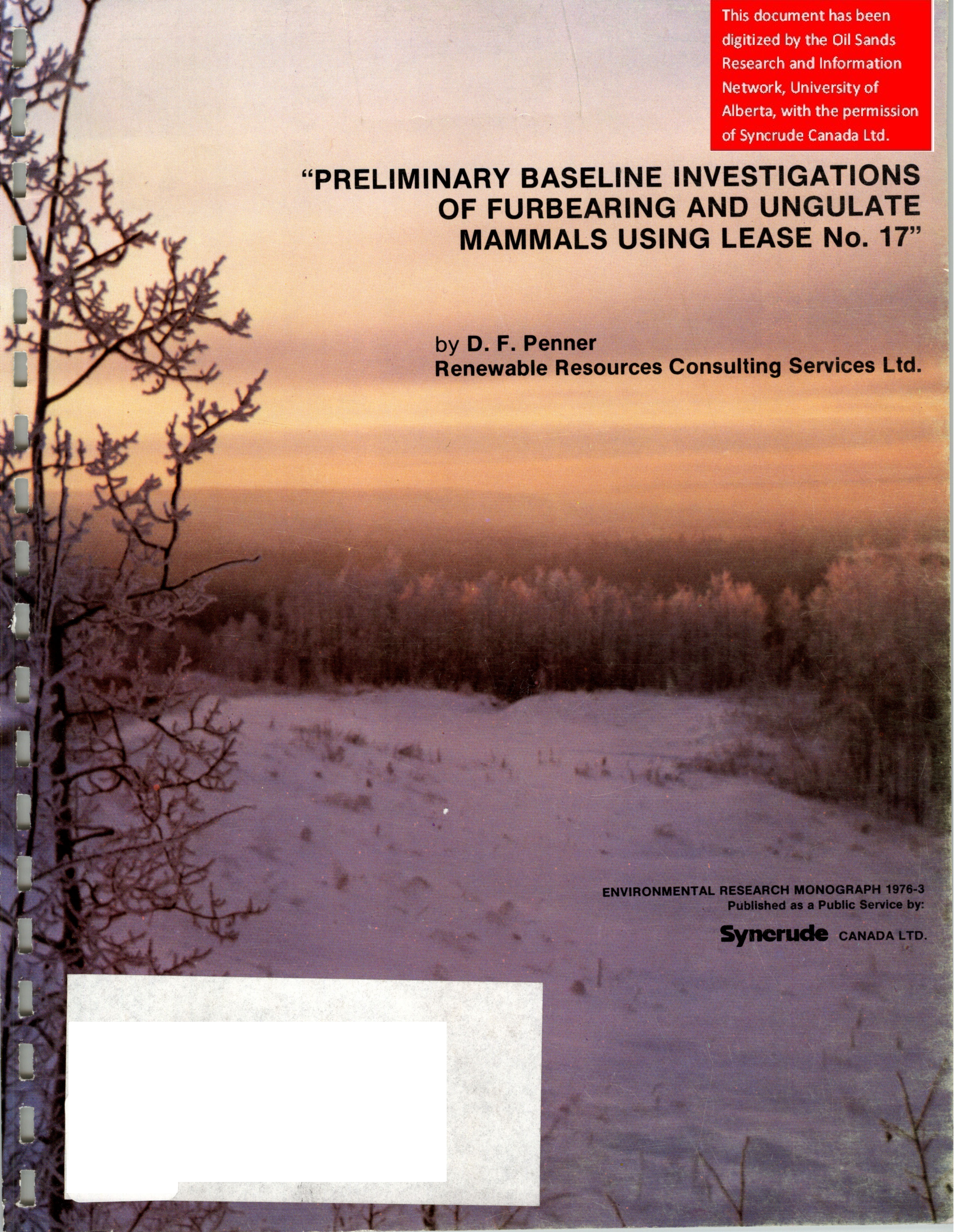

"PRELIMINARY BASELINE INVESTIGATIONS OF FURBEARING AND UNGULATE MAMMALS USING LEASE No. 17"

by **D. F. Penner**
Renewable Resources Consulting Services Ltd.

ENVIRONMENTAL RESEARCH MONOGRAPH 1976-3
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COVER PHOTO BY: P.D. LULMAN

FOREWORD

Syncrude Canada Ltd. commissioned Renewable Resources Consulting Services Ltd. to undertake winter track counts of mammals using Crown Lease #17 in the Athabasca Tar Sands. The study was designed to continue over three winters, and this report presents the information gathered during the winter of 1975-76, the first season of study.

It is Syncrude's policy to publish its consultants' final reports as they are received, withholding only proprietary technical information or that of a financial nature. Because we do not necessarily base our decisions on just one consultant's opinion, recommendations found in the text should not be construed as commitments to action by Syncrude.

Syncrude Canada Ltd. welcomes public and scientific interest in its environmental activities. Please address any questions or comments to Syncrude Environmental Affairs, 9915 - 108 Street, EDMONTON, Alberta, T5K 2G8.

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ABSTRACT

A monitoring study of ungulates and furbearing mammals was initiated for Syncrude Canada Ltd. in the vicinity of Syncrude Lease No. 17 during the period between October 15, 1975, and April 30, 1976. The relative abundance and spatial distribution of moose, deer, and 13 species of furbearers were investigated by systematic aerial surveys and winter track counts along 215 km of established transect lines. The relationships between the distribution of animals and the major environmental features including vegetation, terrain, and disturbances were examined. The relative abundances of ungulates and furbearers are presented as indices of animal activity and/or densities of animals per unit area. The relatively large scale trends in spatial distribution were evaluated by orthogonal polynomial analysis and were presented as structural and trend-surface distribution maps. These baseline data, when compared to data for subsequent years, will enable an evaluation of the impact of the operations phase of the Syncrude development on the distribution and relative abundance of ungulates and furbearers in the vicinity of the development.

ACKNOWLEDGEMENTS

Gratitude is expressed to all those who contributed their time and effort to this project. In particular, thanks are due to our field personnel Lorne Fisher, Gary Klassen, Jim Reist, Terry Van Meer, Marnie Mair, and Pat Young for their enthusiasm and assistance in various phases of the field work. Gary Klassen provided additional and valuable assistance in the investigation and compilation of data on the vegetation of the study area. Dave Wooley undertook the investigations of the regional fur harvest and provided a summary of his discussions with trappers. Garry McGonigal provided the data analysis. Hank Inglis and Dan Riopel of Associated Helicopters piloted us safely on our aerial surveys. The cooperation and assistance of Phil Lulman and Aurel Langevin of Syncrude Canada Ltd. for logistical support are greatly appreciated. R. Thompson, Alberta Energy and Natural Resources, Technical Division, and R. Campbell and staff of the Alberta Remote Censusing Center provided use of their equipment in preparation of vegetation maps. Chuck Hambling, Bill Hall, and C. Campbell of the Alberta Recreation, Parks and Wildlife provided information on fur harvest and ungulate surveys of the Fort McMurray region. Marvin Doran, Fish and Wildlife officer, and Al Boggs, former Fish and Wildlife officer, of the Fort McMurray region provided information on the wildlife and fur harvest of the area. Jim Faichney, the former Hudson Bay Manager at Fort McMurray, was particularly helpful with his comments on long-term wildlife trends in the Fort MacKay area. Bob Hilbert provided assistance by arranging meetings with trappers. We appreciate the cooperation of registered trapline holders Jules Folbert and Joseph Desjarlais of Fort McMurray, and Basil McDonald, Francis Orr, Johnny Orr, and Maxwell Orr of Fort McKay. The accommodation provided during a portion of the trapping study by Johnny Orr and his family was appreciated.

1. INTRODUCTION

The Athabasca Tar Sands area is situated in a region which has a high potential for commercial and industrial development. Industrial development is inevitably characterized by some alteration of the ecosystem in which it occurs. In response to public and governmental concerns for the maintenance of a healthy environment, and to native trappers who are dependent upon the land for their livelihood, Syncrude Canada Ltd. has initiated a comprehensive environmental research program. The study presented herein relates to that portion of the program concerned with furbearing and ungulate mammals in the vicinity of the proposed developments on Syncrude's Lease No. 17, north of Fort McMurray, Alberta.

This study was designed to generate the quantitative data required for assessing the impact of the proposed developments on furbearing and ungulate mammal populations. The basic approach involves the determination of the relative abundance and distribution of the animals to be studied along a gradient from within to beyond the sphere of influence of the main developments. A comparison of the patterns of relative abundance and distribution along the gradients and among years will allow an evaluation of the contribution of the natural factors and of the proposed developments to changes in animal abundance and distribution.

To complement the field research studies, an investigation of the relationships among the harvest of furbearer and ungulate resources, and the industrial developments was initiated.

1.1 The Objectives of the Fall and Winter 1975-76 Investigations were:

1) to determine the winter distribution and relative abundance of furbearers and ungulates in the vicinity of Syncrude tar sands Lease No. 17;
2) to provide baseline information which, when compared with data for subsequent years, will enable an evaluation of the nature and extent of the effect of the operations phase of the Syncrude development on the distribution and relative abundance of furbearers[1] and ungulates in the vicinity of the development;
3) to determine the annual harvest of fur and big game in the vicinity of Syncrude's Lease No. 17. These data, when compared to those of subsequent years, will enable an evaluation of the relationship between this harvest, animal population levels, and the development.

[1]except the black bear

2. THE STUDY AREA

2.1 Location and Size

The study area is located within Syncrude's Leases 17 and 22. This region lies approximately 37 km north of Fort McMurray, Alberta (Figure 1). The main study area (Figure 2) encompasses 259 sq km including portions of Townships 92 and 93, Ranges 10 to 12, west of the fourth meridian. The area covered by the ungulate aerial surveys (Figure 2) includes the main study area and extends north to include all of the Mackay River valley and an additional 65 sq km, including portions of Townships 94 and 95, Ranges 10 and 11, west of the fourth meridian.

2.2 Physiography and Soils

The study area lies within the Clearwater Lowlands Region of the Saskatchewan Plain. The bedrock of this area is composed of Middle Devonian limestones overlain by slightly consolidated and unconsolidated bentonitic shales and sandstones of late Cretaceous age (Bayrock, 1961). These sediments form the large erosional remnants of the Birch and Muskeg mountains which lie to the northwest and east of the study area, respectively.

The study area falls within the Grey Luvisolic soil zone of Alberta. Surficial deposits are derived from Glaciolacustrine materials, ranging from clays and silts to pure sand which generally overlie glacial till. The better

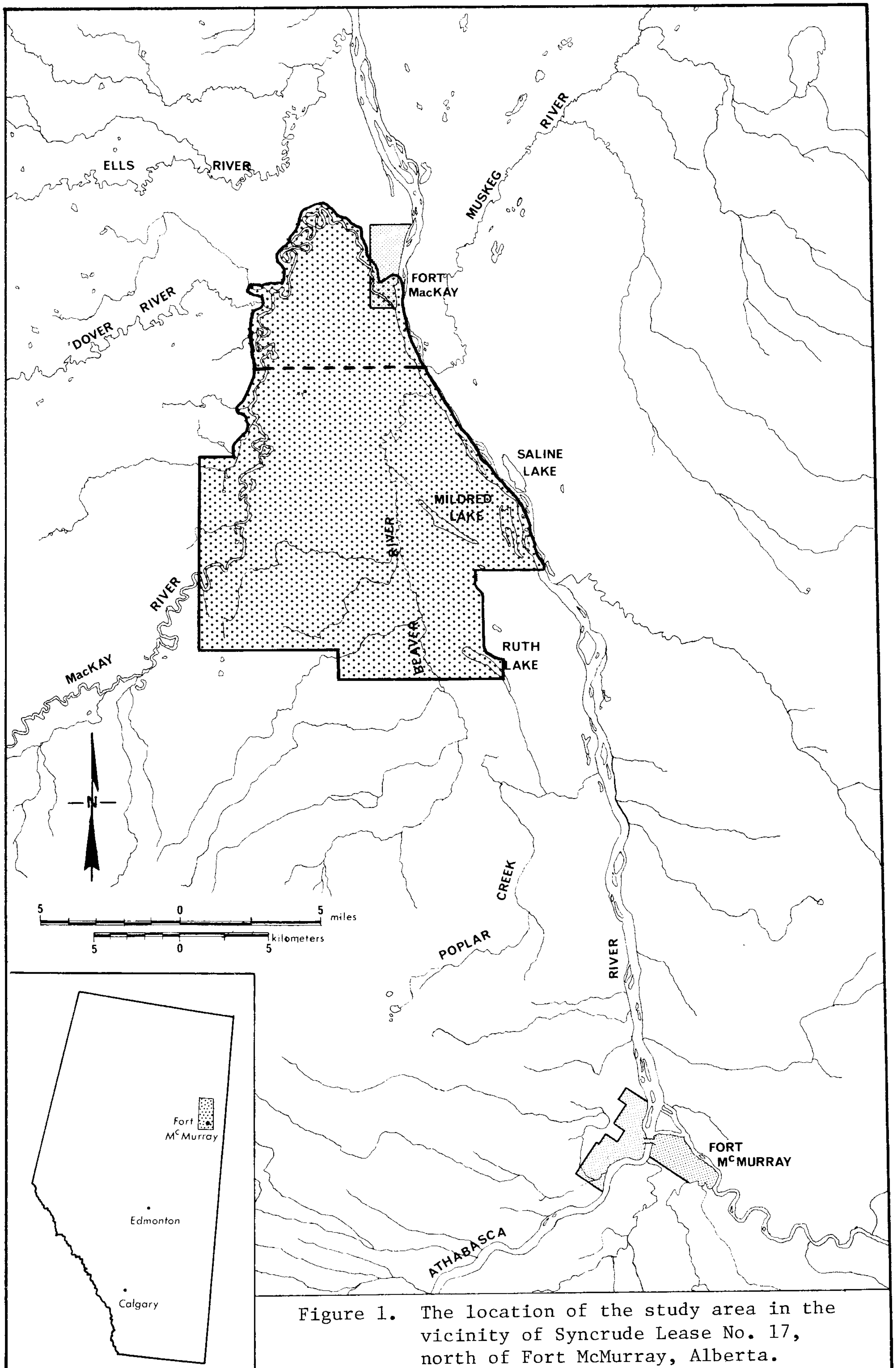


Figure 1. The location of the study area in the vicinity of Syncrude Lease No. 17, north of Fort McMurray, Alberta.

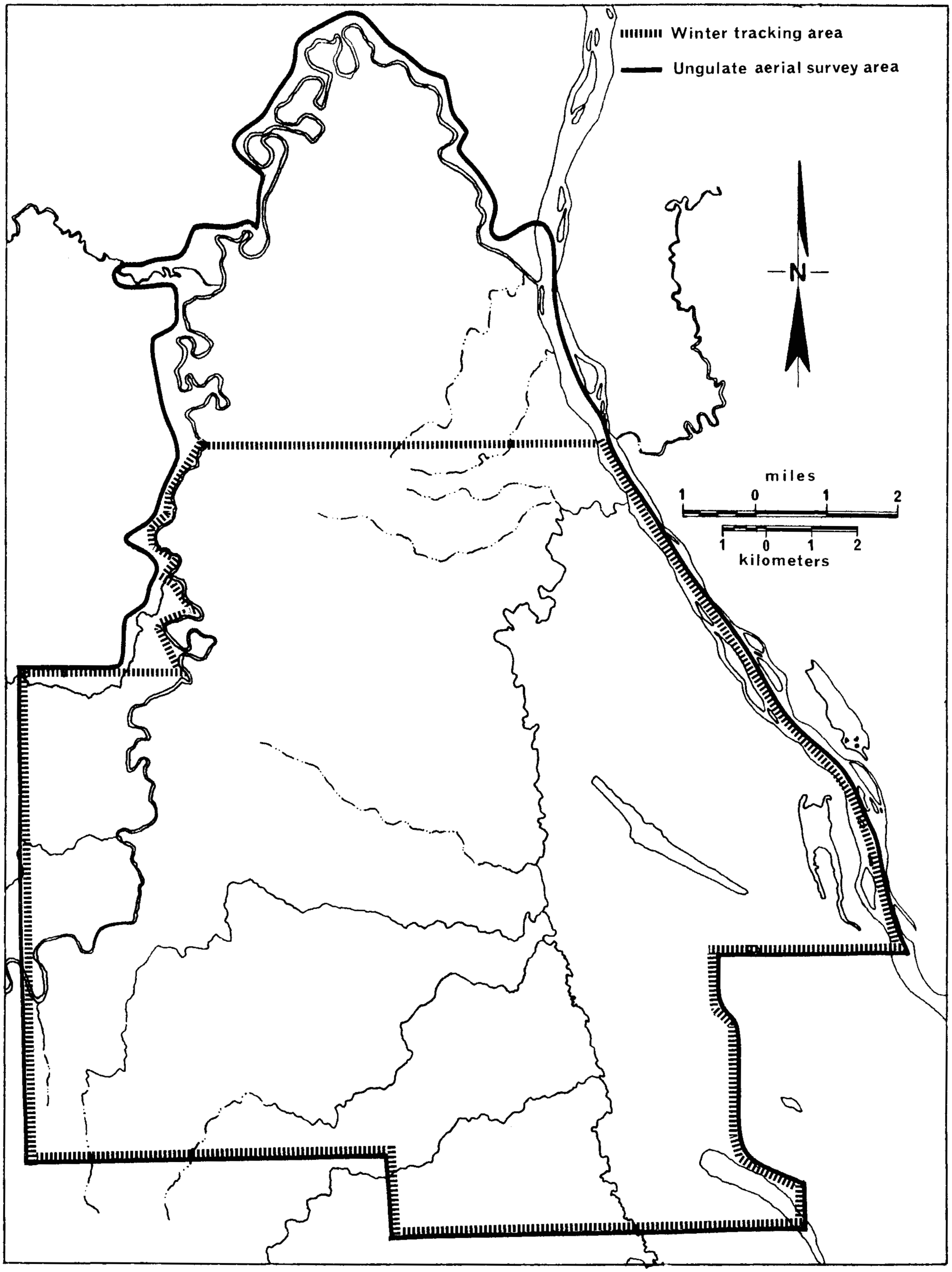


Figure 2. The winter tracking and ungulate aerial survey study areas.

drained mineral soils which developed on either lacustrine or till deposits are primarily Grey Luvisols. Well-drained soils developed on sandy parent material are generally Podzolic. Poorly drained sites are characterized by Gleysolic and Organic soils (Lindsay *et al.*, 1961).

The topography of the western portion of the study area consists of a gently undulating slope from the base of the Birch Mountains towards the Athabasca River. The topography of the remainder of the area is variable, ranging from depressional to rolling land (Lindsay *et al.*, 1961). The range of elevation is from 380 m above sea level in the western edge of the area to 228 m along the Athabasca River.

The major rivers flowing through the study area are the Athabasca and Mackay rivers. These rivers have relatively well-incised valleys, which range from 30 m to 50 m below the surrounding uplands. Beaver Creek drains the central portion of the study area and varies from a meandering stream in the poorly drained lands in the southern portion of the study area to a steep gorge near its confluence with the Athabasca River. The relatively flat uplands are drained by a number of small intermittent streams, the majority of which flowed into Beaver Creek before the construction of the interceptor ditch. Beaver dams along intermittent streams have impeded drainage, resulting in numerous shallow ponds.

Larger water bodies in the area include Ruth, Mildred and Horseshoe lakes. Ruth and Horseshoe lakes are relatively shallow and are characterized by a broad band of emergent and submergent vegetation. Mildred Lake has a greater depth and maintains only a narrow band of emergent vegetation.

2.3 Vegetation

The study area is within the Mixedwood Section of the Boreal Forest Region (Rowe, 1972). This is a large Forest Section extending from southwestern Manitoba to northeastern British Columbia.

The major determining factor in the composition of the forests in the study area has been widespread forest fires (probably in the late 1940's). The ability of trembling aspen (*Populus tremuloides*) to regenerate rapidly following disturbance has resulted in large pure stands of this species. White birch (*Betula papyrifera*) is a minor component as is balsam poplar (*Populus balsamifera*) which usually occurs on sites such as river valleys which have a more favorable moisture regime. White spruce (*Picea glauca*) is generally present in older upland stands while jack pine (*Pinus banksiana*) is the usual associate on sandy areas and drier tills. Wetter areas support black spruce (*Picea mariana*) and occasionally tamarack (*Larix laricina*). A minor balsam fir (*Abies balsamea*) component occupies isolated river valley stands.

Major shrub species of upland areas are saskatoon berry (*Amelanchier alnifolia*), buffalo-berry (*Shepherdia canadensis*), honeysuckle (*Lonicera* spp.), and green alder (*Alnus crispa*). On moist to wet sites common shrub species are willow (*Salix* spp.), river alder (*Alnus tenuifolia*), dwarf birch (*Betula glandulosa*), and common labrador tea (*Ledum groenlandicum*). In addition to these hygrophilous species, river banks and flood plains often support red-osier dogwood (*Cornus stolonifera*) and low-bush cranberry (*Viburnum edule*).

The Boreal Mixedwood Forest is a mosaic of communities at various seral stages brought about by responses to site conditions, repeated disturbance and the autecology of available species (Plate 1). The general successional trend is from the shade-intolerant species (aspen, balsam poplar, birch, jack pine, and tamarack) to the more tolerant white and black spruces, and balsam fir. With the possible exception of the infrequently occurring balsam fir, no species in the boreal forest has all the ecological attributes necessary for the species to form a self-perpetuating climax community. Thus late-successional stands become decadent and unhealthy, awaiting disturbance for rejuvenation.

2.4 Climate

The study area lies within the Cool Temperature climatic zone, which is characterized by short cool summers and long cold winters (Longley, 1967).

Long-term records of mean annual precipitation and temperature, for the years 1941 to 1970, were obtained from the Fort McMurray Airport reporting station (Environment Canada, 1973). The mean annual temperature is -0.5°C. The highest temperatures occur in July, averaging 16.3°C and the lowest temperatures in January, averaging -21.5°C. The extreme temperature range is from 36.1°C to -50.6°C illustrating the great seasonal variability in temperature. The average frost-free period is 67 days with a range of 29 to 101 days.

The mean total precipitation is 43.5 cm, of which 30.5 cm is rainfall. The mean annual snowfall is 139.7 cm which compacts a mean maximum snow

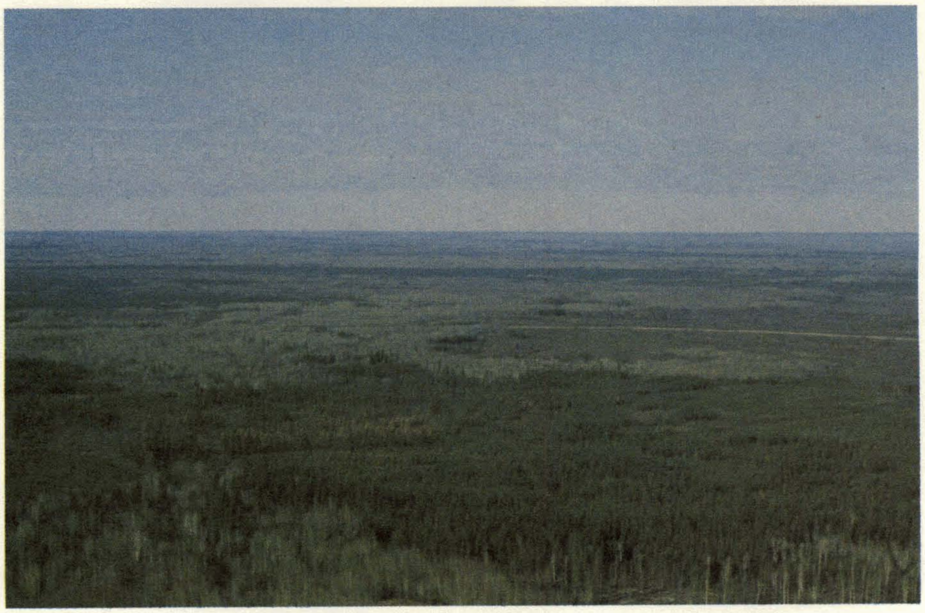


Plate 1. A general view of the northern portion of the study area illustrating typical vegetation patterns.

depth of 38.0 cm in February. Maximum snow depths have reached 66 cm within the reporting periods.

3. METHODS

3.1 Classification of Environmental Parameters

In order to determine baseline conditions of the relative abundance and distribution of mammals within the study area and in relation to disturbance from major and secondary developments, an understanding of the variation due to natural environmental factors is required. By comparing areas with similar environmental features (habitat types), it may be possible to determine the impact of the developments on mammals at various distances from major and secondary disturbances.

Of the numerous environmental variables which interact to constitute an animal's habitat, vegetation and terrain were considered major features which typify a habitat type.

Preliminary vegetation types were qualitatively defined by integrating information from field reconnaissance with previous ecological descriptions in northern Alberta by Lacate *et al.* (1965), Moss (1953a, 1953b, 1955), and Raup (1933, 1935, 1946). These preliminary vegetation types were delineated by interpretation of black and white infra-red aerial photographs taken in August 1972 at a scale of 1:21,120. During field investigations the types were modified according to existing conditions and then recorded for each tracking station. These data were used in reinterpretation of the aerial photographs. A vegetation type map was then produced from the photographs. The proportion of each vegetation type was calculated from the data recorded along the transect lines and checked against the vegetation type map.

Quantitative evaluation of the vegetation types was outside the scope of the study. The decision as to which type best described the vegetation of a tracking station was made on a purely subjective basis. This could be a source of error due to observer bias, however, every effort was made to standardize classification among observers. Additionally, this study was carried out during the winter, which precluded the systematic observation of herbs and smaller shrubs and limited the study of the tall shrubs.

Seven terrain features were recognized during preliminary field investigations. The recognition of a terrain feature required that the potential reaction of furbearers and ungulates to the terrain feature be measurable by the methods employed and be readily recognized or measurable under field conditions.

The classes of terrain features recognized in the field were:

1) 0-10% slope
2) 10-30% slope
3) 30-60% slope
4) 60%+ slope
5) shoreline
6) streambed
7) open water.

For slopes greater than 10%, the directional aspect was described by one of four classes, which corresponded to the nearest quadrant: north, east, south, or west. Terrain features and aspect were noted for each tracking station. This information was summarized and the proportional coverage of each occurring combination was calculated.

Secondary disturbances (roads and cutlines) were noted in order to isolate their effect on distribution and relative abundance of ungulates and furbearers. These disturbances were classified as:

1) Roads: A transportation corridor that receives periodic or sustained use by a four-wheeled vehicle and is subject to periodic snow removal.

Type 1. Light use periodic passage of several vehicles per week or brief periods of heavier use.

Type 2. Moderate to heavy use - multiple passage of vehicles on a daily basis.

2) Cutlines: Any corridor that had disrupted the natural vegetation cover but was not used for road vehicles or was not subject to snow removal.

Type 1. Recently cleared - little or no vegetation cover (Plate 2).

Plate 2. A recently cleared cutline (Type 1) used as temporary winter access road .

Type 2. Old cutline - with light to moderate regrowth of shrubs and trees up to 2 m in height (Plate 3).

Snow depth measurements were recorded after each significant snowfall or at the initiation of a tracking session. Replicated measurements were taken in two representative habitat types: one coniferous (Type J) and one deciduous (Type A) and averaged to yield a mean snow depth for the ensuing period of tracking.

3.2 Aerial Surveys

3.2.1 Aquatic Furbearers

Aerial surveys for aquatic furbearers (beaver and muskrat)[1] were conducted on October 22 and 23, 1976. Surveys were conducted with a Bell 206-B helicopter at air speeds of 65 to 100 km per hour and at an altitude of 60 to 90 m. Observations were conducted by two observers who were assisted by the pilot.

A systematic search pattern was flown by following all river and stream drainages and lake shorelines within the main study area (Figure 2). The location of all beaver lodges, food caches sites, and muskrat lodges were recorded on a 1:50,000 topographic map. The criteria for distinguishing occupied beaver colonies from unoccupied ones were the presence of a freshly mudded lodge or a recent food cache.

[1]Scientific and vernacular names follow Jones *et al.* and are presented in Appendix 1.

Plate 3. An old cutline (Type 2) with extensive shrub regeneration.

Ground checks on the accuracy of aerial surveys and on the activity status of beaver and muskrat lodges were conducted during the winter period.

3.2.2 Ungulates

Aerial surveys for ungulates were conducted during December 13 to 16, 1975 (early winter), and February 4 to 7, 1976 (late winter). Surveys were conducted with Bell 206-B and Bell AJ-2 helicopters, flying at air speeds of 120 to 160 km per hour and at altitudes of 60 to 100 m. Observations were conducted by two observers who were assisted by the pilot.

Complete aerial coverage of the ungulate study area (Figure 2) was effected by flying overlapping transects within recognizable topographical units. For each observation, the species, sex and age class of the animals, and the general habitat type were recorded. The location of each observation was recorded on a 1:50,000 topographic map.

Moose population estimates were determined on the assumption that approximately 55% of all animals present were observed. This correction factor is based on results of controlled aerial survey studies conducted in Alaska by LeResche and Rausch (1974).

3.3 Winter Track Counts

3.3.1 Experimental Design

In order to sample all portions of the study area in a statistically sound manner, the study area was stratified by systematically spaced latitudinal (east-west) zones, 1.2 km wide.

The latitudinal orientation of these zones was selected because both the major drainages within the study area (Athabasca, Mackay, and Beaver rivers) and the industrial developments are oriented longitudinally. Both these parameters were anticipated to exert an influence on mammal distribution.

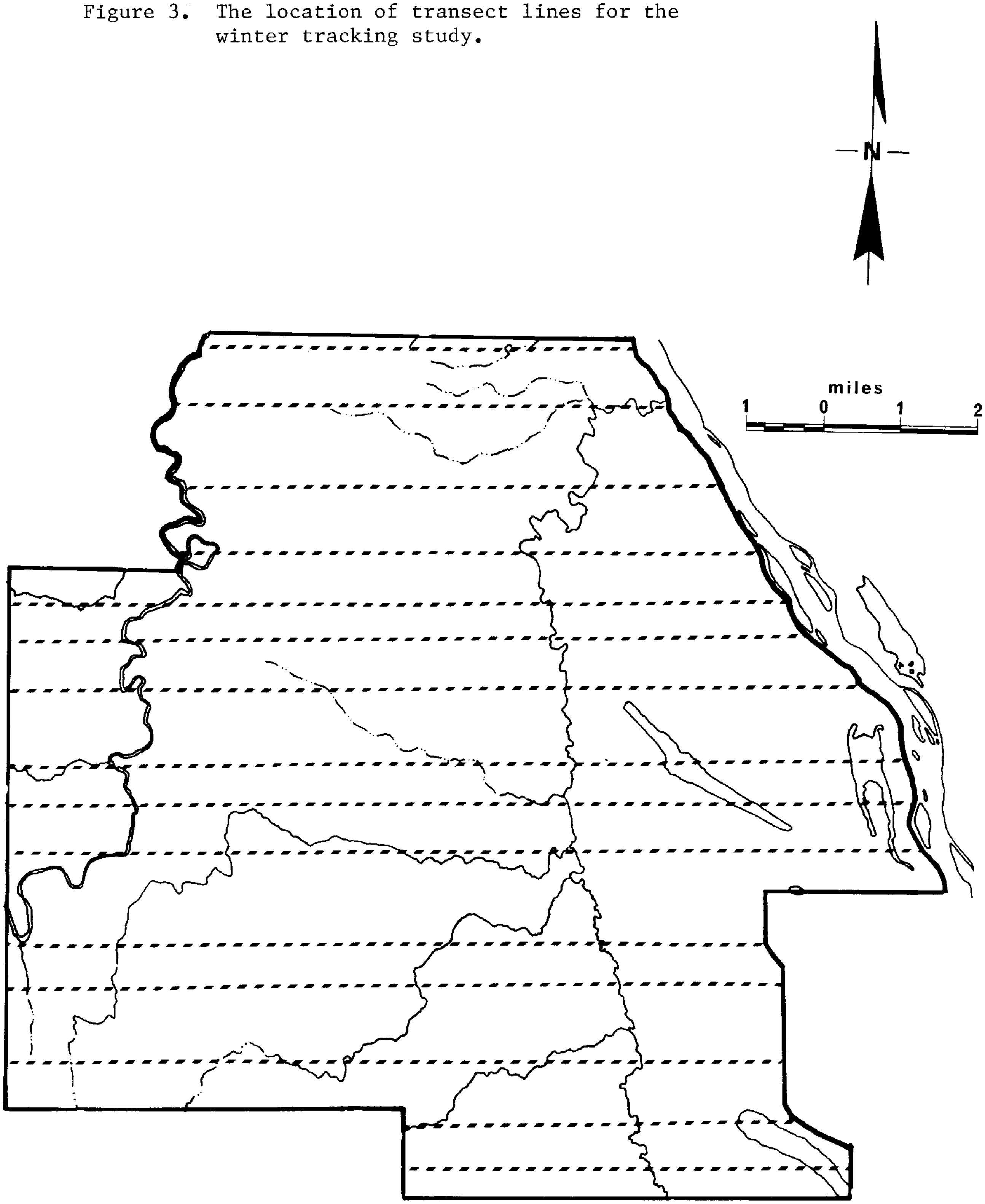
Within each stratified zone one transect line, spanning the length of the zone, was randomly established. The locations of the 15 transect lines are illustrated in Figure 3. The total length of the 15 transect lines was 214.8 km.

