	0.1	0.2	0-0.6	67	<0.1	0.1	0-0.3	83	1.0	0.4	0.4-1.4	0
10± years	4	0.2	0.3	0-1.4	67	0.5	0.4	0-1.0	55	0.3	0.2	0.1-0.6	44
20± years	5	0.0	—	—	100	10.2	7.7	1.2-20.0	0	0.9	0.6	0.3-1.7	0
30± years	5	0.0	—	—	100	3.6	0.6	2.6-4.1	0	<0.1	<0.1	0-0.1	80
1981-1982													
Uncut	5	5.5	2.8	2.3-9.3	0	3.7	4.7	0.7-11.4	0	1.5	1.4	0-3.8	17
<5 years	4	0.0	—	—	100	0.0	—	—	100	2.2	2.7	0-5.5	50
10± years	4	1.1	0.7	0.4-2.2	0	0.4	0.3	0-0.8	33	1.1	1.0	0.4-2.5	17
20± years	4	0.8	0.4	0-1.2	50	0.9	0.8	0-1.5	33	0.9	0.8	0-1.5	40
30± years	5	0.5	0.6	0-1.6	67	<0.1	0.1	0-0.3	83	0.2	0.3	0-0.6	33
1982-1983													
Uncut	4	1.0	0.6	0.5-1.9	0	2.3	1.0	0-3.7	7	0.6	0.5	0-1.2	21
<5 years	4	0.0	—	—	100	<0.1	0.2	0-0.6	90	0.3	0.4	0-0.6	80
10± years	5	0.2	0.5	0-1.1	78	1.9	2.6	0-6.3	28	0.5	0.5	0-1.2	50
20± years	4	<0.1	0.1	0-0.2	67	2.1	1.9	0-4.7	17	0.3	0.5	0-1.1	50
30± years	4	<0.1	0.5	0-2.0	92	0.4	0.8	0-1.7	54	0.2	0.3	0-0.5	46
1983-1984													
Uncut	4	1.6	1.1	0-2.8	35	3.3	3.1	0-7.1	6	1.3	1.2	0-2.9	23
<5 years	4	0.0	—	—	100	0.0	—	—	100	1.4	1.0	0-2.8	12
10± years	4	0.6	0.4	0-1.0	43	2.6	2.4	0.3-5.6	14	0.5	0.5	0-1.0	43
20± years	4	0.4	0.5	0-1.0	50	1.8	1.4	0-3.3	17	0.9	1.3	0-2.7	33
30± years	4	0.1	0.6	0-1.0	92	1.8	1.2	0-3.0	25	0.6	1.1	0-2.0	33
1984-1985													
Uncut	4	0.9	0.6	0.3-1.5	0	2.2	1.2	0.9-3.9	0	0.0	—	—	100
<5 years	4	0.0	—	—	100	0.0	—	—	100	<0.1	0.1	0-0.2	75
10± years	4	0.4	0.5	0-1.2	50	1.1	1.5	0.3-3.3	0	0.2	0.3	0-0.7	75
20± years	4	0.5	0.7	0-1.3	50	1.1	0.7	0.7-2.0	0	0.2	0.3	0-0.7	75
30± years	4	0.3	0.4	0-0.9	50	0.8	0.7	0.3-1.8	0	0.1	0.2	0-0.3	75

NOTE: Values are given as number of replicates (N), average number of tracks ( $\bar{x}$ ), standard deviation (SD), and percentage of all transects where no tracks were recorded ( $n = 4-17$  for marten, squirrel, ermine;  $n = 12-39$  for hare, fox, lynx) (%0).

gested a low population, yet the number of animals captured in 1984 was the highest achieved. We found no correlation between track counts and live captures of squirrels in the following spring (Table 4).

Correlations between track counts and numbers of animals captured by trappers on the study area were not significant for lynx or ermine, and a weak correlation ( $P = 0.10$ ) was found for foxes (Table 4). Our track data indicate that highest lynx numbers occurred in 1981 and 1982 on the sites logged 20± years ago, and that a generally low population existed on the study area during 1983 and 1984-1985 (Table 3, Fig. 1). We observed that numbers of ermine tracks were generally similar among years except in two different years at two sites (Table 3). For foxes, the track counts were significantly lower on most sites in the last 3 years of study than in 1980 and 1981 (Table 3, Fig. 1).

#### Stand age preferences

We found that marten tracks were most abundant in uncut forest compared with any of the logged sites either individually or combined (Table 5, Fig. 1). We recorded a few high track counts of marten in logged areas. These probably resulted from individual marten active in a localized area intersected by a transect.

