

**WINTER HOME RANGE AND HABITAT USE BY SYMPATRIC
FISHERS (*Martes pennanti*) AND AMERICAN MARTENS (*Martes americana*)
IN NORTHERN WISCONSIN**

by

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A Thesis

submitted in partial fulfillment of the

requirements of the degree

MASTER OF SCIENCE

in

Natural Resources (Wildlife)

College of Natural Resources

UNIVERSITY OF WISCONSIN

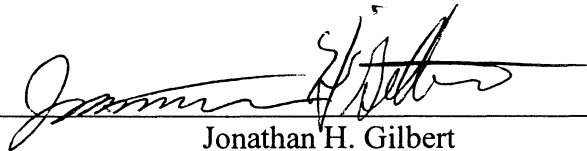
Stevens Point, Wisconsin

August 1999

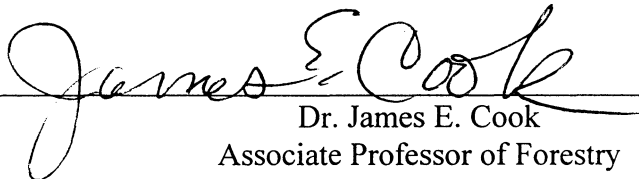
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31 August 1999
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**WINTER HOME RANGE AND HABITAT USE BY SYMPATRIC FISHERS
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NORTHERN WISCONSIN**

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Abstract: Fishers (*Martes pennanti*) and American martens (*Martes americana*) reportedly use mature and older-growth coniferous forests to meet their life history needs. Regional differences in forest species composition, age, and disturbance regimes across fisher and marten ranges suggest that additional factors, beyond cover type, may be influencing their use patterns. Dead woody materials (DWM) are important components of mature or disturbed forests and are reportedly used in winter by fishers and martens for thermal and overhead cover, forage sites, and air spaces for subnivean access. While DWM use has been studied at site specific scales (e.g. subnivean access points), its influence on habitat use at larger scales has not been studied. We monitored fishers and martens during winters in northern Wisconsin to determine if DWM influenced their habitat use at the home range scale.

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Eighteen fishers and 24 martens were monitored during the winters 1990-1995 yielding > 3,300 telemetry locations. Fisher winter home ranges were significantly larger than marten winter home ranges. Male fisher and marten winter home ranges were similar in size to their conspecific females.

Cover type composition in fisher and marten home ranges did not differ significantly between sexes or with the study area composition. Stand diameter class (aggregations of tree bole diameter classes regardless of stocking density or species) composition in fisher and marten home ranges did not differ significantly between sexes or with the study area. Fishers did not select for habitats based on cover type or stand diameter class, nor did selection differ significantly between sexes. Male martens selectively used some cover types while avoiding others. Mixed hardwood and red pine (*Pinus resinosa*) cover types were used significantly more than expected, while aspen (*Populus* spp.), swamp conifer, and nonforested cover types were avoided. Female martens selected for mixed hardwoods, while red pine, aspen, swamp conifer and nonforested cover types were avoided.

Dead woody material characteristics were measured in more than 1,000 circular plots (0.02 ha) randomly within cover types ($n = 625$) and randomly within animal activity centers ($n = 386$). Fisher and marten activity centers had greater numbers, heights and volumes of fine (<0.6cm) down DWM. Additionally, they had greater numbers of stumps and root tip-ups. These results suggest that fine as well as coarse DWM's are important fisher and marten habitat components. Further, it appears

that DWM is important in determining use beyond site specific scales.

JOURNAL OF WILDLIFE MANAGEMENT 00(0):000-000

Key words: American marten, dead woody material, fisher, habitat selection, home range, *Martes americana*, *Martes pennanti*, telemetry, Wisconsin.

Fishers and American martens are sympatric over much of their range (Douglas and Strickland 1987, Strickland and Douglas 1987, Gibilisco 1994). Populations are widely distributed across the forested northern tier of the United States and the southern provinces of Canada (Gibilisco 1994). Exploitation and habitat loss caused distributions of *Martes* spp. to shrink in North America early in the 1600s and population declines continued into the early 1900s (Gibilisco 1994). Since then, populations have expanded, with protection, habitat recovery and reintroduction to portions of their former range.

A similar pattern evolved in Wisconsin. Both species were indigenous to pre-European settlement Wisconsin (Jackson 1961) and distributed throughout most of the state (Douglas and Strickland 1987, Strickland and Douglas 1987, Gibilisco 1994). Unregulated trapping and habitat destruction, through timber harvest, fire and agricultural expansion, reduced numbers of both species by the early 1900s (Jackson 1961). Fishers and martens were given legal protection after 1921 (Schorger 1982), but numbers continued to decline. Hine et al. (1975) reported that martens disappeared from Wisconsin by 1925 and fishers followed in 1932.

Fishers were successfully reintroduced to Wisconsin, with multiple stocking efforts from 1956-1967, by the Wisconsin Department of Natural Resources (WDNR) and the U.S. Forest Service (USFS). One hundred twenty fishers were released in 2 areas; 60 each on the Nicolet³ (NNF) and Chequamegon (CNF) National Forests (Kohn et al. 1993). Fisher/Marten Closed Areas (FMCA), 484 km² on the NNF and 890 km² on the CNF, were established around the release sites (Fig. 1). These areas are closed to dryland trapping and prohibit the harvest of fishers and martens. Fishers established breeding populations at the release sites and subsequently expanded their range throughout northern Wisconsin (Pils 1983, Coleman et al. 1995) (Fig. 2). In 1985 fishers were legally harvested for the first time in 64 years (Kohn et al. 1993).

American martens remain endangered in Wisconsin (Wisconsin statute 5529.415, active 1 Oct. 1972). A marten reintroduction of 5 individuals to Stockton Island (Apostle Islands National Lakeshore) occurred in 1953, but was considered unsuccessful (Kohn and Eckstein 1987). A reintroduction by the USFS, WDNR and University of Wisconsin-Stevens Point (UWSP) released 172 martens between 1975-1983 in the FMCA of the NNF (Davis 1983, Kohn and Eckstein 1987) (Fig. 1). The reintroduced population has not expanded its range like fishers (Kohn and Eckstein 1987). A majority of the population is still found within 20 km of the release sites on

³ The Nicolet and Chequamegon National Forests were combined into a single forest in 1997. For this manuscript, individual forest names were maintained as they were known during the study period.

the NNF (W. Creed, pers. comm.) (Fig. 2). The WDNR and the USFS later released 139 martens in the FMCA of the CNF (Fig. 1) from 1987-1990. The results of this reintroduction effort have not been evaluated although studies by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) in the FMCA on the CNF indicate martens remain in the area and some breeding has occurred (J. H. Gilbert, unpub. data) (Fig. 2).

GLIFWC, representing the natural resource interests of 6 Ojibwa tribes in Northern Wisconsin, has a cultural interest in fishers (Ochig - Ojibwa name) and American martens (Waabizheshi - Ojibwa name). Ojibwa treaty rights enable them to harvest plants and animals from public lands. These usufructuary rights bring with them a responsibility to properly manage the resources being used. Fishers, in 1997, were the most heavily harvested furbearer in Wisconsin by Ojibwa people (J. H. Gilbert, pers. comm.). Fisher fur is valued both for ceremonial outfits and monetary income. Martens, currently protected in Wisconsin under Ojibwa regulations until they reach a sustainable population, were the most heavily harvested furbearer in Minnesota by Ojibwa people (J. H. Gilbert, pers. comm.). The Ojibwa people also have strong spiritual ties to fishers and martens. The Ojibwa's warrior clan, martens, are responsible for protecting the village. A clan designation elevates the marten in stature among wildlife species. For these reasons GLIFWC desired more information on fishers and martens so they can be protected.

Winter habitat characterization for fishers and martens has often focused on

overstory species composition. Although researchers have found significant correlations between overstory composition and use (Davis 1978, Johnson 1984, Lamb 1987, Thomasma et al. 1991, Gilbert 1995), the correlations vary across the ranges of both species. Western coniferous and eastern deciduous forests differ in composition, age, and disturbance regimes, yet both support fisher and marten populations. Regional differences in overstory use may be associated with other habitat characteristics (e.g. forest structure) that function similarly between overstories of different species composition.

Dead woody materials; sticks, logs, snags, stumps, and root tip-ups (root masses of tipped over trees), are important components of forest structure and amounts increase with forest age and disturbance (Maser et al. 1979). Forest structure, especially coarse DWM, has been proposed as an important factor in determining fisher and marten distributions and winter habitat use (Buskirk and Powell 1994). Most studies have focused on site specific responses (e.g. subnivean access points) to coarse DWM by fishers and martens. However, coarse DWM may also influence fishers and martens spatial use at broader scales (i.e. animal home range). Additionally, few studies have included fine DWM in their investigations.

Fisher habitat preference studies have focused on overstory species composition and reflected regional differences in use. Johnson (1984) found reintroduced fishers preferred upland northern hardwoods and avoided lowland conifers and shrubs during winters in Wisconsin. Monotypic upland conifer forests,

even though they provided essential overhead cover, were under utilized (Johnson 1984). Lamb (1987) also reported that fishers preferred upland forests in Wisconsin, but he made no distinction between deciduous and coniferous types nor seasonal use. Schorger (1982) documented that fishers began to surpass martens numerically as Wisconsin's coniferous timber was cut and replaced by hardwoods. Conversely, fishers in the upper peninsula of Michigan selected dense coniferous forests and avoided northern hardwood forests (Thomasma et al. 1991). Likewise, fishers in the White Mountains of New Hampshire avoided stands containing more than 74% deciduous trees (Kelly 1977). Arthur et al. (1989a) reported fishers in Maine preferred coniferous stands and avoided deciduous stands during all seasons except summer. Mixed deciduous/coniferous stands were used in proportion to their availability (Arthur et al. 1989a). Fishers are considered a late successional species in the northwestern United States (Powell 1994). Ingram (1973) reported that Oregon fishers prefer dense, mature coniferous stands and California fishers are considered close associates with conifer and mixed conifer types (Schempf and White 1977).

Although correlations between overstory species composition and fisher use have been shown, forest structure may be as important in influencing use as cover type. This may explain some of the reported regional differences in cover type use. Allen's (1983) fisher habitat suitability index (HSI) summarized optimum winter habitat as mature, dense coniferous and mixed coniferous/deciduous forests with continuous overhead cover and a complex physical structure. Buskirk and Powell

(1994) hypothesized that northern forests structure, which influences prey abundance and vulnerability, is more important than forest type in influencing fisher use.

Johnson (1984) hypothesized that Wisconsin's fishers may use upland hardwoods more because they had more winter den sites and that they avoided upland conifers because they lacked structural diversity, limiting numbers of prey. Ingram (1973) reported that Oregon fishers used areas within mature coniferous stands as long as they had a corresponding high amount of windfall (i.e., structure).

Abundance of DWM in forest stands may influence fisher winter habitat selection in northern Wisconsin. Coarse DWM is important to fishers, at a site scale, because it provides thermal and overhead cover for resting and denning (Douglas and Strickland 1982, Douglas and Strickland 1987, Lamb 1987, Jones 1991, Gilbert et al. 1997), forage sites, and air spaces for subnivean access and travel (Raine 1983, Johnson 1984, Raine 1987). It is not known if fisher winter habitat selection is influenced by DWM at broader scales or if fine DWM influences winter habitat selection.

Habitat preference studies of martens have also concentrated on overstory composition and indicate regional differences in use. Davis (1978) found that reintroduced martens used deciduous, coniferous and mixed deciduous/coniferous habitats relative to their availability in Wisconsin. However, this study of recently reintroduced animals may not reflect the preferences of a self-sustaining population. Gilbert (1995) reported that martens on the NNF selected aspen and upland spruce

(*Picea* spp.) habitats while avoiding lowland conifers, lowland hardwoods, upland mixed balsam fir (*Abies balsamea*)/aspen/paper birch (*Betula papyrifera*), and upland white pine (*Pinus strobus*) types. The NNF, based on literature and expert opinion, reserve older growth eastern hemlock (*Tsuga canadensis*) and yellow birch (*Betula lutea*) for marten use (M. Peczynski, pers. comm.). Martens in western Newfoundland selected mixed balsam fir/paper birch habitats along with coniferous forests with high overstory density (Bateman 1986). Optimum marten habitat in the western United States has been reported as mature-to-old growth coniferous forests (Allen 1982, Buskirk et al. 1989, Koehler et al. 1990).

Dead woody material is a structural component of forests used by martens. Its presence may explain some regional differences in reported use of cover types. Buskirk and Ruggiero (1994) noted that the preference for structure near the ground appears to be universal, especially in winter. Allen's (1982) marten HSI model suggested that DWM enhances suitable winter cover for martens. Buskirk et al. (1989) and Koehler et al. (1990) reported that martens benefit from a complex physical structure within mature coniferous forests. Older growth stands, cleared of DWM, were avoided by pine martens (*Martes martes*), whereas young managed forests with large amounts of DWM were used extensively (Buskirk 1992).

Abundance of DWM in forest stands may influence American marten habitat selection in northern Wisconsin. At site scales, coarse DWM provides winter thermal and overhead cover for resting and denning (Marshall 1951, Steventon and Major

1982, Spencer 1987, Buskirk et al. 1989, Martin and Barrett 1991, Corn and Raphael 1992, Wilbert 1992, Gilbert et al. 1997), forage sites, and air spaces for subnivean access and travel (Raine 1983, Hargis and McCullough 1984, Bateman 1986, Raine 1987, Corn and Raphael 1992). It is not known if martens winter habitat selection is influenced by DWM at broader scales or if fine DWM influences winter habitat selection.

GLIFWC, in cooperation with the USFS and the WDNR, began investigating the interactions within the forest carnivore community on the NNF in 1990. The study was part of a larger mammalian predator study being conducted by GLIFWC documenting interspecific and intraspecific interactions among sympatric mammalian carnivores in northern Wisconsin. Research on the NNF from 1990-1992 was summarized by Gilbert (1995).

A portion of the GLIFWC study focused on fishers and American martens, and in 1992 became the subject of my research. The objectives of this study were to determine home range areas, activity patterns and habitat use of these 2 sympatric forest carnivores, and to determine if differing amounts of DWM in forest stands influenced fisher and marten winter use.

STUDY AREA

Research was conducted in the Nicolet fisher/marten study area (NFMSA), an 83 km² area within the FMCA on the Eagle River District of the NNF, Forest County, Wisconsin (Fig. 3). The study area was north of the Kimball Creek Unit of the

Headwaters Wilderness Area (Fig. 4). Two streams, McDonald Creek and the Pine River, flow through the area (Fig. 4). Topography was typified by northeast-southwest parallel glacial drumlins separated by wet lowlands. The drumlin soils are well to moderately well drained silt loams. Soils between drumlins are moderate to poorly drained, medium silt to fine sandy loams.

The region was subject to extensive logging and fire in the early 1900s and logging remains common within the NFMSA. As a result, a mosaic of cover types, differing in composition, structure, and age were present (Table 1). Mixed hardwoods (MIHA, 42%), the most common cover type on the well drained uplands, were dominated by sugar maple (*Acer saccharum*), American basswood (*Tilia americana*), paper birch, white ash (*Fraxinus americana*), and red oak (*Quercus rubra*). The wet, lowland areas were dominated by mixed swamp conifer (SWCO, 21%) consisting of black spruce (*Picea mariana*), white cedar (*Thuja occidentalis*) and tamarack (*Larix laricina*). Most of the aspen, aspen-spruce, balsam fir (A/AS/B, 12%) cover types were <40 years old and are part of ruffed grouse (*Bonasa umbellus*) and woodcock (*Scolopax minor*) management areas. They were dominated by quaking aspen (*Populus tremuloides*), with components of white spruce (*Picea glauca*) and balsam fir. Scattered stands of red pine (REPI, 7%) and upland conifers (UPCO, 4%) also existed on the well drained, sandy, upland sites. The REPI cover type consisted primarily of plantations that were structurally diverse with a heavy component of balsam fir in the understory. Upland conifers were dominated by large diameter

eastern hemlock and white pine (*Pinus strobus*) that often formed a canopy superstructure over mixed hardwoods. The balsam fir, quaking aspen, and paper birch (B/A/Bi, 4%) cover type was a transitional zone between uplands and lowlands. The least common cover type, upland plantations (PLAN, 2%) consisted of white spruce or jack pine (*Pinus banksiana*) with scattered balsam fir and quaking aspen. White spruce and jack pine plantations differed from red pine plantations in that they were even aged and limited in their structural diversity. The remaining area was nonforested (NOFO, 9%) and included stream side shrub zones, dominated by willow (*Salix* spp.) and alder (*Alnus rugosa*), and upland openings dominated by grasses (*Graminae*) and sedges (*Cyperaceae*).

An extensive network of improved and unimproved roads existed on the study area (Fig. 4). There were no permanent residents, but private holdings (approx. 227 ha) with seasonal cabins were present.