Transect lines were surveyed by hand-held and staff compasses and divided into 50 m sections using a nylon chain. The 50 m sections along transect lines are hereafter referred to as stations or tracking stations. All transect lines originated along the eastern limit of the study area and were marked with surveyor's flagging tape. The end of each station was marked with an aluminum tag. Tags were consecutively numbered from the beginning of the transect line.

3.3.2 Collection of Winter Track Data

During the winter period, three tracking replicates were conducted the last of which was only two-thirds completed. Tracking transects were covered on foot. For each observation of ungulate and furbearer tracks which crossed the transect line, since the most recent significant snowfall, the following information was recorded:

Figure 3. The location of transect lines for the
winter tracking study.



a) species

b) date

c) location by transect and station

d) vegetation cover type

e) terrain features

f) mean snow depth

g) number of days since the last snowfall (track-days).

Figure 4 illustrates the species and environmental parameters considered and the method of coding for efficient recording on field data forms (Figure 5) and computer compilation of data.

The relative abundance of tracks or activity of a given species at a station was considered to be a function of the total number of track crossings and the number of track-days since the last snowfall.

3.4 Red Squirrel Midden Counts

Red squirrel midden counts were conducted along the established transect lines during the period between January 15 and March 15, 1976. These counts were conducted concurrently with the ungulate and furbearer tracking program.

For each active red squirrel midden observed within 2 m of a transect line, the location (by transect and station), vegetation cover type, and

Species

01 Weasel
02 Mink
03 Marten
04 Fisher
05 Wolverine
06 Otter
07 Red Fox
08 Coyote
09 Wolf
10 Lynx
11 Red Squirrel
12 Snowshoe Hare
13 Moose
14 Mule Deer
15 Caribou
16 Unident Furbearer
17 Ruffed Grouse
18 Spruce Grouse
19 Sharptail Grouse
20 Willow Ptarmigan
21 Flying Squirrel
22 Other

Vegetation Cover Type

1 B. Poplar-T. aspen
2 T. aspen
3 T. aspen-alder &/or willow
4 Conif-Decid (11 to 40% Decid)
5 Conif-Decid (11 to 40% Conif)
6 Conif-Decid (41% Conif to 41% Decid)
7 W. spruce
8 Jack pine
9 B. spruce (cover 11 to 40%)
10 B. spruce (cover 41 to 100%)
11 Alder:non-riparian
12 Willow:non-riparian
13 Labrador tea, bog birch
14 Riparian:herbs
15 Riparian:shrubs
16 Disturbed-light regen.
17 No cover
18 B. spruce-willow

Terrain Features

1 0-10% slope
2 10-30% slope
3 30-60% slope
4 60+% slope
5 shoreline (river or lake)
6 Streambed
7 Open Water (ice)
8 Roads-no-light use
9 Roads-mod-heavy use
51 Cutline: Recent-no or little cover
52 Cutline: Older-mod. revegetation

Aspect

1 North-facing
2 East-facing
3 South-facing
4 West-facing

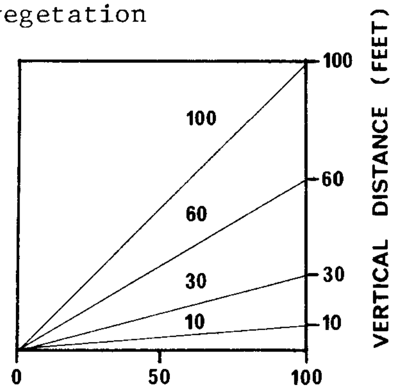


Figure 4. Numerical codes of species and environmental variables recorded on field data forms.

Day	Month	Year	Transect	Station	Species	Vegetation Type	Terrain Features	Snow Depth(cm)	Days Since Last Snowfall		Number of Occurrences
Remarks:											
Remarks:											
Remarks:											
Remarks:											
Remarks:											
Remarks:											

Figure 5. An example of the field data form used to record the winter ungulate and furbearer tracking information.

terrain type were recorded.

Population estimates of red squirrel were based on the assumptions that a) red squirrels occupy mutually exclusive territories, each of which contains one actively used midden (Krasnowski, 1969); and b) the density and distribution of red squirrels along the transect lines were representative of the study area.

3.5 Fur Harvest Records

Trapper fur harvest data for the Fort McMurray and Fort MacKay area were obtained from the Fish and Wildlife Division of the Department of Recreation, Parks and Wildlife. Names of the senior holders of traplines and the location of the lines were also obtained for the study area.

Discussions were held with three active trappers whose lines were adjacent to the Syncrude Lease. In addition, four trappers were interviewed whose lines were located outside the immediate area of the Lease but relatively close to Fort MacKay.

Discussions were held with Alberta Fish and Wildlife personnel from Fort McMurray, an officer from the Alberta Forest Service of the Department of Energy and Natural Resources in Fort MacKay and the former Hudson Bay manager from Fort MacKay. The field portion of the program was carried out during the periods between March 8 and 12 and March 17 and 20, 1976. During the latter period the interviewer accompanied two trappers on their respective traplines.

3.6 Methods of Analysis

The track-counting technique provides quantitative information on the association of each species with the available habitats, the areal extent of activity, and the spatial trend(s) of distribution. The statistical techniques required to assess this information were selected so as to provide an understanding of the geographical variation of activity, the possible existence and form of activity patterns, and the identification of factors that may be influencing these patterns. The findings were presented as proportions to allow for future comparison.

3.6.1 Animal-Habitat Associations

Three habitat groupings were considered: vegetation, terrain and natural versus man-altered (disturbance) features. The observed distribution of each species of animal was defined as the relative frequency of tracks per track-day[1] occurring within each habitat category.

The procedure for analysis followed the methodology described by Neu *et al.* (1974). The hypothesis considered that each species utilized the various types of habitat in proportion to their availability by areal extent, a

[1]Tracks per track-day = N*S/D where N is the number of stations of a given habitat category and stations being the unit of spatial measurement, S is the sum of tracks observed/habitat category and D is the sum of track-days (number of days since last snowfall).

multinomial distribution (Ostle, 1963). The observed distribution of each species was described by its proportional occurrence within each habitat category. Expected distribution of occurrence was equivalent to the proportions of available habitat. The Kolmogorov-Smirnov one sample test, (Kolmogorov, 1933; Siegel, 1956; Sokal and Rohlf, 1969) to determine the goodness-of-fit, compared the overall expected and observed frequency distributions. If a significant difference was found between the two distributions then it was concluded that the animals were not utilizing the habitat in proportion to its availability. Conversely, if no significant difference occurred between the observed and expected distributions, it was concluded that these animals were distributed in and utilized the habitats in the study area in proportion to their availability.

Where a significant difference between habitat availability and animal distribution occurred, the Bonferroni Z statistic was applied to the observed values, providing confidence intervals for each habitat type (Neu *et al.*, 1974). If the expected value fell within the interval, it was concluded that the species was utilizing the habitat type in accordance with its availability. If the expected proportion fell above or below the interval, the species was considered to be exhibiting an avoidance of, or preference for that habitat type, respectively.

This form of analysis provides a quantitative measure of animal-habitat association. Its primary advantage is the ability to examine individually the use of each habitat type by a particular animal species. Its weakness follows the use of a non-parametric test instead of a parametric test. Additionally, the goodness-of-fit test used in this study tends toward a "conservative" bias when the sample size approaches infinity. But in light of the alternatives this "conservatism" or reduced sensitivity to difference should not be considered a serious problem. The technique provides a further refinement of quantitative methods which have been used to test multinomial distribution.

3.6.2 Spatial Distribution of Animal Activity

The spatial distribution of animal activity was evaluated (by grid-mapping) and illustrated as an isodensity map. These maps identify the spatial distribution of animal activity. Proportional to these maps, relative abundance of activity was determined.

The data unit for contour mapping was the sum of tracks per track-day per station. The number of tracks and track-days per station were combined from all track-count replications. Since absence of animal activity within a geographical area was also considered important, a value of zero was assigned to those stations lacking in observations.

Data input consisted of a dimensioned matrix of 4,289 points (one value per station) and corresponding cartesian coordinates. Output was a grid matrix (surface) and a contour map. The grid surface was calculated according to a method of areal extrapolation. Contour lines were interpolated over this surface following user-supplied criteria.

Gridding, mapping and contouring were performed through a series of computer programs, supplied by Computer Sciences Canada Ltd. - ADTOPS, MAP, and PLOTTR. Gridding consisted of extrapolating a set of data values from their respective cartesian coordinates, and generating a map surface (grid matrix) that detailed the entire study area. Input data were positioned within the grid and values at each grid node surrounding a prime point were calculated. Selection of the number of mesh points for extrapolation was determined through an automatic segmentation within the program or as an override option supplied by the user. The X-Y coordinates were converted to grid cell units and placed within the grid. First order planes were then calculated which passed through the prime (input) Z values and which were fitted to surrounding prime values by the least-squares norm.

Extrapolation for values at each mesh point was based upon a search radius covering equal sized sectors that scanned through eight directions. The maximum length of this search radius was 0.125 of the diagonal distance across the grid surface. In order for a value of a cell to be extrapolated it was necessary that six out of eight sectors have a valid data point. Failure to satisfy this criterion deleted the cell from enclosure within the boundaries of the map.

Fitting of a plane to the input data followed a weighting procedure based on the inverse square of the distance from the centroid of the cell (i.e. those values closest to the center received the greatest weight and those positioned at the extremities of the search radius received the least weight).

If more than one value fell within a given cell, a true average was taken of the X, Y, and Z values involved. Secondary gridding followed the method used in the primary stage with the plane now allowed to float to the best least-squares fit of the surrounding values.

A grid size[2] of 86 was selected to provide a sufficient level of detail for interpretation. The resultant grid was rectangular in shape and consisted of 6,794 (86 X 79) mesh points. Extrapolation defined 5,788 valid cells with the remaining 1,006 cells deleted from enclosure. Enclosure of the study area boundaries within this rectangle was by a convex polygon of degree 86. For a grid size of 86 X 79 the radius approximated 14.6 grid cells. Cell size was dependent upon the grid specifications and the map scale. Since the study area covered 254 sq km, and the enclosed grid surface consisted of 5,788 cells, an approximation of cell size was 0.04 sq km, with one side of the cell extending 209.5 m.

Contouring of the grid matrix followed the interpolating process of fitting isolines to the grid matrix. An appropriate contour interval and a lower contour limit were selected for each species to provide an optimum of information on an isodensity map.

A frequency distribution of the relative abundance of track activity within the established contour intervals was calculated from the grid

[2] Specifies the number of grid cells that divide the longest axis with an upper limit of 100. (Note: the larger the number of grid cells the greater detail extrapolated for).

matrix and expressed as proportions of the total study area.

3.6.3 Trend-Surface Analysis

The method of trend-surface analysis selected for this study was an orthogonal algebraic polynomial for irregularly spaced data, which followed a modification of the program developed by Whitten (1974, 1976, pers. comm., Geologist, Northwestern Univ., Chicago, U.S.A.). This method provided a separation and identification of any regional trend(s) from the overall activity pattern within the study area.

This method, as well as others, are well documented in the literature (deLury, 1950; Oldham and Sutherland, 1955; Krumbein, 1959; Krumbein and Graybill, 1965; Harabaugh and Preston, 1968; James, 1966; Marcus and Vandermeer, 1966; Crain and Bhattacharyya, 1967; Whitten, 1970, 1973, 1975).

Data input was as described in Section 3.6.2, except that only those stations reporting activity were used. Output consisted of: the Ƶ square array, the array of orthogonal polynomial coefficients, the percent sum of squares reduction attributed to each individual coefficient (RSS), the corrected percent sum of squares attributed to each degree of surface (%RSS), a map of the surface, and the corresponding orthogonal and surface coefficients as qualified by significance tests.

The Ƶ square array sets out the proportion of the total variability accounted for by each of the orthogonal coefficients. The sum of squares reduction (RSS and %RSS) provides a measure of the sum of the squares of the deviations between each original datum point and the computed surface. The orthogonal and surface coefficients describe the algebraic and surface functions of the trend, respectively.

The Ƶ square array and the %RSS methods of analysis (Grant, 1957; Norcliffe, 1969) were combined to identify the trend, to delineate the trend coefficients, and to generate the surface coefficients. This method proceeded from the following:

1) based on an initial examination of the Ƶ square array, noncontributing coefficients were deleted;
2) the %RSS corrected was assessed by an F-test for the presence of any trend;
3) if a trend was found, the "trend limit" was constructed on the Ƶ square array and the corresponding orthogonal polynomial coefficients were identified; and
4) using only the orthogonal polynomial coefficients within the "trend limit", surface coefficients were computed and a trend map of the specified surface order was produced.

4. RESULTS AND DISCUSSION

4.1 Wildlife Habitat

4.1.1 Vegetation

4.1.1.1 Previous Vegetation Studies

There have been few studies of the vegetation in the immediate vicinity of Syncrude Lease No. 17. The most recent work was performed by Vaartnou (Syncrude, 1974) as background for revegetation species selection. This paper describes in a general manner the soils and species composition of eight community types on Syncrude Lease No. 17. These community types are similar to 12 habitat types described in "The Habitat of Syncrude Tar Sands Lease #17: An Initial Evaluation" (Syncrude, 1973). This latter report lists tree and shrub species for these habitat types and ranks their importance to wildlife as food sources.

The Alberta Forest Service (1967) produced a report on the forest resources of Census Division 12 based on current data. This was updated for the mineable tar sands area by the Alberta Department of Lands and Forests (1973). Forest cover maps and area stand lists were produced, based on the interpretation Alberta Ltd. (1973a, 1973b) summarized the data from these maps and lists.

The most thorough description of the vegetation of northeastern Alberta has been provided by Raup (1933, 1935, 1946). The first of these gives some indication of the identity and distribution of forest types with particular reference to white spruce and Banksian (jack) pine. The second describes the vegetation of Wood Buffalo Park. Information from both of these papers as well as earlier more general publications is updated and summarized in the 1946 paper entitled "Phytogeographic studies in the Athabasca-Great Slave Lake region". This is the only detailed vegetation description that includes the study area. Correlation between the communities described by Raup and those in the present paper are outlined elsewhere in this report.

Studies by Moss (1953a, 1953b, 1955) provide descriptions of the floristic composition and ecological relationships of the major forest types in northwestern Alberta. These descriptions are comparable to vegetation types in northeastern Alberta because of the proximity of the areas and the similarity in environmental conditions.

Quantitative data on phytosociological structure of the forests of Candle Lake, Saskatchewan, and changes therein are presented by Swan and Dix (1966) and Dix and Swan (1971). As mentioned in the former paper, there appears to be a general similarity in physiognomic structure and species composition between the upland boreal forest of Candle Lake and northern Alberta. Jeglum (1968) describes the lowland vegetation of Candle Lake. Descriptions of succession in the boreal forest are provided by many authors including Jarvis *et al.* (1966), Lacate *et al.* (1965) and Rowe (1961) as well as many of the papers mentioned earlier.

An excellent general description of the boreal forest in Alberta is supplied by LaRoi *et al.* (1967).

4.1.1.2 Vegetation of the Study Area

The vegetative cover of the study area is a mixture of varying species composition, height, and density. In order to compare furbearer and ungulate use among areas, it is necessary to account for differences or similarities in the vegetation. For this study, relatively discrete, recurring patterns were grouped into vegetation types. The parameters used in this differentiation varied according to the type and incorporated a bias toward those factors expected to influence furbearer and ungulate distribution. It should be emphasized that the vegetation types used in this study are specific to the study and careful consideration should be given to their descriptive definitions before they are used in other applications.

For the purpose of characterizing the major vegetative features of the habitat, 17 vegetation types were delineated. These vegetation types and their percent coverage of the study area are illustrated in Table 1.

Due to difficulties in interpreting shrub species on aerial photographs and because of map scale limitations, certain vegetation types are consolidated and delineated on the vegetation type map (Figure 6). The types delineated on this map and their synonymity with those used in the field are:

Map Designation	Vegetation Type	Field Designation
1	Trembling aspen-balsam poplar	B

Table 1. Proportional areal coverage of vegetation types on the study area.

Field Designation	Vegetation Type	Area Coverage (%)
A	Trembling aspen	4.8
B	Trembling aspen-balsam poplar	1.2
C	Trembling aspen-willow and/or alder	14.2
D	Mixedwood (11% to 40% coniferous)	7.5
E	Mixedwood (41% deciduous to 41% coniferous)	2.6
F	Mixedwood (61% to 89% coniferous)	6.1
G	White spruce	1.6
H	Jack pine	0.9
I	Black spruce (cover 11 to 40%)	5.7
J	Black spruce (cover 41 to 100%)	15.4
K	Black spruce-willow	6.1
L	Tall shrub	6.0
M	Dwarf birch-tamarack	2.4
N	Riparian shrubs and herbs	2.2
O	Disturbed - with regeneration	0.5
P	Disturbed - recent-no regeneration	5.8
Q	Disturbed - main cleared area	17.3

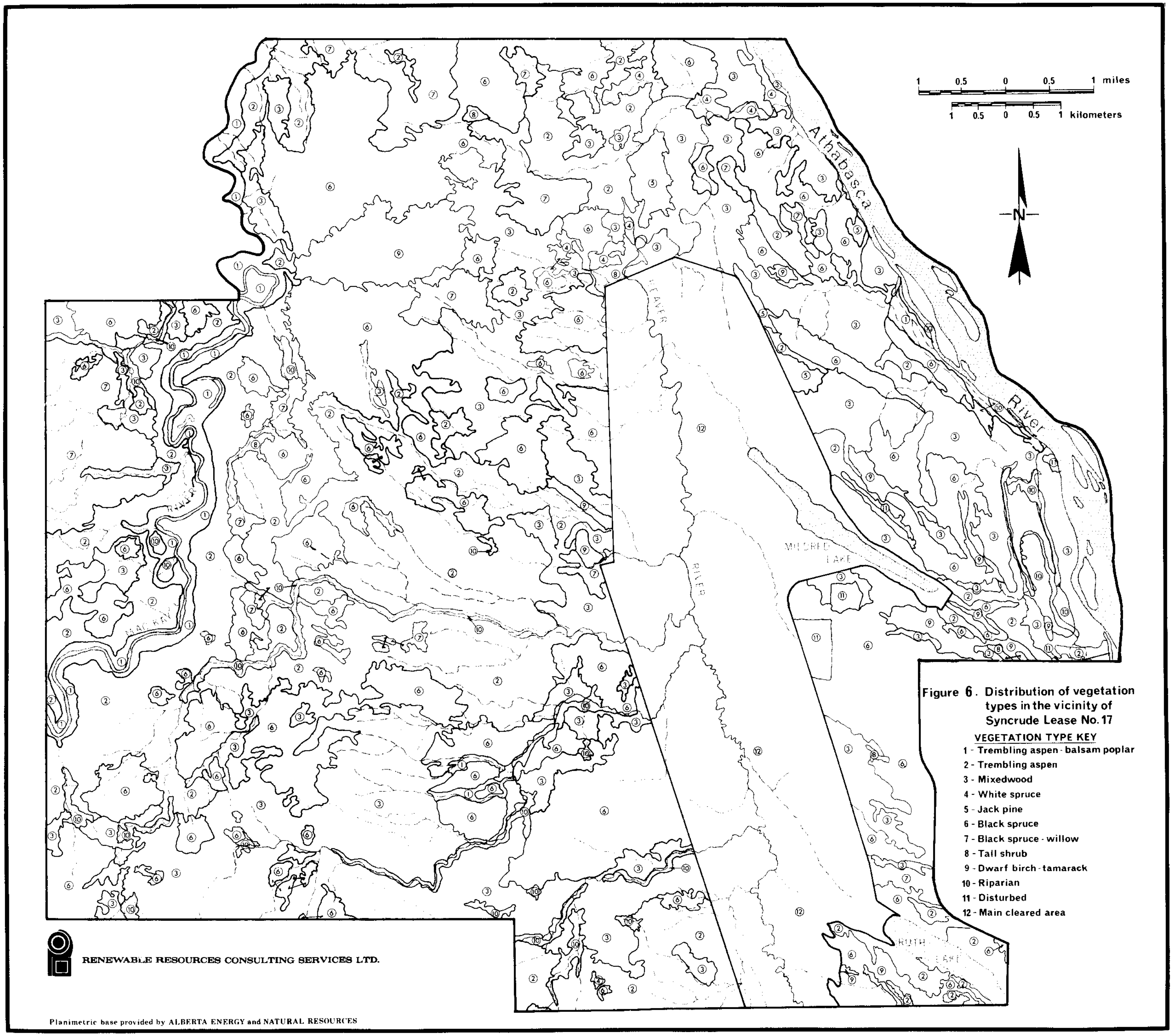


Figure 6. Distribution of vegetation types in the vicinity of Syncrude Lease No. 17

VEGETATION TYPE KEY

1 - Trembling aspen - balsam poplar
2 - Trembling aspen
3 - Mixedwood
4 - White spruce
5 - Jack pine
6 - Black spruce
7 - Black spruce - willow
8 - Tall shrub
9 - Dwarf birch - tamarack
10 - Riparian
11 - Disturbed
12 - Main cleared area

2	Trembling aspen	A and C
3	Mixedwood	D, E, and F
4	White spruce	G
5	Jack pine	H
6	Black spruce	I and J
7	Black spruce-willow	K
8	Tall shrub	L
9	Dwarf birch-tamarack	M
10	Riparian	N
11	Disturbed	O and P
12	Main cleared area	Q

4.1.1.3 Description of Vegetation Types

Trembling Aspen Types (A, B, and C)

Trembling aspen is the primary overstory species of these three types. Their distinction is in site preference and/or the presence of significant proportions of an indicator species (i.e. balsam poplar, willow and/or alder).

These are early-successional types due to aspen's rapid post-fire regeneration and low shade tolerance. Young stands are dense, but they tend to thin with age as there is much competition-related mortality among less aggressive individuals. Succession is generally toward the shore tolerant white spruce. Aspen grows on a wide range of soil texture and moisture, occurring on all but the driest or wettest sites.

White birch stands occur infrequently on the study area and thus were not given a separate designation. Since the species was judged most similar to aspen, it was classified as such during air photo interpretation. The only major stand of white birch observed was recorded along the Fort MacKay highway between Beaver Creek and the Mildred Lake airstrip.

Type A - Trembling Aspen Type

This type represents those aspen stands without a significant proportion of an associated tree or shrub species (Plate 4). It represents 4.8% of the study area with the most widespread examples to the southwest.

Site preference appears to be mesic upland areas. The scarcity of white spruce in the understory may be explained by the long distance between available seed trees. Associated shrub species are buffalo-berry, low-bush cranberry, rose, willow, green alder, and occasionally red-osier dogwood. Aspen stands with greater than 10% coverage of willow were not included in this type.

Type B - Trembling Aspen-Balsam Poplar Type

This type includes all aspen stands with a balsam poplar component greater than 10%. Stands are concentrated along the Mackay and Athabasca rivers with small pockets in upland areas where the water table is high. The type makes up 1.5% of the study area.

Balsam poplar does not have the wide ecological amplitude of trembling aspen. It grows best on moist sites such as alluvial flats. It is on these sites that balsam poplar can survive the intense competition from trembling aspen, and possibly, with its longer lifespan, may outlive it.

Along the Mackay River there is a general progression of vegetation from the river break down to the water's edge, an elevation drop of about 30 m (Plate 4). From the break to the bottom of the slope, aspen (Type A) predominates with a balsam poplar component entering on the lower slopes. This component increases toward the river, in some cases to the exclusion of aspen near the water's edge. Along the river bank there is usually a narrow band of willow and occasionally river alder.

Along the Athabasca River, stands are generally older and more complex. There is often a well-developed shrub layer under large decadent balsam poplar. Scattered white spruce may also be present.

The primary shrub species of this type are willow, river alder, low-bush cranberry, red-osier dogwood, and rose.

Type C - Trembling Aspen-Willow and/or Alder Type

This classification was established because of the presence of a tall shrub stratum which resulted in changes in animal habitat. Major differences between conditions in aspen stands with and without the shrub

Plate 4. A view of the Mackay River valley with aspen (Type A) on the upper slopes, aspen and balsam poplar (Type B) on the lower slopes, and a band of willow (Type N) along the river bank.

layer were not evident, however, the presence of shrubs may be attributable to moister soil. Another possibility is that there may have been post-fire establishment difficulties such as lack of parent stock in the stands that now have no shrub stratum. In older stands with closed canopy cover, tall shrubs are probably reduced or eliminated by low light intensities as expressed by Rowe (1956).

The aspen-shrub type is concentrated in the western portion of the study area where it is often interspersed with the pure aspen type. It comprises 14.5% of the area.

Associated shrub species are the same as for the pure aspen type with the obvious difference of a higher willow-alder component. The most common willow species is probably beaked willow (*Salix bebbiana*) as indicated by Raup (1946).

Types D, E, and F - Mixedwood Types

These habitat types include all mixtures of deciduous and coniferous tree species. The most prominent are various combinations of aspen and white spruce with occasional occurrence of jack pine, black spruce, balsam poplar, and white birch. The subdivision has been made on the basis of relative composition of deciduous and coniferous tree species. The recognized subdivisions and their areal coverage are:

Mixedwood Type	Composition	Areal Coverage (%)
D	11 to 40% coniferous	7.5
E	41% coniferous to 41% deciduous	2.6
F	61 to 89% coniferous	6.1

Sites supporting mixedwood are generally mesic uplands. Drier sites are expected for mixtures of aspen and jack pine and moister sites for black spruce-aspen.

Balsam poplar and white spruce grow together on some river flats, particularly along the Athabasca River. White birch forms a major component of a few stands on the upper western slopes of the Athabasca River valley.

These types are intermediate seral stages. Stands are often two-layered with aspen in the overstory and spruce below. These spruce, in older stands, may have reached or overtopped the aspen canopy.

Major shrub species noted in mixedwood are buffalo-berry, willow, green alder, low-bush cranberry, and river alder, the latter two mainly on moister sites. A much more extensive list of associated species is provided by Raup (1946) for his Upland Mesophytic White Spruce Forests.

Type G - White Spruce Type

The white spruce vegetation type comprises 1.6% of the study area.

Small stands occur in the Athabasca River valley and its slopes and in the south-central section of the study area. The main concentration is along Beaver Creek near its confluence with the Athabasca River. This stand is composed of large, mature trees which have not been disturbed since the origin of the stand, probably some 70 years ago. The lower Beaver Creek valley provides an excellent habitat for white spruce which exhibits best growth on moist alluvial soils.

Balsam fir, near the northern limit of its range, also occurs on this favorable site. This was the only area where the species was noted. Decadent aspen and balsam poplar, the remnants of earlier seral stages, are scattered throughout most white spruce stands.

There is usually little shrub understory in this type due to the heavy shading of the spruce. In low density areas shrub composition is similar to that in mixedwood.

Type H - Jack Pine Type

Less than 1% of the study area supports pure jack pine communities. The majority of these stands are northeast of Mildred Lake. Jack pine has low tolerance to shade and thus is usually found in areas where interspecific competition is low. This, in combination with the species ability to grow on dry sites, usually relegates it to dry sandy knolls, which are limited in the study area.

Mature stands of jack pine are quite open and largely free of shrubs. Occasionally green alder was noted as a widely scattered understory species. On moister sites there may be some invasion by trembling aspen and white spruce.

Types I and J - Black Spruce Types

Together, these types comprise a greater area than any other single vegetation type. Type I (11 to 40% cover) accounts for 5.4% and Type J (41 to 100% cover) makes up 14.9% of the area. The division is on the basis of percent cover, a measure of the availability of shelter for animal prey species.

Black spruce can maintain itself on organic and wet mineral soils. Large pure stands grow in the poorly drained northwestern portion of the study area. Associated shrubs are willow, common labrador tea, dwarf birch, and occasionally river alder.

The general appearance is stunted trees, rarely over 3 m and usually about 2 m in height with crowns extending to the ground and interspersed with scattered low shrubs. On better drained sites the trees generally are more densely spaced, taller, and exhibit better growth. Invasion of tree species such as trembling aspen, white birch, and white spruce was noted on these drier sites. Occasionally tamarack and even jack pine occur on low density sites.

Type K - Black Spruce-Willow Type

Large areas to the west of the Mackay River and in the northwest section of the study area support an interspersion of small black spruce trees and clumps of willow. Small stands occur throughout the study area. Areal extent is 6%.

Stands of this type appear to be quite young, following recent fires. Deadfall and charred snags are abundant. Tree density is low, allowing the willow to grow unshaded. As the spruce trees mature, the willow component can be expected to decrease because of increased shading.

Shrubs associated with this type are, in addition to willow, dwarf birch and common labrador tea.

Type L - Tall Shrub Type

This type incorporates alder and willow communities which are not associated with open water. It occupies 5.6% of the study area.

In general the shrubs are 1 m to 3 m tall. Stands range in density from near impenetrability to clumps spaced about 1 m apart.

From the site requirements of willow and alder and the absence of tree species, it is expected that this type occurs on wet sites exclusively. Changes toward a more favorable water regime would allow the invasion of trees.

Willows are the primary species, often with a river alder component. During field investigations a separation between willow and alder communities was recognized, but this division was eliminated in compilation due to the low number of pure stands.

Type M - Dwarf Birch-Tamarack Type

The dwarf birch-tamarack habitat type comprises 2.1% of the study area. It grows on poorly drained areas dispersed throughout the study area.

The primary species of this type is dwarf birch up to 1 m tall. Often scattered through this shrub stratum are mature tamaracks and dead trees and shrubs.

Associated shrub species are willow, river alder, and occasionally common labrador tea and black spruce.

Type N - Riparian Shrub and Herb Type

This type includes those shrub and herb communities associated with open water. Examples are generally linear, forming a narrow band along the water's edge. Grasses and sedges grade into shrubs which border the forest. The type makes up 2.7% of the study area and is found mainly around Horseshoe Lake and along the small streams draining into Beaver Creek from the west.

Shrub and herb communities were initially separated during field investigations but due to the infrequent occurrence of the herb community, these types were consolidated. Grasses and sedges comprised the herb section while willow and alder were the primary shrub species. Dwarf birch was occasionally present.

Types O, P, and Q - Disturbed Area

Three classes of disturbed areas were distinguished. These, together with their respective proportions of the total area, are:

Type O - Disturbed, light regeneration	- 0.5%
Type P - Disturbed, no regeneration	- 5.8%
Type Q - Main cleared area	-17.3%
TOTAL	23.6%

The areas, now labelled Type O, had been cleared at least one growing season before the field studies. They presently support a light cover of herbs and shrubs which have invaded the exposed mineral soil. Ground cover is seldom more than 80 cm tall.

Areas without regeneration have for the most part have been recently cleared. They now have no vegetative cover and are usually bulldozed to mineral soil. The only exception in this category is open water which, when frozen and covered with snow, becomes virtually indistinguishable from cleared land.