Our track counts of varying hare revealed that most activity

occurred in habitat 20± years after logging, while lowest numbers were found immediately after cutting (Table 5, Fig. 1). In 1980, when we recorded the highest track counts at all sites, similarly high values were found in stands 20± and 30± years old, and during December in uncut sites.

Red squirrel tracks were generally more abundant in uncut forest than in the regenerating stands, based on December track counts (Table 5, Fig. 1). However, results from stands 20± years old were statistically lower than counts in uncut sites in 1980 only, at a time when the squirrel population apparently peaked. Significantly lower values occurred each year in the stands <5 years old compared with all other stand age groups.

Numbers of tracks of red foxes were higher in all logged areas than in uncut sites for 2 of the 5 years (Table 5, Fig. 1). Among the logged sites, track counts were generally similar, except in 1981 when significantly fewer tracks were found in sites <5 years old compared with stands 10± years old.

We seldom recorded lynx tracks in uncut areas or regenerating stands <20 years post-cutting, and significantly more lynx tracks were recorded in stands 20± years old than in most other stands in 1981-1983 (Table 5, Fig. 1). In 1984, tracks of lynx were not common but the only sets that we counted were in 20- and 30-year-old sites (Fig. 1).

We could not detect whether ermine showed a consistent

for all winter periods for hare, fox, and lynx in uncut stands and stands <5 years to 30 years old, near Manitowadge, 1980-1985

All winter periods												
N	Varying hare				Red Fox				Lynx			
	$\bar{x}$	SD	Range	%0	$\bar{x}$	SD	Range	%0	$\bar{x}$	SD	Range	%0
8	56.1	34.1	25.3-112.5	0	1.0	1.2	0-3.3	33	<0.1	0.1	0-0.2	92
8	0.6	0.6	0-1.7	40	0.6	0.6	0-1.4	27	<0.1	0.1	0-0.3	93
10	11.5	10.9	0.8-36.6	7	0.4	0.6	0-1.6	65	0.0	—	—	100
12	77.9	40.5	18.7-191.3	0	1.3	1.7	0-4.9	41	0.1	0.3	0-0.7	88
8	63.7	8.4	48.1-78.8	0	0.6	0.7	0-1.7	41	0.1	0.1	0-0.3	76
12	17.5	11.0	2.7-42.3	0	<0.1	<0.1	0-0.2	79	<0.1	<0.1	0-0.2	96
10	0.4	0.7	0-2.1	62	0.4	0.7	0-2.1	50	0.0	—	—	100
11	16.0	16.5	0.9-55.8	7	0.7	0.6	0-1.5	30	0.0	—	—	100
12	45.5	24.2	11.8-109.5	0	0.5	0.5	0-1.3	37	0.3	0.5	0-1.3	70
12	17.6	14.4	0.5-52.6	3	0.5	0.6	0-2.2	38	0.1	0.1	0-1.0	90
13	3.8	4.7	0-16.3	19	0.2	0.2	0-0.5	56	<0.1	0.1	0-0.3	92
8	<0.1	<0.1	0-0.2	94	0.2	0.3	0-0.6	50	0.0	—	—	100
12	3.1	3.8	0-12.7	23	0.2	0.3	0-1.0	69	<0.1	0.1	0-0.3	92
12	11.8	6.1	0.8-25.0	0	0.5	0.7	0-2.5	50	0.4	0.5	0-1.3	37
12	2.8	3.3	0-9.7	24	0.3	0.4	0-1.1	60	0.0	—	—	100
13	2.2	3.8	0-14.0	36	<0.1	<0.1	0-0.1	87	0.0	—	—	100
10	0.0	—	—	100	0.1	0.3	0-0.9	95	0.0	—	—	100
13	1.1	1.6	0-5.3	33	0.1	0.2	0-0.6	77	<0.1	<0.1	0-0.3	97
12	3.3	4.5	0-15.3	36	0.2	0.5	0-1.7	86	0.1	0.5	0-2.4	86
12	1.2	2.5	0-7.7	54	0.2	0.3	0-1.0	83	0.0	—	—	100
8	2.2	3.3	0-8.8	37	0.0	—	—	100	0.0	—	—	100
8	0.0	—	—	100	<0.1	0.1	0-0.1	62	0.0	—	—	100
8	4.8	6.1	0-16.1	10	0.1	0.2	0-0.7	80	0.0	—	—	100
8	6.5	7.8	0-20.4	8	0.1	0.3	0-0.7	83	0.1	0.2	0-0.4	75
8	2.8	3.4	0-8.6	13	0.2	0.4	0-1.1	75	0.1	0.2	0-0.4	87

preference for stand age. Generally, the fewest tracks were found in sites  $30 \pm$  years old (Fig. 1), but no significant differences among sites occurred. Track counts for ermine were the most erratic of all the species recorded, with substantial among-site, among-month, and among-year variation (Table 1, Fig. 1).

