National Library
of Canada

Acquisitions and
Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale
du Canada

Direction des acquisitions et
des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file   Votre référence

Our file   Notre référence

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

Reproduction in full or in part of this microform is governed by the Canadian Copyright Act, R.S.C. 1970, c. C-30, and subsequent amendments.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

La reproduction, même partielle, de cette microforme est soumise à la Loi canadienne sur le droit d'auteur, SRC 1970, c. C-30, et ses amendements subséquents.

Canada

UNIVERSITY OF ALBERTA

Habitat Use by Fishers (*Martes pennanti*) in the Aspen Parkland of Alberta

By

Micheal J. Badry ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfilment of the requirements for the degree of Master of Science.

Department of Forest Science

Edmonton, Alberta

Fall 1994

National Library
of Canada

Acquisitions and
Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale
du Canada

Direction des acquisitions et
des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file Votre référence

Our file Notre référence

The author has granted an irrevocable non-exclusive licence allowing the National Library of Canada to reproduce, loan, distribute or sell copies of his/her thesis by any means and in any form or format, making this thesis available to interested persons.

L'auteur a accordé une licence irrévocable et non exclusive permettant à la Bibliothèque nationale du Canada de reproduire, prêter, distribuer ou vendre des copies de sa thèse de quelque manière et sous quelque forme que ce soit pour mettre des exemplaires de cette thèse à la disposition des personnes intéressées.

The author retains ownership of the copyright in his/her thesis. Neither the thesis nor substantial extracts from it may be printed or otherwise reproduced without his/her permission.

L'auteur conserve la propriété du droit d'auteur qui protège sa thèse. Ni la thèse ni des extraits substantiels de celle-ci ne doivent être imprimés ou autrement reproduits sans son autorisation.

ISBN 0-315-95001-3

Canada

Name MICHEAL JOHN BADRY

Dissertation Abstracts International is arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation. Enter the corresponding four-digit code in the spaces provided.

FORESTRY AND WILDLIFE
SUBJECT TERM

0 4 7 8
SUBJECT CODE

U·M·I

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture	0729
Art History	0377
Cinema	0900
Dance	0378
Fine Arts	0357
Information Science	0723
Journalism	0391
Library Science	0399
Mass Communications	0708
Music	0413
Speech Communication	0459
Theater	0465

EDUCATION

General	0515
Administration	0514
Adult and Continuing	0516
Agricultural	0517
Art	0273
Bilingual and Multicultural	0282
Business	0688
Community College	0275
Curriculum and Instruction	0727
Early Childhood	0518
Elementary	0524
Finance	0277
Guidance and Counseling	0519
Health	0680
Higher	0745
History of	0520
Home Economics	0278
Industrial	0521
Language and Literature	0279
Mathematics	0280
Music	0522
Philosophy of	0998
Physical	0523
Psychology	0525
Reading	0535
Religious	0527
Sciences	0714
Secondary	0533
Social Sciences	0534
Sociology of	0340
Special	0529
Teacher Training	0530
Technology	0710
Tests and Measurements	0288
Vocational	0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language	
General	0679
Ancient	0289
Linguistics	0290
Modern	0291
Literature	
General	0401
Classical	0294
Comparative	0295
Medieval	0297
Modern	0298
African	0316
American	0591
Asian	0305
Canadian (English)	0352
Canadian (French)	0355
English	0593
Germanic	0311
Latin American	0312
Middle Eastern	0315
Romance	0313
Slavic and East European	0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy	0422
Religion	
General	0318
Biblical Studies	0321
Clergy	0319
History of	0320
Philosophy of	0322
Theology	0469

SOCIAL SCIENCES

American Studies	0323
Anthropology	
Archaeology	0324
Cultural	0326
Physical	0327
Business Administration	
General	0310
Accounting	0272
Banking	0770
Management	0454
Marketing	0338
Canadian Studies	0385
Economics	
General	0501
Agricultural	0503
Commerce-Business	0505
Finance	0508
History	0509
Labor	0510
Theory	0511
Folklore	0358
Geography	0366
Gerontology	0351
History	
General	0578
Ancient	0579
Medieval	0581
Modern	0582
Black	0328
African	0331
Asia, Australia and Oceania	0332
Canadian	0334
European	0335
Latin American	0336
Middle Eastern	0333
United States	0337
History of Science	0585
Law	0398
Political Science	
General	0615
International Law and Relations	0616
Public Administration	0617
Recreation	0814
Social Work	0452
Sociology	
General	0626
Criminology and Penology	0627
Demography	0938
Ethnic and Racial Studies	0631
Individual and Family Studies	0628
Industrial and Labor Relations	0629
Public and Social Welfare	0630
Social Structure and Development	0700
Theory and Methods	0344
Transportation	0709
Urban and Regional Planning	0999
Women's Studies	0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture	
General	0473
Agronomy	0285
Animal Culture and Nutrition	0475
Animal Pathology	0476
Food Science and Technology	0359
Forestry and Wildlife	0478
Plant Culture	0479
Plant Pathology	0480
Plant Physiology	0817
Range Management	0777
Wood Technology	0746
Biology	
General	0306
Anatomy	0287
Biostatistics	0308
Botany	0309
Cell	0379
Ecology	0329
Entomology	0353
Genetics	0369
Limnology	0793
Microbiology	0410
Molecular	0307
Neuroscience	0317
Oceanography	0416
Physiology	0433
Radiation	0821
Veterinary Science	0778
Zoology	0472
Biophysics	
General	0786
Medical	0760

EARTH SCIENCES

Biogeochemistry	0425
Geochemistry	0996
Geodesy	0370
Geology	0372
Geophysics	0373
Hydrology	0388
Mineralogy	0411
Paleobotany	0345
Paleoecology	0426
Paleontology	0418
Paleozoology	0985
Palynology	0427
Physical Geography	0368
Physical Oceanography	0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences	0768
Health Sciences	
General	0566
Audiology	0300
Chemotherapy	0992
Dentistry	0567
Education	0350
Hospital Management	0769
Human Development	0758
Immunology	0982
Medicine and Surgery	0564
Mental Health	0347
Nursing	0569
Nutrition	0570
Obstetrics and Gynecology	0380
Occupational Health and Therapy	0354
Ophthalmology	0381
Pathology	0571
Pharmacology	0419
Pharmacy	0572
Physical Therapy	0382
Public Health	0573
Radiology	0574
Recreation	0575
Speech Pathology	0460
Toxicology	0383
Home Economics	0386

PHYSICAL SCIENCES

Pure Sciences

Chemistry	
General	0485
Agricultural	0749
Analytical	0486
Biochemistry	0487
Inorganic	0488
Nuclear	0738
Organic	0490
Pharmaceutical	0491
Physical	0494
Polymer	0495
Radiation	0754
Mathematics	0405
Physics	
General	0605
Acoustics	0986
Astronomy and Astrophysics	0606
Atmospheric Science	0608
Atomic	0748
Electronics and Electricity	0607
Elementary Particles and High Energy	0798
Fluid and Plasma	0759
Molecular	0609
Nuclear	0610
Optics	0752
Radiation	0756
Solid State	0611
Statistics	0463

Applied Sciences

Applied Mechanics	0346
Computer Science	0984
Engineering	
General	0537
Aerospace	0538
Agricultural	0539
Automotive	0540
Biomedical	0541
Chemical	0542
Civil	0543
Electronics and Electrical	0544
Heat and Thermodynamics	0348
Hydraulic	0545
Industrial	0546
Marine	0547
Materials Science	0794
Mechanical	0548
Metallurgy	0743
Mining	0551
Nuclear	0552
Packaging	0549
Petroleum	0765
Sanitary and Municipal	0554
System Science	0790
Geotechnology	0428
Operations Research	0796
Plastics Technology	0795
Textile Technology	0994

PSYCHOLOGY

General	0621
Behavioral	0384
Clinical	0622
Developmental	0620
Experimental	0623
Industrial	0624
Personality	0625
Physiological	0989
Psychobiology	0349
Psychometrics	0632
Social	0451

UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR:	Micheal J. Badry
TITLE OF THESIS:	Habitat Use by Fishers (*Martes pennanti*) in the Aspen Parkland of Alberta
DEGREE:	Master of Science

YEAR THIS DEGREE GRANTED: 1994

Permission is hereby granted to the University of Alberta Library to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves all other publication and other rights in association with the copyright in the thesis, and except as hereinbefore provided neither the thesis nor any substantial portion thereof may be printed or otherwise reproduced in any material form whatever without author's prior written permission.

Micheal J. Badry
8019 - 74 Avenue
Edmonton, Alberta
Canada T6C 0E5

30 August 1994

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Habitat Use by Fishers (*Martes pennanti*) in the Aspen Parkland of Alberta submitted by Micheal J. Badry in partial fulfilment of the requirements for the degree of Master of Science.

Dr. Gilbert Proulx, Co-Supervisor

Dr. Paul M. Woodard, Co-Supervisor

Dr. Stephen J. Titus

Jan O Murie
Dr. Jan O. Murie

19 August 1994

To my father

Wendelin John Badry
April 15, 1920 - June 27, 1994

ABSTRACT

The seasonal habitat preferences, activity periods, and home range characteristics of a reintroduced population of fishers (*Martes pennanti*) were studied in the aspen parkland region of central Alberta by monitoring 16 radio-collared animals (6 males and 10 females) from March 14,1990 to September 15, 1992. Selection of habitat types by fishers was determined by comparing habitat characteristics at known fisher use locations to adjacent areas which were randomly selected. Activity levels did not differ by time of day for male fishers but females were significantly more active at twilight, and at night, than during the day. Fisher activity was greatest during the spring breeding season and appeared to decrease due to below freezing temperatures and the presence of snow. Mean annual home range areas were 24.3 km^2 for males, and 14.9 km^2 for females. Home range size was also reduced by snow and cold. Male fishers tended to abandon their established home ranges during the spring and mortality was significantly higher during this season. Fishers used deciduous forest cover in greater proportion than its availability throughout the year and were rarely found in areas with little or no overhead cover. Coniferous stands were used more by males than females and were used less during summer than other seasons. The average size of woodlots, forested blocks $\leq$ 2km^2 in size, used by fishers was significantly larger than the average size of woodlots available within the study area. Use of woodlots was greatest, and woodlot size smallest, during the spring. Fishers restricted their movements to continuous forest stands, and avoided using woodlots, during the fall and winter. Roads were usually avoided by fishers but increased movements in spring brought them closer to roads than during other seasons. Males tended to be less tolerant of roads than were females. Neither sex displayed a selection for habitat based on distance to water when compared to available habitat, but a comparison between sexes indicated males were more closely associated with water than were females. Fishers were most commonly found in areas that had greater slope than the average available. A multivariate analysis of detailed characteristics of the overstory and understory within fisher home ranges indicated that the density of understory vegetation was a critical factor for habitat suitability. Canopy cover, slope, and canopy diversity were also important habitat characteristics. Results suggest that aspen parkland habitat is capable of supporting fishers. Extensive coniferous cover, found in northern boreal regions, may not be necessary for fishers to cope with the relatively mild temperature and snowfalls of central Alberta.

ACKNOWLEDGMENTS

I am indebted to many people for their assistance during this study. I am especially grateful to Dr. Gilbert Proulx who made the entire project possible and provided me with unwavering support and guidance throughout. My co-supervisor, Dr. Paul Woodard, gave me invaluable advice and direction. I also thank my committee members Dr. Stephen Titus and Dr. Jan Murie for their helpful comments.

Financial support was provided by the Fur Institute of Canada and the Alberta Research Council. I thank the staff of Elk Island National Park, the Blackfoot Grazing Reserve, and Miquelon Lake Provincial Park, as well as Chris Olsen of the University of Alberta's Ministik Field Station, for allowing me access to the more remote portions of the study area.

A special thanks to the team: Pam Cole, Randy Drescher, and Al Kolenosky for assistance in all aspects of the study. Ken Seidel, Darwyn Berndt, Trudy McKenzie, and Iwona Pawlina also provided valuable assistance in the collection of field data.

I am indebted to Dr. Detlef Onderka for performing necropsies and Terry Taerum for advice on statistical analysis.

I thank Pearl S. Grey for typing this manuscript and for her patience and perseverance throughout the several revisions.

I am most deeply grateful to my wife, Nadine, who aided me in countless ways. Without her support, encouragement, and love, this thesis could not have be completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The fisher (*Martes pennanti*) is found only in North America. Originally its range encompassed forested regions throughout most of the Canadian provinces (Hagmeier 1956). According to historical fur harvest records, however, fisher populations declined and their distribution was reduced early in this century (Banci 1989). Douglas and Strickland (1987) suggested that loss of habitat, particularly in the southern part of its range, through the cutting of forests for timber or conversion to other land uses have reduced the occurrence of fishers. Over-trapping and the widespread use of poisons as a harvest and predator control method have also contributed to the reduction of fisher populations, and resulted in regional extirpations (Douglas and Strickland 1987, Buskirk 1992). Today in Alberta, fishers are found primarily in northern coniferous forests (Skinner and Todd 1988), though it is quite likely that they inhabited the southern deciduous forests of the aspen parkland before European settlement (Hagmeier 1956).

Studies of habitat use by fishers have primarily been conducted within coniferous or mixed-wood habitats in eastern North America (Banci 1989). In fact, few studies have been conducted to assess habitat use in deciduous-dominated forests (Leonard 1980, Arthur et al. 1989a). Strickland et al. (1982) suggested that fisher use areas are most likely governed by the availability of food, but the presence of overhead cover may also be an important factor. Cover is required for denning, concealment and the ability to escape from enemies (Kelly 1977, Powell 1982), and areas with good overhead cover may also reduce the accumulation of snow, which is thought to restrict the movements of fishers (de Vos 1952, Leonard 1980, Raine 1983). Several studies have suggested that optimum fisher habitat consists of a diversity of forest types with high interspersion and, therefore, greater prey abundance (Kelly 1977, Leonard 1980, Johnson 1984, Arthur et al. 1989a).

Allen (1983) developed a hypothetical habitat suitability index (HSI) model for fishers to evaluate year-round habitat requirements within evergreen and deciduous forests, and forested wetlands throughout its range. Based on a review of literature, the habitat variables selected as providing optimal conditions were: 1) percent tree canopy closure, 2) average dbh of overstory trees, 3) tree canopy diversity, and 4) percent of overstory comprised of deciduous species. He concluded that dense stands in the later successional stages were required to provide suitable winter habitat for the fisher, and that the quality of winter/early spring habitat was the most restrictive component for the fisher's annual habitat requirements.

In March and June of 1990 and August of 1991 the Wildlife Section of the Alberta Research Council introduced 20 radio-collared fishers into the aspen parkland region of central Alberta (Badry et al. 1993, Proulx et al. 1994). Those fishers released in March did not initially establish themselves within the study area. They moved extensively, most likely due to the spring breeding season and to the lack of vegetative cover present at that time of year (Proulx et al. 1994). June- and August-released animals, however, adopted the new habitat immediately and remained in the vicinity of their release sites. Whereas information on the life history of fishers in deciduous forest is lacking, especially in the western part of its range, this re-introduced population provided a unique opportunity to study the habitat use and behavior of these animals in their historically occupied habitat (Hagmeier 1956). Therefore, the objectives of this study were to: 1) determine seasonal habitat use, activity periods, and home range characteristics of a re-introduced population of fishers in the aspen parkland region of Alberta, and 2) to develop habitat management recommendations which would contribute to the survival of a viable fisher population in this area.

STUDY AREA

This study was conducted in a 1225 km^2 area situated about 40 km east of the city of Edmonton, Alberta (Fig. 1) (Appendix A). It is dominated by privately owned farms and acreages, and by disconnected public lands (Elk Island National Park - Blackfoot Multipurpose Recreational Area - Ministik Lake Bird Sanctuary complex) which receives heavy recreational use (Proulx and Pawlina 1992).

This entire region was subjected to multiple laurentide glaciation resulting in a thick mantle of glacial till which comprises the predominant surficial material (Nordlund 1977). The topographic relief is a highly variable "knob and kettle" pattern characterized by closely spaced hummocks separated by marshy depressions, ridges, and prairie mounds (Jennings 1983). Although there is an abundance of water-filled depressions, the study area is devoid of permanent streams or the valleys associated with such water courses. The predominant soil type throughout the study area is Gray Luvisol (Hardy Associates Ltd. 1986).

The climate of this region, according to the Koppen system of climatic classification, is microthermal with long cool summers (Longley 1972). January is the coldest month with a mean monthly temperature of -14°C, while July is the warmest with an average temperature of 17°C. The annual precipitation is approximately 450 mm, of which 70% falls as rain, mainly during the period of April to August (Stein 1976). The

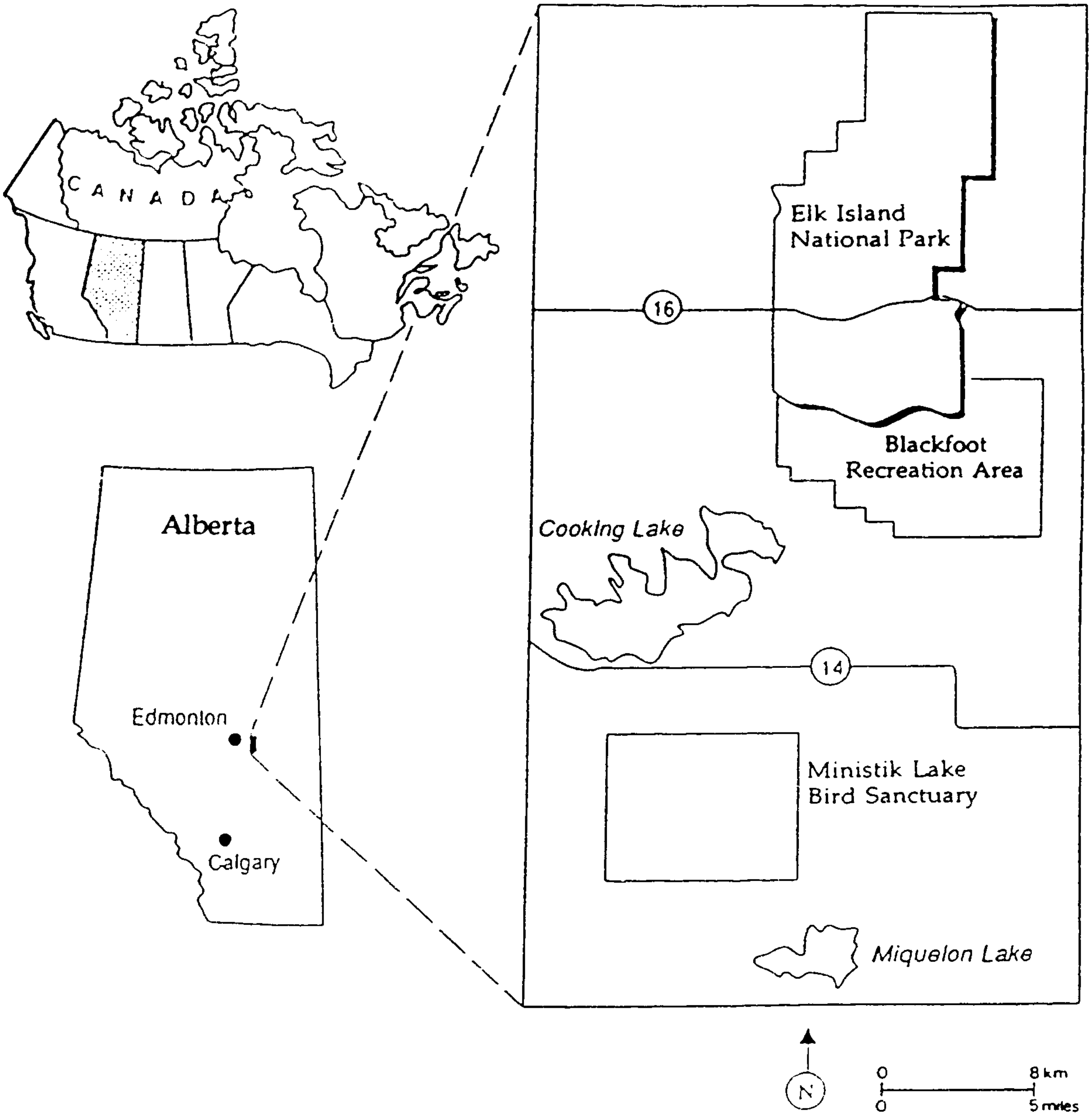


Figure 1. Fisher release study area.

snow free period is from the end of March to the end of October in most years. Above freezing temperatures are also common during this period.

The study area was classified by Rowe (1972) as an outlier of the boreal mixed-wood forest, surrounded by aspen parkland. The overstory vegetation is dominated by aspen poplar (*Populus tremuloides*)[1], balsam poplar (P. *balsamifera*) and white spruce (*Picea glauca*) on high or well-drained ground, with mixtures of white birch (*Betula papyrifera*), black spruce (*P. mariana*), and tamarack (*Larix laricina*) being more prevalent on wet sites (Techman Ltd. 1979). The dominant shrub in the understory is beaked hazel (*Corylus cornuta*), but rose (*Rosa spp.*), saskatoon (*Amelanchier alnifolia*), chokecherry (*Prunus virginiana*), and pincherry (*Prunus pensylvanica*) are also common (Fargey 1982). Dense stands of willow (*Salix spp.*) and alder (*Alnus crispa*) are commonly found around the profusion of lakes and ponds. (Techman Ltd. 1979).

The study area contains an abundance of animal species preyed upon by fishers. A list of the common small mammals include: masked shrew (*Sorex cinereus*), deer mouse (*Peromyscus maniculatus*), and red-backed vole (*Clethrionomys gapperi*). Porcupine (*Erithizon dorsatum*) and snowshoe hare (*Lepus americanus*) are common, and in some years highly abundant. Also, several species of waterfowl commonly nest and rear broods in this region. The area also has a large population of

---

[1] Plant nomenclature follows Moss (1983).

cervids, including moose (*Alces alces*), elk (*Cervus canadensis*), white-tailed deer (*Odocoileus virginianus*), and both wood bison (*Bison bison athabascae*) and plains bison (*B. b. bison*), which may serve as important sources of carrion for fisher.

METHODS

A total of 20 fishers (8 males and 12 females) were released within the study area between March of 1990 and August of 1992. The history of the captive fishers and methods of release were reported by Proulx et al. (1994). All fishers were ear-tagged and monitored with SMRX-3 radio transmitters with STO-1 mortality sensors (Lotek Engineering Inc., Aurora, Ontario)[2]. Locations for all fishers were recorded one or more times per week from the air or by triangulation from ground points. Triangulation consisted of 2 bearings taken at different locations within 10 minutes. Telemetry error was determined to be ≤ 25 m from a fisher's true position when the fixes were obtained ≤ 1 km from the animal. At a receiver distance of 2 km, the error in correctly positioning the animal increased to 185 m (Proulx et al. 1994). Therefore, we attempted to remain ≤ 1 km from the animals when determining their location. Incorrect readings resulting from signal bounce (Lee et al. 1985) were discarded.

Radio-collared fishers that were located by triangulation were recorded as active or non-active depending upon whether the radio signals fluctuated in strength or rhythm, or changed direction between successive readings. Activity was determined at 705 locations, obtained during all seasons, and throughout day and night for the two-year

---

[2] Use of trade or manufacturing names does not imply endorsement.

period. Arthur and Krohn (1991) found that, for paired locations, fishers were as likely to be active or inactive on the second telemetry location, regardless of their initial classification, if locations were separated by ≥ 2 hours. Therefore, only locations separated by ≥ 2 hours for individual fishers were used in analyses of activity. Separate analyses of activity were conducted for each sex and with both sexes combined, as stratified by time of day (diurnal, nocturnal, or crepuscular) and between seasons. Seasons were defined as spring (March to May), summer (June to August), fall (September to November), and winter (December to February). Seasons were also divided according to mean daily temperature (> 0°C vs < 0°C) and by the presence or absence of snow. Data were assessed using Chi-square goodness-of-fit test (SAS 1985). All climatological data and sunrise/sunset schedules were obtained from a local Environment Canada office upon written request.