The main cleared area is a large opening near the center of the study area (Plate 5). It includes areas of both of the other disturbed types. Various combinations of times of clearing and intensity of disturbance together with roads and other constantly disturbed areas produce a denuded and revegetated mosaic.

4.1.1.4 Relationship of Vegetation Types to Previous Studies

Since only the very obvious components of the plant communities on the study area could be observed, it is difficult to relate vegetation types to associations described by other investigators except on a gross scale. The various seral stages of Raup's (1946) Upland Mesophytic White Spruce Forests appear to correspond to upland stands of white spruce (Type G) and to the successionally younger trembling aspen (Types A and C) and mixedwood (Types D, E, and F). Those stands of white spruce (Type G), white spruce-balsam poplar (Types D, E, or F) and balsam poplar-aspen (Type B) occurring along the larger river banks are similar to Raup's Flood Plain White Spruce Forests. An example of Raup's Balsam Fir-White Spruce Forests is located along the lower Beaver Creek and is described as Type G.

The scattered jack pine stands (Type H) on the study area probably correspond to Raup's Sandy Jack Pine Woods.

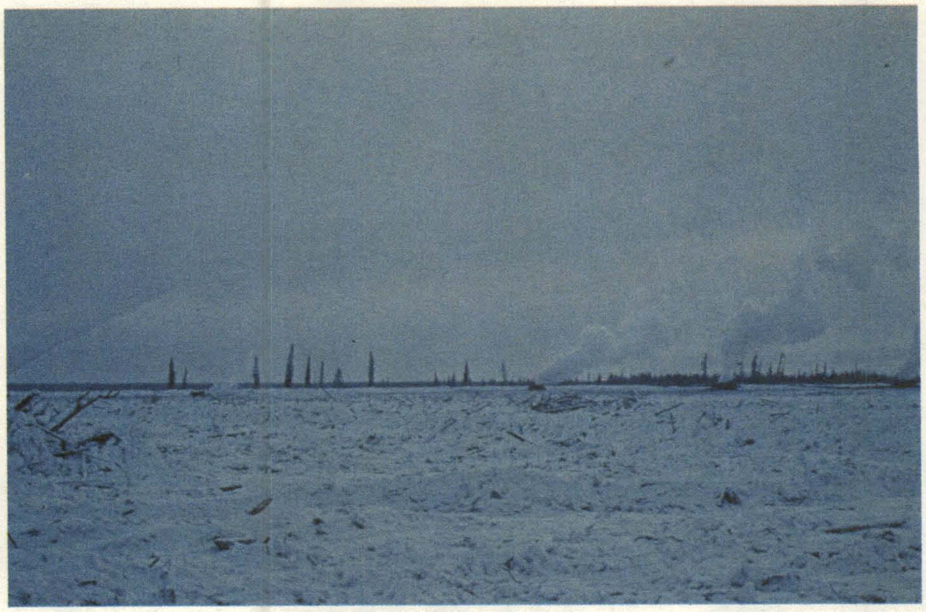


Plate 5. A view of the main cleared area (Type Q) with recent clearing in the foreground, white spruce along the Beaver River to the left, and the Syncrude plant on the horizon.

Raup's Bog Forests can be related to some of the black spruce forests (Types I, J, and K) on the study area, particularly those in depressions which have probably evolved through bog succession. However, there are apparently undescribed upland stands of low density, short black spruce which often occur within large aspen stands in the western portion of the study area. An improved description of this habitat would result from further research.

The black spruce-willow type (Type K) includes both a bog type, in which willows are probably wetland species such as *Salix glauca*, *S. myrtillifolia* and *S. pyrifolia* as described by Raup (1946) and a drier, ecotone type with *S. bebbiana* which will be described later.

The dwarf birch-tamarack type (Type M) can probably be compared to either the Larch-Birch-Hypnum moor of Lewis *et al.* (1928) or the muskeg near Pine Lake described by Raup (1935). Moss (1953b, 1955) also describes a *Larix laricina* association and hypothesizes a possible succession to black spruce communities.

Raup (1946) describes a successional sequence for willows at slough margins along the lower Athabasca River. This is *Salix planifolia* followed by *S. petiolaris* and then *S. bebbiana*. If this sequence occurs on the study area, the seral stages would be classified either as tall shrub (Type L) or riparian (Type N) depending on the presence or absence of a water body.

At the interface between two distinct communities there is often a transition zone or ecotone. This ecotone may combine features of both communities or may be distinct. The most prominent type of ecotone on the study area is a band of willow which often occurs between aspen and black spruce and occasionally between white spruce and black spruce communities. Raup (1946) states that beaked willow, characteristic of the Upland Forest, does not appear in the Bog Forest type (black spruce) except in these transition zones. Although edaphic factors in these ecotones may be marginal, the occurrence of the high density of willow may be related to the relative paucity of interspecific competition. Two vegetation types, the tall shrub (Type L) and black spruce-willow (Type K), classify this ecotone when it is greater than 25 m wide. However, there are frequent narrow bands which are integrated with the surrounding forest for classification.

4.1.1.5 Aquatic Habitats

There are three lakes (Ruth, Mildred, and Horseshoe lakes), three large watercourses (Beaver Creek, and Mackay, and Athabasca rivers) and several small creeks within the study area. These aquatic habitats are used by several species of furbearers including beaver, muskrat, otter, and mink.

Since field investigation for this study was carried out in the winter, sampling of aquatic habitats was not possible. The following descriptions are abstracted from earlier studies.

Ruth Lake

Ruth Lake was studied by Renewable Resources Consulting Services

(1975) during the summer of 1974. According to this study, aquatic vegetation extends over the entire area (144 ha) of Ruth Lake. Three general sections of differing plant growth were described:

1) Dense lily pad growth. This type is characterized by a dense cover of pond lily (*Nuphar variegatum*) to the virtual exclusion of most other species. Dense lily pad growth is generally confined to central portions of the lake with water depths of about 2 m.
2) Dense submergent growth. Submergent plants form an almost continuous cover in this type. Either a dense growth of stonewort (*Chara* sp.) or a mixture of pondweeds (*Potamogeton* spp.) and common bladderwort (*Utricularia vulgaris*) are dominant. Water depths are generally less than 2 m.
3) Emergent growth. This type occurs along the shoreline and in clumps near the middle of the lake. The best development is along the southeast shore. Species composition varies but most important are cattail (*Typha latifolia*), and bulrushes (*Scirpus validus* and *S. americanus*).

The characteristics of the vegetation of Ruth Lake could very well change due to fluctuating environmental variables.

Mildred Lake

The vegetation of Mildred Lake was briefly studied in May 1972 by

Renewable Resources Consulting Services (1972).

The area of Mildred Lake is approximately 138 ha. There is a narrow zone of emergent vegetation forming a band 3 to 10 m wide along most of the shoreline. Major species in this zone are cattail, sedge (*Carex atherodes*), common spikerush (*Eleocharis palustris*) and pickerel weed (*Pontederia* sp.). The north and south ends of the lake have what are described as "floating" edges of marsh reedgrass (*Calamagrostis canadensis*). Submergent vegetation associated with a rich organic bottom at the south end consists of a submerged mat of moss (*Hypnum* spp.), mare's tail (*Hippuris* sp.), hornworts (*Ceratophyllum* sp.), and some green algae. Duckweed (*Lemna minor*) and a few water lilies (*Nymphaea* sp.) were also noted.

Horseshoe Lake

The vegetation of Horseshoe Lake was also noted by Renewable Resources Consulting Services Ltd. (1972).

This lake is much shallower than Mildred Lake and slightly smaller at 130 ha. A canal from the north end of the lake to the Athabasca River results in wide fluctuations in water level. Vegetation growth is lush with a submergent carpet composed mainly of moss and hornwort and an almost continuous floating cover of water lily, duckweed, and filamentous algae (*Spirogyra* sp.). Common emergents are cattail, hardstem bulrush (*Scirpus validus*), and common spikerush. A margin of sedge and marsh reedgrass, wider than that of Mildred Lake, broadens into a meadow at the north end.

River Habitat

Both the Mackay River and Athabasca River are too large and fast-flowing to support much aquatic vegetation. The only areas where minor concentrations of plants might be expected are backwaters where currents are sufficiently slow to allow establishment.

Beaver Creek was studied for fisheries habitat in 1971 (RRCS, 1972) but since that time a large part of the land through which the river flows has been cleared. Aquatic vegetation is probably minimal and with ongoing clearing, shoreline shrubs are being removed.

4.1.2 Terrain Features

The composition of terrain features on the study area is illustrated in Table 2. The study area is basically flat to very gently sloping, as reflected in the proportion of the area having slopes of less than 10%. There is a general gradient increasing from east to west, interrupted only by two incised river valleys and a slight depression near the centre of the study area (Figure 7). Almost all of the slopes occur in the valleys of the Mackay, Beaver, and Athabasca systems. The high proportion of east and west aspects reflects the general north-south orientation of these valleys.

Hydrological features comprise about 3% of the area, mostly on the three lakes.

Table 2. Proportional areal coverage of terrain features on the study area.

Terrain Type		Percent of the Area
Slope and Aspect		
0-10%		94.0
10-30%	north	0.1
10-30%	east	0.7
30-60%	east	0.3
60%+	east	0.1
10-30%	south	0.1
30-60%	south	0.1
60%+	south	0.2
10-30%	west	0.5
30-60%	west	0.6
60%+	west	0.1
Hydrological Features		
Shoreline		0.1
Streambed		0.1
Open water		3.0

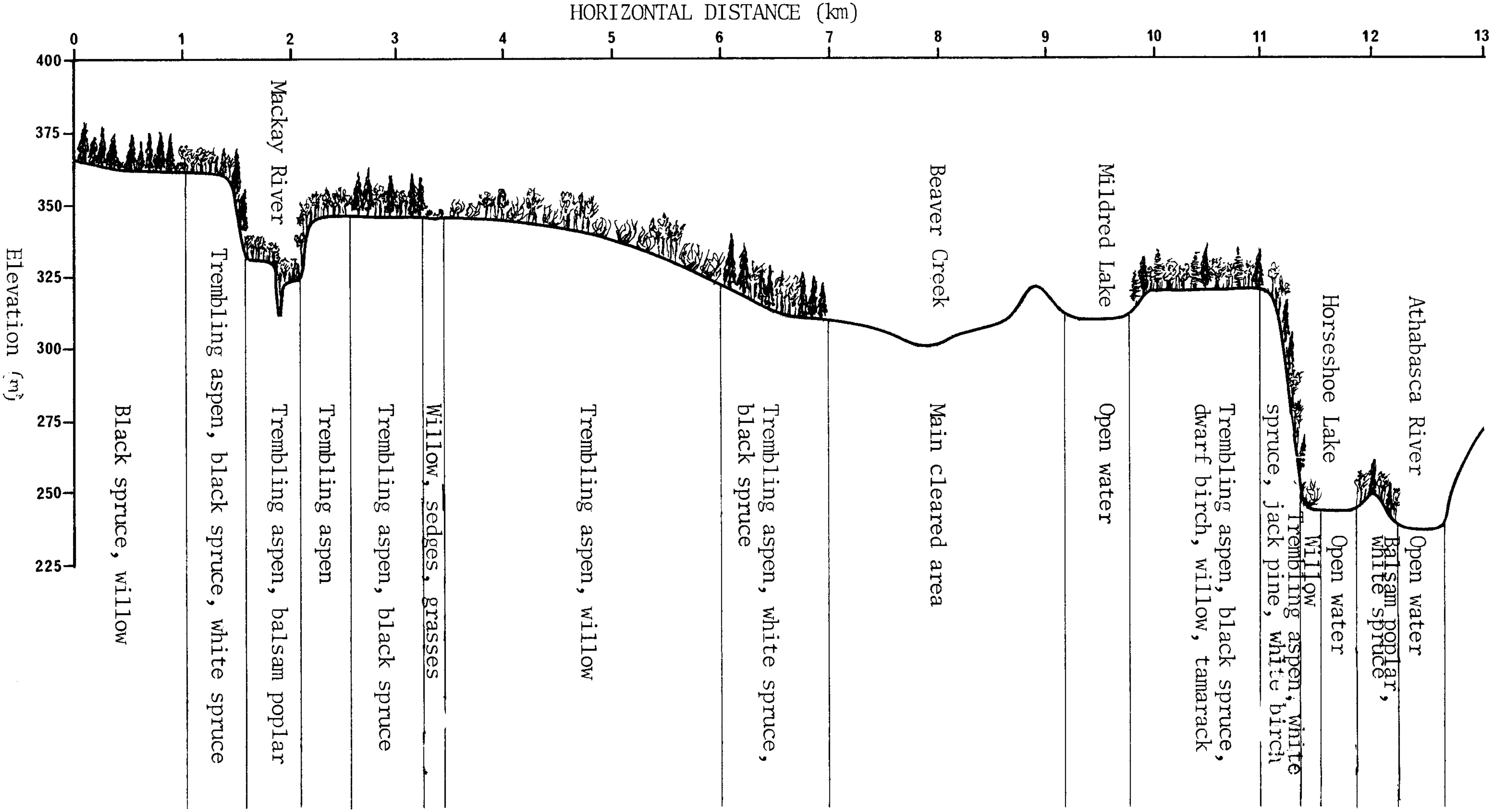


Figure 7. East-west cross-section through the approximate center of the study area illustrating general vegetation zones and topographical changes.

4.1.3 Secondary Disturbance

Most of the study area is crosshatched with roads and cutlines (Figure 8). In the eastern portion, these are mainly Type 2 cutlines (Plate 3) as associated with early exploratory drilling, while to the west a drilling program during the winter of 1975-76 has resulted in many recently cleared (Type 1) cutlines (Plate 2) and drilling sites. There are four moderate to heavy use (Type 2) roads on the study area outside of the main cleared area. These are the Fort MacKay highway, the west interceptor ditch road, the road to the temporary drilling camp on the Mackay River and the connecting road following the Twenty-fourth Baseline. There were light use (Type 1) roads in the northwest and southwest portions of the study area during the field work but toward the end of the study, these were being bulldozed in from the sides leaving a large pile of debris along the center of the road. Table 3 presents the proportions of the various types of secondary disturbance on the study area.

4.2 Ungulates

4.2.1 Moose

4.2.1.1 Relative Abundance

Aerial Surveys

During the winter of 1975-76, the moose population of the ungulate study area was estimated at 73 animals or 0.23 moose per sq km. The moose

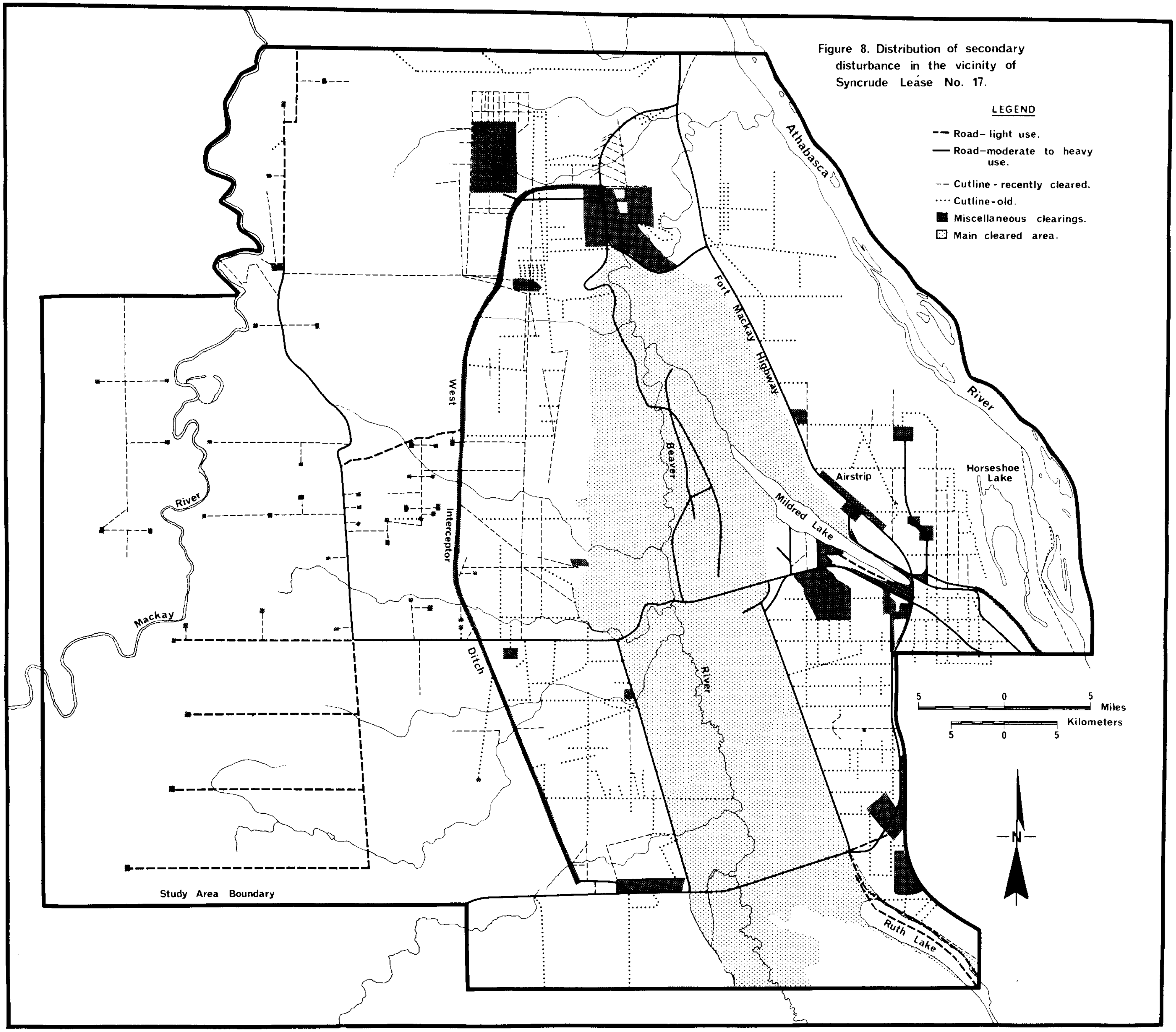


Figure 8. Distribution of secondary disturbance in the vicinity of Syncrude Lease No. 17.

Table 3. Proportions of disturbed and undisturbed habitats on the study area.

Habitat Type	Proportion of the Study Area %
Undisturbed	75.1
Disturbed - with regeneration	0.5
Disturbed - no regeneration	5.8
Disturbed - main cleared area	17.3
Road-Type 1-light use	0.1
Road-Type 2-moderate to heavy use	0.4
Cutline-Type 1-recent	0.5
Cutline-Type 2-old, with regeneration	0.3

population estimate was based on the assumption that approximately 55% of all moose present were observed during the aerial surveys. LeResche and Rausch (1974) found that under ideal survey conditions, inexperienced to current experienced observers saw 43 to 68% of the moose present in a controlled experiment in Alaska. Considering our observer experience and the aerial survey conditions, we feel that a correction factor of 55% is a conservative estimate of our survey accuracy.

A total of 37 moose were recorded during the early winter aerial surveys for an observed density of 0.12 moose per sq km. In the late winter survey, 43 moose were recorded within the study area, yielding an observed density of 0.13 moose per sq km. An additional 14 moose were observed in the area immediately adjacent to the study area during the late winter surveys.

During aerial surveys for beaver on October 22 and 23, 1975, a total of 12 moose were recorded. Study area coverage during this survey was restricted to areas of beaver habitat.

The moose densities recorded within the study area are comparable to observed moose densities reported in other studies in northeastern Alberta (Table 4). Phillips and Pattison's (1972) review of the Alberta Fish and Wildlife Division data for 1968 shows a general moose density of 0.23 moose per sq km for Big Game Zone 1 in northern Alberta and a density of 0.17 moose per sq km for the Fort McMurray area (Area 8). An intensive aerial survey, conducted by the Alberta Fish and Wildlife Division in the mineable portion of the tar sands

Table 4. Comparison of moose population densities on the study area with other areas within the boreal forest.

Location	Moose Density moose/sq km	Census Period	
Syncrude Lease 17 area	0.23[1]	winter 1975-76	This Study
Syndruce Lease 17 area	0.27	winter 1971-72	RRCS, 1972
Fort McMurray - mineable portion of the bituminous sands area			
- quadrat survey	0.31	1973	Bibaud and Archer, 1973
- transect survey	0.27	1973	Bibaud, 1973
Northern Alberta, Big Game Zone 1	0.23	1968	Phillips and Pattison, 1972
Area 8 (Fort McMurray), Big Game Zone 1	0.17	1968	Phillips and Pattison, 1972
Northeastern Alberta, Athabasca Tar Sands Development Area	0.31	1972-73	Department of Environment, 1973
Swan Hills, Alberta, W.M.U. F350	0.62-1.12	1967-68 to 1970-71	Lynch, 1973
Edson region, Alberta	0.62-0.66	1967-68 to 1960-71	Lynch, 1973
Peace River, British Columbia	0.96	1974-75	Penner, 1976
East-central Alberta river valleys[2]			
Athabasca River valley (McMillan Lake to Fort McMurray)	0.39	1972-November	Hall and Bibaud, 1974 (Fish and Wildlife Division)
	0.97	1974-January	
	0.73	1974-March	
Clearwater River valley	1.47	1972-November	
	0.66	1974-March	
Mean of 16 river valleys	0.56	1974-March	
Wandering River-Calling Lake, Alberta	0.43	1974-November	Hall *et al.*, 1974
Peerless Lake, north-central Alberta	0.20	1975-March	Hall *et al.*, 1975
Clear Hills, Alberta	0.50	1973-November	Hall *et al.*, 1973
Wapiti area, Alberta	1.08	1973-November	Hall *et al.*, 1973

[1]Estimated moose densities.
[2]Calculated from moose reported per linear mile.

area in 1972 and 1973, gave an observed density of 0.31 moose per sq km (Department of Environment, 1973). Moose densities in northeastern Alberta are, however, relatively low in comparison to those in west-central Alberta and the Peace River area.

Winter Track Counts

A total of 191 moose track crossings were recorded during the winter track count study. This represents a mean density of 0.71×10^{-2} crossings per station track-day or 0.14 crossings per kilometer track-day.

The relationship between the number of moose tracks per kilometer track-day and the observed moose density (0.13 moose per sq km) of the study area is 1.1:1. Teplov and Karpovich (1959) found a correlation between numbers of moose tracks crossing census lines in a 24 hr period and the density of animals in six studies in the central region of the European U.S.S.R. Their reported relation between numbers of tracks and numbers of animals averaged about 2.0:1 and ranged from 1.7:1 to 2.3:1.

The observed index of relative abundance or activity of moose by track counts in the present study is based on a relatively low sample size and requires additional study to determine the mean and range. The preliminary results show this technique to be well suited for use in determining the impact of development on both the distribution and relative abundance of moose.

4.2.1.2 Population Structure

The moose population structure and rate of recuitment were determined from the age and sex ratios of moose observed during the early and late winter aerial surveys (Table 5).

Cow:Bull Ratios

The cow:bull ratio recorded during the early winter aerial survey was 100:75 (Table 6). The proportion of bull moose in the study area is generally higher than that reported for hunted moose populations in other areas in Alberta and British Columbia (Table 6).

The observed adult sex ratio within the study area may not be representative of the regional trend due to: a) the study area and thus the sample size of moose observed is relatively small, and b) seasonal distribution of moose could have resulted in the presence of proportionately more males to females within the study area; a comparison of the adult:calf ratios of early and late winter suggests this may have occurred.

The relatively high proportion of males in the study area moose population may also be indicative of subsistence hunting by Native and local white residents. The study area occurs within the Alberta Big Game Zone 1, where a relatively long "either-sex" hunting season has occurred for many years.

Table 5. Numbers of moose, segregated by age and sex, which were observed during the early and late winter (1975-76) aerial surveys on the study area.

	AERIAL SURVEY	
Age/Sex	Early Winter	Late Winter
Bulls	12	
Cows	16	
Total Adults	28	28
Calves	9	15
TOTAL MOOSE	37	43

Table 6. Comparison of the age/sex ratios of moose on the study area with other moose populations.

Location	Time Period	Cows:Calves:Bulls	Adults:Calves (Recruitment Rate)	Reference
Syncrude Lease 17 area	December 1975	100 : 56 : 75	100 : 32	This study, early winter 1975
Syncrude Lease 17 area	February 1976	N/A	100 : 54	This study, late winter 1976
Alberta: north-central region	1970 to 1972	100 : 35 : 37	100 : 26	Lynch, 1973
		100 : 35 : 53[1]	100 : 23	
Southern British Columbia	1950 to 1970	100 : 42 : 38	100 : 30	Finegan, 1973
		100 : 41 : 45[1]	100 : 28	
Peace River, British Columbia	1964 to 1975	100 : 67 : 41[2]	100 : 48	Penner, 1976
Montana	1958 to 1960	100 : 59 : 155[2]	100 : 23	Peek, 1962
Wandering River to Calling Lake, Alberta	November 1974	100 : 49 : 27	100 : 18	Hall *et al.* 1974 (Fish and Wildlife Division)
Clear Hills, Alberta	November 1973	100 : 28 : 21	100 : 16	Hall *et al.* 1973
Wapiti area, Alberta	November 1973	100 : 29 : 48	100 : 37	(Fish and Wildlife Division)

[1]Change in sex ratio is in keeping with the effect of an anterless season instituted during these periods.
[2]Mean of annual observations during the specified time period.

Subsistence hunters generally harvest moose at random, by obtaining the first animal encountered, or they selectively harvest females and calves for their better meat qualities. Under both methods of harvesting, a bias for the survival of males may occur and result in the high cow:bull sex ratios observed in the study area. Analogous population trends are reported by Lynch (1973) in north-central Alberta and Finegan (1973) in southern British Columbia, where an increase in the proportion of bulls to cows in the moose population occurred after antlerless moose hunting seasons were introduced (Table 6).

Cow:Calf Ratios

The cow:calf ratio recorded during the early-winter aerial survey was 100:56 (Table 6). The number of calves observed on the study area increased from nine during the early winter survey to 15 in the late winter survey (Table 5). Due to the difficulty in determining the sex of adult moose in late winter, comparisons of cow:calf ratios between the two aerial surveys are not possible. A comparison of the ratio of 100 adults to calves shows a substantial increase in the proportion of calves observed between early winter (100:32) and late winter (100:54) surveys (Table 6). Since the numbers and hence the density of moose on the total study area were not substantially different (37 versus 43 moose) between early and late winter surveys, our data suggest that age and sex related movements of moose may have occurred in the vicinity of the study area during the winter.

The cow:calf ratio recorded on the study area is generally above that reported for moose populations in other regions (Table 6). Reported cow: calf ratios include 100:35 in north-central Alberta (Lynch, 1973); 100:42 in southern British Columbia (Finegan, 1973); 100:49 in Wandering River-Calling Lake, Alberta (Hall *et al.*, 1974); and 100:67 in the Peace River (Penner, 1976).

During the early winter survey, 50% of the cows were accompanied by calves. One set of twins was recorded during this survey and represents 12.5% of the cows accompanied by calves. Pimlott (1959) reviewed the occurrences of twin-calves in seven moose studies in Canada and Alaska and found that twin-calf percentages ranged from 2% to 28%.

Population Recruitment Rate

The observed moose recruitment rate was determined by comparing the number of calves surviving the first six months of life to the total number of adults (adult:calf ratio). The recruitment rate was 32% during the early winter survey and 54% during the late winter survey (Table 6).

These values fall within the range of recruitment rates of moose populations reported in the literature, examples of which are illustrated in Table 6. Considering the many variables that may affect moose reproduction and calf survival, it is difficult to assess the moose recruitment rate in the study area from one season's data. Stelfox (1967) reported that moose reproduction in northwestern Alberta was generally higher following a mild winter than a severe winter. Since the preceding winter of 1974-75 was relatively mild with respect to above average temperatures and below average snowfall, and the present winter 1975-76 was also less severe than normal, we may expect that the observed moose recruitment rate may be above the long-term average and may approach the optimum for the particular age and sex structure of the moose population in the vicinity of the study area.

4.2.1.3 Distribution

Distribution in Relation to Vegetation Types

The distribution of moose in relation to the availability of vegetation cover was significantly different for observations during the late winter track counts and the February aerial surveys (P=0.01) and during the early winter (December) aerial surveys (P=0.05) (Table 7). The distribution during the October aerial survey was not significantly different from that expected, however, the October survey involved only partial coverage of the study area.

During the early winter (December) aerial survey, moose exhibited a preference for tall shrub and deciduous vegetation types and an avoidance of mixedwood cover (Table 7). No use of miscellaneous or disturbed cover types was observed during this period.

During the late winter surveys, moose exhibited a preference for tall shrub cover and an avoidance of coniferous cover types (Table 7). Moose activity in deciduous and mixedwood cover fell within the expected range of

Table 7. Distribution of moose in relation to vegetation types during aerial surveys and winter track-count observations.

Preference for a particular vegetation type is indicated by +, avoidance by -, and neither preference nor avoidance by o.

		PERCENT OF OBSERVATIONS			
	Percent	Aerial Surveys[1]			Track-counts[2]
Vegetation Type	Coverage	October	December	February	January-March
Deciduous	20.2	58.3	45.9 +	39.5 o	25.3 o
Mixedwood	22.3	0	10.8 -	23.3 o	23.6 o
Coniferous	23.6	0	13.5 o	9.3 -	13.4 -
Tall shrub	8.2	41.7	29.7 +	27.9 +	29.2 +
Miscellaneous cover	2.4	0	0 [3]	0 [3]	5.4 o
Disturbed areas	23.6	0	0 [3]	0 [3]	3.6 -
TOTAL OBSERVATIONS	4,296	12	37	43	191
D		0.381 n.s.[4]	0.257*	0.255**	0.201**
D(0.01)		0.471	0.268	0.249	0.118
D(0.05)		0.393	0.224	-	-

[1]Values based on observations of moose.
[2]Values based on moose tracks per track-day.
[3]Sample insufficient for analysis.
[4]n.s. not significantly different, *signifies a significant difference at P=0.05, and **at P=0.01.

values. No moose were observed in the miscellaneous or disturbed cover types during the February aerial survey. During the winter track count survey, moose exhibited an avoidance of areas with disturbed cover.

Distribution in Relation to Terrain Features

The distribution of moose was not significantly different from the proportionate availability of terrain features (Table 8). The apparent trend of greater use of east-facing slopes than the proportion of terrain features corresponds to late winter aerial survey observations and shows a relatively high moose concentration in the Athabasca River valley. Moose activity recorded in the open water (ice) category is primarily related to observations along the Mackay River. Field observations indicate that the riparian willow along the Mackay River sustained moderate to heavy use by moose. Moose also appeared to occasionally use the Mackay River as a travel corridor.

Distribution in Relation to Habitat Disturbance

Moose exhibited a marked preference for undisturbed habitats and an avoidance of large cleared areas (Table 9). Moose activity on roads and cutlines which occur within the area of undisturbed habitats was neither preferred nor avoided. An apparent trend of slightly greater use of light-use roads (Type 1) and cutlines than the proportion of the total area may be related to a tendency of moose to use these features as travel corridors. Additionally, these structures may affect moose movements back into the forest cover because of the windrows of debris along their edges.

Table 8. Comparison of the availability of terrain features with use by moose as determined by winter track densities.

Terrain Features	Proportion of the study area	Number of Observations	Tracks/station track-day	Percent
Slope and aspect				
0-10% - none	94.0	175	27.77	91.4
10-30% - north	0.1			
10-30% - east	0.7	6	0.96	3.2
30-60% - east	0.3	3	0.51	1.7
60%+ - east	0.1			
10-30% - south	0.1			
30-60% - south	0.1			
60%+ - south	0.2			
10-30% - west	0.5			
30-60% - west	0.6			
60%+ - west	0.1			
Hydrological features				
shoreline (river or lake)	0.1	1	0.16	0.5
streambed	0.1			
open water (ice)	3.0	6	0.98	3.2
TOTAL OBSERVATIONS		191		
Statistical significance:				
D				$.026^{n.s.}$
D(0.01)				.118

n.s. - no significant difference at P=0.01.

