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TB132: An Annotated Bibliography of Predator Research in Maine, 1974-1988

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AN ANNOTATED BIBLIOGRAPHY OF PREDATOR RESEARCH IN MAINE, 1974–1988

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AN ANNOTATED BIBLIOGRAPHY OF PREDATOR RESEARCH IN MAINE, 1974-1988

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ABSTRACT

From 1974 to 1988, graduate students (13 M.S. and 5 Ph.D.) and faculty members from the University of Maine conducted a series of studies regarding the ecology of coyotes, red foxes, bobcats, pine martens, fishers, otters, and their prey. This research was reported in 67 theses, journal articles, or other reports, which are abstracted here. An introductory section summarizes the major findings.

CONTENTS[1]

[1]The italic numbers below the headings refer to abstract numbers in Part II.

I. RESEARCH SUMMARY

A. INTRODUCTION

This section summarizes a series of reports from research projects concerning the ecology of coyote, red fox, bobcat, pine marten, fisher, otter, and various prey species conducted at the University of Maine between 1974 and 1988. Most of the results reported here originated from 1 or more of 13 M.S. and 5 Ph.D. thesis projects (Table 1), although a few ancillary studies also were conducted. This summary is intended to serve as a source of information about the ecology of these predators in Maine and as a guide to assist people in finding more detailed information contained in the individual theses and reports.

Research was conducted on 6 study areas in Maine (Fig. 1) and 1 in Newfoundland, Canada. The northern Maine study area, located in the St. John River Valley, included intensive studies of martens and coyotes and a more general study of all predators except otters (Sherburne and Matula 1981). The area was extensively forested, although many areas were clearcut, and all 6 predators were present. Most of the marten research was conducted on the north-central study area, near Moosehead Lake's Spencer Bay. This area also was mostly forested, with several large timber harvesting operations in progress, and all 6 predators occurred there.

Coyotes, red foxes, bobcats, and predator interactions were studied in western Maine near Flagstaff Lake and Pierce Pond, and in eastern Maine near Cherryfield. Both areas were predominantly forested, with some cutover areas. Many commercial blueberry barrens occurred in the eastern area. All 6 predators occurred in both areas, although fishers were rare in the eastern area.

Fishers were studied in south-central Maine, near Monroe. The south-central area was about 75% forested, with many farms, pastures, and small towns. The area had the highest fisher density in the state, but no martens and few bobcats. Fisher harvests and prey populations were assessed in the eastern and south-central areas and their surroundings.

The only otter study was conducted on Mt. Desert Island (MDI). This area was a mixture of farms, seasonal and year-round homes, forest, and National Park land. All 6 predators were present; however, bobcats, martens, and fishers were rare.

Climate in the coastal areas (south-central, eastern, and MDI) was relatively mild, with mean low temperatures reaching about -9 C during January. Winters were more severe in the northern, north-central, and western areas, with mean low temperatures reaching -16 C.

Table 1. Thesis projects involving Maine predators, 1974–1987.

Study Areas	Author	Year	Degree[1]	Species
Northern	H. Hilton	1976	MS	Coyote
	K. M. Wynne	1981	MS	Marten
North-central	E. C. Soutiere	1978	PhD	Marten
	J. T. Major	1979	MS	Marten
	J. D. Steventon	1979	MS	Marten
	A. M. Soukkala	1983	MS	Marten
Western	J. T. Major	1983	PhD	Coyote, Fox, Bobcat
	J. A. Litvaitis	1984	PhD	Bobcat, Hare
	D. J. Harrison	1986	PhD	Coyote, Fox
	D. B. Engelhardt	1986	MS	Coyote, Fox
Eastern	D. W. May	1981	MS	Coyote
	S. L. Caturano	1983	MS	Coyote
	D. J. Harrison	1983	MS	Coyote
	P. W. Rego	1984	MS	Fisher
	J. A. Litvaitis	1984	PhD	Bobcat, Hare
	M. A. Halpin	1984	MS	Fox
	D. J. Harrison	1986	PhD	Coyote, Fox
South-central	P. W. Rego	1984	MS	Fisher
	S. M. Arthur	1987	PhD	Fisher
Mt. Desert Is.	L. J. Dubuc	1987	MS	Otter
Newfoundland	J. E. Snyder	1984	MS	Marten

[1] MS = Master of Science in Wildlife Management; PhD = Doctor of Philosophy in Wildlife.

Most theses were published as 1 or more reports in technical journals. To avoid duplicating citations, most references in Part I are to theses, because these usually contain the most detailed information. However, many journal publications are more easily obtained, and these are referenced following each thesis abstract in Part II.

Major funding for much of this research was provided by the Maine Department of Inland Fisheries and Wildlife (MDIFW), through Federal Aid in Wildlife Restoration Project W-69-R. Additional funding was provided by a variety of sources, including the Maine Agricultural Experiment Station (MAES), Maine Trappers Association, McIntire-Stennis Project ME-09606, Newfoundland (Canada) Wildlife Division, Penobscot County Conservation Association, University of Maine Graduate Student Board and

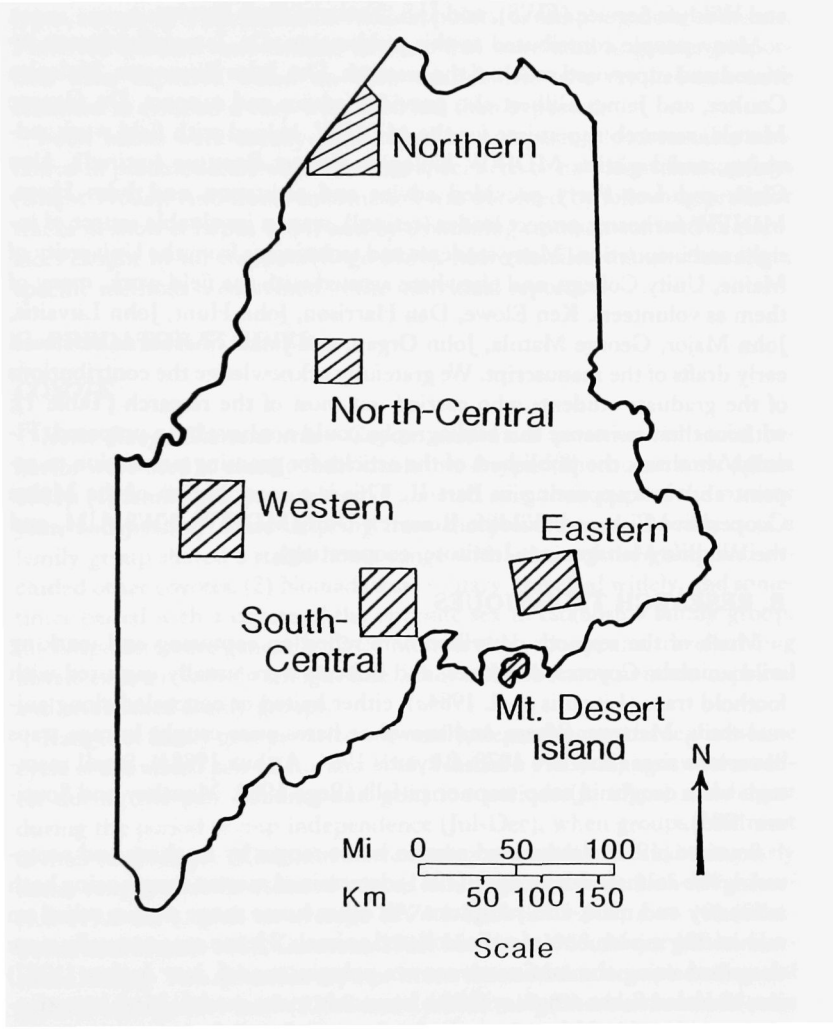

Figure 1. Location of predator study areas in Maine, 1974-87.

College of Forest Resources (UM), U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service (FWS), and U.S. National Park Service.

Many people contributed to this publication. Dr. James Sherburne initiated and supervised much of the research. Drs. John Bissonette, Malcolm Coulter, and James Gilbert also provided advice and support. Dr. George Matula, research supervisor for the MDIFW, helped with field work, advising, and logistics. MDIFW biologists Robert Boettger (retired), Alan Clark and Lee Perry provided advice and assistance, and John Hunt, MDIFW furbearer project leader (retired), was an invaluable source of insight and inspiration. Many students and technicians from the University of Maine, Unity College, and elsewhere assisted with the field work, many of them as volunteers. Ken Elowe, Dan Harrison, John Hunt, John Litvaitis, John Major, George Matula, John Organ, and James Sherburne reviewed early drafts of the manuscript. We gratefully acknowledge the contributions of the graduate students who carried out most of the research (Table 1); without their assistance this bibliography could not have been prepared. Finally, we thank the publishers of the articles for granting permission to reprint abstracts appearing in Part II. This is a contribution of the Maine Cooperative Fish and Wildlife Research Unit (MDIFW, FWS, UM, and the Wildlife Management Institute, cooperating).

B. RESEARCH TECHNIQUES

Much of the research described here relied on capturing and marking wild animals. Coyotes, red foxes, and bobcats were usually captured with foothold traps (Litvaitis et al. 1984*a*), either baited or concealed along animal trails. Martens, fishers, and snowshoe hares were caught in cage traps of various sizes (Soutiere 1978, Litvaitis 1984, Arthur 1988*b*). Small mammals were caught in snap traps or pitfalls (Rego 1984, Monthey and Soutiere 1985).

Soutiere (1978) determined marten home ranges by marking and recapturing the animals. Major et al. (1981) determined marten ranges using both telemetry and mark-and-recapture. All other home range studies relied on monitoring movements of radio-collared animals. Home ranges usually were described using the minimum convex polygon model, but Arthur (1987) also modeled fisher ranges with the harmonic mean model. Most investigators considered $\geq$ 30 locations obtained over $\geq$ 3 months to be necessary to provide an adequate home range model, but shorter periods were used to compare home ranges between seasons (Caturano 1983, Harrison 1983, Litvaitis 1984).

Habitat use was examined by comparing the proportion of radio locations or distance travelled along snow trails in various habitats with the availabil-

ity of those types. Availability of types was determined by mapping all cover types, sampling types present at random points, or sampling along transects. Preferred habitats were defined as those that were used in greater proportion than expected based on their availability, whereas habitats were classified as avoided if they were used less than expected.

Food habits were usually determined by comparing food remains contained in predator scats with reference specimens or hair identification keys (Major 1983*a*). Additional information was obtained by following predator tracks in snow (Halpin 1984) and by examining stomach contents of predators caught by fur trappers (Rego 1984). More detailed information about specific methods is contained in the individual reports.

C. PREDATOR STUDIES

COYOTE

Home Range Characteristics—Coyote movement patterns and social behavior were used to classify individuals into 3 types (Sherburne and Matula 1981): (1) family groups consisted of a mated pair, their pups of the current year, and possibly some offspring from the previous year. Members of a family group shared a stable home range with others of the group and excluded other coyotes. (2) Nomads were solitary, travelled widely, and sometimes paired with a coyote of the opposite sex to establish a family group. (3) Dispersers were generally 12-24 months old, solitary, and travelled long distances in a relatively straight line. They either became nomads or paired and established family groups.

Ranges of family groups varied seasonally, depending on the reproductive cycle of the mated pair (Caturano 1983, Harrison 1983). Ranges were smallest during the pair bonding and gestation periods (Jan-Apr) and largest during the period of pup independence (Jul-Dec), when groups used most of their total ranges. Minimum convex polygon models indicated that yearly home ranges of radio-collared coyote family groups were 25.5-309.4 km^2 (9.8-119.2 mi^2), with an average of 74.1 km^2 (28.5 mi^2, $n = 19$) (Sherburne and Matula 1981, Caturano 1983, Harrison 1983, Major 1983*a*, Harrison 1986*a*). Two nomadic coyotes in northern Maine occupied ranges of 1,365.0 and 2,649.4 km^2 (525.0 and 1,019.2 mi^2) (Sherburne and Matula 1981). Movements of dispersers are summarized in a later section.

Harrison (1986*a*) found that home ranges of most Maine coyotes were larger than ranges of western coyotes, and he believed that this might have been due to a restricted food supply. Although Maine coyotes used large prey (e.g., white-tailed deer) more commonly than did western coyotes, prey populations probably were lower than in the western studies.

Habitat Use—Coyotes in northern, western, and eastern Maine generally preferred coniferous or mixed stands and avoided hardwood stands and open areas (bogs, barrens, or cuts) (Sherburne and Matula 1981, Caturano 1983, Major 1983*a*), except that roads were often used for travelling (Sherburne and Matula 1981, Major 1983*a*) and barrens were used for feeding in eastern Maine during summer (Caturano 1983, Harrison 1983). In western Maine, coyotes usually hunted in coniferous forest (Major 1983*a*). Use of coniferous forest by coyotes may be due to the presence of white-tailed deer in this type (Major 1983*a*, Miller 1984). Harrison (1983) found no selection for habitat types for denning, except that all dens were in sunny locations. Coyotes evidently can use a variety of habitat types, and most rural areas of Maine probably provide suitable habitat (Caturano 1983).

Food Habits—Coyotes are opportunistic feeders, eating foods ranging from berries, mice, and shrews to deer and moose (Major 1983*a*, Harrison 1983). In Maine, the most common year-round food was snowshoe hare, although deer were a common food during winter and fruits were often eaten during summer (Caturano 1983, Harrison 1983, Major 1983*a*). Deer were the most common food of coyote pups in Cherryfield during the post-weaning period, perhaps because deer were most easily transported by adult coyotes (Harrison and Harrison 1984*a*, *b*). The extent to which coyotes prey upon live deer (rather than carrion) has not been documented, but Miller (1984) found that 67% of 22 winter deer deaths in western Maine during 1981-1984 were due to coyote predation. During summer and fall, fruit was the most common food of coyotes in eastern Maine, where extensive commercial blueberry barrens existed (Caturano 1983, Harrison 1983).

Distribution, Morphology, And Mortality—Coyotes were rarely found in Maine until the early 1960's (Richens and Hugie 1974). By 1967, coyotes occupied much of western Maine, and 1 was killed in Washington County in 1969 (Richens and Hugie 1974). By 1980, coyotes were distributed throughout the state (Litvaitis and Harrison 1989). Coyotes in Maine tended to be larger and heavier than their western counterparts (Hilton 1976). Studies during the 1970's found mean weights of 15.9 kg (35 lb.) for males and 14.0-14.5 kg (30-32 lb) for females (Richens and Hugie 1974, Hilton 1976). More than 60 coyotes studied during the 1980's averaged 17.3 kg (38 lb) for males and 15.5 kg (34 lb) for females (Harrison 1986*b*). Data from the 1970's were from dead animals, either whole or skinned carcasses corrected for the weight of the pelt, whereas the 1980's data were from live animals, so the difference in weight does not necessarily imply an increase in weight of the population.

The pelage of Maine coyotes resembled that of western coyotes, and was quite variable. Coyotes typically were brown with white on the ventral sur-

face and a black "saddle" on the shoulders, although some were dark brown, gray, reddish, or blond (Hilton 1976).

Reported weights and body measurements of Maine coyotes were consistently between those of western coyotes and dogs (Richens and Hugie 1974) and between western coyotes and both dogs and wolves (Hilton 1976). Discriminant function analysis of skull measurements indicated that Maine coyotes were more similar to western coyotes and wolves than to dogs (Hilton 1976, 1978). The larger size of Maine coyotes might be the result of hybridization between western coyotes and wolves, rapid evolution of coyotes in an area devoid of wolves, or a combination of these processes (Hilton 1978). Hybridization with dogs, although possible, probably is uncommon.

Human activities accounted for most documented coyote mortality, although this was at least partly because mortalities usually were determined from tag returns, which tend to exaggerate the importance of human factors. Of 41 coyote deaths in western and eastern Maine, 93% were due to hunting, trapping, or automobiles (Major 1983*a*, Harrison 1986*a*). Hunting and trapping alone accounted for 83%. Mortality rates determined from radio telemetry suggested that 66% of deaths of juvenile (≤1.5 year) coyotes in Cherryfield were caused by humans (Harrison 1986*a*), and all 7 recorded deaths of radio-collared coyotes in northern Maine were from hunting or trapping (Sherburne and Matula 1981). In eastern Maine, annual mortality was higher for juvenile females (61%) than for juvenile males (7%), and tag returns suggested that mortality of all juveniles was greater than that of coyotes older than 1.5 years (Harrison 1986*a*).

Reproduction And Dispersal—Caturano (1983) identified 4 seasons in the reproductive cycle of coyotes in Cherryfield: pair bonding/mating (Jan-Feb), gestation (Mar-Apr), nursing (May-Jun), and post weaning/pup independence (Jul-Dec). Litters of 5-9 pups were born in April (Harrison 1986*a*). Dens usually were in sandy soils and ranged from shallow depressions to burrows 8 m long (Harrison 1983). Sherburne and Matula (1981) found 1 coyote den in a hollow log in northern Maine.

The nursing period lasted for about 6 weeks, during which the adult females usually remained near their dens. Coyotes often moved to new dens during this period, especially if a den was disturbed (Harrison 1983). After weaning, adults increased their movements, and pups left den sites at 8-10 weeks of age (Caturano 1983, Harrison 1986*a*). Dispersal of pups began in September, with peaks during October-November and February-March (Harrison 1983, 1986*a*). Eighty-six percent of pups dispersed during their first year, and all dispersed prior to the age of 1.5 years (Harrison 1986*a*). Complete dispersal of young coyotes prevented the formation of large packs, and may have been the result of relatively scarce prey (Harrison 1986*a*).