### Discussion

Animal activity is influenced by weather, level of satiation, presence of predators, and social interactions (Broom 1981). All of these factors will affect the number of tracks encountered on a transect and produce large variances. Pulliainen (1981) also reported considerable fluctuations among years in tracks of small carnivores counted on his study area in Finland. He suggested that mobility of animals and population changes as a result of declining prey accounted for variable results. During periods of low population, animals may only inhabit optimal habitats, as shown by Wolfe (1980) and Keith and Windberg (1978) for hare. Some transects may intersect high density areas, while many will not. Harris (1986) recommended that replication of counts over a short period is the only way to reduce the statistical variance that is inherent to transect data. We used short-term replication, but heteroscedasticity among transects and years required the use of non-parametric statistical analyses.

Remarkably few studies of the habitat preferences of small boreal mammals are available (review in Thompson 1988). Our transect data indicate that stand age preferences existed for most of the species that we investigated and that logging in upland forest affected populations of some species positively, whereas other species remained depressed in numbers for many years.

Our track counts show that marten use of stands up to 38 years after logging remained significantly lower than that seen in uncut sites, regardless of population size. Marten appears to be the only furbearing species with a clear preference for uncut forest (Marshall 1951; Soutiere 1979; Taylor and Abrey 1982; Steventon and Major 1982; Thompson and Colgan 1987a). Possible factors resulting in reduced use of logged areas include an open canopy (Koehler and Hornocker 1977), lower number of deadfalls and other debris in cutovers allowing subnivean access (Steventon and Major 1982), and lower hunting success in regenerating compared with uncut habitats (Thompson 1986).

Hare and lynx preferred successional habitats approximately 20 years old in boreal mixed woods. High track counts for hare in uncut areas reflected the over-mature nature of the stands that we studied. Open areas in these stands supported shrub species used as food by hare. Lynx are essentially obligate predators of hare (Elton and Nicholson 1942; Brand