The climate is typified by long winters and short, cool summers. The first fall and last spring frosts occur in mid-September and early June, respectively. Average annual temperature is 5°C ranging from a mean of -13°C in January to 19°C in July. Average annual precipitation is 78 cm (Natzke and Hvizdak 1988).

METHODS

Trapping and Morphology

Fishers and martens were captured in live traps (25.5 cm x 30.5 cm x 80 cm, Tomahawk Trap Co., Tomahawk, WI) baited with meat and a commercial lure.

Animals were immobilized with ketamine hydrochloride (10mg/kg body weight) combined with xylazine (1mg/kg body weight). Sex, body measurements (total length, body length, neck circumference, weight, foot width and length), and age (juvenile/adult) were recorded for each animal. Adult (>1 year) or juvenile (≤ 1 year) age delineations were determined by weight, size, cranial development, pelage condition and tooth wear (Gilbert 1995). Adult males and females that were free of debilitating injuries were tagged with radio-telemetry collars (Advanced Telemetry Systems, Inc., Insanti, MN). Juveniles were not collared to reduce chances of tagging dispersing animals and to minimize collar related injuries. If juveniles were recaptured longer than 2 months from initial capture, they were collared and followed as resident animals. All animals were tattooed in the ear with unique marks for future identification and released at the point of capture. Comparisons of morphological characteristics were made between species and sexes with a Student t-test. The alpha level was set a 0.006 to reduce the chances of making a type I error due to multiple comparisons. The alpha level was adjusted with a bonferroni technique (Sokal and Rohlf 1995) by dividing the initial alpha of 0.05 by the number of comparisons.

From the onset of the project, animal welfare was very important. Every attempt was made to reduce situations where animals were wearing telemetry collars and not being tracked. In the event of a 'missing' animal, a trapping array was set around the last known location in an attempt to capture and replace/remove the radio collar. At the end of the study, intense trapping was conducted in an attempt to

remove remaining collars from telemetered animals.

Three fishers (2 males, 1 female) and 1 male marten had collars removed because of minor injuries to the neck that were inflamed or caused by the radio collar (Appendix A). Five fishers (2 males, 3 females) and 1 male marten slipped their radio collars (Appendix A). Three fishers (1 male, 2 female) and 8 martens (7 male, 1 female) were not recaptured and have radio collars still attached (Appendix A).

Telemetry

Animals were located a maximum of twice during a 24-hour period, throughout the winter months (November-March), using a vehicle-mounted 5-element directional antenna or a hand-held yagi antenna (Telonics, Mesa, AZ). Locations were obtained throughout a 24-hour period to sample all periods of animal movement. All azimuths to an individual animal were taken within 30 mins. to reduce error associated with animal movement (Schmutz and White 1990). Point locations were obtained using a minimum of 3 azimuths in the microcomputer program Locate II (Nams 1990). Locate II utilizes a maximum likelihood estimator (Lenth 1981) to estimate the point location. Visual locations of animals were mapped on 1:24000 USGS quadrangle maps and included in home range and habitat use analyses.

Radio-telemetry equipment and personnel were tested for accuracy during the winters of 1993 and 1994. Tests in 1993 used a hand-held compass and sighted down the main beam of the directional antenna to determine a transmitter azimuth.

Transmitters were placed at road intersections and other locations easily found on a

1:24000 USGS quadrangle. Overall accuracy was $\pm 5.5^\circ$. Tests in 1994 used an electronic compass mounted in the vehicle to orient the directional antenna and determine a transmitter azimuth. Transmitters were placed randomly in the field and located with a global positioning system. Overall accuracy was $\pm 6.5^\circ$. The differences in accuracy between the 2 systems may be due to differences in transmitter locations between test years. Lovallo et al. (1994) found that an electronic compass was more accurate than a hand-held compass in field trials in Douglas County, Wisconsin.

An overall bearing error angle for all solved locations was calculated in the microcomputer program Locate II (Nams 1990). A bearing error angle of $\pm 3.5^\circ$ was used to calculate error ellipses for solved telemetry locations. This estimate may better represent telemetry error because it takes into account the researcher plotting transmitter locations in the field and discarding 'bad' azimuths.

Home Ranges

Home ranges were determined using the microcomputer program Calhome (Kie et al. 1994) which used adaptive kernel (Worton 1989) and minimum convex polygon (MCP) (Mohr 1947) home range estimators. Home ranges were calculated at the 95% contour for both estimators. The kernel home range estimator was used as the primary home range estimate because it is statistically robust and does not assume animal movement follows any underlying statistical distributions (Powell 1993a). The bandwidth (or smoothing parameter) for the kernel estimate was optimized by the Calhome software for the lowest least squares cross-validation and I set the number of

cells to a 50 x 50 grid. The MCP estimator has been used widely in other *Martes* spp. home range studies and was reported to facilitate comparisons with these studies. All analyses utilizing home range perimeters were done with the kernel estimate. Only animals with ≥ 30 locations were used to determine kernel and MCP home range estimates. Thirty locations was determined sufficient to estimate home ranges by plotting number of locations by home range size and finding an asymptote to the point where the curve levels off. Consecutive winter home ranges for an animal were grouped into 1 home range if the distribution of locations between years was not significantly different. Consecutive years home ranges were compared using a multiple response permutation procedure described by Mielke et al. (1976).

Intra and interspecific home range overlaps were determined using the 95% contour of the kernel home range estimate. Estimated home range perimeters were converted to spatial coverages using the geographic information system (GIS) software Arc/Info (Environmental Systems Research Institute, Redlands, CA). The home range of each animal was overlaid with its nearest neighbor(s) to determine shared area(s).

Habitat Use

The study area was subdivided for habitat analysis using USDA Forest Service compartment exam stand types, which include stocking, tree type and stand diameter class information (Eagle River District, Nicolet National Forest). The USFS MOSS (mapping and overlay statistical system) (Data Systems Support Group, Fort Collins, CO) GIS compartment exam coverages were transferred to Arc/Info GIS coverages (J.

Coleman, GLIFWC environmental modeler) for the analysis. Two habitat maps were constructed from this information. A cover type map was created that combined the 23 USFS stand types in the NFMSA into 8 major cover types (Table 1) similar in composition to other wildlife studies conducted on the NNF (Howe et al. 1995). A stand diameter class map was created that combined the 10 USFS size class/stocking density types into 4 stand diameter classes independent of stocking density (Table 2).

Habitat use was analyzed for home ranges and estimated point locations. Estimated 95 % kernel home range perimeters and the centroid of the error ellipses of telemetry locations were imported into Arc/Info and intersected with cover type and stand diameter class coverages to determine composition and use. Home ranges and telemetry locations were grouped by species and sex (e.g., male fishers) for analyses. All data sets were compared to the study area using a chi-square test described by Nue et al. (1974) at the 0.05 level of significance. Some cover types were dropped from comparisons so that $\leq 20\%$ of the cells in the contingency table had expected frequencies of < 5 and no cell had 0 observations (Cochran 1954). Species/sex groupings were first tested among species. If no differences were found, species/sex groups were combined and tested against the study area.

Dead Woody Material Use

Dead woody materials were sampled randomly with circular plots in the 8 cover types ($n = 625$) and animal activity centers ($n = 386$) of the study area. Activity centers were identified by first finding core areas within individual home ranges using

the 50% kernel contour of the home range estimate. Activity centers within core areas were identified as clusters of ≥ 5 locations within a single cover type in the core area.

The NOFO cover type was not represented in animal activity centers.

Dead woody materials were sampled following a slight modification of Brown's (1974) handbook for inventorying downed woody material for fuel load estimates in the western United States. Woody materials were sampled with a 0.02-ha circular plot in addition to Brown's (1974) 16 m vertical sampling plane. Brown's (1974) sampling plane ran in a random direction through the center of the plot. All standing material, snags (≥ 7.6 cm diameter breast height (DBH) and ≥ 2 m in height) and stumps (≥ 7.6 cm diameter and < 2 m in height) within the circular plot were recorded by diameter, height, and collapsed version of decay classes described by Maser et al. (1979). Maser et al. (1979) decay class 1 was recorded as "new" material, with bark and small branches present. Classes 2 and 3 were recorded as "sound" material, with no small branches but still hard textured. Classes 4 and 5 were recorded as "rotten" material, with no bark and soft or decayed wood. Root tip-ups (the tipped root mass from a fallen tree) within the circular plot were recorded by length, width, height, and the modified Maser et al. (1979) decay classes. Forest type, stand density, slope and aspect were also recorded at each plot.

Brown's (1974) vertical sampling plane was used to inventory DWM. The plane is based on a line intersect technique except that the plane acts as a guillotine dropped down through the woody material. Materials were counted when they

bisected the sampling plane. Sticks (< 7.6 cm diam.) were tallied by diameter size-classes: 1 = 0-0.6 cm; 2 = 0.7-2.5 cm; and 3 = 2.6-7.5 cm. Logs (≥ 7.6 cm diam) were recorded by diameter, length, and the modified Maser et al. (1979) decay classes. Size class 1 and 2 were tallied within the first 2 m of the sampling plane. Size class 3 were tallied within the first 4 m of the sampling plane. Logs were measured along the entire 16 m plane. A measurement of maximum DWM height for each of the 4 size classes was taken every 4 m on the sampling plane. Maximum DWM height was measured from the ground to the point where the material bisected the sampling plane. This provided an average maximum height for each size class in each plot.

Calculations of DWM followed formulas provided by Brown (1974). Volumes of DWM in each cover type and activity center were calculated by size class, with the exception of logs which were separated into the collapsed Maser et al. (1979) decay classes. Volume calculations for size classes 1, 2, and 3 are a product of Brown's (1974) constant, the total number of intersections over all sample points (n), the squared average diameter of each size class (d^2) derived from a composite squared diameter, a correction for slash/nonslash materials (a) and a slope correction (c). This product is divided by the total length of the sampling plane (Nl) to obtain volume.

$$\text{Volume (classes 1, 2, 3)} = \frac{11.64 \times n \times d^2 \times a \times c}{Nl}$$

Log volume, size class 4, is a product of Brown's constant, the sum of the squared diameters over all sample points ($\sum d^2$), a correction for slash/nonslash materials (a) and a slope correction (c). This product is divided by the total length of the sampling

plane (Nl) to obtain volume.

$$\text{Volume (logs)} = \frac{11.64 \times \sum d^2 \times a \times c}{Nl}$$

The volumes were summed for all 4 classes to obtain a total volume per area. Average diameter of logs is obtained by dividing the sum of the diameters by the number of pieces measured per area. Dead woody material height was averaged over all plots for each size class. Average number, diameter, height and decay class of snags, stumps and root tip-ups were determined in each area. Activity centers DWM characteristics were compared to random sites by cover type using a Mann-Whitney test (Zar 1999). The alpha level was set a 0.01 to reduce the chances of making a type I error due to multiple comparisons. The alpha level was adjusted with a Bonferroni technique (Sokal and Rohlf 1995) by dividing the initial alpha of 0.05 by the number of comparisons. Intraspecific comparisons of DWM characteristics were significantly different, therefore each species/sex grouping was tested independently against random samples for each cover type.

RESULTS

Trapping

Sixty one animals, representing 224 captures, were trapped on the NFMSA (1990-1995). Captures consisted of 10 male fishers (5 adult, 5 juvenile), 12 female fishers (7 adult, 5 juvenile) (Appendix B), 29 male American martens (19 adult, 10 juvenile) and 10 female American martens (4 adult, 6 juvenile) (Appendix C). Some juveniles were later recaptured and collared as adults.

Trapping effort for fishers from December 1992-January 1995 (before December 1992, summarized by Gilbert (1995)) was 1,237 trap nights (TN) (Table 3). Nine fishers were captured 10 times (0.7/100 TN). There were 7 incidental captures of raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), badger (*Taxidea taxus*) and red squirrel (*Tamiasciurus hudsonicus*) (0.6/100TN). The most successful trapping occurred in December and January (1.1/100 TN) while incidental catch (0.2/100 TN) was low. Trapping in May and June was least successful (0/100 TN) and had the highest incidental catch (2.9/100 TN). The overall sex ratio of trapped fishers was 1.3 males/1 female.

Trapping effort for martens (December 1992-January 1995) was 1,237 TN (Table 3). Thirty-nine martens were captured 85 times (3.2/100 TN). The most successful trapping occurred in December and January (3.9/100 TN) while incidental catch (0.2/100 TN) was low. Trapping in May and June was least successful (1/100 TN) and had the highest incidental catch (2.9/100 TN). Overall sex ratio of trapped martens was 2.9 males/1 female. Martens were trapped 4.5 times more frequently than fishers.

Morphology

Fishers average weight was 3.4 kg (SD = 1.3 kg). Body length (nose to base of tail) and total length (nose to end of tail) was 57.4 cm (SD = 4.5 cm) and 90.4 cm (SD = 6.0 cm) respectively. Average neck circumference was 19.9 cm (SD = 3.0 cm). Males were significantly longer (7%), heavier (53%) and had larger necks (22%) than

females (all P 's < 0.006) (Table 4). There were no differences in weight, length or neck size between adult and juvenile males, nor between adult and juvenile females (Table 4).

Fishers front foot pads averaged 3.3 cm x 3.9 cm (length x width). Hind foot pads were 3.9 cm x 3.9 cm. Male front foot lengths (P < 0.006) were larger than females (Table 4). There were no differences in front and hind foot pad sizes between adult and juvenile males, nor between adult and juvenile females (Table 4).

Martens average weight was 0.8 kg (SD = 0.2 kg). Body length and total length was 40.3 cm (SD = 2.8 cm) and 56.8 cm (SD = 3.8 cm), respectively. Average neck circumference was 12.2 cm (SD = 1.4 cm). Males were significantly longer (12%), heavier (44%), and had larger necks (18%) than females (all P 's < 0.006) (Table 4). There were no differences in weight, length, or neck size between adult and juvenile males, or between adult and juvenile females (Table 4).

Martens front foot pads averaged 2.5 cm x 2.7 cm (length x width). Hind foot pads were 2.7 cm x 2.8 cm. Male hind foot lengths (P < 0.006) were larger than females. There were no differences in front and hind foot widths of males and females. Adult males had larger hind foot lengths (P < 0.006) than juvenile males. There were no differences between front and hind feet of adult and juvenile females.

Interspecific comparisons were made between female fishers and male martens. Sexual dimorphism in *Martes* spp. suggests that these cohorts may be similar in size. Female fishers were significantly heavier (P < 0.006), had longer bodies (P < 0.006),

and larger necks ($P < 0.006$) than male martens. However only female fishers front foot widths were larger than male martens ($P < 0.006$) (Table 4).

Home Ranges

More than 3,300 animal locations were obtained on 42 individual animals, with $> 2,000$ occurring during the winter months (Appendix D).

Eighteen fishers (8 males, 10 females) were radio-tagged during the study. Nine (4 males, 5 females) of these were monitored through at least 1 winter. Reduced winter access, large relative home ranges, and the balance of collar signal strength vs. battery life combined to limit winter sample sizes. Sampling duration averaged 496 days (SD = 284) (males 537 days, SD = 396; females 463 days, SD = 202). There was an average of 69 (SD = 33) winter locations per animal (males 64, SD = 38; females 72, SD = 32). Adequate samples (>30) were obtained from 3 male and 5 female fishers to determine home range areas (Table 5). Average fisher winter home ranges, using the kernel estimate (Worton 1989), were 14.0 km^2 (SD = 2.6 km^2) for males and 10.0 km^2 (SD = 4.2 km^2) for females. Average winter home ranges using the minimum convex polygon estimate (Mohr 1947) were 9.7 km^2 (SD = 3.2 km^2) and 6.5 km^2 (SD = 2.7 km^2) for male and females, respectively. Average winter kernel home ranges were not significantly different between males and females ($t=1.47$, $P=0.19$).

Twenty-four martens (18 males, 7 females) were radio-tagged during the study. Eighteen (12 males, 6 females) of these were radio-tracked through at least 1 winter. Marten's collar signal strength relative to home range size allowed for better winter

sampling. Sampling duration averaged 667 days (SD = 371) (males 795, SD = 335; females 410, SD = 318). There was an average of 76 (SD = 34) winter locations per animal (males 87, SD = 36; females 53, SD = 9). Adequate samples (≥ 30) were obtained on 12 male and 6 female fishers to determine home range areas (Table 5). Average marten winter home ranges using the kernel estimate (Worton 1989) were 4.7 km² (SD = 2.6 km²) for males and 2.7 km² (SD = 1.4 km²) for females (Table 5). Minimum convex polygon estimates (Mohr 1947) were 2.7 km² (SD = 1.6 km²) and 1.7 km² (SD = 0.8 km²) for males and females, respectively (Table 5). Male and female average winter kernel home ranges were not significantly different ($t = 1.70$, $P = 0.11$). Fisher winter kernel home range areas were significantly larger than marten winter home ranges ($t = 5.94$, $P < 0.01$).