Minimum dispersal distances averaged 94 km (56 mi) for females and 113 km (43 mi) for males (Harrison 1986*a*). Dispersal movements tended to be linear, so that distance from the natal area was maximized.

RED FOX

Home Range Characteristics—Red fox home ranges were studied primarily in relation to ranges of coyotes; those relations are described in the Predator Interactions section. Minimum convex polygon home ranges of radio-collared foxes monitored for ≥90 days were determined for 4 foxes in western (Major 1983*a*), 6 in eastern (Harrison 1986*a*), and 2 in northern Maine (Sherburne and Matula 1981). Ranges of females were 6.0-20.2 km^2 (2.3-7.8 mi^2), averaging 14.8 km^2 (5.7 mi^2), and ranges of males were 7.8-30.7 km^2 (3.0-11.8 mi^2), averaging 17.9 km^2 (6.9 mi^2). Ranges of 3 males and 1 female overlapped (Harrison 1986*a*); ranges of other foxes were not contiguous. Most foxes were monitored for ≤1 year, but 1 adult male monitored during 2 years moved his range 35.0 km (13.5 mi) between years (Major 1983*a*). Another adult male, monitored for only 1 month, travelled over an area of 81.6 km^2 (31 mi^2) (Sherburne and Matula 1981).

Habitat Use—Foxes used a variety of habitat types, and different studies produced conflicting results. Halpin (1984) determined by snowtracking foxes in eastern Maine that hardwood stands were avoided and softwood and softwood-dominated mixed stands were preferred, but Major (1983*a*) and Sherburne and Matula (1981) found that radio locations of foxes in western and northern Maine showed a preference for hardwood and hardwood-dominated mixed stands and avoidance of softwoods. Habitat use by foxes evidently was influenced primarily by snow conditions and prey distribution. In winter, foxes avoided travelling in areas with deep, soft snow, and foraged in areas with dense undergrowth, where snowshoe hares were common (Halpin 1984). During snow-free periods, foxes ate a wider variety of prey, and used a variety of habitats (Major 1983*a*). Dens were located in most forest types (Halpin 1984), and were often associated with dense undergrowth (Sherburne and Matula 1981). Roads and streams were often used for travelling, and scats and urine marks were most common in these areas (Sherburne and Matula 1981, DiBello 1982, Major 1983*a*). Use of habitats by foxes might also be influenced by the presence of coyotes (see Predator Interactions).

Food Habits—Foxes preyed primarily on snowshoe hares and small mammals, although fruit was a common food during summer and fall, and deer carrion was eaten during winter (Sherburne and Matula 1981, Major 1983*a*, Halpin 1984). Hares were eaten most often during winter, when snow cover reduced the availability of small mammals (Halpin 1984). Birds such as

ruffed grouse were eaten occasionally throughout the year (Sherburne and Matula 1981, Major 1983*a*).

History—Halpin (1984) summarized the history of red fox in Maine. Historically, fox distribution was irregular in northern Maine. Foxes were generally more common in agricultural areas in the southern half of the state, although populations fluctuated in reponse to predator control programs during the early 1900's and overharvesting during the 1920's. Since the 1930's, fox populations have generally increased, due to reduced demand for long-haired fur and better management of the harvest. However, the spread of coyotes throughout Maine during the 1960's and 1970's created the potential for reducing fox populations through interspecific competition (see Predator Interactions).

BOBCAT

Home Range Characteristics—Home ranges of 13 adult male radio-collared bobcats monitored for ≥7 months were 47.3-200.4 km^2 (18.2-77.4 mi^2), averaging 109.8 km^2 (42.2 mi^2); 7 adult females occupied ranges of 20.9-41.1 km^2 (8.1-15.9 mi^2), averaging 30.4 km^2 (11.7 mi^2) (May 1981, Major 1983*a*, Litvaitis 1984). The difference in home range size between sexes might have been because the larger males required more food or because ranges of females were in areas where hare densities were higher (Litvaitis 1984). From mid-March through mid-May, bobcats used the largest proportions of their total ranges ($\bar{x}$ = 59%), probably because prey populations were lowest during this season and because of bobcat movements related to mating (Litvaitis 1984). From mid-May through June, bobcats used the smallest proportions of their ranges ($\bar{x}$ = 18%), corresponding with a period of high prey populations and reduced mobility of females caring for young (Litvaitis 1984). Ranges of adult males overlapped those of adult females (Major 1983*a*, Litvaitis 1984), but spatial relations among members of the same sex were not demonstrated. Major (1983*a*) reported that male bobcats occasionally made "sallies" outside their established ranges, and Litvaitis (1984) believed that increased movements of males during late spring (near the end of the mating season) might have been due to attempts to locate females. Ranges left vacant by removal of resident bobcats by fur trapping were quickly occupied by transients, resulting in a stable spatial distribution (Litvaitis 1984).

Habitat Use—Bobcats in Maine used a variety of forested habitats, and usually avoided open areas. May (1981) never found bobcat tracks >100 m (328 ft) from forest cover. Bobcat use of forest types was related to the abundance of prey, particularly snowshoe hares (Litvaitis 1984). May (1981) and Major (1983*a*) found inconsistent patterns of use of overstory types between

western and eastern Maine, and between seasons, suggesting that overstory type did not directly influence bobcat movements. Litvaitis (1984) found that bobcats in both areas preferred dense understory types that also were preferred by hares. In western Maine, softwood understories were the most dense and were preferred. Stands with hardwood understories were preferred in eastern Maine, where they were the most dense. Winter snow conditions can hinder bobcat movements (Major 1983*a*), and these conditions might be affected by habitat type. However, this relationship was not investigated.

Food Habits—The bobcat has the most specialized diet of all predators that have been studied in Maine (Sherburne and Matula 1981, Major and Sherburne 1987). Snowshoe hare was the most common prey species, occurring in ≥60% of bobcat scats throughout the year (Sherburne and Matula 1981, Major 1983*a*, Litvaitis 1984). Bobcats also commonly ate white-tailed deer, especially during winter and especially in areas subject to heavy snowfall (Major 1983*a*, Litvaitis 1984). It was unknown if bobcats were effective predators of deer or if they usually relied on carrion. However, deer were more commonly eaten by large males than by smaller males and females (Litvaitis 1984, Litvaitis et al. 1984*b*), suggesting that large bobcats might be more proficient deer predators. Other mammals (porcupines, muskrats, mice, voles, and shrews) and birds made up a small part of the bobcat diet (Sherburne and Matula 1981, Major 1983*a*, Litvaitis 1984).

Morphology And Mortality—Average weight of radio-collared yearling and adult male bobcats was 12.6 kg (5.7 lb), whereas females averaged 9.0 kg (4.1 lb) (Litvaitis 1984). During winter, body condition of bobcats (as indicated by body fat) was affected by sex, age, and winter severity (Litvaitis et al. 1986*a*). Larger individuals, and particularly males, usually had more body fat and seemed better able to withstand severe winters, perhaps because they were better able to prey upon deer.

For bobcats ≥1 year old, mortality due to hunting and trapping was 38% in western Maine (Major 1983*a*) and 55% in eastern Maine (Litvaitis et al. 1987). Three bobcats from western Maine were killed by automobiles and 2 starved during a severe winter. One bobcat kitten from eastern Maine was killed and eaten by an adult female, perhaps because of territorial behavior (Litvaitis et al. 1982).

PINE MARTEN

Home Range Characteristics—Minimum convex polygon home ranges of 5 adult males and 4 adult females were determined during summer using radio telemetry in northern and north-central Maine. Ranges of males were 4.7-10.0 km^2, averaging 6.8 km^2 (2.6 mi^2), while ranges of females were 1.0-3.6 km^2, and averaged 2.4 km^2 (0.9 mi^2) (Major 1979, Wynne

1981). During winter, 2 males occupied ranges of 9.2 km^2 (3.5 mi^2), while 2 females occupied ranges of 1.6 and 2.5 km^2 (0.6 and 1.0 mi^2) (Steventon 1979). Soutiere (1978) estimated marten ranges of 0.1-4.4 km^2 (0.04-1.7 mi^2) by marking and recapturing marten in north-central Maine, but this technique probably underestimated range size (Major et al. 1981). Males occupied larger ranges in areas where habitat was fragmented by timber harvests, but such areas were not used by females (Soutiere 1978).

Little information was obtained concerning the amount of overlap between ranges of adult marten in Maine. Ranges of 2 neighboring males overlapped only slightly, but ranges of males overlapped ranges of females (Steventon 1979). Degree of overlap among ranges of females was not determined, because ranges of radio-collared females were widely separated.

Habitat Use—Studies of marten habitat preferences were primarily concerned with the effects of timber harvesting. Marten in northern and north-central Maine preferred uncut coniferous and primarily-coniferous mixed stands and avoided clearcuts ≤15 years old (Soutiere 1978, Major 1979, Steventon 1979, Wynne 1981). In mature forest, coniferous stands were preferred and deciduous stands were avoided (Wynne 1981). In winter, marten crossed open areas to forage in isolated uncut coniferous stands, but little foraging was done in the open (Soutiere 1978, Steventon 1979). Marten in Newfoundland also avoided clearcuts and preferred residual stands (Snyder 1984). Winter snow cover probably reduced the availability of small mammal prey in clearcuts, particularly where most slash was removed (Soutiere 1978). During winter, marten usually rested in hollow logs or stumps beneath the snow (Steventon 1979). Tree cavities and logs were used as natal dens during summer, and most other summer rest sites were in thickets in the branches of fir trees (Major 1979, Wynne 1981). Clearcutting of mature coniferous forest probably will reduce marten populations by reducing habitat quality (Steventon and Major 1982). However, viable marten populations probably can be maintained if residual stands with basal area of 20-25 m^2/ha are retained (Soutiere 1979).

Food Habits—Voles were the most common food in scats of marten in northern and north-central Maine (Soutiere 1978, Sherburne and Matula 1981). Birds, mice, shrews, and red squirrels also were common foods in north-central Maine (Soutiere 1978). Snowshoe hare occurred in less than 2% of scats from north-central Maine (Soutiere 1978) but was the second most common food in northern Maine (12% occurrence) (Sherburne and Matula 1981). Some seasonal differences were noted by Soutiere (1978), who found that red squirrels occurred most often in winter scats, and fruits, birds, insects, and shrews occurred most often in summer scats.

Morphology—Marten exhibit pronounced sexual dimorphism, with males

weighing an average of 0.8 kg (1.7 lb) and females 0.5 kg (1.1 lb) (Soutiere 1985). Soutiere (1985) described several skull measurements that could be used to discriminate between age and sex classes. The greatest differences were shown by zygomatic breadth, which increased with age and was greater for males than females, and in the development of a pronounced sagittal crest in adult males. Marten pelage usually was lighter in color during winter than during summer (Soutiere 1981), although color was variable during all seasons. Summer pelage was usually dark grayish brown with a yellow throat patch and a lighter tail tipped with black. In winter, marten were usually yellowish red to brownish yellow, with darker feet and tail and a reddish or yellow throat patch. Extreme cases with colors of dark brown or very pale yellow were found occasionally (Soutiere 1981).

Effects of Harvesting On Marten Populations—Male marten in north-central Maine were more vulnerable to live-trapping than were females, and tag returns indicated a harvest rate of 43% for adult males and 17% for adult females (Soukkala 1983*a*). Juvenile males seemed to be more vulnerable to harvest than were juvenile females, because males were more common in the harvest early in the season (Soukkala 1983). However, more juvenile females than juvenile males were caught later in the season, which indicated that trapping reduced the number of males in the population. Soukkala (1983) used a population model based on the differential vulnerability of sex and age classes to estimate harvest rates of 90% for juvenile males and 63% for juvenile females. Harvesting at this level could cause local population declines (Soukkala 1983*a*).

FISHER

Home Range Characteristics—Home ranges of adult fishers were studied in south-central Maine using radio telemetry (Arthur 1987). Fishers occupied stable ranges from May through December, but males frequently travelled outside their established ranges from February to April. Minimum convex polygon ranges during May–December averaged 30.9 km^2 (11.9 mi^2) for 7 adult males (range = 10.6-78.2 km^2, 4.1-30.2 mi^2) and 16.3 km^2 (6.3 mi^2) for 6 adult females (range = 8.1-39.1 km^2, 3.1-15.1 mi^2). Female ranges were similar in size and location between years, but some males moved to new ranges following their spring movements. Movements of males during spring probably were due to the mating season, and males probably attempted to mate with several females. Ranges of males overlapped those of females, but little intrasexual overlap was found among adults, except for the movements of males during spring. Juvenile fishers shared their mothers' home ranges through July or August. Dispersal began in late September or October, and juvenile males travelled extensively until

the beginning of their second summer (Arthur 1987). One juvenile male in northern Maine occupied a range of 118.8 km^2 (46.4 mi^2) during January-May (Sherburne and Matula 1981). Only 1 juvenile female was monitored during fall and winter, and she dispersed approximately 50 km (19.3 mi) in March (Arthur 1987).

Habitat Use—Fishers in south-central Maine used a variety of forest types, but they avoided deciduous stands and open areas (Arthur 1987). Coniferous stands were used for rest sites during spring, summer, and fall, because fishers usually rested in thickets in the branches of fir trees during warm weather. During winter, fishers usually rested in burrows, and preferred mixed forests for resting. Fishers foraged in all forest types during winter, but foraging was most intensive in areas with dense coniferous undergrowth, where hare tracks were common. Six natal dens were all in cavities in large aspen trees, but no preference for particular forest types was evident (Arthur 1987). In northern Maine, 91% of the locations of a juvenile male were in or near coniferous stands (Sherburne and Matula 1981). Optimal habitat for fishers probably consists of a variety of forest types, with small stands and high interspersion (Arthur 1987).

Food Habits—During winter, apple was the most common food item in fisher scats from south-central Maine (Arthur 1987) and was also common in stomachs of fishers trapped during fall (Rego 1984). Other common foods included hares, porcupines, squirrels (mainly gray, but also red and flying squirrels), mice, voles, and shrews (Sherburne and Matula 1981, Arthur 1987). White-tailed deer, muskrats, and chickens were common in fisher stomachs but probably were due to trap bait (Rego 1984). Raspberry, winterberry, and other fruits were commonly eaten during late summer and fall (Rego 1984, Arthur 1987).

Morphology—Rego (1984) investigated regional differences in body condition of harvested fishers. Sexual dimorphism was evident in measures of body length, weight, and fibula length, which were all greater for males. Fishers from eastern Maine were smaller and had less body fat than those from south-central Maine. Compared to weight, body fat was more variable among individuals and was a poorer indication of long-term condition. Females showed no difference in weight by age class, but juvenile males weighed less than adult males. Differences in condition indices between areas were most pronounced for juvenile males. All age and sex classes showed increasing weight and fat indices during the harvest season, suggesting that food was not limiting during fall.

OTTER

Habitat Use—Otters on Mount Desert Island preferred wetlands occupied

by active beaver colonies and avoided those with no beaver (Dubuc 1987). Beaver flowages provided otters with more abundant food, resting sites, and protection from human disturbance. Most wetlands frequently used by otters were within an area that had burned during 1947, and was covered with predominantly deciduous forest. Otter habitat use was described by a discriminant function that predicted that number of beaver flowages, watershed length, and average shoreline diversity would positively affect otter use of a watershed, and proportion of mixed coniferous-deciduous forest adjacent to the waterway would have a negative effect (Dubuc 1987).

Food Habits—Food habits of otters on MDI varied seasonally, with freshwater foods predominating in otter scats during summer and marine foods predominating in winter (Dubuc 1987). Reptiles and amphibians were the most common foods during summer (69% occurrence), but were rarely eaten during winter (11% occurrence), when fish were the most common food (85% occurrence). Banded killifish was the most common fish species eaten both summer and winter; cunner, a marine fish, was commonly eaten during winter but rarely eaten during summer. Diversity of the diet was highest during summer, when 5 categories of foods were eaten (reptiles/amphibians, fish, invertebrates, birds, and mammals) (Dubuc 1987).

D. PREY STUDIES

SNOWSHOE HARE

Snowshoe hare was a major food of many predators in Maine, and similarities in habitat use were noted by Litvaitis (1984) for hare and bobcat, Halpin (1984) for hare and red fox, and Arthur (1987) for hare and fisher. Fall and winter home ranges of hares in eastern Maine averaged 7.4 ha (18.3 acres) for males and 4.8 ha (11.9 acres) for females, and ranges overlapped others of both sexes (Litvaitis 1984). Although Sherburne and Matula (1981) and Arthur (1987) found hares were most common in coniferous and mixed forest types, understory density probably was more important in determining hare distribution (Litvaitis 1984). Hares preferred dense understory vegetation, especially during winter (O'Donoghue 1983, Litvaitis 1984, Arthur 1987). In eastern Maine the densest understories were composed of deciduous species, but in western Maine coniferous understories were the most dense (Litvaitis 1984). Hares in both areas were more common in the denser vegetation.

During summer, hares used understories with lower densities and more deciduous species (O'Donoghue 1983). This coincided with an increase in cover provided by deciduous species during summer and a shift to a diet including more herbaceous vegetation (O'Donoghue 1983, Litvaitis 1984).

Hares in western Maine preferred areas where preferred browse species (red spruce, white birch, red and striped maple) were common (Litvaitis 1984). Preferred browse of hares in eastern Maine included rhodora, beaked hazelnut, witherod, and gray birch (Litvaitis 1984). Hares did not show preferences for habitats where these species were common, but overall abundance of browse was high (Litvaitis 1984).