Table 9. Comparison of availability of disturbed and undisturbed habitats with use by moose as determined by winter track densities.

Preference for a particular vegetation type is indicated by +, avoidance by -, and neither preference nor avoidance by o.

Habitat Type	Proportion of the Study Area	Numbers of Observations	Tracks/station track-day	Percent	Significance
Undisturbed habitats	75.1	182	29.87	95.47	+
Large cleared areas	23.6	1	0.15	0.47	-
Type 1. Road - light use	0.1	2	0.32	1.01	o
Type 2. Road - moderate to heavy use	0.4	1	0.16	0.58	o
Type 1. Cutline - old, some regeneration	0.5	1	0.16	0.58	o
Type 2. Cutline - recent	0.3	4	0.64	2.03	o
TOTAL OBSERVATIONS		191	31.28		
Statistical significance:					
D				0.204*	
D(0.01)				0.118	

*Significant difference at P=0.01.

Spatial Distribution

The distribution of moose observed during early winter (December 13 to 16) aerial surveys is illustrated in Figure 9. Moderate concentrations of moose were found on the uplands west of the Mackay River (14 moose) and along the uplands and flood plains near the Mackay River at the northern end of the ungulate study area (six moose). Most of the remaining observations were single animals or cow-calf pairs which were widely dispersed in the region between the Mackay River and the main cleared area. One cow-calf pair was located within the Athabasca River valley.

During the late winter (February 4 to 7) aerial survey, moderate concentrations of moose were located within the valleys of the Athabasca River (10 moose) and Mackay River (10 moose) (Figure 10). The majority of moose in upland habitats were located in the area southwest of the main developments. Five moose were recorded west of the Mackay River.

The spatial distribution of moose activity recorded during the track-count survey in late winter (January 14 to March 15) is illustrated as an isodensity map in Appendix 2-A. Areas of moose activity occur within the Athabasca River valley and in localized pockets along the Mackay River valley and upland habitats. This pattern of dispersion may reflect both winter habitat selection and behavioral spacing by moose.

The distribution and habitat selection by moose during the winter

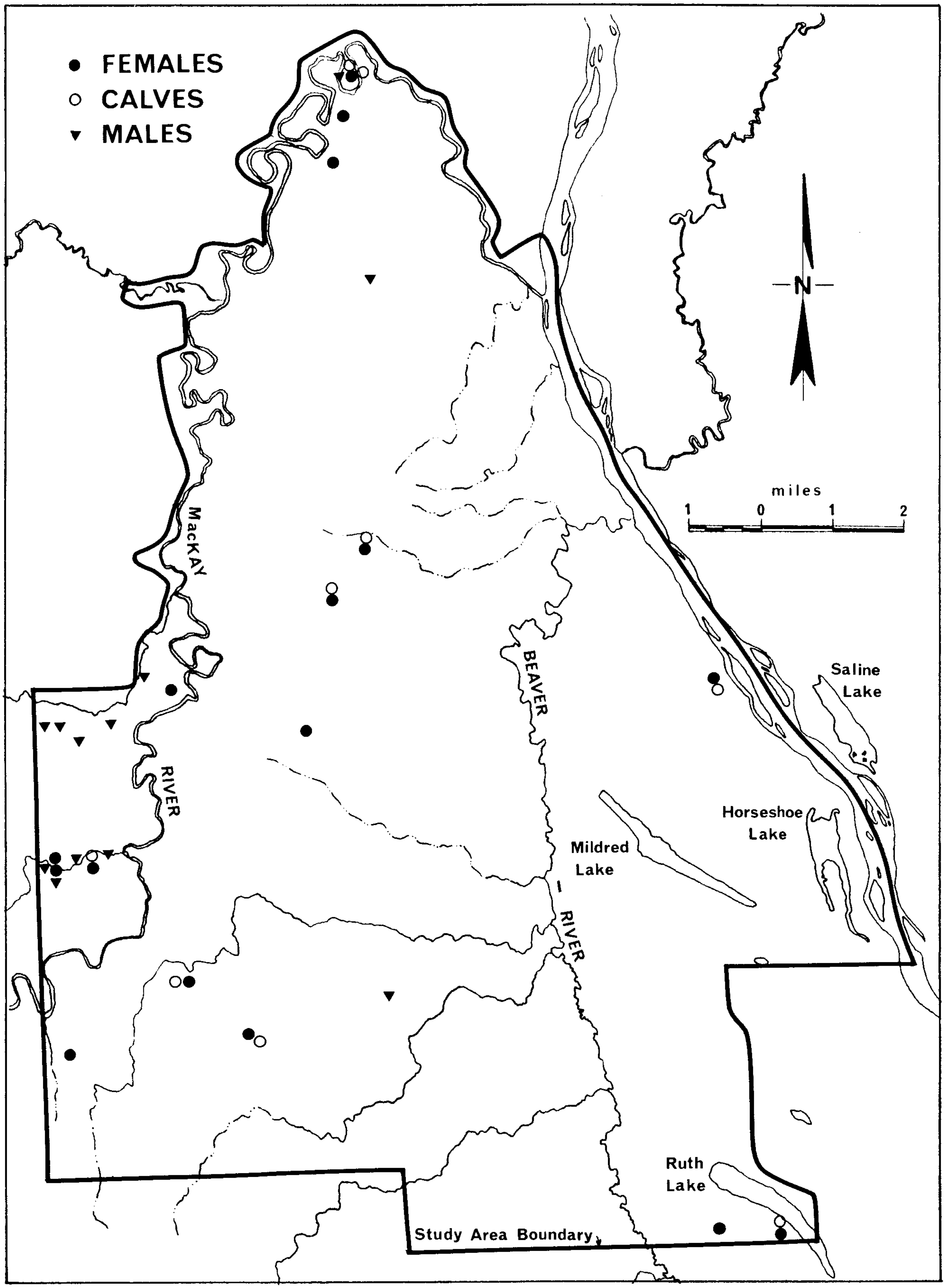


Figure 9. Moose distribution - early winter.

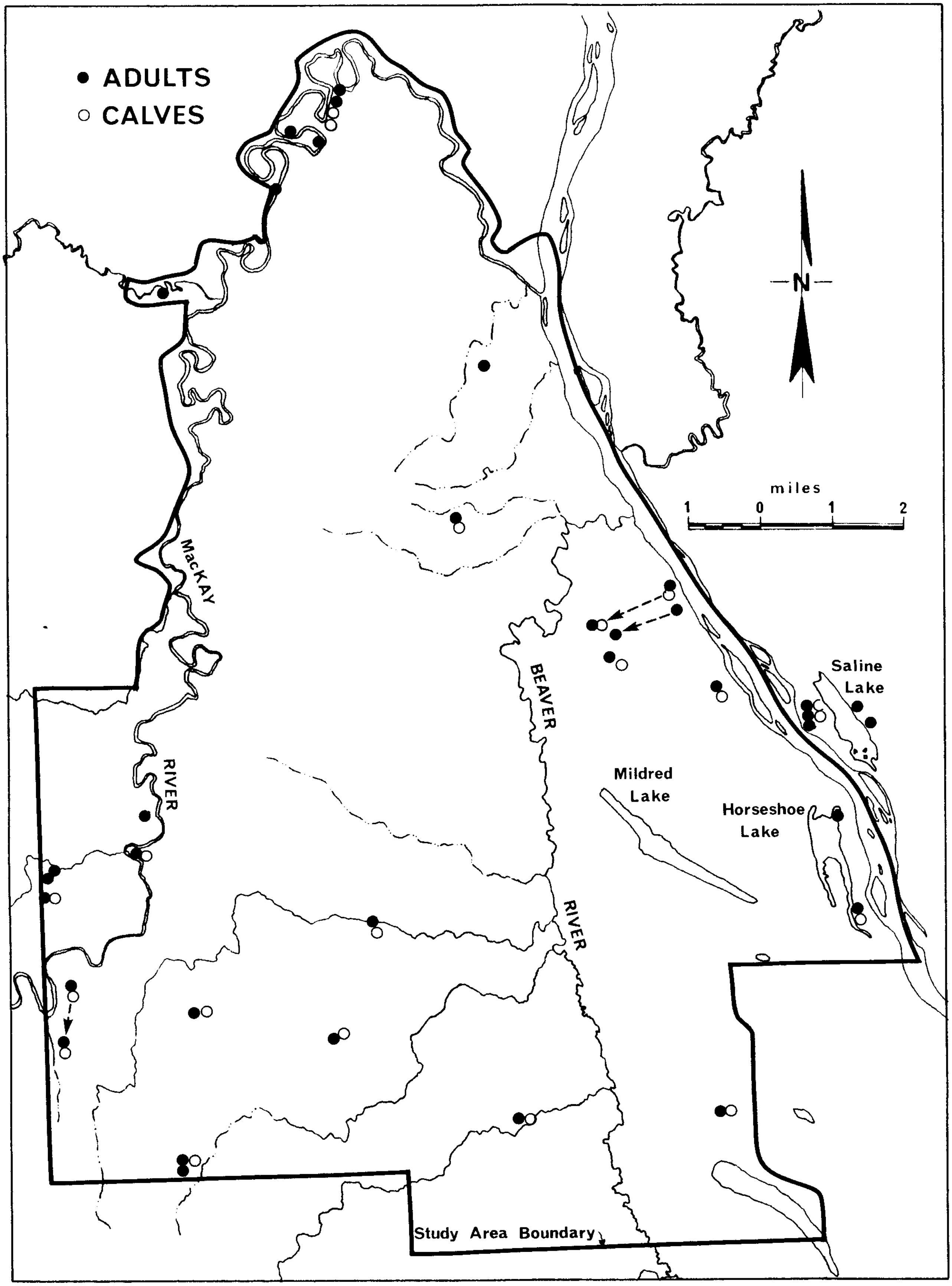


Figure 10. Moose distribution - late winter.

has been shown to be influenced by the depth and quality of snow (Peek, 1971; Kelsall and Prescott, 1971), often resulting in movements from open timber stands to more dense cover (Des Meules, 1964; Kelsall and Telfer, 1971). The availability of an abundant supply of palatable browse also may have a major influence in moose winter distribution (Kelsall and Telfer, 1974). In north-western portions of the boreal forest winter ranges with good combinations of shelter and food species are found in river valleys, wetland complexes, and specific upland sites (Watson *et al.*, 1973).

In this study, a substantial increase in the proportion of moose was observed in river valleys between early winter (16.2%) and late winter (46.6%) aerial surveys (Table 10). The spatial distribution of moose observed during track-counts also shows a generally greater use of river valleys than upland habitats in late winter. Additionally, during the late winter aerial survey, seven moose were observed on the eastern slope of the Athabasca River valley near Saline Lake. Although the winter of 1975-76 was relatively mild with low to moderate snow depths, the congregation of moose in valley habitats in late winter reflects the importance of these areas as winter range. During severe winters with a high snowfall, these valleys would be expected to sustain even greater use by moose and in essence be critical winter range.

Berg and Phillips (1972) examined moose winter spacing in Minnesota and found that although moose have overlapping winter home ranges, individuals and cow-calf pairs are generally solitary and may space themselves by agonistic means. Chamberlin (1972) found that a moose wintering area in

Table 10. Number and proportion of moose located in various topographic units during early and late winter aerial surveys.

	Early winter		Late winter	
	Number	Percent	Number	Percent
River Valleys				
Athabasca	2	5.4	10	23.3
Mackay	4	10.8	10	23.3
Subtotal	6	16.2	20	46.6
Uplands				
West of Mackay River	14	37.8	5	11.6
Between Mackay River and main cleared area	11	29.7	13	30.2
North of main cleared area	3	8.1	3	7.0
Southeast of main cleared area	3	8.1	2	4.7
Subtotal	31	83.7	23	53.5
TOTAL	37	100	43	100

Ontario may extend over several square kilometers with different portions being utilized at various times, depending upon factors such as available browse, snow depth, and suitable cover. On Isle Royale, Krefting (1974) and Murie (1934) indicated that, if food was plentiful, the moose restricts its wanderings to a very limited area.

During the late-winter track counting period, moose activity greater than 0.1 tracks per station track-day was observed over 11.4% of the study area (Appendix 10). The area of relatively high moose activity (track densities greater than 0.5 tracks per station track-day) occurred on 1.5% of the study area.

The spatial distribution of moose illustrates a pattern of local activity in restricted areas. This trend is less pronounced along the Athabasca River valley where a higher density of animals shows a more regional pattern, reflecting the importance of the general area as winter range. The localized distribution and limited movements of moose during the winter is also shown in the limited sample of track observations recorded during the study period. Track-count observations throughout a winter are required to give a better understanding of seasonal (early and late winter) distribution.

No regional trend of moose activity was found. The basic statistics necessary to assess the presence of a regional trend are listed in Appendices 2-B, 11, and 12.

4.2.2 Deer

Both the mule deer (*Odocoileus hemionus*) and the white-tailed deer (*O. virginianus*) are reported to occur in the area between Fort McMurray and Fort MacKay. However, their populations appear to be quite low.

Within the study area, our observations include a single sighting of a female mule deer along the Athabasca River during the early winter aerial survey (Ck Pt 1, Figure 11). Additional deer signs (pellet-groups and tracks) were recorded near the Mildred Lake airstrip in a mixed-coniferous stand (Ck Pt 2) and in an open jack pine-paper birch stand along the Fort MacKay highway (Ck Pt 3). No observations of deer sign were recorded during the winter track-counting study.

J. Faichney (pers. comm., former Hudson Bay Manager in Fort MacKay, Alberta) reported that deer were never abundant in the Fort MacKay area, but a few deer were to be found in several locations. A. Boggs (pers. comm., former Fish and Wildlife Officer in Fort McMurray, Alberta) stated that a few deer continue to occur near Fort McMurray, but in general do not have a good population. Mr. Boggs also reported that during the severe winter of 1973-74, there was a high mortality of deer in the Fort McMurray area. He reports that a number of dead deer were found on "...cat trails..." (seismic lines). The deep snow conditions during this severe winter were the suspected cause of the deer die-off.

Gilbert *et al.* (1970) found that snow depths over 46 cm (18 in)

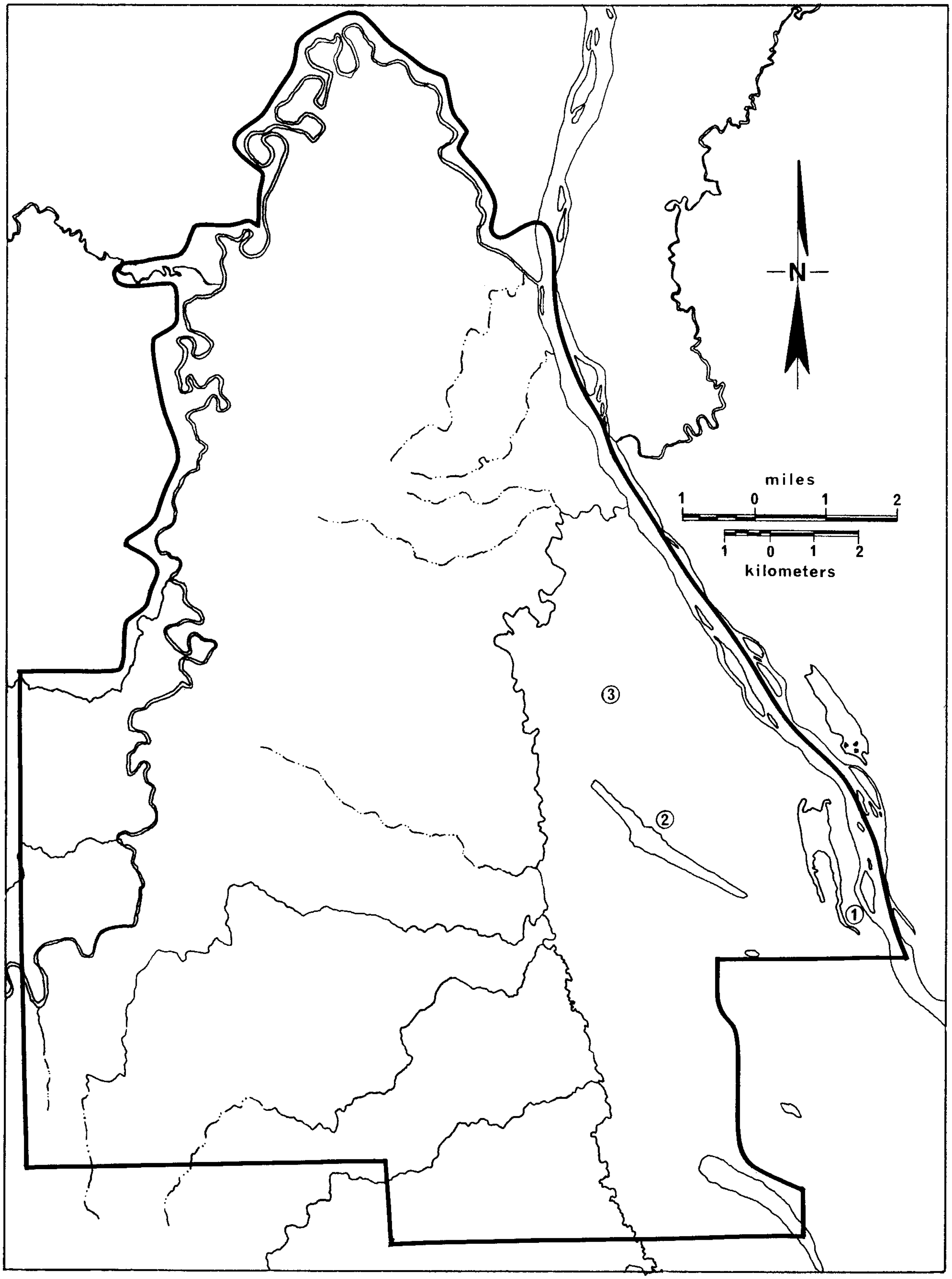


Figure 11. Distribution of field observations (numbered check points) of deer within the ungulate study area.

essentially precluded deer use of mountain ranges and generally governed mule deer winter distribution in Colorado. Severinghaus (1947) found that deep snow, particularly when it remained for long periods, was the principal factor limiting white-tailed deer in the Adirondack region of the United States. Kelsall (1971) found that when snow depths exceeded 40 cm, white-tailed deer movements were severely restricted.

In the Fort McMurray region, the average maximum snow depth of 38 cm occurs in February (Atmospheric Environmental Services, pers. comm.). Snow depth records for the years 1946 to 1972 show maximum snow depths of 43, 58, 66, 64, and 53 cm for the months November to March, inclusive. For some years, winter snow conditions would be unfavorable for mule or white-tailed deer in the Fort McMurray region. However, deer have been shown to be selective of habitats such as coniferous cover where snow depths are less than in surrounding more open cover types (Telfer, 1970). Although snow depths in the Fort McMurray region exceed the tolerance limits for deer mobility in some years, maximum snow depths may not be the major limiting factor to survival of deer in the area.

White-tailed deer are reported to have extended their range into the Fort McMurray area during the period from 1951 to 1960 (Webb, 1967). Kuyt (1966) indicated that the range expansion is still occurring towards the north and west, although the rate of expansion has slowed. The rapid northward invasion of white-tailed deer coincided with the occurrence of agricultural land clearing and the use of nitrogen-fixing hay crops, such as alfalfa. Webb (1967) suggests that white-tailed deer success in northern Alberta seems to be linked with the availability of protein-rich winter foods and micro-habitats that moderate the effects of cold and snow.

As forest clearing, mining, and land reclamation developments increase in the tar sands region of northeastern Alberta, it is anticipated that mule deer and white-tailed deer populations will increase in response to the availability of suitable habitat. Due to their intolerance of deep snow conditions, deer populations may suffer periodic declines during exceptionally severe winters.

4.3 Furbearers

4.3.1 Beaver

4.3.1.1 Relative Abundance

A total of 96 occupied beaver colonies were recorded on the main study area in early winter 1975. This represents a mean density of 0.38 occupied beaver colonies per sq km. The prerequisite for an occupied or active beaver colony was the presence of a recent food cache (Plate 6).

The number of active beaver colonies per kilometer of stream or river for the study area and comparative regions is given in Table 11. The average number of colonies per kilometer was 0.42. The number of beaver colonies ranged from a high of 1.0 colony per km along the Mackay River to a low of 0.14 colonies per km along the west bank of the Athabasca River. On all small

Plate 6. Active beaver colonies, recognized by a freshly mudded lodge and recent food cache, are common along intermittent streams in the study area.

Table 11. Comparison of beaver densities in colonies per kilometer of water course between the study area and other regions.

Region	Active beaver colonies/km	Reference
Study area		
All intermittent streams	0.67	This Study
Beaver River	0.16	This Study
Mackay River	1.00	This Study
Athabasca River (west bank)	0.14	This Study
Mean of all water courses	0.42	
Other regions		
Wood Buffalo National Park, Alberta	0.50	Novakowski, 1958
Fort Smith-Rocher River, N.W.T.	0.68	Fuller, 1955
Hay River, Fort Providence, N.W.T.	1.06	Fuller and Flook, 1951
Red Knife River, N.W.T.	0.62[1]	Fuller, 1953
Kakisa River, N.W.T.	0.87[1]	Fuller, 1953
Mackenzie Delta, N.W.T.		
Beaver sanctuary (untrapped)	0.37	Fuller, 1953
Adjacent area (trapped)	0.19	Fuller, 1953
Fort McPherson District, N.W.T.	0.09	Byrant, 1957
Fort Good Hope District, N.W.T.	0.14	Byrant, 1957
Fort Simpson region, N.W.T.	0.34	Wooley, 1974

[1]Considered to be above saturation levels.

and intermittent streams, the average colony density was 0.67 per km. This value may, however, be an underestimate as some of the intermittent streams recorded from the 1:50,000 topographical maps may not have the potential for supporting beaver. The colony density along Beaver Creek (0.16 colonies per km) was considerably lower than its apparent potential. Clearing and construction activities for the Beaver Creek Dam may have influenced the abandonment of colonies in the area, thus reducing the overall density on the Beaver River. Development activities and elimination trapping are expected to be the cause of five inactive lodges on the tributary to Beaver River near the plant site (A. Langevin, pers. comm., biologist, Syncrude Canada Ltd., Fort McMurray, Alberta).

In comparison to indices of density of beaver colonies for other areas of northern Alberta and the Northwest Territories (Table 11), the beaver densities within the study area approximate the average within the range of densities reported in the literature.

Gunson (1970) reported beaver densities for eight regions in northern Saskatchewan. During the period between 1965 and 1967, inclusive, the mean beaver colony density was 0.27 per sq km and ranged from 0.15 to 0.43 beaver colonies per sq km. Fuller (1953) reported a density of 0.2 beaver colonies per sq km for the Mackenzie District, Northwest Territories.

Novakowski (1958) indicated that "...rarely is a density figure of one or more active colonies per mile (1.61 km) found in the reports for the Northwest Territories". He suggested the following density index:

1.6-3.2 km between colonies: abundant population

3.2-6.4 km between colonies: average population

6.4+ km between colonies: poor population

In relation to this index, the beaver population in the study area (mean = 2.4 km between colonies) would be rated as abundant.

The number of beaver occupying a colony may be highly variable depending upon the trapping intensity, age-structure, and food availability or quality of the habitats (Gunson, 1970). In northern Saskatchewan, Gunson (1970) found that family-group colonies appeared to number about five to six beaver. In Colorado, Rutherford (1964) found a mean of 5.1 beaver in colonies in aspen areas and a mean of 4.1 in willow areas. Hay (1958) reported that in Colorado, the average of five colonies subsisting on aspen was 7.8 beaver, while seven willow-supported colonies averaged 5.1 beavers.

Within the study area, beaver habitat is rated as good to excellent. Aspen and balsam poplar were moderate to highly abundant along most streams and small tributaries occupied by beaver colonies. Willow was present in abundance. Based on a conservative estimate of five beaver per colony, the beaver population on the study area numbers about 480 animals or a density of 1.9 beaver per sq km.

In addition to the occupied beaver colonies, 58 unoccupied or abandoned beaver lodges were recorded. The ratio of active/abandoned lodges was 1.7:1. Abandoned colonies represent 38% of all observations. Bryant (1957) suggests that "...in an expanding population, one would expect a high ratio of active to abandoned colonies. In a decreasing population, a low ratio." Bryant (1957) reports mean ratios of 15.2:1, 4.2:1, 4.4:1, and 2.3:1 for the years 1952, 1953, 1955, and 1957, respectively, in the northern Mackenzie District. Hay (1958) found that counting all lodges resulted in a 34% over-estimation of the number of colonies in his study area in the mountains of Colorado, indicating that about 25% of the lodges were abandoned, or a ratio of about 4:1. He indicated that one colony may keep in good repair as many as three different lodges during the summer but would build a common food cache and utilize a single lodge for winter quarters. Fuller (1955) reported ratios of 12.4:1, 6.2:1, 5.6:1, 3.8:1, and 3.0:1 for active/abandoned lodges in different regions of the Mackenzie District. The ratio of active colonies to abandoned lodges in the study area is somewhat lower than those reported in the literature. Although abandoned lodges occur in relatively high frequency in areas of intensive human and construction activity (Ruth Lake 0:1 and Beaver Creek 0.6:1) the reasons for abandoned lodges in other areas have not been determined.

Factors which may have influenced the high ratio of abandoned lodges in the study area include: a) the use of more than one lodge by a colony during the summer while establishing a single winter food cache (Hay, 1958); b) intensive trapping resulting in the "trapping-out" of some colonies; c) the occurrence of tularemia (*Pasteurella tularemsis* and *P. pseudo tuberculosis*);

this disease has affected beaver populations in other areas (Ruttan, 1953; Rutherford, 1964; Banfield, 1954); and d) the disturbance and forest clearing by the Syncrude development.

Although our survey accuracy was increased by ground checks during the winter, the reported densities must be considered a minimum number. Novakowski's (1959) appraisal of a three-year aerial survey in the Northwest Territories showed that aerial survey efficiency in finding lodges was less than 50% and was approximately 75% efficient in finding feed beds.

4.3.1.2 Distribution

The location of all active beaver colonies and abandoned lodges observed on the study area in early winter 1975-76 is illustrated in Figure 12.

4.3.2 Muskrat

4.3.2.1 Relative Abundance

A total of 41 muskrat houses were recorded in the study area during the winter 1975-76. Local concentrations of muskrat were found on Horseshoe Lake (30 houses) and on Ruth Lake (seven houses). Three muskrat houses were located in the sediment basin adjacent to the Syncrude Lower Camp, and a single muskrat house was observed in a shallow pond on the flood plain adjacent to Morten Island. No muskrat activity was observed on Mildred Lake or on beaver-ponds that are scattered throughout the study area.

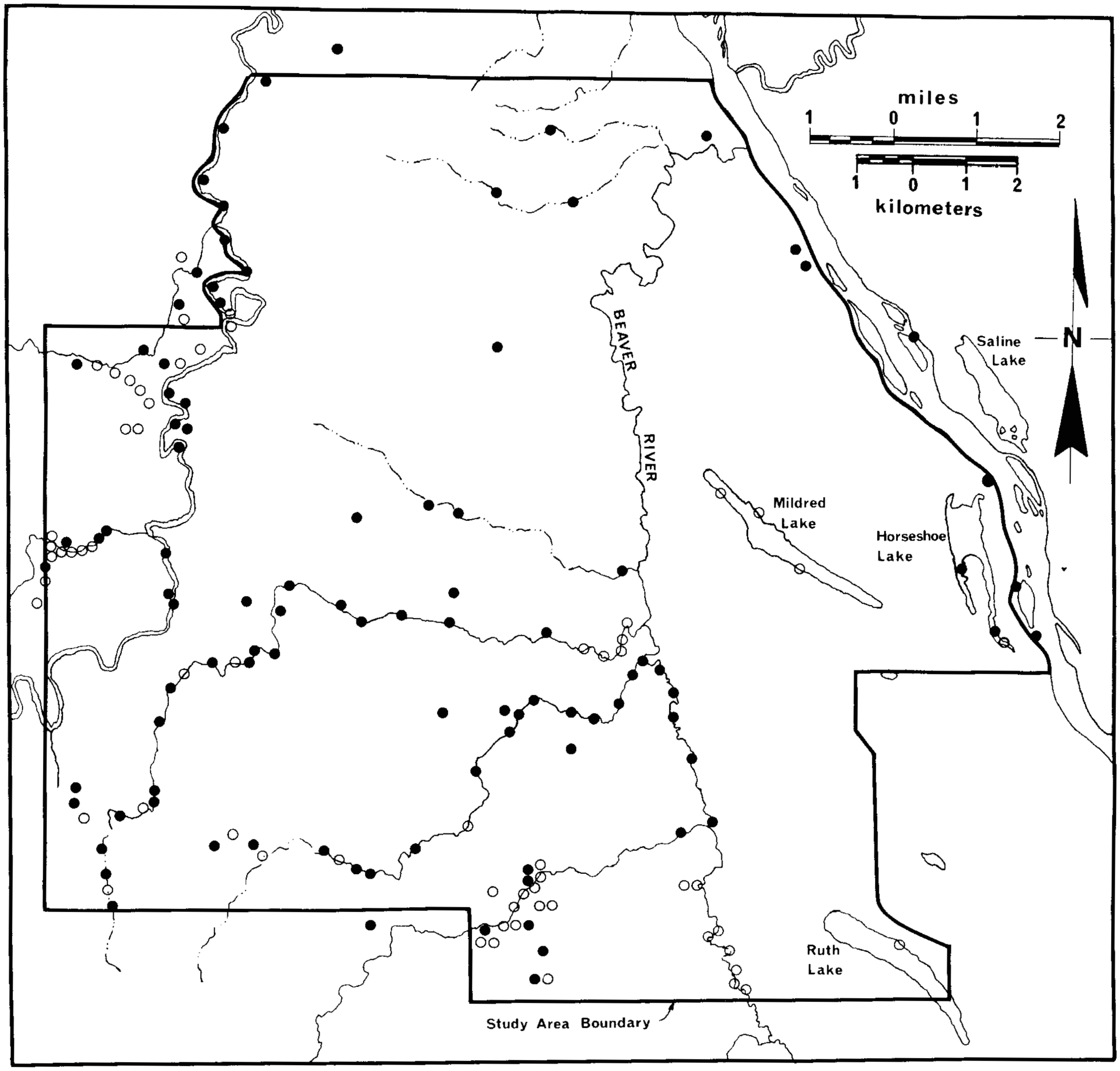


Figure 12. The distribution of active beaver colonies (●) and abandoned lodges (○) within the study area in early winter 1975-76.

Dozier (1965) reported that a figure of five muskrat per house has been generally used as a basis for estimating muskrat populations. Fuller (1951) showed that muskrat population estimates based on five to six muskrat per house were in the same order of magnitude as the estimates based on live-trapping and tagging studies. Using the conservative figure of five muskrat per house, the muskrat population on the study area is estimated to number about 205 animals. For the two main muskrat populations, Horseshoe Lake and Ruth Lake, this represents the following densities:

	Population Estimate	Muskrats/ hectare	Meters of shoreline/ muskrat
Horseshoe Lake	150	2.5	65
Ruth Lake	35	0.3	163

While these values represent our estimate of the current population status, muskrat populations often exhibit marked fluctuations in numbers and density from year to year. Fuller (1951) indicated that important limiting factors to muskrat populations in the boreal forest include: population density, variations in climatic conditions, food supply, intra-specific strife, disease and parasites, and predation and human harvest. To ensure population survival, muskrats compensate high mortality rates with a high reproductive potential.

Thus, the muskrat populations within the study area may exhibit a large range of annual densities, dependent upon seasonal and long-term climatic conditions and other limiting factors. In order to determine the productivity of this furbearer in the study area, additional monitoring studies are required.