Fisher habitat use was assessed by determining the cover type at 444 independent (i.e., separated by ≥ 16 hours) (Arthur 1987) telemetry locations. Locations were plotted on black and white aerial photograph mosaics with scales that ranged from 1: 10,000 to 1:40,000. These photos of the study area were taken between 1984 and 1989 and were representative of the conditions during the 1990 to 1992 sampling period. The cover type surrounding each location was determined by visually estimating mean canopy closure and proportion of deciduous and coniferous species present using the criteria in Table 1. A minimum area of 2 ha was used to identify forest stands (Arthur et al. 1989a). Forested blocks with an area less than 2 km^2 (200 ha) were considered woodlots, while larger blocks were classified as continuous forest. The criteria of $\geq$ 2 km^2 to define continuous forest differs from Proulx et al. (1994) who used $\geq$ 1 km^2 as the criteria. Proulx et al. (1994) considered only initial post-release movements in their analyses. As this study progressed, however, it became evident that larger blocks, which were obviously independent of the continuous forested areas, were available and were being used by fishers. The size of woodlots was therefore increased to 2 km^2.

Overstory cover types were also identified for 677 randomly chosen points, placed within the 1225 km^2 study area that encompassed the entire region occupied by radio-collared fishers. These locations were obtained by plotting 1000 random locations, obtained using a random number generator, at scale of 1:40,000, and overlaying them on aerial photographs of the study area. Plotted points sometimes fell outside the boundaries of the study area and were discarded, leaving a total sample of 677. One male fisher travelled widely outside the study area during the spring of 1990 and these locations were excluded from analysis. Stand types were classified using the same methods and criteria as used in coding fisher use locations. Stand classifications made from aerial

Table 1. Classification of cover types in the aspen parkland of Alberta.

Forest type	Characteristics
Deciduous	Total canopy ≥ 50%, deciduous species >75%
Coniferous	Total canopy ≥ 50% coniferous species > 75%
Mixed	Total canopy ≥ 50, neither type > 75%
Scrub	Forest land, total canopy < 50%
Wetland	Bog, meadow, shallow marsh with emergent vegetation
Open field	No canopy, agricultural fields and pastures
Open water	Lakes, ponds and sloughs

photos were verified by comparing photographs with areas of known cover types (Arthur et al. 1989a), and by field checking a random subsample of 10 locations.

Other habitat characteristics of fisher and random locations were determined using a Geographical Information System (GIS). For these analyses 1000 random locations, all within the study area, were again obtained using a random number generator. ARC/Info software was used to perform nearest distance analyses to primary and secondary roads, as well as to all permanent water bodies in the study area defined by ARC/Info as seasonal thaws. Slope and aspect data for each location were also obtained. Habitat characteristics at fisher use and random locations were compared using the techniques described by Marcum and Loftsgaarden (1980). Separate analyses were conducted to distinguish habitat use between sexes and among seasons. Seasons were defined using the same criteria as described previously.

Annual home range areas were computed for 7 fishers (2 males and 5 females). For the remaining 13 animals there were either too few locations to accurately assess their annual range use or the length of use was too short in time to be of significant value. Adequate data sets were considered to be those that contained 30 or more independent locations obtained during 2 or more calendar seasons. The resulting sample sizes (n = 32 to 195 locations) varied among animals, but areaobservation curves indicated that sample sizes were still adequate, Home range asymptotes were produced by removing locations randomly from data sets and plotting range size vs number of locations. Asymptotes were defined as the point after which additional locations resulted in a minimal increase in range size (Harris et al. 1990). When calculating home range areas by individual seasons, those animals that were followed for short time periods were included in the analyses.

The minimum convex polygon (MCP) method (Mohr 1947, Bowen 1982) of home range determination was used to calculate the 95% MCP area of annual home range areas. The harmonic mean method (HMM) (Dixon and Chapman 1980, Swihart and Slade 1985a, b) for estimating home range size was also used to determine the 95% harmonic mean contours. The harmonic mean method, however, often results in inaccurate home range representations when there is a highly skewed distribution of fixes, because areas that were not visited by the animal become included (Harris et al. 1990). This problem is particularly common when the number of fixes is low. In contrast, the MCP method of home range determination suffers from a dependence on sample size (Worton 1987) but is considered more robust than other techniques when the number of fixes is low (Harris et al. 1990).

Comparison of home range sizes between sexes and among seasons were, therefore, conducted using the MCP method because it appeared to provide the most realistic portrayal of fisher home range areas. Also, because of its historical use and statistical stability, I was able to compare my results to those of previous studies (Kelly 1977, Buck et al. 1979, Raine 1982, Arthur et al. 1989b). The 95% MCP home range areas were also calculated for each fisher using all of the telemetry locations, regardless of independence. All home range areas were determined using Program HOME RANGE (Ackerman et al. 1990). One-way analysis of variance was used to test for effects of sex and seasons on home range size and to test between the different methods of home range analyses (SAS 1985).

Detailed habitat characteristics of 2 male (M25 and M31) and 2 female (F42 and F47) fisher home range areas were measured at 72 locations (36 locations per sex). Home range areas were defined by the 95% MCP method, and fisher locations were chosen at random. At each location, percent tree canopy closure, tree canopy diversity, and percent overstory canopy comprised of deciduous species (Allen 1983) were visually estimated. Overstory trees were sampled using the point-quarter distance method (Ohmann and Ream 1971). The distance from the location to each tree was measured, as was tree height, tree diameter at breast height. The diversity and density of understory vegetation (all live woody stems < 1 m in height) were measured by identifying the number of each plant species within a 1 m^2 plot centred on the fisher locations. The distance between downed woody debris (stems > 5 mm in diameter) was also measured using the point-quarter distance method (Nordyke and Buskirk 1991) and the length and diameter of each log was recorded. Stage of decay of each downed and dead log was characterized using the five decay classes described by Maser et al. (1979), with class 5 being the most advanced state of decay (Table 2). Slope and aspect were also measured at each sampling location.

Seventy random sites were selected in areas that were adjacent to fisher home range areas, but were not known to be used by radio-collared fishers. All these locations fell within continuous forest blocks that appeared, through initial air-photo interpretation and GIS investigations, to be suitable fisher habitat. The sites were also sampled using procedures previously discussed.

The features of occupied and unoccupied sites were compared using two sample t-tests. A stepwise discriminant function analysis between the two types of sites was then performed to eliminate statistically redundant variables. An entry/removal criterion of F = 0.15 was the basis used to include variables in the discriminant model. Variables identified by the stepwise regression procedure were then entered into a canonical discriminant function analysis (SAS 1985) to determine the habitat dimensions (if any) along which occupied and unoccupied sites differed, and to test the predictability of group

Table 2. Five stages of structural change of logs with age described by Maser et al. (1979).

Stage	Description
1	Essentially sound with support points intact.
2	Weakened and sagging slightly on support space points with duff and soil building up on the sides.
3	Bark loosened, support points are gone and the log sags.
4	Log completely on the ground and may be partially buried, with the inside soft enough for small mammals to burrow.
5	Logs soft and powdery, partially buried and with long-established burrow systems both within and under them and used primarily by small mammals.

membership (occupied or unoccupied) for each site. Variables that were excluded by the stepwise regression procedure but showed a significant t-value ($P \leq 0.001$) were then re-entered in the discriminant function analysis to determine if they improved the model's ability to discriminate between sites. Because occupied and unoccupied sites were not sampled at the same frequency (72 fisher vs 70 random), the classification procedure was based on prior probabilities equal to the sample sizes of each site type. All statistical procedures were performed using PC-SAS software (SAS 1985). Probability values ≤ 0.05 were considered statistically significant.

RESULTS

Activity Periods

Sixteen fishers (6 males and 10 females) were located 1006 times from 14 March 1990 to 15 September 1992. No locations were obtained for one male that escaped during the acclimation period and was found dead one week later, or for one male and two females that slipped their radio-collars shortly after being released. The majority of 705 locations, for which activity could be determined, were classified as active (71.2%). Male fishers tended to be active more frequently (76. 3%, $n = 186$ locations) than females (69.4% , $n = 519$ locations), but the difference only approached significance ($\chi^2 = 3.3$, df = 1, $P = 0.07$) (Table 3).

Activity data stratified by time-of-day suggested that the activity level of male fishers did not differ significantly among diurnal, crepuscular, and nocturnal readings ($\chi^2 = 1.2$, df = 2, $P = 0.55$) (Table 3). Female fishers, however, were significantly more active after dark (χ^2= 14.4, df = 1, $P < 0.001$), and at twilight ($\chi^2 = 8.1$, df = 1, $P = 0.004$), than during daylight hours. When comparing time-of-day activity readings between the sexes, male fishers were significantly more active in the daytime than were females ($\chi^2 = 9.0$, df = 1, $P = 0.003$), but there was no significant differences in activity during crepuscular ($\chi^2 = 0.03$, df = 1, $P = 0.87$) or nocturnal ($\chi^2 = 1.8$, df = 1, $P = 0.18$) hours.

Table 3. The proportion of fisher locations classified as active in central Alberta.

	Male		Female	
Locations/Categories	n	% active	n	% active
Total observations	186	76.3	519	69.4
Season				
Spring	19	100.0^{a}	181	86.7^{a}
Summer*	100	80.0^{b}	207	63.8^{b}
Fall*	38	84.2^{ab}	39	53.9^{b}
Winter	29	37.9^{c}	92	54.4^{b}
Temperature				
Above 0°C*	151	82.8^{a}	424	71.7^{a}
Below 0°C	35	48.6^{b}	95	59.0^{b}
Snow				
Absent*	138	81.2^{a}	339	72.3^{a}
Present	48	62.5^{b}	180	63.9^{b}
Time of Day				
Diurnal*	112	77.7^{a}	305	62.0^{a}
Crepuscular	26	80.8^{a}	77	79.2^{b}
Nocturnal	48	70.8^{a}	137	80.3^{b}

*Indicates significant difference between sexes ($P < 0.05$)
^{abc}Indicates significant difference between seasons within each sex ($P < 0.05$)
Values with same superscript indicate no significant difference.

Fisher activity varied among calendar seasons for both males (χ^2= 31.6, df = 3, P < 0.001) and females (χ^2= 42.9, df = 3, P < 0.001). Male fishers were significantly more active during the spring period than during the summer (χ^2= 4.6, df = 1, P = 0.03) or winter (χ^2= 1.89, df = 1, P < 0.001) periods. Their activity was also higher during spring than fall but the difference was not significant (χ^2= 3.4, df = 1, P = 0.07). Male fishers were less active during the winter months than for any other season (vs. **summer**: χ^2= 19.1, df = 1, P < .001; vs **fall**: χ^2= 15.3, df = 1, P < 0.001). Female fishers were also significantly more active during spring than all other seasons (vs **summer**: χ^2= 26.8, df = 1, P <0.001; vs **fall** χ^2= 22.5, df = 1, P < 0.001; vs **winter** χ^2= 34.9, df = 1, P < 0.001), but no other comparisons were significant.

When comparing activity during each calendar season between the sexes, males were more active than females during both summer (χ^2= 8.3, df = 1, P = 0.004) and fall (χ^2 = 8.3, df = 1, P = 0.004). No differences in activity were found between the sexes during spring (χ^2= 2.9, df = 1, P = 0.09) or winter (χ^2= 2.4, df = 1, P = 0.12).

Defining "seasons" by average air temperatures being above or below 0°C resulted in the cold (< 0°C) season extending from 14 to 25 March 1990 and from 1 November 1990 to 27 March 1991. The warm season (> 0°C) was from 26 March to 31 October 1990 and from 28 March to 15 October 1991. Both male (χ^2 = 18.4, df = 1, P < 0.001) and female ($\chi^2 = 5.9$, df = 1, $P = 0.02$) fishers were significantly more active at temperatures above 0°C. Males were more active than females during warm temperatures ($\chi^2 = 7.2$, df = 1, $P = 0.007$) but no difference in activity occurred between the sexes during cold temperatures ($\chi^2 = 1.1$, df = 1, $P = 0.29$).

A continuous snowpack was present on the study area from 14 March to 30 April 1990, and from 1 November to 31 March 1991. The area was snow-free from 1 May to 31 October 1990 and from 1 April to 16 October 1991. Both male ($\chi^2 = 6.9$ df = 1, $P = 0.009$) and female ($\chi^2 = 3.9$, df = 1, $P = 0.05$) fishers were more active when snow was absent from the study area. Males were more active than females during the snow-free period ($\chi^2 = 4.1$, df = 1, $P = 0.04$) but no difference was detected between the sexes when snow was present ($\chi^2 = 0.03$, df = 1, $P = 0.86$).

Home Range Areas

Using the MCP method of home range determination, the mean annual home range area of 5 females was 14.9 (SE = ± 3.5) km^2 and did not differ from that of 2 males (24.3 ± 11.09 km^2) ($F = 1.29$, df = 6, $P = 0.31$) (Table 4). No difference existed between the values above and home range size when using all locations, regardless of independence ($F = 0.00$, df = 13. $P = 0.98$) for females ($\bar{x} = 15.5 \pm 3.7$ km^2) or males ($\bar{x} = 23.6, \pm 10.5$ km^2). There was extensive overlap in annual home

Table 4. The mean home range sizes of adult fishers in central Alberta.

Location Categories	n	Mean home range size (km^2) ± SE
Sex*		
Male	2	24.3 ± 11.1^a
Female	5	14.9 ± 3.5^a
Season**		
Spring	4 (4F)	4.8 ± 0.7^a
Summer	8 (2M + 6F)	8.9 ± 2.8^a
Fall	4 (2M + 2F)	5.9 ± 2.2^a
Winter	3 (1M + 2F)	4.4 ± 1.7^a
Temperature**		
Above 0°C	9 (2M + 7F)	14.5 ± 3.1^a
Below 0°C	4 (1 M + 3F)	3.9 ± 1.3^b
Snow Pack**		
Absent	10 (2M + 8F)	12.9 ± 3.1^a
Present	5 (1M + 4F)	6.1 ± 1.1^a

M = male; F = female
* all seasons combined
** both sexes combined
^{abc} indicates significant difference between sexes or seasons ($P < 0.05$)
Values with same superscript indicate no significant difference

range areas between individuals (Fig. 2). Female home range areas overlapped those of both males and other females. Male home range areas in this study did not overlap those of other males but the sample size was very low ($n = 2$). Home range areas, for those females that overlapped with other females, were re-analyzed after removing spring movements, as the majority of shared range use appeared to occur during this season (see Appendix C). This resulted in a marked decrease in the amount of shared home range between females but some overlap still occurred (Fig. 3). No spring locations were recorded for the 2 male fishers or for fisher F57.

Comparing range sizes between calendar seasons provided sample sizes of 23-46 locations ($n = 4$ fishers) for spring, 9-84 locations ($n = 8$) for summer, 13-29 locations ($n = 4$) for fall, and 30-46 locations ($n = 4$) for winter. Although many of these samples were small, it was decided to use them because they represented home ranges over a short period of time. Also, home range sizes calculated from small samples were consistent in size with those calculated from larger samples. There was no significant difference in fisher home range size between seasons ($F = 0.70$, $df = 18$, $P = 0.56$) (Table 4). However, home ranges tended to be larger in summer (7 = 8.9 ± 2.8 km^2) and smaller in winter ($\bar{x} = 4.4 \pm 1.7$ km^2). The average spring home range size of females only was 4.8 ± 0.7 km^2. Males made frequent long-distance movements outside their usual

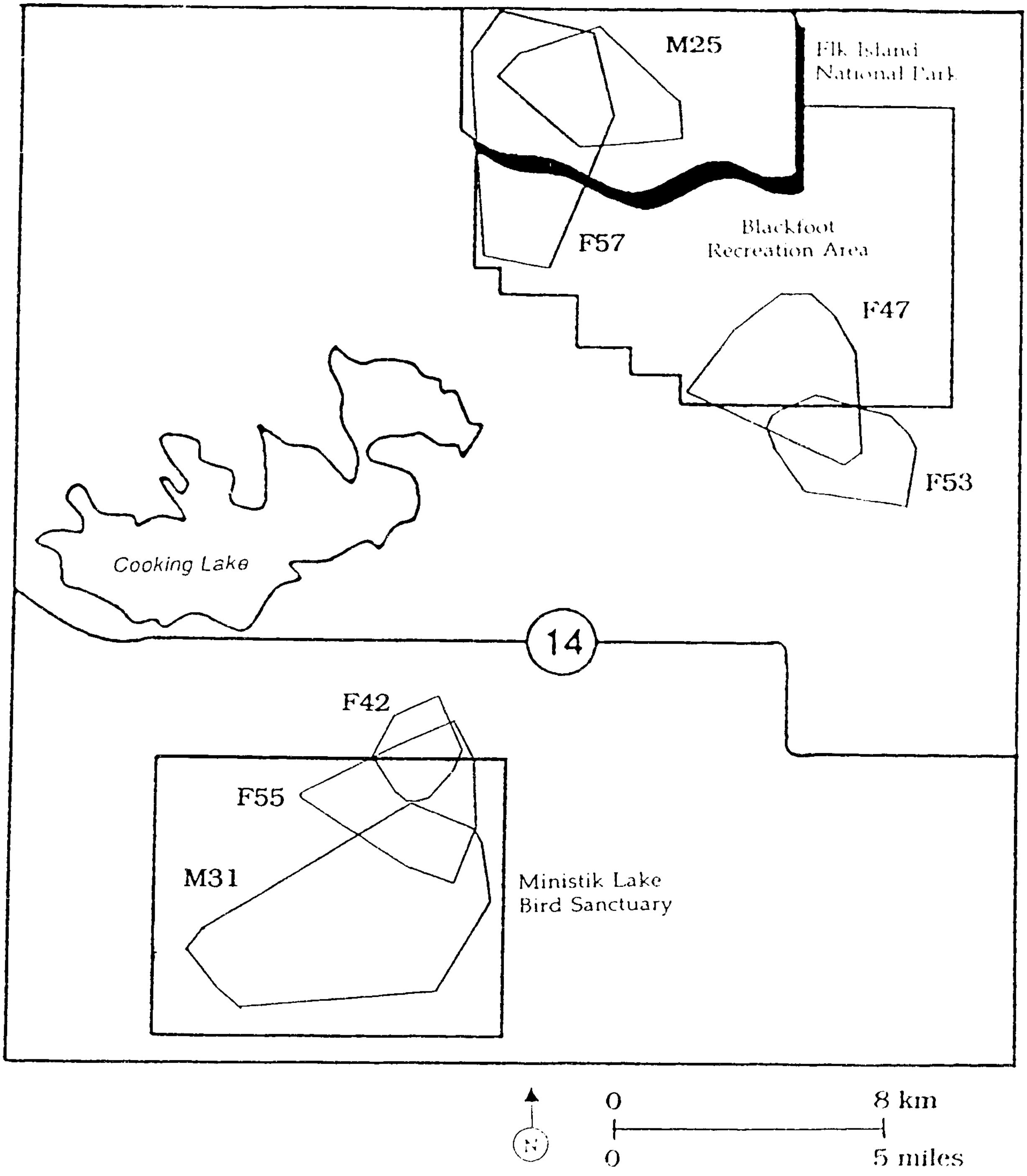


Figure 2. The distribution and size of annual home range areas (95% MCP) for 2 male (M25 and M31) and 5 female (F42, F47, F53, F55 and F57) fishers in central Alberta.

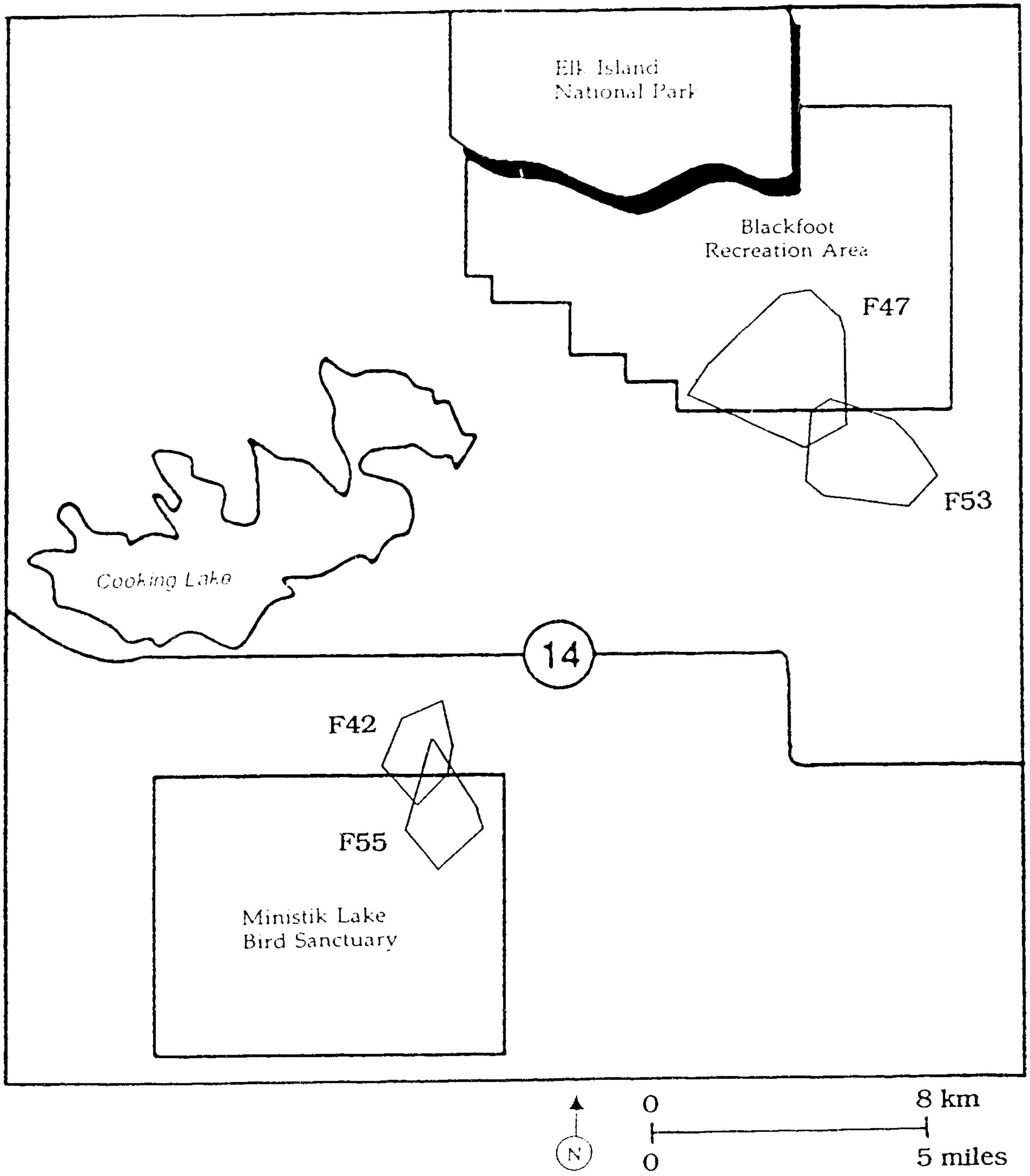


Figure 3. Home range areas (95% MCP) for 4 female fishers (F42, F47, F53, and F55) after removing spring movements.

range between March and May and not enough locations were recorded to determine their spring home range. Fall ranges averaged 5.9 ± 2.2 km^2 for both sexes.

Sample sizes based on temperature related measurements ranged from 11-50 locations (n = 4 fishers) for the cold season and 31-107 locations (n = 9) for the warm season. When the temperature was below freezing, home ranges averaged 3.9 ± 1.3 km^2. Above 0°C, home ranges were significantly larger (F = 4.67 df = 3, P = 0.05) and averaged 14.5 ± 3.1 km^2 (Table 4).

In the presence of snow, the mean home range size of 5 fishers (31 to 51 locations/fisher) was 6.1 ± 1.1 km^2. In the absence of snow, the home range of 10 fishers (11 to 107 location/fisher) was 12.9 ± 3.1 km^2. These means were not significantly different (F = 2.19, df = 14, P = 0.16) (Table 4).