Litvaitis (1984) found fall hare densities of 0.3-0.9/ha (0.1-0.4/acre) in good habitat in eastern Maine, and 0.8-1.5/ha (0.3-0.6/acre) in western Maine. However, preferred hare habitat was more abundant in eastern Maine, so Litvaitis (1984) believed overall hare density was higher in eastern Maine. Rego (1984) found hares were more abundant in south-central than eastern Maine. Temporal variations in hare abundance in Maine and the effects of these changes on predators were not investigated.

SMALL MAMMALS

Small mammal populations were assessed in conjunction with several predator studies (Soutiere 1978, May 1981, Sherburne and Matula 1981, Major 1983*a*, Halpin 1984, Rego 1984). Total numbers of small mammals were generally similar among habitat types, although Rego (1984) captured more small mammals in edge habitats than in deciduous or coniferous forests and Halpin (1984) found more small mammal tracks in deciduous forests than in other types. In most cases, species composition varied among habitat types. Major (1983) caught more deer mice and fewer voles in mature deciduous stands than in other types. Monthey and Soutiere (1985) found that more small mammals were caught in conifer stands after they were clearcut. Captures of voles and shrews accounted for most of the increase.

E. PREDATOR INTERACTIONS

Many predators studied here occupied similar habitats and had similar diets. This suggests that competition may occur if shared resources are limited. The spread of coyotes throughout Maine raised concerns that competition from this species might adversely affect populations of other predators (Major and Sherburne 1987). If populations of all other predators were at carrying capacity and if all prey resources were being used by these predators, then adding another predator would obviously reduce resources available to the original inhabitants. However, if prey resources are not being fully used by predators, then adding a predator might not increase competition within the community. Elimination of the gray wolf from Maine reduced predator demands for prey. Richens and Hugie (1974) believed that coyotes had created a new niche that might overlap those of other preda-

tors. Under these conditions, the importance of competition is difficult to determine.

Sherburne and Matula (1981) suggested that coyotes and foxes in northern Maine might compete for prey. Although they found overlapping home ranges and habitat use patterns between the 2 species, they also noted 4 instances of coyotes killing radio-collared foxes. Major (1983*a*) and Harrison (1986±) found little range overlap between coyotes and foxes in eastern and western Maine, and they believed this might have been due to interference competition. Major (1983*a*) also found different habitat use patterns between coyotes and foxes. Although the presence of coyotes might have reduced the amount of habitat available to foxes, Harrison (1986*a*) believed the 2 species could coexist because foxes could occupy small home ranges between the non-overlapping ranges of coyotes.

Bobcats have the most specialized diet of Maine's predators, relying on hares throughout the year (Litvaitis 1984, Major and Sherburne 1987). This might make bobcats vulnerable to competiton from predators with more generalized diets (Major et al. 1986). Ranges of coyotes and bobcats overlapped, and habitat use patterns were similar (Major 1983*a*, Litvaitis and Harrison 1989). Thus, interference competition did not seem to occur (Major and Sherburne 1987). However, exploitation competition between coyotes and bobcats might occur when food is scarce. The bobcat population in Maine declined during the 1970's, coinciding with an increasing coyote population, although the deer population also declined and several severe winters occurred during the period (Major 1983*a*, Litvaitis and Harrison 1989), so the effect of the coyote increase could not be isolated. Litvaitis and Harrison (1989) believed that exploitation competition from coyotes would cause the bobcat population in eastern Maine to stabilize at a lower level than if coyotes were absent.

Bobcats might also compete for food with fishers, because both commonly prey upon hares (Litvaitis 1984, Rego 1984, Arthur 1987). Bobcats were rare in south-central Maine, where fishers were abundant (Arthur 1987), and fishers were rare in eastern Maine where bobcats were abundant (Litvaitis 1984, Rego 1984). However, there were differences in climate and human population density between areas that might have caused the different predator densities.

Of the predators that were studied in Maine, the most closely related were fisher and pine marten (Sherburne and Matula 1981). Both species occupied similar habitats and ate small mammals and hares (Soutiere 1978, Sherburne and Matula 1981, Rego 1984, Arthur 1987). In Maine, and elsewhere, fisher and marten densities seemed to be inversely related, suggesting that they might compete. Arthur (1987) proposed that snow conditions might deter-

mine which species was more successful, favoring fishers in areas with less snow and marten in areas where snow was deep and soft.

Although much of the evidence of competition among predators is circumstantial, it seems that competition might influence the abundance of red fox, bobcat, fisher, and marten. However, competition may itself be affected by prey populations, habitat, and climatic conditions. Relationships among these factors require further investigation before the importance of competition can be established.

II. ABSTRACTS

This section contains abstracts of all papers concerning predator research at the University of Maine prepared between 1974 and mid-1988. Each entry begins with the appropriate citation. Authors' published abstracts (indicated by [AA] at the end of the abstract) are reprinted verbatim, except for minor grammatical corrections and the removal of scientific names of plants and animals (see Appendix). If no abstract was published, then a compiler's abstract was prepared (indicated by [CA]). Abstracts are arranged alphabetically and sequentially numbered; these numbers cross-reference theses and published papers. Abstracts of theses are followed by a list of numbers referring to publications containing the thesis results. Abstracts of papers that resulted from thesis research are followed by the number of the thesis containing the original results.

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

Home range characteristics, habitat use, food habits, and activity patterns of 43 radio-collared fishers were studied from January 1984–January 1987, in a 500 km^2 area in south-central Maine. Fishers were live-trapped in cage traps and padded-jaw foothold traps, and recaptured by darting them out of trees and by trapping them at burrows.

Minimum convex polygon home range areas during May–December averaged 16.3 km^2 for 6 adult females (range = 8.1-39.1) and 30.9 km^2 for 7 adult males (range = 10.6-78.2); the means were not statistically different (t-test, $P > 0.2$). Ranges of adult females were stable in size and location seasonally and between years. Adult males travelled widely during March–May, and shifted their home ranges between years. Ranges of adults did not overlap with others of the same sex, except for males during the spring. Adult females shifted their ranges to avoid other females, and to occupy areas left vacant by the removal of females by trappers. Adult males also shifted their ranges to include vacant areas, and 1 male was severely injured in a fight with another fisher. Juveniles ($n = 20$ males, 4 females) travelled widely before establishing more stable ranges during their second summer.

Apples were the most common food in scats collected during winter. Hares, porcupines, and several species of mice, voles, shrews, and squirrels also were common.

Fishers travelled through all forested habitats, and were never found in open areas. During winter, fishers rested in burrows, and hunted intensively in dense, brushy areas with many hare tracks. During summer, fishers usually rested in the branches of coniferous trees, and were active in all habitat

types. Tree cavities were used as rest sites during spring and fall, and as natal dens.

Fishers were active most often during early morning and evening, although some activity occurred throughout the day. Less activity occurred during the winter than the summer, and movements were shorter. Behavior patterns suggested that females with young kept them in tree cavities for about 8 weeks during April and May. From mid-June until September, the young probably accompanied their mothers, before becoming independent in late summer. [AA] Reports: 2, 3.

2. Arthur, S. M. 1988*a*. Tracking that elusive fisher. Maine Fish and Wildl. 30(1):6-9, 21.

Fishers were nearly eliminated from Maine during the 1930's, but the population recovered following protection from 1937–1950. Today fishers are the most valuable furbearer in the state. Home ranges, habitat requirements, and movements of radio-collared fishers were studied in Waldo County from 1983–1988. Most home ranges were between 13 and 26 km^2 (5-10 mi^2) and showed little intrasexual overlap, although ranges of males overlapped those of females. Female ranges were stable seasonally and between years, but males moved extensively during February–April, and some changed ranges between years. Fishers ate hares, porcupines, small mammals, and fruits. All forested habitat types were used, but areas with dense coniferous undergrowth were preferred for foraging during winter. Most summer rest sites were in the branches of coniferous trees, and coniferous stands were preferred for resting. Burrows were used for resting during winter, and tree cavities were used occasionally during fall and spring. Natal dens were in tree cavities, and were used for about 8 weeks during March and April. Young fishers probably remained with their mothers at least through August, and then moved extensively during their first fall and winter. Young fishers were the most vulnerable to harvest, followed by adult males. The lower vulnerability of adult females may allow a higher overall harvest rate without causing a population decline. The major threat to fishers in Maine is the potential loss of habitat as areas become developed for human use. Preserving the fisher population will require planning and management to maintain habitat. [CA] Thesis: 1.

3. Arthur, S. M. 1988*b*. An evaluation of techniques for capturing and radio-collaring fishers. Wildl. Soc. Bull. 16:417-421.

This study compared the costs and effectiveness of capturing fishers using cage traps, radio-monitored cages, and padded-jaw foothold traps, hiring trappers on contract, and purchasing fishers from fur trappers. The highest

capture rate was with radio-equipped cages (1.94/100 trapnights [TN]), probably because less human scent accumulated around trap sites. Cost per capture was lowest in monitored cages ($165), followed by purchases from fur trappers ($300), cages without monitors ($525), contract trappers ($940), and foothold traps ($1,720). Trapping was most productive during October, March, and April, but trapping during April may have caused 2 females to abandon natal dens. Darting from trees and trapping at burrows were effective recapture techniques. Darting was the quickest method, but was only effective when fishers rested in trees <15 m tall. Properly fitted radio collars did not injure fishers, although some fur wear usually occurred. Necks of juvenile males increased size between the ages of 6 and 15 months, so they were recaptured at 12-15 months and their collars were refitted. Ketamine hydrochloride was a safe and effective tranquilizer at doses of about 20 mg/kg body weight. [CA] Thesis: 1.

4. Caturano, S. L. 1983. Habitat and home range use by coyotes in eastern Maine. M.S. thesis, Univ. Maine, Orono. 28pp.

Seven radio-collared coyotes, representing 3 social groups, were monitored in eastern Maine from October 1979 to April 1981. Changes were observed in home range size and shape and in habitat use throughout the coyotes' annual reproductive cycle. At least 50% of the relocations for each adult animal were found in a core area representing <25% of its total home range. Coyotes used softwood and mixedwood cover year-round more than expected or in proportion to its availability within their home ranges. Hardwoods and non-forested heaths (bogs) and barrens were used less than expected, except during the summer when blueberry barrens were utilized heavily. Scat analyses showed that snowshoe hare was a staple food source throughout the year. White-tailed deer was also commonly found in winter and spring, while a shift in diet to small mammals and fruit occurred in the summer and early fall. [AA] Reports: 5, 6.

5. Caturano, S. L., and D. J. Harrison. 1981. The coyote: a look at his lifestyle. Maine Fish and Wildl. 23(4):19-23.

Home range characteristics and habitat use of 15 radio-collared coyotes in eastern Maine were examined during 5 periods of the reproductive cycle. During the pairbonding/breeding period coyote pairs usually travelled together, using home ranges of <12.5 km^2. Most hunting was done in coniferous forest types. During gestation, females reduced their movements. A female that was monitored intensively rested in coniferous cover 90% of the time. Her mate travelled extensively, using a range of 17.5 km^2. During the nursing period, females spent 80% of their time at their dens. Males

hunted extensively, and returned to the dens when the females left. Dens were located in cavities under boulders or in excavations of old fox or woodchuck burrows. Most consisted of a single chamber 1.5-2.4 m long and 0.4-0.5 m wide. Family units remained closely associated during summer. Pups were weaned after 6 weeks and began moving away from the den at 8 weeks. Ranges of adults expanded during this period, averaging 40 km^2. Family groups split up during winter, and groups of >2 coyotes rarely travelled together after January. [CA] Theses: 4, 15.

6. Caturano, S. L., and J. A. Sherburne. 1981. Summer activity patterns, habitat use, and food habits of coyotes. Trans. Northeast Fish and Wildl. Conf. 39:29. Abstract.

We equipped our adult coyotes with bimodal radio collars and monitored them in eastern Maine from June to September 1980. We took 1,653 readings at 15-minute intervals day and night to record the activity/inactivity of each coyote. Coyotes were active 81% of the time during any monitored period in June (n = 313), 61% in July (n = 453), 68% in August (n = 521), and 61% in September (n = 366). Of these 1,653 readings, we obtained 972 relocations by triangulation and plotted them by cover-type (hardwoods, conifers, mixedwoods, blueberry barren, heath). We compared these relocations with cover-type availability within each coyote's estimated home range. The use of conifers was high throughout the summer months (54%, n = 972). Coyotes greatly increased their use of blueberry barrens with the onset of the availability of fruit: June 1% (n = 143), July 35% (n = 261), August 25% (n = 283), September 13% (n = 285). The use of mixedwoods was fairly consistent throughout the summer (22%, n = 972). Use of hardwoods (2%, n = 972) and heath (1%, n = 972) was minimal. Coyotes were found to be active 63% of the time in the 3 major cover-types (conifers, mixedwoods, barren) and 95% of the time in hardwoods and heath. We collected 257 coyote scats throughout the summer and examined them for food contents. The food most frequently found was blueberry fruit (62%). The high occurrence of fruit in scats coincided with ripening and declined in late summer. Snowshoe hare was common throughout the summer (37%). The occurrence of small mammals increased from 3% in early June to 25% in September. Other foods, including white-tailed deer (9%), insects (6%), birds (5%), grass (5%), and red squirrel (2%) were less common. [AA] Thesis: 4.

7. DiBello, F. J. 1982. Furbearer use of waterways in Maine. Unpub. Rep., Maine Coop. Wildl. Res. Unit, Univ. Maine, Orono. 7pp.

Comparing the distance to water of 4,180 telemetry locations of 62 radio-

collared coyotes, bobcats, red foxes, fishers, and martens with data from random points revealed that the predators were more likely to be found within 0.1 km of water than was expected. Reports from various researchers indicated that areas near waterways often were characterized by coniferous vegetation, and were used by predators for travel routes and for finding prey. Uncut vegetation along waterways may be especially important in areas subject to intensive clearcutting. [CA]

8. Dubuc, L. J. 1987. Ecology of river otters on Mount Desert Island, Maine. M.S. Thesis, Univ. Maine, Orono. 76pp.

This study was conducted to define and quantify the ecological factors affecting the distribution and status of river otters in Acadia National Park (ANP) on Mount Desert Island (MDI), Maine.

The distribution of otters was determined by searching for otter sign on all watersheds on MDI during 2 winter and 2 summer field seasons between August 1985 and March 1987. Otter sign was documented on 25 of 39 watersheds during 207 sign-searches.

Otter selected watersheds that had the highest proportion of active beaver wetlands and avoided those with no beaver ($P<0.0001$). Beaver activity provided a stable water supply, influenced wetland productivity, and provided a source of den and resting sites.

The level of beaver activity was affected by the distribution of deciduous species such as aspen and birch. These species developed as a result of a 6,800 ha fire that occurred in 1947. Beavers used the burned watersheds more than expected ($P<0.01$). Slowly, these early successional species will be replaced by conifers such as spruce and fir and suitability of the habitat for beaver, and therefore otter, will be reduced.

The diversity of prey items in 200 otter scats was lower during winter than during summer ($P<0.0001$). Fish (85% occurrence) was the predominant food item in 47 scats collected during the winter while amphibians and reptiles (69% occurrence) and fish (61% occurrence) were present most often in the 153 scats collected during the summer. This seasonal change in the diversity of prey consumed by otters reflected the seasonal shift in habitats used. During summer the most common foods were species that inhabit shallow freshwater wetlands. During winter marine species were more common.

A predictive model of habitat use by otters was developed by comparing 19 watersheds used by otters during 2 or more field seasons with 14 unused watersheds. Of 47 habitat variables initially measured, 4 were identified as providing the greatest degree of discrimination between used and unused watersheds. Otter use was negatively associated with the proportion of mixed

hardwood and conifer stands in forested areas adjacent to waterways (MHDCON), and positively associated with the number of beaver flowages (ALLBEAV), watershed length (TOTL), and average shoreline diversity (MIRREG). These variables were combined in the discriminant function:

$$f(x) = -5.40 - 11.94\text{MHDCON} + 5.08\text{ALLBEAV} + 4.75\text{TOTL} + 2.09\text{MIRREG};$$

where: + = used, - = unused.

The model had an overall correct classification rate of 94%.

To maintain or improve the status of otters on MDI, the NPS should conduct periodic sign surveys to monitor population status, maintain patches of early successional vegetation along waterways, and ensure that otters have access to marine resources by establishing resource protection zones. [AA]

9. Engelhardt, D. B. 1986. Analysis of red fox and coyote home range use in relation to artificial scent marks. M.S. thesis, Univ. Maine, Orono. 62pp.

The range expansion of coyotes into Maine caused concern among biologists and trappers about the possibility of negative effects on the red fox population. Researchers in Maine and elsewhere found evidence of spatial segregation between the 2 species, suggesting avoidance of coyote-occupied areas by red foxes. Scent marking has been associated with territorial maintenance in both species. The purpose of this study was to determine whether scent (urine) marking is the cue that stimulates avoidance of coyotes by red foxes.

A series of 7 experimental scent-mark trials was conducted. In the first phase of each trial the home range of a radio-collared red fox or coyote was determined by intensive telemetry. In phase 2, water was distributed through the home range to test whether human presence would interfere with the subject's movements. In phase 3, artificial scent marks of coyote or red fox urine were placed in the home range.

The telemetry data for each trial were analyzed to test the general null hypothesis that home range use did not change among phases. First, a clustering program assigned each location to a particular region in the home range. (Regions refer to intensively-used core areas and extensively-used foraging areas.) The area, center of activity, and usage of each region were then compared among phases. Following a rejection of the general null hypothesis, a specific hypothesis was tested comparing the observed home range changes with those expected for a particular reaction to the experimental scent.