The muskrat population density on the study area falls within the range of that reported in the literature. Bellrose (1950) reported a mean of 4.9 muskrat per ha (Range: 0.5 to 23.5), or based on five animals per house, a mean of 24.5 muskrats per ha (Range: 2.5 to 117.5) for marshes in Illinois. Stevens (1953) reported a density of about 7.4 muskrats per surface ha or one muskrat for each 25 m of shoreline for a lake in the Mackenzie Delta. He considered this population to be unusually high in relation to other lakes examined. Fuller (1951) reported the provisional estimated productivity of the Peace Athabasca Delta as:

Regional Subdivision	Muskrats per hectare[1]
Upper Athabasca	
Lacaille	0.46
General	0.38
Lower Athabasca	0.31
Peace	0.19
Special	
Egg Lake	0.19
Dempsey	0.31
TOTAL	0.28

[1]The author's conversion to metric.

Caution, however, was advised in using these values as average potential productivity. Due to periodic population fluctuations, these data represented an order of magnitude within the possible range of densities.

4.3.2.2 Distribution

The location of all muskrat house observations within the study area is illustrated in Figure 13.

4.3.3 Red Squirrel

4.3.3.1 Relative Abundance

Winter Track Counts

A total of 3,137 red squirrel tracks were recorded crossing the transect lines. This represents a mean density of 11.65×10^{-2} tracks per station track-day or 2.33 tracks per kilometer track-day (Table 12).

Comparative indices of red squirrel tracks per kilometer track-day of the study area and other tracking studies in the boreal forest are illustrated in Table 13.

Red Squirrel Midden Counts

A total of 78 active red squirrel middens were recorded within

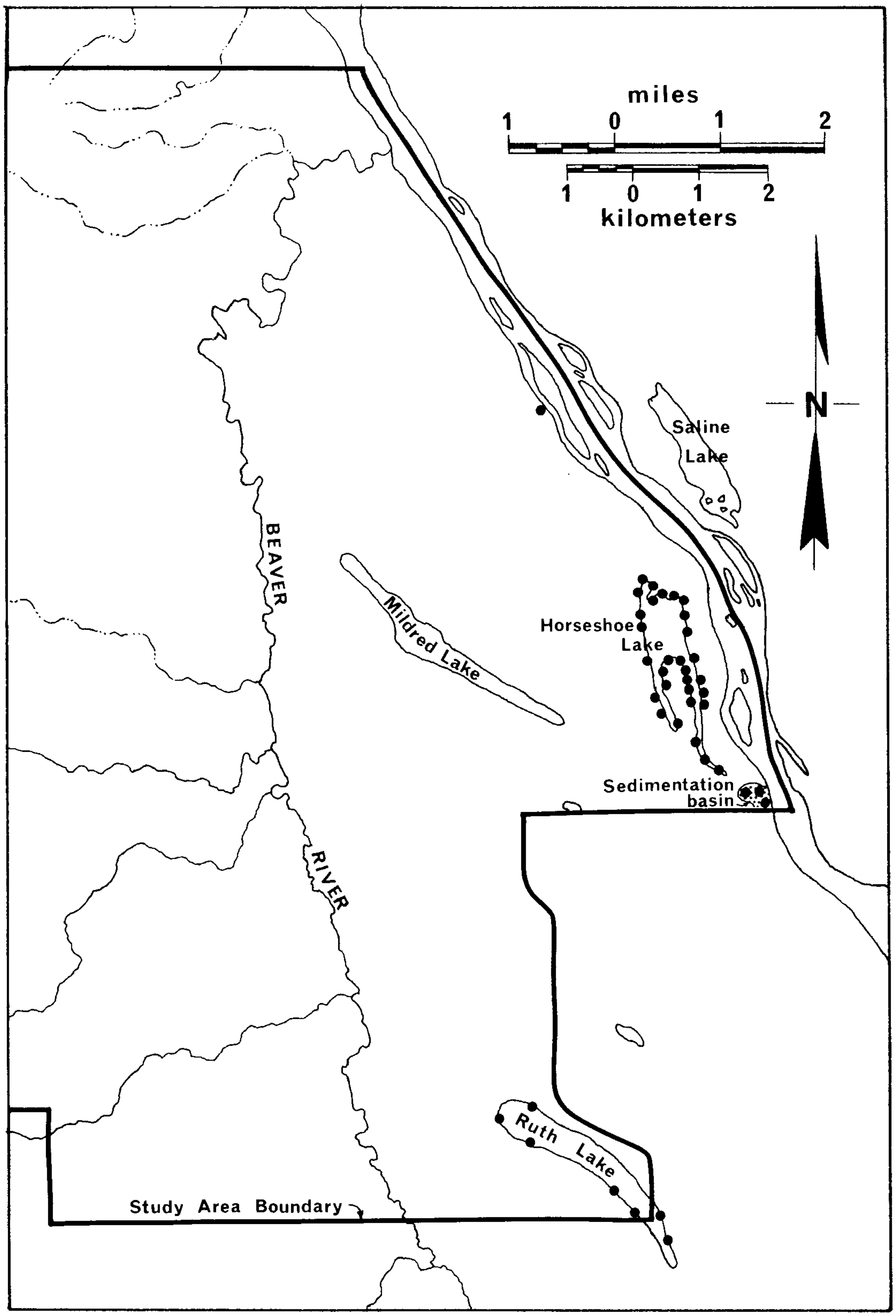


Figure 13. The distribution of muskrat houses recorded on the study area during the winter 1975-76.

Table 12. Relative abundance of terrestrial furbearers on all transect lines within the study area.

Species	Total number tracks	Tracks/station track-day ($x10^{-2}$)	Tracks/km track-day
Red squirrel	3,137	11.65	2.33
Northern flying squirrel	9	0.03	0.01
Snowshoe hare	3,963	14.72	2.94
Ermine	1,983	7.36	1.47
Mink	144	0.53	0.11
Marten and Fisher	79	0.29	0.06
Wolverine	7	0.03	0.01
Otter	1	*	*
Red fox	31	0.12	0.02
Coyote	393	1.46	0.29
Wolf	94	0.35	0.07
Lynx	2	0.01	*

*Less than 0.01.

Table 13. Comparison of relative abundance of furbearers in tracks per kilometer track-day for the study area with other regions within the boreal forest.

LOCATION	Red squirrel	Snowshoe hare	Ermine and Weasel	Mink	Marten	Fisher	Wolverine	Red fox	Coyote	Wolf	Lynx	Kilometer track-days	BOREAL FOREST SECTION
This Study	2.33	2.94	1.47	0.11	-- 0.06 --		0.01	0.02	0.29	0.07	*	1346	Mixedwood
Chick Lake[1] Fall 1974	1.59	2.36	0.54	0.11	4.08	-	*	0.34	*	*	0.03	196	Northwestern Transition
Chick Lake[2] Spring 1973	n.a.	n.a.	0.18	*	0.94	-	0.01	0.01	0.03	0.03	0.07	n.a.	Northwestern Transition
Moon Lake[1] Fall 1974	0.02	3.20	0.13	0.01	3.78	-	0.01	*	*	*	*	271	Northwestern Transition
Moon Lake[2] Spring 1973	n.a.	n.a.	0.09	0.01	1.29	-	*	*	*	*	0.03	n.a.	Northwestern Transition
Bistcho Lake[3] 1973	0.11	0.46	0.72	*	0.11	-	-	0.04	-	-	0.01	140	Hay River
Hotchkiss R.[3] 1973	1.01	n.a.	0.94	0.01	0.09	0.08	0.01	0.03	0.03	0.38	0.61	159	Lower Foothills
Peace River[4] 1974	2.94	2.81	2.00	*	0.06	*	*	0.06	0.63	*	0.06	84	Mixedwood

[1]Douglass, Fisher, and Mair, 1976.
[2]Douglass and Wooley, 1974.
[3]Wooley, 1974.
[4]Penner, 1976.
[5]Rowe, 1972.

[6]Observations of marten and fisher combined.
* Relative abundance less than 0.01.
\- Species not recorded.
n.a. Data not available.

2 m of all transect lines in the study area during the winter period January 15 to March 15, 1976 (Figure 14). The number of middens recorded within each vegetation type and an estimate of red squirrel midden density per hectare and vegetation type within the study area are presented in Table 14.

The highest red squirrel midden density was observed in white spruce cover (8.7 middens/ha). Moderate midden densities were recorded in mixedwood (1.0 to 2.6 middens/ha), jack pine (2.6 middens/ha), and high density black spruce (1.9 middens/ha). Low midden densities (0.2 to 0.4 middens/ha) were recorded in pure deciduous, tall shrub, and low density black spruce types (Table 14).

In northern regions red squirrels characteristically inhabit mature forests with a high coniferous component and feed primarily on seeds of white or black spruce (Wolff and Zasada, 1975; Brink, 1964; Smith, 1966). Brink and Dean (1966) found that red squirrels showed a definite preference for white spruce cones over black spruce cones. Smith (1968) felt that red squirrel competition was for white spruce habitat with the less successful squirrels being forced into marginal black spruce habitat. He also suggested that red squirrel behavior regulates territory size in response to food supply.

The relative abundance of red squirrel on the study area shows a similar trend of habitat preference with the highest midden density in white spruce, followed by jack pine, mixedwood with a white spruce component, high density black spruce, low density black spruce, black spruce-willow, and

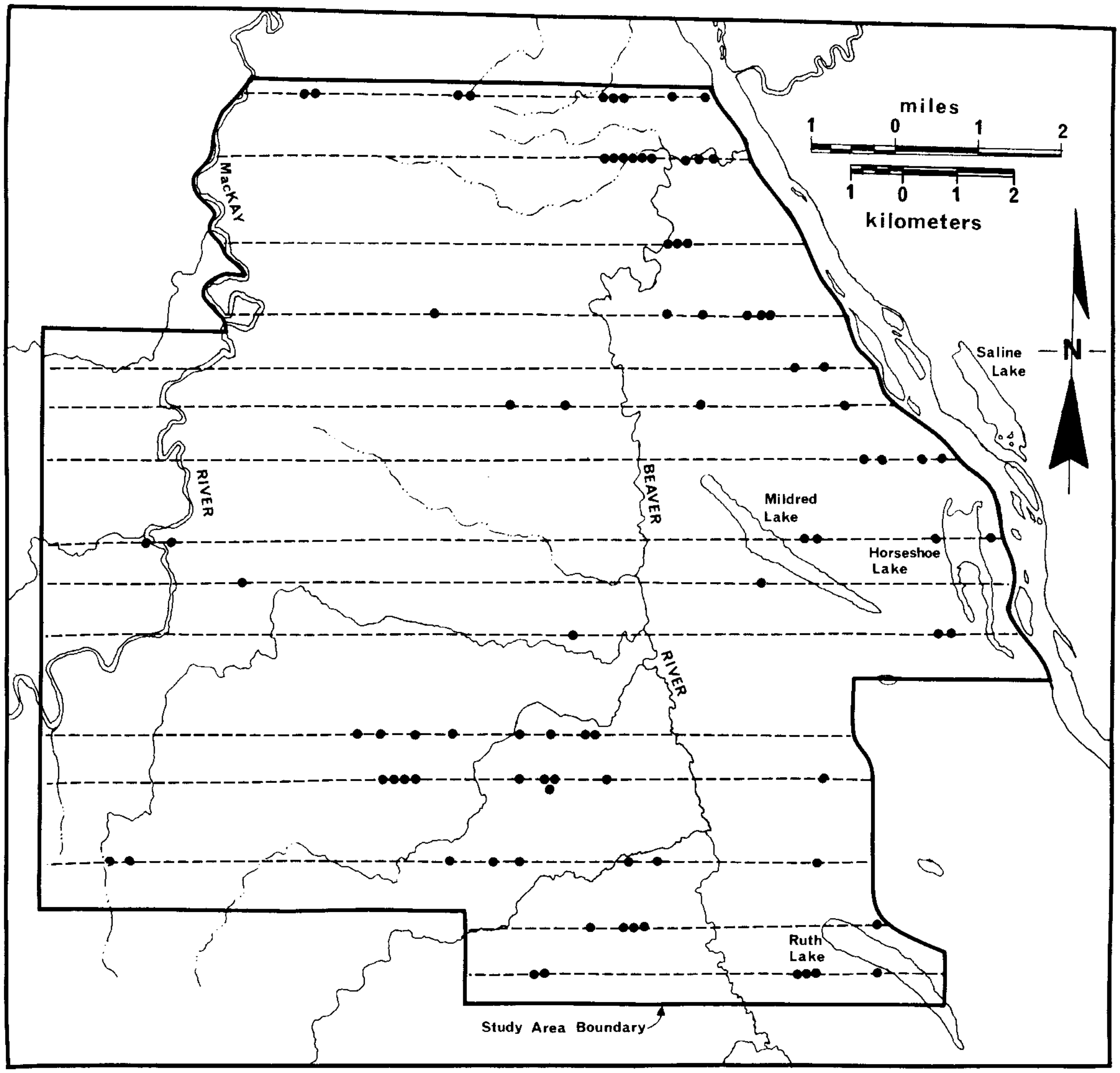


Figure 14. The distribution of red squirrel middens along transect lines in the study area.

Table 14. Numbers of red squirrel middens occurring in various vegetation types on the study area 1976.
"+" indicates that the proportion of observation is significantly greater than the proportion of the vegetation type available in the study area, "-" significantly less and "o" not significantly different.

Vegetation Type	Percent of Study Area	Number of middens observed	Percent of Total Midden Observations	Estiamted number of Middens per hectare	Estimated number of middens or territorial squirrels
Trembling aspen	4.8	0	0.0 -	0.0	-
Trembling aspen-balsam poplar	1.2	0	0.0 -	0.0	-
Trembling aspen-willow and/or alder	14.2	3	3.8 -	0.24	889
Mixedwood (11% to 40% coniferous)	7.5	14	17.9 o	2.12	4,149
Mixedwood (41% deciduous to 41% coniferous)	2.6	2	2.6 o	0.97	992
Mixedwood (61% to 89% coniferous)	6.1	14	17.9 +	2.63	4,144
White spruce	1.6	12	15.4 +	8.70	3,934
Jack pine	0.9	2	2.6 o	2.56	586
Black spruce (cover 11% to 40%)	5.7	1	1.3 -	0.22	296
Black spruce (cover 41% to 100%)	15.4	24	30.8 +	1.88	7,107
Black spruce-willow	6.1	3	3.8 o	0.39	593
Tall shrub	6.0	2	2.6 o	0.41	583
Dwarf birch-tamarack	2.4	0	0.0 -	0.0	-
Riparian	2.2	1	1.3 o	0.43	295
Disturbed	23.6	0	0.0 -	0.0	-
TOTAL		78			23,568
Mean (all forested areas)				1.19	
Statistical significance			D	0.323*	
			D(0.01)	0.185	

*Significant difference at P=0.01.

deciduous vegetation types. Middens within the deciduous habitat were composed of rose hips (*Rosa acicularis*) and mushrooms. Although the vegetation types with low midden densities are considered poor habitat, they support approximately 11% of the red squirrel population of the study area.

Estimates of red squirrel density in each vegetation type are illustrated in Table 14. These estimates were based on the assumption that red squirrels occupy mutually exclusive territories, each of which contains one actively used midden. These assumptions are based on the observations and studies by Smith (1966, 1968), Streubel (1968), Gordon (1936) and Krasnowski (1969).

The estimated density of red squirrels in coniferous cover on the study area is considerably higher than that reported for red squirrels in coniferous habitat in other areas (Table 15). The observed difference may be due to: a) observer error in differentiating auxiliary middens from the main active middens or a bias in estimating the distance of middens from the transect lines, both of which would increase midden density; b) small sample size (0.4% of the total study area) which would compound measurement error; c) a naturally high red squirrel population, or d) an artificially increased density due to the displacement of red squirrels from the main cleared area into adjacent habitats. The latter consideration may also help explain the presence of red squirrels in such unfavorable habitats as deciduous cover. Of these possible causes of high population density estimates, the artificially increased density of red squirrels due to disturbance and thus displacement to adjacent habitats merits special attention in further investigations.

Table 15. Comparison of densities of red squirrel on the study area with other areas.

Location	Red Squirrel Density (squirrels/ha)	Habitat/Comments	Reference
Syncrude Lease No. 17 area	1.19 (0 to 8.7)	Mean of all habitat types	This study
Wood Buffalo National Park, Alberta	1.04	White spruce-poplar	Wood, 1967
Interior Alaska	0.19 to 1.1	White spruce-deciduous	Krasnowski, 1969
Alaska	1.9	Spruce-river island (year of good spruce cone crop production)	Brink, 1964
Ithaca, New York	1.6 to 2.1	Open hardwood forest (in two consecutive years)	Layne, 1954
New York	3.7	Oak-maple forest	Hamilton, 1939
Michigan	0.8 to 1.7	Oak-hickory forest	Linduska, 1950

4.3.3.2 Winter Distribution

Distribution in Relation to Vegetation Types

A comparison of the availability of vegetation types by areal extent and their use by red squirrels as determined by the winter distribution of tracks showed a significant difference (P=0.01) (Table 16). Red squirrels exhibited a preference for: white spruce, coniferous-(primarily white spruce) dominated mixedwood and high density black spruce, and jack pine (Table 16). This trend follows the preference for white spruce over black spruce reported by Smith (1968) and Brink and Dean (1966). Mixedwood with minor to moderate amounts of coniferous cover, low density black spruce, and aspen-balsam poplar types received red squirrel use in relation to their availability within the area, illustrating neither preference nor avoidance of these types. Red squirrels were negatively related with most deciduous vegetation types, including: aspen, aspen-willow, tall shrub, and riparian types, as well as black spruce-willow, dwarf birch-tamarack, and disturbed cover types.

Preference for vegetation types by red squirrel, as determined by track counts, was not significantly different (P=0.05) from that determined from the relative abundance of red squirrel middens in various vegetation types.

The frequency of occurrence of red squirrel middens in the various vegetation types differed significantly from the relative proportions of the vegetation types in the study area (P=0.01). The relationship between midden densities and vegetation types is illustrated in Table 14.

Table 16. A comparison of availability of vegetation types with utilization by furbearers as determined by winter track counts.
Preference for a particular vegetation type is indicated by "+", avoidance by "-", and neither preference nor avoidance by "o" (P=0.01).

Vegetation Type	Percent of Study Area	Percentage of Total Observations Per Track-Day				
		Red Squirrel	Snowshoe Hare	Ermine	Mink	Marten and Fisher
Trembling aspen	4.8	1.2 -	4.1 o	3.6 o	4.6	4.3
Trembling aspen - balsam poplar	1.2	1.5 o	0.2 -	2.6 o	1.6	1.5
Trembling aspen - willow and/or alder	14.2	6.2 -	24.8 +	19.6 +	33.2	8.7
Mixedwood (11% to 40% coniferous)	7.5	7.1 o	5.4 -	5.8 o	10.4	9.1
Mixedwood (41% deciduous to 41% coniferous)	2.6	3.8 o	6.0 +	1.9 o	1.3	3.8
Mixedwood (61% to 89% coniferous)	6.1	20.2 +	13.3 +	5.7 o	6.5	7.8
White spruce	1.6	16.6 +	3.2 o	2.5 o	2.9	8.3
Jack pine	0.9	2.6 +	0.3 -	0.3 o	0	1.0
Black spruce (cover 11% to 40%)	5.7	8.2 o	3.2 -	12.5 +	2.2	21.1
Black spruce (cover 41% to 100%)	15.4	27.3 +	19.1 +	12.7 o	6.4	23.9
Black spruce - willow	6.1	1.9 -	2.9 -	2.5 -	0.7	0
Tall shrub	6.0	2.7 -	16.4 +	12.4 +	14.5	6.8
Dwarf birch - tamarack	2.4	0.1 -	0 -	1.5 o	0	1.4
Riparian	2.2	0.1 -	0.8 -	5.0 o	12.5	0
Disturbed	23.6	0.5 -	0.3 -	11.4 -	3.1	2.3
Total observations per track-day		500.5	632.3	316.4	23.0	12.6
Statistical significance						
D		0.348*[1]	0.268*	0.119*	0.248[n.s.]	0.295[n.s.]
D (0.01)		0.073	0.065	0.092	0.340	0.459

...continued

Table 16. Concluded

Vegetation Type	Percent of Study Area	Percentage of Total Observations Per Track-Day				
		Wolverine	Red Fox	Coyote	Wolf	Lynx
Trembling asepn	4.8	29.3		1.2 -	7.6	
Trembling aspen - balsam poplar	1.2	44.7		0.3 o		
Trembling aspen - willow and/or alder	14.2	14.7	8.1	2.2 -	7.6	
Mixedwood (11% to 40% coniferous)	7.5			2.8 o	3.4	
Mixedwood (41% deciduous to 41% coniferous)	2.6		3.6	4.6 o	4.5	
Mixedwood (61% to 89% coniferous)	6.1	11.3	6.3	6.0 o		
White spruce	1.6			1.2 o		
Jack pine	0.9			1.5 o	0.9	
Black spruce (cover 11% to 40%)	5.7			13.6 o		56.3
Black spruce (cover 41% to 100%)	15.4		24.5	14.4 o	1.0	43.7
Black spruce - willow	6.1			1.3 -	3.3	
Tall shrub	6.0			2.9 o	10.8	
Dwarf birch - tamarack	2.4			1.7 o		
Riparian	2.2			1.0 o		
Disturbed	23.6		57.5	45.3 +	61.0	
Total observations per track-day		1.1	4.9	62.7	15.0	0.3
Statistical significance		d[2]	d	0.220* 0.206	0.378 n.s. 0.421	d

[1]*significant difference at P=0.01, n.s. not significantly different.
[2]d sample size insufficient for testing.

Distribution in Relation to Terrain Types

No significant differences were found between the availability of various terrain features and their use by red squirrel as determined by winter track counts (Table 17).

The largest observed differences occurred on east-facing slopes and areas of reduced forest cover. The high component of white spruce on the east-facing slopes along the Athabasca River was the apparent attraction of the former category.

Distribution in Relation to Habitat Disturbance

Red squirrels exhibited an avoidance of large cleared areas, cutlines, and moderate to heavy-use roads (Table 18). Ninety-nine percent of red squirrel activity was recorded in undisturbed habitats.

Spatial Distribution

An isodensity map illustrating the spatial distribution of the red squirrel is provided in Appendix 3-A. Broader regions of moderate to high densities of red squirrel activity are found within the Athabasca River valley and in the area immediately west and southwest of the main cleared area. Localized areas of activity are found throughout the western and northern portions of the study area. These localities coincide with areas of white spruce,

Table 17. Comparison of the availability of terrain features with utilization by furbearers as determined by winter track counts.

Terrain Features	Proportion of the Study Area	Percent of total observations per track-day: Red squirrel	Snowshoe hare	Ermine	Mink	Marten and Fisher
Slope and aspect						
0-10% none	94.0	90.9	99.2	95.7	82.5	91.0
10-30% north	0.1	0.2	0.0	0.0	0.0	0.0
10-30% east	0.7	3.7	0.3	0.7	5.6	2.5
30-60% east	0.3	0.5	0.2	0.7	0.0	0.0
60%+ east	0.1	0.5	0.0	0.1	0.0	0.0
10-30% south	0.1	0.1	0.1	0.1	0.0	0.0
30-60% south	0.1	0.4	0.1	0.8	0.0	0.0
60%+ south	0.2	0.9	0.0	0.0	0.0	2.3
10-30% west	0.5	0.7	0.0	1.0	0.0	1.7
30-60% west	0.6	0.5	0.0	0.1	0.0	0.0
60%+ west	0.1	0.4	0.0	0.1	0.0	2.6
Hydrological features						
Shoreline (river or lake)	0.1	0.6	0.0	0.3	4.8	0.0
Streambed	0.1	0.6	0.0	0.2	0.7	0.0
Open water (ice)	3.0	0.0	0.0	0.4	6.4	0.0
Total Observations per Track-day		500.5	632.3	316.4	23.0	12.6
Statistical significance:						
D		$0.054^{n.s.}$	$0.058^{n.s.}$	$0.020^{n.s.}$	$.108^{n.s.}$	$.031^{n.s.}$
D(0.01)		0.073	0.065	0.092	.340	.459

... Continued

Table 17. Continued.

Terrain Features	Proportion of the Study Area	Percent of total observations per track-day				
		Wolverine	Red fox	Coyote	Wolf	Lynx
Slope and aspect						
0-10% none	94.0	83.3	96.6	91.2	89.1	0.0
10-30% north	0.1	0.0	0.0	0.5	0.0	0.0
10-30% east	0.7	0.0	0.0	1.0	2.1	0.0
30-60% east	0.3	0.0	0.0	1.1	0.0	0.0
60% east	0.1	0.0	0.0	0.5	0.0	0.0
10-30% south	0.1	0.0	0.0	0.4	0.0	0.0
30-60% south	0.1	0.0	0.0	1.7	0.0	0.0
60%+ south	0.2	0.0	0.0	0.5	0.5	0.0
10-30% west	0.5	16.6	0.0	0.3	0.0	0.0
30-60% west	0.6	0.0	0.0	0.0	0.0	0.0
60% west	0.1	0.0	0.0	0.5	0.0	0.0
Hydrological features						
Shoreline (river or Lake)	0.1	0.0	0.0	0.0	0.0	0.0
Streambed	0.1	0.0	0.0	1.0	0.0	0.0
Open water (ice)	3.0	0.0	3.3	1.3	8.7	0.0
Total Observations per Track-day		1.1	4.9	62.7	15.0	0.3
Statistical significance:						
D		d[1]	0.088 n.s.	0.072 n.s.	0.216 n.s.	d
D(0.01)			0.736	0.206	0.421	

[1]d: sample size insufficient for testing.
n.s. - not significantly different at P=0.01.

Table 18. Comparison of the availability of disturbed and undisturbed habitats with utilization by furbearers as determined by winter track counts.
Preference for a particular type is indicated by +, avoidance by - and neither preference or avoidance by "o" (P=0.01).

Habitat Type	Proportion of the Study Area	Percent of Total Tracks per Track-Day: Red Squirrel	Snowshoe Hare	Ermine	Mink	Marten and Fisher
Undisturbed habitats	75.1	99.2 +	98.9 +	87.3 +	99.9	100.0
Large cleared areas	23.6	0.5 -	0.3 -	11.4 -	0.0	0.0
Type 1. Road - light use	0.1	0.2 o	0.1 o	0.4 o	0.0	0.0
Type 2. Road - moderate to heavy use	0.4	0.0 -	0.0 -	0.0 -	0.0	0.0
Type 1. Cutline - recent	0.5	0.1 -	0.6 o	0.5 o	0.1	0.0
Type 2. Cutline - old, some regeneration	0.3	0.0 -	0.1 o	0.4 o	0.0	0.0
Total observations per track-day		500.5	632.3	316.4	23.0	12.6
Statistical significance:						
D		.238*[1]	.235*	.119*	.245 n.s.	.246 n.s.
D (0.01)		.073	.065	.092	.340	.459

Table 18. Continued.

Habitat Type	Proportion of the Study Area	Percent of Total Tracks per Track-Day				
		Wolverine	Red fox	Coyote	Wolf	Lynx
Undisturbed habitats	75.1	100.0	36.2	49.0 -	29.6 -	100.0
Large cleared areas	23.6	0.0	54.2	44.0 +	52.3 o	0.0
Roads - light use	0.1	0.0	3.2	2.0 o	0.0 o	0.0
Roads - moderate to heavy use	0.4	0.0	0.0	0.5 o	8.5 o	0.0
Cutline - recent	0.5	0.0	6.4	4.5 o	5.3 o	0.0
Cutline - old, some regeneration	0.3	0.0	0.0	0.0 o	4.3 o	0.0
Total observations per track-day		1.1	4.9	62.7	15.0	0.3
Statistical significance:						
D				.264*	.458*	
D (0.01)		d[2]	d	.206	.421	d

[1]* - significant difference at P=0.01.
n.s. - not significantly different at P=0.01.
[2]d - sample size insufficient for testing.

mixedwood and high density black spruce vegetation (Figure 6). The preferences exhibited for these vegetation types by red squirrel are illustrated in Table 16. The locations of red squirrel middens along transect lines (Figure 14) are distributed in patterns similar to the distribution pattern determined by track activity (Appendix 3-A).

A local concentration of red squirrel activity in the western portion of the mine area was found in a stand of dense black spruce during the initial track-count replicate. This stand has now been cleared. Additional occurrences of red squirrel activity within the limits of the cleared area are from small remnant stands still occupied by red squirrels, such as along the Beaver Creek, from red squirrel movement from stands adjacent to the cleared area, and from extrapolation during grid mapping.

The patterns of spatial distribution recorded during this study may have been influenced by the emigration of red squirrels from recently cleared areas into undisturbed cover. However, red squirrels are strongly territorial (Smith, 1965). Displaced animals would be expected to influence the greater use of marginal habitats such as low density black spruce and deciduous dominated mixedwood and/or suffer considerable mortality. Wolff and Zasada (1975) studied the response of red squirrel to timber harvest in Alaska and found that the squirrel population levels in adjacent control areas and along the boundary of clear cut areas remained stable, inferring a mortality proportional to the number of displaced animals.

Red squirrel activity greater than 0.2 tracks per station track-day occurred on 36.2% of the study area (Appendix 10). The vegetation types preferred by red squirrel comprise a similar proportion, 35.9% of the study area (Table 16). High densities of red squirrel tracks (greater than 1.0 tracks per station track-day) covered 3.7% of the study area, and were generally within localized areas.

Comparison of the %RSS values (Appendix 11) to the minimum %RSS required (Appendix 12) suggested a trend of a cubic surface or higher. Inspection of the $\hat{Z}$ square array (Appendix 3-B) indicated that a linear trend best described the overall pattern of activity. The resultant orthogonal polynomial equation:

$$\hat{Z} = 0.8697878 + 0.0097044X + 0.0222095Y$$

represented a first order trend, generating a linear surface of

$$\hat{Z} = 0.8697878 + 0.0069852X + 0.0222095Y$$

and a map, shown in Appendix 3-C.

4.3.4 Snowshoe Hare

4.3.4.1 Relative Abundance

The mean density of snowshoe hare tracks was 14.72×10^{-2} tracks per station track-day or 2.94 tracks per kilometer track-day ((Table 12). Snowshoe hare was the most abundant furbearer recorded in the study area. The relatively high abundance of snowshoe hare as well as red squirrel in relation to the carnivorous furbearers is to be expected, as the relative abundance and biomass of herbivores greatly exceeds that of carnivores in the terrestrial food chain (Odum, 1971).

4.3.4.2 Distribution

Distribution in Relation to Vegetation Types

The relationship between the distribution of snowshoe hare activity (recorded as track densities per vegetation type) and the availability of vegetation types was found to be significantly different (P=0.01) (Table 16).

Snowshoe hares exhibited a preference for tall shrub, aspen-willow, mixedwood with a moderate to high coniferous component, and high density black aspen-balsam poplar, mixedwood with a minor coniferous component, jack pine, low density black spruce, black spruce-willow, dwarf birch-tamarack, and riparian vegetation types as well as areas of disturbed cover. Keith (1963) reviewed the changes in snowshoe hare distribution in relation to population fluctuations and showed that during years of low abundance, snowshoe hares persisted in restricted islands of favored habitat and dispersed into less favorable habitat as their numbers began to increase. Keith (1966) showed that snowshoe hare habitat preference was directly related to the amount of brushy cover available.

Distribution in Relation to Terrain Features

No significant differences were found between snowshoe hare distribution and the availability of the various terrain features (Table 17).

Distribution in Relation to Habitat Disturbance

Snowshoe hares exhibited a preference for undisturbed habitats and an avoidance of large cleared areas and moderate to heavy-use roads (Table 18). Snowshoe hare activity on cutlines and light-use roads occurred within the range of expected values.

Spatial Distribution

The spatial distribution of snowshoe hare on the study area is illustrated in Appendix 4-A. The general pattern of distribution appeared quite similar to the distribution of vegetation types preferred by snowshoe hare. Areas with light or no snowshoe hare activity are found within the main cleared area and in the northwest and west central portions of the study area.

Areas with track densities greater than 0.2 tracks per station track-day cover about 40% of the study area. Local areas of high track densities (greater than 1.0 tracks per station track-day) cover 5.8% of the area. The locations of high snowshoe hare activity are expected to be favored habitats from which animals would disperse to surrounding habitats as their numbers increase, or in which animals would persist during a population low. However, further information is required to determine if these sites are important throughout a winter or from year to year. Once this parameter is established, these sites would provide a basis for monitoring future impacts of the operations phase of the tar sands development.