Habitat Use as Determined by Aerial Photography and GIS Analysis

Fisher vs Random Locations

A total of 444 independent fisher locations and 677 random locations were classified according to cover type and size of forested block. Fisher locations did not occur in proportion to cover type availability ($\chi^2 = 368.6$, df = 6, $P < 0.001$). Fisher used deciduous stands more than expected ($P < 0.05$), while coniferous, mixed, and wetland cover types were used in proportion to their availability ($P > 0.05$).

Scrub, open field and open water were used less than expected ($P < 0.05$) based on their occurrence. Because it has been previously documented that fishers avoid open areas, (de Vos 1952, Ingram 1973, Kelly 1977, Powell 1982), and data from this study re-affirmed this conclusion, the categories of open field and open water were removed and the data were reanalyzed to compare habitat use among the 5 remaining forest types (Table 5). This resulted in a sample size of 434 fisher and 367 random locations. A re-analysis indicated that fisher use did not occur in proportion to the availability of forest types ($\chi^2 = 119.977$, df = 4, $P < 0.001$). Deciduous stands were preferred ($P < 0.05$), and mixed and wetland habitats were used in proportion to their availability ($P > 0.05$). Coniferous stands and scrub were used less than expected ($P < 0.05$). Both males (93 locations) and females (351 locations) used deciduous stands more than expected and used scrub less than expected. However, females used coniferous stands less than expected ($P < 0.05$), while male fishers used them in proportion ($P > 0.05$) to their availability.

Both male and female fishers used continuous forest blocks more than expected based on its availability ($P < 0.01$) (Table 6). Animals were located in continuous forest 71.9% of the time while random locations fell within continuous forest stands only 17.1%. When fishers utilized woodlots, they tended to use stands that were larger than the average available ($P < 0.01$). Fishers were located in woodlots 46 times (10.3%)

Table 5. Cover types at random points and fisher locations with open field and open water categories deleted.

Locations	n	Deciduous %	Coniferous %	Mixed %	Scrub %	Wetland %
Random points	367	40.9	5.5	9.0	27.5	17.2
All locations	434	74.2^{1}	1.2^{3}	7.1^{2}	4.8^{3}	12.7^{2}
Sex*						
Male	87	72.4^{1a}	4.6^{2a}	8.1^{2a}	2.3^{3a}	12.6^{2a}
Female	347	74.6^{1a}	0.3^{3b}	6.9^{2a}	5.5^{3a}	12.7^{2a}
Season**						
Spring	90	66.7^{1a}	-	14.4^{***2a}	5.6^{3a}	13.3^{2a}
Summer	230	76.5^{1a}	-	6.1^{***3a}	4.8^{3a}	12.6^{2a}
Fall	57	77.2^{1a}	-	7.0^{***2a}	5.3^{3a}	10.5^{2a}
Winter	57	73.7^{1a}	-	8.8^{***2a}	3.5^{3a}	14.0^{2a}
Temperature**						
Above 0°C	341	75.4^{1a}	0.6^{3a}	5.9^{2a}	5.0^{3a}	13.2^{2a}
Below 0°C	93	69.9^{1a}	3.2^{1a}	11.8^{2a}	4.3^{3a}	10.8^{2a}
Snow pack**						
Absent	311	77.2^{1a}	0.6^{3a}	5.5^{2a}	4.2^{3a}	12.5^{2a}
Present	123	66.7^{1a}	2.4^{2a}	11.4^{2a}	6.5^{3a}	13.0^{2a}

[*] all seasons combined.
[**] both sexes combined.
[***] coniferous and mixed categories combined.
[1] used more than expected
[2] used in proportion to availability,
[3] used less than expected
[abc] indicates significant difference between sexes or seasons within each forest type category ($P < 0.05$)
Values of same superscript indicate no significant difference

Table 6. The frequency of random points and fisher locations occurring in continuous forest stands and woodlots.

Location Category	Continuous Forest (≥ 2 km^2)		Woodlot (< 2 km^2)		
	n	%	n	%	mean size (km^2) ± SE
Random points	116	17.1	85	12.6	0.18 ± 0.03
All locations	312	71.9^{1}	46	10.3^{2}	0.40 ± 0.08^{1}
Sex*					
Male	74	85.1^{1a}	8	9.2^{2a}	$0.32 \pm 0.10^{1,a}$
Female	238	68.6^{1a}	38	11.0^{2a}	0.48 ± 0.10^{1a}
Season**					
Spring	49	54.4^{1a}	24	26.6^{1a}	0.25 ± 0.07^{3a}
Summer	170	73.9^{1b}	20	8.7^{2b}	0.63 ± 0.15^{1b}
Fall	48	84.2^{1b}	0	0.0^{3b}	-
Winter	45	78.9^{1b}	2	3.5^{3b}	0.05 ± 0.01^{2ab}
Temperature**					
above 0°C	246	72.1^{1a}	33	9.7^{2a}	0.48 ± 0.11^{1a}
below 0°C	66	71.0^{1a}	13	14.0^{2a}	0.22 ± 0.08^{2a}
Snow pack**					
Absent	234	75.2^{1a}	25	8.0^{2a}	0.53 ± 0.13^{1a}
Present	78	63.4^{1a}	21	17.1^{2a}	0.26 ± 0.08^{2a}

*all seasons combined

**both sexes combined

[1] used habit or woodlot size significantly larger than random (P < 0.05)

[2] used in proportion to availability or woodlot size not significantly different from random (P < 0.05)

[3] used habitat or woodlot size significantly smaller than random (P <0.05)

[abc] indicates significant difference in habitat use or woodlot size between sexes and seasons (P <0.05)

Values with same superscript indicate no significant difference

and the mean stand size was 0.40 (SE = ± 0.08) km^2. Eighty-five random locations (12.6%) occurred in woodlots with a mean stand size of 0.18 km^2 (± 0.03).

Measurements of distances to roads, distances to water, slope, and aspect were obtained for all 444 independent fisher locations and 1000 random locations. Both male and female fishers avoided locations ≤ 100 m from primary or secondary roads ($P < 0.05$) and preferred locations ≥ 500 m from them ($P < 0.05$) (Table 7). Habitat use by fishers in this study did not appear to be related to water ($\chi^2 = 5.1$, df = 5, $P = 0.41$) when both sexes were combined (Table 8). However, when male and female use locations were analyzed separately, it was determined that males were located closer to water more often than would be expected ($\chi^2 = 34.4$, df = 5, $P < 0.001$). Males were found within 100-200 m of seasonal thaws more often than expected ($P < 0.05$) and farther than 1 km less than expected ($P < 0.05$) based on a comparison to random locations. Female fishers use showed no relation in the distance from water ($\chi^2 = 3.7$, df = 5, $P = 0.59$).

Average slopes within the study area ranged from 1-5° when measured using the GIS and elevation contours separated by 100 m. Slopes of $\leq 1°$ were used less than expected ($P < 0.05$) and slopes of $> 1°$ were used more than expected ($P < 0.05$) by fishers (Table 9). Fishers showed no preference for any particular aspect when use locations were compared to habitat available ($\chi^2 = 4.7$, df = 7, $P = 0.70$).

Table 7. The distance (m) of random points and fisher locations from primary and secondary roads.

		0-50	50-100	100-200	200-500	500-1000	> 1000
Location Category	n	%	%	%	%	%	%
Random points	1000	11.1	9.2	16.3	33.5	20.0	9.9
All locations	444	2.7^{3}	4.3^{3}	11.9^{2}	34.2^{2}	29.3^{1}	17.6^{1}
Sex*							
Male	93	3.2^{3a}	2.2^{3a}	7.5^{3a}	29.0^{2a}	19.4^{2a}	38.7^{1a}
Female	351^{3a}	2.6^{3a}	4.8^{2a}	13.1^{2a}	35.6^{2a}	31.9^{1a}	12.0^{2b}
Season**							
Spring	94	5.3^{2a}	9.6^{2a}	17.0^{2a}	35.1^{2a}	17.0^{2a}	16.0^{2a}
Summer	235	3.0^{3a}	1.7^{3a}	11.1^{2a}	37.0^{2a}	32.3^{1b}	14.9^{2a}
Fall	57	0.0^{3a}	3.5^{3a}	10.5^{2a}	29.8^{2a}	29.8^{2ab}	26.3^{1a}
Winter	58	0.0^{3a}	6.9^{2a}	8.6^{2a}	25.9^{2a}	36.2^{3ab}	22.4^{3a}
Temperature**							
Above 0°C	349	3.2^{3a}	3.2^{3a}	12.3^{2a}	35.8^{2a}	29.2^{1a}	16.3^{1a}
Below 0°C	95	1.1^{3a}	8.4^{2a}	10.5^{2a}	28.4^{2a}	29.5^{1a}	22.1^{1a}
Snow pack**							
Absent	316	2.2^{3a}	2.5^{3a}	11.1^{3a}	36.4^{2a}	31.0^{1a}	16.8^{1a}
Present	128	3.9^{3a}	8.6^{2a}	14.1^{2a}	28.9^{2a}	25.0^{2a}	19.5^{1a}

* all seasons combined
** both sexes combined
^{1}used more than expected
^{2}used in proportion to availability
^{3}used less than expected
^{abc}indicates significant difference between sexes or seasons within distance categories ($P < 0.05$)
Values with same superscript indicate no significant difference

Table 8. The distance (m) of random points and fisher locations from permanent water bodies.

Location Category	n	0-50 %	50-100 %	100-200 %	200-500 %	500-1000 %	> 1000 %
Random points	1000	6.0	4.8	9.7	24.6	2.1	52.8
All locations	444	5.9^{2}	5.2^{2}	11.7^{2}	26.8^{2}	0.9^{2}	49.6^{2}
Sex[*]							
Male	93	8.6^{2a}	7.5^{2a}	24.7^{1a}	32.3^{2a}	1.1^{2a}	25.8^{3a}
Female	351	5.1^{2a}	4.6^{2a}	8.3^{2b}	25.4^{2a}	0.9^{2a}	55.8^{2b}
Season[**]							
Spring	94	7.5^{2a}	6.7^{2a}	10.6^{2a}	29.8^{2a}	1.1^{2a}	44.7^{2a}
Summer	235	6.0^{2a}	4.7^{2a}	8.5^{2a}	24.7^{2a}	1.3^{2a}	54.9^{2a}
Fall	57	5.3^{2a}	5.3^{2a}	21.0^{2a}	29.8^{2a}	0.0^{2a}	38.6^{2a}
Winter	58	3.5^{2a}	5.2^{2a}	17.2^{2a}	27.6^{2a}	0.0^{2a}	46.6^{2a}
Temperature[**]							
Above 0°C	349	6.0^{2a}	4.9^{2a}	11.2^{2a}	26.9^{2a}	1.2^{2a}	49.9^{2a}
Below 0°C	95	5.3^{2a}	6.3^{2a}	13.7^{2a}	26.3^{2a}	0.0^{2a}	48.4^{2a}
Snow pack[**]							
Absent	316	6.0^{2a}	51^{2a}	10.4^{2a}	26.3^{2a}	1.0^{2a}	51.3^{2a}
Present	128	5.5^{2a}	5.5^{2a}	14.8^{2a}	28.1^{2a}	0.8^{2a}	45.3^{2a}

[*] all seasons combined

[**] both sexes combined

[1] used more than expected

[2] used in proportion to availability

[3] used less than expected

[abc] indicates significant difference between sexes or seasons within distance categories ($P < 0.05$)

Values with same superscript indicate no significant difference

Table 9. Slope and aspect at random points and fisher locations.

		Slope		Aspect							
Location Category	n	≤ 1° %	> 1° %	N %	NE %	E %	SE %	S %	SW %	W %	NW %
Random points	1000	57.0	43.0	14.3	16.5	13.2	8.7	8.7	10.9	11.1	12.6
All locations	444	43.7[3]	56.3[1]	15.5	14.9	12.2	12.4	10.6	11.9	9.9	12.6
Sex*											
Male	93	48.4[2]	51.6[2]	18.3	17.2	6.5	7.5	14.0	17.2	9.7	9.7
Female	351	42.5[3]	57.5[1]	14.8	14.3	14.0	11.4	11.7	10.5	10.0	13.4
Season**											
Spring	94	52.1[2]	47.9[2]	13.8	16.0	14.9	9.6	12.8	9.6	12.8	10.6
Summer	235	40.9[3]	59.2[1]	17.5	15.3	11.1	11.5	12.8	9.4	8.5	14.0
Fall	57	43.9[3]	56.1[1]	8.8	10.5	14.0	12.3	12.3	15.8	14.0	12.3
Winter	58	41.4[3]	58.6[1]	17.2	15.5	12.1	6.9	8.6	22.4	6.9	10.3
Temperature**											
Above 0°C	349	43.0[3]	57.0[1]	14.7	16.8	13.7	8.4	7.4	2.0	8.4	10.5
Below 0°C	95	46.3[3]	53.7[1]	15.8	14.3	12.0	11.2	13.5	9.7	10.3	13.2
Snow pack**											
Absent	316	41.5[3]	58.5[1]	16.8	14.6	11.4	11.4	12.7	10.1	10.1	13.0
Present	128	49.2[2]	50.8[2]	12.5	15.6	14.8	8.6	10.9	16.4	9.4	11.7

*all seasons combined

**both sexes combined

[1] used more than expected. [2] used in proportion to availability. [3] used less than expected

There was no selection of a particular aspect or a significant difference in slope or aspect between sexes or seasons within categories (P< 0.05)

Male vs Female Locations

Habitat use by sex was compared between the 93 male and 351 female locations. When calculating a test statistic which is approximately chi-square distributed, no more than 20% of all categories should contain less than 5 expected observations (Neu et al. 1974, Alldredge and Ratti 1992). Therefore, the stands classified as coniferous forest, which were relatively rare in the study area, were combined with stands classified as mixed forest. This category then contained forested stands that were composed of ≥ 25% coniferous tree species. The category of open water was deleted altogether. Categories were also modified in this way for analysis between seasons. The results suggest no difference in preferred cover types between male and female fishers ($\chi^2 = 9.2$, df = 4, P = 0.06). The distance a fisher was located from a road, however, did differ between the sexes ($\chi^2 = 38.1$, df = 5, $P < 0.001$). Males tended to be found more than 1 km from a road (38% of all locations) more often than did females (12.0%). The sexes also differed in the distance they were located from water ($\chi^2 = 34.5$, df = 5, $P < 0.001$). Males were located less than 500 m from bodies of water 73.1% of the time while females were only within 500 m of water 43.3% of the time. No differences were found in the selection of block size (t = 0.5, df = 44, P = 0.64), slope ($\chi^2 = 9.3$, df = 1, P = 0.24), or aspect ($\chi^2 = 4.0$, df = 1, P = 0.26) between the sexes.

Habitat Use Among Seasons

Male and female fisher locations were combined to compare habitat selection among seasons. Although no difference in the selection of forest type was detected between calendar seasons ($\chi^2 = 7.2$, df = 9, P = 0.62), there was a difference in selection when each season was compared to the proportion of forest types available. Fishers used deciduous stands more than expected and used scrub habitat less than expected during all season ($P < 0.05$), but mixed stands (coniferous and mixed categories combined) were used less than expected only during the summer season ($P < 0.05$). Fishers used continuous forest stands less ($\chi^2 = 24.53$, df = 3, $P < 0.001$), and woodlots more ($\chi^2 = 33.67$, df = 3, P = 0.001) in the spring than during any other calendar season. Of the 94 locations obtained in spring, only 49 (52.1%) were within continuous forest blocks, while 24 (25.5%) were in woodlots. In comparison, of 236 summer locations 170 (72.0%) were in continuous forest, and 20 (8.5%) were in woodlots; 57 fall locations were in continuous forest 48 (84.2%) times, and never occurred in woodlots; and 57 winter locations were found within continuous forest stands 45 (78.9%) times, and within woodlots only twice (3.5%). The mean size of woodlots used by fishers was significantly (F = 3.51, df = 2, P = 0.04) smaller in the spring (0.25 km^2) than in the summer (0.63 km^2). When the size of the woodlots used by fishers each season was compared to the size of the woodlots available in the study area, spring was the only season in which woodlots used were not significantly larger than those available (t = 0.93, df = 107, P = 0.35).

The distance of fisher locations from primary or secondary roads varied with the calendar season (χ^2 = 32.1, df = 15, P = 0.006). However, sample sizes proved too small to detect whether the differences in use occurred when distances were compared within seasons using the Bonferroni Z-statistic (P = 0.05) (Marcum and Loftsgaarden 1980). The exception was the category of 500-1000 m from roads in which fisher were located significantly more often in summer than spring ($P < 0.05$). Furthermore, the proportion of fisher locations occurring less than 500 m from a road was greater in the spring (67.0%) than in any other season (summer 52.8%, fall 43.9%, winter 41.4%).

Comparisons of habitat selection by fishers between warm (> 0°C) and cold (< 0°C) seasons indicated no significant preferences for cover type (χ^2 = 8.1, df = 4, P = 0.90), forest block size (t = 1.4, df = 44, P = 0.16), distance to roads (χ^2 = 8.9, df = 5, P = 0.11) distance to water (χ^2 = 1.9, df = 5, P = 0.86), slope (χ^2 = 0.3, df = 1, P = 0.56), or aspect (χ^2 =10, df = 7, P = 0.16). Comparing habitat used during each of these seasons to habitat available however indicated a difference in the use of cover types. Deciduous stands were used more than expected ($P < 0.05$) while scrub stands were used less than expected ($P < 0.05$) during both warm and cold seasons, but coniferous stands were used less than expected ($P < 0.05$) only during the warm season, and used in proportion to their availability ($P > 0.05$) during the cold season.

Analyses of selection between seasons when snow was absent versus when snow was present also revealed no difference in selection of cover type ($\chi^2 = 9.2$, df = 4, P = 0.60), stand size (t = 1.7, df = 44, P = 0.09), distance to water ($\chi^2 = 2.4$, df = 5, P = 0.80), slope ($\chi^2 = 2.2$, df = 1, P = 0.14), or aspect ($\chi^2 = 6.1$, df = 7, P = 0.53). Habitat use did appear to vary with distance to roads ($\chi^2 = 12.5$, df = 5, P = 0.03). However no differences were detected when the Bonferroni Z-statistic (P = 0.05), was used to compare seasons within distance categories. Again, when each season was compared with habitat available, coniferous stands were used less than expected ($P < 0.05$) only during the season when snow was absent, and used in proportion to availability ($P > 0.05$) when snow was present.

Habitat Use as Determined by Field Sampling

Based on univariate tests, fisher locations had higher values of canopy cover ($P < 0.001$), total number of woody stems in the understory ($P < 0.001$) slope (SL) (P = 0.002), distance between downed woody debris (P = 0.01) percent deciduous species in the overstory (P = 0.026), tree height (P = 0.027), and dbh (P = 0.046) than did random locations (Table 10).

A stepwise discriminant function analysis of the 13 habitat variables identified 5 potential discriminators (canopy cover, canopy

Table 10. Habitat features of 72 occupied and 70 unoccupied fisher locations.

Habitat variable	Mean Value		P
	Occupied site ± SE	Unoccupied site ± SE	
Overstory			
Canopy cover	1.7 ± 0.05	1.3 ± 0.06	< .001
Canopy diversity	2.2 ± 0.08	2.1 ± 0.06	.138
% of Deciduous species	96.2 ± 1.31	99.3 ± 0.40	.026
Tree height (m)	6.3 ± 0.71	4.4 ± 0.47	.027
DBH (mm)	65.5 ± 8.69	44.0 ± 6.05	.046
Distance between trees (cm)	491.0 ± 133.64	214.7 ± 71.16	.072
Understory			
Woody stem density (/m^2)	25.3 ± 1.37	12.5 ± 1.05	< .001
Debris length (cm)	178.0 ± 30.12	135.2 ± 14.66	.207
Debris diameter (mm)	28.1 ± 2.89	19.2 ± 1.75	.010
Distance between debris (cm)	138.6 ± 47.18	113.8 ± 48.07	.714
Stage of decay	3.1 ± 0.09	2.9 ± 0.08	.125
Topography			
Slope	5.8 ± 0.68	1.9 ± 0.31	.002
Aspect (N = 0°)	94.5 ± 4.42	90.0 ± 4.77	.476

diversity, slope, distance between trees, and stage of decay of downed woody debris) of occupied and unoccupied sites (Table 11). A test for homogeneity of within-group covariance matrices (Morrison 1976) was rejected ($\chi^2 = 74.7$, df = 15, $P < 0.001$). Therefore, the canonical analysis was performed using a quadratic discriminant function (i.e. using the within-group, rather than pooled, covariance matrix) (SAS 1985).

The discriminant function based on these 5 habitat variables was significant ($F = 13.2$; 5, df = 132, $P < 0.001$), but the relationship between discriminant scores calculated from the quadratic function and group membership was not strong ($r = 0.67$). Habitat variables identified as significant by univariate analysis were brought into the discriminant function in an attempt to improve its ability to discriminate between fisher and random locations. The discriminant function based on 4 habitat variables (canopy cover, canopy diversity, slope, and understory density) was significant ($F = 15.8$, .4, df = 137, $P < 0.001$), and there was a stronger relation between discriminant scores and group membership ($r = 0.68$). Occupied and unoccupied sites were best discriminated by the density of woody stems in the understory (Table 12). Fisher use areas contained a greater density of total stems ($\bar{x} = 25.3/m^2$) than did random locations ($\bar{x} = 12.5/m^2$). Also, canopy cover, slope, and canopy diversity were all greater at occupied sites than at

Table 11. Stepwise discriminant function analysis of 13 habitat variables measured at occupied and unoccupied locations.

Habitat variable	Step entered	Partial R^2	F	P
Canopy cover	1	.11	16.45	< .001
Distance between trees	2	.07	9.68	.002
Canopy diversity	3	.09	12.90	< .001
Slope	4	.08	12.31	< .001
Stage of decay	5	.07	10.60	.001

Table 12. Pooled within-groups correlations between canonical discriminant function scores and discriminating variables of occupied and unoccupied locations.

Habitat variable	Correlation coefficient
Woody stem density	.70
Canopy cover	.62
Slope	.39
Canopy diversity	.19

unoccupied sites (canopy cover: 1.7 vs 1.3; slope: 5.8 vs 1.9; canopy diversity: 2.2 vs 2.1).

The quadratic discriminant function had an overall classification success rate of 81.0%. Based on the 4 habitat variables considered, 57 of 72 (79.2%) occupied sites, and 58 of 70 (82.9%) unoccupied sites were correctly classified. Because the data used to generate the discriminant model were also used in the classification procedure, these classification rates may be slightly inflated (Klecka 1980).

DISCUSSION

Activity patterns of female fishers were consistent with results from previous studies of fishers in different habitat types (Grinnell et al. 1937, de Vos 1952, Hamilton and Cook 1955, Coulter 1966, Kelly 1977, Pittaway 1978, Leonard 1980, Powell 1982, Johnson 1984, Arthur and Krohn 1991). Fishers were active both day and night, but were most active at sunrise and sunset and throughout the evening. Kelly (1977) reported similar activity periods for fishers in New Hampshire as did Johnson (1984) in Wisconsin. Increased activity by fishers in early morning and early evening may relate to behavior of fisher prey, which are generally more active at those times as well (Green 1980, Dodge 1982). The crepuscular and nocturnal movements of fishers may also allow them to decrease the risk of being preyed upon by larger predators or coming in contact with humans (Buskirk 1992).

The activity rate of male fishers did not vary by time of day during this study, and males tended to be active more often than females. Kelly (1977) and Johnson (1984) also found that movements of adult males were greater than those of adult females. Daily straight line distances travelled ranged from 0.8 to 2.8 km for males (Kelly 1977, Buck et al. 1979, Raine 1981) and from 0.5 to 2.5 km for females (Kelly 1977, Raine 1981, Johnson 1984). Kelly (1977) suggested sexual dimorphism in body size to be largely responsible for the differences in movements.

