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Ecology of reintroduced fishers in the Cabinet Mountains of northwest Montana

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ECOLOGY OF REINTRODUCED FISHERS IN THE CABINET MOUNTAINS OF NORTHWEST MONTANA

By

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As part of a reintroduction program, 32 fishers (Martes pennanti) were imported from Minnesota and released in the Cabinet Mountains of Northwest Montana in 1988-90. All fishers were radio tagged and soft released; 12 were released on 1 January 1989, 15 released 1 January 1990, and 5 released 9 March 1990. Fishers were monitored until June of each year and were radio relocated a total of 531 times. Fishers ate mostly snowshoe hares (Lepus americana) and deer (Odocoileus sp.) carrion. Fishers were active at all times of the day and night, and no clearly defined activity patterns were noted. At least 9 of the 32 fishers were killed by predators, 3 were killed by trappers, and 2 died from unknown causes. Twelve of the 14 dead fishers were healthy prior to death. Males had a higher mortality rate than females. At least 2 fishers gave birth in the study area and 1 became pregnant, but all 3 died before the kits weaned. No fisher developed a true home range during the monitoring period. Distances between standard locations (3-5 day intervals) were short in January and February, but increased in the breeding season of March and April. Habitat selection included mostly young, dense mixed conifer stands.

The habitat and prey base in the Cabinet Mountains seems sufficient to allow fisher survival; however, high mortality and emigration rates, and no documented reproduction, present major problems to fisher recovery. Instead of immediately dispersing from the study area, the fishers waited until the breeding season in March and April to begin long distance movements. Fisher reintroductions in areas of apparently suitable habitat but with new and diverse predator complexes may have a low potential for success. Management recommendations include: obtain fishers from a nearby geographic location, an earlier release date, the release of females with kits in April, continuation of soft release procedures, release of approximately equal sex ratios, the development of a core population, and appropriate protection.

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TABLE OF CONTENTS

APPENDICES Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

As the natural environment becomes more and more fragmented, the preservation and re-establishment of species on areas of historic occurrence and suitable habitat becomes increasingly important. With appropriate protection, species may naturally repopulate suitable habitat. In areas where natural recolonization is unlikely, managed reintroductions may be necessary to reestablish viable populations.

Fishers represent an interesting situation in managed recoveries. With protection and reintroductions, fishers successfully re-colonized forested regions of northeast and central North America (Coulter 1966, Powell 1982). Similar management occurred in western North America, but fisher populations have failed to recover to pre-European settlement levels.

Although many fisher reintroductions were performed throughout historical fisher range (Berg 1982), evaluation relied on incidental observations. Little is known about appropriate timing of release, post-release movements, mortality, and home range requirements of translocated fishers. Detailed studies concerning these aspects of post release behavior should aid in the development of improved release procedures, and may illuminate the underlying motivations of dispersal and movement patterns.

Fishers are good subjects for the study of post-reintroduction behavior for the following reasons: (1) large areas of unoccupied but suitable habitat remain, (2) fishers can dramatically increase population numbers in the absence of trapping (Hamilton 1957, Coulter 1960, Balser and Longly 1966, Yocum and McCollum 1973), (3) some previous reintroductions established secure populations while others did not (Berg 1982), and (4) no detailed studies have focused on movement and dispersal patterns of reintroduced fishers.

Description

Fishers are the largest members of the genus *Martes* (Mustelidae), and possess long, slim, streamlined bodies. The pelage is fine, soft, and dark brown or grizzled, and female fur is usually finer and softer than males. Although the largest recorded wild specimen weighed 9.13 kg (Blanchard 1964), males average 4-5 kg and females 2-2.5 kg (Powell 1982). The average length is 90-120 cm for males and 75-95 cm for females, and the long bushy tail constitutes about one-third of the total body length (Powell 1982). The sexual dimorphism in size may help to satisfy female energy demands for lactation (Powell and Leonard 1983), or decrease intersexual competition for food (Brown and Lasiewski 1972). However, fishers in New Hampshire showed no significant difference in prey selection between sexes, which suggests that food partitioning may not be a major contributing factor for sexual dimorphism (Guiliano et al. 1989).

History and Current Distribution

Over-trapping and habitat destruction decimated fisher populations from around 1800-1930, causing extirpation from vast areas of former range (Hagmeier 1956). Historic range included all of forested Canada and New England, the Appalachian Mountains, the Great Lake States and Provinces, the mid to northern Rockies, and western Oregon, Washington, and California (Parmalee 1958). By 1920, fisher range included only remote areas of Canada, with small remnant populations remaining in Maine (Coulter 1960), Minnesota (Balser and Longly 1966), and probably Oregon (Yocum and McCollum 1973). Fishers are vulnerable to over-trapping; even small increases in fisher mortality above natural levels may cause local fisher extinction (Powell 1979b). This vulnerability, in conjunction with habitat fragmentation and large predator poisoning campaigns, may have catalyzed fisher declines (Douglas and Strickland 1987).

De Vos (1951b) stressed the importance of protected refugia populations from which dispersing fishers could radiate into the surrounding trapped areas, and suggested the incorporation of protected areas into fisher management plans. After the development of trapping regulations in the 1940's, fishers recovered in many areas. It is likely that refugia populations acted as reservoirs from which fishers dispersed after the establishment of protective legislation (Coulter 1966).

In addition to natural recolonization, several fisher reintroductions have been attempted (Appendix A). The most successful transplants incorporated feasibility studies, the use of box traps rather than cage traps, short handling and transportation periods, sex ratios slightly favoring females, the release of >30 individuals, and an acclimatization period prior to release (Berg 1982).

Under appropriate circumstances, reintroductions can create viable fisher populations. Davis (1978, 1983) and Slough (1989) evaluated the success of pine marten (*Martes americana*) reintroductions with radio telemetry, but no radio-telemetry or extensive snow tracking studies focused on reintroduced fishers. As a result of reintroductions and natural recolonization, fishers have recovered throughout New England and the Lake States and Provinces. However, fisher populations in Oregon, Washington, and California have failed to recover, and local environmental groups petitioned to list the fisher under the Endangered Species Act in 1990. Contemporary fisher harvests in British

Columbia are the lowest since 1919 and 3 separate fisher reintroductions are planned (Banci 1990). The fate of the reintroduced fishers may help explain why western fisher recovery has not been successful.

Prior to the 1959-1960 Montana fisher reintroduction, the last fisher sighting in Montana occurred in the 1920's (Weckwerth and Wright 1968). The 1959-1960 Montana fisher reintroduction effort centered around 3 release areas: 4 males and 5 females at Pink Creek (near Eureka, MT), 8 males and 7 females at Holland Lake (just south and east of the Bob Marshal Wilderness Area), and 4 males and 8 females at Moose Lake (southwestern Montana). Based on the reclamation of tagged and non-tagged animals, the Pink Creek and Holland Lake releases were the most successful (Weckwerth and Wright 1968).

The closest release to the Cabinet Mountains was the Pink Creek release, about 100 km to the northeast. Large rivers may limit fisher movement (Kelly 1977); the Kootenai river may have halted southwestern expansion from the Pink Creek release toward the Cabinets. Indeed, most retrieved fishers from the Pink Creek release in the following 10 years were east of the release site near the North Fork of the Flathead River (Weckwerth and Wright 1968). Currently, fishers are rare throughout western Montana, and the closest sizable fisher population is in the Swan mountain range, about 100 km east of the Cabinet Mountains. Although large tracts of apparently suitable habitat remain in the Cabinets, fisher sightings are infrequent, and few have been documented.

Diet and Activity

Snowshoe hares typically constitute a major proportion of fisher diets. As snowshoe hare populations decline, fishers utilize a greater proportion of small mammals and carrion; consequently fisher populations do not tend to follow snowshoe hare population trends (Kuehn 1989). In addition to snowshoe hares, fishers commonly prey on squirrels (*Sciurus* sp.), shrews (Insectivora), and other small mammals (Rodentia) depending on abundance and availability. Birds, including passerines, corvids, and grouse (Phasianidae) are common prey. Fruits, berries, and other vegetation are eaten depending on availability. Fishers utilize deer carrion heavily in fall and winter. Even foxes (Pittaway 1978) and pine martens (Raine 1987, Brown and Will 1979) are potential prey. For additional diet information from different locations, see: de Vos 1951*a*, Hamilton and Cook 1955, Coulter 1966, Clem 1977, Kelly 1977, Grenfell and Fasenfast 1979, Leonard 1980, Powell 1982, Rego 1984, Douglas and Strickland 1987, Raine 1987, Arthur et al. 1989*b*, and Giuliano et al. 1989.

Fishers are capable of consistently preying on porcupines (*Erithizon dorsatum*) (Cook and Hamilton 1957, Powell 1979*a*, 1981, 1982, Rego 1984), and porcupines often constitute an important component of fisher diets. The relatively large size and low to the ground body form of fishers enable them to efficiently attack the unprotected face of the porcupine until a mortal wound is inflicted (Powell and Brander 1977). Fishers are so efficient at porcupine predation that areas of increasing fisher populations exhibited decreasing sympatric porcupine populations in northern Michigan (Powell and Brander 1977, Earle 1978), Wisconsin (Olson 1966), Maine (Coulter 1960), New York (Hamilton and Cook 1955, Hamilton 1957), Minnesota (Balser and Longly 1966), and Ontario (Strickland and Douglas 1981). Indeed, the major goal of several fisher reintroductions was porcupine control (Irvine et al. 1964, Olson 1966, Weckwerth and Wright 1968, Dilworth 1974).

Average fishers require 200-600 kcal/day, which is equivalent to one-quarter to one-half of a snowshoe hare per day, 0.5 to 1.5 squirrels per day, 0.2 to 0.5 kg deer carrion per day, 1 porcupine per month, or 5 to 22 mice per day (Powell 1981). In a separate study, Davison et al. (1978) estimated that a 2.5 kg fisher required 0.25 snowshoe hares, 16 small mammals, 1 quail, or 0.252 kg deer carrion per day. Because of their smaller body size, females generally require less food than males; however, during lactation female food requirements increase by up to 50%, and approach those of the larger males (Powell and Leonard

1983). Snowshoe hares have the highest digestible protein levels of the major fisher prey species (Davison et al. 1978), and may be especially valuable to juveniles and lactating females.

Clem (1977) found little competition for resources between fisher and pine marten except during short periods of winter, and Raine (1983) noted a difference in habitat use during this period due to differential responses to snow cover. Consequently, the resident marten population and the new fisher population were not expected to interact extensively.

Fishers may be active at all hours of the day and night, and no clearly defined activity pattern has been documented (Powell 1982).

Reproduction

Parturition occurs during late March or early April (Hall 1942, Leonard 1986, Eadie and Hamilton 1958, Hamilton and Cook 1955), usually in dens at least 10 m above ground in standing snags (Leonard 1986). Litters consist of 1-5 (mean of 3) very altricial kits (Eadie and Hamilton 1958, Kelly 1977, Leonard 1986, Wright and Coulter 1967, Strickland and Douglas 1981) that wean at about 5 weeks (Coulter 1966, Powell 1982, Douglas and Strickland 1987). Pregnancy rates of wild fishers range from 81% in Manitoba and Nova Scotia (Leonard 1986) to nearly 100% in Ontario and

Maine (Strickland and Douglas 1981, Wright and Coulter 1967, Douglas and Strickland 1987). However, pregnancy rates may greatly exceed whelping success; Arthur (pers. comm. 1988) estimated natal denning frequency at only 60% in Maine. Mating occurs in April about 1-2 weeks post partum (Hall 1942, Leonard 1986), and ovulation may be induced (Douglas and Strickland 1987). The blastula grows to about 800 cells and then enters a 10 month period of delayed implantation (Enders and Pearson 1943). The increasing photoperiod in February probably initiates implantation (Douglas and Strickland 1987). Although the duration of active pregnancy is unknown, estimates range from 30 (Powell 1982) to 60 days (Hamilton and Cook 1955). Total gestation lasts about 327-358 days, with an average of 352 days (Hall 1942).

Females breed at 1 year, but because of the extended gestation period, they do not give birth until their second birthday (Wright and Coulter 1967, Strickland and Douglas 1981, Leonard 1987, Eadie and Hamilton 1958). Males become reproductively fertile at 1 year, but the actual contribution of young males to pregnancy rates remains uncertain (Wright and Coulter 1967, Strickland and Douglas 1981) and probably varies with population demographics (Leonard 1987).

The extended gestation period can be an asset to reintroduction success. The majority of adult females imported in winter should be pregnant and ready to give birth after release.

Movement Patterns and Home Range

Home range data have been gathered by snow tracking (de Vos 1951a, Coulter 1966) and by radio telemetry (Kelly 1977, Buck et al. 1979, Powell 1982, Raine 1983, Johnson 1984, Arthur et al. 1989a); both methods indicate a solitary lifestyle with fairly well defined home range boundaries except during the breeding season. Most mustelids exhibit intrasexual territoriality, in which conspecifics defend their home range against individuals of the same sex but not against individuals of the opposite sex (Powell 1979c). While fishers exhibit this pattern for much of the year (Johnson 1984), traditional boundaries break down during the breeding season. Kelly (1977) and Buck et al. (1979) found extensive male-male home range overlap in yearly home ranges, due mostly to the extended movements during the breeding season; non-breeding season monthly male-male home ranges were more exclusive. As with many other mustelids, female fisher home ranges are typically smaller than those of males. Male home range estimates average about 15-20 km^2, females about 8-10 km^2 (see review in Powell 1982, Johnson 1984).

Fisher movement patterns vary considerably month-to-month. Because breeding takes place only 1-2 weeks post partum, females restrict movements to the vicinity of the den in late spring, and the burden of mate-finding falls primarily on the males (Johnson 1984). Deep snow may restrict fisher movements during midwinter (Raine 1983), and the formation of crust on the snow may facilitate the increase in movements in March. Female patterns resemble those of males, except that female movements increase in February and March as they look for suitable nesting sites (Kelly 1977). Female movements remain extensive in April and May as they strive to obtain sufficient prey to satisfy the increasing energetic demands of lactation (Powell 1982). Because of their smaller size and weight, deep snow may not limit female movement as severely as males (Raine 1983).