Significant efforts were made to radio-tag animals with adjacent home ranges. However, winter track observations suggested that uncollared animals could be found among telemetered animals. With this understanding, intersexual, intrasexual and interspecific territoriality, represented by overlap of kernel estimated home ranges, was investigated. Intrasexual home ranges of female fishers and female martens did not overlap (Figs. 5, 7 and 8). Male fisher home ranges and male marten home ranges overlapped by 21% and 17%, respectively (Figs. 5, 6, 7 and 8). Intersexual home ranges overlapped 20%-70% for fishers (Figs 5, 6, 7 and 8) and 40% -100% for martens (Figs 5, 6 and 8). Interspecific home ranges overlapped 50%-100% (Figs. 5, 6, 7 and 8).

There were 2 cases of extensive intrasexual home range overlap in male martens. Male marten 05's home range encompassed 88% of male marten 14's home range during winter 1991-1992 (Fig 5). Male marten 22's home range encompassed 88% and 73% of male marten 23's home range during winters 1992-1993 and 1993-1994, respectively (Figs. 7 and 8). Excluding these individuals, male marten home ranges overlapped by 8%.

Two male martens shifted home ranges during the study. Male marten 14's winter 1992-1993 home range was 2 km west of his winters 1991 -1992 and 1990-1991 home range (Figs. 5, 6 and 7). Male marten 21's winter 1993-1994 home range was 3 km northeast of his winter 1992-1993 home range (Figs. 7 and 8).

Habitat Use

Composition of fisher home ranges did not differ in cover type or stand diameter class between sexes ($\chi^2 = 2.0$, $P = 0.96$; $\chi^2 = 0.5$, $P = 0.48$) or the study area ($\chi^2 = 0.6$, $P = 0.99$; $\chi^2 = 0.6$, $P = 0.91$). The MIHA cover type (males 40%, females 47%) and POLE stand diameter class (males 40%, females 51%) were the largest types represented in home ranges. Similarly, MIHA (42%) and POLE were the largest classes (45%) on the NFMSA (Tables 1 and 2).

Fishers did not select for habitats based on cover type (males: $\chi^2=11.5$, $P=0.07$; females: $\chi^2=10.3$, $P=0.06$) (Fig. 9) or stand diameter class ($\chi^2=3.3$, $P=0.34$) (Fig. 10). Stand diameter class use did not differ between sexes ($\chi^2=2.3$, $P=0.50$). Location information was insufficient in the BABI, UPCO and PLAN cover types to include in

the contingency table. The largest percent of fisher telemetry locations (males 44% and 48%, females 47% and 52%) were in the MIHA type (Table 6) and POLE stand diameter class (Table 7).

Composition of marten home ranges did not differ in cover type or stand diameter class between sexes ($\chi^2=10.7$, $P=0.15$; $\chi^2=1.92$, $P=0.59$) or the study area ($\chi^2=7.38$, $P=0.39$, $\chi^2=2.75$, $P=0.43$). Male and female marten home ranges, like fishers, were predominantly the MIHA cover type (50% and 63% respectively) and POLE stand diameter class (53% and 59% respectively).

Male martens selected some cover types while avoiding others ($\chi^2=132.3$, $P<0.01$) (Fig. 11). Mixed hardwood and REPI cover types were used significantly more than expected, while A/AS/B, SWCO, and NOFO cover types were avoided. Female martens also selectively used some cover types while avoiding others ($\chi^2=81.1$, $P<0.01$) (Fig. 11). The MIHA cover type was used significantly more than expected, while REPI, A/AS/B, SWCO, and NOFO cover types were avoided.

Martens also selected some stand diameter classes (males: $\chi^2=69.2$, $P<0.01$; females: $\chi^2=42.4$, $P<0.01$) (Fig. 12). Male and female martens selected POLE and avoided NOFO and SEED stand diameter classes. Additionally, male martens selected SAW stand diameter classes, whereas females used this size class in proportion to its availability.

Dead Woody Material Use

Dead woody materials were found in greater numbers, heights and volumes in

activity centers than randomly in cover types. The type and amount of DWM differed by cover type and animal activity center.

For male fishers, activity centers were defined in AASB, MIHA, SWCO, and UPCO cover types (Tables 8 and 9). Except for activity centers in SWCO, size class 1 materials, the smallest size class, were found in greater numbers (all P 's<0.01) and volumes than random (all P 's<0.01). This material was also found in greater heights in the AASB cover type (P <0.01). The next larger size class material, size class 2, had a greater volumes only in the MIHA cover type (P <0.01). The number of new stumps was significantly greater in both SWCO and AASB cover types (both P 's<0.01). However, only AASB had significantly greater numbers and larger diameters of total and sound stumps, and larger diameters of rotten stumps (all P 's<0.01). The total number of root tip ups was greater only in the MIHA cover type (P <0.01). However, several cover types had greater numbers and diameter of root tip ups based on decomposition class. Mixed Hardwoods and AASB had a greater number of sound root tip ups (both P 's<0.01), while rotten root tip ups had greater diameters in SWCO (P =0.01). The total number of new logs was greater in MIHA cover type (P <0.01). For snags, only the total number of rotten snags was found in greater numbers in UPCO (P <0.01).

For female fishers, activity centers were located only in the MIHA cover type (Tables 8 and 9). These centers were similar to male fishers activity centers in MIHA by having greater numbers and volumes of the small size class 1 materials, greater

volumes of the size class 2 materials, and greater numbers of total and sound root tip-ups (all P 's<0.01). Female fisher activity centers also had dead material characteristics similar to male fisher centers found in AASB and SWCO cover types, including greater numbers of total and new stumps (P 's<0.01) and height of size class 1 (P <0.01) materials. Dead materials found significant for females fishers but not for males in any cover type were greater numbers of rotten stumps and greater diameters for new stumps, and larger volumes of total dead materials (all P 's<0.01).

Male marten activity centers were located in all cover types, except NOFO (Tables 8 and 9). Of these, the amount of dead material in PLAN and AASB cover types showed no significant differences from random. Similar to the fishers, smaller size materials, stumps, and root tip-ups were important characteristics. The numbers of size class 1 material was greater in MIHA and BABI cover types (both P 's<0.01), while volumes were greater in MIHA (P <0.01). Male marten activity centers in MIHA and REPI had greater numbers of total and rotten stumps, respectively (both P 's<0.01). Additionally, MIHA had greater numbers of new stumps and REPI had greater numbers of sound stumps (both P 's<0.01). Total, sound, and rotten root tip-ups were found in greater numbers in MIHA (all P 's<0.01), while the REPI cover type had only greater numbers (P <0.01) and the SWCO cover type had only larger diameters (P <0.01) of total root tip-ups. Snag characteristics were not found different from random except in the UPCO cover type where rotten snags had larger diameters (P <0.01). Log characteristics also showed few differences from random. Only the

BABI cover type had larger diameters of total logs and greater numbers of rotten logs (both P 's < 0.01).

Female marten activity centers were delineated in 6 of the cover types. Nonforested and UPCO types were not represented (Tables 8 and 9). Dead material characteristics found significant for female marten activity centers were similar to male martens activity centers except a slight difference in corresponding cover types. Again, the number of size class 1 materials was greater in MIHA and PLAN cover types (both P 's < 0.01), and PLAN had larger volumes of this material ($P = 0.01$). The number of total and rotten stumps was greater in AASB while only number of total stumps was significantly greater in MIHA (all P 's < 0.01). Dead material characteristics that differed from male martens were significantly larger diameters of total and rotten stumps in AASB, greater numbers of new root tip-ups in BABI, and greater numbers of new snags in AASB and PLAN cover types (all P 's < 0.01). Plantation cover types also had greater numbers of total snags ($P < 0.01$).

DISCUSSION

Home Ranges

Fishers and martens have large spatial requirements for carnivores their size (Buskirk and McDonald 1989). Fishers in this study weighed 3.4 kg and used home ranges of 11.5 km². Martens weighed 0.8 kg and had home ranges averaging 4.2 km². Buskirk and McDonald (1989) analyzed the variability in marten home range size and found home ranges that were 3 times larger than body size alone would predict. Using

Lindstedt's et al. (1986) model for carnivores south of 45° latitude:

$$A_{hr} = 115 * M^{0.94}$$

(where A_{hr} is area of the home range and M is mass of the animal)

martens in this study had home ranges 4½ times larger than predicted by body size.

The model also underestimated fisher home ranges by a factor of 3.

Powell (1994) generalized that *Martes* spp. home ranges are positively correlated with body size, and male home ranges tend to be larger than females. Data from this study, although not significant, support these generalizations. The small, unequal sample sizes from this study may have contributed to the lack of significance in the results. Still, male fishers were 113% larger than females and had 40% larger home ranges. Male martens were 83% larger than females and had 74% larger home ranges. The trend also holds well with interspecific comparisons. Fishers were 325% larger than martens and had 174% larger home ranges.

Fishers had small home ranges, using the MCP estimate, compared with other studies (Johnson 1984, Arthur et al. 1989b, Kohn et al. 1993, Powell 1994). However, many studies report annual not winter home ranges and there is inconsistency in the methods used to determine home range size. Fisher home ranges have been reported smaller during mid-winter than at any other time (Kelly 1977), although Arthur et al. (1989b) reported fisher home ranges remain stable in size and location throughout the year, excluding male spring breeding trips. Small home ranges may indicate good site conditions for fishers. Buskirk and McDonald (1989) hypothesized that there would

be a strong relationship between home range size and site conditions in terrestrial carnivores, like fishers, because they lack a social pattern of dominance interaction, occur in high densities in high quality habitats, have low reproductive capacity, and are habitat specialists.

Martens also had small home ranges, using the MCP estimate, compared with other studies (Davis 1983, Buskirk and McDonald 1989, Steventon and Major 1982, Powell 1994). Buskirk and McDonald (1989) found no geographic pattern explaining home range size variation of martens in 9 studies across North America. However, home range size has been shown to vary according to prey abundance (Soutiere 1979) and habitat type (Thompson and Colgan 1987). Relationships between habitat quality and population density may apply to the relationship between home range size and site conditions in martens (Buskirk and McDonald 1989). Small home ranges reported in this study may indicate good site conditions for martens.

Some researchers have felt energetic demands are the primary forces determining home range size. Sandell (1989) modeled the relationship between energetics and home range size in solitary carnivores. His formula assumes that male range size is determined by food abundance and access to receptive females, and female range size is determined solely by food abundance. With that, the body weight of the 2 sexes could be used to predict male range size:

$$\text{male range size} = (\text{female range size} * (\text{male weight})^{0.75})/(\text{female weight})^{0.75}$$

However, his model did not perform well under his own tests and Sandell (1989)

concluded that energetics alone do not adequately explain home range size. His prediction performs well for fishers and martens in this study, possibly because these data were collected during nonbreeding periods. Average male fisher home range size was expected to be 17.5km² and actually was 14.0km². Average male marten home range size was expected to be 4.2km² and actually was 4.7km². These results suggest that energetics may play a large role in determining winter home range size of fishers and martens in Wisconsin.

The observation of little or no intrasexual home range overlap in this study is a consistent theme reported for *Martes* spp. (Powell 1994). In a review of the literature, Powell (1994) found a correlation between intrasexual territoriality and large sexual dimorphism. The lack of intersexual territoriality may increase breeding opportunities while sexual dimorphism reduces the chances of competing for limited resources. Territorial spacing can act as a control of population density in many terrestrial carnivores (Buskirk and McDonald 1989). Population densities of resident adult animals within the study area, based on home range size and interspecific defense of home ranges, and complete land area use were 14 fishers (0.2 fishers/km²) and 48 martens (0.6 marten/km²) or 3 martens for every fisher. Arthur et al. (1989b) reported 0.1 adult fisher/km² in Maine an area with similar vegetative characteristics. Soutiere (1979) reported 1.22 martens/km² in partially cut forests in Maine.

There were 3 exceptions to observed intraspecific territoriality, all by male martens. All animals were judged adult at capture but cementum anuli were not

examined and age classification by physical characteristics could have been incorrect. Others (Archibald and Jessup 1984) have reported that adult martens may tolerate non-breeding cohorts within their home ranges. Adults may be sharing home ranges with other adults of the same sex during non breeding periods if resources are not limiting. Other researchers (Mech and Rogers 1977, Wynne and Sherburne 1984) have also observed home range overlaps in adult martens of the same sex.

There was no evidence of interspecific territoriality in this study. However, the spacing of individual locations used to determine the 95% kernel home range estimates were not examined. Fishers and martens could be avoiding each other within overlapping home ranges. Fishers and martens could also be in direct competition. A radio-tagged marten in this study was partially eaten, cached in a tree, and covered with moss suggesting a fisher caused mortality. There may also be some reciprocation by martens. During this study a radio-tagged male marten was observed chasing a radio-tagged female fisher. The marten's home range was completely encompassed by the fisher's but basis for the altercation was not determined. Both animals appeared healthy the following day.

Habitat Use

Fishers did not select winter habitats based on cover type or stand diameter class. These results support the hypothesis that other factors are more important or work in conjunction with cover type in determining habitat selection by fishers. Some researchers have hypothesized that forest structure and prey associated with that

structure may be more important to fishers than cover type (Buskirk and Powell 1994). Forest structure may supply similar habitat niches for fishers even when created by different tree species and size compositions. Dead woody material, an integral component of forest structure, may be the factor influencing habitat selection by fishers in Wisconsin.

Martens, unlike fishers, selectively used some winter habitats while avoiding others. The avoidance of young seral stages (aspen cover type and seedling size class) and nonforested types are consistent with other studies, but selection of mixed hardwoods is inconsistent with the literature (Buskirk and Powell 1994). Most researchers report martens selecting mature to old-growth conifer stands, especially in the western United States (Buskirk and Powell 1994). Buskirk and Ruggiero (1994) found no place, in published literature from the West, where martens preferred hardwood stands. Like fishers, this inconsistency may be explained by forest structural components working in conjunction with cover type in determining marten habitat selection. It may be that mixed hardwood forests in Wisconsin act similarly to western conifer dominated stands. Dead woody material, an integral component of forest structure, may be an important factor influencing marten habitat selection.

Dead Woody Material Use

Dead woody material is important to fisher and marten winter site selection at broader scales than previously reported. There was a positive relationship between DWM and animal use beyond the site specific scale, although at this scale it cannot be

determined why the area was being used. Wilbert (1992) considered scale during research on marten in Wyoming and found they were selecting dead woody material for resting sites at fine scales, but were relatively non-selective at larger scales. Site specific studies have shown that DWM is important for thermal cover, hunting and subnivean access (for fishers; Raine 1983, Douglas and Strickland 1987, Lamb 1987, Jones 1991, Gilbert et al. 1997)(for martens; Spencer 1987, Martin and Barrett 1991, Corn and Raphael 1992, Gilbert et al. 1997); though Gilbert et al. (1997) hypothesized that for fishers it may not be as close an association as for martens.

There may be 2 responses by fishers and martens to DWM at the activity center scale. Greater numbers of standing DWM (e.g., stumps, snags, and root tip-ups) may be related both to site specific benefits and indicate that fishers and martens preferentially use areas within home ranges that contain greater amounts of this material. The increased numbers, heights, and volumes of dead and down fine material (< 2.5cm), much in the form of downed tree tops, and the greater numbers of new stumps, indicate a response to recently disturbed areas. The biological value of fine material and new stumps is unknown and has not been noted in other *Martes* spp. studies. Fine materials may loft snow and provide easier subnivean access. However, increased snow fluff has been hypothesized to be less desirable to fishers because it impedes movement (Krohn et al. 1995). The increase in woody biomass at or near the ground may cause a short-lived but dramatic local increase in preferred prey. Voles (*Clethrionomys* spp. and *Microtus* spp.) and snowshoe hares (*Lepus americanus*),

preferred fisher and marten prey, are reported bark browsers during winter (Gill 1992). Voles may have been especially sought because of a low in the hare cycle during this study (K. McCaffery pers. comm.). Fisher have responded to past cyclic lows in hare populations by using alternative foods (Kuehn 1989, Powell 1993b) such as voles. Vole capture rates were higher in winter marten areas than winter non-marten areas in Montana and vole biomass decreased more in winter marten areas (Coffin et al. 1997). Martens have experienced lower fecundity and general population decline when vole populations were reduced (Thompson and Colgan 1987).

Management Implications

My results support the hypothesis that vertical and horizontal structure, provided by standing and down DWM, is more important in determining fisher and marten habitat selection than stand composition or age (Buskirk and Powell 1994). Further, DWM is important both in larger geographic areas (i.e. home range, this study) as well as at more site-specific locations (e.g. winter rest and maternal den sites, Gilbert et al. 1997). Thus, habitat management techniques which provide DWM at both of these scales is needed to increase habitat suitability for fishers and martens.