Home range use changed significantly in all 7 completed trials. Regional centers of activity changed location in at least 78.2% of all between-phase

comparisons, and usage of the regions was dependent upon treatment. However, the changes could only be correlated with presence of the scent in 2 trials where adult male conspecific urine was applied to the home range of a female yearling subject. In 4 trials where coyote urine was applied to red fox home ranges, the home range changes could not be attributed to presence of the scent. In conclusion, coyote scent marks alone are insufficient to stimulate an avoidance reaction by red foxes.

Any area of suitable habitat not being intensively used by coyotes can probably be used by red foxes. Red foxes can also use smaller areas of habitat than coyotes. Although some fox habitat probably was removed by coyotes when they colonized the state (perhaps reducing statewide fox densities), there seems to be enough remaining to support a healthy red fox population. [AA]

10. Gilbert, J. R. 1981. Techniques and problems of population modeling and analysis of age distributions. Pp. 13-133 *in* Bobcat research conference proceedings. Natl. Wildl. Fed., Sci. Techn. Ser. 6. 137pp.

Models presently available to analyze the status of bobcat populations have several assumptions that are difficult to meet. Often data available are not appropriate for application to such models. Interpretation of age distributions of legal take should be done with caution, although supplemental information will allow some analysis. Managers should obtain data from sources in addition to that from the legal kill, and should use several analyses as the basis for management decisions. [AA]

11. Halpin, M. A. 1984. Winter habitat use and ecology of red fox in eastern Maine and the history of red fox in Maine. M.S. thesis, Univ. Maine, Orono. 92pp.

Habitat use by red foxes in eastern Maine was studied during the winters of 1982 and 1983. One hundred and twenty-five km of fox trails were followed during periods of snow cover. Relationships between habitat use, snow conditions, food availability, and reproductive activities were examined.

Red foxes used all available habitats, but greatest proportions of travel distance occurred in softwood stands and open areas. Foxes avoided hardwood stands. Roads and trails were used for short-distance travel.

Snow depth was greatest in hardwood and mixed stands during both winters. In 1982, the period of snow cover was prolonged, and surface snow structure differed with habitats. Windblown, supportive crusts were found in open barrens, and soft, powdery conditions prevailed in hardwoods and mixed stands. Traveling was easiest during periods of predominantly crusty conditions in all habitats. Foxes sank least in the snow during these periods,

and distances in hardwood stands, where snow was usually deepest and softest, increased.

Snow influenced relative prey availability among habitats. Fox hunting activities shifted with changing snow conditions. No discernible pattern to fox pursuit of small mammals relative to habitat was evident in the first winter. In 1983, however, when snow was shallower, foxes hunted open habitats for small mammals. Proportions of small mammals in the fox diet decreased as snow accumulated. When snow was deep, foxes hunted habitats with softwood regeneration and other dense understories that supported snowshoe hare concentrations. As snow accumulated and limited the availability of small mammals and other food, fox dependency on snowshoe hare increased. Habitat selection focused on hare habitat.

Other fox activities were not strongly associated with winter habitats. Foxes often rested in sunny locations with some canopy cover. Paired trails indicating a male and female traveling together were observed throughout both winters. Movements became restricted in late March, and fox activities were centered around den sites.

The history of the red fox in Maine during the last 400 years was reviewed. Public sentiment toward the species and fox population trends were examined. Habitat, exploitation, and disease have most conspicuously influenced fox distribution and numbers. Red fox occurrence in northern forested areas of Maine has been patchy. In historically agricultural regions, the species has been more abundant. Fox numbers noticeably declined in some southern sections in the late 1800s as a result of anti-predator poisoning efforts. As the value of fox fur climbed in the early 1900s, attitudes toward the species changed. Fur harvest increased, and by the late 1920s fox numbers were again low. Demand for long-haired fur decreased through the 1930s, and as trapping pressure subsided, the fox population recovered. Local fluctuations in fox populations during the last 50 years were related to mange and rabies outbreaks. Coyotes have only recently become established in Maine, and as potential competitors with red foxes, they may have an increasing role in influencing the red fox population. [AA] Reports: 12, 13, 14.

12. Halpin, M. A., and J. A. Bissonette. 1983. Winter resource use by red fox (*Vulpes vulpes*) in eastern Maine. Trans. Northeast Fish and Wildl. Conf. 40:158. Abstract.

Winter resource use by red foxes in eastern Maine was examined with snow tracking methods during January–March of 1982 and 1983. Distributions of traveling, hunting, and resting activities were evaluated relative to snow conditions, food availability, and social interactions. Habitats were

classified as hardwood, softwood, mixed, open, or bog, and by understory density. Preliminary analyses indicate that all available habitats were used for travel during both winters but that the distribution of hunting activity among habitat types differed between the 2 years. During 1982, when snow accumulated to 90 cm, red foxes concentrated hunting in areas of dense undergrowth, particularly in stands of coniferous regeneration. Snowshoe hares, the major food item found in fox scats (% occurrence = 82.2, n = 62), were most abundant in these habitats. Other food items in the 1982 winter diet included deer, (% occurrence = 17.7), small mammals (9.6%), birds (11.3%), and vegetation (3.2%). In contrast, snow only accumulated to 31 cm in 1983. Small mammal sign on the snow surface in 1983 was more abundant than in 1982 in all habitats. Contents in 1983 scats represented a more varied diet. Snowshoe hare and deer decreased in frequency of occurrence (56.0% and 9.1% respectively), but small mammals (36.3%) and vegetative matter (7.5%) increased. Bird occurrence in 1983 fox scats did not differ from 1982. The timing of activities associated with breeding differed between years with den preparation first noted in 1982 during March but as early as January in 1983. With the commencement of den visitation, fox movements and activities were concentrated in areas around denning sites, which were found in all cover types except bogs. In the 2 contrasting winters of 1982 and 1983, differences in the distribution of red fox activities were most closely associated with the relationship between available food resources and habitats. [AA] Thesis: 11.

13. Halpin, M. A., and J. A. Bissonette. 1986. The history of occurrence of red fox in Maine: presettlement to 1984. Maine Agric. Exp. Stn. Misc. Publ. 683, Univ. Maine, Orono. 45pp.

The history of occurrence of red fox in Maine during the last 400 years was reviewed. Public sentiment toward the species, as well as fox population trends, were examined. Habitat change, exploitation, and disease have most conspicuously influenced its distribution and numbers. Red fox occurrence in the northern forested areas of Maine has been patchy, whereas in historically agricultural regions the species has been more abundant. Fox numbers declined noticeably in some southern sections in the late 1800's as a result of anti-predator poisoning efforts. As the value of fox fur increased in the early 1900's, attitudes toward the species changed and numbers increased locally. However, as fur prices climbed, harvest became heavier and by the late 1920's fox numbers were again low. Demand for long-haired fur decreased through the 1930's, and as trapping pressure subsided, the fox population recovered. Mange and rabies outbreaks during the last 50 years were related to local fluctuations in fox populations. Coyotes have become

established in Maine in recent years and may have an increasing role as potential competitors influencing red fox populations. The dynamic and interactive nature of the major influences, i.e., 1) habitat change, 2) human activities, 3) disease, and 4) interspecific canid competition on red fox populations must be recognized and more thoroughly understood if management is to be improved. [AA] Thesis: 11.

14. Halpin, M. A., and J. A. Bissonette. 1988. Influence of snow depth on prey availability and habitat use by red fox. Can. J. Zool. 66:587-592.

Habitat use by red fox was studied during the winters of 1982 and 1983. A total of 125 km of fox trails in eastern Maine was followed during periods of snow cover to examine the influence of snow conditions on fox habitat selection and prey availability. Red foxes used all available habitats but showed preferences for softwood stands and open areas. Hardwood forests were avoided. During both winters, snow depth was greatest in hardwood and mixed stands where soft, powdery conditions prevailed. Windblown, supportive crusts were found in open barrens. Foxes showed habitat preferences for traveling and hunting. Fox sinking depths were least in all habitats when crust conditions prevailed, and during these periods travel distances were more evenly distributed among habitats. Snow influenced relative prey availability. Hunting activities shifted among habitats for small mammals during most of the second winter, when snow was shallow. Proportions of small mammals in the fox diet decreased as snow accumulated and as crusts formed. When snow was deep, foxes hunted in habitats with softwood regeneration and other dense understories that supported snowshoe hare concentrations. [AA] Thesis: 11.

15. Harrison, D. J. 1983. Denning ecology, movements, and dispersal of coyotes in eastern Maine. M.S. thesis, Univ. Maine, Orono. 48pp.

Denning ecology, family associations and movements of 16 (4 adult, 12 juvenile) coyotes from 4 family groups were studied in eastern Maine from May 1981 through April 1982. Pups from 6 to 24 weeks of age were equipped with radio collars with compressible foam inserts. Monitoring of collared animals resulted in 2,760 radio locations.

Coyote families used several dens when pups were <10 weeks of age. Den entrances ($n = 7$) were all oriented towards the south. Two pair of adult coyotes relocated their pups to new den sites on 9 occasions. The mean distance between den sites was 1.3 km. Pups 10-25 weeks old centered their activity around rendezvous sites.

Radio fixes of adult coyotes were <500 m from den entrances 55% of the

time during nursing (May) and 54% during weaning (June and July). For 2 females with pups, distances traveled between consecutive independent relocations increased from nursing to weaning and from weaning to pup independence (August–April). Percent use of overall home ranges by females increased from 16% during nursing, to 63% during weaning, and 76% during pup independence.

For pups, home range sizes, mean distances traveled between independent relocations, and distances from den and rendezvous sites increased with age.

Coyote families centered their activity within a common territory that was adjacent to but discrete from those territories of neighboring groups. Prior to dispersal, the overall home ranges of juveniles were similar in size and position to those of their parents. Territory sizes of 3 coyote families known to contain pups ranged from 71-76 km^2. The size and position of 3 family territories were similar to those observed during the year previous to this study. Seventy-three percent (8 of 11) of juveniles dispersed during their first year. In each of 3 families, 1 pup remained within the family territory until at least 1 year of age.

Food habits of pups and adults were compared from May 1981 through October 1981. Blueberries occurred most frequently (68%) in coyote droppings. White-tailed deer was the most commonly occurring animal (43%), followed by snowshoe hare (29%) and small mammals (Cricetidae, Soricidae, Zapodidae) (21%). Deer was the primary food of pups prior to their independence, and deer occurred in a higher percentage of pup droppings than adult droppings during June and July. Pups consumed hare more frequently than adults during July and August. Small mammals composed a smaller percentage of the diet of pups than adults during July. [AA] Reports: 5, 17, 18, 19, 20, 21.

16. Harrison, D. J. 1986*a*. Coyote dispersal, mortality, and spatial interactions with red foxes in Maine. Ph.D. thesis, Univ. Maine, Orono. 109pp.

Coyote dispersal, mortality, denning ecology, and spatial relationships with red foxes were studied in Maine during 1981-1984. Sixty-five juvenile (<1 year) coyotes, 8 adult (>2 years) coyotes, and 11 adult (>1 year) red foxes were captured and ear-tagged. Forty-seven juvenile coyotes, 8 adult coyotes and 11 adult red foxes were equipped with radio collars.

Coyote pups began to move short distances from dens at 6-8 weeks of age. The radius and rate of pup movements increased with age. Large increases from September to October in pup home range sizes (+194%) and movement rates (+59%) were associated with the breakup of the family group and onset of dispersal. Movements of pups stabilized by late fall; neither their rates of travel nor their home range sizes were different from those of

adults by early winter. Predispersal home range sizes were not different between 8 juvenile males ($\bar{x}$ = 43.0 km^2) and 6 juvenile females ($\bar{x}$ = 45.0 km^2).

Dispersal of juvenile coyotes began during late September of their first year. Peaks in onset of dispersal occurred during October–November and during February–March. No dispersals were initiated during late December–January. Timing of dispersal coincided with periods of highest interfamily strife. Eighty-six percent of pups (n = 36) dispersed during their first year of life; 100% departed prior to 1.5 years of age. Most coyotes completed dispersal between 1 and 2 years of age.

Minimum distances dispersed averaged 94 km for 11 juvenile female coyotes and 113 for 9 juvenile males; distances averaged 98 km for 7 coyotes monitored until completion of dispersal. There were no differences ($P>0.10$) between sexes in the proportion, timing, or distance of dispersal. Coyotes homed along their initial bearing of dispersal ($P<0.025$), thus they maximized distances from natal areas. Water barriers deflected movements of dispersing coyotes and resulted in concentrations of dispersers adjacent to water features.

Delayed dispersal and pack formation have previously been associated with coyote populations subsisting on large food items. Predominant first year dispersal and lack of pack formation by coyotes in Maine, despite high use of white-tailed deer, suggests that low food densities preclude delayed dispersal and pack formation in this population.

Mortality was documented for 57% of tagged juvenile coyotes and indicated that human causes were responsible for 92% of documented deaths. Tag recovery rates were higher ($P<0.10$) for coyotes aged 0.5-1.5 years than for those older than 1.5 years. Based on telemetry data, the annual survival rate of pups from 6-58 weeks of age was 0.59. Survival was lower among juvenile females (0.39) than among juvenile males (0.93), suggesting that females were more susceptible to human caused mortality. Sixty percent of pup mortality rate was attributable to human causes. Annual survival rate from 0.5-1.5 years was lower for dispersers (0.47) than for residents (0.74).

Annual home ranges of 6 adult red foxes averaged 14.7 km^2. Fox home ranges were equated to the 46.4 km^2 mean home range for 8 adult coyotes by the relationship: Metabolic Home Range Size = km^2 / kg$^{0.87}$ body weight. Seventy-eight percent of the difference in mean home range size between coyotes and foxes was attributable to greater metabolic requirements of coyotes.

No fox captures (n = 11) occurred within core portions of coyote territories despite more intensive trapping effort in core portions. Home ranges of foxes were situated outside of coyote territories and along boundaries be-

tween adjacent coyote groups. Fox home ranges were associated with water features; however, no use by foxes of lakeshores or riparian zones within coyote territories was observed. Interspecific territoriality between coyotes and red foxes likely resulted from interference competition and avoidance of coyote territories by red foxes. The presence of resident coyotes limits the available habitat for red foxes in Maine. Smaller spatial requirements enable foxes to persist in boundary areas and prevent their complete displacement from regions occupied by coyotes. [AA] Reports: 17, 22, 29, 45.

17. Harrison, D. J. 1986*b*. Coyotes in the Northeast: their history, origin, and ecology. Appalachia 46:30-39.

Coyotes expanded their range into the northeastern United States during the first half of the 20th century. The period of most rapid expansion was during the 1950's and 1960's. Possible explanations for this expansion include the elimination of gray wolves from the area, which created a vacant niche, and habitat changes resulting from abandonment of farmland. Although eastern coyotes are frequently reported to hybridize with domestic dogs, differences in physiology, behavior, and timing of the reproductive cycle make this unlikely. Generally weighing 30-40 pounds, coyotes in the northeast are larger than western coyotes, and this may be the result of interbreeding with wolves or of adaptation to the new environment. In eastern Maine, coyotes usually lived in family groups consisting of a mated pair of adults and their pups. Breeding occurred in February, and litters of 5-9 pups were born in April. Pups were weaned at about 6 weeks, and dispersed from the family range at 5-18 months of age. Only 1 adult pair inhabited a particular area, so coyote behavior seemed to limit the population size. Major foods included deer, snowshoe hare, small mammals, and fruits. [CA] Theses: 15, 16.

18. Harrison, D. J., and J. R. Gilbert. 1985. Denning ecology and movements of coyotes in Maine during pup rearing. J. Mammal. 66:712-719.

Den attendance, movements, and home ranges of 8 adult coyotes attending pups were investigated during 1981-1983 in eastern Maine. Coyote families used several dens during pup rearing, and dens were frequently relocated following human disturbance. Six den entrances were oriented 120-236° from north. Two coyote families abandoned dens when pups were 8-10 weeks of age. Males and females shared in the duties of pup raising, and both frequently attended pups. Movement rates and home ranges of adult coyotes increased from the nursing to weaning periods, but movements and home ranges of adults were greatest after pups became independent. Movements suggested that males centered their activities near den sites during

the nursing period to supply food for mates and protection for pups. Females were more restricted than males during pup rearing because of nursing responsibilities. [AA] Thesis: 15.

19. Harrison, D. J., and J. A. Harrison. 1983. Denning ecology, movements, and dispersal of coyotes in eastern Maine. Trans. Northeast Fish and Wildl. Conf. 40:108. Abstract.

The objectives of this study were to investigate (1) the denning ecology, family associations, and interfamily spacing of coyotes, and (2) the movements, mortality, and dispersal of juvenile coyotes. Eighteen coyotes (6 adult, 12 juvenile) from 4 family groups were radio monitored in eastern Maine from May 1981 through April 1983. Pups from 6-24 weeks of age were equipped with radio collars with compressible foam inserts. Monitoring of collared animals resulted in 3,002 radio locations. Two coyote families used several dens when pups were <10 weeks of age. All den entrances ($n = 7$) were oriented south. Two pair of adult coyotes relocated their pups to new den sites on 9 occasions. The mean distance between den sites was 1.3 km. Pups 10-25 weeks old centered their activity around above ground rendezvous sites that were situated adjacent to blueberry barrens. Adult coyotes were <500 m from den entrances 55% of the time during nursing (May) and 54% of the time during weaning (June and July). For 3 adult females with pups, distances traveled between consecutive radio fixes (taken ≥6 hours apart) increased from nursing ($\bar{x} = 1.43$ km, $P<0.1$) to weaning ($\bar{x} = 1.78$ km) and from weaning to pup independence (August–April) ($\bar{x} = 2.59$ km, $P<0.05$). Mean percent use of total yearly home ranges by these 3 adult females increased from 16% during nursing, to 51% during weaning, to 82% during pup independence. For pups, home range sizes, mean distance traveled between consecutive radio fixes (taken 96 hours apart), and distances from den and rendezvous sites increased with age. Pup home ranges increased 390% and distances traveled between consecutive radio fixes increased 220% from September–October.