Small carnivores may defend territories through active physical defense or covert threat in the form of scent marks (Lockie 1966). Through use of the abdominal gland, anal gland, feces, and urine, scent marking influences spacing in pine martens (Lockie 1964, Pulliainen 1981), stoats (*Mustela erminea*, Erlinge 1977), wolverines (*Gulo gulo*, Hornocker and Hash 1981, Koehler et al. 1980), and other small carnivores (Lockie 1966). Fishers lack a conspicuous abdominal gland (Hall 1926), but use urine for scent marking purposes (Powell 1982, Pittaway 1978, 1984). Bobcats (*Felis rufus*) and house cats (*Felis domesticus*) mark conspicuous objects with foot pad secretions (Lockie 1966); fishers also possess foot pad glands (Powell 1982), but no observations have documented their function. Pulliainen (1981) suggests that pine marten scent marks act as an indicator that an area has already been hunted rather than as a strict defensive warning. Similar suggestions have arisen concerning wolverines (Koehler et al. 1980) and mountain lions (Felis concolor) (Hornocker 1969), and may pertain to fishers. Although adult male fishers sometimes show signs of intraspecific aggression (Arthur et al. 1989a), these incidents relate directly to male-male competition for females in the breeding season after traditional home range boundaries have broken down (Douglas and Strickland 1987, Arthur et al. 1989a). No published evidence from fisher home range analyses indicates a concentration of use at the boundaries of the range. Home range defense in fishers may therefore relate to scent and avoidance rather than physical aggression near the home range boundary.

Habitat Use

Fishers prefer continuous, mature, coniferous forest (Clem 1977, Coulter 1966, de Vos 1951a, Kelly 1977, Powell 1982) and have a marked aversion to open areas such as natural meadows, clearcuts, and frozen lakes and rivers (Quick 1953, Powell 1982). However, Kelly (1977) reported that during summer months fishers used clearcuts that contained sufficient tall grass and shrubs to provide adequate cover. Fishers avoid birch (Betula sp.) and aspen

(Populus tremuloides) stands (de Vos 1951a) and muskeg (Quick 1953) in all seasons. Lowland swampy stream bottoms are commonly used in greater proportion than their relative abundance (Kelly 1977, Johnson 1984, Rand 1944, Raine 1981, J. Jones pers. comm. 1988). Fishers may select ecotones because of high prey diversity rather than high prey abundance (Kelly 1977, Johnson 1984). Snags and deadfalls are important as denning sites (Leonard 1986). Winter habitat use varies with snow cover; fishers may have locomotory difficulty in areas of deep soft snow and consequently select areas with hard crusts or less snow depth (Raine 1983). Different foraging strategies are used in different habitats: fishers use the relatively time consuming "zig-zag" foraging pattern in lowland hare habitat, and the rapid "bee-line" pattern in typical porcupine habitat (Powell 1979a).

Optimum fisher habitat in the eastern United States is characterized by: (1) greater than 80% canopy closure, (2) 50-90% of the overhead cover comprised of coniferous trees, (3) at least 3 levels of vertical stratification, and (4) an average diameter at breast height (dbh) of overstory trees > 38 cm (Allen 1983). However, Arthur et al. (1989b) found that fishers do well in diverse habitats, and that fishers often hunt in brushy second growth coniferous areas. Similarly, Jones (in press) found that fishers in Idaho hunted in young to medium age stands during winter.

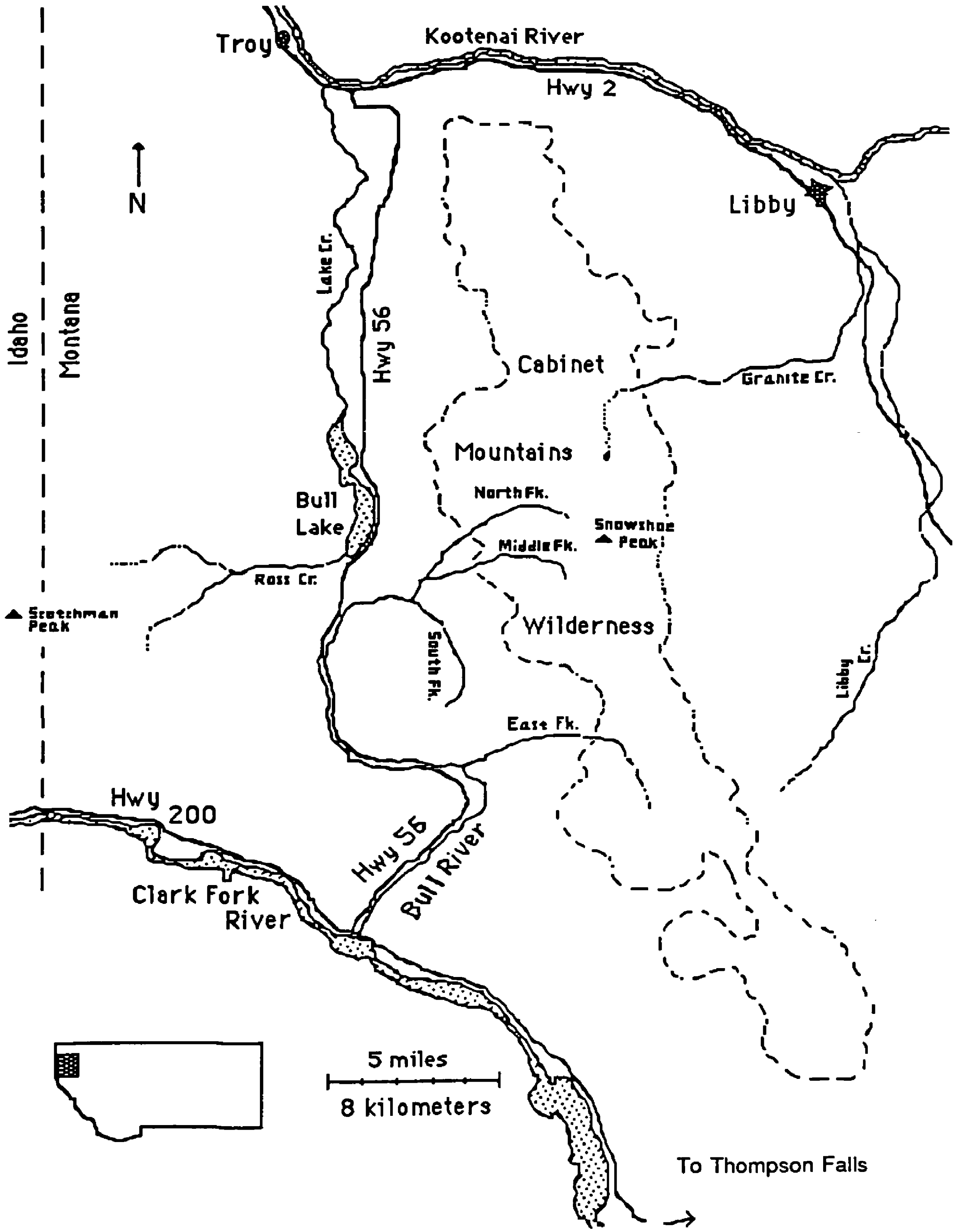
CHAPTER II

STUDY AREA

The Cabinet Mountain Wilderness is located within Lincoln and Sanders counties in the Kootenai National Forest of northwest Montana (Fig. 1). The Wilderness Area itself is long and thin, encompassing 38,180 ha excluding 33,000 ha of proposed additions. The topography is extremely rugged, with elevations ranging from 1,000 m to 2,680 m. Several mountain lakes dot the higher elevations. Cool summers and wet snowy winters characterize the area. The vast majority of precipitation falls as snow, which usually averages at least 2 m at higher elevations. Snow conditions in the Cabinets vary widely by aspect, shading, and time of day. Western and northern exposures are typically wetter than southern and eastern.

Western red cedar (Thuja plicata) and western hemlock (Tsuga heterophylla) dominate the lower valley overstories, with ferns and Devil's club (Oplopanax horridum) beneath in older stands. Mixed conifer stands of Douglas-fir (Pseudotsuga menziesii), ponderosa pine (Pinus ponderosa), and western larch (Larix occidentalis) dominate the drier midslopes, with some lodgepole pine (Pinus contorta) stands prevalent, especially in the southern Cabinets. Subalpine fir (Abies lasiocarpa), lodgepole pine and Engleman spruce

Fig. 1. Map of the study area



(_Picea engelmanii_) are found above 1,500 m on northern exposures and 1,800 m on southern exposures. The high basins and meadows above 1,800 m are chiefly huckleberry (_Vaccinium globulare_) and beargrass (_Xerophylum tenax_) interspersed with shrubby subalpine fir, mountain hemlock (_Tsuga mertensiana_), and alpine larch (_Larix lyallii_). Avalanche chutes of mostly alder (_Alnus_ spp.) line the upper drainages. A lodgepole pine bark beetle infestation has created abundant standing snags and deadfalls in many pure lodgepole and mixed conifer stands. The area surrounding the Wilderness Area is somewhat less rugged and managed primarily for timber, and clearcutting is the major harvest system. However, human habitation in the area is sparse and large tracts of suitable fisher habitat remain in these areas. Trapping pressure is severe in some areas, but is usually restricted to roadsides.

Potential prey species in the area included snowshoe hares, red squirrels (_Tamiasciurus hudsonicus_), roughed grouse (_Bonasa umbellus_), porcupines, and several species of small mammals (including _Neotoma_, _Tamius_, _Peromyscus_, and _Microtus_ spp). From visual observation and occurrence of snow tracks, snowshoe hares and squirrels were abundant during the study, but porcupines were not. Although the local deer population was high during the study, neither winter was particularly harsh and few carcasses were available, except for those provided by the researchers.

Pine martens were present in many places throughout the study area, but no quantitative data exist to document the population size or density.

CHAPTER III

METHODS

Twelve fishers, 7 females and 5 males, were imported from Minnesota in December 1988 and released on 1 January 1989. Twenty fishers, 12 females and 8 males, were imported from Minnesota in November 1989 and released on 1 January, or 9 March 1990. All fishers were released in and around the East Fork and South Fork of the Bull River, near the Cabinet Mountains Wilderness Area.

Handling Procedures

Fishers were captured on the Red Lake Wildlife Management area of northwestern Minnesota in November of 1988, and between 15 October and 17 November of 1989. Except for 1 female, all fishers were caught in cage-type live traps (Tomahawk Live Trap Co., model number 211a, 1.0 x 0.3 x 0.3 m) and housed in 0.75 x 0.75 x 2.0 m cages in unheated sheds. On 5 December 1988, female F7 was found stunned by the side of a road by a game warden near Ely, Minnesota, and the fisher was donated to the project after recovery. All holding cages contained wooden nest boxes and straw bedding. Fishers were watered and fed approximately 0.5 kg fresh thawed venison twice daily, and supplied with high quality cat food (Iams brand) ad lib. Tetracycline powder (Polyotic, 10 mg/kg) was mixed with food and water to help avoid infection and as a biomarker in the teeth (Johnston and Watt 1981). Fishers were weighed periodically to help determine health trends.

In 1988, holding times varied from 2-25 days in Minnesota with no observable ill effects. However, 2 fishers died from unknown causes while in captivity in Minnesota in 1989.

In December 1988, fishers were transported from Minnesota to Montana in 0.2 x 0.2 x 0.6 m sheet metal cages in a covered pickup truck. The travel period lasted 24 hours and was extremely stressful for the fishers. In November 1989, fishers were transported in the more spacious live traps (1.0 x 0.3 x 0.3 m) and arrived in much better condition.

In Montana, fishers were anesthetized with ketamine hydrochloride (Ketaset, 22 mg/kg, Kelly 1977) and xylazine (Rompun, 2.0 mg/animal). Under anesthesia, the lower right pre-molar was pulled for estimation of age (Strickland et al. 1982), 3 ml of blood drawn for protein analysis, tooth wear examined, vaccinations for canine and feline distemper administered, ventral spotting pattern photographed for identification, and ear tags and radio collars (AVM in 1988-89 and Telonics MOD 200 with 13-hour delay mortality switches in 1989-90) fitted and attached. On the following morning, radio collars were inspected and re-fitted if necessary. The remaining 5 fishers in 1989 were implanted with Telonics IMP 300 intraperitoneal transmitters with temperature sensors.

In an attempt to minimize post-release commercial trapping mortality, fishers imported in November 1989 were held for 40 days in 1 m^2 commercial fox farm cages; the resultant 1 January release date corresponded with the end of fisher and pine marten trapping season. In cooperation with a separate study (Heinemeyer, in prep.) and to help determine the benefits of a spring release, 1 male and 4 female fishers were held in commercial fur farm facilities from 25 November 1989 until release on 9 March 1990.

Release sites in the Cabinet Mountains were chosen based on remoteness, seclusion, and habitat suitability. All release sites were located in mature coniferous stands near the Cabinet Mountains Wilderness Area, in hopes that the fishers would establish a relatively untrapped refugia population in the Wilderness Area from which dispersers could radiate into the surrounding trapped areas (de Vos 1951b).

Because gentle release procedures significantly decreased post-release dispersal for pine marten (Davis 1983), all fishers were gentle-released. In December 1988, 6 fishers were held in individual 0.75 x 0.75 x 2.0 m wire cages at each of the 2 release sites for 5 days. In December 1989, 1 male and 1 female fisher were held in similar individual cages at each of 8 release sites for 11 days. In March 1990, 1 individual fisher was held at each of 5 release sites for 6 days. All release cages contained nest boxes and straw bedding, and were heavily camouflaged with brush. Good escape cover, such as a hollow log or slash pile, was within 3 m of all cage doors. Large quantities of venison were supplied to each caged fisher, and carcasses were placed throughout the release sites on the day before release. The deer carcasses were laid on the snow in the first year, and hung 3 m high in the trees in the second year. In 1990, bedding and scats were collected from each animal and scattered in a 50 m radius around the release cage to supply familiar scents upon release. Human disturbance at the release sites was limited to 1 trip per day to supply fresh water. On the morning of the release date, the cage doors were opened and all humans immediately left the area.

Data Collection and Analysis

Radio locations in 1989 were obtained by standard aerial and ground methods (Mech 1983) facilitated by truck, snow mobile, skis, snowshoes, mountain bike, and foot. Aerial locations were obtained with either a single rotational 3 element yagi mounted under a Supercub airplane, or with a 2 antennae bi-directional system on a Cessna 206 airplane (Mech 1983). Aerial locations were plotted on

1:24,000 USGS orthophoto quadrangles. Inclement weather in both field seasons severely limited the frequency of aerial locations, and it was often impossible to fly for weeks at a time.

For ground signal detection and direction, I used a Radio Shack magnetic base omnidirectional antenna, Telonics TR-2 receivers, RA-2A twin element directional antennas, and RH-1 headsets. Radio locations were obtained by a combination of the "error polygon" and "ad hoc" methods described by Nams and Boutin (1991). Ground triangulation accuracy was tested by taking 40 bearings on known location transmitters, from which 95% error arcs (16°) were calculated. All ground bearings then became 16° error arcs rather than single line directions. Usually, >5 error arcs were obtained for each location, and error polygons (Springer 1979) were determined by the intersection of at least 3 error arcs compiled on 1:24,000 USGS orthophoto maps. Topographic features such as ridgelines often allowed for the removal of some areas from the error polygon location.