DWM occurs in both managed and unmanaged forests (Maser et al. 1979). Older growth forests tend to contribute larger diameter DWM than younger stands (Tyrrell 1991) but may not have small diameter structure found important in this study. In the absence of older growth forests and their associated DWM, small disturbances (e.g., wind throw, insect and disease damage, selective tree harvesting) will enhance

fisher and marten habitats by increasing both fine and coarse DWM. Silvicultural practices that decrease DWM (i.e., whole tree harvest and slash burning) would be detrimental to fishers and martens and should be avoided in areas designated for these species. Clear cutting may increase DWM (Howard 1973) and associated small mammal populations, depending on the post cut treatment of residual material. However, areas with complete canopy removal are avoided by fishers and martens (Buskirk and Powell 1994) and thus would not result in increased habitat suitability despite increases in DWM.

Silvicultural treatments such as selective tree harvest will increase some DWM by leaving tops, stumps and unmarketable logs. These silvicultural practices will enhance fine DWM but most of the coarse DWM would be removed as merchantable timber. Maser et. al. (1979) proposed that slash piles and root tip-ups could mitigate the loss of logs as wildlife habitat and these structures should be provided in areas of selective tree harvest. Selective removal of large trees will also open the canopy and allow more light to penetrate to the forest floor stimulating herbaceous growth and attracting prey (Hunter 1990). Fine DWM, however, is lost more rapidly than coarse DWM because of decomposition. Hardwood branches 2cm dia. can decompose in <30 years (Swift et al. 1976). Thus it is important to provide this habitat component on a more frequent basis than for coarse DWM.

There is a variety of attributes which should be balanced to provide habitats for fishers and martens. Canopy cover should be maintained, large diameter trees must be

provided for maternal den sites, and forest structure must be provided in the form of DWM. These attributes can be provided in a variety of stands including both deciduous and coniferous types. Habitat results of management should be monitored to insure that this balance is maintained.

ACKNOWLEDGMENTS

Many people and organizations contributed to this project. Without their collaboration and support this work would not have been possible. GLIFWC and its member tribes contributed financial support, personnel support, advice, and encouragement during this project. Financial support was provided by UWSP, USDA North Central Research Station (NCRS), NNF, WDNR, and Wisconsin Trappers Association. NCRS granted me the time and resources to complete this project while under their employment. GLIFWC Wildlife Technicians, GLIFWC Interns, USFS personnel, and UWSP student volunteers contributed invaluable time, skills, and dedication in the field. Significant advice, encouragement and patience came from my graduate committee; Dr. Raymond K. Anderson, Jonathan H. Gilbert, Dr. James E. Cook, and Dr. Robert Rogers.

A few individuals need special mention. My wife, Deahn, provided endless encouragement and support throughout the project. She also spent countless voluntary hours in the field and made significant improvements to the manuscript with her outstanding editorial skills. Jonathan Gilbert, GLIFWC Wildlife Section Leader, was integral in the formulation of the research design. Without his advise, encouragement

and time the project would not have been possible. Ron Parisian, GLIFWC Wildlife Technician, provided valuable knowledge of trapping techniques and life histories of the study animals as well as countless hours in the field. David Lauten dedicated a year to the field and whose enthusiasm for all things wild improved both the quantity and quality of the research.

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Table 1. Cover Types of Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Cover Type ¹	Code	Dominant Species	Percent of Study Area
Red Pine	REPI	Red Pine (<i>Pinus resinosa</i>)	7%
Upland Conifer	UPCO	White Pine (<i>Pinus strobus</i>), Eastern Hemlock (<i>Tsuga canadensis</i>)	4%
Balsam Fir/Aspen/Birch	B/A/Bi	Balsam Fir (<i>Abies balsamea</i>), Quaking Aspen (<i>Populus tremuloides</i>), Paper Birch (<i>Betula papyrifera</i>)	3%
Plantations	PLAN	White Spruce (<i>Picea glauca</i>) or Jack Pine (<i>Pinus banksiana</i>), Balsam Fir (<i>Abies balsamea</i>), Quaking Aspen (<i>Populus tremuloides</i>)	2%
Mixed Hardwoods	MIHA	Sugar Maple (<i>Acer saccharum</i>), American Basswood (<i>Tilia americana</i>), White Ash (<i>Fraxinus americana</i>), Paper Birch (<i>Betula papyrifera</i>)	42%
Aspen/Aspen-Spruce/ Fir	A/AS/B	Quaking Aspen (<i>Populus tremuloides</i>), Bigtooth Aspen (<i>Populus grandidentata</i>), White Spruce (<i>Picea glauca</i>), Balsam Fir (<i>Abies balsamea</i>)	12%
Swamp Conifer	SWCO	White Cedar (<i>Thuja occidentalis</i>), Black Spruce (<i>Picea mariana</i>), Tamarack (<i>Larix Laricina</i>)	21%
Non-Forested	NOFO	Willows (<i>Salix</i> spp.), Alder (<i>Alnus rugosa</i>), Sedges (<i>Cyperaceae</i>), Grasses (<i>Graminae</i>), frozen lakes	9%

¹ Cover types were aggregations of compartment stand exam data, Eagle River District, Nicolet National Forest, Wisconsin.

Table 2. Stand diameter classes of Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Stand diameter Class	Code	Description	Percent Area
Seedling-Sapling	SEED	all species: < 12.7cm dbh	19%
Pole timber	POLE	hardwoods: \geq 12.7cm dbh & < 22.9cm dbh conifers: \geq 12.7cm dbh & < 27.9cm dbh	45%
Sawlog timber	SAW	hardwoods: \geq 22.9cm dbh conifers: \geq 27.9cm dbh	27%
Non-Forested	NOFO		9%

Table 3. Trapping summary for Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin, December 1992-January 1995.

Season	Year	Trap Nights ^a	Fisher	Marten	Incidentals
Late Fall (Oct.-Nov.)	1993	502.5	3	15	3
Captures / 100 trap nights			0.6	3.0	0.6
Sex Ratio (male : female)			1 : 2	2.8 : 1	
Early Winter (Dec.-Jan.)	1992-1993	205.0	4	8	1
	1993	32.0	1	2	0
	1994	26.0	0	0	0
	1994-1995	194.5	0	8	0
Captures / 100 trap nights			1.1	3.9	0.2
Sex Ratio (male : female)			4 : 1	2 : 1	
Late Winter (Feb.-Mar.)	1993	176.0	1	5	0
Captures / 100 trap nights			0.6	2.8	0.0
Sex Ratio (male : female)			0 : 1	5 : 0	
Late Spring (May-June)	1993	101.0	0	1	3
Captures / 100 trap nights			0.0	1.0	2.9
Sex Ratio (male : female)			0 : 0	1 : 0	
TOTAL		1237.0	9	39	7
Captures / 100 trap nights			0.7	3.2	0.6
Sex Ratio (male : female)			1.3 : 1	2.9 : 1	

^a A trap sprung without a capture was counted as ½ trap night.

Table 4. Morphology of fishers and martens, Nicolet National Forest, Wisconsin.

Animal	\bar{x} wt		\bar{x} Body Length		\bar{x} Total Length		\bar{x} Neck Circum.		Front Foot (cm)				Hind Foot (cm)			
	(kg)	SD	(cm)	SD	(cm)	SD	(cm)	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD	\bar{x}	SD
Adult Male Fisher	5.3 ^a	1.1	59.2	4.3	96.2 ^a	4.6	23.5 ^a	2.9	3.7 ^a	0.3	4.4	0.1	4.2	0.4	4.1	0.6
Juvenile Male Fisher	4.0	0.2	57.8	2.2	95.8	1.1	20.9	2.0	3.5	0.3	4.1	0.3	4.3	0.5	4.3	0.2
Adult Female Fisher	2.5 ^{a,c}	0.2	52.3 ^c	1.7	85.9 ^{a,c}	3.7	18.3 ^{a,c}	1.6	3.0 ^a	0.2	3.6 ^c	0.6	3.3	0.4	3.4	0.6
Juvenile Female Fisher	2.4	0.2	50.5	2.7	85.4	1.9	17.4	0.6	2.9	0.3	3.6	0.3	3.4	0.2	3.9	0.4
Adult Male Marten	0.9 ^{a,c}	0.1	40.9 ^c	2.1	57.9 ^{a,c}	2.4	12.7 ^{a,c}	1.3	2.7 ^b	0.4	2.8 ^c	0.4	3.0 ^{a,b}	0.4	2.9	0.5
Juvenile Male Marten	0.8	0.1	41.9	3.1	59.4	3.5	12.5	0.9	2.2 ^b	0.6	2.5	0.4	2.4 ^b	0.4	2.6	0.3
Adult Female Marten	0.5 ^a	0.1	37.6	0.5	51.1 ^a	0.5	10.4 ^a	0.2	2.3	0.4	2.7	0.2	2.3 ^a	0.2	2.8	0.2
Juvenile Female Marten	0.6	0.1	37.6	1.7	52.4	1.4	11.0	1.1	2.1	0.5	2.8	0.6	2.5	0.6	2.9	0.5

^a Denotes significant intraspecific differences between adult males and adult females.

^b Denotes significant intraspecific differences between adults and juveniles.

^c Denotes significant differences between female fishers and male martens.

Table 5. Winter home ranges (km²) of fishers and martens, calculated by the kernel (Worton 1989) and minimum convex polygon estimators (Mohr 1947).

Animal ^a	No. Locations	95% Kernel	95% MCP	Winter(s) Tracked
FM01	86	16.9	13.1	1990, 1991, 1992
FM09	51	13.2	6.9	1993
FM11	36	11.8	9.1	1993
mean	58 (SD = 26)	14.0 (SD = 2.6)	9.7 (SD = 3.2)	
FF01	37	14.7	9.5	1990
FF05	61	7.3	4.9	1992
FF07	97	11.0	7.0	1992, 1993
FF08	92	12.6	8.1	1992, 1993
FF11	37	4.2	2.8	1993
mean	65 (SD = 29)	10.0 (SD = 4.2)	6.5 (SD = 2.7)	
MM05	37	2.3	1.6	1991, 1992
MM08	40	5.4	2.3	1990
MM13	31	7.2	4.5	1990
MM13	78	7.3	5.5	1991, 1993
MM14	65	4.2	2.5	1990, 1991
MM14	64	1.8	0.9	1992
MM15	39	1.5	0.9	1991, 1992
MM16	55	11.2	6.1	1993
MM21	56	3.3	2.2	1992
MM21	44	7.2	3.7	1993
MM22	101	4.9	3.4	1992, 1993
MM23	100	5.0	3.4	1992, 1993
MM25	62	3.5	2.1	1993
MM26	58	2.7	1.7	1993
MM29	60	3.4	2.3	1993
mean	59 (SD = 21)	4.7 (SD = 2.6)	2.7 (SD = 1.6)	
MF02	38	3.2	2.2	1990
MF03	42	2.6	1.4	1990, 1991
MF06	57	3.8	2.1	1993
MF07	55	4.6	2.6	1993
MF08	58	2.1	1.4	1993
MF09	42	0.4	0.3	1993
mean	49 (SD = 9)	2.7 (SD = 1.4)	1.7 (SD = 0.8)	

^a Animal species code (F=fisher, M=marten), sex (F=female, M=male), number

Table 6. Cover type availability and winter use (1990-1994) for fishers and martens on the Nicolet Fisher/marten study area, Nicolet National Forest, Wisconsin.

Cover Types	Study Area		Male Fishers		Female Fishers		Male Martens		Female Martens	
	ha	%	No. Locations	%	No. Locations	%	No. Locations	%	No. Locations	%
Red Pine	955	6.0	16	8.1	15	4.9	99	10.9	7	2.4
Upland Conifer	655	4.1	10	5.1	13	4.3	35	3.9	11	3.8
Balsam / Aspen / Birch	527	3.3	3	1.5	18	5.9	41	4.5	18	6.2
Upland Plantations / Balsam / Aspen	433	2.7	0	0.0	2	0.7	15	1.7	10	3.4
Mixed Hardwoods	6708	42.4	83	42.1	141	46.4	487	53.6	184	63.0
Aspen / Aspen-Spruce / Balsam	1845	11.7	33	16.8	41	13.5	70	7.7	17	5.8
Swamp Conifer	3305	20.9	37	18.8	53	17.4	111	12.2	37	12.7
None Forested	1395	8.8	15	7.6	21	6.9	50	5.5	8	2.7
TOTALS	15822		197		304		908		292	

Table 7. Stand diameter class availability and winter use (1990-1994) for fishers and martens on the Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Stand Diameter Classes	Study Area		Male Fisher		Female Fisher		Male Marten		Female Marten	
	ha	%	No. Locations	%	No. Locations	%	No. Locations	%	No. Locations	%
Non-Forested	1395	8.8	15	7.6	21	6.9	50	5.5	8	2.7
Seedling/Sapling	3028	19.1	32	16.3	58	19.1	103	11.4	27	9.2
Pole Timber	7176	45.4	95	48.2	158	52.0	485	53.4	177	60.6
Saw Log Timber	4223	26.7	55	27.9	67	22.0	270	29.7	80	27.4
TOTALS	15822		197		304		908		292	

Table 8. Mean dead and down woody material measurements for animal activity centers by cover type on the Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin. Comparisons were made between animal activity centers and random plots within cover types. Alpha was set at $P=0.0125$. Values followed by asterisks indicate those materials that were significantly greater than random. Variables with no differences are not shown.

Animal	Cover Type	No. Activity Centers	Class 1			Class 2	All Logs	New Logs	Total
			No.	Height (cm)	Vol. (m³/ha)	Vol. (m³/ha)	diam. (cm)	No.	Vol. (m³/ha)
FISHER									
Males	Aspen-Aspen/ Spruce-Balsam Fir	1	17.8*	59.3*	0.20*	0.83	13.2	0.0	6.01
	Mixed Hardwoods	2	13.4*	30.8	0.16*	0.83*	15.7	0.8*	7.8
	Swamp Conifer	2	22.6	58.3	0.25	0.55	14.9	0.4	7.39
	Upland Conifer	1	158.8*	34.8	1.77*	0.72	19.0	0.0	6.42
	Females	Mixed Hardwoods	8	19.8*	42.1*	0.25*	1.00*	16.3	0.5
MARTEN									
Males	Aspen-Aspen/ Spruce-Balsam Fir	2	10.1	28.3	0.11	0.53	10.2	0.0	2.10
	Balsam Fir- Aspen-Birch	4	18.9	46.3	0.21*	1.21	21.9*	0.1	14.14
	Mixed Hardwoods	14	11.1*	24.7	0.13*	0.58	15.4	0.2	8.68
	Plantation	5	14.8	20.8	0.16	0.36	12.7	0.1	3.14
	Red Pine	8	10.2	38.2	0.11	0.71	13.3	0.2	4.93
	Swamp Conifer	3	18.1	33.5	0.13	0.64	11.6	0.3	2.90
	Upland Conifer	1	28.0	36.3	0.31	1.11	13.8	0.2	7.33
	Females	Aspen-Aspen/ Spruce-Balsam Fir	4	14.6	32.6	0.16	0.70	14.7	0.3
Balsam Fir- Aspen-Birch		1	23.0	76.8	0.26	0.89	19.5*	0.2	10.15
Mixed Hardwoods		3	13.9*	27.8	0.17*	0.58	16.4	0.3	7.68
Plantation		1	29.0	49.3	0.40*	0.74	9.9	0.8	4.46
Red Pine		1	8.0	18.4	0.09	0.13	.	0.0	0.22
Swamp Conifer		2	5.3	15.4	0.06	0.02	9.3	0.1	0.61
RANDOM									
Aspen-Aspen/ Spruce-Balsam Fir		10.6	28.6	0.12	0.80	13.0	0.2	5.55	
Balsam Fir- Aspen-Birch		10.8	36.4	0.12	0.80	13.6	0.1	8.08	
Mixed Hardwoods		7.8	23.8	0.08	0.52	15.5	0.2	7.80	
Nonforest		15.8	38.5	0.07	0.28	13.0	0.0	1.67	
Plantation		15.3	32.8	0.17	0.65	13.2	0.2	4.27	
Red Pine		10.1	33.6	0.11	0.90	13.9	0.1	5.32	
Swamp Conifer		11.5	38.7	0.11	0.48	15.1	0.2	8.71	
Upland Conifer		15.4	27.1	0.17	0.63	15.7	0.1	6.60	

Class 1 (0-0.6cm diam.); Class 2 (0.7-2.5cm diam.); Logs (>7.6cm diam)

Table 9. Mean dead standing woody material measurements for animal activity centers by cover type on the Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin. Comparisons were made between animal activity centers and random plots within cover types. Alpha was set at $P=0.0125$. Values followed by asterisks indicate those materials that were significantly greater than random. Variables with no differences are not shown.