No regional trend of snowshoe hare activity was found. The basic statistics necessary to assess the presence of a regional trend are listed in Appendices 4-B, 11 and 12.

4.3.5 Ermine and Weasel

Both ermine (*Mustela erminea*) and weasel (*Mustela nivalis*) are found within the study area. Due to the considerable overlap in their track dimensions, these species were indistinguishable during field studies and information obtained for both species is combined under the heading of ermine. The ermine is also generally considered the more common of the two species in the boreal forest (Banfield, 1974). The weasel is relatively uncommon to rare (Soper, 1964).

4.3.5.1 Relative Abundance

The density of ermine tracks averaged 7.36×10^{-2} tracks per station track-day or 1.47 tracks per kilometer track-day (Table 12). The observed density is higher than that reported for tracking studies in the Northwest

Territories and somewhat lower than those reported for the Peace River area (Table 13). The relative abundance of ermine was considerably greater than all other mustelids on the study area. This trend was not observed in the studies at more northern latitudes.

Within a given area, the relative abundance of ermine may vary considerably among years. Banfield (1974) indicated that ermine populations exhibit drastic fluctuations, depending upon the population of mice. In order to interpret the influences of development on ermine populations, the magnitude of their population fluctuations and their relation to the abundance of their prey species should be investigated.

4.3.5.2 Distribution

Distribution in Relation to Vegetation Types

Ermine activity was recorded in all of the available vegetation types. Preference for particular vegetation types was observed in aspen-willow, low density black spruce, and tall shrub types. Black spruce-willow and areas of disturbed cover were avoided (Table 16). Banfield (1974) indicated that ermine occupy a wide range of habitats within the boreal coniferous or mixed forests. This trend was also observed during the winter tracking studies.

Distribution in Relation to Terrain Features

The winter distribution of ermine was not found to be significantly different from the availability of terrain features (Table 17).

Distribution in Relation to Habitat Disturbance

The relationship between the distribution of ermine and types of habitat disturbance was found to be significantly different (P=0.01) (Table 18). Ermine exhibited a preference for undisturbed habitat and an avoidance of large cleared areas and moderate to heavy-use (Type 2) roads (Table 18). Cutlines and light-use (Type 1) roads generally occurred in areas of undisturbed cover and they were neither avoided nor preferred.

Spatial Distribution

Ermine were distributed throughout the study area. Although no regional distribution patterns are apparent, local areas of high or low track activity were found (Appendix 5-A). Areas of high track densities may relate to areas of high small mammal abundance to which ermine respond (Erlinge, 1974; Robina, 1960) or be near one of the activity centers of an ermine's territory or home range. Home range sizes for weasel vary from 1 to 1.5 ha (Polderboer, 1942; Erlinge, 1974) and from 4 to 120 ha for the long-tailed weasel (Banfield, 1974). D. Wooley (pers. comm., biologist, Renewable Resources Consulting Services Ltd., Edmonton, Alberta) indicated that ermine home ranges in the northern boreal forest appear considerably larger than those reported for weasel and long-tailed weasel and would approximate 1.0 or 1.5 sq km for females and an even larger area for males.

Ermine track densities greater than 0.1 tracks per station track-day cover about 64% of the study area. Higher track densities (greater than 1.0 tracks per station track-day) were found on less than 1% of the area. Although ermine generally avoided recently cleared areas (Table 18), moderate track densities were occasionally found in older cleared areas with herbaceous and low shrub cover.

No regional trend of ermine activity was found. The basic statistics necessary to assess the presence of a regional trend are listed in Appendices 5-B, 11, and 12.

4.3.6 Mink

4.3.6.1 Relative Abundance

The mean density of mink track activity was 0.53×10^{-2} tracks per station track-day or 0.1 tracks per kilometer track-day (Table 12). Mink were considerably less abundant than ermine but more abundant than other mustelids. The relative abundance of mink in the study area is generally greater than that reported in tracking studies in other regions (Table 13).

4.3.6.2 Distribution

Distribution in Relation to Vegetation Type

The distribution of mink activity was not significantly different from that expected on the basis of the availability of vegetation types (Table 16). This is partially due to the low sample size. The data, however, illustrate several trends. In relation to the availability of the vegetation types, mink activity is proportionately higher in riparian, aspen-willow and deciduous dominated mixedwood types and proportionately lower in black spruce cover types and in areas of disturbed cover. Marshall (1936) examined late winter cover type preferences of mink in Michigan and reported a preference for hydrophytic cover types. This is comparable to the apparent preference of the riparian types on the study area.

Distribution in Relation to Terrain Features

Although no statistical differences were found between the availability of terrain features and their use by mink, the hydrological features, including shoreline, streambed and open water habitats, received considerably more use in relation to their proportion of the study area than other types (Table 17). This observation is in keeping with the reported mink habitat associations (Banfield, 1974).

Distribution in Relation to Habitat Disturbance

Nearly all observations of mink activity were recorded in undisturbed habitats (Table 18). The observed trends indicate mink generally avoid large cleared areas, recent cutlines, and roads with vehicular traffic.

Spatial Distribution

The spatial distribution of mink activity is illustrated in

Appendix 6-A. Mink are found in localized pockets along the Athabasca and Mackay river valleys and in the region north and southwest of the main cleared area. Most of these locations coincide with riparian habitats associated with Horseshoe Lake, rivers and streams, or beaver dams. No mink activity was recorded in the vicinity of Ruth Lake or Mildred Lake. Mink activity greater than 0.1 tracks per station track-day was distributed over 7.2% of the study area.

Mink are considered to be territorial, with females restricting their movements to an area from 7 to 20 ha, while males range over territories from 7 to 8 sq km (Banfield, 1974). The localized distribution of mink on the study area may approximate the extent of individual mink territories or home ranges although continued track-counting studies are required to provide a better estimate of these parameters. Segregation of male and female mink distributions by track observations would provide further refinements to establish present conditions for comparisons with those during the production phase of the developments.

No regional trend of mink activity occurred on the study area. The basic statistics necessary to assess the presence of a regional trend are listed in Appendices 6-B, 11, and 12.

4.3.7 Marten and Fisher

4.3.7.1 Relative Abundance

The track dimensions and track patterns of marten and fisher overlap to the extent that they are not readily distinguishable in the field. Although both marten and fisher occur within the study area, the fur harvest records and communications with trappers indicate that fisher predominate. Since marten are considered to be susceptible to trapping and no marten have been reported in the fur harvest records since 1970, their relative abundance on the study area is expected to be very low. Data collected for these species will be considered under the heading of fisher.

The density of fisher tracks averaged 0.29×10^{-2} tracks per station track-day or 0.06 tracks per kilometer track-day (Table 12). Considering that fishers are solitary animals and that their home range may encompass an area 16 km in diameter (Banfield, 1974), the observed track density may indicate a moderate to high population density. Comparative indices of fisher and marten track densities are illustrated in Table 13.

4.3.7.2 Distribution

Distribution in Relation to Vegetation Types

The distribution of fisher was not significantly different from that expected on the basis of the availability of the vegetation types (Table 16). The largest observed differences between availability of vegetation and fisher activity show a trend of high activity in pure white and black spruce cover and an avoidance of areas of disturbed cover. Banfield (1974) indicated that fisher inhabit climax coniferous forests, preferring the vicinity of water courses, but will venture into sub-climax deciduous cover. A similar trend of habitat use by fisher was observed on the study area.

Distribution in Relation to Terrain Features

The difference between the distributions of fisher and terrain features was not statistically significant (Table 17).

Distribution in Relation to Habitat Disturbance

All observations of fisher activity were in undisturbed habitats (Table 18).

Spatial Distribution

The distribution of fisher track activity is illustrated in Appendix 7-A. The low sample size of track observations presents a trend of local pockets of activity found in the Athabasca and Mackay river valleys and scattered locations in the uplands. Considering the reported size of a fisher home range (Banfield, 1974), regional groupings of these activity patterns would be a better indication of fisher distribution on the study area. As with other less abundant furbearers, additional track-count observations are required to provide a more accurate pattern of distribution.

No regional trend of fisher activity was found. The basic statistics necessary to assess the presence of a regional trend are listed in Appendices 7-B, 11, and 12.

4.3.8 Wolverine

4.3.8.1 Relative Abundance

The density of wolverine tracks averaged 0.03×10^{-2} tracks per station track-day or 0.01 tracks per kilometer track-day (Table 12). This density is similar to the highest densities reported in comparable tracking studies elsewhere (Table 13).

Literature reports on wolverine densities are sparse. Krott (1959) provided estimates for Scandinavia, varying from one wolverine per 200 to 500 sq km. In relation to the relative abundance of wolves, Kelsall (1968) reported an average of 8.5 wolves per wolverine from information from a three year predator control program in the Northwest Territories. The ratio of wolves to wolverine determined from track densities in this study was 11.7:1.

4.3.8.2 Distribution

The majority of wolverine track observations were located in the western portion of the study area in the vicinity of the Mackay River (Figure 15). This area was subject to relatively minor disturbance from the construction of winter roads and operations at test drilling sites (Figure 8).

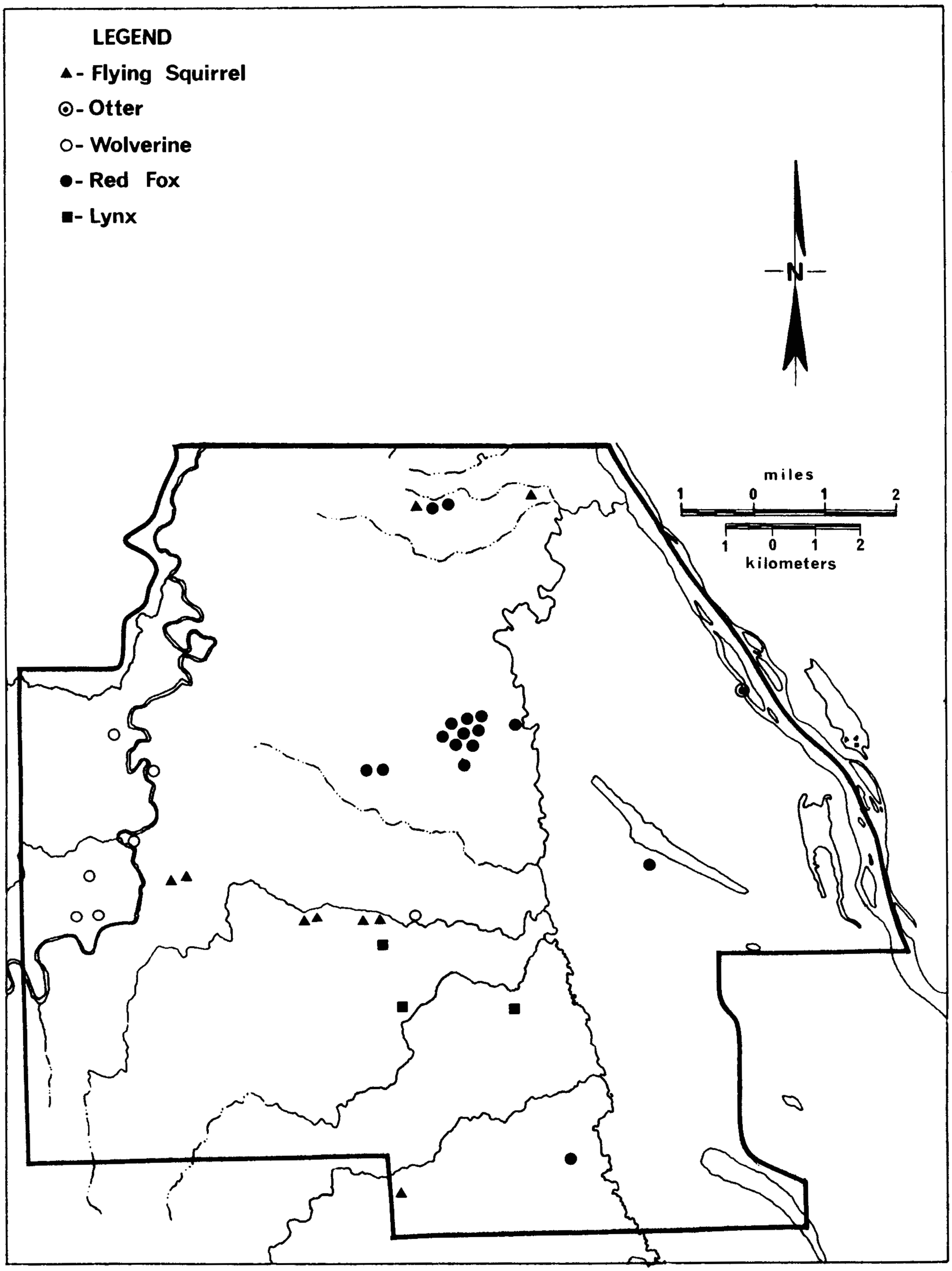


Figure 15. Distribution of track sightings for flying squirrel, otter, wolverine, red fox, and lynx.

Distribution in Relation to Environmental Parameters

Due to the low sample size of observations, no statistical comparisons with environmental parameters could be conducted. The proportions of wolverine track observations in various vegetation, terrain, and disturbed habitat types are illustrated in Tables 16, 17, and 18, respectively.

4.3.9 Otter

4.3.9.1 Relative Abundance

Only one observation of otter was recorded along tracking transects. The resulting track density was 0.04×10^{-3} tracks per station track-day or 0.07×10^{-2} tracks per kilometer track-day (Table 12). Otter were one of the least abundant furbearers present on the study area. The local trappers report that observations of otter sign were becoming more frequent in recent years than formerly.

4.3.9.2 Distribution

Otter sign was observed only along the Athabasca River near the origin of transect 11 (Figure 15). This animal was recorded traveling along the edge of the river, utilizing both the river ice and shoreline habitats.

4.3.10 Red Fox

4.3.10.1 Relative Abundance

The density of red fox tracks averaged 0.12×10^{-2} tracks per station track-day or 0.02 tracks per kilometer track-day (Table 12). The relative abundance of red fox on the study area is lower than that for other canids, coyote and wolf. Fur harvest returns and communications with trappers also indicate red fox abundance is at a low level.

4.3.10.2 Distribution

Distribution in Relation to Environmental Parameters

The sample size of red fox observations was insufficient for statistical analysis. The largest observed difference between the availability of cover types and red fox track densities shows relatively higher activity in areas of reduced or disturbed cover (Tables 16 and 18).

Distribution Patterns

The distribution of red fox track sightings is illustrated in Figure 15. Most of the observations are located in the north-central region of the study area with a cluster of observations within the main cleared area in proximity to the garbage dumps.

4.3.11 Coyote

4.3.11.1 Relative Abundance

Coyote track densities averaged 1.46×10^{-2} tracks per station track-day or 0.29 tracks per kilometer track-day (Table 12). The coyote was the most abundant large carnivorous furbearer recorded on the study area. The relative abundance of coyotes in the study area is considerably higher than those reported in tracking studies in the Northwest Territores and somewhat less than in the Peace River area (Table 13).

4.3.11.2 Distribution

Distribution in Relation to Vegetation Types

Coyote distribution was significantly different from that expected on the basis of availability of vegetation types (Table 16). Although coyotes were recorded in all vegetation types in the study area, they exhibited a preference for areas of disturbed or reduced cover. The availability of garbage at the main dump within the cleared area may have attracted coyotes to this habitat. Coyotes exhibited an avoidance of aspen, aspen-willow and black spruce-willow vegetation types. Banfield (1974) indicates that coyotes are adaptable to a wide range of habitats but appear to prefer more open hilly country with patches of deciduous and riparian cover.

Distribution in Relation to Terrain Features

The distribution of coyotes was not significantly different from the availability of terrain features (Table 17).

Distribution in Relation to Habitat Disturbance

Coyote activity was significantly greater on large cleared areas and lower on undisturbed habitats than expected from their available proportions in the study area (Table 18). Coyote activity was greater on light-use roads and old cutlines than moderate to heavy-use roads and recent cutlines.

Spatial Distribution

The spatial distribution of coyote activity on the study area is illustrated in Appendix 8-A. Coyote activity greater than 0.1 tracks per station track-day covered 17.5% of the area (Appendix 10). The main concentration of coyote activity occurred in and adjacent to the cleared area north of the plant site. Another region of activity is located in the uplands west of the cleared area.

Comparison of the %RSS values (Appendix 11) to the minimum %RSS required (Appendix 12) suggested a trend of a cubic surface (third order) or higher. Inspection of the $\hat{Z}$ square array indicated a trend limit containing only first and second order coefficients. The resultant orthogonal polynomial equation:

$$\hat{Z} = 0.5076807 + 0.0196077Y$$

represented a second order trend, generating a quadratic surface of

$$\hat{Z} = 0.8460574 - 0.0344741X - 0.0212634Y + 0.0002065X^2 + 0.0019608XY$$

and a map illustrated in Appendix 8-C. This surface accounted for only 7.24%

of the total variation, suggesting a high percentage of local variability. The basic statistics necessary to assess the presence of a regional trend are listed in Appendix 8-B.

4.3.12 Wolf

4.3.12.1 Relative Abundance

Wolf track densities averaged 0.35×10^{-2} tracks per station track-day or 0.07 tracks per kilometer track-day (Table 12). Observations during aerial surveys and the tracking study indicate at least one pack of six wolves and two or more single wolves frequent the study area (Plate 25).

4.3.12.2 Distribution

Distribution in Relation to Environmental Features

The distribution of wolf activity was not significantly different from the expected distribution based on the availability of vegetation types (Table 16). The data, however, illustrate a trend of general avoidance of coniferous cover and a concentration of activity within areas of disturbed or reduced cover. The relatively high activity observed in the latter type may in part be attributed to wolves' propensity for travel along corridors where snow depths are less restrictive to movements. Within the study area, wolves were observed moving along rivers and lakes (Table 17), snowshoe trails, power toboggan trails, cutlines, and roads in an apparent preference to undisturbed snow cover. The garbage dumps within the cleared area may also have been an attraction to wolves, particularly lone individuals. Observations of the wolf pack activities were generally restricted to the relatively undisturbed area west of the main cleared area.

Spatial Distribution

The spatial distribution of wolf activity (Appendix 9-A) is not felt to be representative of their true distribution pattern. The home range of a wolf pack may cover from 250 to 650 sq km (Banfield, 1974). Wolf packs generally patrol their home range along fixed runways and at regular intervals (Banfield, 1974). Observation during all phases of field work found that wolf pack activity often occurs along the Mackay River in the northwestern portion of the study area, and east to the interceptor ditch and the western limit of the cleared area. Due to the limited number of tracking replicates, this trend was not recorded during the track counting study as indicated by the proportion of the study area with wolf track densities greater than 0.1 tracks per station track-day (Appendix 10). The observed distribution by track counts is of interest because it illustrates some interaction with the current developments.

Comparison of the %RSS values (Appendix 11) to the minimum %RSS required (Appendix 12) suggested a trend of a quadratic surface. Inspection of the Ƶ square array indicated a linear trend. The resultant orthogonal polynomial equation:

$$\text{Ƶ} = 0.5233529 - 0.0231782X + 0.0104136Y$$

represented a first order trend, generating a linear surface of

$$\hat{Z} = 0.7424542 - 0.0214575X + 0.0104136Y$$

and a map shown in Appendix 9-C. The basic statistics necessary to assess the presence of a regional trend are listed in Appendix 9-B.

4.3.13 Lynx

4.3.13.1 Relative Abundance

Lynx sign was rarely encountered during the study. Lynx track densities averaged 0.01×10^{-2} tracks per station track-day or 0.002 per kilometer track-day (Table 12).

Lynx populations are known to exhibit marked cyclic fluctuations in response to the abundance of their major prey species, the snowshoe hare (Nellis *et al.*, 1972). The snowshoe hare population had dropped to a low since 1971-72 (RRCS, 1972) and now appears to be increasing. Corresponding lynx population levels are expected to increase in the coming years.

4.3.13.2 Distribution

The location of lynx observations is illustrated in Figure 15. Both observations on the transect were associated with black spruce cover. Snowshoe hare activity was also related to high density black spruce (Table 16).

4.4 Other Mammals

4.4.1 Northern Flying Squirrel

4.4.1.1 Relative Abundance

The northern flying squirrel appears to be relatively uncommon on the study area. Flying squirrel observations averaged 0.03×10^{-2} tracks per station track-day or 0.01 tracks per kilometer track-day (Table 12). This species was considerably less abundant than the red squirrel which shares its habitat and is the dominant competitor (Banfield, 1974). Due to their arboreal habitats, the flying squirrel may be more abundant than indicated by our data. Flying squirrels are considered valueless as a furbearer, because their fur is too soft.

4.4.1.2 Distribution

The locations of flying squirrel observations are illustrated in Figure 15. This species was generally associated with mixedwood, high density black spruce, and mature aspen vegetation cover. The aspen stands where flying squirrel tracks were observed were invariably old burns with an abundance of standing snags where woodpecker holes were common.

4.5 Big Game Harvest

No systematic surveys or hunting checking stations have been conducted to determine the big game harvest of the Fort McMurray region by the

Department of Recreation, Parks and Wildlife (Bill Hall, pers. comm., biologist, Alberta Recreation, Parks and Wildlife, Edmonton, Alberta). An indication of the importance of moose to registered trapline holders is discussed elsewhere in this report.

4.6 Fur Harvest Records

The following data were obtained from the Fish and Wildlife Division of the Department of Recreation, Parks and Wildlife:

a) trapper affidavits for the years 1970-71 to 1974-75,

b) the average fur prices for the Province of Alberta for the period 1970-71 to 1973-74, and

c) a description of traplines in the vicinity of the Syncrude Development (Figure 16) with the names of the senior holders of the licence.

There are no affidavits on file for the years prior to 1969-70 (Hambling, 1976). The affidavit method of keeping fur records consists of having the trapper declare his previous years catch when he renews his trapping licence. While the accuracy of this method has limitations, including reporting inaccurately and non-reporting of furs for personal use, attempts to conceal information on personal income and poor quality or damaged furs, it does give a picture of the trappers' harvest. Mr. A. Boggs, the officer in charge of collecting the data from the Fort McMurray area during this period, feels the data are quite accurate as they can be compared with fur sale records. Trappers have little to gain by falsifying the affidavits.

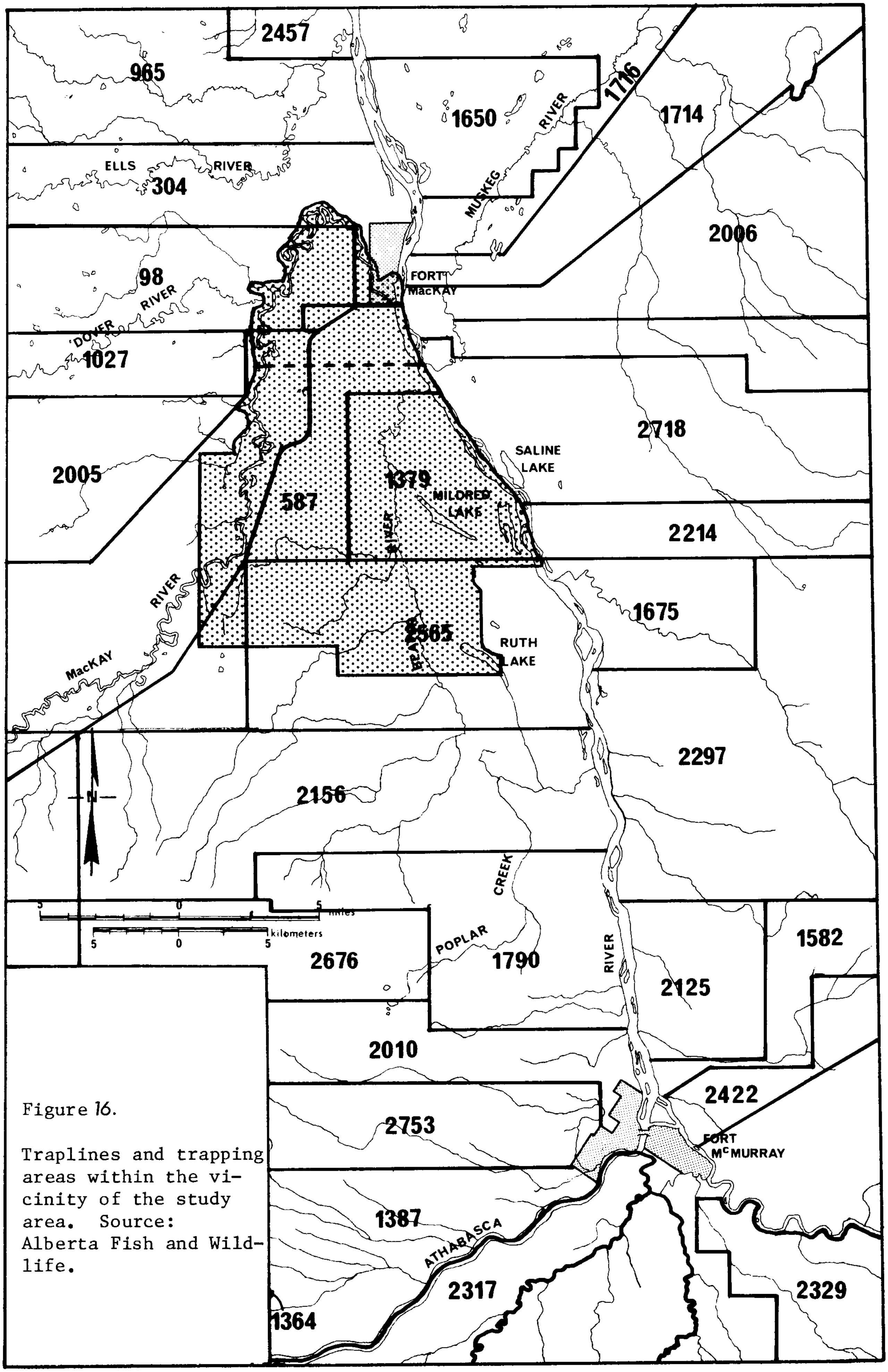


Figure 16.

Traplines and trapping areas within the vicinity of the study area. Source: Alberta Fish and Wildlife.

4.6.1 Analysis of Fur Returns by Species

4.6.1.1 Beaver

At the present time, beaver are the most important fur species taken in the Fort McMurray area. Based on the average returns for all trappers in the study area, the beaver harvest has remained relatively constant since 1970-71. The highest beaver harvest on the trapping study area (Figure 16) was 562 pelts in 1972-73 (Table 19). The largest catch by an individual trapper in a single season was 74 beaver. Since 1970, the average price of beaver in the Province of Alberta rose from a low of $11.58 in 1970-71 to a high of $20.61 in 1972-73 but declined to $18.35 in 1973-74 (Table 20). The combination of large numbers of beaver harvested and relatively high prices results in beaver providing the best monetary return of all furbearers taken in the vicinity of the study area. This corresponds to the overall provincial returns, where income from beaver pelts exceeds that of any other fur species for the period between 1970 and 1974.

According to the local residents of Fort MacKay, beaver are considerably more abundant now than in the past. Today beaver are of major importance to trappers in this area. Due to the present low numbers of lynx, fox, and mink, only beaver are available in sufficient quantities to provide a reasonable return for the trapper. For the trapper attempting to live off the land, beaver are even more important as they are a source of food.

4.6.1.2 Muskrat

Muskrats are not an important component of the trappers' catch in

Table 19. Total numbers of pelts and average number of pelts per reporting trapper taken in the vicinity of Syncrude Lease No. 17 for the years 1970-71 to 1974-75.

Trapping Season	Number of Trappers		Beaver	Muskrat	Squirrel	Rabbit	Weasel	Ermine	Mink	Fisher	Otter	Blue Fox	Cross Fox	Red Fox	Coyote	Wolf	Lynx
1970-1971	4	No.	150	13	299	1250		1	4	2					1		29
		Ave.	37.5	3.25	74.75	312.5		0.25	1.0	0.50					0.25		7.25
1971-1972	9	No.	197	100	450	1147	2	6	29	1			2	6	2	5	234
		Ave.	21.88	11.11	50.0	127.44	0.22	0.66	3.22	0.11			0.22	0.66	0.22	0.55	26.0
1972-1973	13	No.	562	58	994	170	9	13	33	7			1	35	22	1	53
		Ave.	43.23	4.46	76.46	13.08	0.69	1.0	2.54	0.54			.08	2.69	1.69	.08	4.08
1973-1974	14	No.	362	33	468	20	12	14	27	4	2	4	5	6	9	2	18
		Ave.	25.86	2.36	33.43	1.43	0.86	1.0	1.93	0.28	0.14	0.28	0.36	0.43	0.64	0.14	1.29
1974-1975	12	No.	358	369	1005	66	30	27	24	9	3			7		2	12
		Ave.	29.83	30.75	83.75	5.50	2.50	2.25	2.0	0.75	0.25			0.58		0.17	1.0

Table 20. Average value and total catch of selected furs in the province of Alberta, 1970-71 to 1973-74.

Species \ Year	1970-71		1971-72		1972-73		1973-74		4 Year Average	
	Total Number	Average Value ($)	Total Number	Average Value ($)	Total Number	Average Value ($)	Total Number	Average Value ($)	Total Number	Average Value ($)
Beaver	47,287	11.58	57,322	16.59	79,439	20.61	61,982	18.35	61,508	16.78
Muskrat	185,996	1.27	233,589	1.73	266,273	2.35	211,522	2.24	224,345	1.90
Squirrel	237,542	.31	211,444	.56	157,368	1.15	53,336	.97	164,922	.75
Ermine	14,283	.63	11,365	.64	36,791	1.64	15,724	1.50	19,541	1.10
Mink	7,495	9.33	6,941	14.12	13,632	20.28	4,993	19.73	8,265	15.87
Fisher	571	20.86	699	24.00	3,146	35.33	2,266	40.96	1,671	30.29
Otter	156	26.21	144	33.54	313	41.41	140	43.57	188	36.18
Fox-Blue	1	6.50	-	-	14	19.45	14	28.50	7	13.61
Fox-Red	501	10.42	1,347	15.18	1,376	27.74	1,596	38.71	1,205	23.01
Coyote	12,376	9.11	18,416	13.92	34,413	26.49	44,784	35.55	27,497	21.27
Wolf	177	43.74	519	47.20	880	76.64	671	70.04	562	59.41
Lynx	15,397	23.03	22,776	35.00	18,084	90.65	6,540	85.16	15,699	58.46

the study area. Compared to an annual provincial catch of nearly a quarter million animals, the Fort MacKay harvest is insignificant, although prices for muskrat have been good in recent years ($2.24 average in 1973-74) with a continuing good price at the present time.

In order for muskrat trapping to be an economically viable proposition it is necessary to have many small lakes in proximity, each with large numbers of muskrats. This habitat type is not found in the study area and for this reason muskrats contribute little to the fur harvest in the Fort MacKay area.

4.6.1.3 Squirrel

The squirrel harvest represents only a small portion of trappers' incomes in the study area. The harvest appears to fluctuate, but the fluctuation bears no relation to the provincial harvest which declined steadily from 237,542 in 1970-71 to 53,336 in 1973-74. According to Mr. J. Faichney, squirrel harvests were extremely high in the past and he considered them one of the important fur species at that time. Squirrels appear relatively abundant along rivers in the Fort MacKay area. It is doubtful they will achieve their former prominence as a major fur species because of the extensive effort required to capture them. As pelts have brought approximately $1.00 each, a large number must be handled to make an economically viable operation. They will remain a small to moderate source of income for the trapper in this area.

4.6.1.4 Snowshoe Hare

Although not normally considered to be an economically important furbearer, snowshoe hare were reported on the affidavits for the Fort MacKay-Fort McMurray trappers. Although the accuracy of these records is undoubtedly poor, the returns do show an interesting trend. Average returns show a 60-fold decline from 1971-72 to 1974-75 in the study area. This is the key to explaining the parallel decline in the lynx harvest. This year the snowshoe hare population is still low. The importance of this species to the trapper lies in the fact it is a food source for important furbearers such as the lynx and in years of snowshoe hare abundance it is a supplementary food source for people.