Activity data were recorded for each bearing. Readings with at least 2 different pulses out of 10 were considered active; steady, non-variable signals were considered inactive. Tracking efforts centered around daylight hours, and most locations were obtained between 0800 and 2200 hours. In addition to daylight locations, twenty-five

24-hour and one 72-hour diel counts were performed, in which activity data were recorded every half hour.

Matson's Lab (Milltown, MT) performed age analysis by tooth cementum annuli counts on upper right premolar sections (Strickland et al. 1982). Dietary analysis was performed by an independent contractor (Dan Pond) by comparison of museum specimens with bone and hair fragments from scats (Kennedy and Carbyn 1981, Moore et al. 1974).

Causes of mortality were determined by a combination of snow tracks and necropsy analysis. Suspected predator kills were skinned, and wounds accompanied by subcutaneous hemorrhages were considered proof that the fisher was alive when the wound was inflicted. Patterns of wounds and sizes of teeth and talon punctures (O'Gara 1978) were used in conjunction with tracks and other signs to determine what species of predator made the kill.

Persistence rates, defined as the combination of mortality and emigration, were calculated with the Kaplan-Meier staggered entry method (Pollock et al. 1989), which allows for the addition of new individuals to the study population survival curve. Comparisons between the proportion of males and females killed by predation was accomplished with chi-square analysis, and the difference between death site elevation and the elevation for all other radio locations was compared with a two tailed t-test. The age of dead kits was extrapolated from Powell's (1982:61) graph.

Each fisher was located as often as possible in 1989. Radio locations were tested for independence of locations (Swihart and Slade 1985) with the "Home Range" computer program (Ackerman et al. 1990) on an IBM compatible personal computer. Because locations were autocorrelated for all time frames between locations (Swihart and Slade 1985), only "standard relocations" (3-5 day interval between locations) were included in further movement analyses. Fishers were radio located only at 3-5 day intervals in 1990. The use of standard relocations enables direct comparisons between movement distances over all time frames, and acts as a standardization technique to compensate for the lack of independence of locations. Fishers were radio relocated a total of 531 times, but only 285 locations passed the criteria for "standard relocations." Only standard relocations were used in movement and habitat use analyses.

Because analysis of variance (ANOVA) calculations require normal distributions and similar standard deviations, the distances between standard relocations were transformed to log scale (with all zero km movements changed to 0.1 km) prior to the ANOVA calculations. The difference in movement distances between months for each sex was quantified with an ANOVA test, and with 95% confidence intervals for the medians. The difference in movement distances for males versus females within each month was assessed with a t-test.

As part of a separate study, the Kootenai National Forest created habitat component map overlays for the southern Cabinet Mountains. Radio locations were compared with these overlays to determine habitat utilization for stand tree composition, tree size within the stand, and stand density. Only locations that fell within the mapped area were included in habitat analysis. All radio location error polygons that were not at least 95% contained within 1 timber stand type were eliminated from further habitat analyses. Elevation data for radio locations were obtained directly from USGS 1:24,000 quadrangles for the center of each radio location.

Habitat availability proportions for tree size, stand density, and stand composition variables were accumulated by the random point sampling method of Marcum and Loftsgaarden (1980) using the Kootenai National Forest's habitat polygon overlays. Z-tests were used to compare use versus availability proportions for these variables.

All statistical comparisons, including t-tests, Z-tests, ANOVA tests, and the calculation of the 95% simultaneous confidence intervals for the medians, were performed by the Data Desk (Velleman 1989) statistical software package on a MacIntosh computer.

Protection

Because fishers are extremely vulnerable to trapping and over harvest (de Vos 1951b, Hagmeier 1956, Coulter 1960, Weckwerth and Wright 1968, Powell 1979b, Rego 1984), most reintroductions have incorporated suspension of all trapping in release areas. The West Virginia release, however, received so much public protest that officials allowed trapping during and after all release procedures. The release was successful in establishing a viable population despite the trapping pressure (Pack and Cromer 1981). Initial trapper opinions were hostile to season closures during the present study as well, and regular trapping seasons were allowed. Efforts were made to work with local trappers on a case by case basis, and trappers were requested to remove traps from areas into which fishers had dispersed. Major access routes to drainages occupied by fishers were marked with informative signs designed to discourage trapping. In 1989-90, the release date was postponed until the end of commercial fisher and pine marten trapping seasons.

CHAPTER IV

RESULTS

In Minnesota, our trappers averaged 1 capture per 114 trap nights (st. dev.=104). Male and female fishers weighed an average of 4.6 kg (st. dev.=1.0) and 2.7 kg (st. dev.=0.4), respectively. In 1988, 12 of 13 fishers gained weight in captivity in Minnesota, but 11 of 13 lost weight during the 24-hour trip to Montana. A 7-year-old male fisher (M6) died soon after arrival in Montana in 1988, probably from stress associated with transport. Two fishers died in captivity in Minnesota in 1989, but the cause of death remained inconclusive after laboratory analysis.

The age of captured fishers ranged from juvenile to 9 years of age (Appendix B). Because of trap related injuries, the dentition of 1 female and 1 male were in too poor condition to warrant tooth removal to determine their age. However, from skull palpation and tooth inspection, they were determined to be juveniles.

Nine fishers remained in their release cages for several days after the doors were opened (Table 1). In the most extreme example, female 0220 stayed in her release cage for 64 days after her cage door was opened. After heavy snows completely covered the cage, she excavated a 10 cm diameter tunnel to the surface, which she used for

Table 1. Duration fishers spent in release cages after the cage doors were opened. Only those fishers that remained in their cages for at least 1 day are presented.

Fisher ID	Sex	Release Date	Days in cage
F1	Female	1 January 1989	9
F2	Female	1 January 1989	3
F6	Female	1 January 1989	11
F7	Female	1 January 1989	10
0590	Female	1 January 1990	1
0220	Female	1 January 1990	64
M1	Male	1 January 1989	9
M5	Male	1 January 1989	1
0490	Male	1 January 1990	5

ventilation and for periodic forays to drag meat in from the deer carcass just outside. Snow tracks revealed that a wolverine approached to within 1 m of the cage opening on 2 occasions, but 0220 remained in the cage.

Diet and Activity

From scat analysis, snowshoe hares comprised the majority of fisher diets, followed by other assorted small mammals (Fig. 2). However, the importance of deer carrion may be under-represented by the scat analysis; fishers used deer carcasses extensively on 8 known occasions, and scats were not collected in those areas.

Most radio locations were obtained between 0800 and 2200 hours (Fig. 3). No clear activity pattern was noted from the 24-hour diel counts and activity readings from location bearings; fishers were active at various times both day and night (Fig. 4).

Mortality

Due to predation and trapping mortality, the number of fishers declined throughout the monitoring period during both field seasons (Figs. 5,6). Within the first 5 months after release in both years, a total of 14 dead fishers were recovered.

Predation caused the deaths of at least 9 of the 32 released fishers. From snow tracks and necropsy analysis,

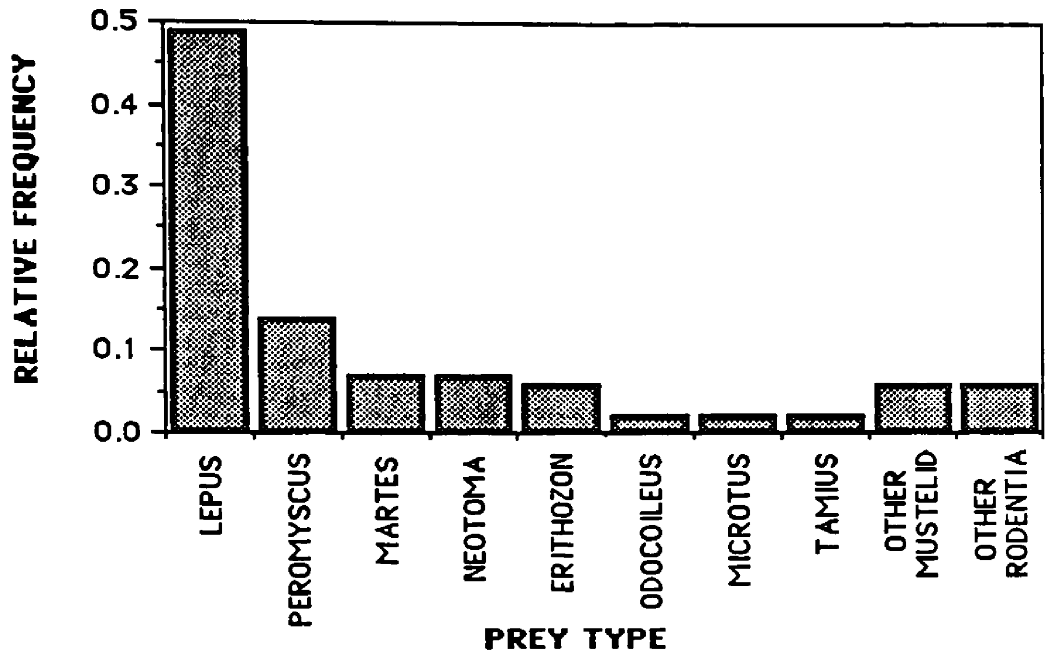


Fig. 2: Relative frequency of prey types found in 80 fisher scats in the Cabinet Mountains during winter and spring of 1989.

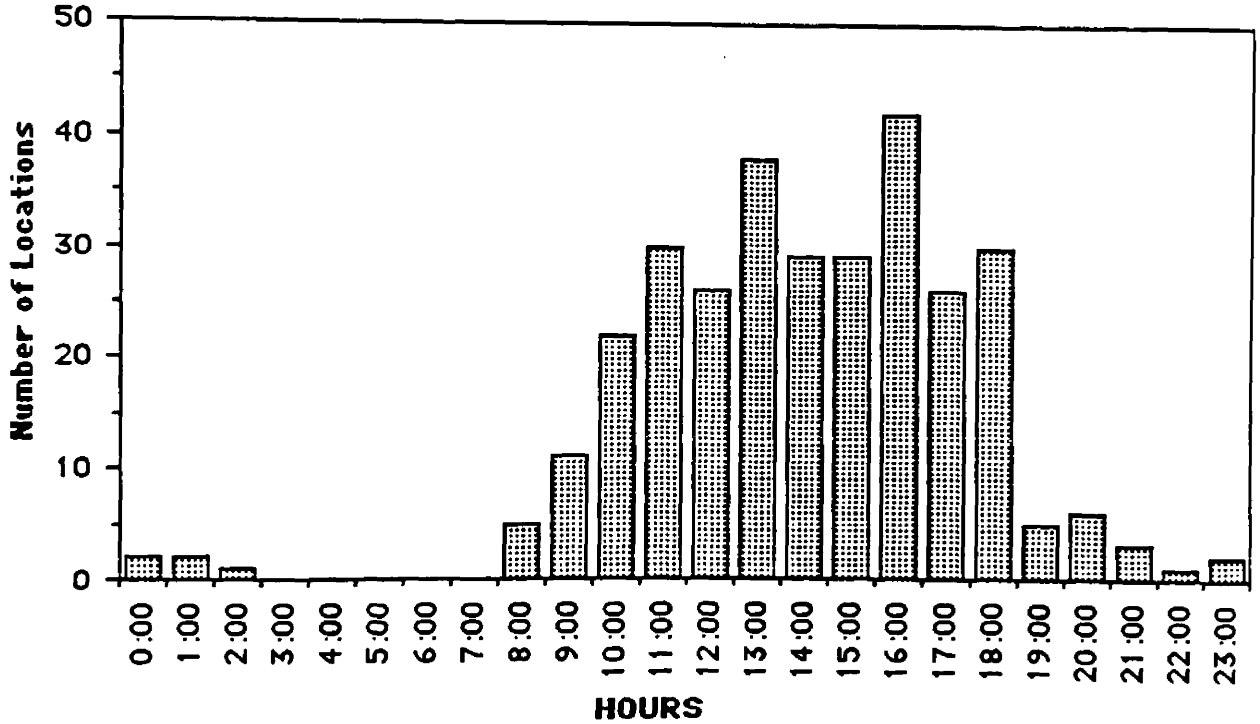


Fig. 3. Number of fisher radio locations obtained for each hour of the day, January-May of 1989 and 1990.

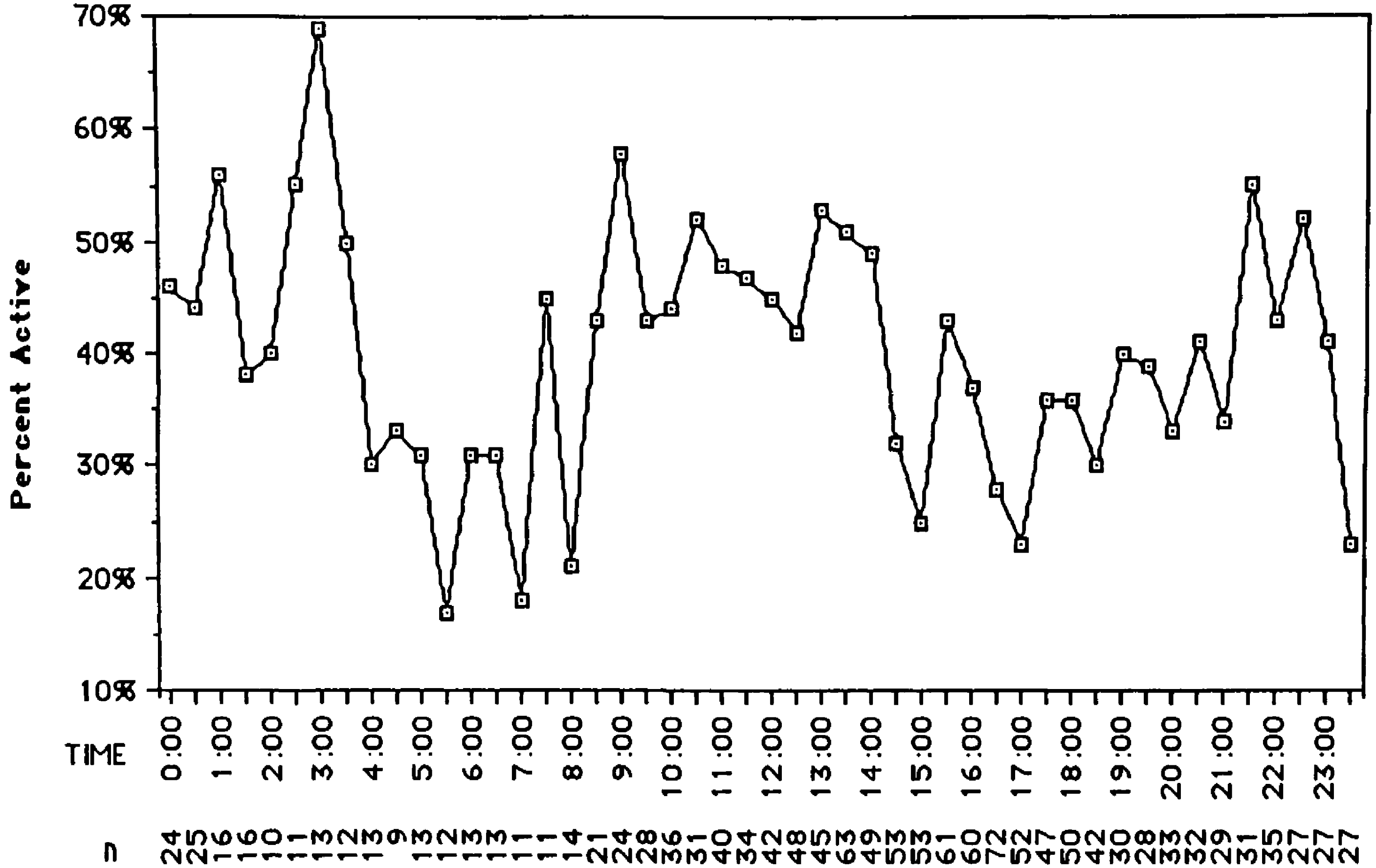


Fig. 4. Percent of radio readings at 1/2 hour intervals in which fishers were active. Data presented include 24-hour diel counts and activity readings from radio-location bearings from all fishers from January to May of 1989 and 1990. The number of readings (n) is presented on the x-axis.