Animal	Cover Type	No. Activity Centers	Snags			Stumps							
			No./ha	New No./ha	Rotten No./ha	All		New		Sound		Rotten	
						No./diam. ha (cm)	diam. (cm)	No./diam. ha (cm)	diam. (cm)	No./diam. ha (cm)	diam. (cm)	No./diam. ha (cm)	diam. (cm)
FISHERS													
Males	Aspen-Aspen/												
	Spruce-Balsam Fir	1	0.1	0.1	0.0	14.4	30.5*	1.2	23.5	8.8	28.9*	4.4	37.4*
	Mixed Hardwoods	2	1.3	0.5	0.0	5.8	26.8	1.7	20.9	1.2	18.5	2.9	27.7
	Swamp Conifer	2	6.4	1.5	0.1	10.2	17.9	0.4	18.3	5.0	14.6	4.9	20.2
	Upland Conifer	1	2.0	0.0	0.2*	7.2	20.0	0.0	.	0.4	36.8	6.8	19.7
Females	Mixed Hardwoods	8	1.9	0.5	0.1	6.2*	28.8	1.7*	30.0*	1.6	23.0	3.0*	30.4
MARTEN													
Males	Aspen-Aspen/												
	Spruce-Balsam Fir	2	3.1	1.2	0.0	2.4	14.5	0.2	7.6	1.5	10.7	0.7	25.4
	Balsam Fir-												
	Aspen-Birch	4	2.6	0.8	0.1	8.3	32.4	0.0	.	1.5	19.9	6.8*	34.3
	Mixed Hardwoods	14	1.6	0.3	0.1	5.1*	26.5	0.9*	26.1	1.7	20.0	2.6*	28.6
	Plantation	5	4.9	2.4	0.1	6.1	32.0	0.0	.	0.7	27.8	5.4	31.9
	Red Pine	8	2.3	0.5	0.0	8.2*	24.8	0.4	23.7	4.0*	21.5	3.8*	30.8
	Swamp Conifer	3	5.8	0.7	0.0	7.4	18.7	0.0	.	4.3	14.5	3.1	21.6
Upland Conifer	1	2.8	0.4	0.2*	7.6	36.4	0.0	.	1.0	22.9	6.6	38.0	
Females	Aspen-Aspen/												
	Spruce-Balsam Fir	4	3.2	1.7*	0.0	7.8*	38.8*	0.1	17.8	0.8	23.6	6.9*	40.5*
	Balsam Fir-												
	Aspen-Birch	1	3.8	1.2	0.0	3.8	21.6	0.2	15.2	0.0	.	3.6	22.3
	Mixed Hardwoods	3	1.7	0.5	0.0	5.1*	25.9	0.7	30.0	1.9	20.0	2.5	25.9
	Plantation	1	12.3*	4.0*	0.0	2.3	15.0	0.3	30.5	0.8	14.4	1.3	16.5
	Red Pine	1	0.0	0.0	0.0	0.0	.	0.0	.	0.0	.	0.0	.
Swamp Conifer	2	2.0	0.6	0.0	3.1	9.4	0.0	.	2.3	9.2	0.8	9.7	
RANDOM													
Aspen-Aspen/													
Spruce-Balsam Fir		2.3	0.6	0.1	5.1	24.3	0.2	19.6	2.0	20.8	2.9	25.5	
Balsam Fir-													
Aspen-Birch		4.2	0.6	0.0	5.6	25.7	0.1	17.8	2.6	17.9	2.9	32.3	
Mixed Hardwoods		1.4	0.2	0.0	3.9	27.6	0.4	22.8	1.6	23.1	1.8	29.8	
Nonforest		0.1	0.0	0.0	1.4	31.9	0.0	.	0.8	32.3	0.6	17.2	
Plantation		5.3	1.3	0.0	7.1	26.6	0.0	.	1.3	15.8	5.9	28.4	
Red Pine		2.2	0.3	0.1	4.3	31.5	0.2	27.4	1.8	21.0	2.3	38.6	
Swamp Conifer		4.7	0.9	0.1	7.6	18.8	0.1	14.3	3.1	16.5	4.4	21.1	
Upland Conifer		1.8	0.2	0.0	5.3	26.4	0.1	20.3	2.3	20.6	3.0	27.4	

Snags (>7.6cm dbh and >2m height); Stumps (>7.6cm diam. <2m height).

Table 9. Continued

Animal	Cover Type	No.	Root tip-ups						
		Activity Centers	All		New	Sound	Rotten		
			No./ha	diam.(cm)	No./ha	No./ha	No./ha	diam.(cm)	
FISHERS									
Males	Aspen-Aspen/ Spruce-Balsam Fir	1	0.8	116.8	0.0	0.8*	0.0	.	
	Mixed Hardwoods	2	1.1*	72.4	0.1	0.8*	0.3	56.7	
	Swamp Conifer	2	1.3	200.8	0.0	0.9	0.4	310.8*	
	Upland Conifer	1	0.6	69.2	0.2	0.4	0.0	.	
	Females	Mixed Hardwoods	8	0.9*	91.2	0.1	0.7*	0.1	101.0
MARTEN									
Males	Aspen-Aspen/ Spruce-Balsam Fir	2	0.1	50.8	0.1	0.0	0.0	.	
	Balsam Fir- Aspen-Birch	4	1.1	79.0	0.1	0.9	0.2	110.1	
	Mixed Hardwoods	14	0.8*	65.5	0.0	0.6*	0.2*	68.4	
	Plantation	5	0.6	91.3	0.0	0.4	0.2	156.2	
	Red Pine	8	0.8*	89.1	0.1	0.6	0.1	56.4	
	Swamp Conifer	3	0.9	242.1*	0.3	0.6	0.1	203.2	
	Upland Conifer	1	0.0	.	0.0	0.0	0.0	.	
	Females	Aspen-Aspen/ Spruce-Balsam Fir	4	0.9	101.0	0.2	0.6	0.1	186.7
		Balsam Fir- Aspen-Birch	1	1.2	132.1	0.6*	0.6	0.0	.
Mixed Hardwoods		3	0.8	94.5	0.1	0.5	0.2	69.9	
Plantation		1	1.8	80.4	0.0	1.8	0.0	.	
Red Pine		1	0.0	.	0.0	0.0	0.0	.	
Swamp Conifer		2	0.0	.	0.0	0.0	0.0	.	
RANDOM									
Aspen-Aspen/ Spruce-Balsam Fir		0.5	70.6	0.1	0.4	0.1	89.5		
Balsam Fir- Aspen-Birch		1.0	77.2	0.1	0.6	0.3	116.5		
Mixed Hardwoods		0.5	101.2	0.1	0.3	0.1	129.0		
Nonforest		0.3	69.8	0.0	0.2	0.1	105.8		
Plantation		0.7	96.2	0.1	0.4	0.2	77.9		
Red Pine		0.3	54.7	0.1	0.2	0.0	52.1		
Swamp conifer		1.6	135.2	0.2	1.1	0.3	87.3		
Upland conifer		0.5	67.5	0.0	0.3	0.2	61.3		

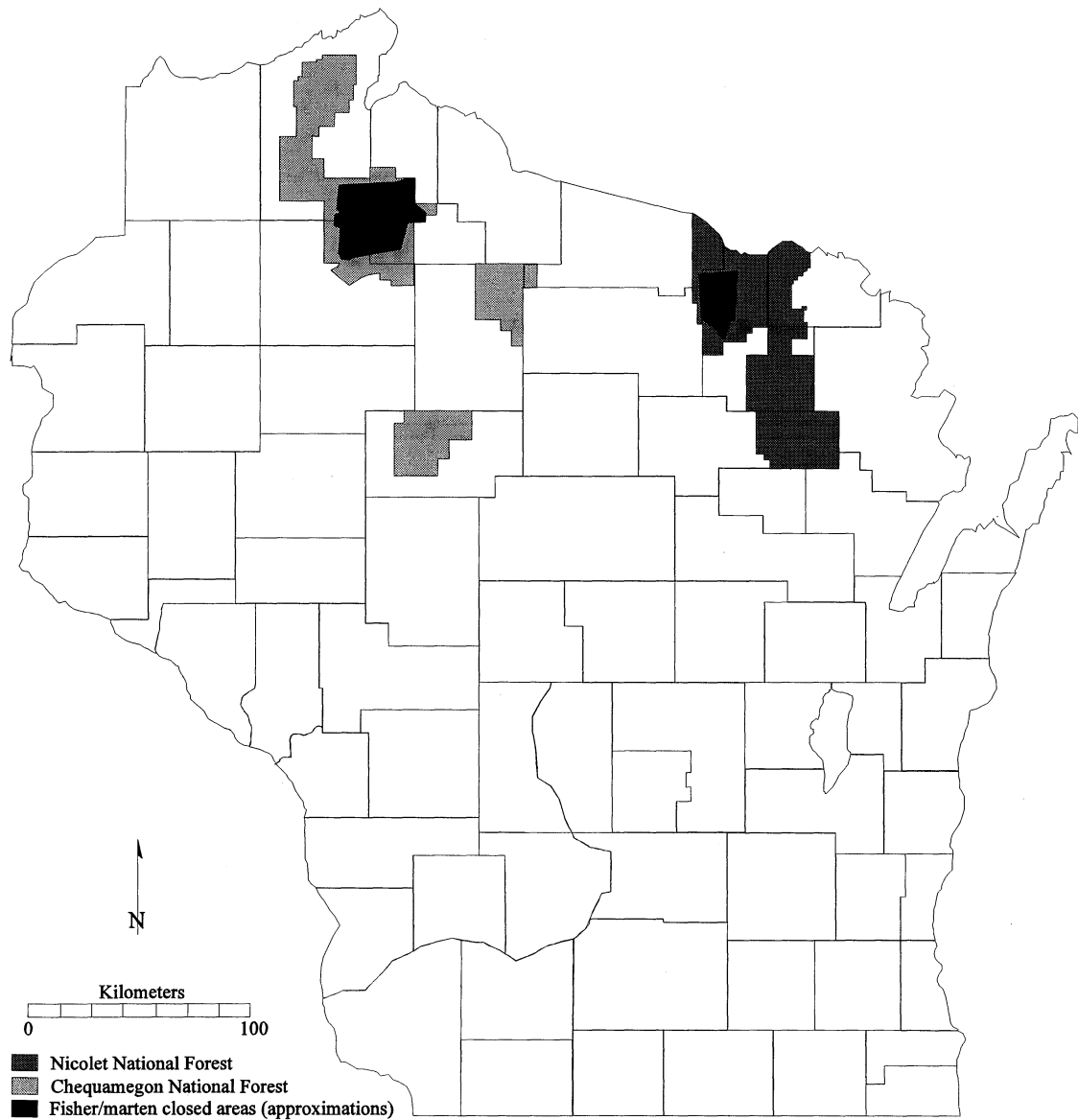


Fig. 1. Fisher/marten closed areas within the Nicolet and Chequamegon National Forests, Wisconsin.

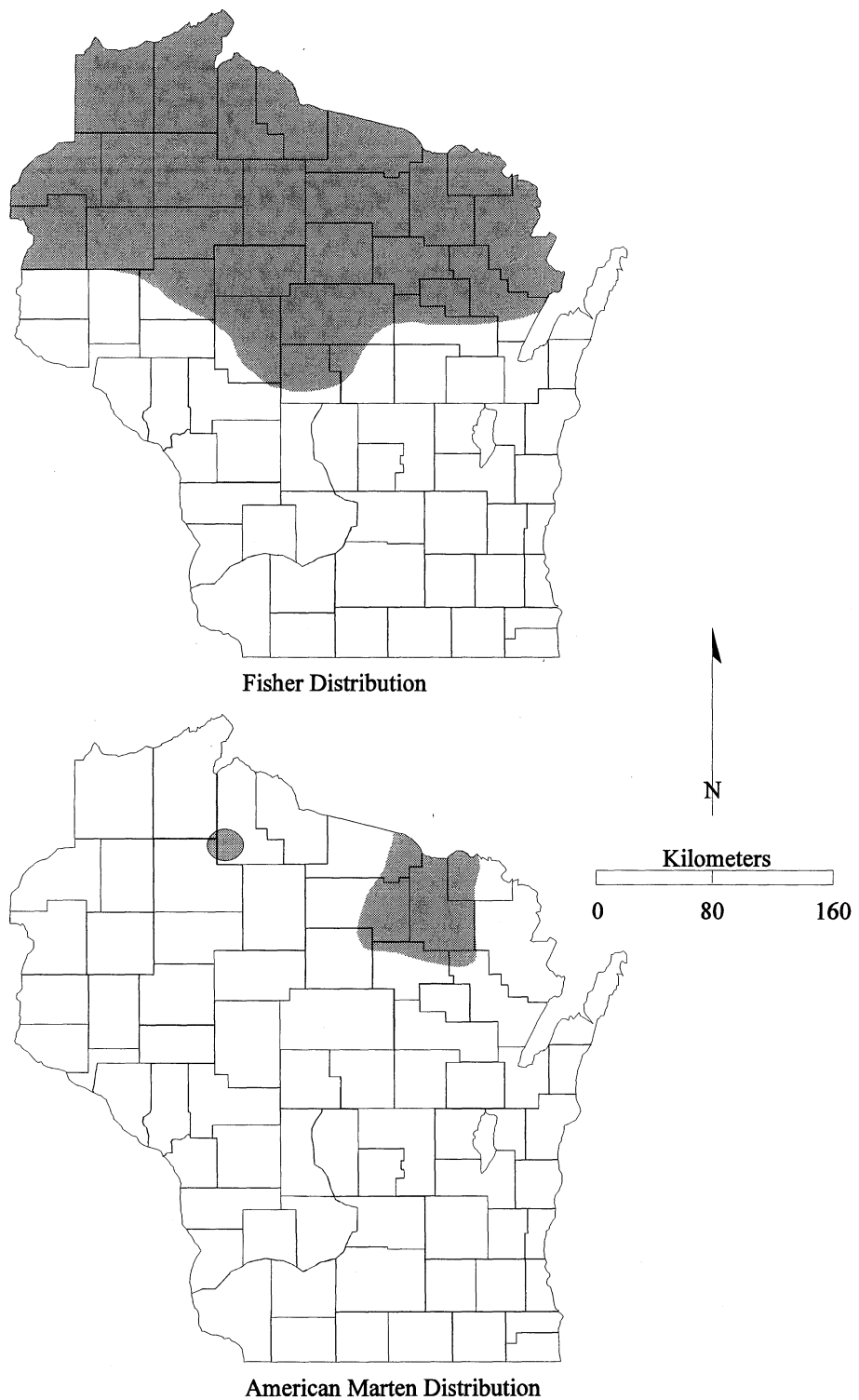


Fig. 2. Wisconsin distribution of fishers (Kohn et al. 1989, Coleman et al. 1995) and American martens (Kohn and Eckstein 1987, Gilbert unpub. data).