Male body length averages about 20% more than that of females, and the mean male weight is nearly twice that of females (Douglas and Strickland 1987). Therefore, males presumably spend more time searching for food than females because of a greater energy requirement.

Leonard (1980) found that fishers were less active from late December to mid-February. Activity increased during late February and March, possibly because of the breeding season (de Vos, 1952, Raine 1981), or to the formation of a spring snow crust (Leonard 1980). Fishers may be hindered in mid-winter by deep soft snow and often leave a body track (Raine 1983), but will lope or gallop on firm ground and snow crusts (Pittaway 1978, Raine 1983). Johnson (1984) found that fisher movements were restricted by snow depths greater than 46 cm and temperatures below -17°C. The maximum snow depth recorded during this study was 26 cm. Other studies have also found that fishers are inactive during storms and extreme cold (de Vos 1952, Coulter 1966, Powell 1982). Fishers in this study were most active in spring (likely due to breeding season movements) and least active in winter. Increased activity during the breeding season is evident predominantly in males (Coulter 1966) but Kelly (1977) found both sexes made similar movements during March and April. The mobility of females in this study was probably not restricted by kits as all females were barren when released and no evidence of reproduction was obtained during the

2 years of radio-tracking. Johnson (1984) found that females raising kits had restricted mobility in Wisconsin, but Leonard (1980) found no difference in activity between females with kits and without kits in Manitoba. Decreased activity by fishers during the winter months was likely due to snow and cold temperatures. By remaining inactive at times when movements are restricted, and prey items are less available, fishers are able to conserve energy. Activity increases in the spring, as does the food supply since most prey species have their young in spring, and remains relatively high over summer and fall when fishers take advantage of easy travel and expand their search for food.

The concept of home range was defined by Burt (1943) as "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young". Minimum convex polygon was one of the earliest and simplest techniques for calculating this area. This procedure of determining home range ares has since been superseded by statistical procedures specified in terms of bivariate models that give the probability of finding an animal at a particular location on a plane. The harmonic mean method of home range analysis would be an example of this.

Home range areas of fishers in this study were better represented using MCP than HMM. The 95% MCP boundaries contained little area not used by the fisher while 95% HMM isopleths included large areas in which animals were never located. Similar results have been noted by Arthur et al. (1989b) for fishers and Spencer and Barrett (1984) for pine marten (*Martes americana*). Because minimum area techniques are "non-statistical" methods of analyzing use areas, the number of locations used to depict a use area and sampling duration may not be important sources of variability in this study. Home range sizes of fishers were no different using smaller, independent data sets than using larger, temporally autocorrelated data sets. Buskirk and McDonald (1989) came to the same conclusions when reviewing the variability in marten home range size measurements.

Estimates of annual home range size of fishers using radio telemetry and the MCP method were consistent with other studies which ranged from 14.0 -30.9 km^2 for adult males and 3.6 - 16.3 km^2 for adult females (Kelly 1977, Buck et al. 1979, Johnson 1984, Arthur et al. 1989b). Because of the variability of home range size for each sex found in this study, the sample size may not have been large enough to detect any significant difference in mean home range size between the sexes. Without exception, reports of male home range sizes are always larger than those of females. By increasing the size of their home range area, male fishers increase their chance of encountering or overlapping several female home ranges, and this may increase their opportunity to breed. Sexual dimorphism may also explain why males utilize larger areas than females. The larger body size of male fishers requires a greater amount of food be obtained to sustain it. Males would, therefore, cover a larger area than females presumably in order to increase their prey base.

All fishers in this study, with locational data sets sufficient for modeling annual home range areas, overlapped in range with other fishers. Spatial distribution of fishers is generally thought to be intrasexual territoriality, where the range of one male will overlap that of more than one female, but home ranges within adults of the same gender are exclusive (Powell 1982). Although male home range areas in this study did not overlap with those of other males, the areas used by females did overlap with that of other females. When spring movements were deleted from the analyses the amount of overlap decreased but female home ranges were still not exclusive of other females. Trespassing further into the home range areas of other females in spring may be due to a search for males. Because of the low number of males released, and their relatively high rate of mortality, few opportunities for breeding were available to female fishers. This may have resulted in higher tolerance between females with adjoining home range areas, especially during the spring breeding season.

The clumping of home range areas, when so much habitat appeared to be vacant, would seem to indicate that optimal habitat was at a premium and was therefore being shared by fishers. If this were true the possibility of further expansion into the area may be limited. It is difficult to reach any firm conclusions about the distribution of the animals, however, because their of a lack of data on several released fishers, whose areas could not be determined. The effect that those fishers had on animals whose home range areas were calculated is unknown.

Fisher home range areas in this study were always located within relatively contiguous blocks of forest with roads, houses, and farms located along the perimeters. Fishers did, however, cross roads and open areas within their home ranges in order to move between forested areas. Similar findings were reported by Arthur et al. (1989b) in their study of fishers in a populated area of Maine.

Seasonal differences in home range characteristics of males and females were consistent with reports by Kelly (1977) and Arthur et al. (1989b) who reported that female home ranges were stable throughout the year. Significant changes in female home range size were not observed during the breeding season. Adult males, however, abandoned their established home range areas during the breeding season, likely in search of females in estrus (de Vos 1952, Coulter 1966, Kelly 1977, Buck et al. 1979, Johnson 1984, Arthur et al. 1989b). Male home range sizes obviously increased during the spring, as noted by Kelly (1977) and Raine (1982), suggesting that late winter - spring movements be considered separately for modeling ranges during this period (Laundré and Keller 1984, Arthur et al. 1989b). For this study, however, data were insufficient to determine male home range sizes during the breeding season.

Long-distance movements by males during the breeding season left them more vulnerable to predation, human-caused mortality, and intra- and interspecific aggression. Animals travelled through unfamiliar environment during late winter-early spring, a time of year when vegetation cover is reduced and food sources are limited (Proulx et al. 1994). In Maine male fishers trespassed into other male territories most frequently during the mating period (Arthur et al. 1989b). Four adult male fishers from this study died during long-distance movements made in spring; one died as a result of injuries received from a large canid (most likely a domestic dog), one was hit by a motor vehicle, and evidence suggests two died due to injuries received through intra-specific fight wounds and trauma of unknown origin (Proulx et al. 1994).

The variability of fisher home range size compared by season was too great to detect an actual difference between means in most cases. However, dividing the seasons of the year by the mean daily temperature above and below 0°C, did indicate fishers expanded their movements during warmer weather. Kelly (1977) also found that both sexes inhabited relatively small home ranges in the month of January, and speculated that severe weather conditions caused them to den often in order to reduce thermal stress. The increase in fisher movements, which coincided with the increase in temperature, could be attributed to greater food abundance, denser vegetative cover, which provides protection from predators, and/or the loss of snow leading to less restriction of movement.

Fishers are always found in or near forests with continuous overhead cover (Powell 1982). Kelly (1977) reported that fishers in New Hampshire selected forested habitats with 80-100% canopy closure while stands with less than 50% canopy closure were generally avoided. This was also true for fishers in this study. Both sexes used deciduous stands more often than expected, and used scrub habitat less often than expected, during all seasons. Use of deciduous forest, as opposed to coniferous, is opposite of what Arthur et al. (1989a) discovered for fishers in Maine. They found that fishers used small clumps (often <0.5 ha) of coniferous forest for resting sites during much of the year. These areas were thought to provide more shade and concealment than deciduous habitats. However, little evidence was found for selection of particular forest types when fishers were active. Arthur et al. (1989a) concluded that, given the diversity of the fisher's diet, optimum habitat may consist of many different cover types. This is especially true in areas where heavy snow fall is not a factor. The parklands of central

Alberta receive relatively little snow compared to northern boreal forest or montane regions. Therefore, it is not surprising that fishers would commonly use deciduous forest stands in this area.

The relatively low use of coniferous stands by females is difficult to interpret because the occurrence of this habitat type is low. The majority of coniferous cover was found in the northern end of the study area which was never inhabited by radio-collared fishers. This was perhaps because of the high density of ungulates in the northern section of Elk Island National Park. Browsing and trampling in this area has resulted in a sparse understory, which may reduce prey populations, and render the habitat unsuitable for fishers. Much of the coniferous forest in the study area also consists of black spruce bog. Coulter (1960) found that low lying coniferous forests containing a high proportion of bogs did not support high populations of fishers.

The greater use of coniferous forest by males than females, when compared to the proportion of habitat available, may have been due to their greater mobility. By covering a larger area, males have a greater chance of encountering the relatively rare patches of coniferous cover, as compared to the more sedentary females. As well, coniferous stands within the study area were often associated with lakeshores and males were found close to lakes and ponds more often than were females.

Another explanation of the differential habitat use between male and female fishers may be resource partitioning. Because of the pronounced sexual size dimorphism in the species, it seems likely that male fishers would be able to handle larger prey more efficiently than would females. Several earlier studies found few differences in diet between the sexes (Clem 1977 - in Banci 1989, Coulter 1966, Stevens 1968 - in Banci 1989). The differences observed, however, suggested that females may consume a greater portion of smaller prey at certain times of the year (Banci 1989). Porcupine quills, on the other hand, were found more frequently in males (Kelly 1977, Leonard 1980, Strickland and Douglas 1987, Arthur et al. 1989a). Powell (1982) suggested that male and female fishers are both opportunistic predators that eat anything they can catch and both are capable of killing porcupines. The only sexual difference in diet may be found in the maximum size of porcupine that can be killed. No data were available on the distribution of prey species by habitat type in the study area. However, one possible prey item that was abundant near water bodies, but may have had limited potential as prey for female fishers due to its size, was beaver (*Castor canadensis*).

Mixed forest stands (coniferous and mixed categories combined) were used less than expected by fishers only during the summer when separating the year by calendar season. They were also used less when the temperature was > 0°C and when snow was absent from the study area. This suggest that coniferous forest was utilized as thermal cover or to take advantage of a reduced snowpack. Leonard (1980) and Raine (1981) showed that habitat use by fishers in the boreal forest of Manitoba was altered by the thick, soft snow cover of midwinter. Fishers used different cover types and changed their activity patterns when snow levels were high. The greater overhead cover provided by coniferous stands, at a time of year when deciduous vegetation is reduced, may also provide fishers better protection from larger predators.

Few studies of habitat selection by fishers have considered stand area or stand insularity as a habitat variable (Rosenberg and Raphael 1986, Buskirk 1992). The size and spacing of woodlots in fragmented habitats may be crucial for animals to seek mates, find new food resources, or recolonize areas left vacant. Rosenberg and Raphael (1986) inventoried terrestrial vertebrates in Douglas-fir (*Pseudotsuga menziesii*) forests in northwestern California and found that fishers were relatively sensitive to forest fragmentation. The presence of fisher was most highly correlated with stand insularity. A weak, but positive, association between stand area and fisher occurrence was also noted, with fishers decreasing sharply in frequency of occurrence in stands < 100 ha. In central Alberta, fishers preferred continuous forest but their frequency of occurrence in insular stands, or woodlots, was in proportion to the availability. They did, however, selectively use woodlots with a larger mean area than those available. Larger forest blocks presumably offer greater cover and a higher abundance of prey species. The relatively large amount of edge, or ecotonal habitat, found around large woodlots may be important foraging habitat for fishers (Kelly 1977).

The use of woodlots by fishers increased in spring, likely due to movements associated with breeding and increased prey abundance. The animals abandoned continuous forest blocks, using small patches of forested habitat, and crossing roadway and open areas. This was an extremely dangerous time for fishers and most mortalities occurred then. In summer, fishers returned to continuous blocks but still used larger woodlots while vegetation was dense, presumably to explore and maximize prey encounters. Movements outside of the continuous forest continued to decrease in fall, when no fishers were located in woodlots, and winter, when they were found there only twice.

The use of woodlots by fishers increased during the cold season and when snow was present. This would seem to contradict our earlier conclusion that woodlots were used less during fall and winter. However, average below 0°C temperatures, as well as snow cover, continued well into March during both years of the study and increased use of woodlots associated with spring movements occurred mainly between March and April. This change in behavior during the breeding season appeared to be independent of external climatic factors such as snow and cold.

Fishers in this study preferred to inhabit inaccessible forest stands, well away from roadways, housing, farms and other human activity. These areas, however, would be traversed by fishers while travelling between forested blocks, especially in springtime when increased exploratory movements made encounters necessary. Arthur et al. (1989a, b) found similar results in a densely populated (15 people/km^2) region of south-central Maine. Fishers there also inhabited relatively continuous blocks of forest, but tolerated a fairly high degree of human activity. The fact that male fishers were located farther from roads than were females may relate to their apparent selection for water. Most large bodies of water found in the study area were located within the reserves, far from roadways. If males associated themselves with water for the coniferous cover present, or for specific prey items found in that habitat, as discussed earlier, they would concurrently appear to avoid roads. On the other hand, if males were intolerant of roads, they would need large areas of relatively pristine habitat to establish home ranges that would not be bisected by roads. This requirement could only be found within the sanctuaries where the lakes and ponds were located. Female fishers were often located within forest stands that were surrounded by road corridors and housing developments, but with few major water bodies.

Fishers also selected areas with greater slope than expected based on the habitat available. This was due in large part to the agricultural industry that dominates the study area. Locations with little slope were most often found in fields, pastures and small clearings. The areas left forested were rolling and often marshy; they were unsuitable for development but able to support fishers. The high degree of diversity and interspersion found in this "knob and kettle" habitat most likely added to prey diversity and denning opportunities.

Multivariate analysis of habitat characteristics, sampled within occupied and unoccupied areas, indicated that density of the understory vegetation was the most important habitat requirement for fishers. Most studies of fisher habitat use recognize the necessity of cover, but measure only the overstory type and density to define it (de Vos 1952, Clem 1977, - in Banci 1989 Raine 1981, Johnson 1984). Arthur et al. (1989a) measured understory while surveying fisher trails in Maine and found that stands with no understory and those with sparse coniferous understory, were most frequently used. Although this result appears to conflict with what was found in central Alberta, when compared to habitat availability, no strong preference or avoidance of understory type by fishers in Maine was observed. As well, distances that fishers travelled in dense understory were underestimated by Arthur et al. (1989a) due to dense snowshoe hare patches found in that habitat, obscuring any fisher tracks that may have occurred. A selection for habitat with dense understory vegetation by fishers in Maine may, therefore, have gone undetected.

Allen's (1983) Habitat Suitability Index model for fishers also did not consider understory vegetation as an important component of fisher habitat. He assumed that fisher populations were restricted by their winter/early spring habitat requirements, i.e., a dense canopy consisting mainly of mature coniferous trees. He also assumed that this habitat type would support adequate numbers of prey to meet the fisher's food requirements, and contain sufficient numbers of potential den sites to meet the reproductive needs of the species. Thomasma et al. (1991) provided the first attempt at validating this model in the northern hardwood forest of Michigan. She concluded that mean dbh of overstory trees and percent of overstory canopy composed of deciduous species were the only variables that significantly contributed to the model. Percent tree canopy and tree canopy diversity were not significant and did not enter into the model. Conversely, in this study, canopy closure and diversity were the only two components of tree overstory that improved the ability to distinguish between occupied and unoccupied sites.

The characteristics of habitat selected by fishers in this study all reflect the requirements of cover and structural diversity that are commonly noted in studies of fisher habitat use (all studies cited). In the deciduous-dominated forests of central Alberta, these requirements are provided by a combination of parameters found in both the overstory and understory. The presence of dense coniferous cover to cope during winter is probably not necessary in the aspen parkland region because temperatures are relatively mild and snowfall is light. The results of this study agree with the conclusions of Strickland et al. (1982) and Arthur et al. (1989a) that, given the diversity of the fisher's diet, optimum habitat may consist of any forested area that provides a suitable prey base.

Although Allen's (1983) model was developed for application throughout the range of the fisher, it appears to have limited ability to predict suitable fisher habitat in the aspen parkland of Alberta. A problem with HSI models is that, even in the case of species for which systematic studies have been done, models tend to over generalize. Much ecological literature indicates that from one subspecies, ecotype, or local population to another, important behavioral differences in habitat use can occur (Laymon and Barrett 1986). Also, HSI models have essentially been based on site-specific, structural characteristics of habitats without including landscape characteristics such as habitat size and spacing, or biological components such as competition and predation (Capen et al. 1986, Krohn 1992).

Interpretation of studies involving habitat use versus non-use are problematic for several reasons. The primary difficulty is obtaining the assurance that plots classified as non-use are not suitable habitat. An important assumption of habitat selection models based on multivariate statistics is that as population density increases habitats of decreasing suitability will be used (Brennan et al. 1986, Krohn 1992). Because this study involved a re-introduced population of fishers, it is likely that the population was below carrying capacity and areas of suitable habitat, which were classified as un-used, were vacant only because there were no animals available to occupy them. As the population expands, best habitats should be occupied first, fair habitats next, and poor habitats last. It is therefore also likely that habitat classified as "used" in this study was the most suitable habitat available to fishers.

Furthermore, differences between habitat parameters of fisher use sites and habitats available, which are interpreted as habitat selection, may or may not represent habitat selection in the view of the fisher (Edge et al. 1987). An attempt was made, however, to decrease confounding variables in this study by sampling habitat available in areas adjacent to fisher home range areas. This served to keep landscape characteristics, such as forest type, distances to disturbance, etc., relatively equal. Therefore, I believe that this analysis accurately reflects the pattern of fisher habitat selection during this study.

MANAGEMENT IMPLICATIONS

Because fisher have likely been absent from the aspen parkland of Alberta for almost a century, nothing was known of their life history and behavior in this habitat type. Studies of fishers in boreal forest areas suggest that they are restricted to coniferous habitat due to the thermal cover and more favorable snow conditions found there. However, the relatively low snowfall received in east-central Alberta, and milder temperatures, may render large expanses of coniferous cover unnecessary for fishers, assuming there is a large enough prey base to support them. Fishers in this study did use the small patches of coniferous cover available more often in winter, suggesting that they do provide some refuge from the weather. Therefore it is important to maintain this forest diversity within the deciduous stands. Large tracts of contiguous forest must be retained in its pristine condition to give fishers access to undisturbed areas large enough to establish their relatively large home range areas. It has been estimated that martens and fishers have home ranges that are about 50 times that predicted on the basis of body size (Buskirk 1992). Areas within forested blocks that have reduced canopy closure may still be suitable fisher habitat if the density of woody stems in the understory is high. Rolling topography and high tree canopy diversity are also important for habitat quality because they maintain forest diversity and the abundance of prey species.

For the fisher population in central Alberta to expand it will be necessary to develop and retain large woodlots and treed travel corridors for dispersal and exploratory movements. Arthur et al. (1993) observed that the dispersal distance of juvenile fishers in Maine was quite short ($\bar{x}$ = 10.8 km for males and $\bar{x}$ = 11.2 km for females) suggesting that they would not readily recolonize large areas from which they had been extirpated. The fisher re-introduction area in this study is well removed from populations to the north found in boreal forest habitat and invasion from that area is extremely unlikely. Short dispersal distances also suggest that maintaining viable fisher populations may be difficult in areas where suitable habitat patches are small and widely separated. By maintaining large expanses of habitat, connected by a mosaic of forested patches within the agricultural areas, fishers will be provided with suitable and safe travel routes, which may reduce mortality associated with the crossing of open areas during long-distance movements.

The pattern of woodlot usage by fisher in the aspen parkland points to further management strategies. Fishers are easily captured in traps set for felids and canids (Cole and Proulx 1994). In a fisher population management program, fall and winter trapping of these furbearers could be restricted to woodlots that are not connected to corridors which are infrequently used by fishers during those seasons. The future success of the reintroduced fisher population will also be contingent upon the cooperation of the landowners to tolerate the presence of this carnivore. Although no cases of damages to domestic animals were documented during this study, many residents were concerned about potential problems. Because fishers will readily take bait they are also susceptible to traps and poisons that have been set out for species such as skunks (*Mephitis mephitis*) and coyotes (*Canis latrans*) which are deemed to be a problem. The practice of indiscriminate predator control methods by some landowners must therefore be addressed.

FUTURE RESEARCH

Further studies of habitat selection by fishers should include the analyses of both landscape characteristics and site-specific structural characteristics of the habitat. Parameters that can be measured through airphoto interpretation, such as forest type, canopy cover, and distance to roads and water, were not enough to define suitable habitat in this study. Field-sampling of the understory, overstory and topography revealed that unoccupied sites, classified as suitable fisher habitat through landscape measurements, differed from occupied at a finer scale. It may also be useful to observe the sequence of habitat occupancy or abandonment as the population changes in order to measure the degree of habitat suitability. Once we know what distinguishes "best" habitat from fair habitat, poor habitat, or unsuitable habitat, and know the behavior of fishers within each, we may accurately predict the carrying capacity of the area for this species.

In order to manage the population for sustainability, it will also be necessary to gather information on its demography. Biological variables such as natality, mortality, predation, and competition need to be integrated with habitat data in order to project models that will accurately predict habitat-population dynamics in space and time. As well, testing the validity of these predictive models will be crucial in allowing us to manage for population maintenance and biological diversity as habitats continue to change.

As the population expands animals may be forced to occupy areas that are less remote, and be subjected to a relatively higher level of disturbance. How fishers react to these disturbances, such as roads, farms, housing, and other developments, should be closely monitored. If animals are unable to utilize areas subject to considerable impacts by humans, the potential for further expansion of fisher populations in central Alberta, or other high use areas, will be severely limited.

Although the establishment of a viable fisher population in the aspen parklands of Alberta is far from certain, it does look hopeful. Since the conclusion of this study, fisher sightings have been reported from several locations within the study area. No conclusive evidence of reproduction has been obtained but two observations of juveniles (one of unknown sex sighted by a local resident, and one male inadvertently trapped in a beaver set) were reported in the fall of 1993.

LITERATURE CITED

Ackerman, B. B., F. A. Leban, M. D. Samuel, and E. O. Garton. 1990. User's Manual for Program Home Range. 2nd ed. Tech. Rep. No. 15, For., Wildl. and Range Exp. St., Univ. Idaho, Moscow, Idaho, USA. 80pp.

Alldredge, J. R., and J. T. Ratti. 1992. Further comparison of some statistical techniques for analysis of resource selection. J. Wildl. Manage. 56: 1-9.

Allen, A. W. 1983. Habitat suitability index models: fisher. U.S. Fish Wildl. Serv. FWS/OBS-82/10.45. 19pp.

Arthur, S. M. 1987. Ecology of fishers in south-central Maine. Ph.D. Thesis, Univ. Maine, Orono. 112pp.

_____, and W. B. Krohn. 1991. Activity patterns, movements, and reproductive ecology of fishers in south-central Maine. J. Mamm. 72: 379-385.

_____, _____, and J. R. Gilbert. 1989a. Habitat use and diet of fishers. J. Wildl. Manage. 53: 680-688.

____, _____, and _____. 1989b. Home range characteristics of adult fishers. J. Wildl. Manage. 53: 674-679.

_____, T. F. Paragi, and W. B. Krohn. 1993. Dispersal of juvenile fishers in Maine. J. Wildl. Manage. 57: 868-874.

Badry, M. J., G. Proulx, and P. M. Woodard. 1993. Reintroduction of fisher in the aspen parkland of Alberta. The Edmonton Naturalist 21(1): 23-26.

Banci, V. 1989. A fisher management study for British Columbia. B. C. Ministry of Environ., Wildl. Bull. No. B-63. Victoria, B. C. 127pp.

Bowen, W. D. 1982. Home range and spatial organization of coyotes in Jasper National Park, Alberta. J. Wildl. Manage. 46: 201-216.

Brennan, L. A., W. M. Block, and R. J. Gutierrez. 1986. The use of multivariate statistics for developing habitat suitability index models. Pages 177-182 in J. Verner, M. L. Morrison, and C. J. Ralph, eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison.

Buck, S., C. Mullis, and A. Mossman. 1979. A radio telemetry study of fishers in northwestern California. Cal-Neva Wildl. Trans. 1979: 166-172.

Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24: 346-352.

Buskirk, S. W. 1992. Conserving circumboreal forests for martens and fishers. Conserv. Biol. 6: 318-320.