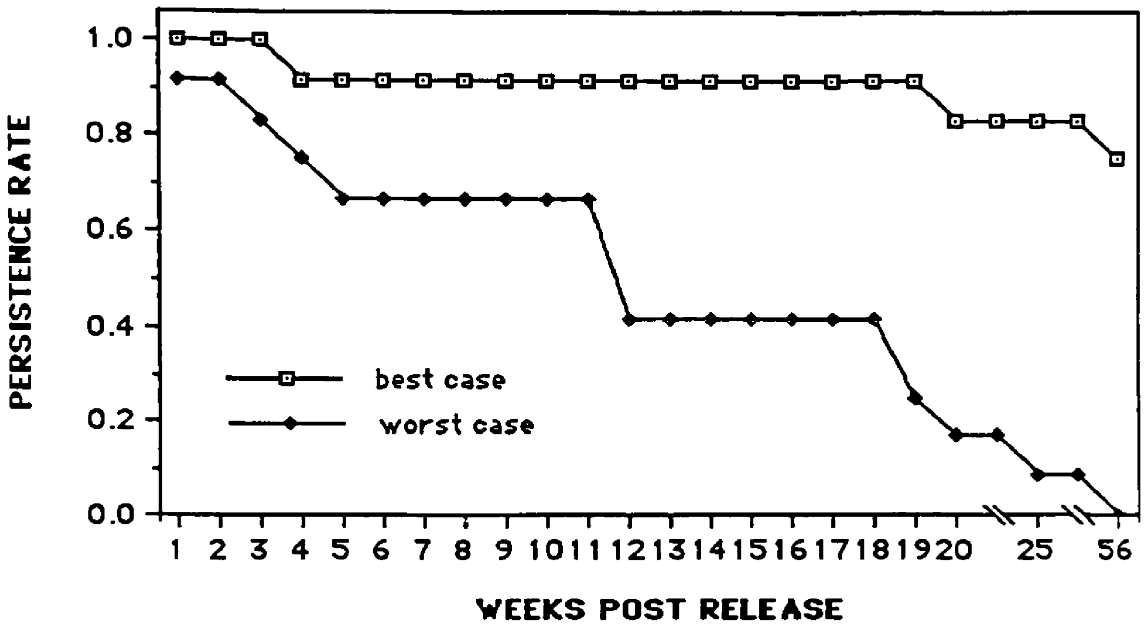


Fig. 5: Persistence rate for fishers released 1 January 1989. "Best case" assumes that all lost fishers are still in the study area with non- functioning collars, and each decrease indicates a confirmed mortality. "Worst case" assumes that all lost fishers died or emigrated after the last radio location.

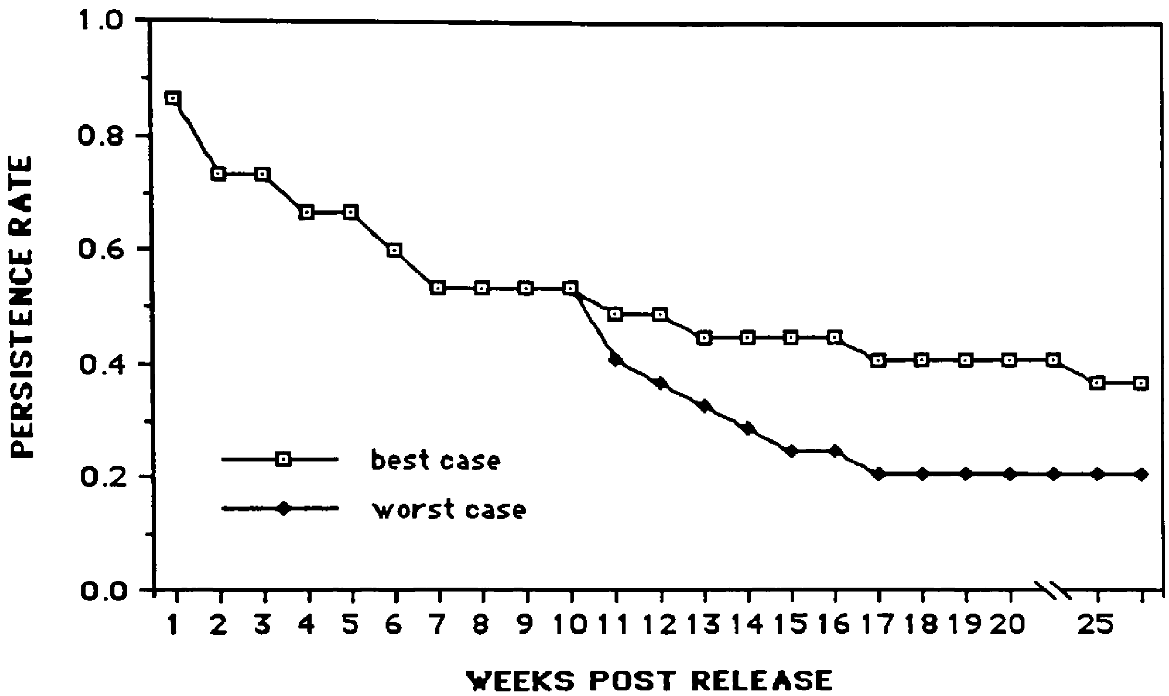


Fig. 6: Persistence rate for fishers released 1 January and 9 March1990. "Best case" assumes that all lost fishers remained in the study area with non-functioning collars, and all decreases indicate a confirmed mortality. "Worst case" assumes that all lost fishers died or emigrated after the last radio location.

predation was attributed to: 3 males by mountain lions, 1 male and 2 females by coyotes (Canis latrans), 1 male by a wolverine, 1 female by an eagle (probably Aquila chrysaetos), and 1 female by a lynx (Felis lynx). Although the differences are only marginally statistically significant, the majority of predation deaths were males (6 males:3 females) despite the original 13 male:19 female sex ratio ($0.05<p<0.10$). Predation deaths occurred at a higher elevation (mean=1,403 m, st. dev.=388) than other radio locations (mean=1,139 m, st. dev.=271, $0.05<p<0.10$). Additionally, 1 male and 2 females died from commercial trapping, and 1 male and 1 female died from unknown causes. All but 3 carcasses were recovered within 3 days of death, and all other carcasses were well preserved because of the cold temperatures. All carcasses were completely intact and had not been consumed, except for the 2 deaths by unknown causes.

All of the confirmed predator and trapping killed fishers appeared to be in good health prior to death. From visual inspection, fat levels were all high and parasite infections were undetectable. On all confirmed predator kills, the kidneys were completely encased in thick layers of fat, and fat was laced throughout the greater omentum and around the pelvic girdle. No evidence of disease or organ problems were noted.

Reproduction

Of 8 breeding age females, 2 had kits and 1 had implanted embryos at the time of death. One additional breeding age female was killed by a lynx on 12 February 1990, but her uterus was poorly preserved and no embryos were found. Four breeding age females left the study area in March or April, and their reproductive status remained unknown.

Both females that gave birth died shortly after parturition, and the kits did not survive. Female F7 gave birth in a downed hollow log to 1 female and 2 male kits in the 3rd week of April 1989. Throughout most of the preceding March and early April, she used a snow den and fed on a deer carcass that was also in the den. In the second week of April, just before parturition, she moved 18 km over the main Cabinet ridge and began frequenting a natal den site. Immediately after the discovery of her death on 16 May, the natal den was explored (Fig. 7), but the kits had already died. F7's carcass was 1.8 km from the natal den. The downed den log was 11 m long with a convoluted cavity averaging 30 cm in diameter, accessible from both ends. The kits were 3 m from the more open end, lying on a dense nest of dried pine needles and moss. The tree cavity was partially blocked by woody material on both sides of the kits. A large pile of approximately 40-50 fisher scats was found 20 cm behind the kit chamber, just behind a partial

Fig. 7: Female fisher F7;s natal den.

block in the tree cavity. The 2 male kits weighed 255 g each, the female weighed 225 g, and they were about 3 weeks old, which gives them a birth date of approximately 25 April.

Female 0220 exhibited similar movement patterns prior to parturition. She remained in her release cage from the 1 January 1990 release date until 5 March, feeding on deer carrion stocked near the release site. More than 1 m of snow completely covered her release cage. She began frequenting an area 7 km south on 8 March and remained near there until her trapping death on 27 March. No den had been located prior to her death, but examination of the carcass revealed she had been lactating.

At least 1 female became pregnant in Montana after release. Female f4, released on 1 January 1989, had 3 implanted embryos at the time of her trapping death on 5 February 1990. She had slipped her collar shortly after release and her whereabouts remained unknown until her trapping death.

Movement Patterns

In general, the fishers did not immediately disperse from the study area. Movement distances in January and February were relatively short and most fishers remained in the study area until mid March. During the breeding season, late March and April, fishers of both sexes moved long distances between standard relocations and abandoned areas of previous use. Also, distances between standard relocations in March and April had high variability and several outlier points (Figs. 8,9). In an extreme example, one female (1076) travelled >30 km over extremely rugged terrain in 2 days during April. The 5 fishers released on 9 March moved long distances between locations, in contrast to the relatively short movements exhibited after releases on 1 January. The movement distances between males and females were very similar for the months of February and April ($p>0.25$), and although the difference is only marginally statistically significant, males moved farther than females in January ($0.05<p<0.10$) and March ($0.05<p<0.10$).

The ANOVA table on log-transformed movement distances indicated that the difference in mean movement distances varied significantly from month to month for both males ($F=9.43$, $p<0.0001$) and females ($F=10.8$, $p<0.0001$). However, although the long distance outliers are interesting movements, they affect the means and ANOVA test considerably. The median distance is not affected by outlier points, and is a more conservative comparison for movement distances between months. Figures 8 and 9 illustrate the 95% confidence intervals for the medians, which facilitate direct comparisons between months.

The only fisher that emigrated immediately after release was a 7-year-old, 6.8-kg male. He remained in his

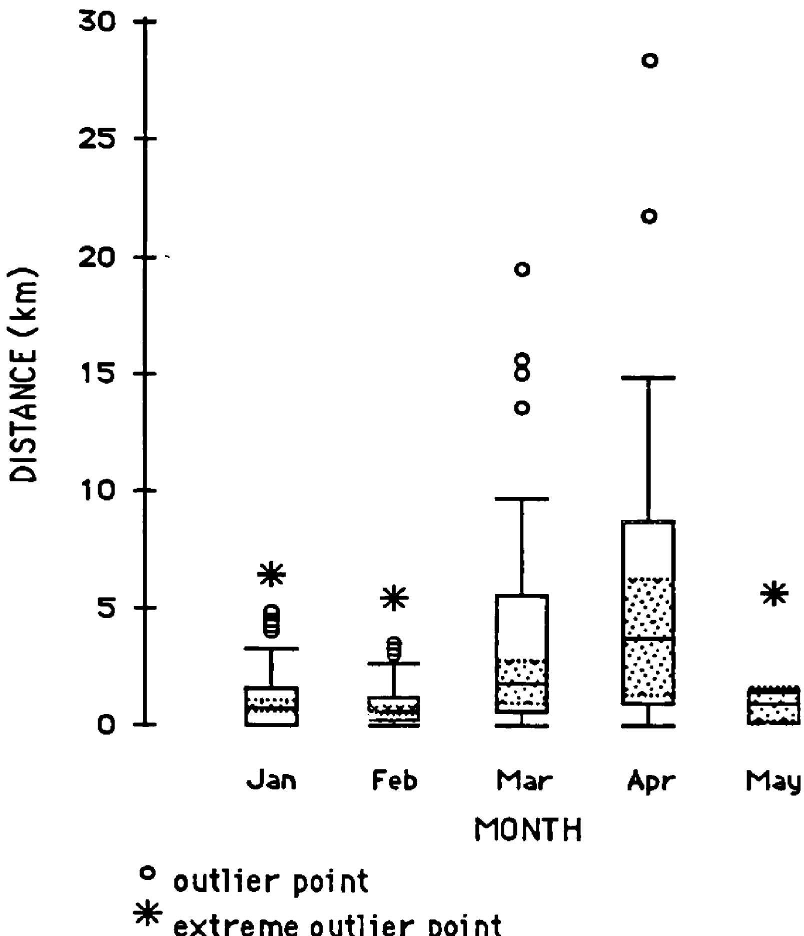


Fig. 8: Boxplot for distance between standard 3-5 day radio relocations for female fishers in the Cabinet Mountains, January-May 1988 and 1990. The shaded regions indicate the simultaneous 95% confidence intervals for the medians; if the shaded regions do not overlap month-to-month, the difference is statistically significant.