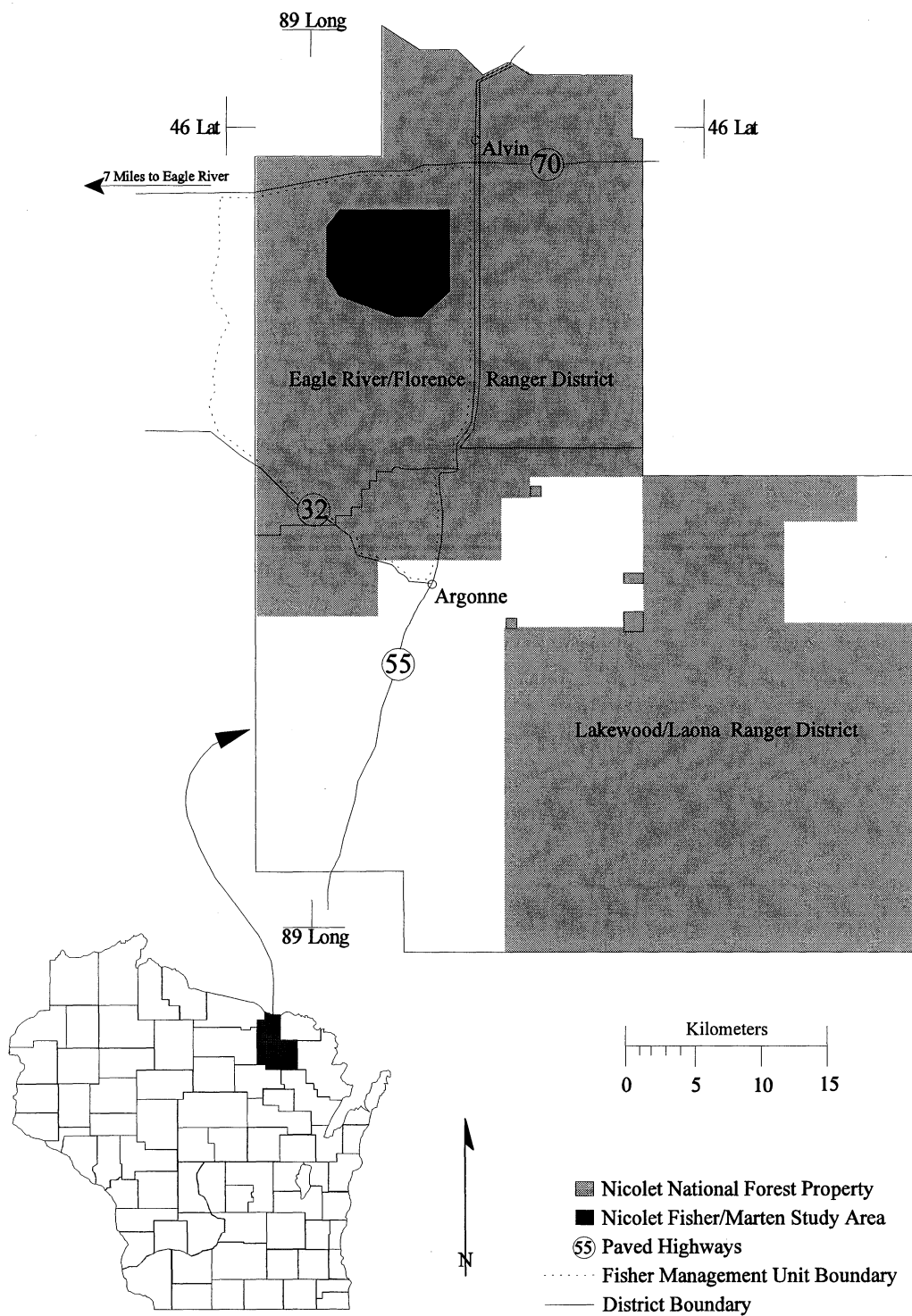


Fig. 3. Nicolet fisher/marten study area, Nicolet National Forest, Forest County, Wisconsin

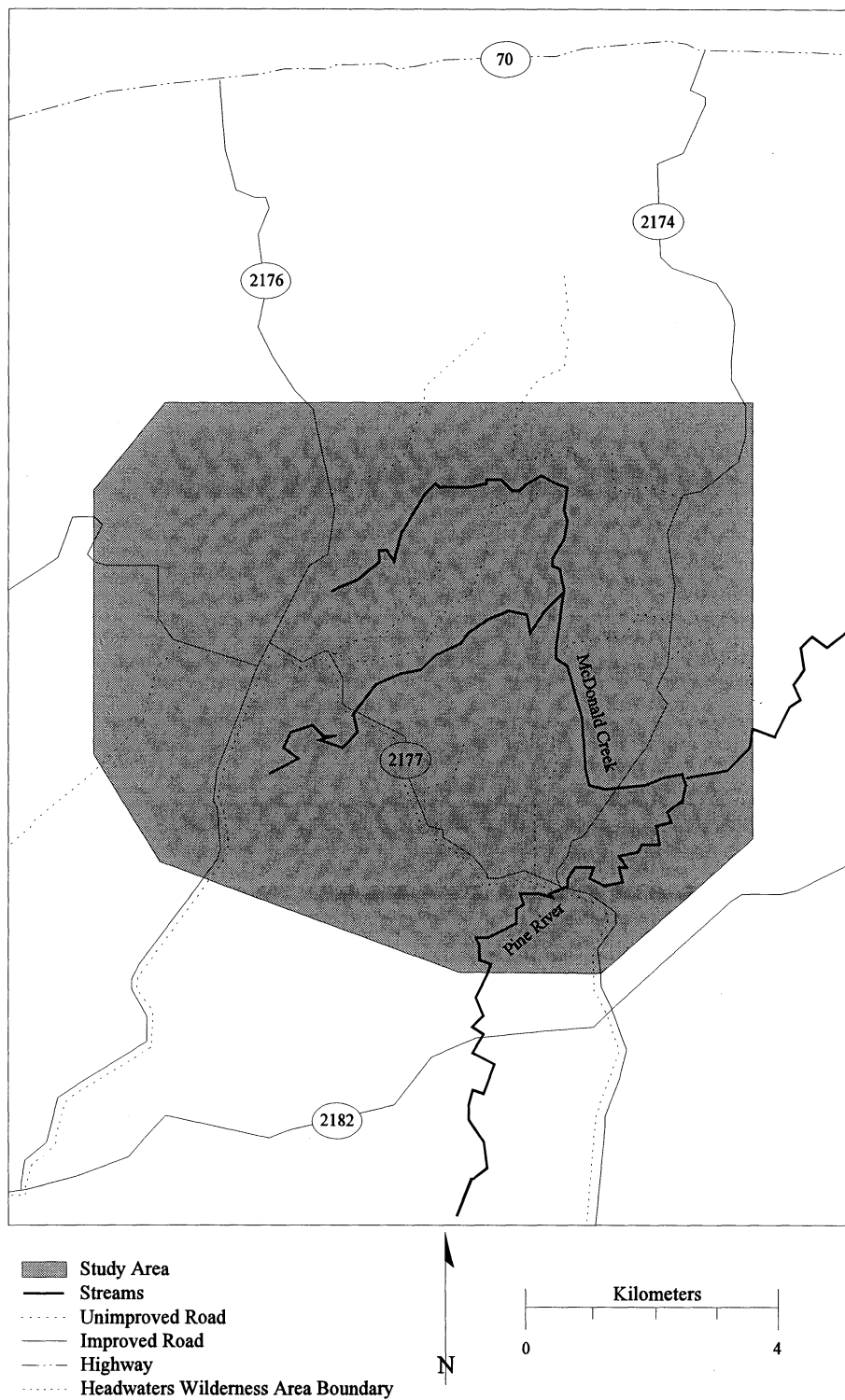


Fig. 4. Roads and streams of the Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

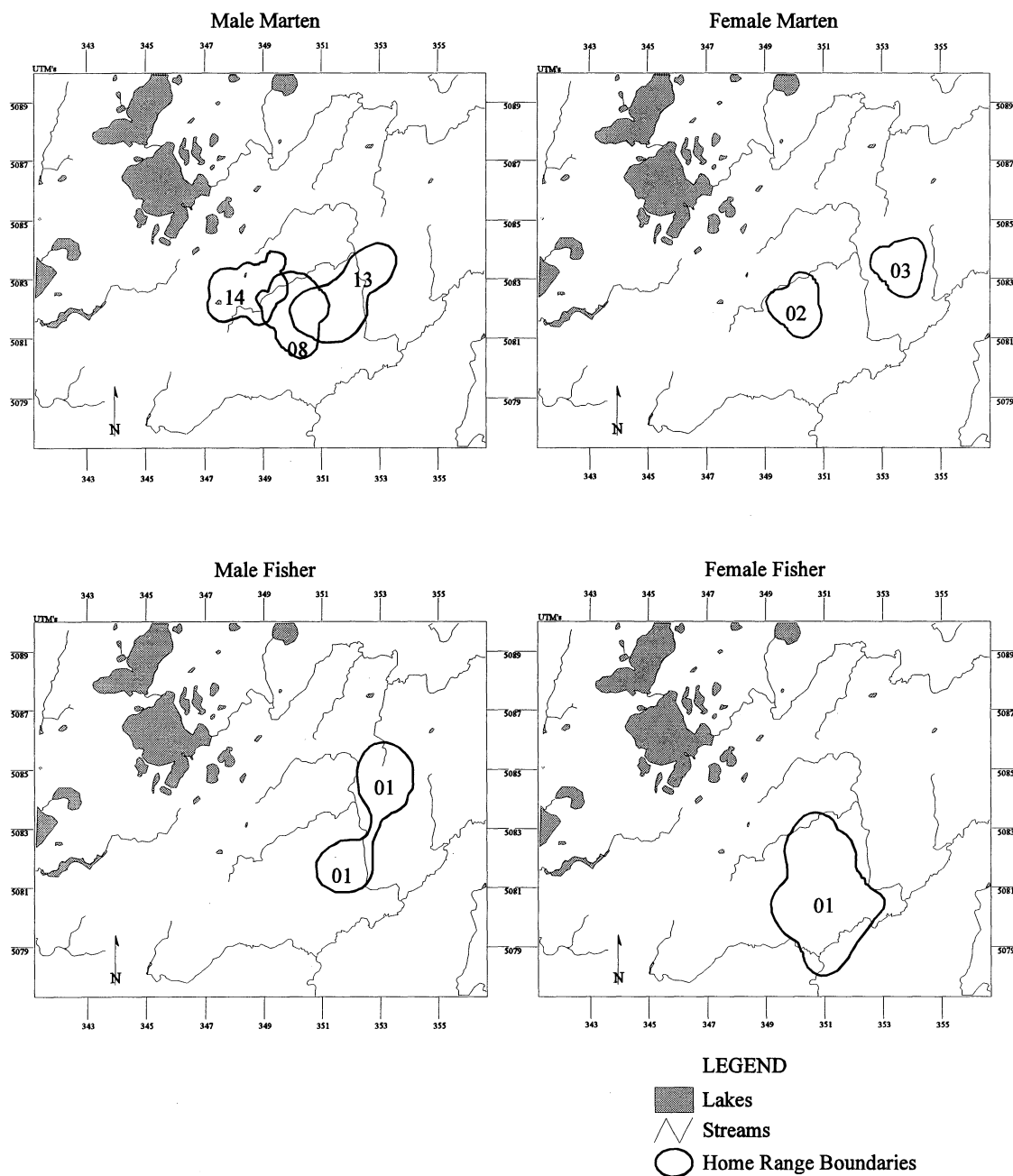


Fig. 5. Fisher and American marten home ranges, winter 1990-1991, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin

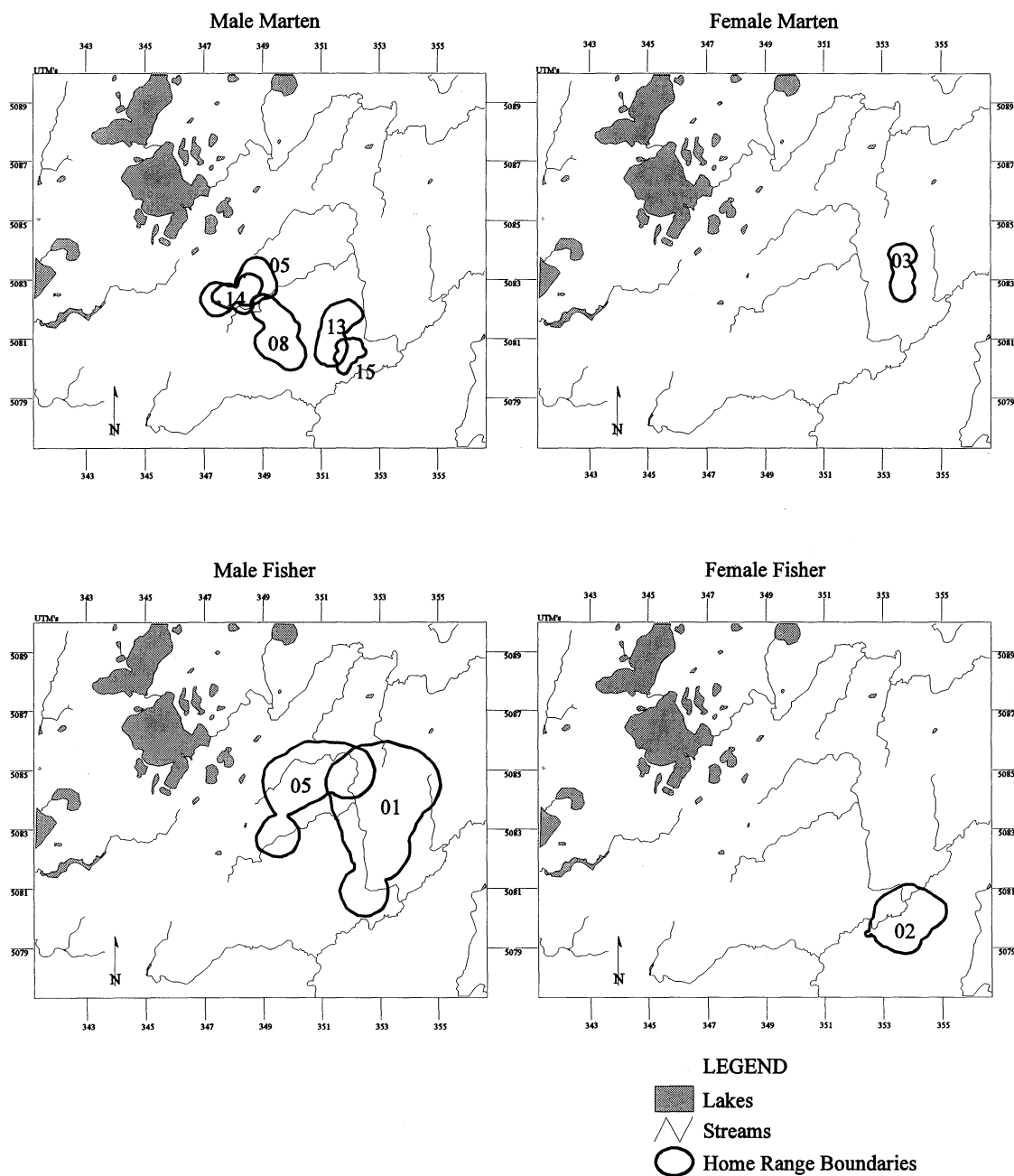


Fig. 6. Fisher and American marten home ranges, winter 1991-1992, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

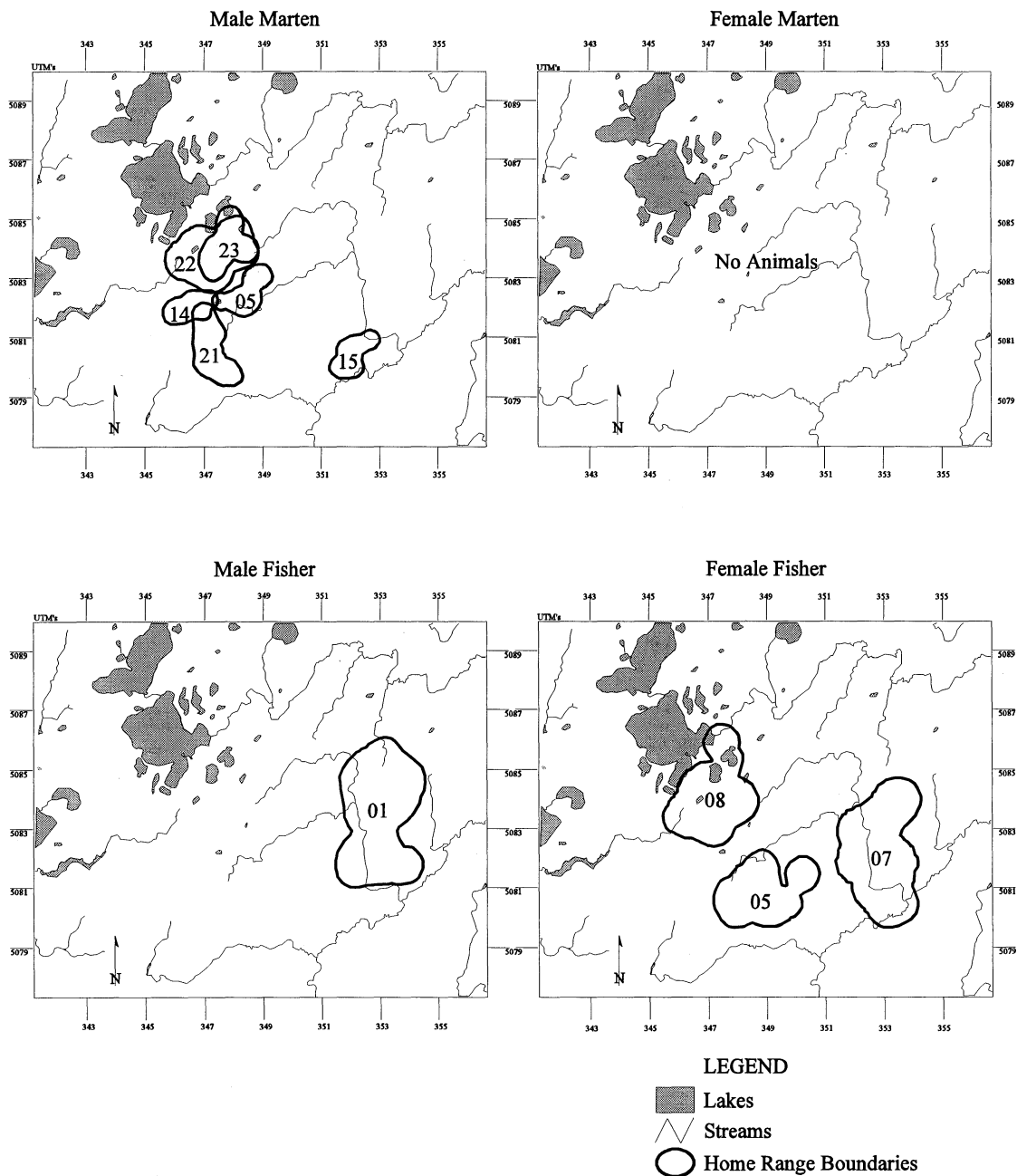


Fig. 7. Fisher and American marten home ranges, winter 1992-1993, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