_____, and L. L. McDonald. 1989. Analysis of variability in home-range size of the American marten. J. Wildl. Manage. 53: 997-1004.

Capen, D. E., J. W. Fenwick, D. B. Inkley, and A. C. Boynton. 1986. Multivariate models of songbird habitat in New England forests. Pages 171-175 in J. Verner M. L. Morrison, and C. J. Ralph. eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison.

Cole, P. J., and G. Proulx. 1994. Leghold trapping: a cause of serious injuries to fishers. *Martes* Working Group Newsletter 2(1): 14-15.

Coulter, M. W. 1966. Ecology and management of fishers in Maine. Ph.D. Thesis, Syracuse Univ., Syracuse, N.Y. 183pp.

de Vos, A. 1952. Ecology and management of fisher and marten in Ontario. Tech. Bull. Ont. Dep. Lands For., Wild. Series No. 1. 90pp.

Dixon, K. R., and J. A. Chapman. 1980. Harmonic mean measure of animal activity areas. Ecology 61: 1040-1044.

Dodge, W. E. 1982. Porcupine *Erethizon dorsatum.* Pages 355-366 in J. A. Chapman and G. A. Feldhamer, eds., Wild Mammals of North America: biology, management and economics. The John Hopkins Univ. Press, Baltimore, MD.

Douglas, C. W., and M. A. Strickland. 1987. Fisher. Pages 511-529 in. M. Novak, J. A. Baker, M. E. Obbard, and B. Malloch, eds., Wild furbearer management and conservation in North America. Ontario Trapper's Assoc., North Bay, ON.

Edge, W., C. L. Marcum, and Sally L. Olson-Edge. 1987. Summer habitat selection by elk in western Montana: a multivariate approach. J. Wildl. Manage. 51: 844-851.

Fargey, P. 1982. Ministik Lake Bird Sanctuary: resource evaluation for the AEC. Unpubl. Rep., Alberta Environmental Centre, Vegreville, AB. 50pp.

Green, J. E. 1980. Small mammal populations of northern Alberta. AOSERP Report, 107-108. Alberta Environment. Edmonton, AB.

Grinnell, J., S. J. Dixon, and L. M. Linsdale. 1937. Fur-bearing mammals of California: their natural history, systematic status and relations to man. Vol. I. Univ. Calif. Press, Berkeley. 375pp.

Hagmeier, E. M. 1956. Distribution of marten and fisher in North America. Can. Field Nat. 70: 149-168.

Hamilton, W. J., Jr., and A. H. Cook. 1955. The biology and management of the fisher in New York. N. Y. Fish and Game J. 2: 13-35.

Hardy Associates Ltd. 1986. Ecological land classification of Elk Island National Park. Rep. prepared for Parks Canada, Calgary, AB. 44pp.

Harris, S., W. J. Cresswell, P. G. Forde, W. J. Trewhella, T. Woollard, and S. Wray. 1990. Home-range analysis using radio-tracking data - review of problems and techniques particularly as applied to the study of mammals. Mammal Rev. 20: 97-123.

Ingram, R. 1973. Wolverine, fisher, and marten in central Oregon. Oreg. State Game Comm., Cent. Reg. Admin. Rep. No. 73-2. 41pp.

Jennings, D. B. 1983. The late quaternary geomorphology of Elk Island National Park, Central Alberta. M. S. Thesis. Univ. Alberta, Edmonton, AB. 199pp.

Johnson, S. A. 1984. Home ranges, movements, and habitat use of fishers in Wisconsin. M.S. Thesis, Univ. Wisconsin, Stevens Point, Wis. 78pp.

Kelly, G. M. 1977. Fisher (*Martes pennanti)* biology in the White Mountain National Forest and adjacent areas. Ph.D. Thesis, Univ. Massachusetts, Amherst. 130pp.

Klecka, W. R. 1980. Discriminant analysis. Sage Publications, London, U. K. 71pp.

Krohn, W. B. 1992. Sequence of habitat occupancy and abandonment: potential standards for testing habitat models. Wildl. Soc. Bull. 20: 441-444.

Laundré, J. W., and B. L. Keller. 1984. Home-range size of coyotes: a critical review. J. Wildl. Manage. 48: 127-139.

Laymon, S. A., and R. H. Barrett. 1986. Developing and testing habitat-capability models: pitfalls and recommendations. Pages 87-91 in

J. Verner, M. L. Morrison, and C. J. Ralph, eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison, Wis.

Lee, J. E., T. C. White, R. A. Garrott, R. M. Bertmann, and A. W. Alldredge. 1985. Assessing accuracy of a radio-telemetry system for estimating animal locations. J. Wildl. Manage. 49: 658-663.

Leonard, R. D. 1980. The winter activity and movements, winter diet, and breeding biology of the fisher (*Martes pennanti*) in southeastern Manitoba. M.S. Thesis, Univ. Manitoba, Winnipeg. 181pp.

Longley, R. 1972. The climate of the provinces. Environ. Can, Atmospheric Environ. Climatological Studies 13: 79pp.

Marcum, C. L., and D. O. Loftsgaarden. 1980. A non-mapping technique for studying habitat preferences. J. Wildl. Manage. 44: 963-968.

Maser, C., R. G. Anderson, K. Cromack, Jr., J. T. Williams, and R. E. Martin. 1979. Dead and downed woody material. Pages 78-95 in J. W. Thomas ed., Wildlife habitats in managed forests - The Blue Mountains of Oregon and Washington. USDA For. Serv. Agric. Handb. No. 553. 511pp.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. Am. Wildl. Nat. 37: 223-249.

Morrison, D. F. 1976. Multivariate statistical methods. Second ed. McGraw-Hill, New York, N. Y. 415pp.

Neu, C. W., C. R. Byers and J. M. Peek. 1974. Technique for analysis of utilization - availability data. J. Wildl. Manage. 38: 541-545.

Nordlund, H. J. 1977. Blackfoot Grazing Association and the Cooking Lake Moraine. Internal Rep., Public Lands Division, Alberta Dep. Energy and Natural Resources, Edmonton, AB. 18pp.

Nordyke, K. A. and S. W. Buskirk. 1991. Southern red-backed vole (*Clethrionomys gapperi*) populations in relation to stand succession and old-growth characteristics in the central Rocky Mountains. Can. Field Nat. 105: 330-334.

Ohmann, L. F., and R. R. Ream. 1971. Wilderness ecology: a method of sampling and summarizing data for plant community classification. USDA For. Serv. Res. Pap. NC-49. 14pp.

Pittaway, R. J. 1978. Observations on the behaviour of fisher (*Martes pennanti*) in Algonquin Park, Ontario. Nat. Can. (Que.) 105: 487-489.

Powell, R. A. 1982. The fisher: Life history, ecology, and behavior. Univ. Minnesota Press, Minneapolis. 217pp.

Proulx, G., A. J. Kolenosky, M. J. Badry, R. K. Drescher, K. Seidel, and P. J. Cole. 1994. Post-release movements of translocated fishers. Pages 197-203 in S. Buskirk, A. Harestad, M. Raphael, and R.

Powell, eds. Martens, sables, and fishers: biology and conservation. Comstock Publ. Assoc. Cornell Univ. Press, Ithaca, New York.

_____, and I. M. Pawlina. 1992. A plan of research for the management of the Beaver Hills Ecosystem. Unpubl. Rep. Alberta Research Council, Edmonton, AB. 25pp.

Raine, R. M. 1981. Winter food habits, responses to snow cover and movements of fisher (*Martes pennanti*) and marten (*Martes americana*) in southeastern Manitoba. M.S. Thesis, Univ. of Manitoba, Winnipeg. 145pp.

_____. 1982. Ranges of juvenile fisher, *Martes pennanti* and marten, *Martes americana*, in southwestern Manitoba. Can. Field Nat. 96: 431-438.

_____. 1983. Winter habitat use and responses to snow cover of fisher, *Martes pennanti* and marten, *Martes americana* in southeastern Manitoba. Can. J. Zool. 61: 25-34.

Rosenberg, K. V., and M. G. Raphael. 1986. Effects of forest fragmentation on vertebrates in Douglas fir forests. Pages 263-272 in J. Verner, M. L. Morrison, and C. J. Ralph, eds. Wildlife 2000: modeling habitat relationships of terrestrial vertebrates. Univ. Wisconsin Press, Madison, Wis.

Rowe, J. S. 1972. Forest regions of Canada. Dept. Environ. Can. For. Serv. Publ. 1300: 172pp.

SAS Institute Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. Cary N.C. 956pp.

Skinner, D. L. and A. W. Todd. 1988. Distribution and status of selected mammals in Alberta as indicated by trapper questionnaires in 1987. Alta. Fish and Wildl. Div., Edmonton, AB. 45pp.

Spencer, W. D., and R. H. Barrett. 1984. An evaluation of the harmonic mean measure for defining carnivore activity areas. Acta Zool. Fenn. 171: 255-259.

Stein, R. 1976. Hydrogeology of the Edmonton area, (NE Segment), Alberta. Alberta Research Council Rep. 76-1. 21pp.

Strickland, M. A., C. W. Douglas, M. Novak and N. P. Hunzinger. 1982. Fisher. Pages 586-598 <u>in</u> J. A. Chapman and G. A. Feldhamer, eds., Wild Mammals of North America: biology, management and economics. The John Hopkins Univ. Press, Baltimore, MD.

Swihart, R. K., and N. A. Slade. 1985a. Influence of sampling interval on estimates of home range size. J. Wildl. Manage. 49: 1019-1025.

_____, and _____. 1985b. Testing for independence of observations in animal movements. Ecology 66: 1176-1184.

Techman Ltd. 1979. Vegetation classification and evaluation - Elk Island National Park. Rep. prep. for Parks Canada, Western Region, Dept. Indian and North. Affairs. 138pp.

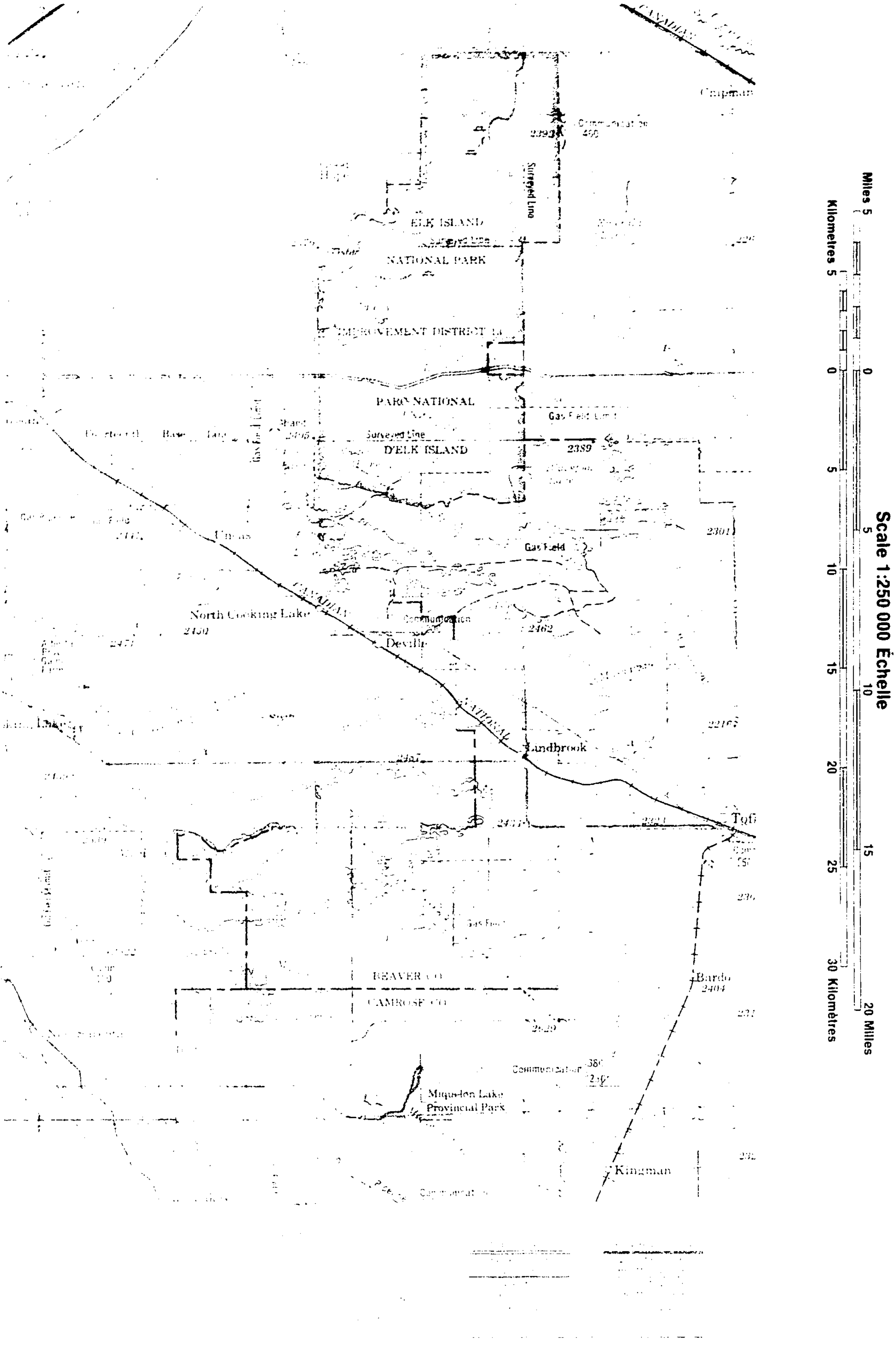
Thomasma, L. E., T.D. Drummer and R.O. Peterson. 1991. Testing the Habitat Suitability Index model for the fisher. Wildl. Soc. Bull. 19: 291-297.

Worton, B. J. 1987. A review of models of home range for animal movements. Ecological Modelling. 38: 277-298.

APPENDIX A

Map of the study area indicating primary and secondary highways, and permanent water bodies

(Series A502, Map 83H, Department of Energy,
Mines and Resources, 1983).


CANADIAN
Chipman
Communication 460
2392
Surveyed Line
ELK ISLAND
NATIONAL PARK
IMPROVEMENT DISTRICT
PARC NATIONAL
D'ELK ISLAND
Surveyed Line
Gas Field Limit
2389
2301
Uncas
Gas Field
North Cooking Lake
2450
Communication
2462
Deville
CANADIAN
NATIONAL
Lindbrook
2216
2321
Tofield
BEAVER CO
CAMROSE CO
Bardo
2404
2629
Communication
Miquelon Lake
Provincial Park
Kingman
Scale 1:250 000 Échelle
Miles 5 0 5 10 15 20 Milles
Kilometres 5 0 5 10 15 20 25 30 Kilomètres

APPENDIX B

Seasonal distribution of radiotelemetry locations

for fisher in central Alberta, 1990-1992.

Fisher	Month	Year	Relocations	Total
F10	Aug.	1991	5	
	Sep.	"	4	
	Oct.	"	3	
	Nov.	"	4	16
M11	Aug.	1991	3	
	Sep.	"	3	6
M12	Aug.	1991	3	
	Sep.	"	3	
	Oct.	"	1	7
F24	Mar.	1990	2	
	Apr.	"	1	3
M25	Jun.	1990	13	
	Jul.	"	5	
	Aug.	"	5	
	Sep.	"	7	
	Oct.	"	26	
	Nov.	"	2	58
M26	Apr.	1990	16	16
F28	Jun.	1990	13	
	Jul.	"	3	
	Aug.	"	4	
	Sep.	"	3	
	Oct.	"	2	
	Nov.	"	2	
	Dec.	"	2	
	Jan.	1991	2	
	Mar.	"	5	36

Fisher	Month	Year	Relocations	Total
M31	Jun.	1990	23	
	Jul.	"	53	
	Aug.	"	4	
	Sep.	"	4	
	Oct.	"	14	
	Nov.	"	2	
	Dec.	"	12	
	Jan.	1991	18	
	Mar.	"	2	132
M32	Jun.	1990	10	
	Jul.	"	1	11
F36	Mar.	1990	20	
	Apr.	"	1	
	Mar.	1991	4	
	Apr.	"	4	
	May	"	3	
	Jun.	"	3	
	Jul.	"	3	
	Aug.	"	1	39
F42	Mar.	1990	13	
	Apr.	"	43	
	May	"	30	
	Jun.	"	27	
	Jul.	"	26	
	Aug.	"	4	
	Sep.	"	5	
	Oct.	"	21	

Fisher	Month	Year	Relocations	Total
	Dec.	"	12	
	Jan.	1991	21	
	Feb.	"	2	
	Mar.	1991	5	
	Apr.	"	43	
	May	"	4	
	Jun	"	2	
	Jul.	"	3	261
F44	Mar.	1990	13	
	Apr.	"	6	
	May	"	51	
	Jun.	"	3	
	Jul.	"	10	
	Aug.	"	2	85
F46	Mar.	1990	3	3
F47	Jun.	1990	16	
	Jul.	"	7	
	Aug.	"	4	
	Sep.	"	4	
	Oct.	"	11	
	Nov.	"	2	
	Dec.	"	18	
	Jan.	1991	24	
	Feb.	"	2	
	Mar.	"	5	
	Apr.	"	26	
	May	"	3	

Fisher	Month	Year	Relocations	Total
	Jun.	"	1	
	Jul.	"	2	
	Aug.	"	1	
	Sep.	"	2	128
M50	Mar.	1990	13	
	Apr.	"	4	17
M52	Mar	1990	2	2
M53	Jun.	"	9	
	Jul.	"	3	
	Aug.	"	5	
	Sep.	"	4	
	Oct.	"	2	
	Nov.	"	2	
	Dec.	"	1	
	Jan.	1991	4	
	Feb.	"	1	
	Mar.	"	5	
	Apr.	"	27	
	May	"	6	
	Jun.	"	1	
	Jul.	"	3	
	Aug.	"	2	
	Sep.	"	4	
	Oct.	"	3	
	Nov.	"	1	
	Dec.	"	3	
	Jan.	1992	1	

Fisher	Month	Year	Relocations	Total
	May	"	2	89
F55	Jun.	1990	10	
	Aug.	"	3	
	Mar.	"	2	
	Apr.	"	22	
	May	"	3	
	Jun.	1990	3	
	Jul.	"	2	
	Aug.	"	1	
	Sep.	"	2	
	Oct.	"	2	
	Nov.	"	1	
	Dec.	"	2	
	Jan.	1992	2	
	Mar.	"	3	
	Jun.	"	1	
	Jul.	"	1	
	Sep.	"	1	61
F56	Mar.	1990	3	3
F57	Jun.	"	14	
	Jul.	"	9	
	Aug.	"	4	
	Sep.	"	4	
	Oct.	"	2	33

APPENDIX C

Individual case history of fishers reintroduced into the aspen parkland of Alberta, 1990-1991.

The release program involved 20 fishers captured in Ontario and Manitoba (3 were born in captivity). The animals were held in captivity in Vegreville, Alberta for 18-24 months. They were then kept in a quarantine situation allowing no contact with other animals and minimal contact with humans. One female and two males were sent to Washington State University where they underwent physiological testing for one year. They were returned to Vegreville. Observations in enclosures before release did not reveal any anomaly in the behavior of the animals.

Nine animals (3 groups consisting of two females and one male) were released in March, 1990, in the Ministik Sanctuary. In June 1990, 8 fishers (2 groups of two females and one male, and one group of one female and one male) were released in Elk Island National Park, the Blackfoot Grazing Reserve, and the Ministik Sanctuary. Three animals (one female and two males) were released individually in August, 1991, two in Ministik and one in the Blackfoot. All release sites were in continuous forest stands. Fishers were kept at sites in their respective nest boxes and connecting wire mesh holding pen for 3-5 days before release. Within a group, adult females were released one day before the males in hopes that they would scent-mark the grounds and entice the male to remain in their vicinity. Beaver meat was left at the nest box locations immediately prior to release. During the March, 1990, releases, the release area was saturated with beaver carcasses in an attempt to keep the fishers in the vicinity.

The following are individual case histories of each fisher reintroduced into the aspen parkland of Alberta during this study. Figures depicting annual home areas, of those animals for which sufficient data were obtained, have been included. Examples of home range areas divided by calendar season, temperature, and snow have also been included for several individuals. The case histories have been listed in order of release date.

FISHER M52

Fisher M52 was transported to his release site in central Ministik on March 8, 1990. His nest box was revisited on March 10 to add food and water and it was discovered that the animal had escaped through a broken seam in the mesh. Subsequent searches failed to locate his signal till March 15 when his carcass was located approximately 9 km northeast of his release site near a road. A postmortem revealed massive trauma to the left side of his body. suggestive of a vehicular accident.

FISHER F36

Fisher F36 was released March 14, 1990 at the north end of the Ministik Lake Bird Sanctuary. She moved steadily north and on March 18 was located north of Cooking Lake and in the same area as fisher M50. No contact between the two animals, however, was recorded. She continued to move north and by March 20 had crossed Highway 16, north of Ardrossan and inhabited scattered woodlot, surrounded by agricultural lands and poultry farms. Her signal was then lost till April 3 when it was located on mortality mode. The slipped collar was recovered in a willow bog, south of Joseph Lake in the southwest end of Ministik , almost 40 km south of her previous location. Fisher F36 was recaptured on March 11, 1991, north of Islet Lake in the Blackfoot Grazing Reserve, in a trap set for fisher F28. Her release weight of 4.7 kg had dropped to 2.7 kg and she was in excellent body condition. She was located regularly for several months afterwards, covering a large area from the north east end of Cooking Lake to the east side of Islet Lake. On August 22, 1991 her collar was located on mortality mode and her carcass was found 1 km west of Wanisan Lake in a small bog. Her body had been mostly eaten by animals and a postmortem could not determine the cause of death.

FISHER F56

Fisher F56 was released March 14, 1990 in central Ministik. By March 23 she had moved over 17 km south and was at the southern end of the study area. Intensive agricultural activity and little overhead cover likely deterred her from continuing southward movements. Her signal was then lost and not picked up again till March 28 when her slipped was collar located less than 1 km from her release site. The collar was found near a small snow den dug under a fallen tree.

FISHER M50

Fisher M50 was released on March 15, 1990 at the north end of the Ministik Sanctuary. He began moving north on March 15, crossing Highway 14 and then crossing Cooking Lake over the ice in the early hours of March 16. He remained on the north side of Cooking Lake till March 20, during which time he was often within 500 m of fisher F36. No actual physical contact between the two was recorded. On March 21 fisher M50 again began to move north. His signal was lost and subsequent searches failed to locate him. A telemetry flight on April 3 enabled us to find his signal approximately 10 km west of Redwater, 35 km northwest of his previous location. Fisher M50 was located again on April 11 and had moved over 30 km back south and was inhabiting a 200 x 800 m patch of deciduous forest at the northwest corner of Sherwood Park. The area was heavily populated and immediately adjacent to a busy city freeway. M50 could not be located again till April 20 at which time his collar was on mortality mode. His body was found in an open pasture on the west side of Beaverhill Lake, again over 30 km from his last location. A postmortem indicated that he died from intraspecific fight wound inflicted by fisher M26 who was discovered dead over 8 km to the north.

FISHER F24

Fisher F24 was released on March 27, 1990 near the centre of the Ministik Lake Sanctuary. No reliable locations were ever obtained for this animal because her radio-frequency was interfered with by an elk collar of the same frequency being stored at the University of Alberta's Ministik research facility. On April 5 F24's signal was received on mortality mode and her body retrieved approximately 1 km southwest of her release site. A postmortem revealed puncture wounds most likely inflicted by a bird of prey. Fisher F24 was the smallest animal involved in the reintroduction program with a release weight of 2940 g.