Coyote families centered their activity within a territory that was adjacent to but not overlapping those of neighboring families. Prior to the time that juveniles dispersed, their home ranges were similar in size and position to those of their parents. Territory sizes of 4 coyote families known to contain pups ranged from 53-76 km^2. The size and position of the 4 family territories were stable for at least 2 years. Seventy-three percent (8 of 11) of juveniles dispersed during their first year. In each of 3 families known to contain pups, 1 pup remained within the family territory until at least 1 year of age. Social organization and dispersal are potential factors regulating coyote populations in Maine. [AA] Thesis: 15.

20. Harrison, D. J., and J. A. Harrison. 1984*a*. Deer use by coyote families during pup rearing. Trans. Northeast Deer Tech. Comm. 20:34. Abstract.

The purpose of this study was to assess the use of white-tailed deer by coyote families during pup development, and to determine the age and reproductive status of coyotes feeding on deer. This research was conducted during 1981 in eastern Maine as part of a long-term study of furbearer ecology by the Maine Cooperative Wildlife Research Unit, in cooperation with the Maine Department of Inland Fisheries and Wildlife (Pittman-Robertson Project W-69-R).

Analysis of 452 scats from 3 breeding coyote pairs and their known-aged pups indicated that deer was the most commonly occurring animal food (43% frequency of occurrence) during May–October. For the first 2 months following weaning (June and July), deer were found in a greater percentage of pup than adult droppings ($P<0.01$). Until pups began to forage independently during August, they fed primarily on deer (86% occurrence, $n = 156$). We believe that it was energetically and/or nutritionally less efficient for parent coyotes to catch and transport sufficient quantities of small prey items to sustain their litters than to prey upon and transport deer. This strategy probably caused adult coyotes attending pups to kill proportionately more deer during June and July than non-reproductive coyotes ($P<0.05$). After pups became independent the occurrence of deer decreased to <11% for both age groups. This decrease in deer use probably resulted from the small size and inexperience of pups, a decreasing vulnerability of deer fawns, and the availability of ripening blueberries in adjacent barrens.

The high incidence of deer remains observed during this study may have partly resulted from the forested nature of the habitat. The few open areas that existed were mainly bogs and blueberry barrens, and they supported fewer small mammals than forested habitats.

During 2 subsequent years (1982-1983), scats containing fawn or adult deer remains were differentiated to determine the relative occurrence of each age group. Of 31 coyote scats containing deer remains during May, 100% were identified as adult deer. However, during June 50% of scats containing deer remains ($n = 20$) were identified as fawns. By July it appears that fawn remains in scats are not easily recognized from remains of adult deer. [AA] Thesis: 15.

21. Harrison, D. J., and J. A. Harrison. 1984*b*. Foods of adult Maine coyotes and their known-aged pups. J. Wildl. Manage. 48:922-926.

Four radio-collared coyotes representing 3 breeding pairs were monitored

during spring and summer, 1981. Natal dens were located, and 15 pups were tattooed at <10 days of age. At the age of 6 weeks, 6 of these were recaptured and radio-collared. Movements of radio-collared coyotes were used to locate home ranges, dens, and rendezvous sites, and evaluate relationships between pups and adults. Scats were collected at dens and rendezvous sites after coyotes left the sites. Scats were dried, crumbled, and examined so that hair remains could be identified. Pup scats could be distinguished from those of adults until September 1. White-tailed deer was the most common food during June, and was more common in scats of pups than those of adults during June ($P<0.01$) and July ($P<0.001$). Blueberries were the most common food of both pups and adults from July-October, and were the most common food overall. Snowshoe hare was the third most common food, and was more common ($P<0.05$) in pup than adult scats during July and August. Small mammal remains were less common in pup than adult scats during July ($P<0.001$). The heavy reliance on blueberries probably was due to their abundance. The higher frequency of occurrence of larger mammals in pup scats than in those of adults may have been because these species were more efficiently carried to the dens by adults. Occurrence of deer remains declined sharply in August, probably because of decreased vulnerability of fawns and increasing independence of pups. [CA] Thesis: 15.

22. Harrison, D. J., J. A. Bissonette, and J. A. Sherburne. 1989. Spatial relationships between coyotes and red foxes in eastern Maine. J. Wildl. Manage. 53:181-185.

We studied area use and spatial relationships among sympatric coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) in eastern Maine during 1981–84. Foxes established home ranges outside of coyote territories or in boundary areas between adjacent coyote groups. Fox home ranges were associated with lakeshores or riparian zones, but foxes did not use these habitats within coyote territories. Foxes were never captured (>7,000 trap nights) within core portions of coyote territories. The presence of resident coyotes appears to limit the available habitat for red foxes in eastern Maine. Smaller spatial requirements enable foxes to persist in boundary areas between coyote territories and may prevent their complete displacement from regions occupied by coyotes. [AA] Thesis:16.

23. Hilton, H. 1976. The physical characteristics, taxonomic status and food habits of the eastern coyote in Maine. M.S. thesis, Univ. Maine, Orono. 66pp.

Carcasses of 107 wild canids were autopsied in the laboratory. The mean weight of adult males and females, respectively, was 15.9 and 14.5 kg; mean

total lengths were 1,233 and 1,193 mm and skull lengths were 205 and 195 mm. Pelage was of 4 general phases similar to those described for northeastern coyotes and eastern wolves, and was distinct from dogs especially in the banding pattern of the guard hairs.

Females examined did not bear young until the second year. The average number of distinct and indistinct uterine scars for 5 adult females indicated an average litter size of 7 with a potential implantation of 9.3 eggs. Young appeared to be born about mid-April and reached near-adult weight and body proportions by January. Pup survival to 12 months was estimated to be 4-7%.

Seventy adult skulls from Maine and 44 from Quebec were analyzed taxonomically using the linear discriminant function. Of all the Maine samples including several skulls previously examined, 67 were identified or confirmed as eastern coyotes and 3 as dogs. The taxonomic position of the Maine coyote sample represented a shift from both western coyotes and wolves in a trend first reported by B. Lawrence and W. Bossert in 1969. Quebec coyotes exhibited a noticeable dichotomy, some being more coyote-like than the Maine specimens, others very similar to the Maine specimens. The Maine population seems to represent the purification of a wild hybridized form as it has moved eastward away from all pure wild *Canis*. The occurrence of domestic dog genes in the Maine coyote population was not apparent.

Stomach and scat analyses indicated an opportunistic feeding habit, with snowshoe hare and white-tailed deer important in wilderness regions in winter. There were no observations of predation on moose and beaver. Coyotes demonstrated a 15-48% success rate killing deer, preying primarily on fawns in early winter and adults over 4 years old in late winter. Predation increased in late winter and early spring with 50% of the deer kills located in March. Carrion was revisited by coyotes often in winter, parts of deer carcasses lasting 2-3 months; in spring carcasses lasted less than 1 week. Food consumption rates in captivity were 0.72 kg/coyote/day of meat; in 1 case in the wild 3.7-5.6 kg/coyote/day or 0.11-0.16 kg meat/day/kg of coyote.

The Maine coyote is considered intermediate to wolves and western coyotes in nearly all respects including niche and systematics, probably the result of hybridization with *C. lupus lycaon* (Algonquin or Tweed type) in southern Ontario and Quebec. [AA] Report: 24.

24. Hilton, H. 1978. Systematics and ecology of the eastern coyote. Pp. 209-228 *in* M. Bekoff, ed. Coyotes: biology, behavior, and management. Academic Press, NY. 384pp.

Coyotes evidently dispersed into New York and New England from On-

tario and Quebec during the early 1900's. Eastern coyotes are larger than their western counterparts, and it has been suggested that this is a result of hybridization with domestic dogs or wolves or because of rapid evolution in response to a vacant niche left by the removal of wolves from eastern North America. Although coyote-dog hybrids are fertile, they exhibit a phase shift in the reproductive cycle, causing young to be born in mid-winter. These hybrids also resemble dogs more than coyotes in physical appearance. Hybridization with wolves, particularly the race *C. l. lycaon*, Tweed Type, found in Ontario, seems more likely. Discriminant function analysis placed skulls of Maine coyotes intermediate to those of western coyotes and wolves, and separate from dogs. Female coyotes became sexually active during February, and young were born in mid-April. Five mature Maine coyotes had an average of 7 uterine scars, but no yearling eastern coyotes were found to be pregnant or to have produced litters. Most coyotes harvested in Maine are from areas of mixed-growth forest and small farms, although they also occupy the extensively forested parts of the state. Coyotes in northern Maine had a more restricted diet than coyotes elsewhere, and major prey species included white-tailed deer, snowshoe hare, muskrat, beaver, mice, and birds. In winter, the diet was almost exclusively composed of deer and hares, but in summer mice were more common than deer. Snow tracking suggested that many of the deer eaten by coyotes were killed by them, but the effects of predation on the deer population could not be determined. Fawns were killed more often than adults during December–February, and adults were more common during March and April. Groups of 3-4 coyotes were recorded most often during late winter. Moose were consumed only as carrion, but beaver were commonly eaten in all seasons. [CA] Thesis: 23.

25. Hilton, H., and N. P. Kutscha. 1978. Distinguishing characteristics of the hairs of eastern coyote, domestic dog, red fox and bobcat in Maine. Amer. Midl. Natur. 100:223-227.

Hairs from 32 coyotes, 15 domestic dogs, 8 red foxes, and 5 bobcats taken in Maine were examined to determine the essential distinguishing characteristics. Although several characteristics are strongly overlapping, hairs can often be distinguished by number, order and color of bands, the cross-sectional translucence and shape, and the cuticular scale pattern. [AA]

26. Licht, D. S. 1988. Research trapline: getting a handle on the northeastern fisher. Fur-Fish-Game 85(5):10-12.

Fishers were live-trapped in Maine as part of a radio telemetry study. Cage traps equipped with radio monitors were set on prominant land forms near the edges of mixed forest stands and small streams or bogs. Traps were

often set several miles apart so as to cover home ranges of several different fishers. Captured fishers were tranquilized, then weighed and measured. A premolar was removed to determine the animal's age, and a radio collar was attached. Data obtained from these animals were used to assess potential effects of fur trapping and habitat changes and make management recommedations. [CA]

27. Litvaitis, J. A. 1984. Bobcat movements in relation to prey density. Ph.D. thesis, Univ. Maine, Orono. 103pp.

Bobcat prey use, habitat use, and home range size were compared to the distribution and density of snowshoe hare in 2 study areas in Maine. The habitat variables that influenced hare habitat use and density were identified within each study area. These variables were then sampled within the home ranges of transmitter-equipped bobcats to examine the relationships among bobcat habitat use and home range size, and hare abundance.

In Cherryfield, hare preferred hardwood and avoided mixedwood and open understories ($P<0.05$). Hare use of understories increased as hardwood stem density increased ($r = 0.36$, $P<0.0001$). In Pierce Pond, hare used softwood more, and hardwood and open understories less than expected ($P<0.05$). Hare pellet density was strongly associated with softwood stem density in this area ($r = 0.52$, $P<0.0001$). Although differences in understory cover and composition existed between areas, snowshoe hare responded similarly to relative differences in understory cover within each area.

Snowshoe hare remains were observed in over 60% of the bobcat feces collected during all seasons in both study areas. Other prey included whitetailed deer, moose, small mammals, muskrats, porcupines, and birds. Prey remains in 230 bobcat carcasses indicated that prey use varied with bobcat age, sex, and weight.

Thirty bobcats were captured, marked, and released. Twenty-one individuals were monitored for >3 months. Resident adult males occupied ranges ($\bar{x} = 95.7$ km^2) approximately 3 times as large as adult females ($\bar{x} = 29.8$ km^2) and yearling females ($\bar{x} = 35.5$ km^2). Male and female bobcats occupied the largest portion of their total home ranges (>50%) during the gestation season (16 Mar-15 May) and the smallest portion (<20%) during the nursing season (16 May–15 Jun).

Over 6,000 habitat samples were collected along 400 km of transects within bobcat home ranges. Use-availability analysis revealed several bobcat habitat preferences. In Cherryfield, bobcats preferred hardwood understories, while in Pierce Pond, softwood understories were used more than expected ($P<0.05$). These patterns corresponded to the habitat preferences

of snowshoe hare in both areas. Bobcats also avoided open understories and steep slopes, possibly because these areas contained few hare.

Resident bobcat home range size was compared to bobcat age, weight, an index of winter severity, estimated hare density, and other habitat variables within home ranges. When all bobcats were combined into a single multiple regression model, bobcat weight explained 45% of the variation in home range size ($P<0.0002$). The combination of weight and the amount of edge within a home range accounted for 60% of the variation of home range size. Therefore, hare density was a poor indicator of bobcat home range size in the 2 study areas. [AA] Reports: 28, 29, 30, 31, 33, 34, 35, 36, 37, 38, 45.

28. Litvaitis, J. A., A. G. Clark, and J. H. Hunt. 1986*a*. Prey selection and fat deposits of bobcats (*Felis rufus*) during autumn and winter in Maine. J. Mammal. 67:389-392.

The effects of age, sex, weight, and winter severity index (WSI) on bobcat food habits and fat deposits were determined by examining carcasses of bobcats caught by fur trappers. Skinned carcasses were weighed and assigned to classes based on the amount of visceral fat present. Stomach contents were examined to identify prey remains. Adult ($\bar{x}$ = 12.3 kg) and yearling ($\bar{x}$ = 8.9 kg) male bobcats were heavier than females of the same age ($\bar{x}$ = 7.2 kg for adults, $\bar{x}$ = 7.3 kg for yearlings; $P>0.01$), but weights of juveniles were similar between sexes ($\bar{x}$ = 5.1 kg for males, $\bar{x}$ = 4.8 kg for females; $P>0.63$). Age, weight class, WSI, and the interaction of weight class with WSI all influenced bobcat fat deposits ($P<0.03$), but sex did not ($P>$ 0.47). However, during severe weather, more females than males were classified as in poor condition. Fat deposits of females also decreased from October through February, whereas fat deposits of males did not change. Major prey species included snowshoe hare, white-tailed deer, porcupines, and a variety of smaller mammals and birds. Bobcat food habits were influenced by age, sex, and weight of the predator. Juveniles consumed smaller prey more frequently than did older bobcats ($P < 0.10$), and had empty stomachs more often ($P< 0.05$). White-tailed deer were more common in stomachs of male bobcats than in females ($P< 0.05$), and in stomachs of bobcats weighing 12 kg (unskinned) compared to smaller bobcats ($P<$ 0.001). The ability of large male bobcats to prey upon deer probably makes them less susceptible to the effects of severe weather. However, deep snow and very low temperatures may decrease survival of both large and small bobcats, and may determine the northern boundary of the species. [CA] Thesis: 27.

29. Litvaitis, J. A., and D. J. Harrison. 1989. Bobcat-coyote niche relationships during a period of coyote population increase. Can. J. Zool. 67:In press.

Resource partitioning between bobcats and coyotes was investigated in eastern Maine during 1979-1984, when colonizing populations of coyotes were rapidly expanding. A total of 2,615 radio locations of 10 resident bobcats and 6 resident coyotes was used to investigate activity patterns, spatial relationships, and habitat use. The daily distribution of activity by both species was similar during all seasons, and neighboring bobcat-coyote home ranges overlapped. Simultaneous locations of 8 sympatric bobcat-coyote pairs ($\geq$10% home range overlap) indicated an apparent lack of attraction or avoidance between neighboring heterospecifics. Bobcats preferred hardwood stands during all seasons ($P < 0.05$), and occupied softwood-dominated stands less than expected ($P < 0.05$) during autumn and winter. Coyote habitat use was less consistent, and indices of habitat-use overlap with bobcats varied from 0.60 during autumn to 1.00 during winter. Seasonal indices of diet diversity, based on the examination of 1,495 feces, indicated that bobcats were more specialized than coyotes. Coyotes became omnivorous during summer and autumn, while bobcats remained strict carnivores during all seasons. Indices of diet overlap were higher during winter (0.76) and spring (0.72) than during summer (0.49) and autumn (0.49). The numbers of bobcats and coyotes trapped in eastern Maine during 1977-1986 were negatively correlated ($r = -0.75$, $P < 0.02$), suggesting a population response to exploitation competition between these 2 carnivores. [AA] Theses: 16, 27.

30. Litvaitis, J. A., J. T. Major, and J. A. Sherburne. 1986*b*. A status report: bobcat movements in relation to snowshoe hare density. Page 375 *in* S. D. Miller and D. D. Everett, eds. Cats of the world: biology, conservation, and management. Nat. Wildl. Fed., Washington, D.C. 501pp. Abstract.