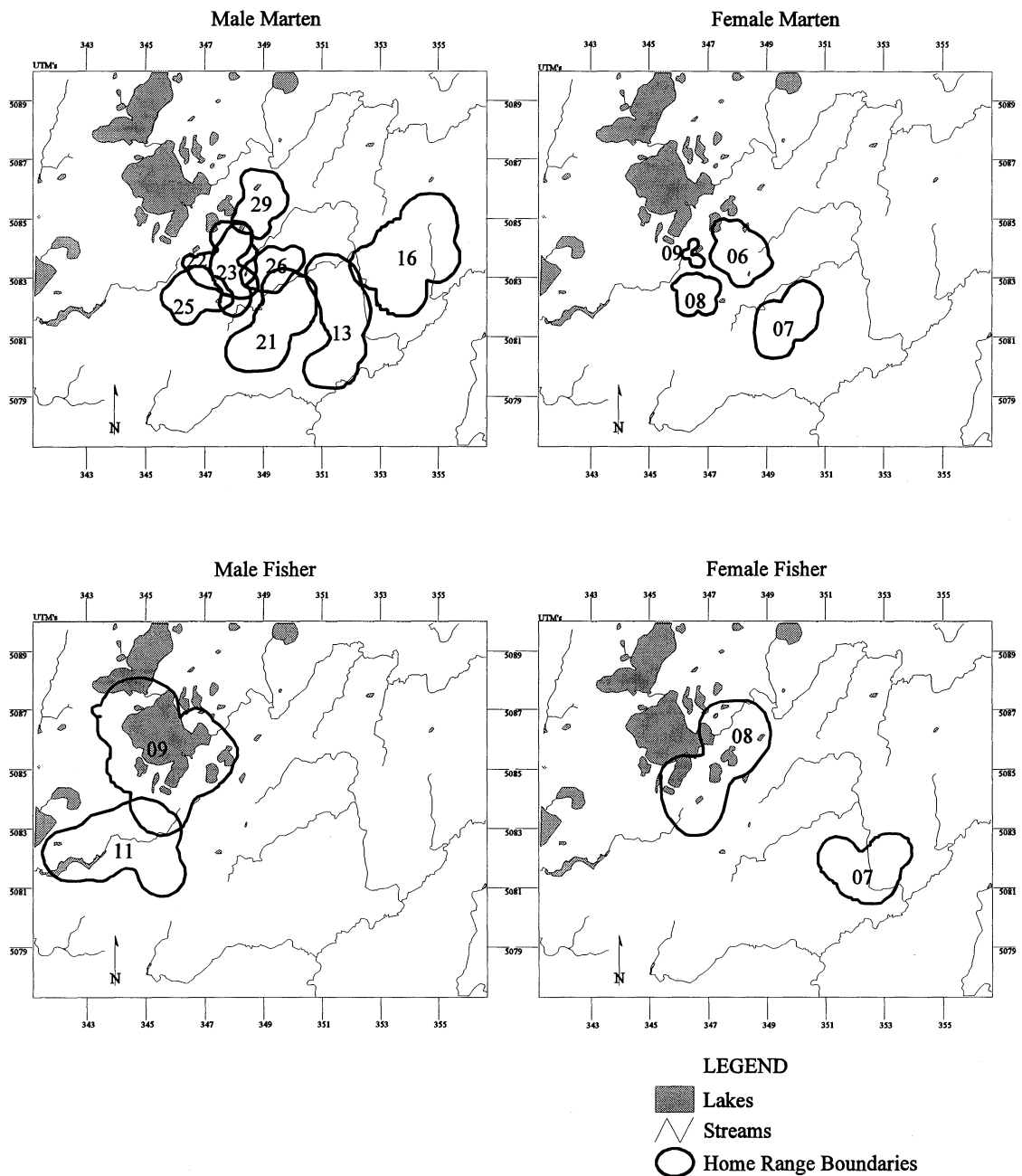


Fig. 8. Fisher and American marten home ranges, winter 1993-1994, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

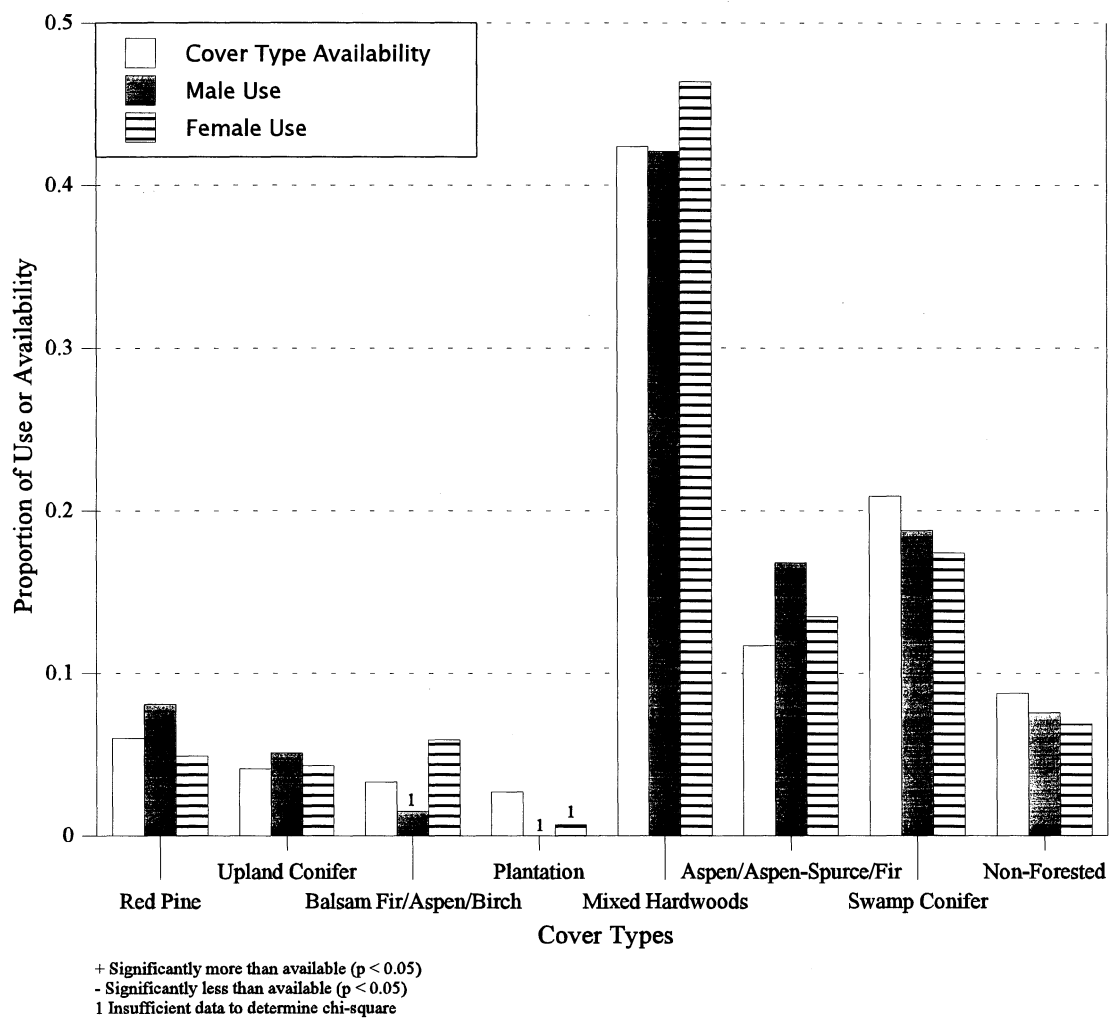


Fig. 9. Fisher cover type use and availability, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

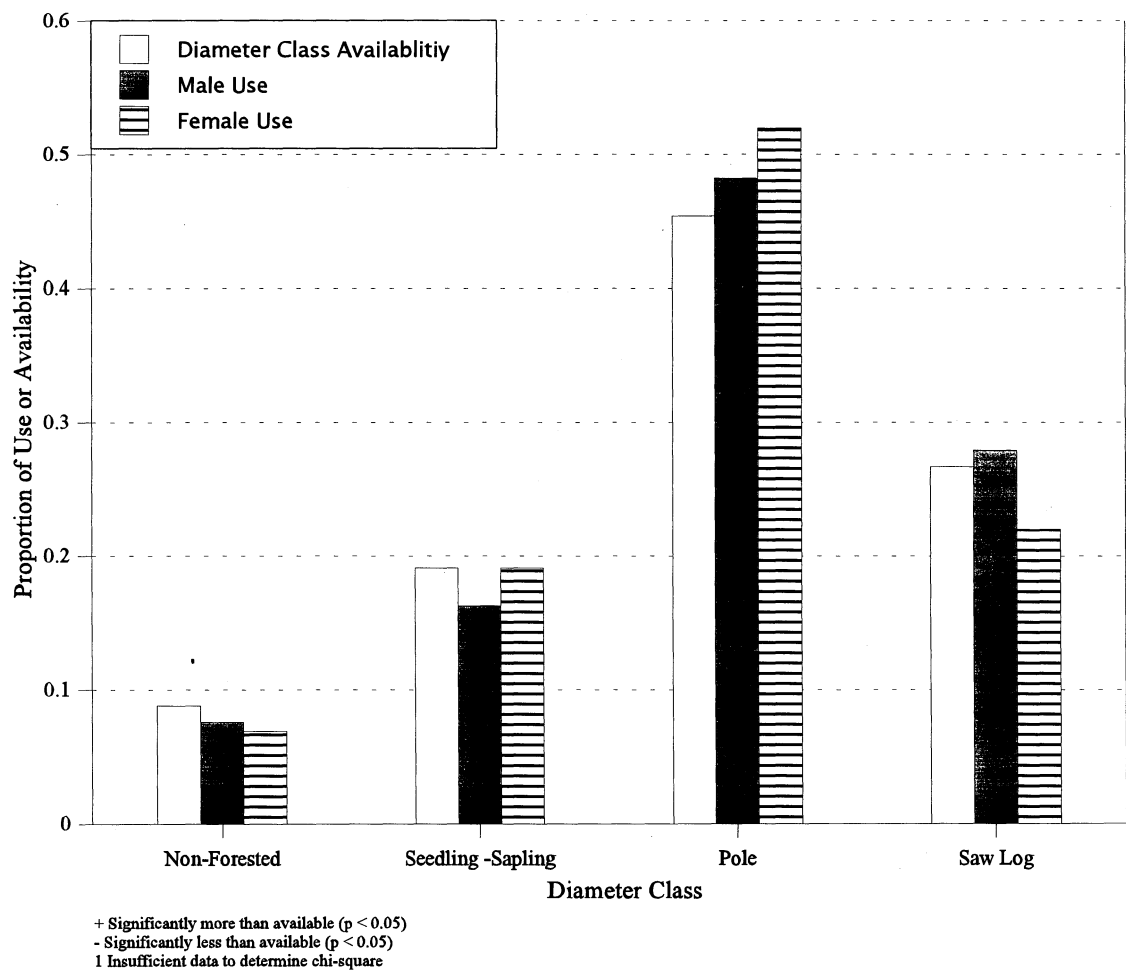


Fig. 10. Fisher stand diameter class use and availability, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

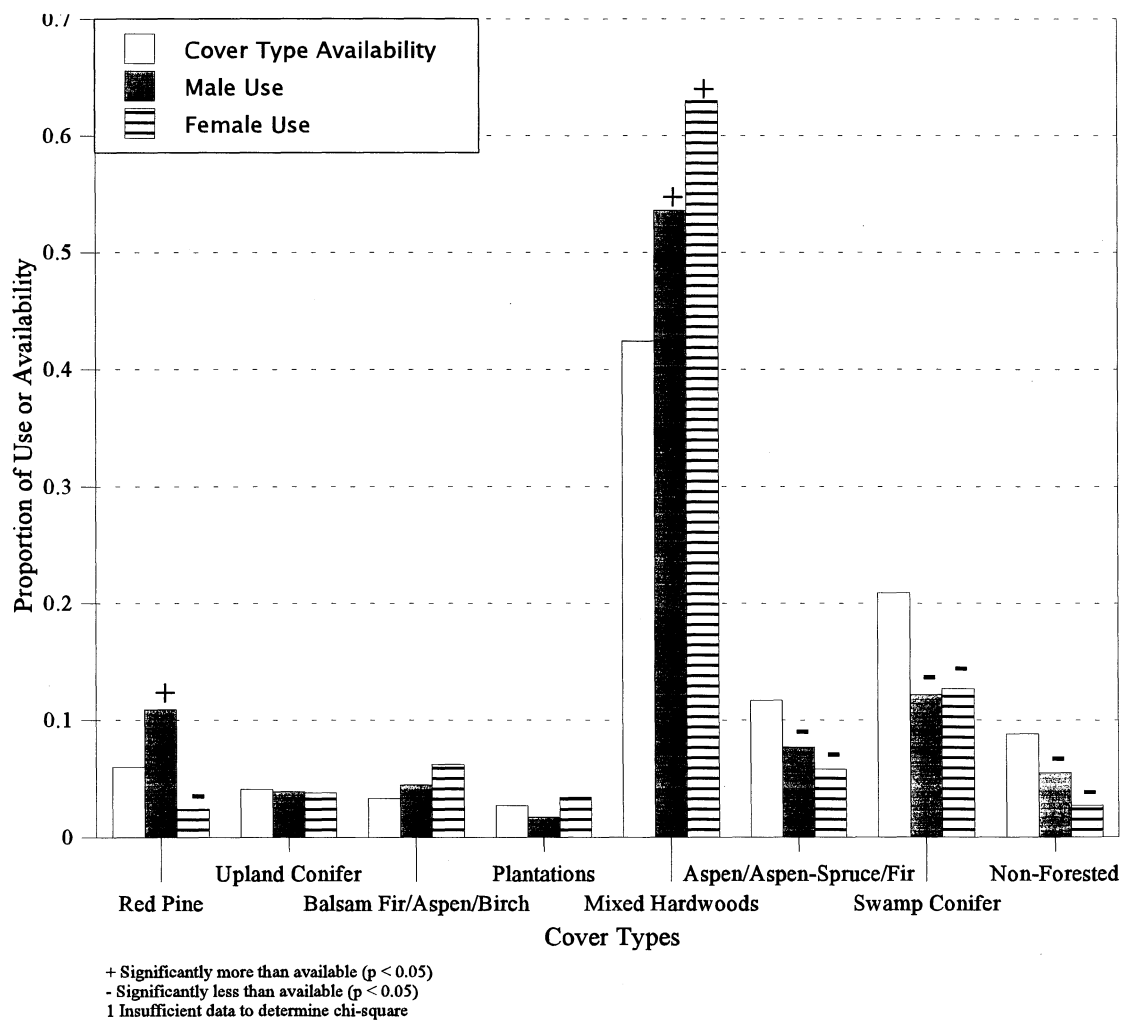


Fig. 11. Marten cover type use and availability, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

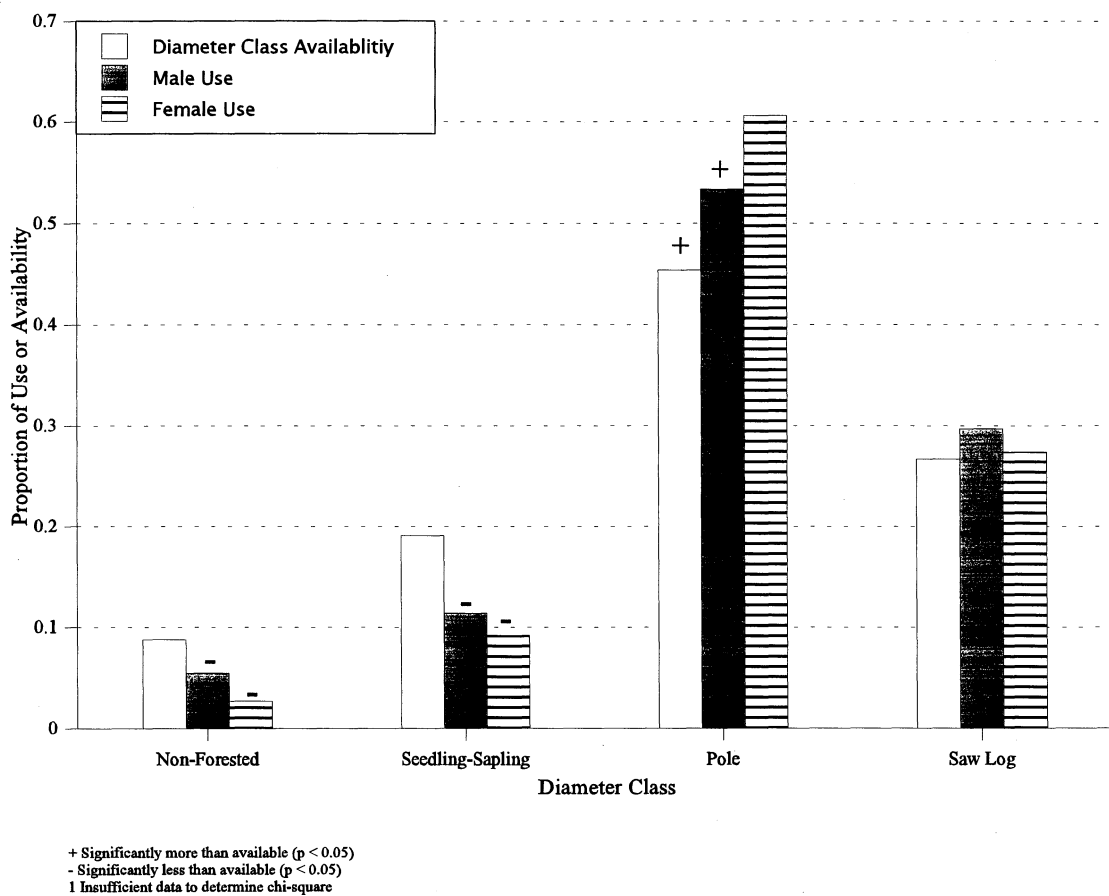


Fig. 12. Marten stand diameter class use and availability, Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Appendix A. Monitoring status for fishers and martens on the Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