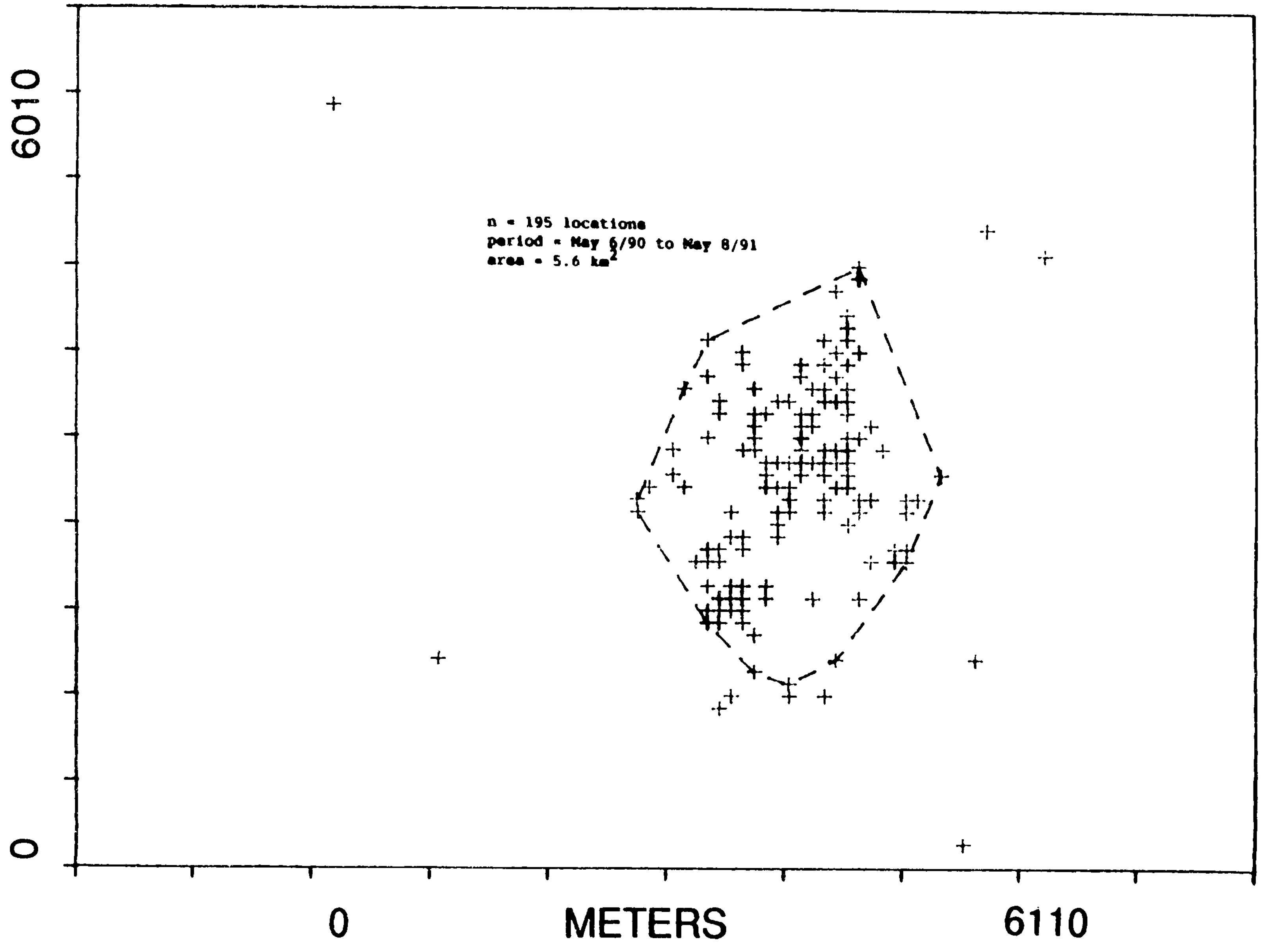
FISHER F46

Fisher F46 was released on March 27, 1990 near the centre of the Ministik Sanctuary. Due to problems with one of the telemetry receivers her signal could not be located after her release and her movements were unknown. On April 20 her signal was found on mortality mode and her slipped collar was located approximately 5 km west of her release location. No sign of the fisher was found near the collar but a snowshoe hare kill was located 150 m to the west.

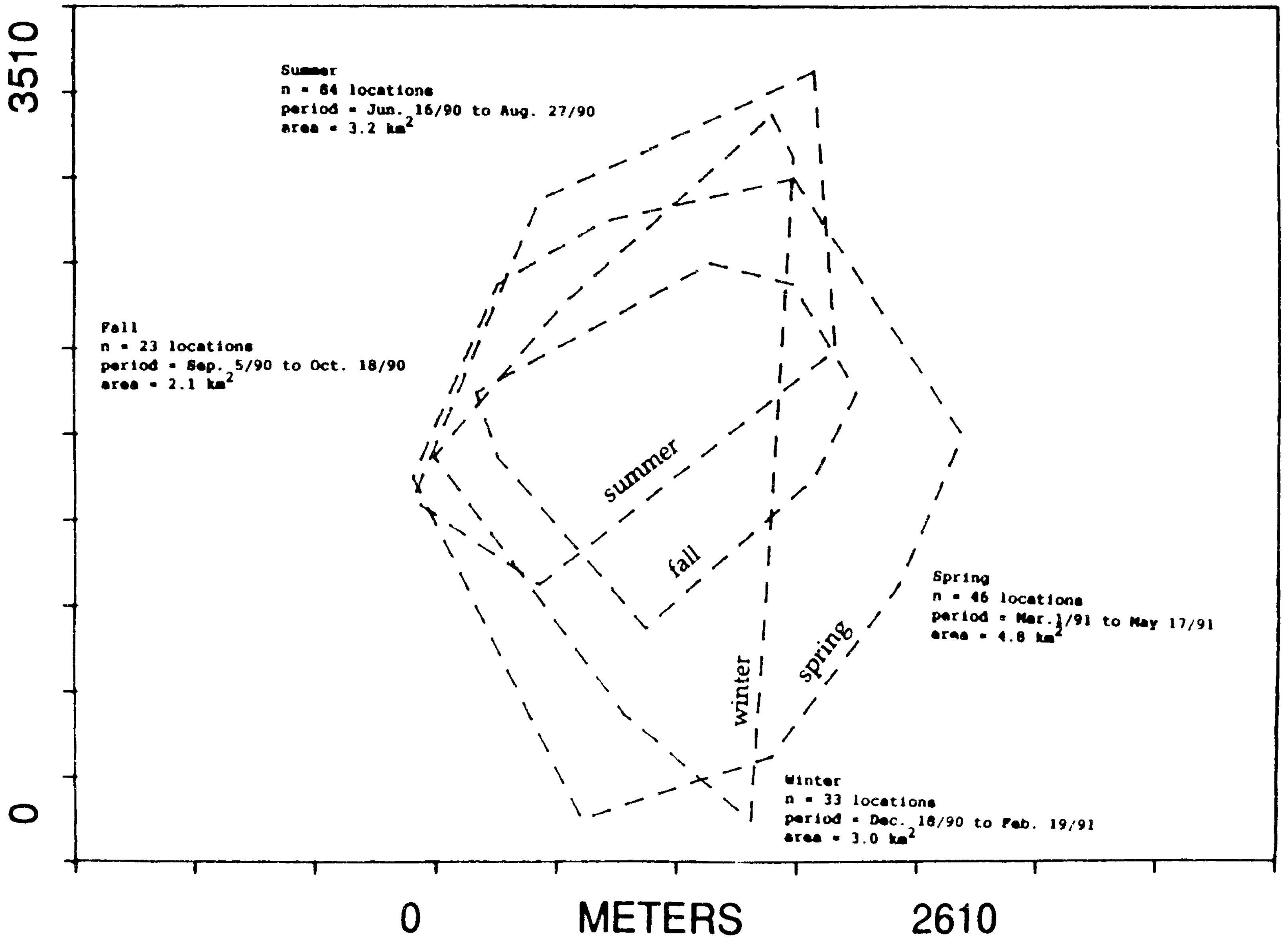
FISHER F42

Fisher F42 was released March 29, 1990 in the south east area of the Ministik Bird Sanctuary. She initially moved southeast, and the day following her release had travelled approximately 6 km to the north end of Miquelon Lake. Her signal was then lost for 3 weeks and on April 20 she was picked up again, now at the south end of Miquelon Lake, within the provincial park. She remained there till May 1, after which her signal was again lost. On May 6 F42 was located just north of the Ministik Lake Bird Sanctuary, approximately 17 km north of her previous location. She stayed in this area for the remainder of the time she was monitored, rarely crossing the roads that surrounded her small home range area. On February 14, 1991 F42 was recaptured and fitted with a radio collar. Her initial release weight of 4.5 kg had dropped to 3.6 kg and she was in good body condition. Two porcupine quills were embedded in her left cheek. From late February to early April she began to cross Township Road 510 to the south, entering the Ministik Lake Bird Sanctuary. It was at this time that she overlapped in range with fisher F55. On June 28, 1991 F42 was located east of Range Road 210, which was the first time she was known to have crossed that road. On July 19, 1991 fisher F42 was found in the ditch, 15 m from Range Road 210. She had been fatally struck by a vehicle.

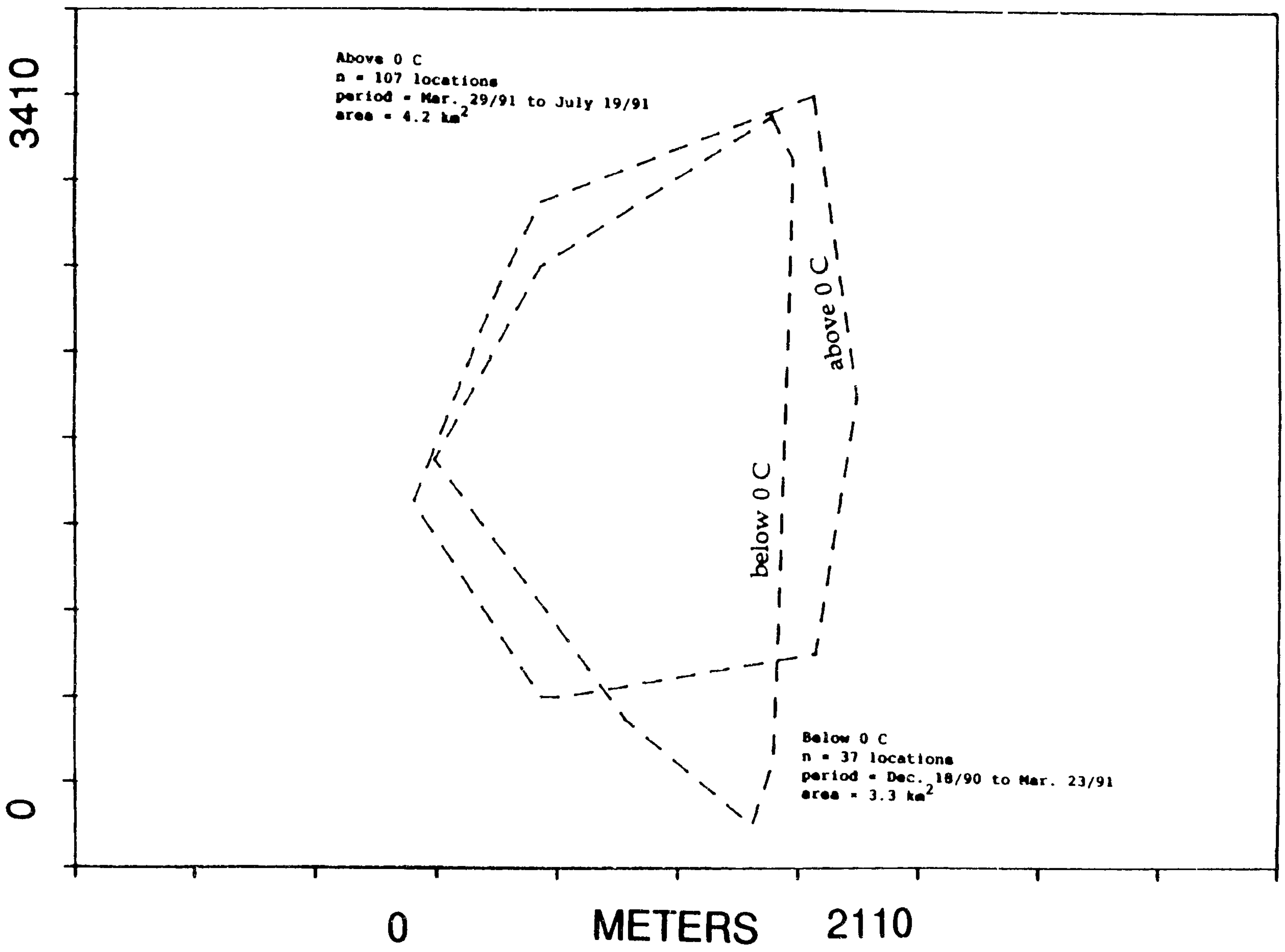
FISHER F42 ANNUAL HOME RANGE AREA



FISHER F42 CALENDAR SEASON HOME RANGE AREAS



FISHER F42 TEMPERATURE HOME RANGE AREAS



FISHER F44

Fisher F44 was released on March 29 at the south end of the Ministik Lake Sanctuary. She began moving east and by April 6 was over 15 km from her release site. She appeared to be using scattered, small stands of deciduous cover as she moved outside of the study area and into agricultural lands. On April 9 F44 had moved over 18 km back west, returning to the continuous forest stands. She remained in that area till April 30 when she was located 7 km further north, in a block of forest surrounded by roads, farms, and subdivisions. On May 8 she abandoned this area and began moving southeast. By May 14 she had travelled over 22 km and was just east of Miquelon Lake. She remained there till at least May 17, after which her signal was lost. She was not located again till June 15 when she was found on the east side of Hastings Lake, 18 km north of her last location. She continued to move northeast through the Blackfoot, then travelled south and on July 12 was located at the southeast corner of Blackfoot. She inhabited a heavily forested area surrounded by roads which she often crossed. On August 2 her collar was located on mortality mode. The slipped collar was later retrieved in dense bush.

FISHER M26

Fisher M26 was released on March 30, 1990 at the south end of the Ministik Lake Bird Sanctuary. On April 10 he was located approximately 22 km northwest of his release site in an area heavily populated with acreages and farms. By April 17 he had moved another 25 km to the west and was in the northeast corner of the Blackfoot Reserve. He remained there till April 20 when he again began moving north and crossed Highway 16. On April 23 his body was found in the middle of a pasture. He appeared to be in good health and had porcupine quills embedded under his jaw. A postmortem revealed bite marks on his body that coincided with the canine span of fisher M50 who was also found dead over 8 km away. It was concluded that fisher M25 died of intraspecific fight wounds.

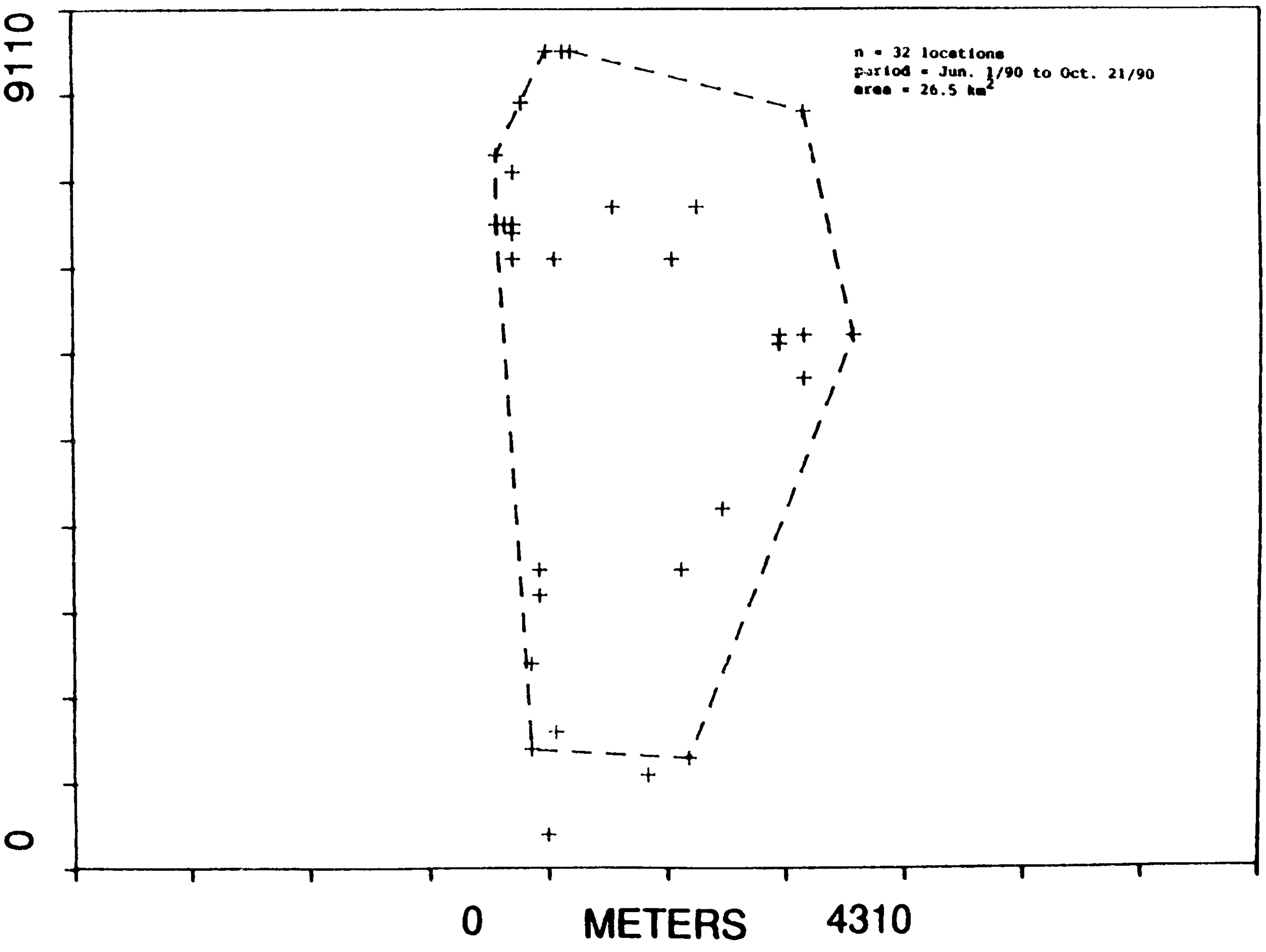
FISHER F28

Fisher F28 was released on June 1, 1990 in the southern portion of Elk Island National Park. She slowly moved south until June 18 when she was located on the east side of Islet Lake in the Blackfoot Grazing Reserve, approximately 6 km south of her release site. Fisher F28 remained in the Islet Lake area till March 29, 1991, when her collar was located on mortality mode and her body was later recovered. A postmortem revealed that she likely died of trauma caused by attack from a large domestic dog.

FISHER F57

Fisher F57 was released June 1, 1990 in the southern portion of Elk Island National Park. She remained in the vicinity of her release site throughout the summer and overlapped home range areas extensively with fisher M25 who had been released in the same area, at the same time. In September 1990, fisher F57 expanded her home range south into the Blackfoot Grazing Reserve and remained there till her last location was obtained October 9, 1990. Searches by ground and by air failed to locate her signal after that date and it was suspected that her collar failed prematurely.

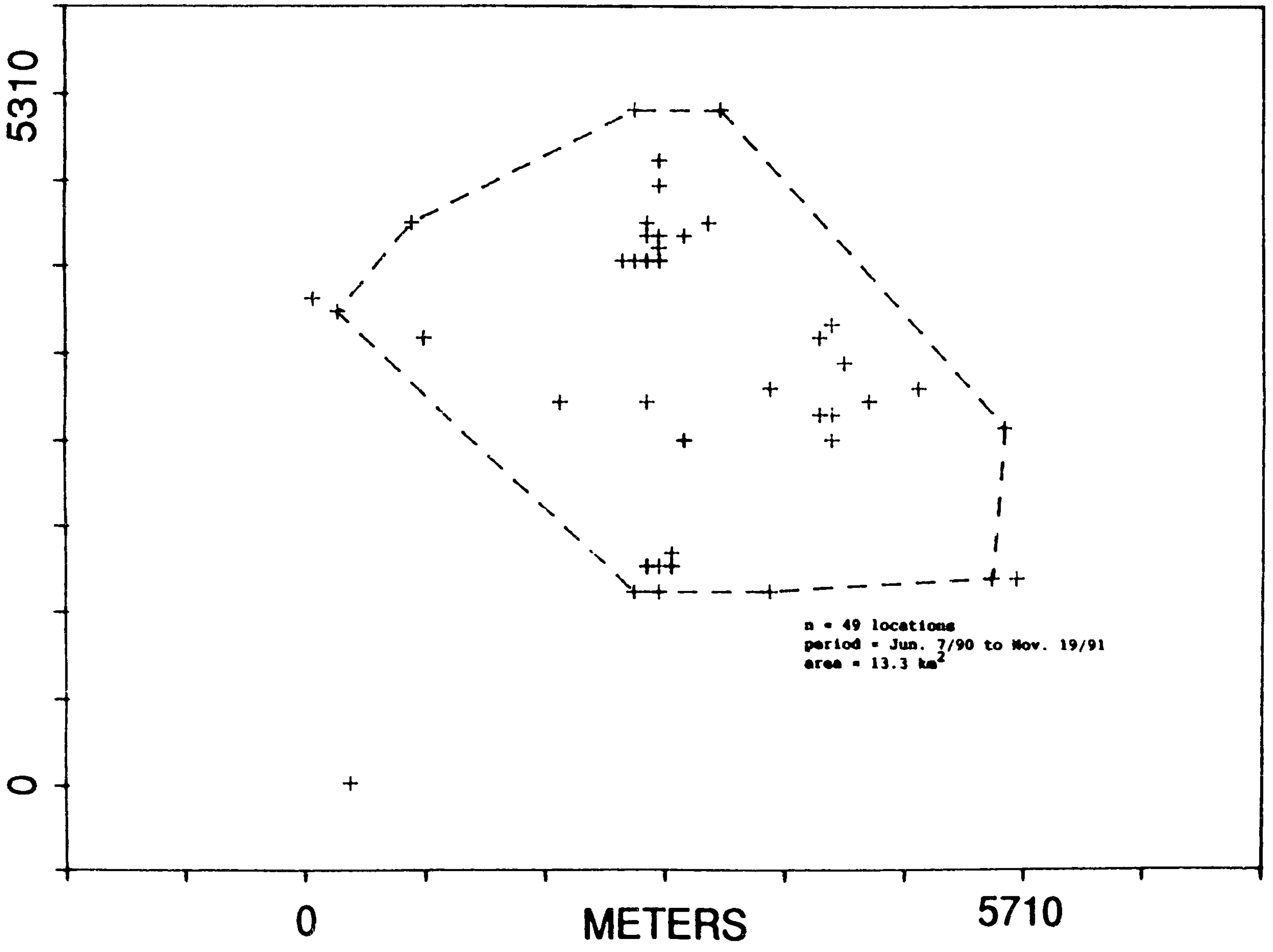
FISHER F57 ANNUAL HOME RANGE AREA



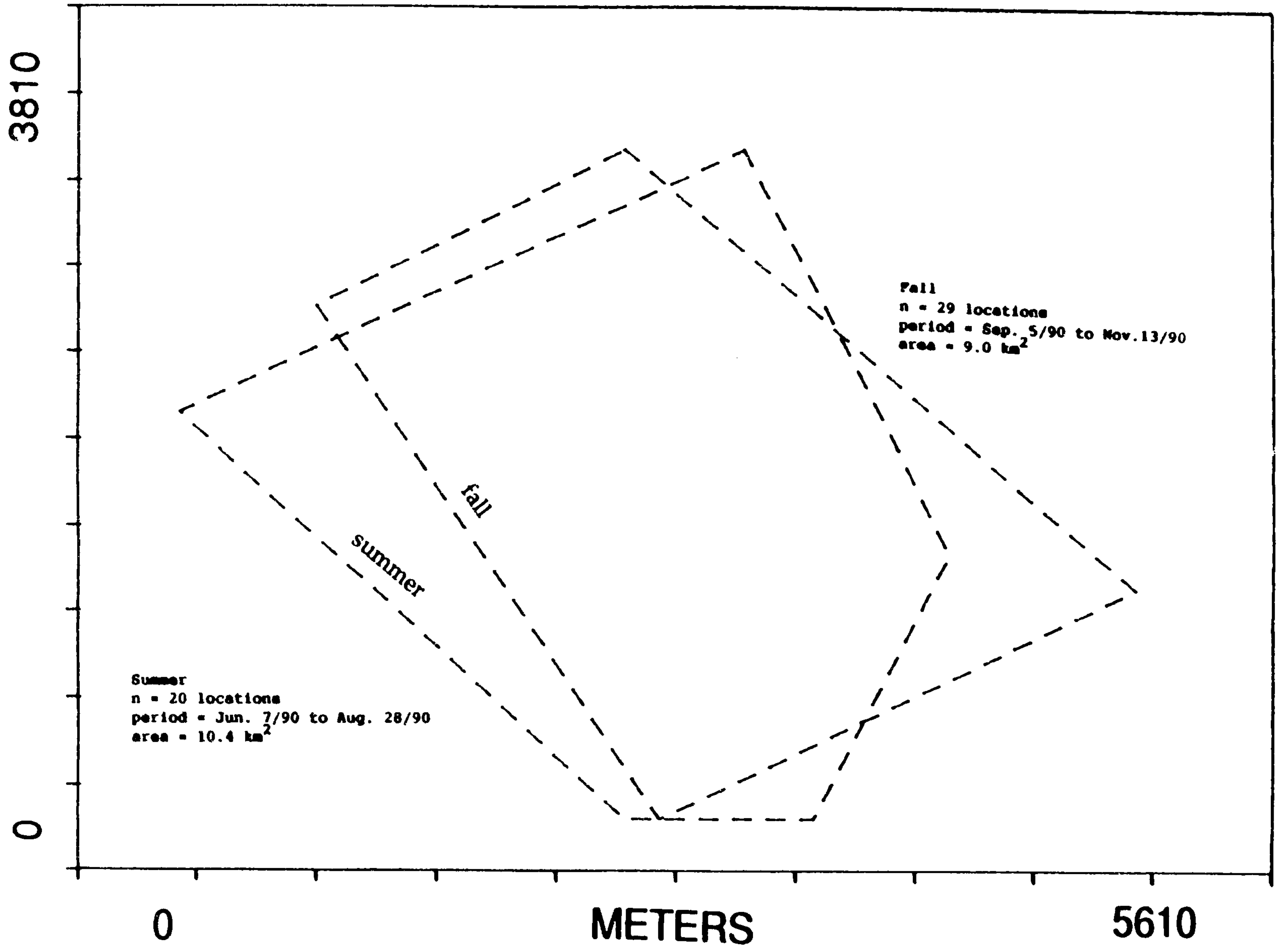
FISHER M25

Fisher M25 was released June 2, 1990 in the southern portion of Elk Island National Park. He remained in the area of his release site and did not make any long distance movements for the entire period that he was monitored. Fisher F57 was released in the same area, at the same time, and there was extensive overlap between her home range area and that of M25. The signal from fisher M25's radio-collar began sounding erratic in late August and attempts to recapture him to replace the collar were unsuccessful. The last location obtained for this animal was on November 28, 1990. At this time he appeared to be shifting his home range area to the east but too few locations were obtained to substantiate this.