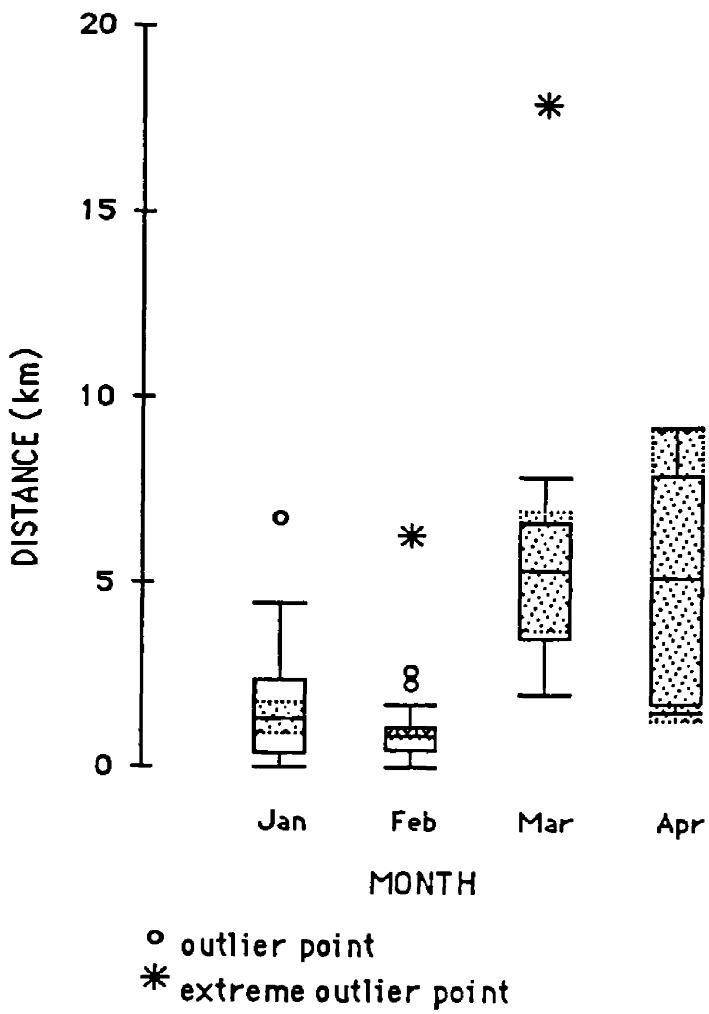


Fig. 9: Boxplot for distance between standard 3-5 day radio relocations for male fishers in the Cabinet Mountains, January-April 1989 and 1990. The shaded regions indicate the simultaneous 95% confidence intervals for the medians; if the shaded regions do not overlap month-to-month, the difference is statistically significant.

nest box for 9 days after release, but 10 days later he was 12 km away, and was 66 km away 90 days later. The furthest radio location from the release site was a female (1150), who had moved 163 km northwest by late April. The furthest radio location from the release site for a male (M1) was 71 km away.

Fishers were snow tracked a total of 34.8 km, and fishers travelled 1.8 times farther along the ground than the linear distance between track end points (Table 2).

Habitat Use

In the following presentation of habitat use data, the term "prefer" indicates selection of habitat types in significantly greater proportion than availability, and the term "avoid" indicates selection of habitat types in significantly lower proportions than availability.

The majority of radio locations occurred in mixed conifer stands (Fig. 10), in which no single tree species comprised >50% of the trees in the stand. Fishers preferred mixed conifer ($p<0.01$) and cedar/hemlock stands ($p<0.001$), and avoided subalpine fir ($p<0.001$), and hardwood ($p<0.01$) stands.

Dense, well stocked stands of pole and medium sawtimber size class contained the majority of locations, although habitats used by the fishers were similar to the proportions available (Figs. 11,12). Poorly stocked stands (recent or

Table 2. Total distance snow tracked versus linear distance travelled for all fishers, 1 January - 30 April 1989 and 1990. Distance tracked is the sum distance of all fisher tracks in that sex category, and linear distance is the strait-line distance between track end points. DT/LD represents the ratio of the actual distance travelled by fishers along the ground to the total linear distance between track end points.

Sex	Distance Tracked, km (DT)	Linear Distance, km (LD)	DT/LD
Males	15.3	9.3	1.6
Females	11.7	6.0	2.0
Unknown	7.9	4.4	1.8
Total	34.8	19.7	1.8

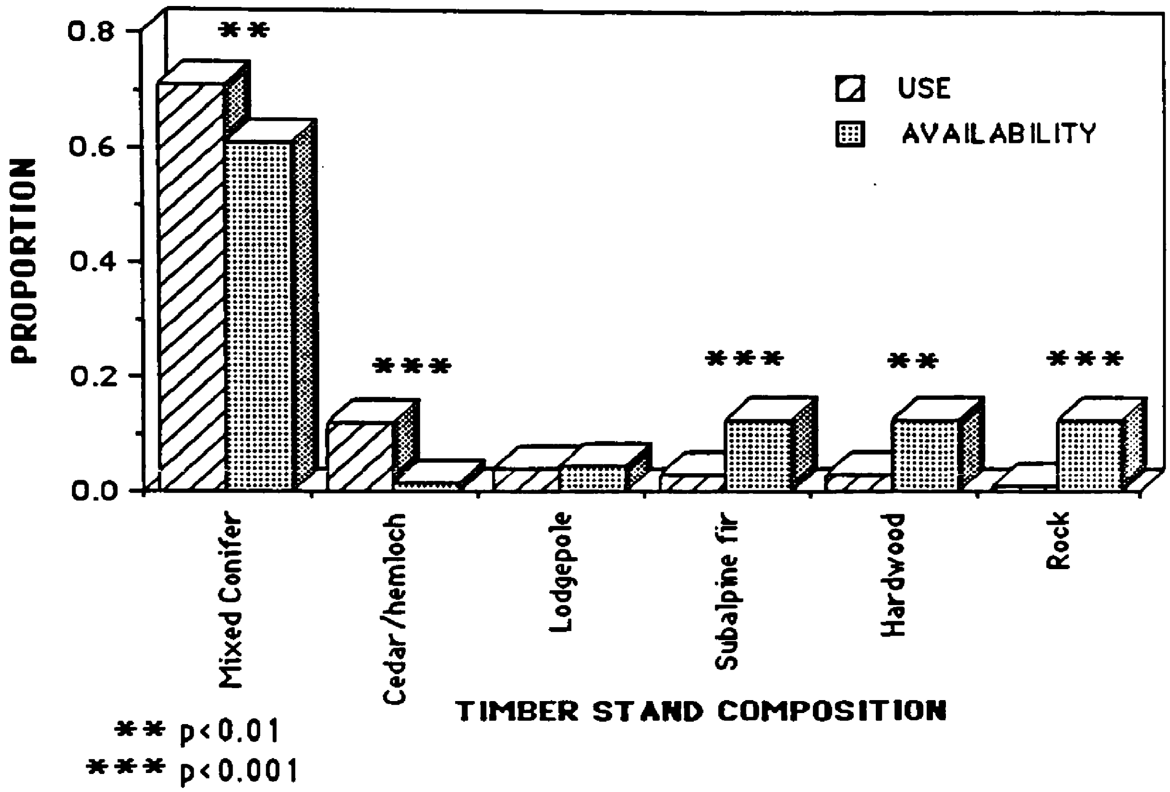


Fig. 10: Proportion of fisher radio locations in timber stand composition categories, and comparisons with availability in the Cabinet Mountains, 1989-1990. Timber stand composition was categorized by the tree species that comprised >50% of the stand.

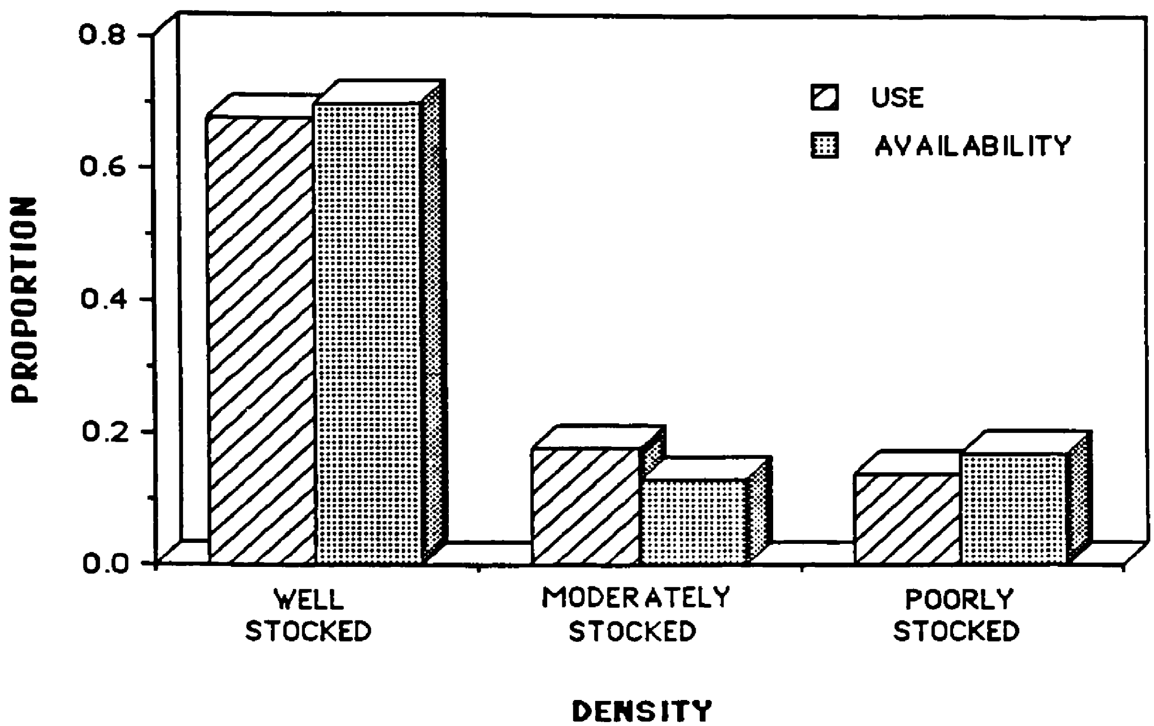


Fig. 11: Proportion of fisher radio locations in timber stand density categories, and comparisons with availability in the Cabinet Mountains, 1989-1990. Density categories are described as follows:

1. Well stocked: 76-100% canopy closure for pole/sawtimber stands, and seedling/sapling stands that exceed minimum stocking levels;
2. Moderately stocked: 50-75% canopy closure for pole/sawtimber stands, and seedling/sapling stands that meet minimum stocking levels;
3. Poorly stocked: 10-49% canopy closure for pole/sawtimber stands, and seedling/sapling stands that fail to meet minimum stocking levels.

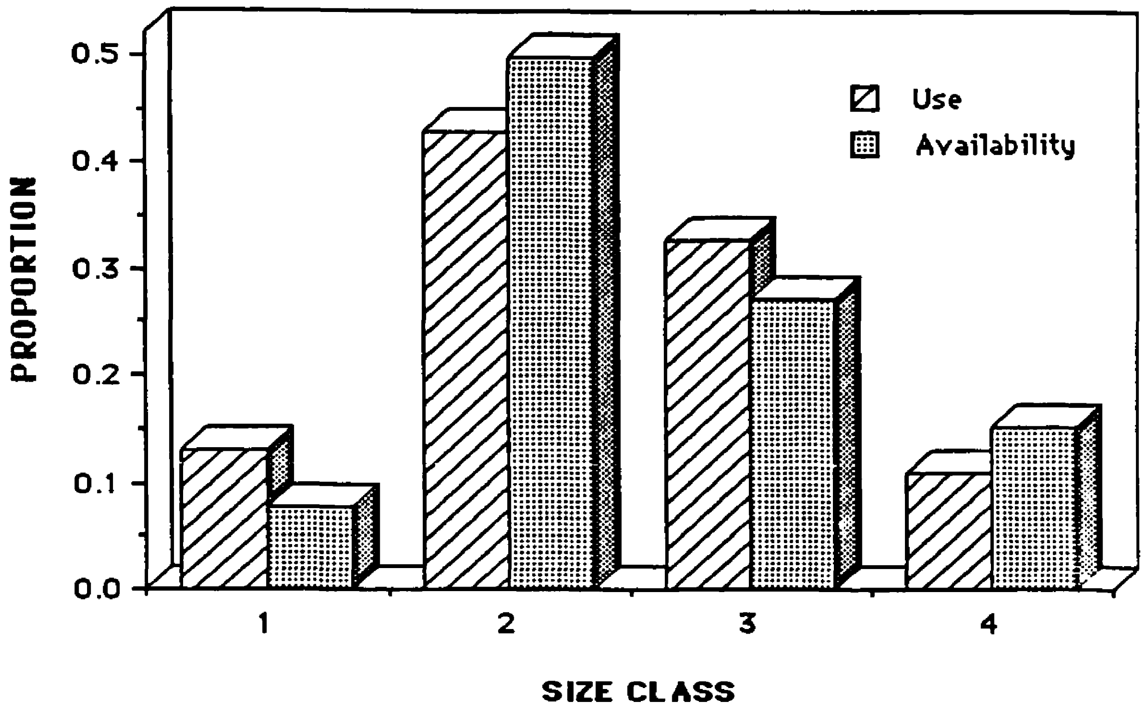


Fig. 12: Proportion of fisher radio locations in timber size class categories, and comparisons with availability in the Cabinet Mountains, January-May 1989 and 1990. Size class categories are as follows:

1. seedling/sapling stands, crowns 1-3 m, height 1-15 m, DBH 1-12 cm;
2. pole/small sawtimber stands, crowns 3-6 m, height 9-21m, DBH 12-21cm;
3. medium sawtimber, crowns 6-9 m, height 15-30 m, DBH 21-34 cm;
4. large sawtimber, crowns > 9 m, height > 21m, DBH > 34 cm.

unregenerated clear cuts and alpine zones) were generally avoided, except for an adult female that utilized a deer carcass in an old but unregenerated clear cut during February-April 1989.

CHAPTER V

DISCUSSION

Diet and Activity

Fisher use of prey species in the study area is consistent with diet studies in other areas (Powell 1982). Kuehn (1989) suggested that fishers use prey species in proportion to their relative abundance, and snowshoe hares are often the most abundant prey species. Although no quantitative prey density data were collected, the frequency of sightings and snow tracks suggests that snowshoe hares were common in the study area; predictably, snowshoe hares comprised the majority of fisher diets. Porcupines were not abundant and were not heavily used. Curiously, no squirrel remains appeared during scat analysis, even though squirrels seemed to be fairly abundant. Contrary to most other authors, Bateman (1986) also found squirrels conspicuously absent from pine marten diets in Newfoundland. Although snowtracking indicated fishers preyed on pine marten on at least 1 occasion, a large percentage of the *Martes* hair fragments were probably from fisher grooming behavior.

The importance of porcupines and deer carrion in the scat analysis may be under-represented. Small predators eating chiefly muscle tissue from a porcupine or deer carcass pass fewer hairs in proportion to the mass eaten than for smaller prey species (O'Gara 1986). Also, fishers used deer carcasses extensively on 8 known occasions, and scats were not collected in those areas. Seven of the 8 known deer carrion feeding examples occurred on carcasses supplied as part of the release procedures. Fishers sometimes moved from one release sight to the next, feeding on the carrion at each site.

No authors have documented a true diel pattern for fishers (Powell 1982). The activity pattern exhibited in the present study also attests to the lack of a strictly defined diel cycle. A slight decrease in activity may be associated with the hours between 0400 and 0700, but the sample size is correspondingly low for this time period.