CODE	DATE 1ST CAPTURE	LAST KNOWN DATE	DIFFERENCE IN DAYS	STATUS
FM01	05/17/90	05/19/93	1098	Lost Signal-status unknown
FM02	03/19/91	06/01/92	440	Uncollared-neck injuries
FM03	03/19/91	08/26/91	160	Slipped Collar-status unknown
FM05	10/04/91	03/15/93	528	Mortality-predation
FM06	10/09/91	10/20/91	11	Mortality-trap related
FM08	05/29/92	11/09/92	164	Uncollared-neck injuries
FM09	11/16/93	09/23/94	311	Slipped Collar-status unknown
FM10	12/19/93	11/15/94	331	Mortality-harvested
FM11	12/20/93	07/20/94	212	Mortality-unknown cause
		Mean	362	
		SD	317	
FF01	05/17/90	10/09/91	510	Uncollared-neck injuries
FF02	03/20/91	12/28/92	649	Mortality-predation
FF05	11/03/92	05/29/93	207	Mortality-unknown cause
FF06	11/04/92	12/30/92	56	Slipped Collar-status unknown
FF07	11/05/92	06/24/94	596	Lost Signal-status unknown
FF08	02/09/93	01/06/95	696	Active-on last contact
FF10	11/15/93	12/08/93	23	Slipped Collar-status unknown
FF11 ^a	11/18/93	09/23/94	309	Active-on last contact
FF12	12/21/93	07/22/94	213	Slipped Collar-status unknown
		Mean	362	
		SD	257	
MM02	05/11/90	12/31/90	234	Mortality-predation
MM03	05/16/90	02/08/91	268	Uncollared-left study area
MM05	10/15/90	02/16/93	855	Lost Signal-status unknown
MM08	05/10/90	11/04/92	909	Lost Signal-status unknown
MM13	11/15/90	04/15/94	1247	Lost Signal-status unknown
MM14	11/15/90	08/30/93	1019	Lost Signal-status unknown
MM15	02/06/91	08/03/93	909	Slipped Collar-status unknown
MM16	02/06/91	01/06/95	1430	Uncollared-at end of study
MM18	03/20/91	12/31/92	652	Mortality-unknown cause
MM21	11/05/92	01/01/95	787	Uncollared-at end of study
MM22	02/02/93	08/12/94	556	Mortality-unknown cause
MM23	02/02/93	06/02/94	485	Lost Signal-status unknown
MM24	03/02/93	05/10/93	69	Lost Signal-status unknown
MM25	05/08/93	12/30/94	601	Uncollared-at end of study
MM26	11/03/93	09/23/94	324	Active-on last contact
MM28 ^b	11/05/93	11/12/93	7	Mortality-trap related
MM29	11/05/93	12/31/94	421	Uncollared-at end of study
		Mean	634	
		SD	400	
MF01	10/05/90	11/15/90	41	Mortality-collar related
MF02	11/15/90	06/04/91	201	Mortality-unknown cause
MF03	02/06/91	11/24/93	1022	Mortality-unknown cause
MF06	11/04/93	03/13/94	129	Mortality-suffocation
MF07	11/06/93	09/23/94	321	Active-on last contact
MF08	11/11/93	12/30/94	414	Uncollared-at end of study
MF09	12/23/93	12/31/94	373	Uncollared-at end of study
		Mean	357	
		SD	322	

^a FF11's skeleton was found on 06/95 by USFS personnel.

^b MM28 was originally captured by B.Kohn, WDNR, in 08/84 making 3390 days (9.3yrs) of known animal activity.

Appendix B. Fisher capture data for Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Animal ^a	Date ^b	Age ^c	wt (kg)	Body Length (cm)	Total Length (cm)	Neck ^d Circum. (cm)	Front Foot (cm) ^e		Hind Foot (cm) ^e		Tattoo ^f
							Length	Width	Length	Width	
FM01	05/17/90	Juv	3.9	54.6	96.5	22.2	3.8	4.1	4.1	4.5	R1(black)
FM02	03/19/91	Ad	7.2	62.2	101.6	27.6	3.5	4.5	4.6	4.4	R2(red)
FM03	03/19/91	Juv	3.9	56.5	97.2	22.9	----	----	----	----	R1
FM04	09/24/91	Juv	3.8	60.3	95.3	17.8	3.1	3.7	5.0	4.0	L4(red)
FM05	10/04/91	Ad	4.5	60.4	98.0	22.4	3.8	4.2	4.4	4.1	L2(black)
FM06	10/09/91	Juv	4.0	58.6	95.8	21.2	3.3	4.2	4.0	4.2	L3(black)
FM08	05/29/92	Ad	4.5	61.0	97.0	19.7	3.7	4.3	4.2	4.7	-----
FM09	11/16/93	Ad	5.2	51.6	89.2	23.0	4.1	4.3	3.5	4.2	R9(green)
FM10	12/19/93	Juv	4.4	58.9	94.2	20.6	3.6	4.3	4.2	4.4	L2(green)
FM11	12/20/93	Ad	5.1	60.7	95.2	24.8	3.4	4.5	4.4	3.2	R2(green)
FF01	05/17/90	Ad	2.5	53.3	85.1	18.4	3.2	3.5	3.5	2.7	R2(black)
FF02	03/20/91	Ad	2.3	53.3	83.8	17.8	----	----	----	----	R3(red)
FF03	10/18/91	Juv	2.4	51.7	85.7	16.7	2.9	3.8	3.4	4.2	R3(red)
FF04	10/30/91	Juv	2.4	52.6	87.0	17.5	3.3	4.0	3.6	4.0	R7(red)
FF05	11/03/92	Ad	2.5	50.2	94.0	17.5	----	4.4	----	4.1	L2(black)
FF06	11/04/92	Juv	2.1	50.0	87.0	17.0	----	3.5	----	3.8	L3(black)
FF07	11/05/92	Ad	2.4	51.7	86.0	19.0	----	----	----	----	L10(black)
FF08	02/09/93	Ad	2.3	55.2	85.1	16.2	----	----	----	----	L7(black)
FF09	11/13/93	Ad	2.7	50.8	83.9	21.4	2.9	3.4	3.6	3.5	R9(green)
FF10	11/15/93	Juv	2.6	52.2	84.8	17.4	2.8	3.3	3.1	3.3	L9(green)
FF11	11/18/93	Ad	2.7	51.5	83.4	17.8	2.8	3.1	2.8	3.2	R2(green)
FF12	12/21/93	Juv	2.3	46.0	82.5	18.2	2.5	3.6	3.4	4.3	L2(green)

^a Animal species code (F=fisher, M=marten), sex (F=female, M=male), number

^b Date of original capture. Animal may have been captured multiple times at later dates.

^c Age estimate based on initial capture using body weight, tooth wear, sagittal crest development, baculum development and overall appearance.

^d Neck Circumference will vary slightly with pelage condition.

^e Distances measured from edges of foot pad.

^f Tattoo code Ear, Number, (Color).

Appendix C. American marten capture data for Nicolet fisher/marten study area,
Nicolet National Forest, Wisconsin.

Animal ^a	Date ^b	Age ^c	Weight (kg)	Body Length (cm)	Total Length (cm)	Neck ^d Circum. (cm)	Front Foot (cm) ^e		Hind Foot (cm) ^e		Tattoo ^f
							Length	Width	Length	Width	
MM02	05/11/90	Ad	0.90	41.3	56.5	13.3	3.8	3.5	3.2	3.5	R2(black)
MM03	05/16/90	Juv	1.04	38.9	56.7	13.3	----	----	----	----	R3(black)
MM04	05/18/90	Juv	0.90	47.1	70.0	12.4	3.0	2.2	2.9	1.9	R4
MM05	10/15/90	Ad	0.95	36.2	55.9	12.7	2.5	2.5	2.3	2.2	R1(black)
MM06	10/15/90	Juv	----	46.9	64.1	11.8	2.5	2.5	2.7	2.8	L10
MM07	10/15/90	Juv	----	41.3	61.9	12.7	2.5	2.5	2.9	2.2	L9
MM08	05/10/90	Ad	0.90	43.9	61.0	13.3	2.5	3.2	3.8	3.2	R1(black)
MM09	10/19/90	Juv	----	41.9	63.5	12.7	2.7	2.4	2.7	2.8	R2
MM10	10/11/90	Juv	----	41.3	59.7	13.3	1.0	1.9	1.9	2.2	L7
MM11	10/11/90	Juv	----	42.6	59.4	13.7	1.5	1.9	1.9	2.5	L6
MM12	11/16/90	Ad	1.04	42.3	59.4	15.2	2.5	3.5	3.8	3.8	R7
MM13	11/15/90	Ad	0.86	41.3	59.7	14.0	3.5	2.5	3.8	3.5	L5(red)
MM14	11/15/90	Ad	0.72	40.0	55.3	12.0	2.5	2.4	2.9	2.5	R3(red)
MM15	02/06/91	Juv	0.72	37.4	53.5	11.3	2.7	3.1	2.6	3.1	R9(black)
MM16	02/06/91	Ad	0.86	40.0	55.9	11.5	2.5	2.7	2.7	2.6	L1(black)
MM17	03/19/91	Ad	1.08	43.2	61.0	14.3	----	----	----	----	R1(red)
MM18	03/20/91	Juv	0.72	40.1	55.3	----	2.0	2.6	2.3	2.6	R2(red)
MM19	11/13/91	Ad	1.05	39.9	58.4	13.2	2.9	3.2	2.9	3.4	R3(red)
MM20	06/12/92	Ad	----	----	----	----	2.7	2.9	2.8	2.9	-----
MM21	11/05/92	Ad	1.00	42.5	18.0	13.0	2.7	2.9	2.8	2.9	R0(black)
MM22	02/02/93	Ad	0.85	40.7	17.6	14.6	2.7	2.8	2.8	3.0	L4(black)
MM23	02/02/93	Ad	0.63	36.2	17.2	10.6	2.7	2.8	2.5	2.6	R1(green)
MM24	03/02/93	Ad	0.93	42.2	59.8	11.9	2.5	2.7	2.7	2.8	L7(black)
MM25	05/08/93	Ad	0.87	39.5	54.0	12.5	2.5	2.7	2.8	2.7	L5(black)
MM26	11/03/93	Ad	0.84	42.2	59.5	11.6	2.6	2.8	3.0	3.2	L1(green)
MM27	11/04/93	Juv	0.74	41.4	58.9	11.4	2.5	2.9	2.6	2.8	L0(green)
MM28	11/05/93	Ad	0.67	39.6	55.2	11.7	2.6	2.7	2.9	2.8	R0(green)
MM29	11/05/93	Ad	0.85	42.1	59.7	12.9	2.5	2.6	3.0	2.8	R9(green)
MM30	11/13/93	Ad	0.82	42.6	58.3	10.9	2.4	2.7	2.6	2.8	L9(green)
MF01	10/05/90	Juv	----	38.1	53.3	12.0	1.3	2.1	1.6	2.4	L5(black)
MF02	11/15/90	Juv	0.50	40.7	54.0	----	2.2	3.5	3.0	3.5	R4
MF03	02/06/91	Juv	0.63	36.7	52.3	10.2	2.5	3.1	2.9	3.2	R0(black)
MF04	03/21/91	Juv	0.77	37.5	52.1	11.4	----	----	----	----	L4
MF05	10/28/92	Juv	0.60	36.5	50.0	12.0	----	----	----	----	R9(black)
MF06	11/04/93	Juv	0.47	35.8	52.5	9.3	2.3	2.4	2.4	2.6	R0(green)
MF07	11/06/93	Ad	0.55	37.1	51.3	10.4	2.3	2.4	2.5	2.6	L9(green)
MF08	11/11/93	Ad	0.50	37.8	50.6	10.6	1.9	2.8	2.1	2.7	L9(green)
MF09	12/23/93	Ad	0.39	38.0	51.5	10.2	2.6	2.8	2.2	3.0	L9(green)
MF10	12/31/94	Ad	----	----	----	----	----	----	----	----	----

^a Animal species code (F=fisher, M=marten), sex (F=female, M=male), number

^b Date of original capture. Animal may have been captured multiple times at later dates.

^c Age estimate based on initial capture using body weight, tooth wear, sagittal crest development, baculum development and overall appearance.

^d Neck Circumference will vary slightly with pelage condition.

^e Distances measured from edges of foot pad.

^f Tattoo code Ear, Number, (Color).

Appendix D. Animal locations and sampling durations for Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Animal ^a	Winter ^b Locations	Non-Winter ^c Locations	Sampling ^d Duration	Animal ^a	Winter ^b Locations	Non-Winter ^c Locations	Sampling ^d Duration
FM01	120	73	1098	MM02	3	28	234
FM02	8	5	440	MM03	1	1	268
FM03	2	43	160	MM05	40	28	855
FM05	47	26	528	MM08	69	63	909
FM08	1	18	164	MM13	127	47	1247
FM09	54	19	311	MM14	141	71	1019
FM10	15	0	331	MM15	44	31	909
FM11	37	11	212	MM16	59	22	1430
totals	284	195	3,244	MM18	3	20	652
				MM21	115	27	787
FF01	46	71	510	MM22	128	55	556
FF02	3	97	649	MM23	121	50	485
FF05	68	17	207	MM24	16	14	69
FF06	5	0	56	MM25	71	44	601
FF07	109	43	596	MM26	71	21	324
FF08	101	67	696	MM29	61	5	421
FF10	7	0	23	totals	1,070	527	10,766
FF11	37	33	309				
FF12	9	12	336	MF01	3	1	41
totals	385	340	3,382	MF02	42	3	201
				MF03	54	54	1022
				MF06	59	0	129
				MF07	59	22	321
				MF08	63	28	414
				MF09	43	28	373
				totals	232	136	2,501

^a Animal species code (F=fisher, M=marten), sex (F=female, M=male), number

^b November-March

^c April-October

^d Calendar days

Appendix E. Reproductive evidence of fishers and martens for Nicolet fisher/marten study area, Nicolet National Forest, Wisconsin.

Season	Description
Spring 1990	Fisher 01 lactating when captured in May. No evidence of kits after capture.
Spring 1991	Fisher 01 no evidence of reproduction. Fisher 02 no evidence of reproduction. Marten 02 no evidence of reproduction. Marten 03 no evidence of reproduction.
Spring 1992	Fisher 02 no evidence of reproduction. Marten 03 no evidence of reproduction.
Fall 1992	Fisher 05 no evidence of nursing, mammae well haired at capture 11/03/92. Fisher 07 no evidence of nursing, mammae well haired at capture 11/05/92.
Spring 1993	Fisher 05 no evidence of reproduction. Fisher 07 visual on adult in maternal den tree, kit(s) heard but no visual. Fisher 08 suspected of having a maternal den but no evidence of kits.
Fall 1993	Fisher 08 no evidence of nursing, mammae well haired at capture 11/12/93. Fisher 09 no evidence of nursing, mammae well haired at capture 11/13/93. Fisher 11 mammae well developed and naked at capture 11/18/93, suspected of nursing that summer. Juvenile female fisher caught in same trap 2 days prior to this capture.
Spring 1994	Fisher 08 had 1 kit on 04/07/94. Visual on kit naked and blind, sex unknown. Fisher 11 suspected of having maternal den because of repeated use of an area. Abandoned that use pattern, no evidence of reproduction was found. Marten 07 suspected of having maternal den because of repeated use of an area. Abandoned that use pattern, no evidence of reproduction was found. Marten 08 no evidence of reproduction. Marten 09 no evidence of reproduction.

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1999