FISHER M25 ANNUAL HOME RANGE AREA



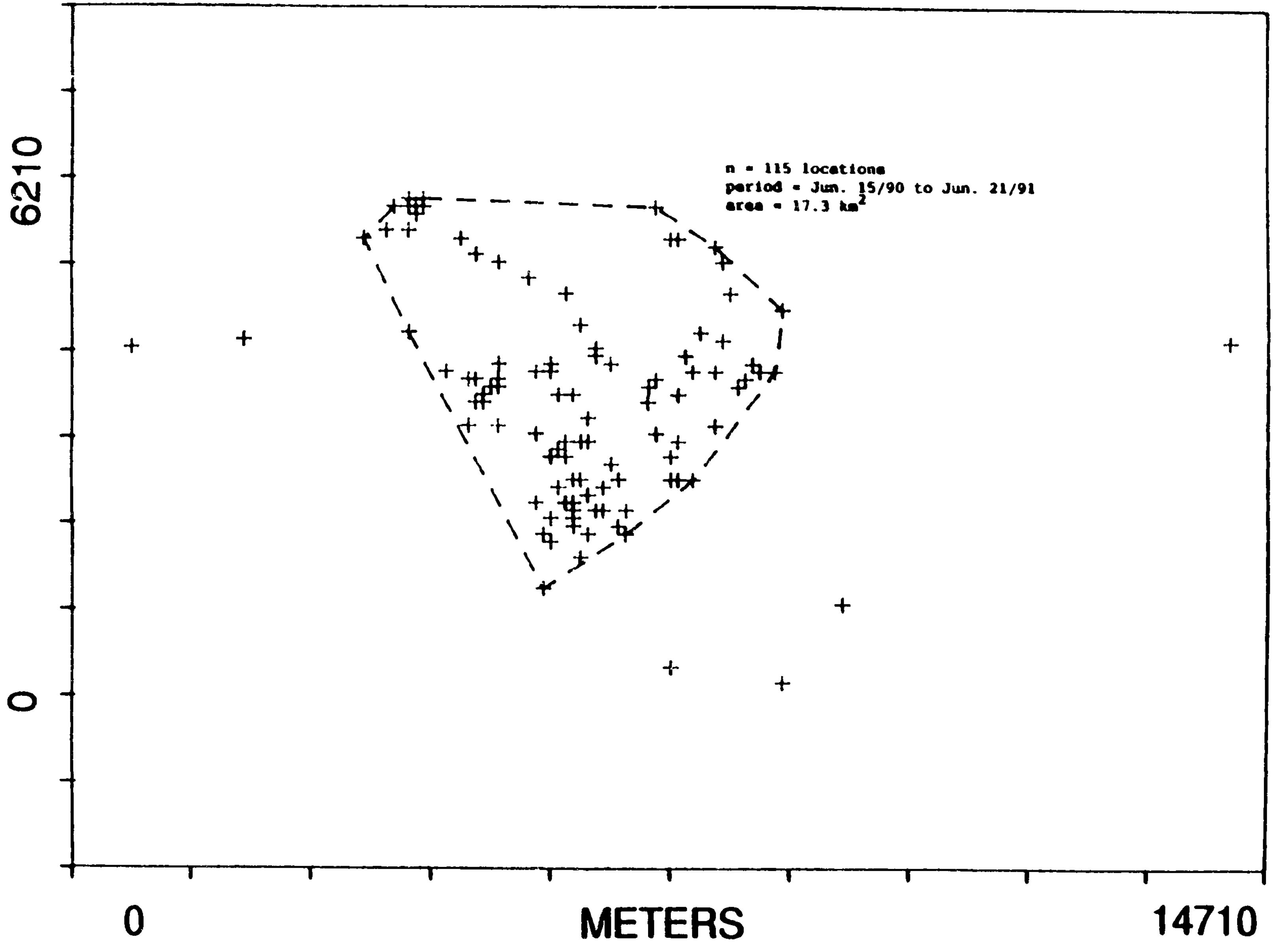
FISHER M25 CALENDAR SEASON HOME RANGE AREAS



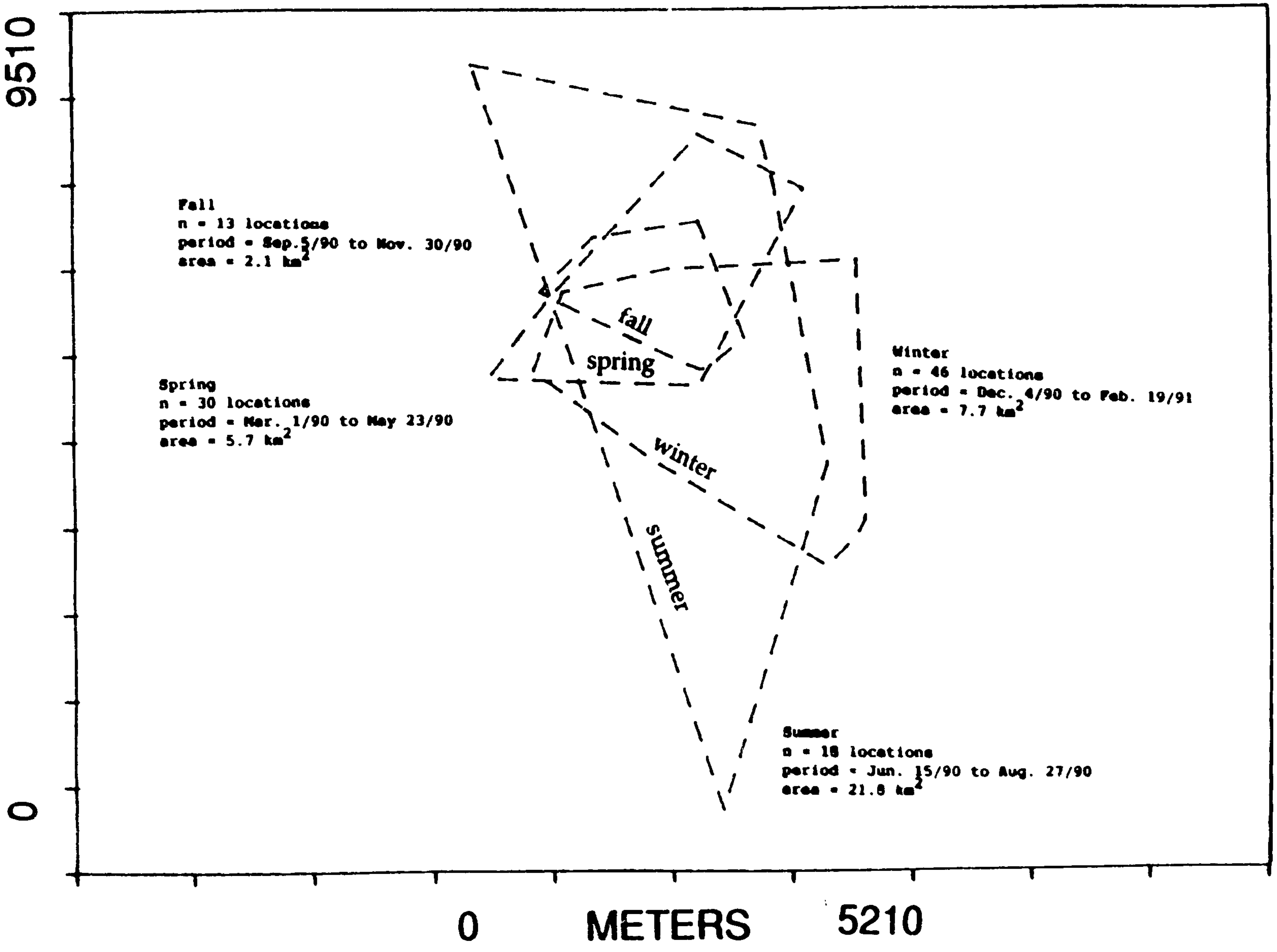
FISHER F47

Fisher F47 was released on June 7, 1990 in the southern end of the Blackfoot Grazing Reserve, near Islet Lake. She remained in that area for the entire time that she was monitored. On February 11, 1991 she was recaptured on the shore of Islet Lake and fitted with a new radio-collar. Her weight had dropped from 3.0 kg at release to 2.5 kg and she appeared to be in good health. In mid-April, fisher F47 shifted her activities to the southeast where she overlapped in range with fisher F53. It was suspected that a large male, fisher M32, may have been in this area also because it was near his release site. As well, two sightings of a large fisher had previously been reported. Unfortunately, fisher M32 had slipped his collar shortly after release and his location was never confirmed. Fisher F47 remained in this southeast section for only a few days before returning to the Islet Lake area where she remained until her last location was obtained on September 21, 1991. Her signal was lost due to suspected collar failure.

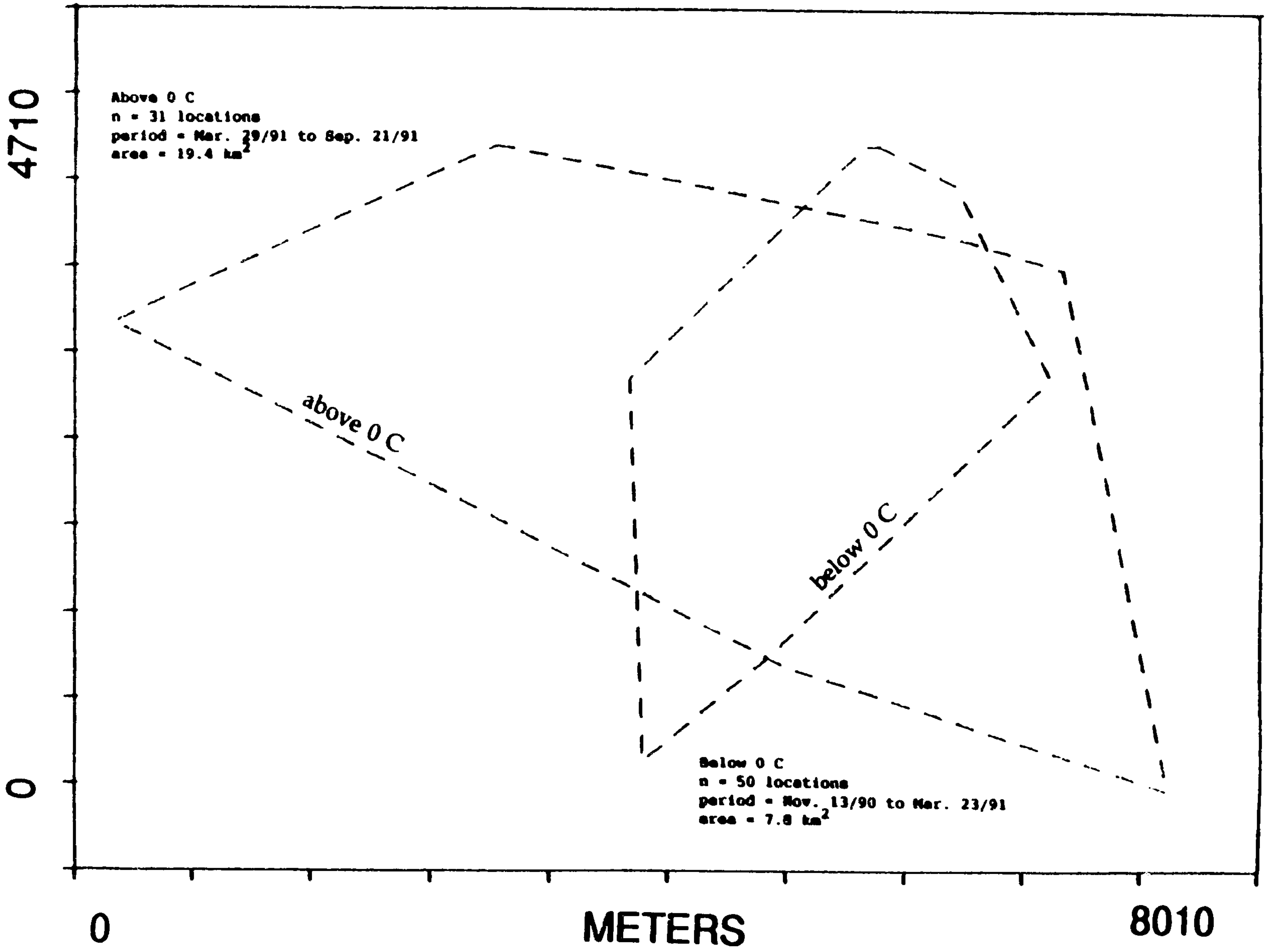
FISHER F47 ANNUAL HOME RANGE AREA



FISHER F47 CALENDAR SEASON HOME RANGE AREAS



FISHER F47 TEMPERATURE HOME RANGE AREAS



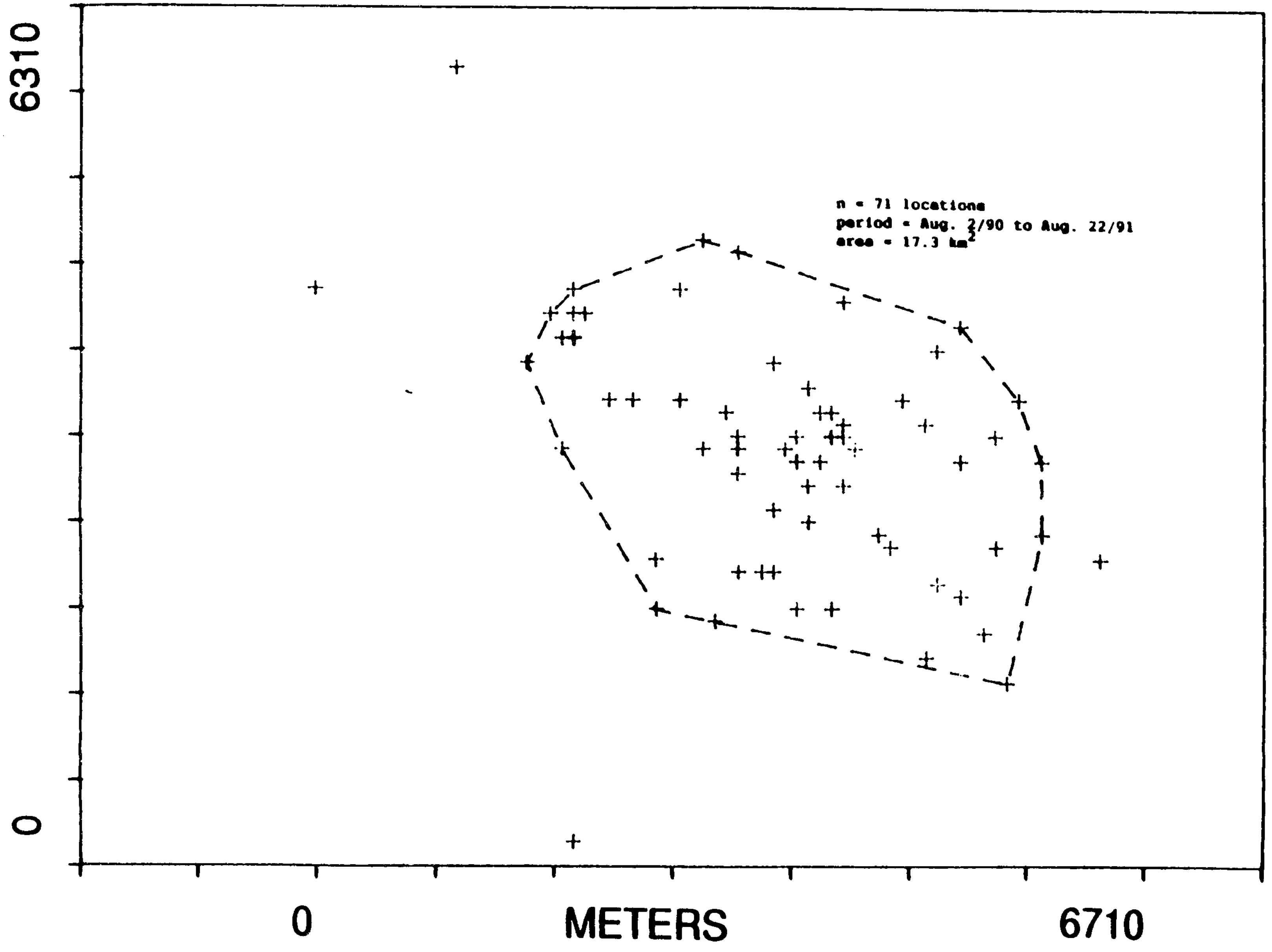
Above 0 C
n = 31 locations
period = Mar. 29/91 to Sep. 21/91
area = 19.4 km^2

Below 0 C
n = 50 locations
period = Nov. 13/90 to Mar. 23/91
area = 7.8 km^2

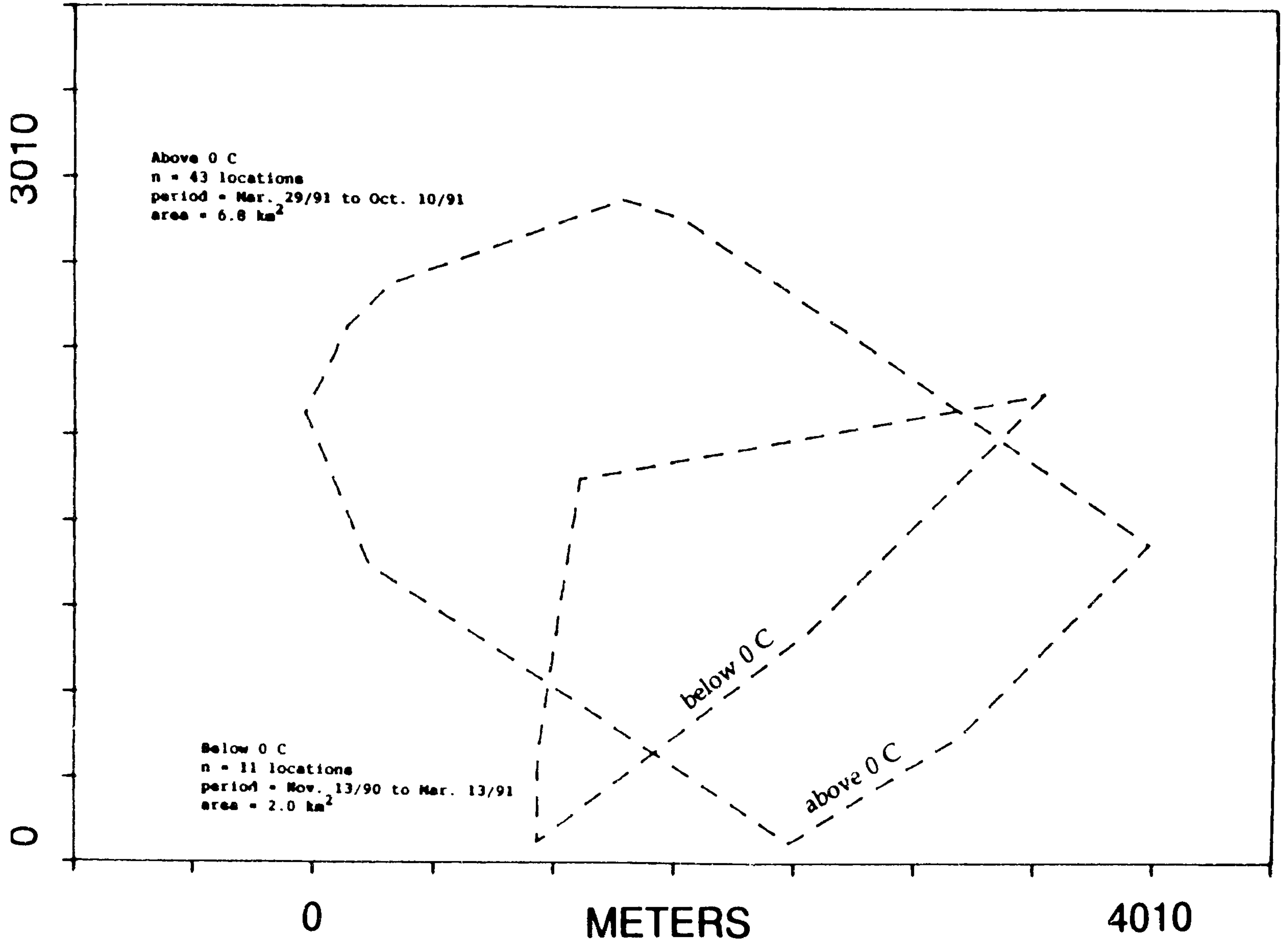
FISHER F53

Fisher F53 was released June 7, 1990 in the southern end of the Blackfoot Grazing Reserve. She immediately began moving north and by June 26 she was just north of Elk Island National Park, approximately 30 km from her release site. She turned back south and by August 2 was located at the south east boundary of the Blackfoot Grazing Reserve, less than 5 km from her release site. She remained in this area for the remainder of the time that she was monitored. On February 22, 1991, fisher F53 was recaptured and her radio collar was replaced. Her weight was 2.3 kg, down from her release weight of 3.1 kg. Fisher F53's home range overlapped with that of F47's during April of 1991 when it was suspected that male M32 was in the area. However, M32 had slipped his collar shortly after release and his location was never confirmed. An attempt to recapture F53 in January 1992 was unsuccessful and her signal became very erratic. She was last located on May 25, 1992. Subsequent searches for her signal were unsuccessful.