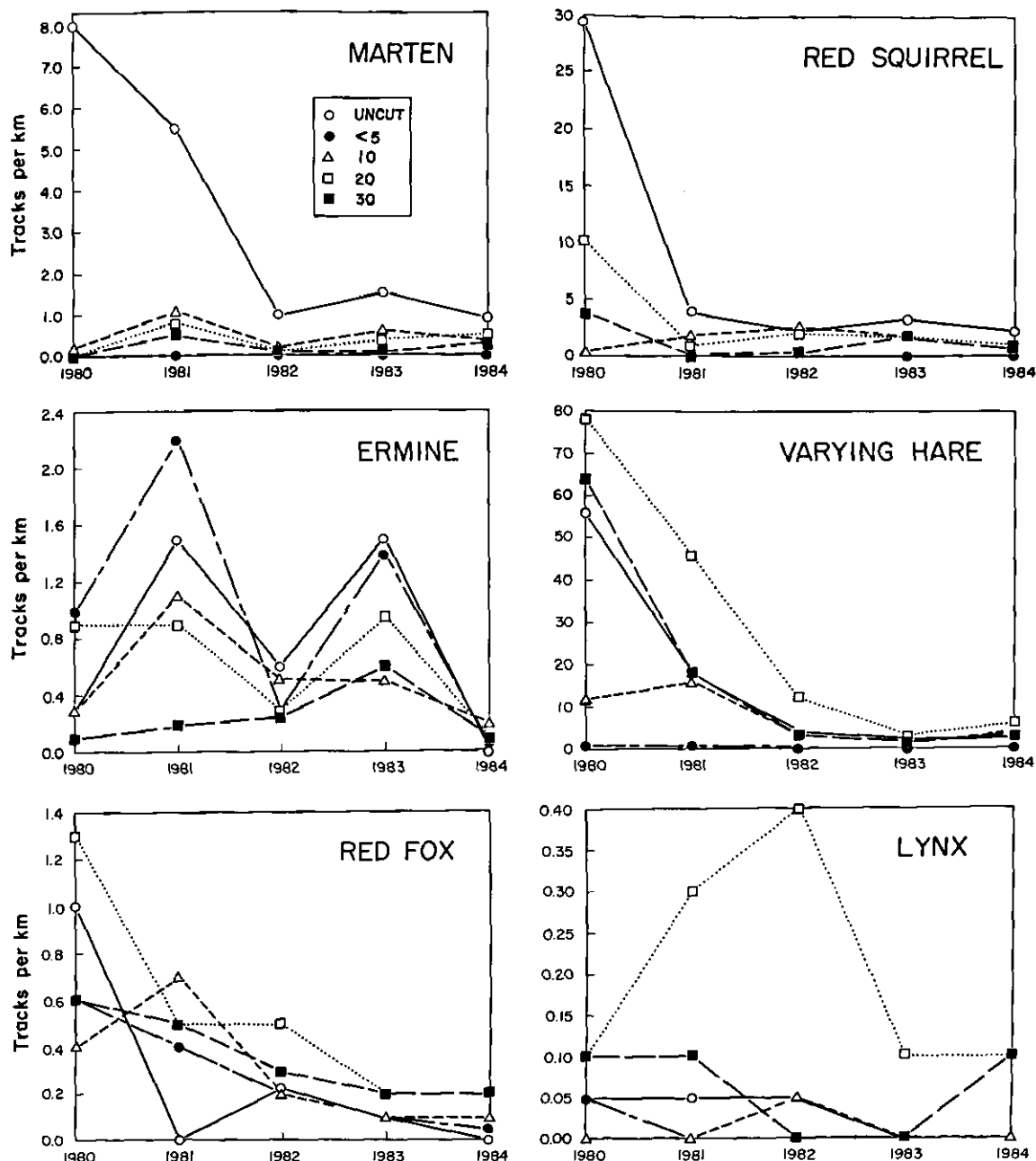


FIG. 1. Average December track counts of marten, ermine, and red squirrel and average track counts from all winter periods of varying hare, red fox and lynx recorded in five ages of upland mixedwood stands at Manitouwadge, Ontario, 1980–1985.

and Keith 1979) and therefore the overlap in stand age preferences for these two species was expected. Parker et al. (1983) also reported that 20-year-old stands were preferred by lynx and hare, but found greater than expected use of mature forest by lynx. Lynx at Manitouwadge seem to have made little use of mature forest; on 113 km of transects in uncut habitat we counted four lynx tracks.

A major food of red squirrels is the seeds of coniferous trees, with total mast directly affecting population density (Smith 1968; Rusch and Reeder 1978). However, numerous other foods are eaten, including hazel nuts, berries, and fungi (Flyger and Gates 1984), all of which are more common in young successional stands than in uncut forest. We believe that the latter foods and seeds from balsam fir and spruces in uncut islands within 10- to 30-year-old stands supported red squirrel

populations similar to those in uncut sites in some years.

We found most fox tracks in 10- to 30-year-old stands. No habitat descriptions for red fox have been published for northern boreal forest areas, although Lindstrom (1982) and Henry (1986) reported that foxes preferred edge habitats in boreal Sweden and Saskatchewan, respectively. Foxes in Maine preferred open areas and mixed conifer stands in early winter with mixed woods becoming more important in later winter if snow was crusted (Halpin and Bissonette 1988).

Habitat data are not available for ermine in boreal forest. In southern Ontario, where the ranges of long-tailed weasels (*Mustela frenata*) and ermine overlap, Simms (1979) reported that ermine showed a preference for successional areas whereas long-tailed weasels were more general in their choice of habitat. Our observation that ermine occurred in stands of

TABLE 2. Months of significantly higher track counts compared with other periods in 2 or more years, recorded for some mammal species, near Manitowadge, Ontario, 1980–1985

	Months with most tracks <sup>a</sup>
Uncut	
Marten	December (3)
Red squirrel	December (4)
Ermine	December (2)
<5 years	
Red fox	December (2)
10± years	
Marten	December (2)
Red squirrel	December (2)
Ermine	December (2)
20± years	
Marten	December (2)
Red squirrel	December (3)
Ermine	December (3)
30± years	
Red squirrel	December (3)

NOTE: Numbers in parentheses are the number of years with significant difference for month indicated. "December" is actually late November or early December.

<sup>a</sup> $P < 0.05$ , Kruskal–Wallis test, Dunn's multiple comparisons.