4.6.1.5 Ermine and Weasel

Fur returns for these species may be confusing as the two names are frequently interchangeable. The pelt of the "ermine" (*Mustela erminea*) which is most common in wooded areas is less valuable than the larger longtailed weasel (*M. frenata*) which occurs in more southern regions. The least weasel (*M. nivalis*) is rare in this area (Soper, 1964; Banfield, 1974) and is less valuable than the ermine because of its smaller size. The contribution of these species to the trapping economy in the vicinity of the study area is extremely limited because of the low prices. The low financial return for ermine provides little compensation for the effort of trapping and handling this fur. The fur returns do not reflect the relative abundance of this animal in the study area.

4.6.1.6 Mink

The mink harvest in the study area has been low in recent years. In 1972-73, 13 trappers took 33 mink, the highest production in the 5 yr period. Production in the period from 1971-72 to 1974-75 has remained relatively stable. The provincial harvest of mink has fluctuated between a high of 13,632 in 1972-73 and 4,993 in 1973-74 (Table 20). The average provincial price remained stable in the $19 to $20 range from 1971-72 to 1973-74. Based on the opinion of trappers, the mink population in the study area is presently low. Mr. Faichney stated that mink was once one of the important fur species in the Fort MacKay area. However, at present it does not provide a large source of income to the trapper. The future performance of this species is unknown.

4.6.1.7 Marten

No marten were reported from the study area for the period 1970-71 and 1974-75. Communications with trappers reveal that marten are very scarce in the study area. Mr. J. Faichney indicated that marten populations have always been low in the Fort MacKay area. Marten are highly prone to trapping. Even in areas of suitable habitat, it is difficult for marten populations to increase when faced with even moderate trapping pressure. Considering the composition and successional stage of the forest habitat in the vicinity of the study area, it is doubtful that marten will become an important fur species in the near future.

4.6.1.8 Fisher

Fisher are taken in low numbers in the study area. Mr. J. Faichney, formerly the Hudson Bay post manager at Fort MacKay for 40 yr, said that fisher were never very abundant in the Fort MacKay area. Trappers in the study area confirm this statement. This species is not important as a fur which a trapper can depend upon to sustain him but it is valuable from the standpoint of a windfall which the trapper can expect from time to time.

In relation to other furbearers, fisher are not abundant anywhere in the province. Despite a relatively high price (provincial average of $40.96 in 1973-74), the largest recorded annual catch in the 4 yr period is slightly in excess of 3,000 fisher (Table 20).

4.6.1.9 Otter

Otter are infrequently taken by trappers on the study area. In the entire Province of Alberta, the highest annual catch was 313 in the period between 1970-71 and 1973-74. Prices are relatively high and the low return reflects the scarcity of the animal. Trappers report that otter have moved into the study area in recent years where before they had been seen only rarely. One trapper south of the Syncrude Lease reported three on his line. Other trappers to the north also saw otter sign on their traplines this season. Otter are regarded by the trappers in this area as a pest rather than a valuable fur animal. Trappers located in such areas as northern Manitoba, where lakes and streams provide habitat for large numbers of otter and an abundant supply of fish for food, find it economical to trap otter. In the Fort MacKay area, however, otter apparently feed on beaver and muskrat to a greater extent. The potential revenue lost in such instances is greater than the value of the occasional otter which they manage to trap.

4.6.1.10 Fox

The harvest of foxes in the study area has been very low since 1971-72 (Table 19). This reflects a similar comparatively low harvest for the entire province (Table 20). The average price of foxes received by trappers in the province is in excess of $20.00. Mr. J. Faichney stated that foxes were once an important fur for the residents of the Fort MacKay area. Mr. F. Orr, a trapper near the Syncrude development, stated that this year he has seen no fox tracks in an area where foxes are normally found. The importance of foxes as a fur species in the study area must be considered as low at the present time.

4.6.1.11 Coyote

Very few coyotes are taken in the study area. The larger coyote population in southern Alberta accounts for the very large provincial harvest of this species. Prices have increased dramatically from an average $9.11 in 1970-71 to $35.55 in 1973-74 and have continued to climb to present reported values in excess of $100 for good quality pelts. Coyotes were never common in the Fort MacKay area (J. Faichney, pers. comm., former Hudson Bay Manager, Fort Mackay, Alberta) and they remain scarce at the present time. They do provide a valuable windfall for the trapper who is fortunate enough to shoot or trap one.

4.6.1.12 Wolf

Wolves are occasionally taken in the vicinity of the study area (Table 19). Wolves occupy a large home range, often encompassing several traplines. Even with moderate to high wolf population levels, the number of wolves taken per trapline would be low. This is also reflected in the low number of wolves reported in the provincial harvest record (Table 20).

Wolf fur prices have remained good with averages exceeding $70 in the 1972-73 and 1973-74 seasons. Current prices are expected to be above this level. The capture of a wolf is considered a windfall to supplement the trapper's main income received from sustained yield furbearers such as beaver. Trappers consider the wolf extremely difficult to trap but somewhat easier to shoot. However, the number of wolves harvested is not considered a reflection of population abundance.

4.6.1.13 Lynx

Fur return records show that the harvest of lynx in the study area has fluctuated widely from a high of 234 in 1971-72 to a low of 12 in 1974-75 (Table 19). Indications are that the harvest this year will be very low again. This downward trend was experienced throughout the province although the fluctuation was not as dramatic. These changes in the harvest are a result of a decreasing lynx population which has responded to a decline in snowshoe hare abundance. This is a cyclical event which occurs over a 10 yr period. The population is expected to begin to increase again to a peak in the beginning of the next decade. A dramatic increase in price of lynx is related to the reduced supply. A provincial average of $90.65 and $85.16 was reached in 1972-73 and 1973-74. Since then, the price has increased even further with lynx pelts bringing a lucrative return. Trappers report that few lynx tracks have been seen in the study area this year. Lynx harvest is expected to be low in the 1975-76 season. Mr. Faichney claims that lynx have never been abundant in the Fort MacKay area as they have been in other centers. Lynx are not important at the present time, although any lynx taken by trappers do provide a lucrative return. Lynx will continue to contribute to the trapper income, although their importance will fluctuate with population abundance.

4.7 Evaluation and Application of Data to Determine the Impact of Tar Sands Development on Mammals

This study was designed to provide quantitative data on the relative abundance, distribution, and annual harvest of ungulates and furbearers. This information, when compared with that of subsequent years, would enable an evaluation of the effects of the operations phase of the development on these mammals. The techniques selected for the collection and analysis of data have proven to be logistically and statistically suitable to evaluate the potential impacts on mammals in the study area.

Much of the initial season's field work was employed in surveying and establishing permanent transect lines. Due to unusually infrequent snowfalls in late winter (January 15 to March 15, 1976), only three track-counting replicates were conducted, the last of which was only two-thirds completed. For the more abundant furbearers such as red squirrel, snowshoe hare, and ermine, these replicates provided sufficient data to illustrate their distribution patterns, habitat associations, and relative abundance. For moose and the larger less abundant furbearers, this sample size does not appear adequate.

The relative abundance of moose and terrestrial furbearers is presented as an index of tracks per station track-day. This index may be directly compared to that of subsequent years. This comparison will enable an evaluation of population levels and relative use of plant communities between years. Since population levels and animal use of habitat may change with time (cyclic fluctuations) or with climatic conditions (mild versus severe winters), the monitoring of existing (base-line) conditions should be conducted through several seasons.

Aerial counts of moose, active beaver lodges, and muskrat houses may be directly compared to similar counts in subsequent years for an evaluation of changes in population levels and distribution. Comparison of moose population structure between years may also assist in the identification of any patterns of change if they occur.

The spatial distributions of moose and the more abundant terrestrial furbearers which were recorded during track counting are presented as isodensity maps for visual representation of the extent and intensity of animal activity on the study area. The areal extent of animal activity is presented as a proportion of the study area covered by a particular track density. This index may be directly compared to subsequent measurements.

The development of isodensity maps allows for the comparison of the spatial distribution of animals between years. A statistical evaluation of the grid matrices compares the mesh coordinates and generates a third isodensity map. This map will identify the location, extent, and magnitude of changes between years. A comparison of frequency distribution will identify shifts in animal movement, particularly where clumping or spreading of activity occurs. Comparison of the absolute values of grid cells will identify the significance of any changes in distribution.

The trend-surface analysis provides a separation and identification of any regional trend or trends of animal activity in the study area. Data from further track-count investigations may be directly compared to this data base. A comparison of the orthogonal polynomial equations will allow for statistical evalua ion of any changes. However, the spatial distribution of moose and most of the terrestrial furbearers do not currently exhibit a regional trend of distribution and may not be expected as a biological phenomenon within the confines of the study area. Hence, the comparison of animal distribution patterns between years will be based on the isodensity maps of track activity.

The statistical evaluation of the grid matrices which comprise the isodensity maps would also provide a more sensitive measure of changes in relative abundance and spatial distribution than the trend-surface analysis.

5. SUMMARY

A. The initial phase of the ungulate and furbearing mammal monitoring study was conducted in the vicinity of Syncrude Lease No. 17 during the period between October 15, 1975, and April 30, 1976. The study was designed to generate quantitative data on the relative abundance and distribution of ungulate and furbearing mammals along a gradient from within to beyond the sphere of influence of the main developments. These data, when compared with data for subsequent years, will enable an evaluation of the nature and extent of the impact of the operations phase of the Syncrude development on these animals. Aerial surveys were employed for the census of ungulates, beaver colonies, and muskrat houses. Moose and terrestrial furbearers were investigated by winter track-counts replicated along 215 km of established transect lines.

B. The distribution of major environmental features including: 17 vegetation types, eight terrain types, and five categories of habitat disturbance were evaluated, mapped, and compared to animal distribution.

C. The moose population density was estimated at 0.23 moose per sq km. The ratio of cows:calves:bulls was 100:56:75 in the December survey. In the February survey, a proportional decrease in the numbers of bulls and an increase in the number of calves was observed, suggesting age and sex related movements were occurring within the study area. The distribution of moose was positively associated with tall shrubs and deciduous vegetation and negatively associated with coniferous cover and disturbed areas. No significant relationships were found within terrain types. Spatial distribution of moose showed relatively higher densities within the Athabasca River valley and in the area west of the Mackay River.

D. Both mule deer and white-tailed deer are reported to occur within the area. Their populations appear very low.

E. Ninety-six occupied beaver colonies were recorded in the study.

F. Concentrations of muskrat activity were recorded in two locations: Horseshoe Lake (30 houses) and Ruth Lake (7 houses).

G. The relative abundance and distribution of terrestrial furbearers were determined by winter track counts along 215 km of established transect lines. Observations were conducted on 1,346 km track-days between January 13 and March 15, 1976.

The herbivorous furbearers, snowshoe hare and red squirrel were the most abundant species recorded with track densities of 2.9 and 2.3 tracks per kilometer track-day, respectively. The density of red squirrel middens ranged from none in deciduous cover to 8.7 per hectare in white spruce cover and averaged 1.2 middens per hectare for the entire area. The distribution of red squirrel track activity was positively related to the distribution of coniferous vegetation, particularly white spruce cover.

Snowshoe hare distribution was generally associated with deciduous and mixed-wood cover.

Ermine were the most abundant carnivorous furbearer with an index of 1.5 tracks per kilometer track-day. Ermine occupied a wide range of habitats and were distributed throughout the study area. The relative abundance index of the less common mustelids, mink, fisher, and wolverine, were 0.11, 0.06, and 0.01 tracks per kilometer track-day. Marten and otter were rarely encountered. Due to a low sample size, only the general trends of spatial distribution and habitat associations were established for these species. The most striking trend showed a general avoidance of areas subject to construction activities and habitat disturbance.

The coyote and wolf were generally more abundant than the larger mustelids with track densities of 0.29 and 0.07 tracks per kilometer track-day, respectively. Red fox activity was relatively uncommon (0.02 tracks per kilometer track-day). The distribution of these species was commonly associated with areas of disturbed habitat, particularly transportation corridors and the northern end of the main cleared area. The presence of a garbage dump in the latter area may have been an attraction to some animals. The distribution of wolf pack activities was more common in the western portion of the study area.

Lynx were rarely encountered during the study period.

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APPENDICES

Appendix 1. Scientific and vernacular names[1] of mammals recorded in the study area.

Order Insectivora	
Family Soricidae	
Sorex cinereus	Masked shrew
Order Lagomorpha	
Family Leporidae	
Lepus americanus	Snowshoe hare
Order Rodentia	
Family Sciuridae	
Tamiasciurus hudsonicus	Red squirrel
Glaucomys sabrinus	Northern flying squirrel
Family Castoridae	
Castor canadensis	Beaver
Family Cricetidae	
Peromyscus maniculatus	Deer mouse
Clethrionomys gapperi	Gapper's red-backed mouse
Ondatra zibethicus	Muskrat
Order Carnivora	
Family Canidae	
Canis latrans	Coyote
Canis lupus	Gray wolf

[1]Scientific and vernacular names follow those presented by Jones *et al.* (1973).

Vulpes vulpes	Red fox
Family Ursidae	
Ursus americanus	Black bear
Family Mustelidae	
Martes americana	Marten
Martes pennanti	Fisher
Mustela erminea	Ermine
Mustela nivalis	Weasel
Mustela frenata	Long-tailed weasel
Mustela vison	Mink
Gulo gulo	Wolverine
Mephitis mephitis	Striped skunk
Lontra canadensis	River otter
Family Felidae	
Lynx lynx	Lynx
Order Artiodactyla	
Family Cervidae	
Odocoileus virginianus	White-tailed deer
Odocoileus hemionus	Mule deer
Alces alces	Moose

SPATIAL DISTRIBUTION OF MOOSE ACTIVITY

Contour: Index of tracks/station track-day x 10^3

Lower contour limit - 100
First contour interval - 150
Regular contour interval - 250

MOOSE

Appendix 2-B. Basic statistics used to assess the presence of a regional trend in moose distribution.

A. Z Square Array

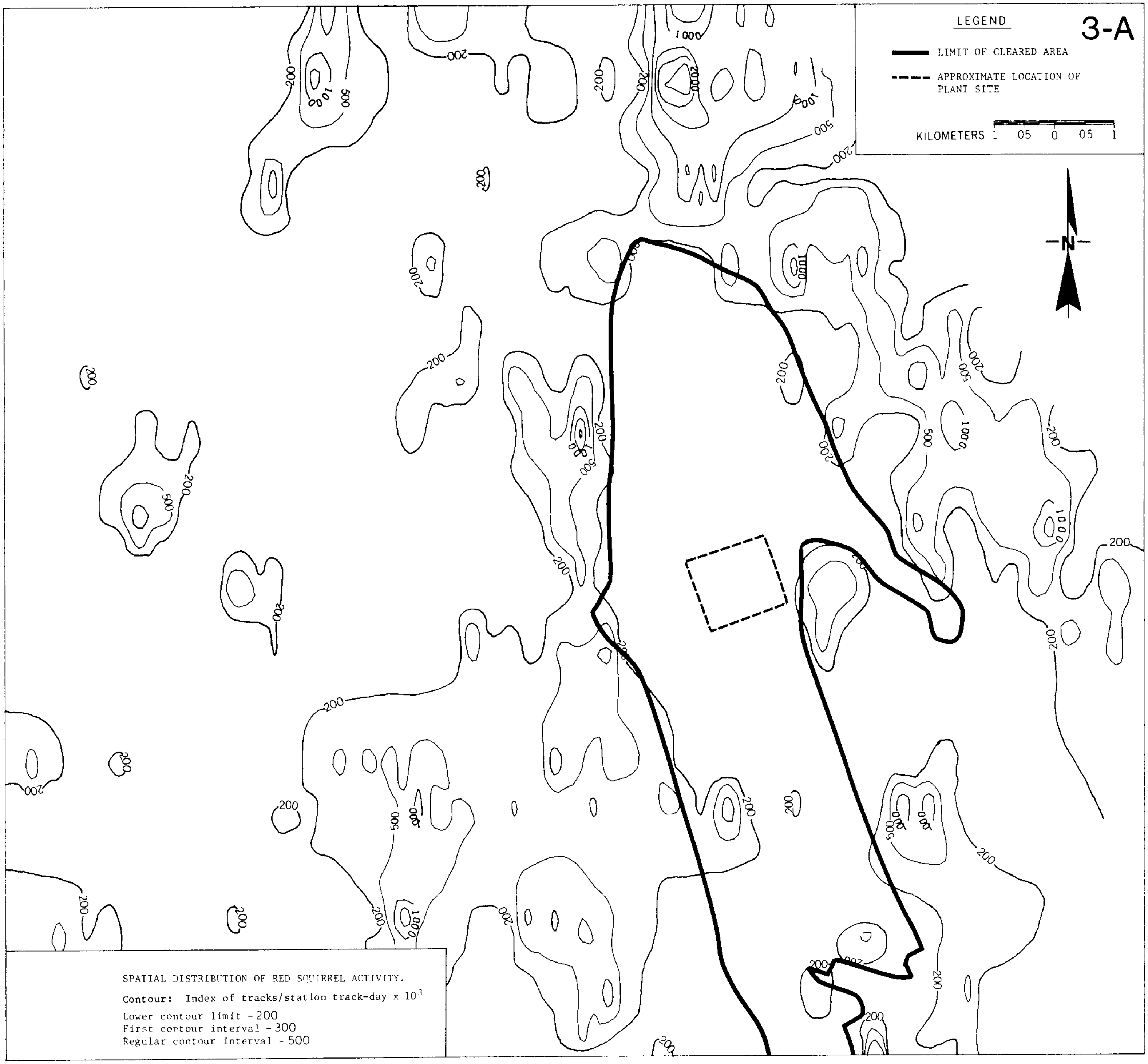
.0000	.3195	.0737	4.3003	.4004	.0008	.0820	.4299	.0022
.2479	.4502	.1465	.4342	.1192	.0489	.0719	.0032	
.2010	.0689	1.1560	.4708	.0016	.3092	.1146		
.9059	.0381	.1702	.2692	.3901	.0558			
.1595	.4116	.7968	.1039	.0274				
.4515	.0697	.4909	1.0143					
.1191	.1270	.4200						
.1018	.9046							
.6331								

B. Array of Orthogonal Polynomial Coefficients

.7773	.0064	-.0005	-.0005	.0000	-.0000	-.0000	-.0000	.0000
.0057	-.0013	-.0001	-.0000	.0000	.0000	.0000	.0000	
.0007	.0001	-.0001	-.0000	-.0000	.0000	.0000		
-.0002	.0000	-.0000	.0000	-.0000	-.0000			
-.0000	-.0000	-.0000	.0000	-.0000				
.0000	-.0000	-.0000	.0000					
-.0000	.0000	.0000						
.0000	.0000							
-.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	.896	.207	12.057	1.122	.002	.230	1.205	.006
.695	1.262	.411	1.217	.334	.137	.201	.009	
.563	.193	3.241	1.320	.005	.867	.321		
2.540	.107	.477	.755	1.094	.156			
.447	1.154	2.234	.291	.077				
1.266	.195	1.376	2.844					
.334	.356	1.177						
.285	2.536							
1.775								



RED SQUIRREL

Appendix 3-B. Basic statistics used to assess the presence of a regional trend in red squirrel distribution.

A. Z Square Array

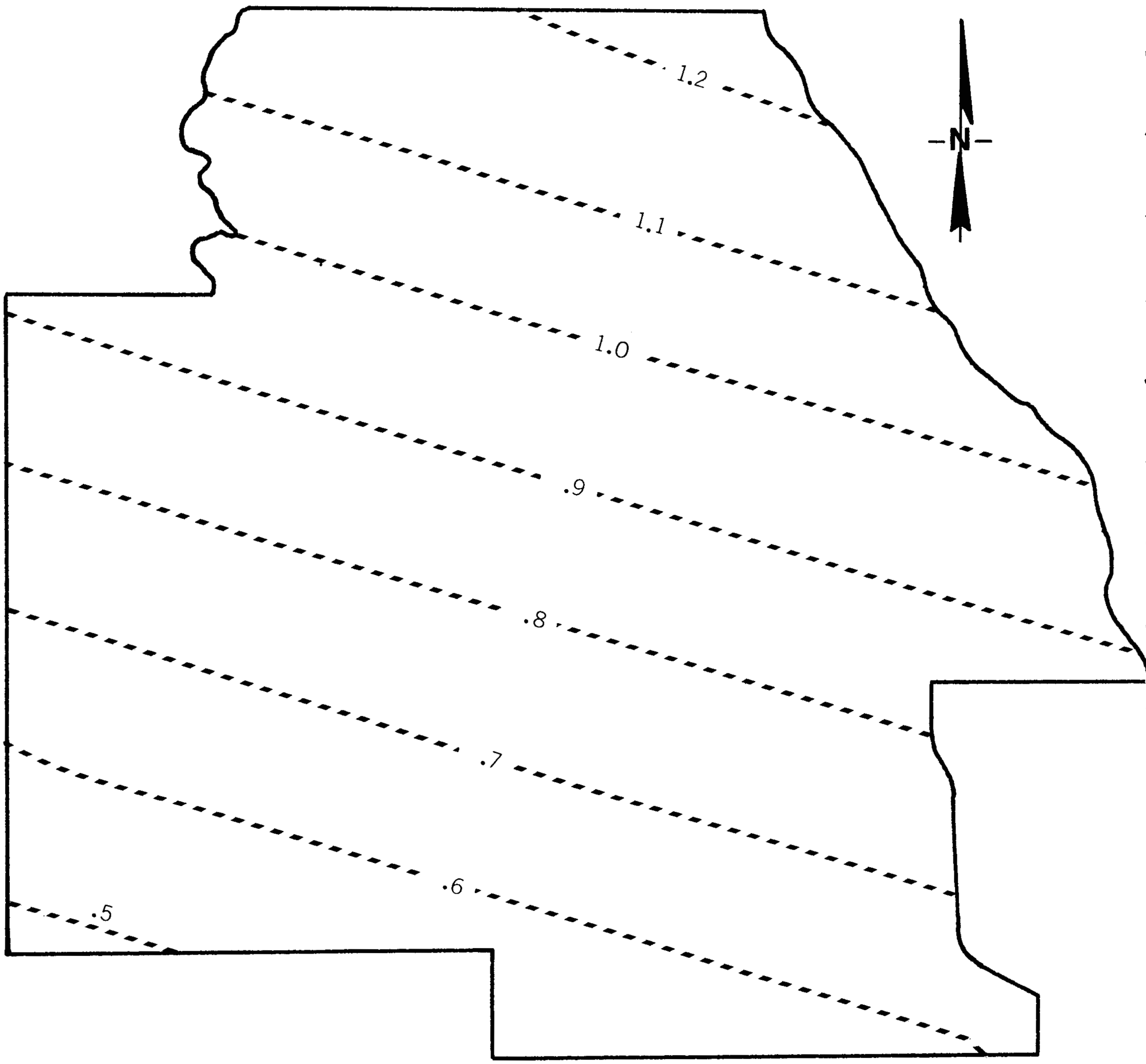
.0000	29.8813	1.7305	.0026	.0689	1.0145	3.2260	.8535	.1277
3.8319	1.2502	1.9356	.1588	.3294	.5246	2.5900	.1875	
.3130	.0893	1.0706	.5512	.1568	.0613	.0949		
1.3757	.2826	1.2445	.0108	2.2421	1.1579			
.0474	.8234	3.2175	2.9749	.3120				
2.8541	3.8559	.2660	.3920					
.0248	.1018	.0745						
2.6421	2.1864							
.0146								

B. Array of Orthogonal Polynomial Coefficients

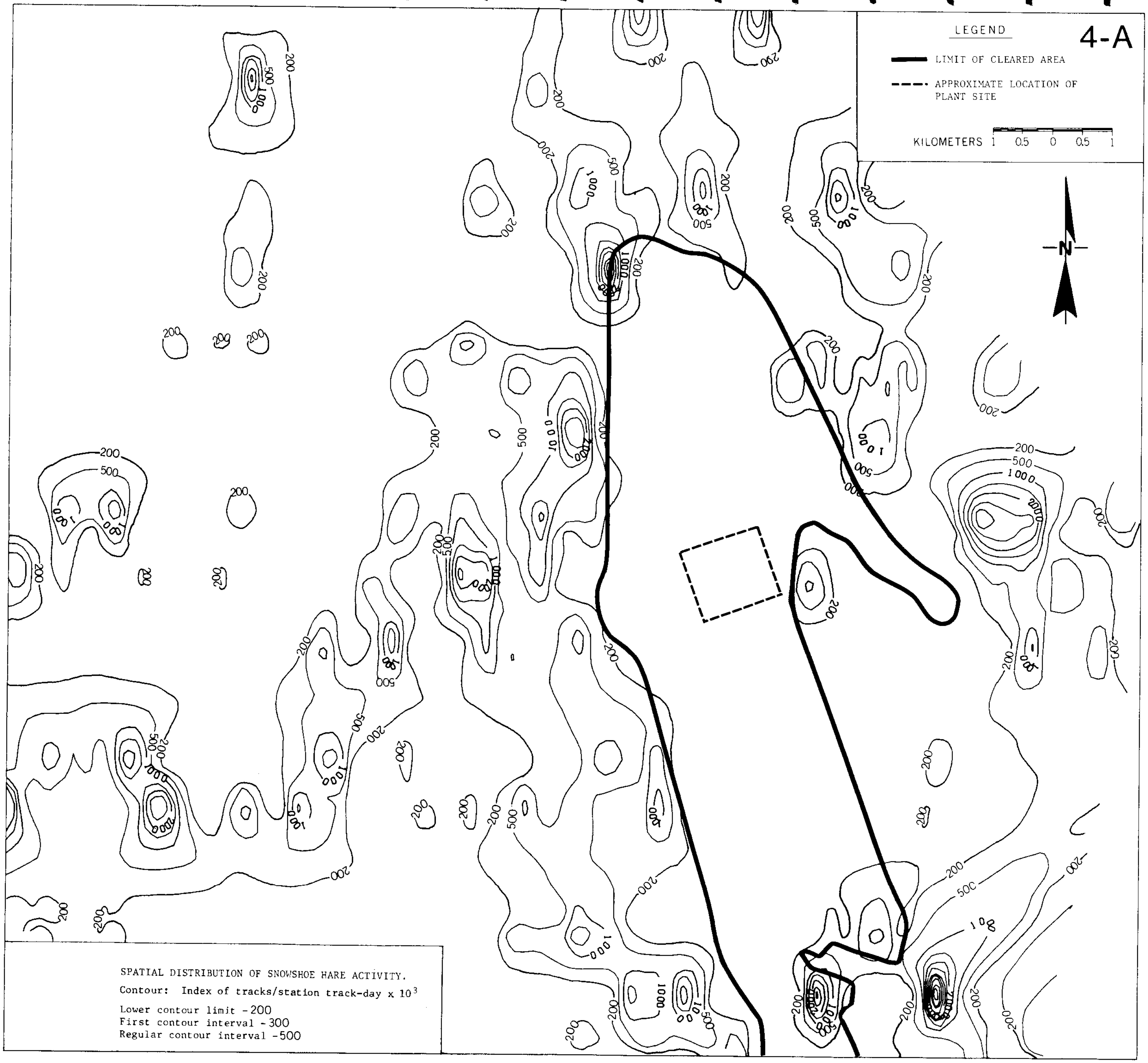
.8698	.0222	.0008	.0000	-.0000	-.0000	-.0000	-.0000	-.0000
.0097	.0008	.0001	.0000	-.0000	.0000	.0000	.0000	
-.0003	.0000	-.0000	.0000	.0000	-.0000	.0000		
-.0001	-.0000	-.0000	.0000	-.0000	.0000			
-.0000	-.0000	-.0000	-.0000	-.0000				
.0000	.0000	.0000	-.0000					
.0000	-.0000	-.0000						
-.0000	-.0000							
.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	6.638	.384	.001	.015	.225	.717	.190	.028
.851	.278	.430	.035	.073	.117	.575	.042	
.070	.020	.238	.122	.035	.014	.021		
.306	.063	.276	.002	.498	.257			
.011	.183	.715	.661	.069				
.634	.857	.059	.087					
.006	.023	.017						
.587	.486							
.003								



Appendix 3-C. First order trend surface map of red squirrel distribution.



SNOWSHOE HARE

Appendix 4-B. Basic statistics used to assess the presence of a regional trend in snowshoe hare distribution.

A. % Square Array

.0000	.2026	5.8446	2.0594	.6159	20.4403	12.1003	8.3668	.1339
1.1319	.4177	15.2642	2.5410	.0619	39.3531	.0049	7.5323	
12.8642	.1707	.6313	2.4767	4.6433	4.2187	9.4984		
.0945	1.6770	3.9309	.2249	1.4727	2.3534			
.8107	1.3543	7.0078	.2758	2.1655				
4.5613	.6085	.1427	.5151					
2.7663	1.6940	.3384						
5.7556	.6275							
5.5267								

B. Array of Orthogonal Polynomial Coefficients

1.3459	-.0024	.0017	-.0001	.0000	.0000	-.0000	.0000	.0000
.0054	-.0005	.0005	-.0000	.0000	.0000	-.0000	.0000	
.0021	-.0000	-.0000	.0000	.0000	.0000	-.0000		
-.0000	.0000	-.0000	-.0000	.0000	-.0000			
-.0000	.0000	.0000	.0000	.0000				
.0000	.0000	.0000	.0000					
-.0000	-.0000	.0000						
-.0000	-.0000							
.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	.017	.480	.169	.051	1.679	.994	.687	.011
.093	.034	1.254	.209	.005	3.232	.000	.619	
1.056	.014	.052	.203	.381	.346	.780		
.008	.138	.323	.018	.121	.193			
.067	.111	.576	.023	.178				
.375	.050	.012	.042					
.227	.139	.028						
.473	.052							
.454								

SPATIAL DISTRIBUTION OF ERMINE ACTIVITY.

Contour: Index of tracks/station track-day x 10^3

Lower contour limit - 100
First contour interval - 150
Regular contour interval - 250

ERMINE

Appendix 5-B. Basic statistics used to assess the presence of a regional trend in ermine distribution.