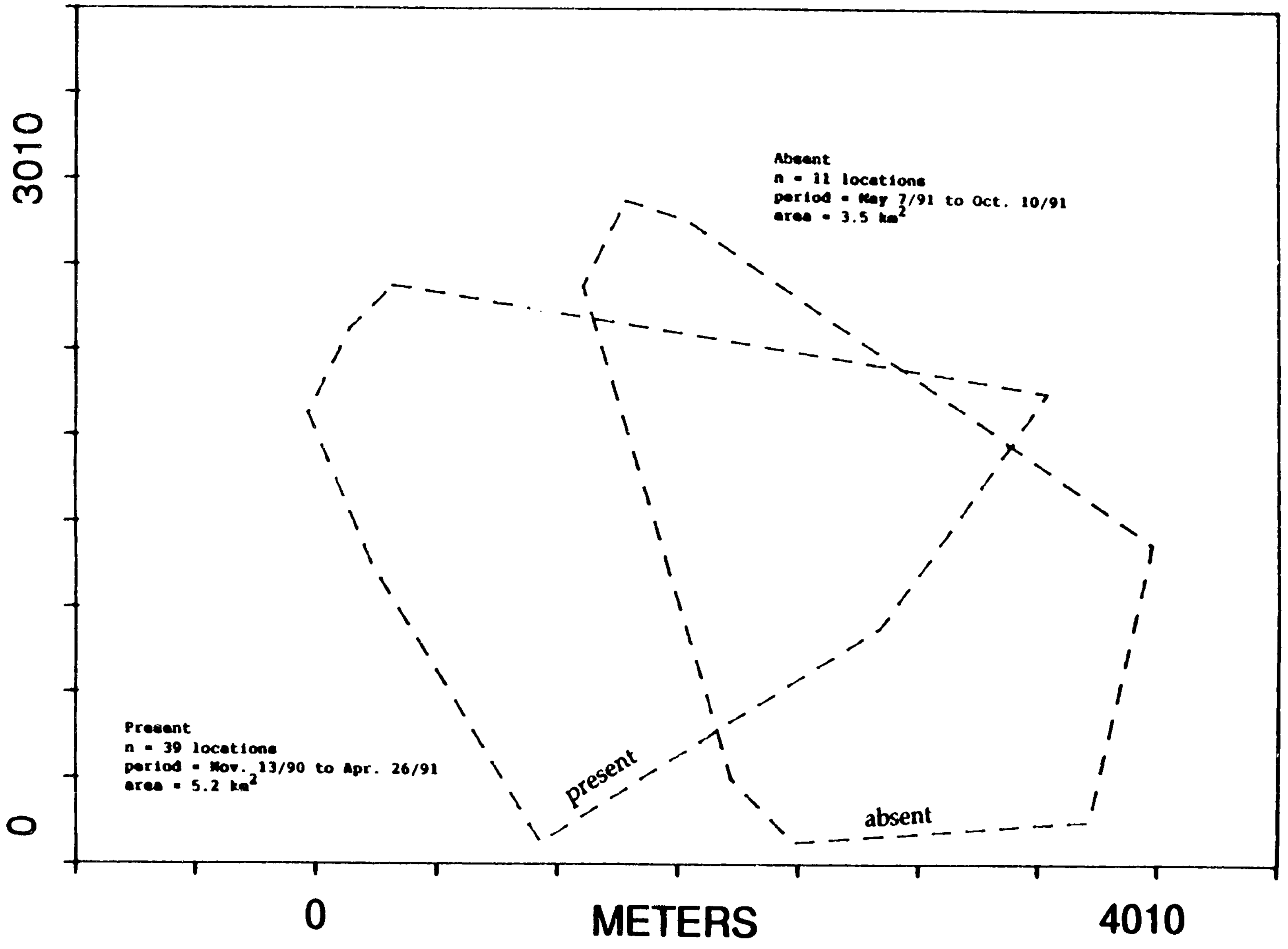
FISHER F53 ANNUAL HOME RANGE AREA



FISHER F53 TEMPERATURE HOME RANGE AREAS



FISHER F53 SNOW HOME RANGE AREAS



Absent
n = 11 locations
period = May 7/91 to Oct. 10/91
area = 3.5 km^2

Present
n = 39 locations
period = Nov. 13/90 to Apr. 26/91
area = 5.2 km^2

FISHER M32

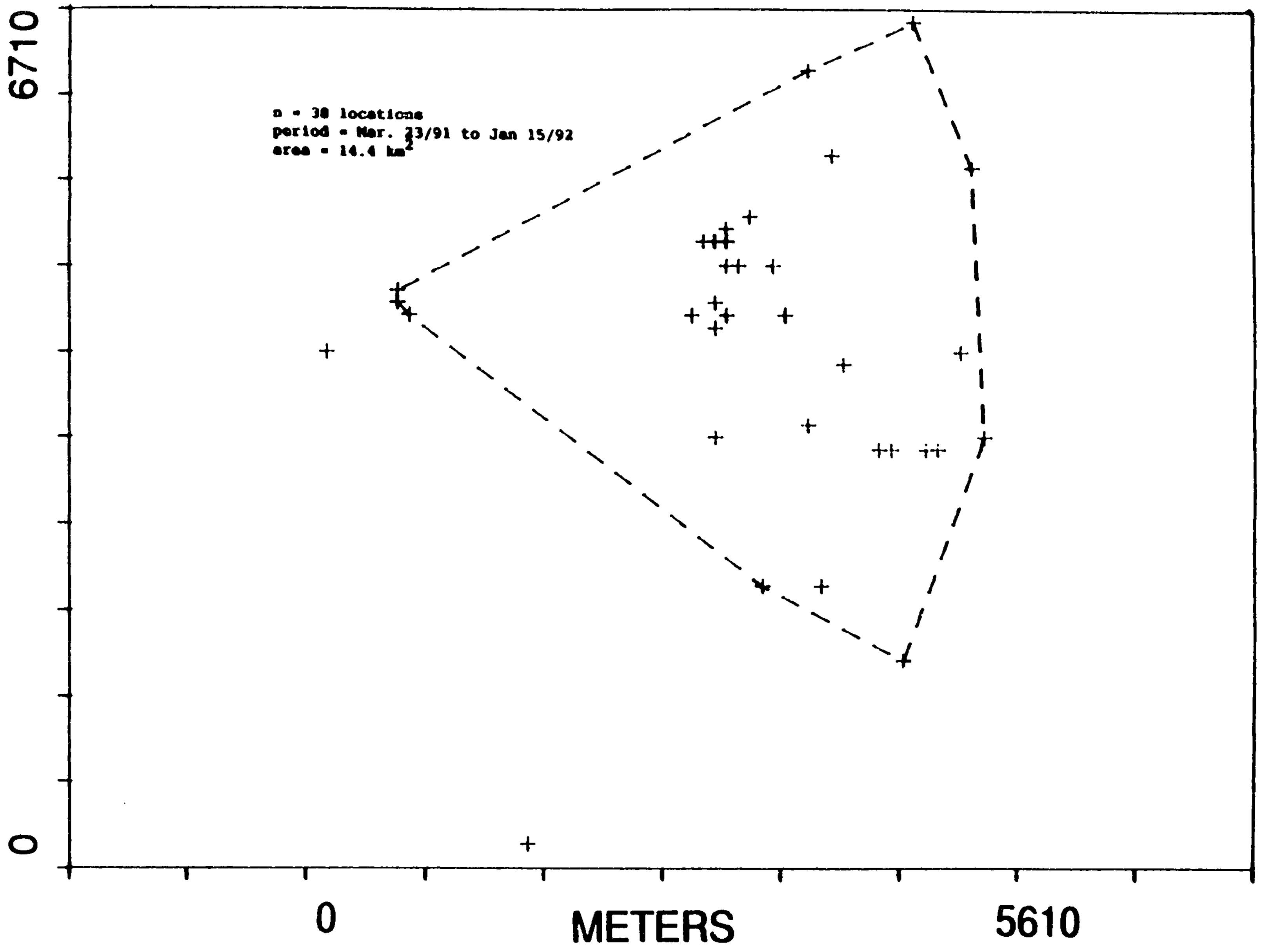
Fisher M32 was released on June 8, 1990 in the Blackfoot Grazing Reserve, north of Islet Lake. He remained at his nest box location and on June 15 was located approximately 200 m east of his release site. Three days later his collar was on mortality mode and was found at his previous location. An unsuccessful attempt was made to recapture M32 near his release site. A large male fisher was later sighted in the area, once the same summer by a wildlife technician, and again in December 1991 by a resident. This fisher was suspected to be M32.

FISHER F55

Fisher F55 was released June 13, 1990, in the north end of the Ministik Lake Bird Sanctuary. She began moving north east and by June 27 she had travelled over 32 km and was just east of Elk Island National Park, north of Highway 16. Her signal was then lost but picked up again on August 2. She had now travelled approximately 35 km west and occupied a heavily populated, but treed subdivision area to the south of Ardrossan. She was known to used that area until August 9 after which her signal was again lost. On March 23, 1991, while attempting to trap fisher M31, F55 was recaptured in the Ministik Lake Bird Sanctuary. Her original collar was no longer functioning and was replaced with a new one. Her weight had dropped from her release weight of 3.2 kg to 2.5 kg and she was in good body condition. She occupied the Watt Lake area, which had been occupied by M31 the previous fall, and was close to both fishers release locations. From mid-April to mid-May she moved slightly north and began overlapping with fisher F42. On April 11 both females appeared to be in almost the exact location. It was not possible to verify, however, if they made any physical contact. Fisher F55 then returned to the Watt Lake area and remained there till her last location was recorded on September 16,

1992. Subsequent searches failed to pick up her signal and it was assumed that her collar had failed.

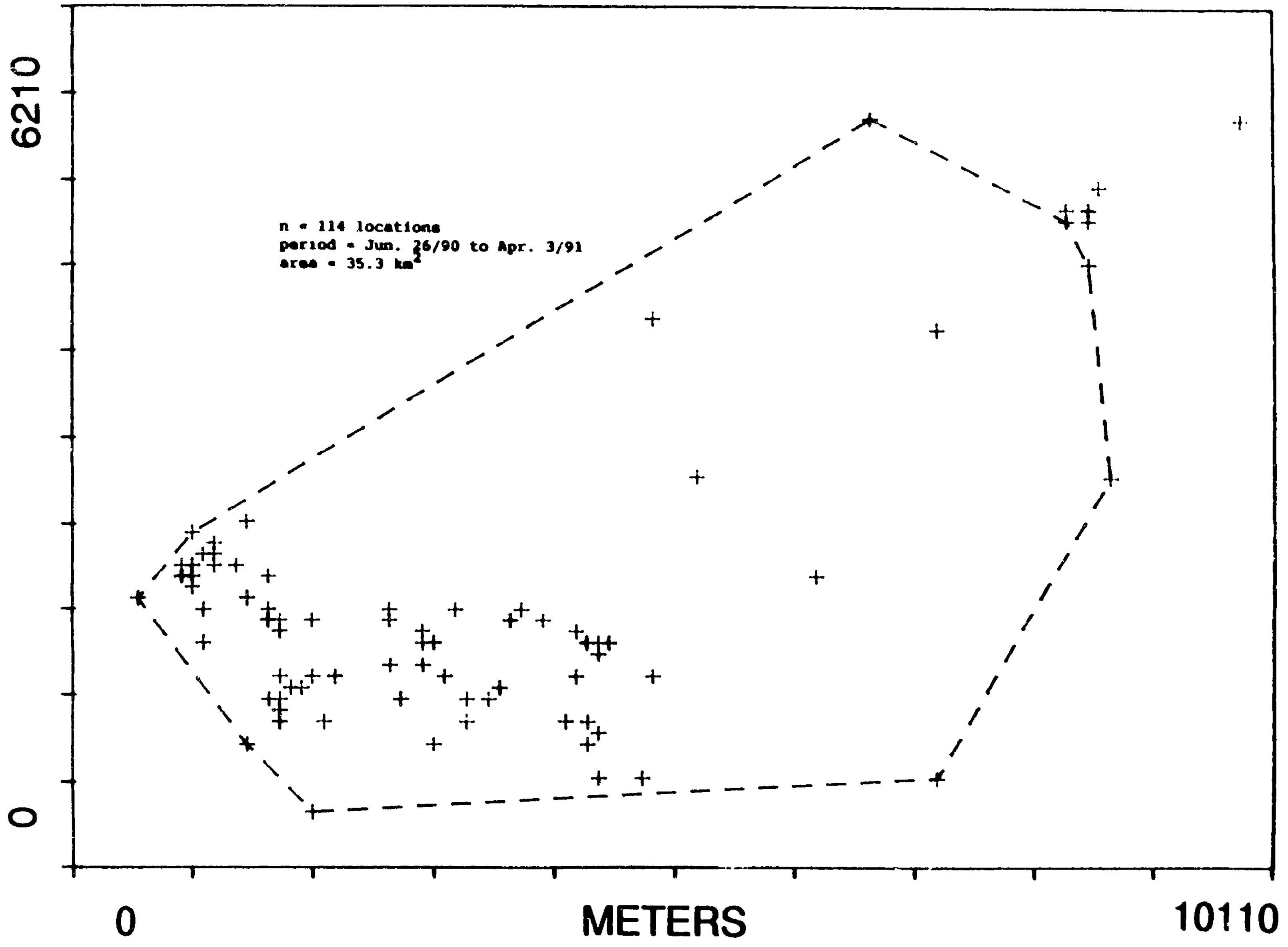
FISHER F55 ANNUAL HOME RANGE AREA



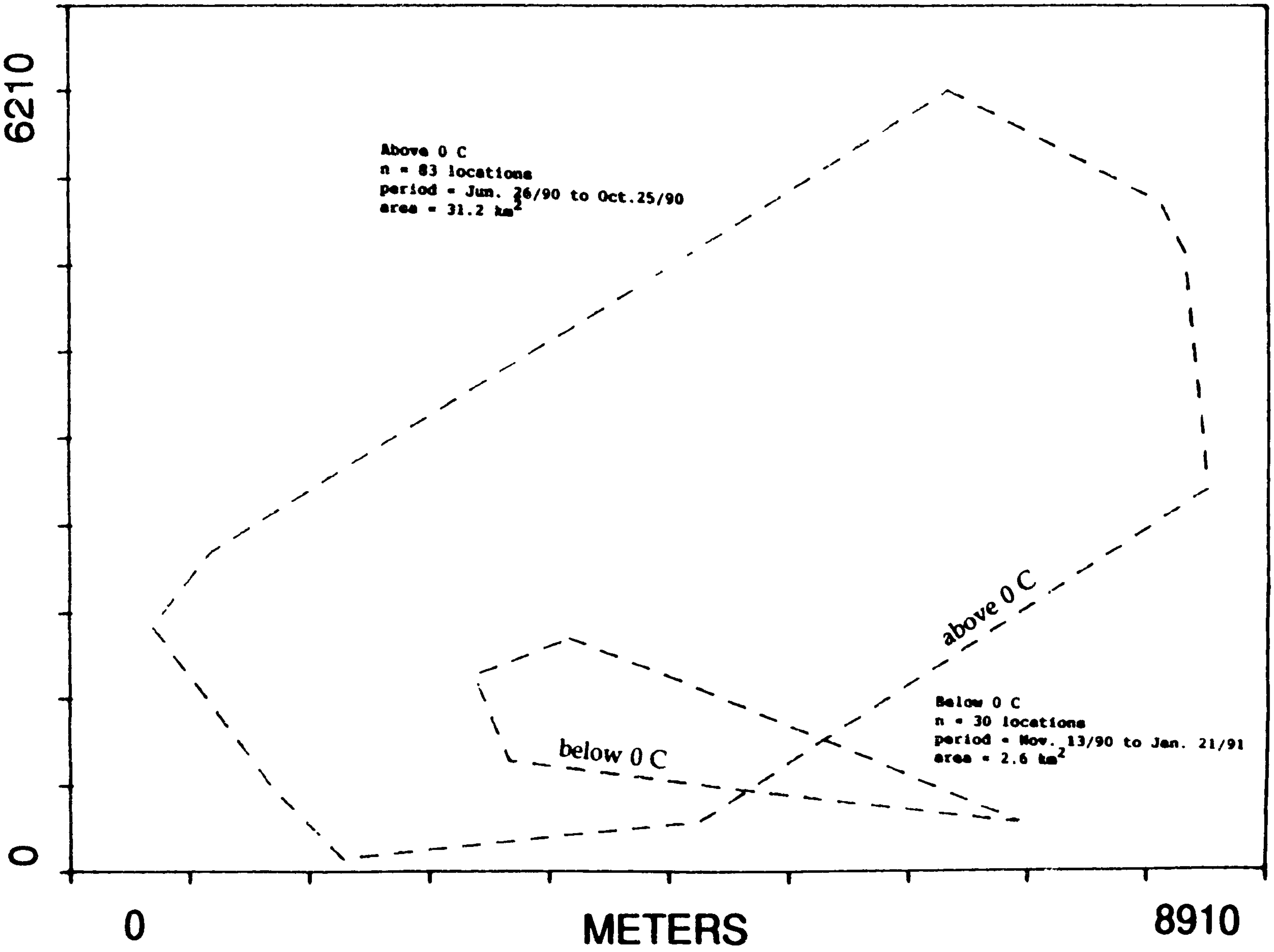
FISHER M31

Fisher M31 was released June 14, 1990 in the north end of the Ministik Lake Bird Sanctuary. He remained in the vicinity of his release site until June 24 at which time he travelled approximately 6 km to the south side of Ministik Lake. In October, 1990 M31 expanded his range northeast to the Watt Lake area, near the area he had occupied following his release. He stayed near Watt Lake until mid-December, at which time he returned to the south end of Ministik Lake. In February 1991, unsuccessful attempts were made to recapture M31 and replace his radio collar. On March 1 he began to move north. His signal was lost until March 23, on which day it was located on mortality mode. His body was found in a clearing at the north end of Islet Lake, approximately 20 km from his previously established home range area. A post-mortem examination concluded that he had been killed by a large domestic carnivore, as evidenced by the space between canine marks on his body. Extensive trauma suggested he may also have been struck by a vehicle.

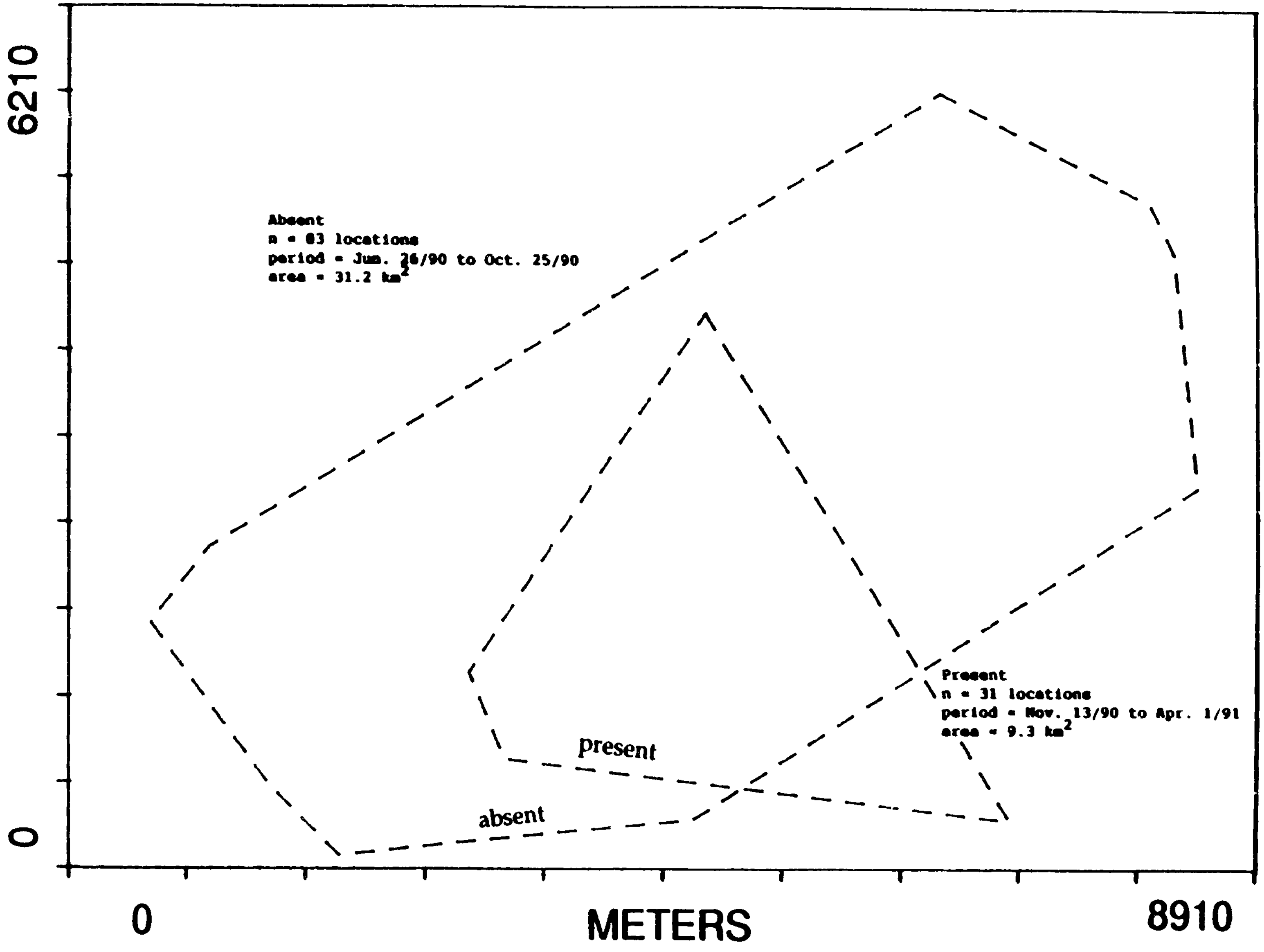
FISHER M31 ANNUAL HOME RANGE AREA



FISHER M31 TEMPERATURE HOME RANGE AREAS



FISHER M31 SNOW HOME RANGE AREAS



FISHER 10

Fisher F10 was released August 9, 1991 at the north end of the Ministik Sanctuary, in the area that had been previously inhabited by fisher F42. She remained at the nest box location till August 20 at which time she began to move north-west. She never travelled more than one kilometre from her release site and inhabit the area left vacant when F42 was killed. The last location obtained was on November 23, 1991 and it was suspected that her collar failed prematurely.

FISHER M11

Fisher M11 was released on August 10, 1991 at the south end of the Ministik Lake Sanctuary, in the area that had been vacated by fisher M31. He immediately travelled east approximately 5 km and remained in an area just east of M31's annual home range till September 10. The area was remote and relatively inaccessible. On September 21, M11 was located 3 km west of his release location, a distance of 8 km. Subsequent searches for his signal including aerial searches, were unsuccessful, and it was suspected that either his collar had failed or he had made an extremely long movement outside of the study area.

FISHER M12

Fisher M12 was released at the southwest side of the Blackfoot Grazing Reserve on August 10, 1991. He remained near his release location on the east side of Wanisan Lake till September 28. On October 5 the signal of M12 was on mortality mode and his body was retrieved on the west side of Wanisan Lake, approximately 2 km from his previous position. A postmortem revealed that the animal was in an emaciated body condition and had significant lesions over the right and left ribcages. These wounds were spaced in such a fashion to suggest possible attack by a bird of prey. This animal may have been susceptible to predation because of his emaciated condition.

APPENDIX D

An aerial photograph of typical habitat within the study area delineating forest types.


Open Field
Deciduous Woodlot
Forest
Wetland
Coniferous Forest