Persistence Rates and Mortality

The persistence rates, corresponding to the number of fishers remaining in the release area, continued to decline throughout the monitoring period in both years. The "best case" persistence line of 1989 (Fig. 6), which assumes that all lost fishers remained in the study area with non-functioning collars, appears high and encouraging in comparison with the best case line of 1990 (Fig. 7). However, the best case line of 1989 may be artificially inflated because of a lower sample size and 4 slipped collars within the first 5 weeks. With better equipment in 1990, no collars slipped off and the persistence rate is more accurate. The worst case persistence rates, which assumes that all lost fishers died or emigrated after the last location, are very similar for both years. Most sea otter reintroductions exhibited steadily declining population persistence curves for the first 10 months after release (Estes et al. 1989).

With an early January release, fisher numbers may decrease up to 80% by May. However, fisher movements decrease after the breeding season (Kelly 1977), and emigration from the study area may decrease correspondingly. Consequently, persistence rates may level off beginning in May and June.

Except for the present study, very little evidence of predation on fishers has been documented. In studies of endemic fishers, Grinnell et al. (1937) recorded 2 deaths by mountain lions in California, Buck et al. (1983) had 4 of 21 fishers possibly killed by predators, and Jones (in press) had 3 of 21 fishers killed by predation. No radio telemetry studies east of the Rockies (Kelly 1977, Leonard 1980, Raine 1982, Powell 1982, Johnson 1984) have documented a single instance of predation, except for Arthur (pers. comm. 1990) who had only 1 extremely old female killed by a coyote, out of over 100 radio collared fishers. At 9 confirmed predation deaths out of 32 fishers, the present study has by far the highest predation rate recorded for fishers. However, the current study is also the first to radio-monitor reintroduced fishers, and is consequently the first to gather objective mortality data on introduced fishers.

The stress associated with translocation could be a key factor in the high predation rate. The fishers were in a new area with new habitats and new predators. Although wolves are fairly abundant in the Red Lake Wildlife Management Area in Minnesota, the area lacked or had few mountain lions, wolverines, coyotes, lynx or eagles (J. Vorland, pers. comm. 1990). The fishers were probably naïve and unwary of the Montana predators.

Nine fishers were killed and not eaten, atypical behaviors for larger predators. The Montana predators may have been unaccustomed to fishers, attacking them but finding them bad tasting, or more trouble than expected. However, 4 dead fishers (2 mountain lion kills, 1 lynx kill, and 1 unknown) were cached in snow caves, and may have been retrieved by the researchers prior to the return of the predator.

Passive competitive exclusion, in which competing species exclude each other through more efficient use of scarce resources, probably was not directly responsible for the continued decrease in fisher persistence rates. Twelve of the 14 dead fishers were in very good physical condition prior to death, and were not under stress for food. Alternatively, active competitive exclusion, in which individuals of different species actively attack direct competitors to decrease competition for resources, is an important mechanism in several interspecific predator relationships in Idaho, and may be important in the Cabinets. In Idaho, mountain lions killed bobcats and coyotes while defending or usurping food caches, especially during winter when snow depths confined predators to similar habitats (Koehler and Hornocker in press). Similarly, mountain lions sometimes kill coyotes and do not consume them in Montana (Boyd and O'Gara 1985). In turn, the tendency of coyotes to kill or exclude foxes (Vulpes vulpes) is widespread (Sargeant et al. 1987, Harrison et al. 1989). The Montana predators may have actively, intentionally killed the fishers to decrease competition for resources, or while defending or usurping food caches.

In Idaho, competitive exclusion occurred primarily when many predator species were confined to low elevations because of deep snow in the high elevations (Koehler and Hornocker in press). In contrast, fishers in the Cabinets were killed at higher elevations (with correspondingly deeper snow) than other radio locations, and predators were not necessarily concentrated at the fisher death sites. The fishers may have been restricted by the deep snow, perhaps more restricted than the larger, longer-legged predators.

Fishers have been absent from the Cabinet Mountains since the early 1900's, and the environment in the Cabinets is quite different now than when fishers naturally inhabited the area. Land management actions have disturbed the habitat, and the local predator complex has changed. Sea otter reintroductions have been plagued by failure because of new and diverse habitats and behaviors; Estes et al. (1989) stress that, "Because of various ecological and behavioral barriers, local extinctions and their ecological consequences may not be simply reversed by protecting or reintroducing depleted or locally extinct species." The niche that fishers formerly inhabited in the Cabinets may now be filled by other members of the local predator complex, chiefly coyotes. The ecological role of fishers in the Cabinets may have been replaced by other predators capable of excluding fishers.

The aggressive nature of the males, and the male's greater susceptibility to deep snow (Raine 1983) may have contributed to the demise of some individuals. Fisher reintroductions in very snowy areas may have a low potential for success (Banci 1990). With the 1 January release date, the deep snow in the Cabinets may have increased fisher susceptibility to predation, especially because most predation deaths occurred at high elevations. However, snow tracking showed that fishers commonly moved long distances in all snow conditions, and they regularly crossed snowy ridges more than 1,000 m above the valley bottoms. The good body condition of the dead fishers indicates they could move well enough to obtain prey during all winter months. Indeed, female 0590, killed by a lynx on 12 February 1990, was so obese that her ability to avoid larger predators could have been significantly impaired. Additional research concerning foot loadings of fishers, prey species, and larger predators may help to determine the limitations and vulnerabilities of fishers in different snow conditions.

Only 1 fisher was killed near a release site, so the potential problem of stocking the release sights with carrion, and consequently attracting other predators, is probably not an important factor. However, carrion at the release sites may attract bears (Ursus spp.) at earlier release dates.

The radio collars and implants may have hindered the fisher's movements and defence, and increased their susceptibility to predation. However, most of the fishers were fat and healthy at the time of death, which suggests they could move well enough to catch prey.

In addition to predation, commercial trapping caused the deaths of 1 male and 2 female fishers. The reproductive state of both females was especially discouraging: one was lactating in April, and the other had just implanted 3 embryos in early February. Although a trapping season exists on fishers in the Cabinets, 2 trapping deaths occurred after the close of pine marten and fisher seasons, and all three trapping deaths were incidental captures in sets designed for pine marten or bobcats.

Reproduction

Both females that gave birth in the study area were very sedentary and established temporary dens near deer carcasses for weeks prior to long movements just before birth. Energetic stress associated with pregnancy and lactation is extremely costly in fishers (Powell and Leonard 1983). A good food source such as a deer carcass would provide significant energetic gains at low cost, especially for pregnant and lactating females (Kelly 1977). However, even though meat remained on the deer carcasses, both females abandoned their dens and carcasses just prior to parturition. Evidently, snow caves and the surrounding areas did not satisfy the necessary den site criteria, regardless of the amount of food present. Perhaps one criteria for an appropriate natal den-site is an adequate distance from a known predator attractant, such as a deer carcass. Although both females had good fat reserves at the time of death, the increased energetic demands of lactation and the associated increased activity (Leonard 1986) may have contributed to their vulnerability to predation and trapping.

Kelly (1977) found that 1 pregnant female fisher had her smallest yearly home range just prior to parturition in

March, and he felt that she may have increased her movements in January in search of appropriate den sites. The long movements of the 2 females in the Cabinets within days of parturition were probably associated with den site selection. The females may have been too disoriented just after release in January to search for appropriate den-sites, and waited until March to begin the search.

In contrast with the scrupulously clean standing snags described by Leonard (1986), the natal den in the study area was in a downed hollow log and had a large pile of scats inside. The female was healthy and 10 years old at the time of death, and probably had previous reproductive experience. However, she had moved 18 km within a week of parturition, and may have settled for the downed log as a suboptimal den.

Movement Patterns

In the Cabinets, both sexes made significantly longer movements during the breeding season than at other times of year. Fishers of both sexes in New Hampshire made long movements during the breeding season (Kelly 1977), but only male fishers increased their movements during the breeding season in Maine (Arthur et al. 1989a). Also, fishers usually returned to their old home ranges after long breeding movements in Maine (Arthur et al. 1989a). Because no fishers in the Cabinets returned to their areas of previous use after long movements during the breeding season, I feel that no true home ranges were developed during the monitoring period. The 1 January and 9 March release dates probably did not allow sufficient time for the development of home ranges prior to long movements in March and April.

Fishers may have stopped dispersing and established home ranges after the monitoring period, which ended in May-June of each year. However, even if the fishers did establish home ranges in late summer, most fishers that were still alive had moved far enough from the study area that their contribution to a breeding population would appear doubtful.

Individuals may gain a fitness advantage by dispersing from areas of high density to areas of low density (Shields 1987). Fishers, especially ones from a dense population as in the Red Lake Wildlife Management Area in Minnesota, may tend to disperse into areas devoid of other fishers of the same sex. Fishers in Maine shifted home ranges into new areas when the previous residents had been removed by fur trapping (Arthur et al. 1989a). Lockie (1966) suggested that a territorial system can not exist with either too much or too little competition for resources. The release areas had high fisher densities just after release, but not after long breeding season movements. With very little intraspecific competition for resources, and after the long distance movements in the breeding season, fisher densities may have been too low to stimulate home range behavior. Without barriers to dispersal or limits to nearby suitable habitat, fishers may have had few reasons not to disperse into the surrounding intraspecific vacuum (Calhoun and Webb 1953). After the long movements during the breeding season produced low fisher density, all of the surrounding area may have provided an outlet for wandering impulses: the "dispersal sink" described by Lidicker (1975). With similar logic, Slough (1989) recommended releasing large numbers of pine marten to advance the reestablishment of normal spacing patterns.

Fishers moved long distances from release sites in other reintroductions. From incidental captures and observations, fishers moved an average of 43.7 km (maximum of 90 km) after release in West Virginia (Pack and Cromer 1981), and moved up to 96 km from release sites in Wisconsin (Olson 1966). A captive fisher made successive movements of 136 km and 163 km from its release site in the Catskills of New York (Brown and Parsons 1983). Females moved up to 56 km from release sites in Montana, and males moved up to 102 km (Weckwerth and Wright 1968). Because all of the above examples are incidental captures, some fishers may have moved even farther. Radio relocation data in the present study reinforce the idea that fishers commonly move long distances after reintroduction.

Because fishers can move such long distances in short periods of time, the release of females just prior to parturition does not guarantee they will have kits in the study area. An earlier release date such as October or November, or the release of females with young in April, may be necessary to keep breeding-related dispersal to a minimum. An October/November release would provide less snow cover and greater mobility for fishers; fishers may be less susceptible to predation with less snow, but may show increased initial post-release dispersal because of easier travel (Raine 1983). The release of females with young in April would decrease post-release dispersal, and the juveniles may not disperse as far after imprinting on the local area. Alternatively, females might abandoned the kits and disperse anyway. However, Hobson et al. (1989) successfully reintroduced female pine marten with young in Alberta, and preliminary observations indicate that marten are still present in that area. One female fisher gave birth during translocation procedures in Idaho (Williams 1962a), and the female remained in the nest box with the healthy kits after release (Williams 1962b).

Habitat Use

The extremely rugged topography of the Cabinet Mountains makes ground telemetry imprecise. The size of error polygons varied dramatically, and were probably influenced by ease of access. Although this bias was reduced as much as possible, it cannot be eliminated. Radio location error polygons were often smaller and more precise in the lowlands near the roads; fishers in high elevation areas were more difficult to locate and error polygons were usually larger. Radio location error polygons that were not at least 90% contained within 1 timber stand type were eliminated from habitat analyses; consequently, the results may be biased toward habitat types typical of lowland areas. Additionally, most radio locations were obtained between 0800 and 2200, so fisher use of thermal cover at night may be under represented. Because of these limitations, generalizations about fisher habitat use based on the available data are limited mainly to daylight, lowland habitat use.

Fishers in the present study preferred dense mixed conifer and cedar-hemlock stands of young to medium age. Most authors (de Vos 1951a, Coulter 1966, Kelly 1977, Clem 1977, Powell 1977) have found that fishers prefer dense, mature conifer stands rather than young to medium age stands. However, in the only other detailed fisher study in the Northwest, Jones (in press) found that fishers used young to medium age stands to hunt during winter. The habitat use of the reintroduced fishers in the Cabinets correspond well with winter habitat use in Idaho (Jones in press). Because of the increased incidence of prey species, Arthur et al. (1989b) suggested that optimum fisher habitat in the southern part of the species' range was characterized by a diversity of forest types with high interspersion. Dense, young to medium age conifer stands in the Cabinets may provide better fisher foraging opportunities than mature stands, especially for snowshoe hares (Dolbeer and Clark 1975). However, few radio locations were obtained at night during the times of most severe thermal stress, and fishers may have retreated to mature areas and used the more abundant snags and deadfalls for thermal cover at night.

Comparison With Other Reintroductions

The 1959-60 Montana fisher reintroduction was a success (Weckwerth and Wright 1968). Only 9, 15, and 12 individuals were released in 3 widely separate sites throughout western Montana in 1959-60, but fishers are still present near 2 of these areas. Despite the 78.7% chance of success calculated from Griffith et al.'s (1989) reintroduction success formula, the release of 32 fishers in the Cabinets in 1989-90 currently has a low potential for long term success.

A major difference between the 1959-60 and the 1989-90 Montana fisher reintroductions lies with the translocation distance. The fishers in the 1959-60 release came from central British Columbia, an area of relatively similar habitat and predators, but the fishers in the 1989-90 release came from Minnesota, an area of widely different habitat types and predators. Because of the long translocation distance and the dissimilar habitat and predators, the 1989-90 fishers may have been genetically and behaviorly disadvantaged.

Connecticut and Alberta recently reintroduced fishers, and used release timing and methods similar to the present study (P. Rego and G. Proulx, pers. comm.). In both studies, fishers in all age and sex classes waited until the breeding season in March and April to begin long distance movements, although the movement distances were shorter in Connecticut than in Montana.

Translocation distance is an important factor in fisher reintroduction success (Berg 1982). In the Northwest, released fishers in Oregon (Kebbe 1961, Morse 1961) and Idaho (Williams 1962b) came from areas of similar habitat in British Columbia, and both were successful, at least over the short term. The West Virginia release (Pack and Cromer 1981), and releases in Nova Scotia (Dodds and Martell 1971) and New York (Wallace and Henry 1985) also used fishers from relatively nearby parent populations. In Wisconsin, 18 fishers were introduced from New York in the late 1950's (Olson 1966), but the success of the reintroduction remained in doubt (Bradle 1957) until the importation of an additional 103 fisher from nearby Minnesota (Irvine et al. 1964).