Twenty-one bobcats have been equipped with radio transmitters in 2 study areas in eastern and western Maine to investigate the relationship between bobcat movements and prey density. Bobcat home range size and habitat use are being determined. Snowshoe hares are the major prey of bobcats in both study areas. Relative density of hare is being investigated within major vegetative communities using live- trapping, track and pellet counts, and radio telemetry methods. Community characteristics including ground cover, understory and overstory composition, slope, and aspect are being compared to relative hare densities. These same characteristics are being

used to index hare abundance within bobcat home ranges and will be compared to bobcat habitat use patterns and home range size. [AA] Thesis: 27.

31. Litvaitis, J. A., J. T. Major, and J. A. Sherburne. 1987. Influence of season and human-induced mortality on spatial organization of bobcats (*Felis rufus*) in Maine. J. Mammal. 68:100-106.

Movement patterns of 30 radio-equipped bobcats in 2 areas in Maine were studied in relation to reproductive seasons and trapping/hunting removals from 1979 to 1984. Resident male and female bobcats occupied stable home ranges ($\bar{x}$ = 95.7 and 31.2 km^2, respectively), with substantial seasonal variation in the percentage of total home range occupied. Resident males and females occupied the largest portion of their total home ranges during the gestation season ($\bar{x}$ = 59%) and the smallest portion during the nursing season ($\bar{x}$ = 18%). This variation may have been a response to seasonal availability of prey. The average overlap between successive seasonal ranges was 71%, indicating strong site fidelity by resident bobcats. Transient bobcats moved extensively through areas >220 km.^{2} Annual survival rates of bobcats ≥1 year old varied by bobcat sex, age, and study area. Trapper- and hunter-caused mortality accounted for 55% of the total annual mortality of bobcats ≥1 year old (33%). Transients quickly settled into ranges after the removal of a resident bobcat, resulting in a stable spatial organization. [AA] Thesis: 27.

32. Litvaitis, J. A., M. O'Donoghue, M. Miller, and J. A. Sherburne. 1984*a*. An evaluation of trapping efforts to capture bobcats, coyotes, and red fox. Proc. Eastern Animal Damage Control Conf. 1:125-127.

The use of steel-jaw leg-hold traps using scent post, blind, and baited sets was evaluated for effectiveness of capturing coyotes, bobcats, and red fox, and for effects on non-target species. Captures were compared by season and by set type. Captures of bobcats, red fox, and adult coyotes were greater during spring than during summer and fall, perhaps because of increased activity of the animals. Captures of coyote pups were most frequent during fall, and capture rates for all species were lowest during summer. Bobcats and adult coyotes were most susceptible to blind sets, whereas coyote pups were more susceptible to baited sets and red fox were usually caught at scent posts. Blind sets also had the highest capture rate for non-target species. Trapping caused few injuries to target species, but 40% of non-target animals caught had severe cuts, fractures, or other severe injuries. Captures of small non-target species were reduced by using traps with adjustible tension screws on the trap pan. Staking traps with short (15-18 cm) chains reduced

injuries due to an animal's struggling. The effort and cost per capture were greatest for bobcats, at about 900 trapdays and $1,100. Red fox required 476 trapdays/capture, adult coyotes required 473 trapdays, and coyote pups required 270 trapdays. [CA]

33. Litvaitis, J. A., and J. A. Sherburne. 1983*a*. Ecology of snowshoe hare in Maine. Trans. Northeast Fish and Wildl. Conf. 40:176. Abstract.

Movements, habitat use, diet, and density of snowshoe hare were studied in 2 areas having differences in climate, vegetation, land use, and topography. The eastern area, Cherryfield, is located near the Atlantic coast and is typified by a patchy distribution of cover types, with some extensive stands of immature hardwoods. The western area, Pierce Pond, is mountainous and extensive logging operations have resulted in dense stands of regenerating spruce and fir. Hare densities were estimated on 4 grids (2/area) during spring and fall capture-recapture periods. Nine hare in Cherryfield were equipped with transmitters and monitored during the fall and winter. Mean home range sizes of males and females were 6.9 and 4.7 ha, respectively, and ranges overlapped substantially. Live-trapping, snow track counts, and fecal pellet counts indicated that hare prefer stands with understory stem densities of >20,000/ha. Browse use by hare was examined by identifying and counting clipped twigs from 0-2.5 m above ground level. Twig diameter at point of browsing also was measured to evaluate the intensity of use. Rhodora, beaked hazelnut, and witherod were consumed in large amounts in Cherryfield, whereas red spruce, white birch, and red maple were major browse species in Pierce Pond. Intensity of browse use by snowshoe hare was not correlated with browse protein content. Hare densities were at least twice as great in Pierce Pond in comparison to populations in Cherryfield. These differences in density may be partially explained by differences in understory composition between the 2 areas. Stands of regenerating spruce and fir in Pierce Pond may support higher densities of hare by ameliorating climate extremes and providing denser escape cover than the hardwood stands in Cherryfield. Such activities as clearcutting may rejuvenate showshoe hare habitat as the habitat matures. Rejuvenation will be most successful in areas having coniferous regeneration. [AA] Thesis: 27.

34. Litvaitis, J. A., and J. A. Sherburne. 1983*b*. The snowshoe hare in Maine: a most important animal. Maine Fish and Wildl. 25(4):8-9.

Snowshoe hare in northern forests convert plant material into animal matter, and they are the major prey of many carnivores. Hare were studied by radio telemetry, pellet counts, track counts, and box trapping. Hare ranges varied from 2.5-12.1 ha.; male ranges were larger than female ranges. Hares

preferred areas with dense undergrowth. Young coniferous stands were preferred in winter and deciduous stands were preferred in summer. In Maine, hare populations vary with location and over time, probably because of changes in vegetation. [CA] Thesis: 27.

35. Litvaitis, J. A., J. A. Sherburne, and J. A. Bissonette. 1985*a*. A comparison of methods used to examine snowshoe hare habitat use. J. Wildl. Manage. 49:693-695.

Fecal pellet counts, snow track counts, and live-trapping were used to determine habitat use by snowshoe hares and the results obtained by different methods were compared. Hare pellets were counted on 1-m-radius plots spaced at 50-m intervals along transects. Live traps were placed near the pellet plots, and tracks were counted along transects between plots. Understory stem density was measured on two 15 x 0.5-m plots set perpendicular to each pellet plot. All 3 indices provided the same result in 3 of 8 habitat comparisons, and 2 indices agreed in the remaining comparisons. No instances were observed where 1 index indicated a type was preferred while another index indicated the type was avoided. Live-trapping was the most costly and labor intensive. Track counts were inexpensive and could be used for large areas, but use was restricted to the occurrence of snow. Pellet counts were also inexpensive when applied over large areas, and could be used to study seasonal patterns of habitat use. [CA] Thesis: 27.

36. Litvaitis, J. A., J. A. Sherburne, and J. A. Bissonette. 1985*b*. Influence of understory characteristics on snowshoe hare habitat use and density. J. Wildl. Manage. 49:866-873.

The influence of forest understory characteristics on snowshoe hare habitat use and density was studied in eastern (Cherryfield) and western (Pierce Pond) Maine during 1981–1983. Fecal pellet counts indicated that hares at Cherryfield preferred hardwood and avoided mixedwood and open understories during the leaf-off season (Oct–May) ($P < 0.05$). At Pierce Pond, hares used softwood more and hardwood and open understories less than expected during leaf off ($P < 0.05$). Hardwood understories provided the densest cover at Cherryfield, whereas at Pierce Pond softwoods were the densest cover. Hares in both areas used dense understories less during the leaf-on season (Jun–Sept). Spring population densities (0.1-1.7/ha) were correlated with understory density ($r = 0.94$, $P < 0.001$). Overwinter survival also was associated with understory density ($r = 0.74$, $P < 0.04$). Dense understories provided escape and thermal cover. [AA] Thesis: 27.

37. Litvaitis, J. A., J. A. Sherburne, and J. A. Bissonette. 1986*c*. Bobcat habitat use and home range size in relation to prey density. J. Wildl. Manage. 50:110-117.

Bobcat diet, habitat use, and home range size were studied in relation to snowshoe hare density and distribution in 2 areas in Maine during 1979-1984. Hare remains occurred in 63-76% of bobcat feces collected during all seasons in both areas. Habitat use patterns of 12 transmitter-equipped bobcats in eastern Maine indicated that they used hardwood understories more, and softwood and mixedwood understories less than expected ($P < 0.05$). Nine bobcats in western Maine preferred softwood understories ($P < 0.05$). Bobcats avoided sparse understories (<12,000 stem cover units/ha) and topographic slopes >5^3 ($P < 0.05$). The average home range of resident male bobcats (95.7 km^2) was 3x as large as that of resident females (31.2 km^2)($P < 0.05$), and home range size was correlated with bobcat weight ($r^2 = 0.45$, $P < 0.002$). Metabolic home range size (km^2/kg$^{0.75}$ body wt) of bobcats was inversely correlated with stem cover unit density and estimated hare density ($r^2 = 0.22$, $P < 0.05$). Estimated hare density and average topographic slope within bobcat home ranges accounted for 50% of the variation in metabolic home range size ($P < 0.006$). [AA] Thesis: 27.

38. Litvaitis, J. A., J. A. Sherburne, M. O'Donoghue, and D. May. 1982. Cannibalism by a free-ranging bobcat, *Felis rufus*. Can. Field-Nat. 96(4):476-477.

An adult female bobcat apparently killed and consumed a kitten. This cannibalism may have been partially influenced by territorial behavior since it occurred on the edge of the adult's home range. [AA] Thesis: 27.

39. Litvaitis, J. A., C. L. Stevens, and W. W. Mautz. 1984*b*. Age, sex, and weight of bobcats in relation to winter diet. J. Wildl. Manage. 48:632-635.

Bobcat carcasses from New Hampshire were collected and examined to determine age, sex, weight, and food habits. Yearlings and adults consumed white-tailed deer more often than did juveniles. Male bobcats ($\bar{x} = 8.4$ kg) were heavier than females ($\bar{x} = 6.2$ kg), and males consumed deer more frequently and snowshoe hare less frequently than did females. Frequency of consumption of deer increased with increasing body weight, suggesting that dietary differences among age and sex classes might have been partly due to differences in body size. [CA]

40. Major, J. T. 1979. Marten use of habitat on a commercially clear-cut forest during summer. M.S. thesis, Univ. Maine, Orono. 32pp.

Summer habitat use by marten was studied in an area of northern Maine where commercial clear-cutting was conducted 3-18 years ago. Four adult resident marten (3M:1F) were equipped with radio collars. Information on habitat use was obtained from 1,350 radio locations. Marten were found to underutilize the regenerating clear-cuts most of the summer, although the availability of red raspberries as food was believed responsible for increased use of this habitat in late summer. Marten rely on the uncut softwood residual stands and partially-cut mixedwoods throughout the summer. The female studied was associated with one of the larger continguous softwood blocks. Commercial clear-cutting, though not a recommended management practice for marten, can be compatible with the maintenance of a residual marten population if sufficient uncut and partially-cut softwoods and softwood-dominated mixedwoods are retained. [AA] Reports: 46, 65.

41. Major, J. T. 1983*a*. Ecology and interspecific relationships of coyotes, bobcats, and red foxes in western Maine. Ph.D. thesis, Univ. Maine, Orono. 64pp.

Interspecific relationships among coyotes, bobcats, and red foxes were examined in western Maine between 1979-1982. Habitat selection, spatial relationships, and activity patterns were determined through radio telemetry of 9 coyotes, 10 bobcats, and 4 foxes. Similarity in niche parameters between pairs of furbearer species was compared using overlap indices.

During winter, radio-collared bobcats and coyotes selected forest stands of predominantly coniferous overstory, while radioed foxes avoided this type and selected hardwood dominated stands. Snowtracking of both radio-collared and other individuals indicated that bobcats and foxes used stands characterized by softwood regeneration more than did coyotes. Coyotes and foxes used roads and open areas extensively for travel and demarcation of territory boundaries whereas bobcats made little use of these areas. Overlap indices for the 3 species indicated that habitat selection during all seasons was least similar between coyotes and foxes.

Home range sizes averaged 43.3 km^2 for coyotes, 19.9 km^2 for foxes, and 138.6 km^2 for male bobcats. A female bobcat had a home range of 27.5 km^2. Home ranges of bobcats overlapped those of coyotes both spatially and temporally. Fox home ranges abutted but did not overlap coyote home ranges. Simultaneously monitored coyotes, bobcats, and foxes occupying adjacent or overlapping ranges maintained separation distances that did not differ from random ($P>0.05$), except that members of social groups

tended to aggregate. Coyotes, bobcats, and foxes exhibited variable activity patterns, with no definite diel patterns.

Snowshoe hares were abundant and ranked first or second in frequency of occurrence during all seasons for all species from analysis of 826 scats. White-tailed deer also ranked first or second in frequency of occurrence in 3 of 4 seasons for coyotes and bobcats, but occurred in <15% of seasonal fox diets. The occurrence of deer in furbearer diets was related to the severity of the particular winter. Small mammals (Cricetidae, Soricidae, Zapodidae) occurred frequently in the fox diet, but occurred rarely in bobcat and coyote diets. The canids ate fruits and berries in summer and fall, whereas bobcats were carnivorous year-round. The least dietary overlap was between coyotes and foxes during all seasons except summer, when bobcats and foxes had the least similar diet.

Interference competition was inferred from spatial segregation between coyotes and foxes on the study area. There was no evidence that competitive relationships existed between bobcats and red foxes. Although coyote and bobcat use of food and habitat overlapped, no supporting data for interference competition was obtained for these species. [AA] Reports: 43, 44, 45.

42. Major, J. T. 1983*b*. Master of adaptation: the eastern coyote is in Maine to stay. Habitat 1(1):14-17.

The eastern coyote became established in Maine during the 1940's and 1950's. By this time, wolves had been eliminated from Maine and much of the area consisted of second-growth forests with abundant prey. Eastern coyotes are larger than western coyotes, and frequently eat white-tailed deer during winter and spring. This has caused some conflicts with sportsmen and others who believe coyotes are harmful to the deer population. Few details about the relationship between coyotes and deer in Maine are known. Animal damage control efforts directed toward coyotes are the responsibility of the Maine Department of Inland Fisheries and Wildlife, and are intended to remove specific individuals or groups of coyotes that are causing damage. Because of the coyote's adaptability, it probably will remain a part of Maine's wildlife community. With time, coyotes might become better accepted by sportsmen. [CA]

43. Major, J. T., and J. A. Sherburne. 1981. Predator and prey: how do they relate? Maine Fish and Wildl. 23(4):14-16.

Research efforts in the Pierce Pond area of western Maine centered around capturing and radio-tracking coyotes, foxes, and bobcats. Data were analyzed to determine habitat and home range requirements. Scat analyses in-

dicated that major foods included snowshoe hare, white-tailed deer, and small mammals. The effects of winter severity on predator and prey species were also investigated. [CA] Thesis: 41.

44. Major, J. T., and J. A. Sherburne. 1987. Interspecific relationships of coyotes, bobcats, and red foxes in western Maine. J. Wildl. Manage. 51:606-616.

Interspecific relationships among coyotes, bobcats, and red foxes were examined in western Maine between 1979 and 1982. During winter, radiocollared bobcats ($n = 10$) and coyotes ($n = 9$) selected forest stands of predominantly coniferous overstory, whereas radioed foxes ($n = 4$) avoided this type and selected hardwood-dominated stands. Habitat selection during all seasons was least similar between coyotes and foxes. Home ranges of bobcats overlapped those of coyotes both spatially and temporally. Fox home ranges abutted but did not overlap coyote home ranges. Simultaneously monitored coyotes, bobcats, and foxes occupying adjacent or overlapping ranges maintained random separation distances ($P > 0.05$). Coyotes, bobcats, and foxes exhibited variable activity patterns. Snowshoe hare were abundant and were first or second in frequency of occurrence during all seasons for all species. White-tailed deer also ranked first or second in frequency of occurrence in 3 of 4 seasons for coyotes and bobcats, but occurred in <15% of seasonal fox diets. Small mammals (Cricetidae, Soricidae, and Zapodidae) occurred frequently in the fox diet, but occurred rarely in bobcat and coyote diets. Interference competition was inferred from spatial segregation between coyotes and foxes on the study area. There was no evidence that competitive relationships existed between bobcats and red foxes. Although coyote and bobcat use of food and habitat overlapped, no supporting data for interference competition was obtained for these species. [AA] Thesis: 41.

45. Major, J. T., J. A. Sherburne, J. A. Litvaitis, and D. J. Harrison. 1986. Resource use and interspecific relationships between bobcats and other large mammalian predators in Maine. Page 291 *in* S. D. Miller and D. D. Everett, eds. Cats of the world: biology, conservation, and management. Nat. Wildl. Fed., Washington, D.C. 501pp. Abstract.

The bobcat, coyote, and red fox occur in sympatric populations throughout much of Maine and depend upon a shared resource base for food, space, and other life requirements. This paper describes progress in analyzing the structure of 1 such community with respect to niche and competition theory and the effects of physical disturbance and predation. Since the initiation of fieldwork in the fall of 1979, 23 bobcats, 51 coyotes, and 11 foxes have been

captured and eartagged in 2 study areas representing differences in topography, vegetation, climate, and human development within Maine's bobcat range. Sixty-eight of these are also equipped with radio transmitters. Data are being collected on habitat use, activity patterns, home range characteristics, and inter- and intra-specific spatial and temporal relationships. Snowtracking provides similar information on both marked and unmarked predators. Prey availability is assessed annually using indices of abundance for small mammals (Cricetidae, Zapodidae, Soricidae), snowshoe hares and white-tailed deer.