A. Ƶ Square Array

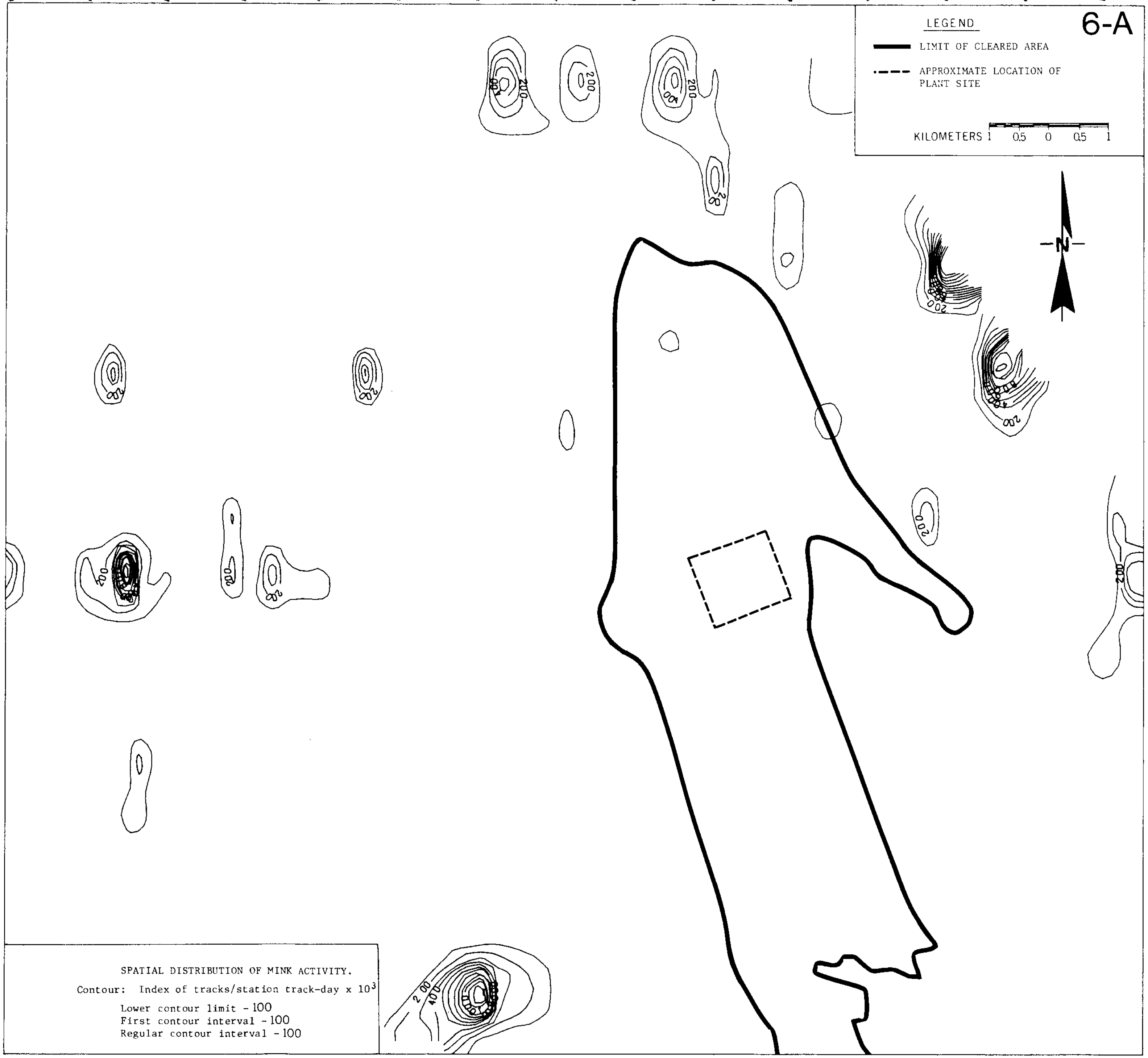
.0000	.3343	.0885	2.2754	.0294	1.2835	.0009	.0061	.8615
.0033	.0107	1.6375	1.2065	.1868	.0853	2.9462	1.2924	
.0030	2.6146	.3446	.4255	2.7642	.5351	.6511		
.4772	.0000	.0019	.3837	.5795	.4333			
1.8732	.0140	.5837	.6696	.1465				
.0722	.3515	1.7413	4.5285					
.7348	1.5168	.1669						
2.1237	4.1861							
.0266								

B. Array of Orthogonal Coefficients

.6842	.0024	-.0002	-.0001	-.0000	.0000	.0000	.0000	-.0000
-.0002	-.0001	.0001	-.0000	-.0000	-.0000	.0000	-.0000	
.0000	.0002	-.0000	.0000	.0000	-.0000	.0000		
-.0000	.0000	.0000	.0000	-.0000	.0000			
-.0000	.0000	.0000	.0000	.0000				
.0000	.0000	-.0000	-.0000					
.0000	.0000	-.0000						
-.0000	-.0000							
-.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	.093	.025	.636	.008	.359	.000	.002	.241
.001	.003	.457	.337	.052	.024	.823	.361	
.001	.730	.096	.119	.772	.149	.182		
.133	.000	.001	.107	.162	.121			
.523	.004	.163	.187	.041				
.020	.098	.486	1.265					
.205	.424	.047						
.593	1.169							
.007								



SPATIAL DISTRIBUTION OF MINK ACTIVITY.

Contour: Index of tracks/station track-day x 10^3

Lower contour limit - 100
First contour interval - 100
Regular contour interval - 100

MINK

Appendix 6-B. Basic statistics used to assess the presence of a regional trend in mink distribution.

A. Z Square Array

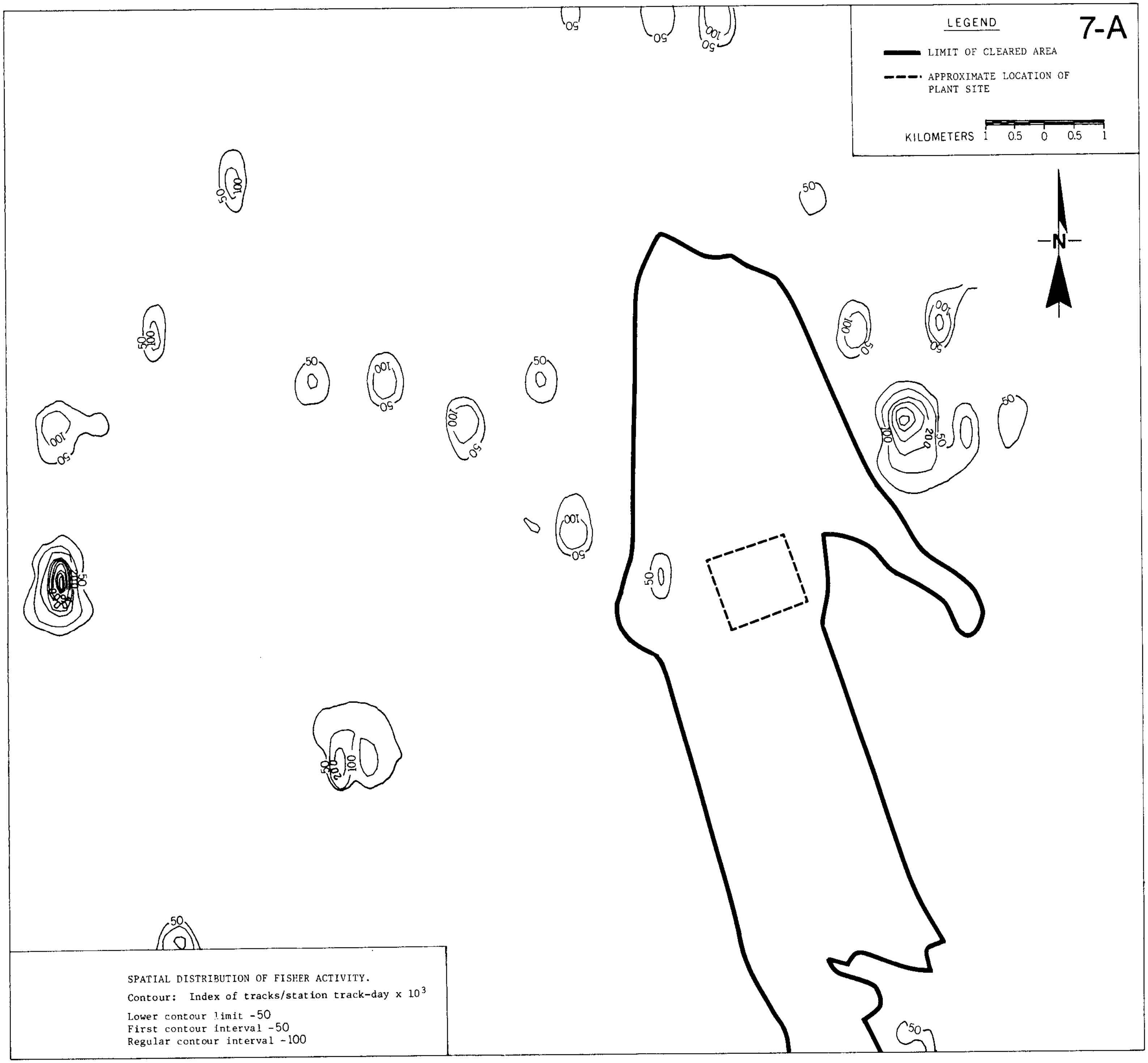
-.0000	.8095	.1697	.1736	.0102	.6452	.1687	.3530	.5977
.3461	.2236	.2579	.0013	.5521	.1438	.0273	.0484	
.0219	.9617	.0080	.0912	.0266	.0121	.0022		
.0513	.2830	.0009	.2894	.0916	.0504			
1.4559	.2145	.5394	.0261	.0471				
.3691	.0167	.0531	.0306					
.0803	.3629	.2719						
.2325	.0262							
.0758								

B. Array of Orthogonal Polynomial Coefficients

.6173	.0133	-.0010	-.0003	-.0000	.0000	.0000	-.0000	-.0000
-.0074	-.0017	-.0003	-.0000	.0000	.0000	-.0000	-.0000	
.0002	.0004	-.0000	.0000	.0000	.0000	.0000		
.0001	-.0001	-.0000	.0000	-.0000	.0000			
-.0000	-.0000	-.0000	.0000	-.0000				
.0000	.0000	-.0000	.0000					
.0000	.0000	.0000						
-.0000	-.0000							
.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

-.000	3.467	.727	.743	.044	2.763	.722	1.512	2.560
1.482	.957	1.105	.005	2.364	.616	.117	.207	
.094	4.119	.034	.391	.114	.052	.009		
.220	1.212	.004	1.239	.392	.216			
6.235	.919	2.310	.112	.202				
1.581	.071	.227	.131					
.344	1.554	1.165						
.996	.112							
.325								



SPATIAL DISTRIBUTION OF FISHER ACTIVITY.
Contour: Index of tracks/station track-day x 10^3
Lower contour limit -50
First contour interval -50
Regular contour interval -100

FISHER

Appendix 7-B. Basic statistics used to assess the presence of a regional trend in fisher distribution.

A. Ƶ Square Array

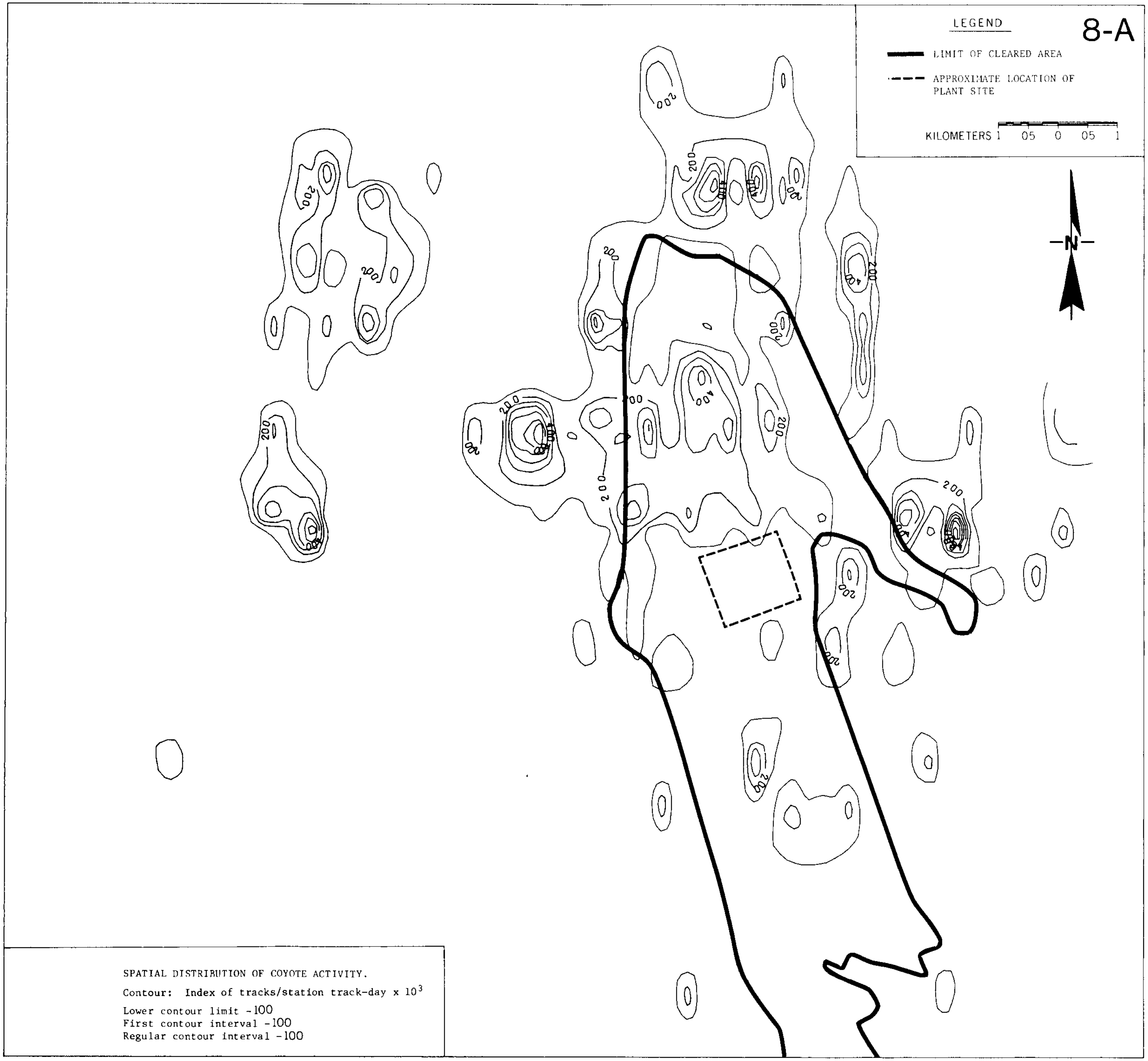
.0000	.0538	.0562	.1053	.0085	.0212	.0405	.1854	.0212
.1349	.5983	.0834	.1038	.7773	.0855	.0010	.2894	
2.0887	.6470	.0494	.0198	.5769	.6383	.0011		
.4921	.5915	.0044	.0350	.5984	1.7352			
.0008	.4423	.0140	.0683	.2736				
.2924	.1113	.0056	.1171					
.3873	.2475	.1672						
2.4178	.1775							
.2592								

B. Array of Orthogonal Polynomial Coefficients

.5039	.0043	.0005	-.0001	.0000	.0000	.0000	.0000	-.0000
-.0058	.0023	-.0002	-.0000	.0000	-.0000	.0000	.0000	
.0030	-.0004	.0000	.0000	-.0000	-.0000	.0000		
-.0003	.0001	-.0000	.0000	.0000	.0000			
-.0000	-.0000	.0000	-.0000	-.0000				
-.0000	.0000	.0000	-.0000					
-.0000	.0000	-.0000						
.0000	-.0000							
-.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	.274	.286	.536	.043	.108	.206	.943	.108
.686	3.044	.424	.528	3.954	.435	.005	1.472	
10.626	3.292	.251	.101	2.935	3.247	.006		
2.503	3.009	.022	.178	3.044	8.828			
.004	2.250	.071	.348	1.392				
1.487	.566	.029	.596					
1.970	1.259	.850						
12.300	.903							
1.319								



SPATIAL DISTRIBUTION OF COYOTE ACTIVITY.

Contour: Index of tracks/station track-day x 10^3

Lower contour limit -100
First contour interval -100
Regular contour interval -100

COYOTE

Appendix 8-B. Basic statistics used to assess the presence of a regional trend in coyote distribution.

A. Z Square Array

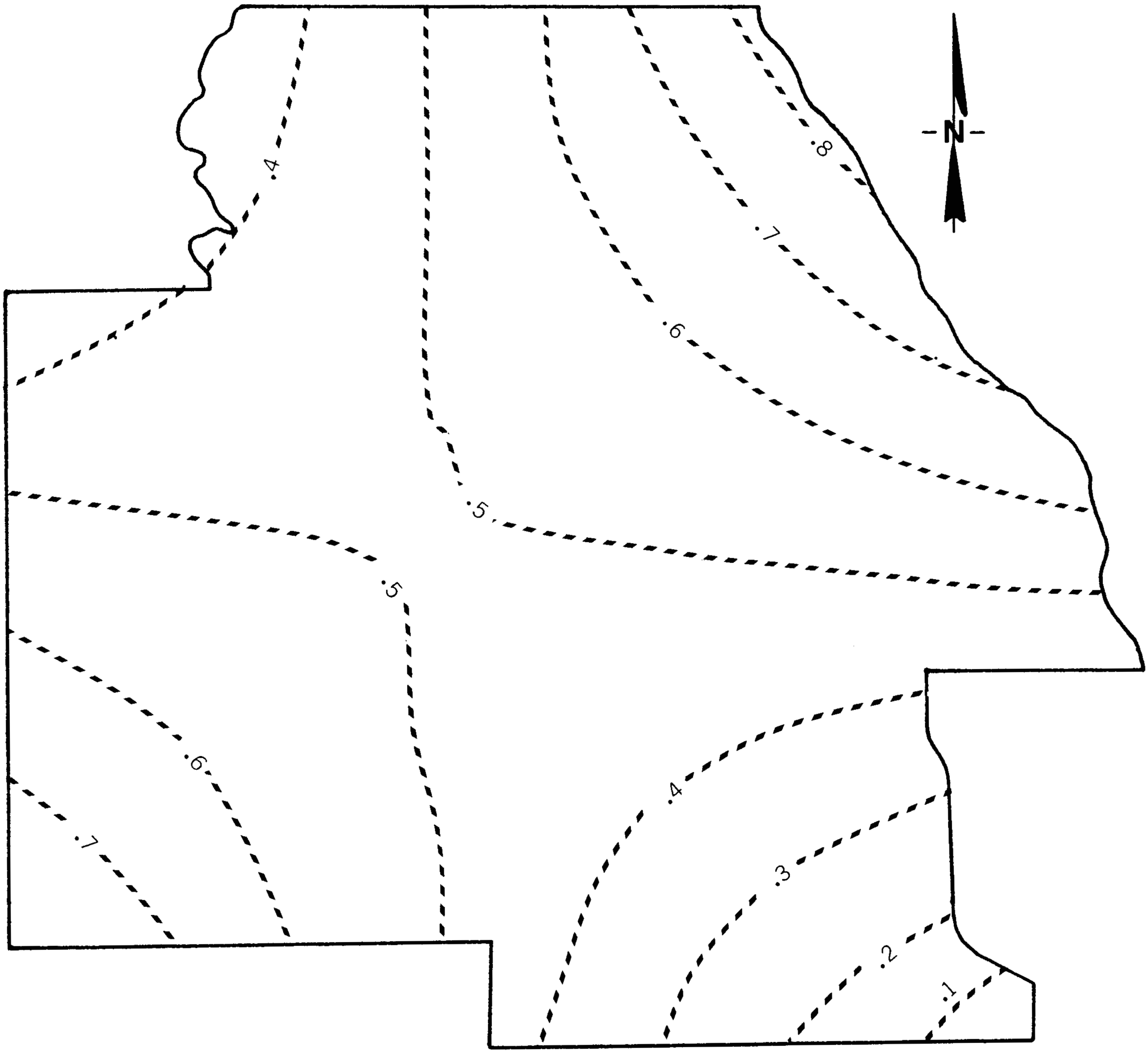
.0000	1.3891	.0787	.0316	.0675	.0308	.1287	.2856	.0968
.0163	.8689	.2890	.1319	1.5260	.0542	.1448	.0335	
.0011	.1459	.2291	.3980	.0639	.1385	.5852		
.0008	.0705	.4864	.1052	.0044	.2144			
.5810	.0002	.0563	.3397	.2075				
.0676	.1851	.0013	.0002					
.0026	.0296	.0023						
.2513	.0721							
.3963								

B. Array of Orthogonal Polynomial Coefficients

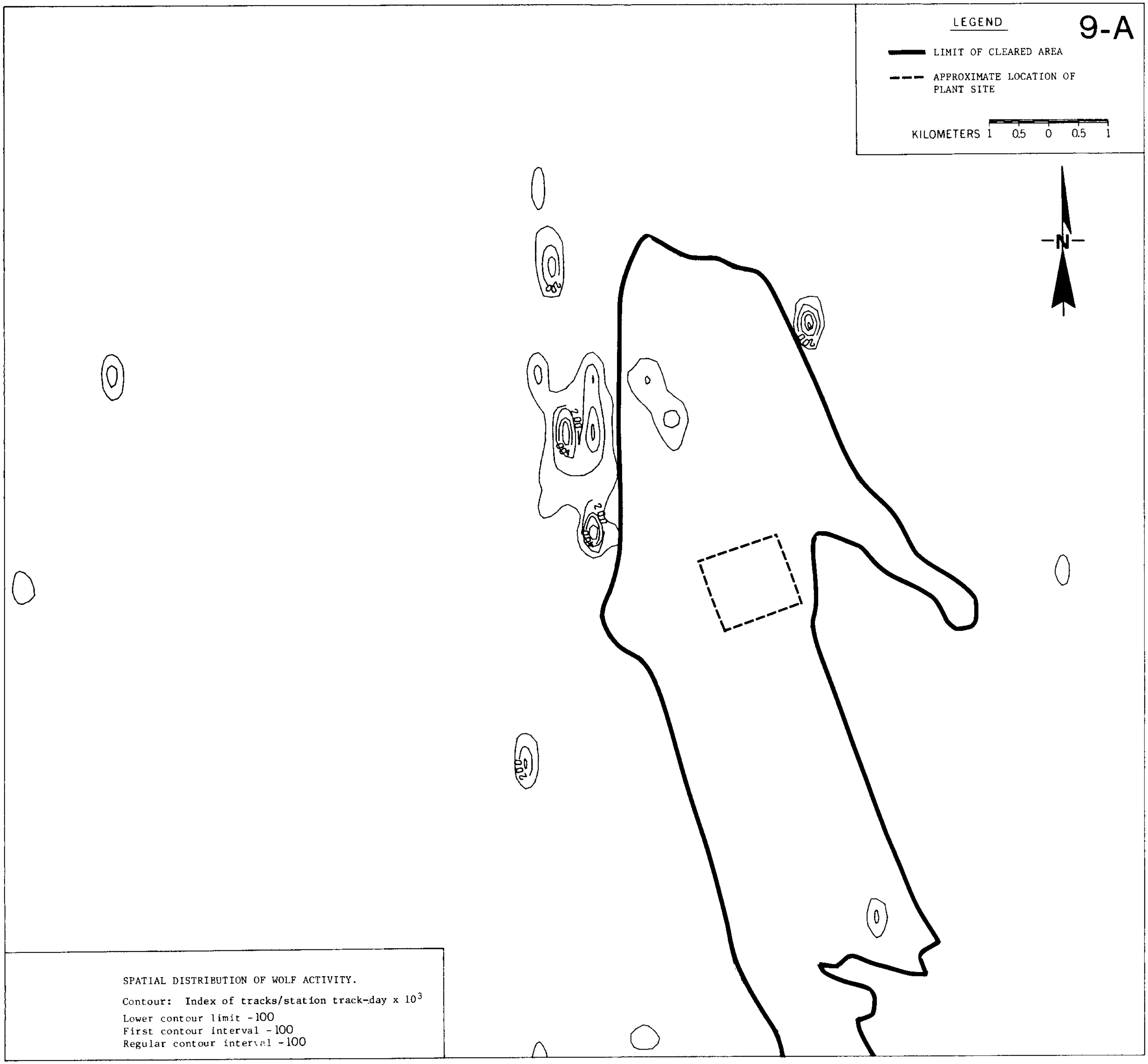
.5077	.0137	.0005	-.0001	.0000	-.0000	.0000	-.0000	-.0000
.0013	.0020	.0002	-.0000	-.0000	-.0000	-.0000	-.0000	
-.0000	.0001	.0000	.0000	.0000	-.0000	-.0000		
-.0000	-.0000	-.0000	-.0000	.0000	-.0000			
-.0000	-.0000	-.0000	-.0000	-.0000				
-.0000	-.0000	-.0000	.0000					
.0000	.0000	.0000						
-.0000	.0000							
.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	4.270	.242	.097	.208	.095	.396	.878	.298
.050	2.671	.888	.405	4.691	.167	.445	.103	
.003	.448	.704	1.223	.196	.426	1.799		
.003	.217	1.495	.323	.013	.659			
1.786	.001	.173	1.044	.638				
.208	.569	.004	.001					
.008	.091	.007						
.772	.222							
1.218								



Appendix 8-C. Second order trend surface map of coyote distribution.



SPATIAL DISTRIBUTION OF WOLF ACTIVITY.

Contour: Index of tracks/station track-day x 10^3

Lower contour limit - 100
First contour interval - 100
Regular contour interval - 100

Appendix 9-B. Basic statistics used to assess the presence of a regional trend in wolf distribution.

A. % Square Array

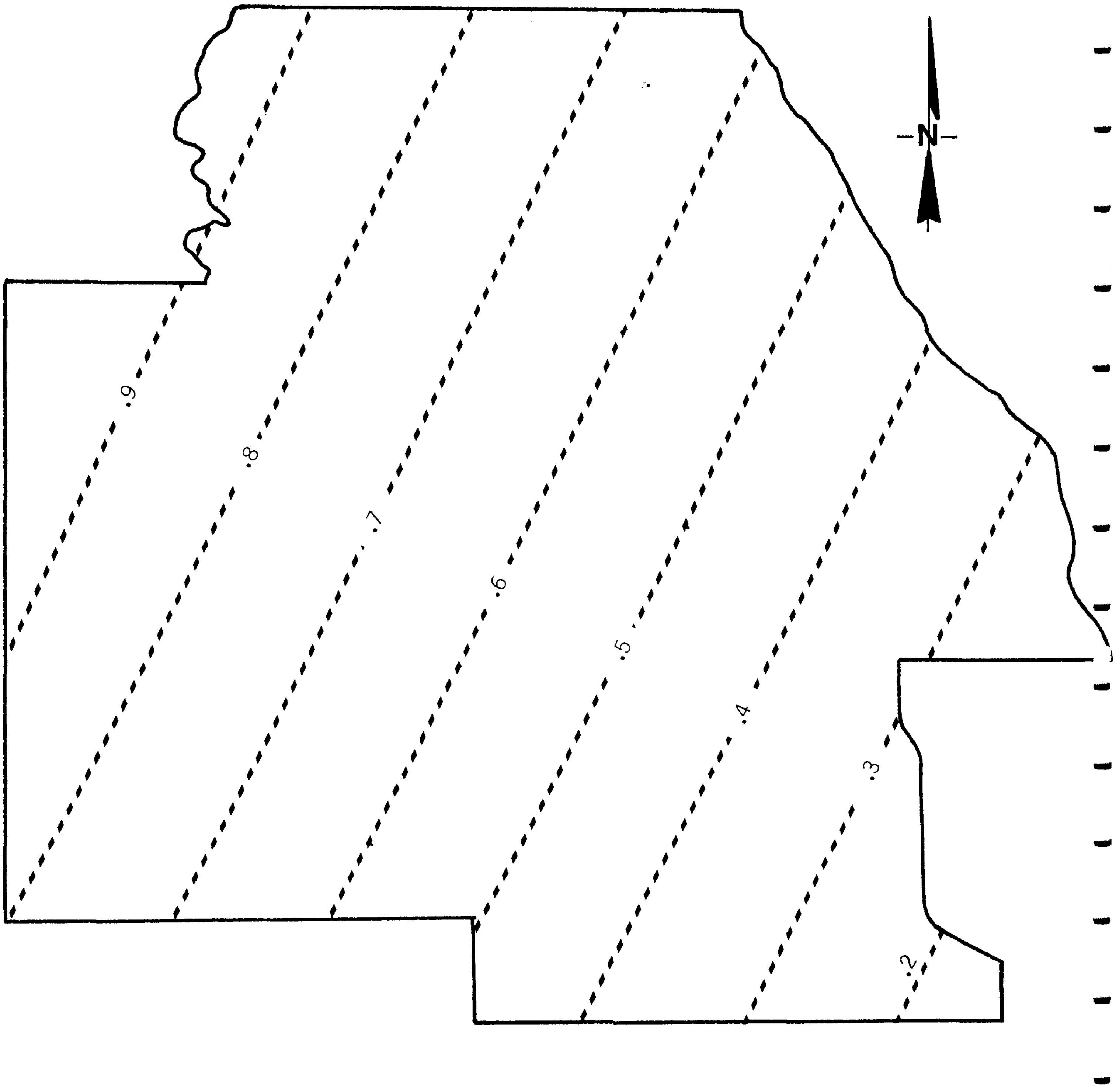
.0000	.2246	.0604	.0008	.4880	.0079	.0042	.0079	.3304
.7287	.0006	.6023	.0234	.3182	.3450	.3616	.1593	
.0040	.0100	.0000	.0000	.0137	.0583	.2111		
.1047	.0248	.0466	.0940	.0597	.0000			
.0799	.1544	.0137	.0882	.1196				
.3254	.0651	.0016	.1752					
.0616	.5678	.0068						
.0005	.0194							
.0039								

B. Array of Orthogonal Polynomial Coefficients

.5234	.0104	-.0007	.0000	-.0001	-.0000	-.0000	.0000	-.0000
-.0232	-.0002	.0011	-.0001	.0001	.0001	.0001	-.0000	
.0002	-.0001	-.0000	.0000	.0000	-.0001	.0001		
.0001	-.0000	.0001	-.0000	-.0001	.0000			
-.0000	.0000	.0000	.0000	-.0000				
-.0000	-.0000	.0000	.0001					
.0000	.0000	.0000						
-.0000	-.0000							
-.0000								

C. Percent Sum of Squares Reduction Attributed to Each Individual Coefficient

.000	3.871	1.041	.014	8.409	.137	.072	.136	5.693
12.555	.011	10.378	.403	5.483	5.944	6.230	2.744	
.068	.172	.000	.000	.237	1.004	3.637		
1.804	.427	.803	1.620	1.029	.000			
1.376	2.661	.236	1.521	2.061				
5.606	1.121	.027	3.019					
1.062	9.783	.118						
.009	.334							
.068								



Appendix 9-C. First order trend surface map of wolf distribution.

Appendix **10.** Areal extent (%) of the various track densities[1] within contour intervals illustrated in the spatial distribution maps.

Contour Interval			Moose	Red Squirrel	Snowshoe Hare	Ermine	Mink	Fisher	Coyote	Wolf
0-100			88.6			33.8	92.8		82.5	97.5
	0-50							94.7		
		0-200		63.8	60.1					
	50-100							3.3		
100-200							3.6	1.5	10.6	1.7
	100-250		7.1			36.8				
		200-500		22.5	22.1					
200-300							1.5	0.3	4.1	0.4
	250-500		2.8			22.2				
300-400							0.7	0.1	1.7	0.2
400-500							0.3		0.6	0.1
	500-750		0.9			5.3				
		500-1000		10.1	12.1					
500-600							0.2		0.4	0.1
600-700							0.1	0.1	0.1	
	750-1000		0.3			1.3				
700-800							0.2			
800-900										
900-1000							0.1			
	1000-1250		0.2			0.5				
		1000-1500		2.7	3.5					
1000-1100							0.1			
1100-1200							0.1			
	1250-1500		0.1			0.1				
1200-1300							0.1			
1300-1400							0.1			
1400-1500							0.1			
	1500-1750									
		1500-2000		0.7	1.2					
		2000-2500		0.2	0.6					
		2500-3000		0.1	0.4					
		3000-3500			0.1					

[1] **Index of tracks/station trackday x 10^3**

Appendix 11. Minimum explanation levels of non-random trends (.05 level of significance).

Species	Sample[1] Size	Minimum % Sum of Squares Explanation Required 1st order	2nd order	3rd order
Moose	114	5.27	9.62	14.25
Red Squirrel	834	0.72	1.32	2.02
Snowshore Hare	679	0.89	1.63	2.49
Ermine	1008	0.59	1.10	1.89
Mink	82	7.30	13.29	20.08
Fisher	65	9.22	16.73	25.12
Coyote	285	2.11	3.89	5.91
Wolf	51	11.73	20.13	31.66

[1]Number of stations in which tracks occur.

Appendix 12. Percent sum of squares attributed to each order of surface.

	Percent RSS (corrected) by Species							
Degree	Moose	Red Squirrel	Snowshoe Hare	Ermine	Mink	Fisher	Coyote	Wolf
1	1.59*	7.49	0.11*	0.09*	4.95*	0.96*	4.32	16.43
2	3.62	8.22	1.68	0.12	6.63	14.92	7.24	17.55
3	18.82	8.98	3.12	2.08	12.60	21.67	8.67	29.91*
4	24.96	9.34	3.64	3.04	20.05	25.51	11.99	40.53
5	29.51	10.85	6.34	3.60	27.67	33.43	19.71	55.22
6	33.40	13.30	11.81	4.97	32.56	39.79	21.54	65.51
7	39.08	15.91	13.61	7.79	36.62	60.97	25.21	85.25

* Value was less than minimum percent sum of squares explanation required at the 0.05 level of significance.