Pine marten releases in Wisconsin and the Yukon have several parallels with the current fisher release. In Wisconsin, the habitat and prey base seemed sufficient to allow marten recovery, and all re-trapped marten were healthy and had gained weight. However, 3 female pine marten that remained sedentary for 2-4 months left the study area because of breeding-related movements. Because of emigration and lack of reproduction, the reintroduction had a low potential for success (Davis 1983). In the Yukon, 19 of 27 radio tagged reintroduced marten were classified as transient or only temporary residents (Slough 1989).

Trapping season restrictions may be an important factor for reintroduction success. Berg (1982) found that all but 1 successful fisher reintroductions incorporated local trapping season closures to protect the introduced fishers, and several authors have stressed the importance of season closures prior to fisher reintroductions (Bradle 1957, Kebbe 1961, Irvine et al. 1964, Weckwerth and Wright 1968). The release areas in the 1959-60 Montana fisher reintroduction were closed to pine marten trapping to protect the reintroduced fishers. Despite the informal protection measures and education attempts during the present study, many trappers were confused about legalities, and several trappers established trap lines in and around the release drainages. The fishers were vulnerable to 15 days of pine marten and fisher seasons in January of 1989, and to 45 days of lynx and bobcat seasons in 1989 and 1990. To avoid commercial trapping pressure in the fisher and pine marten trapping seasons, fishers were held in captivity for an additional 18 days in December of 1989; this extended captivity time may have detrimentally affected post-release behavior. All trappers in the release areas voluntarily moved their traplines after becoming aware of the specifics of the reintroduction project, but 3 fishers were trapped in the interim. Season closures would have removed all ambiguity, and might have saved 3 fishers, 2 of which had kits.

CHAPTER VI

CONCLUSIONS

1. **Fisher reintroductions in areas of suitable habitat but with new and diverse predator complexes may have a low potential for success.** The habitat and prey base in the Cabinets meets fisher requirements, but the larger predators present a major obstacle to recovery. The larger predators were new and diverse to the reintroduced fishers, and the high predation rate is probably a factor of the fisher's naivete'. Also, because of habitat modification and other human influences, the predator complex in the Cabinets may be very different now than when fishers occurred there historically. The fisher niche may have been usurped by other members of the predator community, and fishers may be precluded from returning to high densities.

2. **Long distance movements in the breeding season are deeply ingrained in fisher behavior.** The reintroduced fishers did not disperse from the release area until the breeding season. Both males and females moved long distances into unknown areas in the breeding season, often into areas that contained few if any other fishers. Long breeding movements occurred despite the stresses of a new environment and completely unfamiliar terrain.

CHAPTER VII

MANAGEMENT RECOMMENDATIONS

1). Obtain fishers from a nearby locality. A short translocation distance would help insure similar predator complexes and habitat, and would decrease the chance of introducing behaviorly disadvantaged fishers. For the present study, securing fishers from British Columbia would be optimal. However, fishers are currently rare in British Columbia and throughout the western states and provinces, so obtaining adequate numbers of fishers from an area closer than Minnesota will be difficult.

2). Change the release timing. An earlier release, such as October or November, may provide sufficient time for the development of home ranges prior to long movements in the breeding season. With an earlier release, fishers may develop home range fidelity and return after the breeding season. Also, the release of females with kits in April may limit adult female dispersal and imprint the kits to the local area. This approach is risky, but it has worked for pine marten (Hobson et al. 1989). Because pregnant females can move long distances in short periods of time, the release of pregnant females in March will not insure fidelity to the release area.

3). Continue gentle release procedures. The gentle release procedures may have kept fishers from dispersing immediately after release. The deer carcasses associated with the release process were used by several fishers, and did not increase predation mortality by attracting larger predators. Because of possible effects on post-release behavior, the handling period associated with trapping and translocating the fishers should be minimized.

4). Release approximately equal sex ratios. Because the males had a higher mortality rate than females, the temptation to release more females than males should be resisted. The release of pregnant females is important, but without a sufficient supply of males, the reproductive potential for the following years may be sacrificed.

5). Concentrate on developing a core population. Fishers may require a critical population density to establish a home range system and limit exploratory or wandering movements. Without the presence of other nearby fishers to restrict movements, fishers may continue to wander. Nearby fishers of the opposite sex may help decrease long distance movements in the breeding season.

6). Appropriate protection. To protect the reintroduced fishers, and to develop a refugia population, most successful fisher reintroductions have incorporated trapping season closures. I recommend trapping season closures in the immediate release area, especially if fishers are released earlier (see recommendation 2). Even though fur prices were relatively low and fishers were not released until after the fisher and pine marten seasons were over, 3 fishers (including 2 females with kits) were killed by trappers in the study area. With a minimal public education campaign, trapper support for season closures could be secured. Most trappers were cooperative during the study, but if fur prices rose and trapping continued in the release area, problems could arise. Specifically for the Cabinets, I recommend the following:

A). Close the fisher season in the Kootenai National Forest south of the Kootenai river. The only fishers in the area are reintroduced and the fisher population does not warrant a harvest. A closed fisher season will not reduce incidental captures, but it may preclude trappers from placing sets on fisher sign and add incentives for releasing incidental captures.

B). Close all land-base furbearer seasons in the release drainages. Several fishers remained in the release drainages until March, after the close of most trapping seasons. A moratorium on trapping in the release drainages would effectively protect most fishers until the trapping seasons were over.

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Appendix A

Notes on Previous Fisher Reintroductions.

Location	Date	Sex Ratio Males, Females	Source	Comments
Oregon	1960	10,14	Kebbe 1961, Morse1961	Marginally successful, 2 sites
Wisconsin	1955-57	6,8	Bradle 1957	Successful, 1 site
Wisconsin/ Michigan	1956-63	78,43	Irvine et al. 1964	Successful
Wisconsin	1966-77	30,30	Petersen et al. 1977	Successful
New Brunswick	1966-68	10,15	Dilworth 1974	No reproduction, 3 sites
West Virginia	1968	6,10; 7 unknown	Pack & Cromer 1981	Larger release more successful, 2 sites
Nova Scotia	1947-48, 1963-66	31,57	Benson 1959, Dodds & Martell 1971	Successful, 7 sites
Idaho	1962	5,6	Williams 1962a	Successful, 1 site
New York	1977	43 unknown	Brown & Parsons 1983, Wallace & Henry 1985	Successful
Montana	1959-60	16,20	Weckwerth & Wright 1968	Moderately successful
Minnesota	1968	15 unknown	W. Marshal (Berg 1982)	No evaluation
Ontario	1956	25 unknown	C. Douglas (Berg 1982)	No evaluation
Ontario	1956-63	37,60	C. Douglas (Berg 1982)	Successful
Ontario	1979-82	27,30	C. Douglas (Berg 1982)	No evaluation
Manitoba	1972-73	4 unknown	R. Leonard (Berg 1982)	Failure
Vermont	1959-60	19,16, 89 unknown	T. Fuller (Berg 1982)	Successful
Maine	1972	7 unknown	J. Hunt (Berg 1982)	Failure
Oregon	1981	8,5	J. Schneeweis (Berg 1982)	No evaluation

Appendix B

Sex, age, weight, release date, number of relocations, and fate of reintroduced fishers

Fisher ID	Sex	Age (Yrs) at Release	Weight (KG)	Release Date	Number Locations	No. Standard Locations[a]	Fate: Date (Month/day/year)
M1	m	7.7	6.8	1/1/89	16	4	Left study area: 5/8/89
M2	m	0.7	5.0	1/1/89	14	3	Slipped collar: 2/12/89
M3	m	0.7	4.5	1/1/89	46	16	Last location: 6/21/89
M4	m	0.7	4.9	1/1/89	7	1	Dead in trap: 1/24/89
M5	m	0.7	4.1	1/1/89	21	9	Left study area: 5/28/89
F1	f	0.7	3.1	1/1/89	25	12	Collar failed: 3/19/90
F2	f	0.7	2.7	1/1/89	4	1	Slipped collar: 1/4/89
F4	f	6.7	3.6	1/1/89	1	0	Slipped collar: 1/2/89, dead in trap, pregnant: 2/5/90
F5	f	1.7	2.6	1/1/89	9	3	Last location: 3/20/89
F6	f	1.7	2.6	1/1/89	28	7	Last location: 3/19/89
F7	f	9.7	2.6	1/1/89	56	20	Killed by coyote: 5/16/89; 3 kits
F8	f	0.7	2.2	1/1/89	15	5	Slipped collar: 2/7/8
0050	m	0.7	3.5	1/1/90	1	0	Killed by wolverine: 1/2/90
0030	m	0.7	3.8	1/1/90	3	1	Killed by mt. lion: 1/11/90
0490	m	0.7	3.2	1/1/90	5	3	Killed by mt lion: 1/13/90
0111	m	1.7	3.7	1/1/90	9	5	Cause of death unknown: 1/22/90
0212	m	1.7	5.6	1/1/90	13	10	Killed by coyotes: 2/11/90
0070	m	1.7	4.0	1/1/90	27	19	Left study area: 3/12/90
1332	m	1.7	5.2	1/1/90	19	11	Still in study area as of 5/30/90
0191	f	0.7	3.3	1/1/90	4	1	Killed by eagle: 1/3/90
0590	f	6.7	3.0	1/1/90	10	7	Killed by lynx: 2/12/90
1415	f	1.7	2.4	1/1/90	9	3	Left study area: 3/18/90
0220	f	2.7	2.4	1/1/90	28	28	Dead in trap: 3/27/90; lactating
1160	f	0.7	2.3	1/1/90	37	29	Last location: 4/13/90
0170	f	1.7	3.0	1/1/90	33	24	Left study area: 4/15/90
1198	f	0.7	2.4	1/1/90	34	26	Still in study area as of 5/30/90
1150	f	0.7	2.4	1/1/90	22	14	Still in study area as of 5/30/90
0250	m	2.9	5.0	3/8/90	2	1	Killed by mt lion: 3/12/90
1210	f	0.9	3.0	3/8/90	4	2	Left study area: 3/13/90
0750	f	1.9	2.4	3/8/90	6	3	Left study area: 4/15/90, dead by unknown cause by 5/30/90
0610	f	0.9	2.6	3/8/90	10	8	Killed by coyote: 4/25/90
1076	f	0.9	2.5	3/8/90	14	9	Last location: 5/10/90

1. Locations falling 3-5 days apart.

Appendix C

Age, weight change, and body temperature for fishers captured in 1988.

Fisher ID[a]	Age at release (months)	Capture date	Capture Weight (kg)	Weight (kg) 12/4	Weight (kg) 12/15	Release Weight (kg) 12/22	Body Temp (°F)
M1	93	11/18	5.5	6.9	6.8	6.6	102.8
M2	9	11/22	3.8	4.5	5.0	4.7	103.2
M3	9	11/28	4.1	4.1	4.5	4.1	103.5
M4	9	11/29	4.4	4.4	4.9	4.4	102.9
M5	9	11/21	3.5			4.1	102.8
M6	93	12/14	4.0		4.0		
F1	9	11/18	2.1	2.8	3.1	2.5	102.8
F2	9	11/21	2.7			2.8	104.2
F4	9	11/21	2.7	3.9	3.6	2.9	101.8
F5	21	11/22	2.3	2.6	2.6	2.4	103.8
F6	21	11/24	2.7	2.7	2.6	2.4	102.8
F7	108	12/07	2.1		2.6	2.9	102.0
F8	9	12/10	2.1		2.2	2.2	103.0

a. M = male, F = female

Appendix D

Linear distance between standard radio relocations for all fishers, 1 January - 30 May of 1989 and 1990.

	Males				Females			
Month		s	n_l	n_a	$\bar{X}$	s	n_l	n_a
January	1.6	1.48	44	10	1.2	1.39	75	13
February	1.1	1.32	23	7	1.0	1.16	45	10
March	6.5	4.71	9	7	3.6	4.33	58	11
April	5.2	3.18	6	2	6.5	7.60	23	9
May	4.3	0.02	2	1	1.5	1.82	8	5

$\bar{X}$: mean distance between standard 3-5 day interval radio relocations

s : standard deviation

n_l : number of locations

n_a : number of animals upon which data are based

Appendix E

Preference indices for timber stand composition categories for all fishers, 1 January - 15 June, 1989 and 1990. P_{io} represents the expected number of locations if they fell in each cover type in exact proportion to availability, and is defined as the product of the total number of locations (N) and the proportion available for that cover type. Preference indices > 1 indicate selection, and preference indices < 1 indicate avoidance.

Cover type[a]	No. radio locations (n)	Proportion Available	Expected Use (P_{io})	Preference Index (n/P_{io})
MC	202	0.611	165.6	1.22
WH	34	0.017	4.6	7.39
AF	9	0.123	33.3	0.27
LP	12	0.047	12.7	0.94
H	11	0.123	33.3	0.33
Rock	3	0.123	33.3	0.09
Total (N)	271			

a. Timber stand composition types are described as follows:

MC: Mixed conifer type, no single species comprises the majority (>50%) of the stand.

WH: Western red ceder/hemloch type (>50% of the stand), moist, usually occurs near drainage bottoms.

AF: Alpine fir type (>50%), usually high elevations (>1,650 m).

LP: Lodgepole pine type (>50%), usually pure, even age stands.

H: Hardwood type (>50%), usually alder, avalanche chutes or recent clear cuts.

Rock: Rock type, usually talus or scree fields, rocky cliffs or faces.

Appendix F

Preference indices for timber stand density categories for all fishers, 1 January - 15 June, 1989 and 1990. P_{io} represents the expected number of locations if they fell in each cover type in exact proportion to availability, and is defined as the product of the total number of locations (N) and the proportion available for that cover type. Preference indices > 1 indicate selection, and preference indices < 1 indicate avoidance.

Density class[a]	No. radio locations (n)	Proportion Available	Expected Use (P_{io})	Preference Index (n/P_{io})
Well stocked	193	0.700	199.5	0.97
Moderately stocked	52	0.132	37.6	1.38
Poorly stocked	40	0.168	47.9	0.84
Total (N)	285			

a. Density classes are described as follows:

Well stocked: 76-100% crown closure for pole/sawtimber stands, and seedling/sapling stands that meet minimum stocking levels.

Moderately stocked: 50-75% crown closure for pole/sawtimber stands, and seedling/sapling stands that meet minimum stocking levels.

Poorly stocked: 10-49% crown closure for pole/sawtimber stands, and seedling/sapling stands that fail to meet minimum stocking levels.

Appendix G

Preference indices for timber stand size class categories for all fishers, 1 January - 15 June, 1989 and 1990. P_{io} represents the expected number of locations if they fell in each cover type in exact proportion to availability, and is defined as the product of the total number of locations (N) and the proportion available for that cover type. Preference indices > 1 indicate selection, and preference indices < 1 indicate avoidance.