Preliminary results indicate that home ranges of bobcats broadly overlap those of coyotes and foxes in both study areas. We have observed no instances of bobcat displacement from home areas that could be attributed to interspecific strife. However, spatial segregation appears to be maintained between coyotes and red foxes.

Snowshoe hare is the most frequently occurring prey item in the bobcat diet. Hare is also important in both canid diets, although surpassed seasonally by deer in coyote diets, and by small mammals in the summer diet of red fox. The canid species are more opportunistic in feeding than bobcats, as shown by the greater variety of items included in the diet.

Mortality and survivorship information of bobcats from the western Maine study area indicate that bobcats are strongly affected by severe winter climatic conditions.

Bobcats share a common resource base with coyotes and foxes in Maine. These species are spatially interspersed, and instrumented bobcats and canids occupy overlapping home ranges. The large home areas occupied by these furbearers provide an opportunity for temporal avoidance and separation within these shared areas. We have obtained no evidence that interference competition between bobcats and either canid is important. However, observations of bobcats starving in some winters and the high overlap in winter diets between bobcats and coyotes suggest that a better understanding of exploitation competition and predator-prey relationships is needed to assess interspecific relationships between bobcats and other large mammalian predators in the northern mixed hardwoods-spruce-fir forest ecosystem.

The research presented in this paper is conducted by the Maine Cooperative Wildlife Research Unit, with funding provided by Job 102 of Pittman-Robertson Project W-69-R. Cooperating agencies include the U.S. Fish and Wildlife Service, the Maine Department of Inland Fisheries and Wildlife, the University of Maine at Orono, and the Wildlife Management Institute. [AA] Theses: 16, 27, 41.

46. Major, J. T., J. D. Steventon, and K. M. Wynne. 1981. Comparison of marten home ranges calculated from recaptures and radio locations. Proc. Northeast Fish and Wildl. Conf. 38:109. Abstract.

Home range sizes of marten have been used as indicators of population density and habitat quality. Our recent studies using radio telemetry have yielded home ranges several times larger than those previously reported in the literature. To aid interpretation of results from studies using live-trapping or telemetry, we examined the relationship between home ranges obtained by numerous recaptures and radio locations of several marten to determine the extent to which home range size reflects methodology, rather than underlying biological factors. Three male and 2 female marten were captured from 6 to 21 times and located by radio telemetry from 51 to 729 times. Capture locations, radio location, estimates of range length, and estimates of home range areas derived from the convex and modified minimum area (MMA) polygon methods were compared.

Scaled computer plots revealed that 27 of 41 capture sites were inside the MMA polygon constructed from radio locations for each animal. Nine capture locations were on the periphery of the MMA polygon, and 3 were between the MMA and convex polygons. Only 2 capture locations were 0.1 km beyond the home range boundary as determined by the convex polygon drawn from radio locations.

Convex polygon areas constructed from live-trapping data were 5.2, 2.2, and 1.3 km^2 for the males, and 1.6 and 0.5 km^2 for the females. Convex polygons based on radio locations were 16.0, 28.3, and 6.9 km^2 for males, and 6.7 and 2.8 km^2 for females. MMA polygons constructed from the telemetry data were intermediate in size (13.1, 23.5, and 5.5 km^2 for males; 2.9 and 1.9 km^2 for females) and were believed to represent "true " home ranges more closely by excluding some areas in which no locations were obtained. Range lengths determined from trapping data (3.2, 2.3, and 1.8 km for males; 2.6 and 2.0 km for females) were less for each animal than range lengths from telemetry data (5.7, 8.5, and 4.3 km for males; 4.3 and 2.5 km for females).

Live-trapping recaptures were generally nested within the home range boundaries determined from radio locations for each individual marten. Home range size estimates by the convex polygon method using recapture data varied from 8 to 32% of the area determined by the same method with radio location data. Range length indices from trapping were 27 to 82% of the range length determined by telemetry. These data suggest that estimates of marten home range size in the literature derived from live-trapping are underestimates. Analysis of trapping data from radio-collared marten gave

estimates of home range size comparable to mark-recapture studies. The larger home ranges from radio locations reflect a larger sample size, the ability to locate marten without relying on trap response, and the inclusion of areas not used by the study animals. [AA] Theses: 40, 64, 66.

47. May, D. W. 1981. Habitat utilization by bobcats in eastern Maine. M.S. thesis, Univ. Maine, Orono. 36pp.

Habitat utilization and food habits of bobcats were studied by radio telemetry, snow tracking and scat analysis from October 1979 to January 1981. Bobcat ranges were divided into 6 habitat types based upon the dominant vegetation. Two intensively monitored adult females had a mean annual home range of 23 km^2; winter ranges were 30% larger than summer ranges. These females used small (<50 ha) areas intensively within their summer ranges. The intensively used areas were characterized by variable aged vegetation due to past disturbance. Based upon snow tracking, bobcats showed a preference for softwood cover. During summer, 515 telemetry relocations on the 2 females suggested no obvious relationship between habitat use and overstory cover type. Only large tracts of open land were clearly avoided. Snowshoe hare were represented in nearly 80% of the 168 scats examined. White-tailed deer remains occurred in 17% of the winter scats, but were not found in summer scats. [AA] Report: 48.

48. May, D. W. 1982. Habitat utilization by bobcats in eastern Maine. Trans. Northeast Fish and Wildl. Conf. 39:22. Abstract.

Bobcat habitat utilization was investigated from October 1979 to January 1981 in eastern Maine. Four bobcats were relocated 712 times using radio telemetry, and 44 km of bobcat trails were followed on snow. In addition, food habits were determined from the examination of 168 scats, 5 kills, and 13 feeding sites. Bobcats used all 6 of the habitat types on the study area. These 6 habitat types included hardwoods, softwoods, mixed stands that were predominantly hardwood, mixed stands that were predominantly softwood, riparian swales, and open land. Only large expanses of open land appeared to be entirely unsuitable as bobcat habitat. Belts of vegetation situated between tracts of blueberry land were important as travel corridors, particularly for 1 radio-collared female. Two instrumented females, 1 in the spruce-fir zone and the other in an area of intolerant hardwoods, showed contrasting habitat use patterns during summer, suggesting that factors other than overstory cover type influenced summer habitat utilization. However, snow-tracked bobcats exhibited a preference for softwood cover and an avoidance of open land. Two instrumented females used small areas (<50 ha) intensively during summer; smallest areas were occupied during late May

and early June and larger areas were used as summer progressed. The females had a mean annual home range of 23 km^2, and winter ranges were 30% larger than summer ranges. Snowshoe hare were common on the study area and represented 80% of the bobcat diet. Percentages of hare, birds, and small mammals in the diet increased during summer, whereas deer and porcupine were not found in summer scats. [AA] Thesis: 47.

49. Miller, M. 1984. Coyote use of white-tail deer as a winter food item in western Maine. Trans. Northeast Deer Tech. Comm. 20:36. Abstract.

Because there is a significant increase of white-tail deer in coyote diets during the winter months, this study was initiated to further investigate this occurrence. Three topics were focused upon: 1) document coyote response to winter concentrations of deer; 2) determine the effects, if any, winter severity has on the rate of coyote predation on deer; and 3) determine cause of winter deer mortalities. Field work commenced in May 1981 and concluded in April 1984 with emphasis on the months from December–April.

Four variables were investigated; the first is winter severity. A winter severity index (WSI) was calculated for each month for each winter. Winter 1982 was the most severe in the last 10 years; winter 1983 was the second mildest in the past decade; and winter 1984 was moderate.

Eight coyotes were captured and fitted with radio transmitters during the 3 winters (3, 1, 4 for winters 1982, 1983, and 1984 respectively). Coyotes were relocated 2-3 times a week during the winter months, and home ranges were calculated using the convex polygon method. The number of relocations varied from 9-38 and winter home ranges varied from 25-140 km^2. All 8 coyotes had a portion of a deer wintering area (DWA) incorporated within each home range. For each coyote the number of relocations within and outside the DWA was analyzed using a chi-square test; and 6 of 8 coyotes were found to use DWA more than expected.

Fifty-eight randomly-selected 500-m snow transects were run from February–April 1983 to augment the telemetry data. The transects were stratified so that one-half fell within DWA. Predator and deer tracks were counted using the line-intercept method. Coyote tracks accounted for 67% of all predator tracks encountered. Coyote tracks were found twice as frequently in DWA than other areas.

Twenty-two deer mortalities were located during the 3 winters (12, 3, 7 for winters 1982, 1983, and 1984 respectively). Coyote predation accounted for 67% of the total mortality for each winter and for the entire study period. Seventy-five percent of the predator mortalities had bone marrow fat above 30%, indicating good nutritional condition.

In summary: 1) coyotes key in on winter concentrations of deer; 2) coy-

otes kill seemingly healthy deer; 3) the rate of coyote predation is constant regardless of winter severity but the number of deer succumbing to coyote predation increases as winter severity increases; and 4) coyote predation is a major component of winter mortality of white-tail deer in Western Maine. [AA]

50. Monthey, R. W., and E. C. Soutiere. 1985. Responses of small mammals to forest harvesting in northern Maine. Can. Field-Nat. 99:13-18.

Comparisons between relative abundance of small mammals in harvested and uncut softwood and hardwood stands were made between 1975 and 1977 in northern Maine. Twelve softwood clearcuts representing three successional stages (slash, *Rubus*, sapling), two partially cut stands, and four uncut stands were snap and pit trapped for 60,279 trap nights. The total small mammal community increased following harvesting in softwood stands. Red-backed voles were more common in slash and sapling stages and partially cut softwoods than in uncut softwoods. Deer mice were more abundant in uncut and partially cut softwoods than in *Rubus* or sapling stages. Meadow voles preferred partially cut softwoods and the *Rubus* stage compared to uncut softwoods. Masked shrews, smoky shrews, and pygmy shrews were collectively more common in harvested stands than in uncut softwoods or hardwoods. [AA] Thesis: 60.

51. O'Donoghue, M. 1983. Seasonal habitat selection by snowshoe hare in eastern Maine. Trans. Northeast Fish and Wildl. Conf. 40:100-107.

Seasonal habitat selection by snowshoe hare was investigated in eastern Maine. A 100-ha study area was divided into 10 cover types based on understory density and species composition. Hare activity was evaluated in each cover type using winter track counts and winter, spring, and summer pellet counts. Vegetation was sampled to provide more detailed information on composition and density of the overstory, understory, and ground cover in each cover type. Hare selected cover with dense understory in all seasons, and showed a significant shift in activities from coniferous understories in winter to hardwood understories in summer. Coniferous cover may be of the greatest value to showshoe hare in winter as protection against harsh weather and predation. In summer, increased density and greater availability of summer food in hardwood cover may make it the most favorable habitat. [AA]

52. Rego, P. W. 1984. Factors influencing harvest levels of fisher in south-central and southeastern Maine. M.S. thesis, Univ. Maine, Orono. 54pp.

Fisher harvest levels differ greatly between 2 adjacent regions in south-central and southeastern Maine. The region of high harvests (approximately Wildlife Management Unit [WMU] 7) sustains an estimated population density of 1 fisher per 4.1 km^2, compared to an estimated density of 1 per 65 km^2 in the low density region (WMUs 5 and 6). Prey abundance, as a causal factor, was examined between regions. Carcass condition and demographic parameters were also examined to delineate their relationship with fisher population levels.

Small mammal trapping, fecal pellet counts, and snow track counts were used to compare prey abundances. Small mammal captures were similar between regions, while snowshoe hare and white-tailed deer appeared more abundant in WMU 7. The proportion of hare and deer in fisher diets increases during winter. Incidence of quills in carcass musculature suggested that use of porcupine as prey was similar between regions. Fifty-four percent ($n = 14$) of stomachs examined contained fruit or berries, suggesting that they are a seasonally important food.

Fisher collected from the region of high density were heavier and tended to have larger fat deposits than fisher from the low density region. The higher productivity of WMU 7 is reflected in both the high fisher population it supports and by the fact that body weights of fisher from that region are among the heaviest reported. Condition improved through November suggesting that food was abundant during that period.

The poorer condition of fisher in WMUs 5 and 6 along with the lower abundance of hare and deer in that region suggest it may not support fisher populations as high as those of WMU 7. However, prey abundance differences were of lower magnitude than fisher density differences, suggesting WMUs 5 and 6 may have potential to support greater fisher densities. I was unable to test whether condition is influencing population levels of fisher. The relationship could be investigated by examining condition of fisher from WMUs with population densities intermediate between the high and low density regions.

Trapping may be important in maintaining present population levels of fisher in the two regions. Stability of annual harvests in both regions suggests trapping mortality coupled with other forms of mortality may approximately equal annual population increases. The effect of trapping on population levels could be examined through reduction of trapping mortality. [AA]

53. Richens, V. B., and R. D. Hugie. 1974. Distribution, taxonomic status, and characteristics of coyotes in Maine. J. Wildl. Manage. 38:447-454.

Eastern coyotes may have appeared in Maine as early as 1936; their range now includes most of 8 western counties and eastward extensions into central and northwestern Maine. Ninety coyotes, killed in 1968-1973, were examined and new distribution records are given. Skull and tooth characteristics of Maine coyotes tended to be intermediate to those of dogs and western coyotes. Adult males averaged 15.8 kg and females 13.7 kg; the mean body measurements were 1,251 : 363 : 209 and 116 mm for males and 1,179 : 343 : 197 and 113 mm for females. Carrion, snowshoe hare, small mammals, and miscellaneous items composed most of the stomach contents of 51 coyotes killed in the fall and early winter. Identification of Maine canids is discussed. [AA]

54. Sherburne, J. A., and G. J. Matula., Jr. 1981. Predator habitat utilization studies, Dickey-Lincoln School Lakes project, Maine. Unpublished Report, Maine Coop. Wildl. Res. Unit, Univ. Maine, Orono. 67pp.

Abundance and habitat use of small mammals, snowshoe hare, white-tailed deer, bobcat, fisher, marten, coyote, and red fox were examined in northern Maine using traps, track counts, and radio telemetry. Small mammal populations were believed to be low, with habitat preferences varying among species. Hares were abundant, and were most common in conifer stands and clearcuts. Deer density was estimated at 1.4/km^2, and was highest in conifer-dominated mixed stands. Lynx were extremely scarce, although prey and habitat conditions seemed suitable. Bobcats were uncommon; data from 2 radio-collared males suggested that habitat types were used in proportion to their availability. Fishers also were uncommon, and 1 radio-collared subadult male occupied a range of 119 km^2 during January-May, 1980. Most radio locations were in conifer stands along rivers or streams. Marten were abundant. Home ranges of 5 adults (2 M, 3 F) averaged 2.9 km^2, and male ranges overlapped those of females. Conifer and mixed stands were used in proportion to availability, and deciduous stands were avoided. Females showed a stonger preference for conifer stands, while males showed a stronger preference for conifer-dominated mixed stands. Resting sites were in large trees, logs, or mistletoe clumps in tree crowns. Redbacked voles and hares were the most common foods in marten scats. Coyotes were common in the area, and density was estimated at between 3-13/km^2. Home ranges averaged 1,129 km^2 for males and 124 km^2 for females. Coyotes avoided deciduous and deciduous-dominated mixed stands, and

used other types in proportion to availability. Deer were the most common food in scats, followed by hare, small mammals, and raspberries. Use of deer was most frequent during winter and spring; hares were eaten primarily during winter, and the summer diet consisted mainly of fruits and small mammals. Foxes were abundant, with density of resident adults estimated at 20/100 km^2. Home ranges of 5 radio-collared foxes averaged 9.8 km^2. Conifer stands were avoided by radio-collared foxes, and conifer-dominated mixed stands and non-forest types (primarily roads) were preferred. Small mammals were the most common food in fox scats, followed by fruits and snowshoe hare. Deer carrion was commonly eaten during winter. At least 1 and possibly 4 radio-collared foxes were killed by coyotes. Competition between predator species was indicated by overlapping food habits and habitat use patterns, but the importance of competition could not be determined. The predicted effect of creating the Dickey-Lincoln School Lakes impoundment was to reduce predator populations by reducing prey populations and the amount of habitat available. [CA]

55. Snyder, J. E. 1984. Marten use of clear-cuts and residual forest stands in western Newfoundland. M.S. thesis, Univ. Maine, Orono. 31pp.

The objectives of this study were to determine 1) if stage of regeneration in clear-cuts influenced use by marten; 2) if size of residual balsam fir and black spruce stands was related to their use by marten; and 3) which habitat variables characterized successful trap sites. Habitat use by marten was investigated by live-trapping and snow tracking. Residual stands were classified into five size categories and clear-cuts into three categories based on height of balsam fir regeneration.

From June to December 1983, marten were trapped in 43 residual stands and 35 clear-cuts. A total of 3,587 trap-nights yielded 57 captures of 10 male and 8 female marten. Six (10.5%) captures were in clear-cuts, all less than 8 years old; 51 (89.5%) marten were captured in residual stands. Capture rates were greater in larger residual stands. Only 5 captures were in residual stands <15 ha.

From January to March 1984, marten tracks were followed for 29 km. Although clear-cuts represented 41% of the study area, only 26% of marten travel was recorded here, all in clear-cuts <10 years old. Residual stands and undisturbed forest composed 46% of the study area; 74% of marten travel was recorded in these forested habitats. These data indicate that marten seldom use clear-cuts, or residual stands <15 ha, but do use larger residual stands. Management recommendations are discussed. [AA] Reports: 56, 57.

56. Snyder, J. E., and J. A. Bissonette. 1985. Marten use of clear-cuts and residual forest stands in western Newfoundland. Trans. Northeast Fish and Wildl. Conf. 41:198. Abstract.