TABLE 3. Significant differences among years in track counts for some mammal species on 1-km transects, near Manitowadge, Ontario, 1980–1985

	Years with highest track counts <sup>a</sup>
Marten <sup>b</sup>	
Uncut	1980, 1981
10± years	1981
30± years	1981
Hare <sup>c</sup>	
Uncut	1980, 1981
<5 years	1980, 1981
10± years	1980, 1981
20± years	1980, 1981
30± years	1980, 1981
Red squirrel <sup>b</sup>	
Uncut	1980
20± years	1980
30± years	1980
Ermine <sup>b</sup>	
Uncut	1981
30± years	1983
Red fox <sup>c</sup>	
Uncut	1980
<5 years	1980, 1981
10± years	1980, 1981, 1982
20± years	1980, 1981, 1982
Lynx <sup>c</sup>	
20± years	1981, 1982

<sup>a</sup> $P < 0.05$ , Kruskal–Wallis test, Dunn's multiple comparisons.

<sup>b</sup>December track counts; see Table 1.

<sup>c</sup>Tracks from all months pooled; see Table 1.

all ages including uncut stands suggests that habitat partitioning may result in areas where the ranges of the two weasel species overlap. Ermine may be excluded from forest areas by long-tailed weasels.

Several studies have used tracks to infer habitat preferences of boreal mammal species (Keith and Windberg 1978; Soutiere 1979; Pulliainen 1981; Raine 1983). Habitat use reported here refers to relative occurrence in certain stand ages (successional stages of boreal mixed woods habitat) during the winter. Although tracks may provide an indication of habitat use, care must be taken since habitat requirements of a species may change seasonally (van Horne 1983), particularly during breeding. Our data suggest habitat preferences for some species, but more intensive study is needed to describe all habitats of importance to the species reported here.

The assumption that track counts reflect animal abundance has been made elsewhere. Keith and Windberg (1978) showed that there was a direct relationship between track abundance and hare population among years, and van Dyke et al. (1986) suggested that tracks of mountain lions (*Felis concolor*) could be used to assess relative abundance of that species among sites and presumably also among years. Reid et al. (1987) believed that track counts provided an accurate index to otter (*Lutra canadensis*) populations. Limitations of the technique must be recognized: results provide an index to population size and must be placed in context with counts from preceding years to infer trends in population size.

Correlations between numbers of animals livetrapped and track counts for marten, hare, and red squirrels suggest that the track transect method correctly described population changes for these three species during our study. We are unable to explain numerous live captures of squirrels in fall 1984 and the low track counts 2 months later.

Lack of correlation between the reported fur harvest and track abundance for ermine, red fox, and lynx is not surprising since there is a low probability of obtaining a rank correlation with five data points (Siegel 1956). Further, we suspect that numerous uncontrolled density-independent variables influence the catch of individual furbearers by trappers in a given year. Some examples include the price for the fur, snow depth as it influences access to traplines, and the availability of other employment for trappers (Thompson 1988). Catch from a trapline as a valid index to population has also been criticized by Weinstein (1977) and Smith and Brisbin (1984) on the basis of variable probability of capture among years and socioeconomic factors.

Transect studies are best conducted in early winter (before mid-December) to reduce variance from over-winter mortality factors among years. For some species, comparisons of track counts between months suggested that time of winter was not a factor affecting numbers, but for other species counts declined as winter progressed. We believe that reduced counts for marten in late winter probably reflected two factors: trapping mortality that occurred from November to late February, and significantly reduced activity in late winter, particularly during extreme cold, compared with more moderate periods in November–December (Thompson 1986). Colder weather and deep snow in late winter compared with early winter may also have reduced track counts for red squirrels. Squirrels in late winter spend considerable time in subnivean tunnels (Pruitt 1960) and tend to be inactive during extreme cold (Banfield 1974). Subnivean activity by ermine was probably also

TABLE 4. Spearman correlations ( $r_s$ ) of track counts with spring and fall live captures for marten, varying hare, and red squirrels in uncut and regenerating stands, and with reported fur harvest for red fox, lynx, and ermine at Manitouwadge, Ontario, 1980–1985