Size class[a]	No. radio locations (n)	Proportion Available	Expected Use (P_{io})	Preference Index (n/P_{io})
1	36	0.077	21.9	1.64
2	124	0.499	142.2	0.87
3	94	0.272	77.5	1.21
4	31	0.152	43.3	0.72
Total (N)	285			

a. Size class codes are described as follows:

1. Seedling/sapling stands, crowns 1-3 m, height 1-15 m, DBH 1-12 cm.
2. Pole/small sawtimber stands, crowns 3-6 m, height 9-21m, DBH 12-21cm.
3. Medium sawtimber, crowns 6-9 m, height 15-30 m, DBH 21-34 cm.
4. Large sawtimber, crowns > 9 m, height > 21m, DBH > 34 cm.

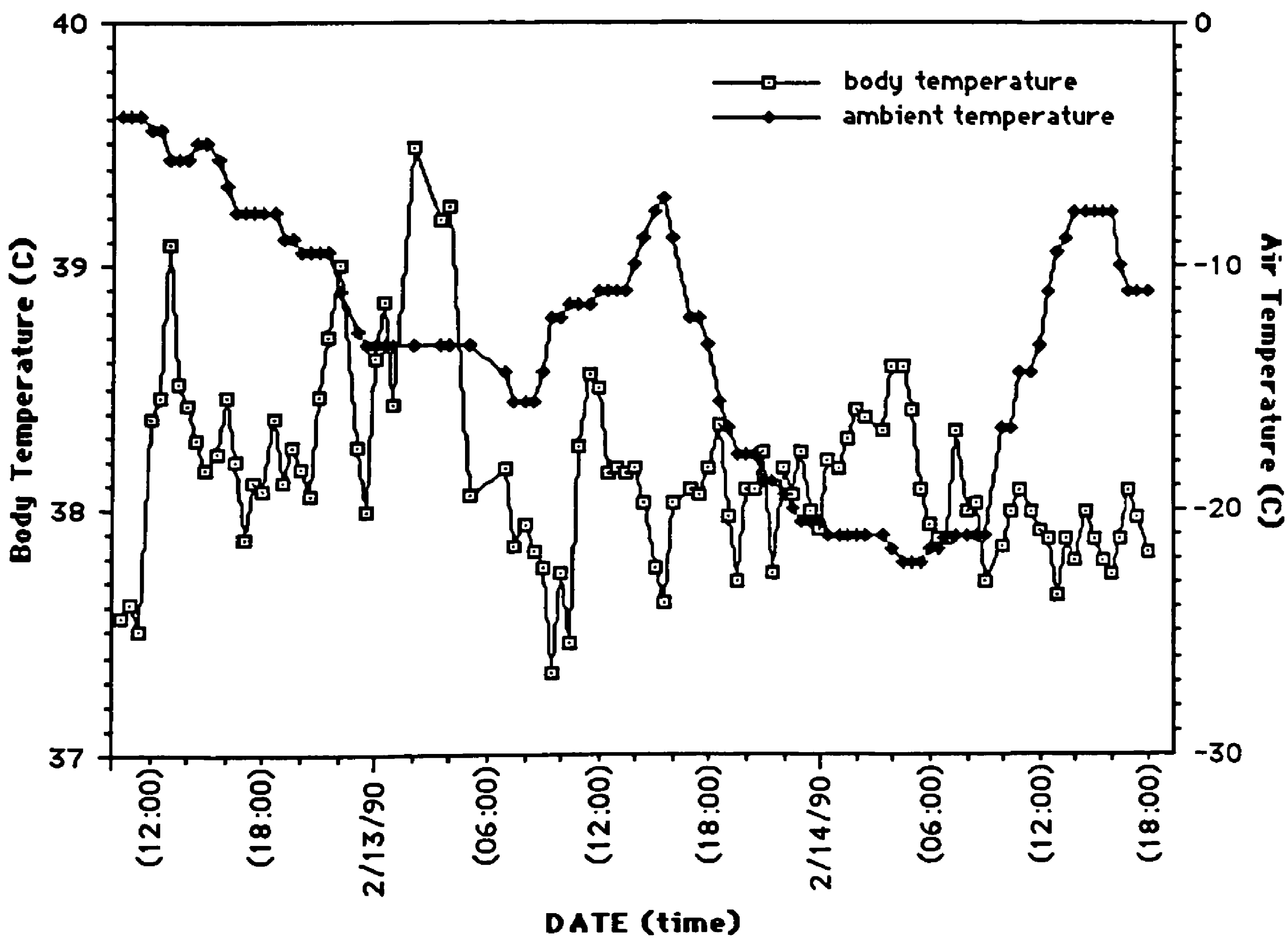
Appendix H

Body temperature versus ambient air temperature for adult, pregnant female fisher 0220, from 1030 on 12 February to 1800 on 14 February 1990. The data presented here are the result of a collaborative effort between Kim Heinemeyer and Kevin Roy, and may also appear as part of Kim Heinemeyer's Masters thesis work. Any future publications from this material will list Kim Heinemeyer as senior author.

Body temperature data were collected for adult, pregnant female fisher 0220. Under anesthesia, a Telonics IMP-300 temperature sensitive implant was placed in the peritoneal cavity, which allowed for telemetric monitoring of the fisher's inner body temperature. The pulse interval was determined by averaging the duration of 20 pulses with a stop watch. The pulse interval was then regressed through a standardized formula to determine the body temperature.

By remaining in her release cage for 64 days after release, fisher 0220 provided an excellent opportunity to monitor body temperature versus ambient air temperature under field conditions. From a distance of 400 m, I recorded her temperature at 1/2 hour intervals for 54 continuous hours in February 1990, during which the fisher remained in her snow cave. The period between 0200 and 1200 on 13 February is particularly interesting: when the ambient temperature dropped to -13°C, the fishers body temperature dropped 2.5°C over an 8-hour period.

To conserve energy in winter, pine marten enter a limited torpor and drop their body temperature an average of 2.9°C during resting
episodes (Buskirk et al. 1988). The 2.5°C decrease in fisher 0220's body temperature is comparable to the mean decrease for pine marten. The potential for fishers to enter a limited torpor during winter deserves more study.



APPENDIX I

Description of fishers killed by predation and unknown causes. All carcasses were necropsied by Kevin Roy and Dr. Bart O'Gara, except for fisher F7, which was autopsied by Kevin Roy and Dr. Doug Griffiths, DVM. The only fisher that was partly consumed was fisher 0111.

Fisher F7 (adult female): Released on 1 January 1989, dead by 13 May 1989, and recovered on 16 May 1989. The carcass was 22 km from her release site, in a mature mixed conifer/subalpine fir stand near the top of Horse Mountain, 15 km east of the main Cabinet ridge: elevation 1,735 m, slope 30%, aspect 150°, canopy cover 80%, and average stand height 30 m. The snow was crusty, but I found coyote hair and fairly fresh tracks nearby.

The left scapula and surrounding muscles were completely crushed, with accompanying hemorrhages and small punctures in the skin. The back was broken at the 1st and 5th thoracic vertebrae, and the chest cavity was punctured. As a result of the death struggle, the claws and last 2 phalanges on toes 4 and 5 on the right rear paw were missing. The wounds were characteristic of coyote kills.

She had 3 dark placental scars, but no sign of new fertilized embryos. She had been nursing kits for 3 weeks, but still had large fat reserves on the kidneys, hips and greater omentum. The stomach and intestines were full of snowshoe hare remains.

Fisher 0050 (juvenile male): Released 1 January 1990, dead 16 hours after release, and recovered on 2 January 1990. The carcass was 0.4 km down the drainage from the release site, in a mixed conifer valley bottom near Snake Creek Pass: elevation 975 m, slope 20%, aspect 170°, canopy cover 50%, and average stand height 15-20 m. Although 8 cm of fresh snow covered the carcass, wolverine tracks were found in the immediate area on the preceding and following day.

The aluminum casing on the radio collar was heavily dented, and the neck region surrounding the collar was severely traumatized. The 3rd-5th cervical vertebrae were fractured, and the surrounding muscle tissue was crushed. The wounds appeared to have been inflicted by a dull, grinding bite characteristic of wolverines. No additional hemorrhages were noted.

Fisher 0191 (juvenile female): Released 1 January 1990, dead by 20:00 on 2 January 1990, recovered on 4 January 1990. The carcass was 3.2 km from the release site, in an open subalpine fir stand on the west side of Ibex Peak: elevation 1,415 m, slope 40%, aspect 220°, canopy cover 10%, and average stand height of 10-20 m. The carcass was covered with 20 cm of fresh snow, and no snow tracks could be found.

The abdomen was swollen near the mammary glands, and several puncture wounds dotted the lumbar and abdominal regions in patterns of three. Many of the puncture wounds pierced the peritoneal wall, and 1 severed the right femoral artery. The puncture wounds were characteristic of eagle talons. The hips, inner thighs, and greater omentum were heavily lined with fat.

Fisher 0030 (juvenile male): Released on 1 January 1990, dead by 02:55 on 11 January 1990, and recovered on 13 January 1990. The carcass was 2.6 km from his release site, in a small natural opening in a subalpine fir stand on the west face of Bald Eagle Peak: elevation 1,740 m, slope 60%, aspect 225°, canopy cover 0%, and average stand height 0-15 m. The fisher had been cached under 40 cm of snow by the predator.

Although the skin and trachea remained intact, the head was almost completely severed behind the axis vertebrae. The skin in the neck region was heavily bruised with transverse, linear lesions. The wound may have been caused when a mountain lion bit the fisher behind the neck, with the canines passing around the throat and the carnassials slicing the spine. The hips were laden with fat, and no other hemorrhages were noted.

Fisher 0490 (juvenile male): Released on 1 January 1990, died at 05:28 on 13 January 1990, and recovered on 14 January 1990. The carcass was 2.5 km from his release site, in an open ponderosa pine stand near the crest of Hayes Ridge, on the north face of the East Fork of the Bull River: elevation 1,680 m, slope 60%, aspect 225°, canopy cover 30%, and average stand height 20-30 m. The carcass was on a patch of bare ground, and the surrounding snow was patchy and crusty. No fresh snow tracks were noted.

The back was broken at the 5th thoracic vertebrae, and several ribs on both sides were broken. The abdomen was swollen and leaked blood through the skin. Deep, opposing puncture wounds accompanied the broken ribs and swollen abdomen, as if the fisher had been bitten around the spine and from underneath the abdomen. The depth of the wounds and amount of trauma indicated the predator was a mountain lion.

Fisher 0111 (adult male): Released on 1 January 1990, and dead by 04:22 on 23 January 1990. We made 2 attempts to recover the carcass, but were driven back by heavy storms and avalanches. We finally recovered the carcass on 18 February 1990. He was 4.2 km from his release site, in a small subalpine fir draw near the top of Berray Mountain: elevation 1,600 m, slope 40%, aspect 155°, canopy cover 20%, and an average stand height 10-25 m. He was buried under

1.9 m of snow, and only the front paws and head remained.

The masseter muscles were highly necrotic and the sagittal crest was crushed. We found no evidence of hemorrhages, and he may have been scavenged. The cause of death remains unknown.

Fisher 0212 (adult male): Released on 1 January 1990, dead by 00:37 on 11 February, and recovered on 13 February 1990. He was 5.1 km from his release site, in a mixed conifer draw near Snake Creek Pass: elevation 944 m, slope 30%, aspect 130°, canopy cover 40%, and average stand height 20-25 m. A pack of coyotes had killed a whitetail buck on the previous day, and the fisher was lying 8 m from the deer carcass. The fisher was probably killed by the coyotes in competition for the deer carcass.

The back was broken between the 2nd and 3rd thoracic vertebrae, with massive internal hemorrhages throughout the thoracic region that indicated the fisher had been bitten several times. The left rear paw had suffered severe trauma. The peritoneum was punctured and filled with blood. The fisher was large and healthy prior to death, and had plenty of fat reserves.

Fisher 0590 (adult female): Released on 1 January 1990, dead by 00:45 on 12 February 1990, and recovered on 15 February 1990. She was 2.7 km from her release site, on the edge of an old but unregenerated clearcut near Moran Basin: elevation 1,839 m, slope 40%, aspect 300°, canopy cover 10%, and average stand height of 0-5 m. Because of heavy snows, no snow tracks were available. She was in a snow cave at the base of a medium-sized subalpine fir, 1.7 m from the surface.

Hemorrhaging and small puncture wounds lined the cervical and lumbar regions of the back, but no vertebrae were broken. There were small punctures and scratch marks that resembled claws on the left ribs, and both front paws had punctures and hemorrhages. She had slight bruising and trauma throughout the body. No single wound was severe enough to cause death, and she may have escaped her aggressor and died of blood loss. From the death site elevation and the characteristics of the wounds, we attributed the death to a lynx.

The fisher was obese. From external observation, the abdomen was distended to the point that it may have hindered her movements. The greater omentum was ridiculously fat, and the stomach was full of deer meat and hair. She had remained sedentary for 2 weeks prior to her death, and had probably been feeding on a deer carcass. The uterus was small and thin, and no embryos were found.

Fisher 0250 (adult male): Released on 9 March 1990, dead by 10:00 on 12 March 1990, and recovered on 13 March 1990. He was 6.7 km from the release site, in an old but unregenerated clearcut near Dad peak: elevation 1,655 m, slope 50%, aspect 265°, 0% canopy cover, and average stand height of <2 m. The snow tracks were partially obscured by recent snows, but signs indicated that the fisher had led a mountain lion on an extended chase throughout the clearcut. The tracks led to the base of 2 trees, but there were no signs that the fisher successfully climbed either tree. The lion finally caught the fisher and cached him in a snow cave at the base of a small subalpine fir.

The fisher suffered massive damage to the head and neck region. The masseter muscles, sagittal crest, both zygomatic arches, and part of the brain case were completely crushed. The spinal cord was severed at the 2nd axial vertebrae, and internal hemorrhages surrounded the hips. The fisher had large fat reserves around the hips, kidneys, and in the greater omentum, and the stomach contained snowshoe hare remains. The colon contained deer hairs, presumably from the release site. The fisher showed no signs of infection from the implanted radio transmitter.

Fisher 0610 (juvenile female): Released on 9 March 1990, dead by 09:30 on 19 April 1990, and recovered on 27 April 1990. She had made exploratory movements up to 8.5 km from the release site, but was only 3.1 km from the release site at the time of death. She was 10 m from a clearcut in a mixed conifer stand in the bottom of the South Fork of the Bull River: elevation 809 m, slope 20%, aspect 300°, canopy cover 60%, and average stand height 20-25 m. The death site contained several large trees and an old logging slash pile for escape cover.

The back was broken between the 9th and 10th thoracic vertebrae, and between the 2nd and 3rd lumbar vertebrae. Except for the tail, the entire dorsal region posterior to the shoulders exhibited moderate to severe internal hemorrhages. She had no trauma in the head and neck region. The wounds were probably inflicted when a coyote grabbed and shook the fisher.