Marten prefer undisturbed, dense conifer or mixed forest habitat and once ranged over most forested areas of Newfoundland. However, their present distribution is restricted to isolated areas of mature forest in the western part of the province. Forest harvesting in the area has been increasing, and large contiguous clear-cuts are common. This project was initiated to determine how size of residual balsam fir and black spruce stands was related to their use by marten. This information is intended to help formulate management recommendations for forest harvesting practices. Marten habitat use was investigated by live-trapping and snow-tracking. Residual stands were classified into 5 size categories and clear-cuts into 3 age categories. From June to December 1983, trapping was conducted in 43 residual stands and 31 clear-cuts. A total of 3,587 trap nights yielded 57 captures of 10 males and 8 female marten. Six captures were in clear-cuts, all <8 years old; 51 marten were captured in residual stands. Capture rates were greater in larger residual stands. Only 5 captures were in residual stands <15 ha. From January to March 1984, marten tracks were followed for 29 km. Although clear-cuts represented 41% of the study area, only 25% of marten travel was recorded here, all in clear-cuts <10 years old. Residual stands and uncut forest composed 46% of the study area; 75% of marten travel was recorded in these forested habitats. These data indicate that marten seldom use clear-cuts, or residual stands <15 ha, but do use larger residual stands. [AA] Thesis: 55.

57. Snyder, J. E., and J. A. Bissonette. 1987. Marten use of clear-cuttings and residual forest stands in western Newfoundland. Can. J. Zool. 65:169-174.

Marten inhabit primarily old-growth coniferous and mixed-wood forest habitats. Widespread forest harvest operations have prompted inquiries into whether residual patches of forest left after harvesting, or regenerating clear-cuttings, provide adequate habitat for marten. In western Newfoundland, the primary method of tree harvest has been clear-cutting of large tracts of balsam fir and black spruce. The only remaining populations of marten in the province also are found in the western part of the island, with greatest densities near Little Grand Lake. This study was designed to determine if marten used regenerating clear-cuttings and small remnant patches of residual forest left after forest operations. Habitat use by marten was investigated by livetrapping and snow tracking. Residual stands were classified into 5 size categories, and clear-cuttings into 3 categories based on height of bal-

sam fir regeneration. From June to December 1983, marten were trapped in 43 residual stands and 35 clear-cuttings. A total of 3,587 trap nights yielded 57 captures of 10 male and 8 female marten. Six (10.5%) captures were in clear-cuttings, all <15 years old; 51 (89.5%) marten were captured in residual stands. Capture rates were 0.48 captures/100 trap nights in the clear-cuttings and 2.19 captures/100 trap nights in residual stands. Capture rates were greatest in residual stands 25 to 34.9 ha in size (4.62 captures/100 trap nights). From January to March 1984, marten tracks were followed for 29 km. Although clear-cuttings represented 41% of the study area, only 26% of marten travel was recorded there, all in clear-cuttings <15 years old. Residual stands >25 ha and undisturbed forest composed 41.3% of the study area; 41.8% of marten travel was recorded there. Smaller residual areas (<25 ha) made up only 4.2% of the total area, but 32.4% of the marten travel was recorded in these areas. These data indicate that marten seldom used clear-cuttings and used residual stands 25 ha and undisturbed forests in proportion to their occurrence, but the use of smaller residual stands <25 ha was greater than expected. [AA] Thesis: 55.

58. Soukkala, A. M. 1983*a*. The effects of trapping on marten populations in Maine. M.S. thesis, Univ. Maine, Orono. 41pp.

The main objective of this study was to determine the effects of trapping on marten populations in Maine. Additional objectives were to estimate marten harvest rates, to determine the relative vulnerability of various sex and age groups to trapping, and to examine the influence of increased access on trapping pressure.

Between March and October 1980, 107 marten from a heavily trapped population were live-trapped, tagged, and released. Thirty-four tagged marten were harvested during the 1981 trapping season. The sex and age composition of marten harvests were determined from 1,585 carcasses collected in 1980-81.

Males were more vulnerable to live-trapping than females, and they also sustained greater mortality during the fall trapping season. Trapping has caused a decrease in the relative abundance of males in heavily harvested populations. Younger and relatively fewer males were trapped in townships with greater marten harvests, and more adult females than adult males were live-trapped from a population previously subjected to heavy fur-trapping pressure. For the heavily trapped population studied, harvest rates of 43% for adult males and 17% for adult females were estimated from tag recoveries. Harvest rates of 90% for juvenile males and 63% for juvenile females were estimated from a cohort analysis. Modeling the female population with

a modified Leslie matrix predicted that current harvest rates may be causing a decline in some local marten populations. Expanding road networks associated with more intensive forestry may intensify trapping pressure in local areas by providing increased access to trappers. [AA] Report: 59.

59. Soukkala, A. M. 1983*b*. Effects of trapping on marten population structure in Maine. Trans. Northeast Fish and Wildl. Conf. 40:97. Abstract.

Sixty-four adult and 43 juvenile marten from a heavily trapped population were live-trapped, tagged, and released between March and October 1981 to study the effects of trapping on marten population structure. In addition, sex and age were determined for 1,320 marten carcasses collected from trappers during the 1981 trapping season. Live-trapping data indicated that males were more vulnerable to trapping than females. Adult males ($n = 28$) were recaptured more often ($\bar{x} = 5.1$ captures/male) in live traps than adult females ($n = 36$) ($\bar{x} = 3.2$ captures/female). More juvenile males ($n = 32$) than juvenile females ($n = 11$) were live-trapped between June and October, although populations were assumed to be equal. Tag returns and harvest data also indicated that males suffered greater trapping mortality than females. Thirty-two percent of the tagged marten were reported trapped during the 1981 trapping season. A greater proportion of the tagged adult males (43%) was reported trapped than tagged adult females (17%). The harvest of juveniles consisted predominantly of males (28M:11F) early in the trapping season. The relative catch of juvenile males, however, declined during the season. This suggested that juvenile males became less abundant than juvenile females as the season progressed. Age and sex of adults taken by trappers were related to the 1979-81 marten harvest/km^2 in the township trapped. The adult catch was composed of younger and relatively fewer males in townships with a greater harvest/km^2. This study indicates that trapping is affecting the sex- and age-class structure of the marten population by causing a decrease in the relative abundance of adult males. The proportion of adult males in the harvest decreased as total trapping effort increased. Therefore, the sex- and age-class structure of adult marten harvests may be useful in identifying areas where trapping pressure is heavy and additional management is needed to avoid depleting populations. [AA] Thesis: 58.

60. Soutiere, E. C. 1978. The effects of timber harvesting on the marten. Ph.D. thesis, Univ. Maine, Orono. 62pp.

The influence of timber harvesting upon marten was studied on privately owned forest land in the Moosehead Lake Region, Maine, from 1974 to 1977. The two harvest methods examined were partial harvesting and com-

mercial clearcutting of spruce-fir-hardwood forests. In the partially-harvested forest, basal area was reduced by about 40%. In the commercial clearcut forest, 50% of the forest was clearcut and 25% partially cut.

A total of 16,065 trap days yielded 609 captures of 81 males and 42 females. Density of adult resident animals averaged 1.2/km^2 in both the undisturbed and partially-harvested forests, but dropped to 0.4/km^2 in the commercial clearcut forest. Partial harvesting did not affect the population structure, but there were proportionately fewer transient and immature marten captured in the commercial clearcut forest. Marten living in the commercial clearcut forest had the larger home ranges. Males travelled freely across clearcut areas from one uncut "island" to another, but females were more restricted to the large blocks of residual cover. Based on winter track counts along 360 km of transects, marten in undisturbed forests preferred softwood-dominated mixed stands. Hardwood stands were used less frequently than expected from their occurrence along the transects. In the partially-harvested forest, tracks were found in all cover types about in proportion to the occurrence of the cover types along the transects. Marten rarely used the 0- to 15-year old clearcut areas, but the associated lightly cut hardwood stands and islands of uncut softwoods were heavily used.

Voles were the major food items found in 412 marten scats. Birds and fruit were common summer foods. The total number of small mammals captured on sampling grids in the partially harvested forest did not significantly differ from that in the undisturbed forest, nor was species composition changed. In clearcut areas, small mammal captures were higher, primarily due to increased numbers of *Microtus pennsylvanicus* and *Sorex cinereus*.

Marten are not restricted to wilderness spruce-fir forests. Harvesting methods that maintain a residual stand of 20-25 m^2/ha basal area in pole stage and older trees provide adequate habitat for marten. Zero to 15-year old clearcuts are poor marten habitat. [AA] Reports: 50, 61.

61. Soutiere, E. C. 1979. Effects of timber harvesting on marten in Maine. J. Wildl. Manage. 43:850-860.

The influence of timber harvesting upon marten was studied in spruce-fir-hardwood forests in the Moosehead Lake Region, Maine, during 1973-77. Partial harvesting and commercial clear-cutting were examined. In the partially harvested forest, basal area was reduced by about 40%. In the commercial clear-cut forest, 50% of the forest was clear-cut and 25% was cut selectively. Density of adult, resident marten averaged 1.2/km^2 in the undisturbed and partially harvested forests, but was 0.4/km^2 in the commercial clear-cut forest. Home range lengths were longest in the commercial clear-cut forest. In the undisturbed forests, marten preferred softwood-dom-

inated mixed stands. In the partially harvested forest, tracks were found in all cover types in proportion to the occurrence of the cover types. Marten rarely used the 0- to 15-year-old clear-cut areas, but the associated lightly cut hardwood stands and islands of uncut softwoods were heavily used. Of the more common foods eaten by marten, meadow voles, ground nesting birds, and raspberries were more abundant in the harvested forests, whereas red-backed vole numbers were not affected by logging. Harvesting methods that maintain a residual stand of 20-25 m^2/ha basal area in pole and larger trees provide adequate habitat for marten. Clear-cuts up to 15 years old are poor marten habitat. [AA] Thesis: 60.

62. Soutiere, E. C. 1985. Skull and dental characterisitcs of eastern marten from Maine. Trans. Northeast Fish & Wildl. Conf. 41:213-217.

The skulls and teeth of 205 marten trapped in northern Maine were examined and measured. Eighteen measurements were taken that showed age or sex differences, and that are used to express quantitative characteristics of a species. Discriminant analysis provided good classification and separation of age and sex groups. Skull measurements of both male and female adults are significantly larger than comparable measurements of immatures. With age, zygomatic breadth increases, postorbital constriction decreases, there is a lengthening and narrowing of the rostrum, and males develop a prominent sagittal crest. The marten shows pronounced sexual dimorphism. Live-trapped males weighed an average of 760 g; females 500 g. With the exception of postorbital constriction breadth, skull and dental measurements for males are significantly larger than those of females. Sagittal crest length and zygomatic breadth are the measurements that best separate age and sex groups. Tooth measurements add little to the ability to discriminate among groups. The skull and dental measurements of Maine marten fall within the range of measurements reported for marten from Ontario. [AA]

63. Soutiere, E. C., and J. D. Steventon. 1981. Seasonal pelage change of Marten (*Martes a. americana*) in Maine. Can. Field-Nat. 95:356.

The twice yearly molt and seasonal coat color of marten in Maine are documented. The summer pelage is dark whereas the winter pelage is usually paler with reddish-yellow hues predominating. [AA]

64. Steventon, J. D. 1979. Influence of timber harvesting upon winter habitat use by marten. M.S. thesis, Univ. Maine, Orono. 25pp.

Winter habitat use by marten was studied by radio telemetry and snow tracking on a commercially clear-cut spruce-fir-hardwood forest in Maine. About 1/3 of the area was 3-18 year old regenerating clear-cuts, 1/3 was uncut

softwood stands, and the remainder was partially cut mixed stands (average basal area reduced 50%). Intensive study of 2 males and 1 female yielded 420 locations and 97 km of tracking. Clear-cuts were used less than their proportional occurrence within the study area or within marten home ranges. Uncut softwood stands and partially cut mixed stands were heavily used. Both males had home ranges of nearly 9.5 km^2 of which 35-40% were clear-cuts. These males often crossed clear-cuts to reach isolated patches of residual forest cover. Females were located only in large blocks of residual forest and had ranges as large as 2.5 km^2, with up to 25% in clear-cuts. The female that was intensively studied rarely crossed clear-cuts. Typical resting sites for marten were cavities in large decayed stumps or logs. Some potential impacts of intensive forestry on marten habitat are discussed. [AA] Reports: 46, 65.

65. Steventon, J. D., and J. T. Major. 1982. Marten use of habitat in a commercially clear-cut forest. J. Wildl. Manage. 46:175-182.

Habitat use by eastern marten was studied in northern Maine where commercial clear-cutting had been conducted 3-18 years ago. Four adult resident marten were intensively studied through radio telemetry and snow-tracking. Analysis of 1,734 radio locations and 97 km of winter snow-tracking indicated that uncut softwood islands and partially cut mixed stands were heavily used by marten during both summer and winter. Regenerating clear-cuts were generally used less than expected, although marten foraged there for red raspberries in late summer. Home ranges determined by radio telemetry were several times larger than those obtained in the same area by live-trapping in an earlier study. The female, located mostly in a large block of uncut forest, had a home range of 2.0-2.5 km^2, of which 25% was clear-cut. The 3 males occupied home ranges of 5.0-10.0 km^2, 16-50% of which was in clear-cuts. Winter resting sites for marten were cavities in large decayed stumps or logs. Marten rested in the crowns of conifers during the summer months. Although marten relied on the uncut and partially cut stands within the commercially clear-cut forest, they were apparently able to tolerate and make seasonal use of extensive areas of regenerating clear-cuts within their home ranges. [AA] Theses: 40, 64.

66. Wynne, K. M. 1981. Summer home range use by adult marten in northwestern Maine. M.S. thesis, Univ. Maine, Orono. 19pp.

Home range and habitat utilization data for adult marten were gathered from May to September 1980 in northwestern Maine. Analysis of 455 radio locations of 3 post-lactating females and 2 adult males showed that overall summer ranges averaged 2.9 km^2 for females and 5.6 km^2 for males, with

females showing preferential use of softwood stands. The frequency distribution of activity radii differed during this period for females but not for males, while use of habitats did not change. Thirty-eight resting sites and dens were located; 6 of 21 sites used by females were identified as natal dens. All resting sites used by males were in tree canopies, commonly in "witches brooms." Den characteristics are discussed in relation to the presence and development of kits. [AA] Reports: 46, 67.

67. Wynne, K. M., and J. A. Sherburne. 1984. Summer home range use by adult marten in northwestern Maine. Can. J. Zool. 62:941-943.

Home range and habitat utilization data for adult marten were gathered from May to September 1980 in northwestern Maine. Analysis of 455 radio locations of three postlactating females and two adult males showed that overall summer ranges averaged 2.9 km^2 for females and 5.6 km^2 for males, with females showing preferential use of softwood stands. The frequency distribution of activity radii differed during this period for females but not for males, while use of habitats did not change. Thirty-eight resting sites and dens were located; 6 of 21 sites used by females were identified as maternal dens. All resting sites used by males were in tree canopies, commonly in "witches brooms" (abnormal clumped growth of balsam fir branches caused by rust fungi). Den characteristics are discussed in relation to the presence and development of kits. [AA] Thesis: 66.

APPENDIX

Common and scientific names of species mentioned in summary and abstracts.

Common Name	Scientific Name
MAMMALS	
Artiodactyla:	
Moose	*Alces alces*
White-tailed deer	*Odocoileus virginianus*
Carnivora:	
Bobcat	*Lynx rufus*
Coyote	*Canis latrans*
Fisher	*Martes pennanti*
Gray wolf	*Canis lupus*
Lynx	*Lynx canadensis*
Otter	*Lutra canadensis*
Red fox	*Vulpes vulpes*
Pine marten	*Martes americana*
Insectivora:	
Least shrew	*Cryptotis parva*
Masked shrew	*Sorex cinereus*
Pygmy shrew	*Microsorex hoyi*
Short-tailed shrew	*Blarina brevicauda*
Smoky shrew	*Sorex fumeus*
Lagomorpha:	
Snowshoe hare	*Lepus americanus*
Rodentia:	
Beaver	*Castor canadensis*
Mice:	
Deer mouse	*Peromyscus maniculatus*
Meadow jumping mouse	*Zapus hudsonicus*
Woodland jumping mouse	*Napaeozapus insignis*
Muskrat	*Ondatra zibethecus*
Porcupine	*Erethizon dorsatum*
Squirrels:	
Red squirrel	*Tamiasciurus hudsonicus*
Gray squirrel	*Sciurus carolinensis*
Northern flying squirrel	*Glaucomys sabrinus*

Common Name	Scientific Name
Voles:	
Meadow vole	*Microtus pennsylvanicus*
Red-backed vole	*Clethrionomys gapperi*
BIRDS	
Ruffed grouse	*Bonasa umbellus*
FISH	
Banded killifish	*Fundulus* spp.
Cunner	*Tautogolabrus adspersus*
PLANTS	
Aspen	*Populus* spp.
Balsam Fir	*Abies balsamea*
Beaked hazelnut	*Corylus cornuta*
Black spruce	*Picea mariana*
Blueberry	*Vaccinium angustifolium*
Gray birch	*Betula populifolia*
Raspberry	*Rubus* spp.
Red maple	*Acer rubrum*
Red spruce	*Picea rubens*
Rhodora	*Rhododendron canadense*
Striped maple	*Acer pensylvanicum*
White birch	*Betula papyrifera*
Winterberry	*Ilex verticillata*
Witherod	*Viburnum cassinoides*