	Live captures per 100 trap nights <sup>a</sup>						Fur harvest <sup>b</sup>		
	Marten		Hare		Red squirrel		Fox	Lynx	Ermine
	S	F	S	F	S	F			
1980							30	44	30
1981									
Uncut	0.046	0.070	7.9	1.8	2.4	1.9			
Cut	0.007	0.009	10.8	8.3	1.6	1.4	58	30	8
1982									
Uncut	0.030	0.048	1.5	0.2	0.8	1.7			
Cut	0.004	0.003	3.4	0.6	0.7	0.3	22	21	12
1983									
Uncut	0.040	0.040	0.1	0.0	0.5	0.4			
Cut	0.005	0.005	0.5	0.1	0.5	0.2	14	19	10
1984									
Uncut	0.033	0.054	0.0	0.0	0.9	2.0			
Cut	0.003	0.004	0.0	0.0	1.0	3.2	17	2	4
$r_s$ with track counts	0.69*	0.96*	0.99*	0.97*	ns	0.76*	0.80	ns	ns

NOTE: S, spring; F, fall. Data from all cutover sites were pooled, omitting the <5 year category ("cut").

<sup>a</sup>One trap night is one trap set for 24 h. No livetrapping was conducted in 1980.

<sup>b</sup>Harvest could not be partitioned between cutover and uncut sites; therefore correlations were done with track data from pooled cutovers with the sites <5 years old omitted for fox and lynx.

\* $P < 0.05$ ; ns, not significant.

TABLE 5. Stand selection as indicated by consistently highest track counts for some mammal species on 1-km transects, at Manitouwadge, Ontario, 1980–1985

	Significant comparison: high counts vs. low counts	No. of yrs. in 5 with highest counts <sup>a</sup>
Marten <sup>b</sup>	Uncut vs. all cuts <sup>c</sup>	5
Hare <sup>d</sup>	20± yrs. vs. all sites	3
	20± yrs. vs. all except 30± yrs.	4
	All sites vs. <5 yrs.	5
Red squirrel <sup>b</sup>	Uncut vs. <5 yrs.	5
	Uncut vs. 10± yrs.	2
	Uncut vs. <5 yrs., 30± yrs.	2
	All sites vs. <5 yrs.	5
Red fox <sup>d</sup>	All cuts vs. uncut	2
Lynx <sup>d</sup>	20± yrs. vs. all sites	2
	20± yrs. vs. uncut, <5 yrs., 10± yrs.	3

<sup>a</sup> $P < 0.05$ , Kruskal–Wallis test, Dunn's multiple comparisons.

<sup>b</sup>December track counts; see Table 1.

<sup>c</sup>"Cuts" refers to counts from all regenerating stands pooled or from individual stand by age group.

<sup>d</sup>Tracks from all months pooled; see Table 1.

responsible for lower track counts of that species in January and March compared with December.

Red fox and lynx are also trapped on the study area, yet no significant over-winter reductions in track counts were seen. We suspect that high variability in track counts for these two species masked any decline. We cannot explain the observed similarity between early and late winter counts for snowshoe hare.

Based on published densities of resident and transient animals, and the home range sizes (assuming circular shape) of the mammals that we studied, a 1-km transect could intersect the tracks of 1–5 marten (Thompson and Colgan 1987a), 15–300 hare (Boutin et al. 1985), 16–70 red squirrels (Rusch and Reeder 1978), and 0–5 lynx. The latter figure of 5 lynx

assumes the presence of a female and kits and therefore 0–1 is a more likely figure to expect based on a home range size near 19 km<sup>2</sup> reported by Parker et al. (1983). There are no data on density or home range size for red fox or ermine in boreal forest habitats. Erlinge (1983) indicated densities for the larger European ermine (or stoat) as similar to those reported for marten. Ranges of red foxes in agricultural and wooded areas are near 6 km<sup>2</sup> (Ables 1975), larger than for marten but less than for lynx. We believe that track counts on four or more permanent 1-km transects, located in at least two different sites, can be used to index population trends among years for ermine, marten, hare, and red squirrel. Transects should traverse habitats in proportion to their occurrence. Because of the low density of foxes and lynx, transects for

these two species should be greater than 1 km. Longer transects (probably 3–5 km) would reduce the number of zero counts and result in fewer tied ranks, increasing the power of the Kruskal–Wallis test (Andrews 1954).

### Acknowledgments

We thank P. Martindale and the Ontario Ministry of Natural Resources at Manitouwadge, and R. Collings of American Can Co. Canada Ltd. at Camp 15 for logistical support. This project was supported in part by the Ontario Ministry of Natural Resources and the Ontario Board for Industrial Leadership and Development. We also wish to thank L. Krysl and S. McGovern, who helped with some of the transects. G. Parker, S. Boutin, S. Barry, and D. Voigt reviewed various drafts of the manuscript.

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