REINTRODUCTION OF THE PINE MARTEN INTO THE NICOLET NATIONAL FOREST, FOREST COUNTY, WISCONSIN

by

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ABSTRACT

One hundred twenty-four pine marten (Martes americana) (97 males: 27 females) were live-trapped in Canada and reintroduced into the 216 sq. mi. (560 sq. km) Fisher Management Unit (FMU) in the Nicolet National Forest between January 29, 1975 and April 3, 1976. Eight males and 18 females were released from holding pens a minimum of 1 week after arrival (gentle-release). The remaining pine marten were released within 1 day of arrival (quick-release).

Twenty-one pine marten (9 males:12 females were radio-tagged to facilitate evaluation of the reintroduction program. There was a significant difference between post-release movement measurements of radio-tagged gentle-release pine marten and radio-tagged quick-release pine marten. Gentle-release pens reduced post-release movements. Five radio-tagged pine marten (2 males:3 females) moved out of the FMU and into the upper peninsula of Michigan; maximum straight-line movement in a 30-hr. period was 14.48 mi. (23.30 km). Two females were radio-tracked during April 1975 and 6 females were radio-tracked during April 1976; no evidence of reproduction was found. Extrapolation of the radio telemetry data to the entire reintroduced population indicates that 12 females remained on the FMU in April 1976. Ten percent of the radio-tagged pine marten were victims of predation. Five dead pine marten were recovered: 1 male was trapped, 1 male was shot, 1 male and one female were killed by predators, and 1 female died from injury inflicted by the radio-tag.

Radio-tagged pine marten did not utilize any specific habitat type; the amount and types of habitat selected were directly proportional to

the amount and types available. The FMU is closed to dry-set trapping to protect the reintroduced population. The success of the reintroduction program is still uncertain because of significant survival data and the relatively few females released, emigration, and there being no documentation of reproduction.

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INTRODUCTION

History

Pine marten (Martes americana), and its close relative the fisher (M. pennanti) were originally indigenous to most of the wooded areas of Wisconsin. Excessive trapping and habitat destruction during the 1800's and the early 1900's resulted in the drastic reduction of both pine marten and fisher ranges in North America. The pine marten was extirpated from Wisconsin in 1925 when the last animal was trapped in Douglas County (Jackson 1961). It is currently classified as "endangered" in Wisconsin (Chapter 275, Wisconsin Laws of 1971).

Declining pine marten and fisher populations in Ontario stabilized and then spread to adjacent areas after several game preserves were closed to trapping (deVos 1951). A harvestable pine marten and fisher population exists in Ontario today because of a restocking program from 1956 to 1963, game preserves, and strict trapping regulations.

The Fisher Management Unit was established in the Nicolet National Forest when fishers were released in 1955-57 in the Nicolet and Chequamegon National Forests of Wisconsin. This area was closed to dry-set trapping to protect the reintroduced population. An immediate evaluation of the reintroduction program was never conducted. Weckwerth and Wright (1968) report that fisher, which were reintroduced into Montana, traveled up to 64 mi. (102.98 km) from the release site. The Wisconsin Department of Natural Resources (WDNR) believes, based on observations and track counts, that fishers are now found throughout northern Wisconsin.

Ninety-nine pine marten were released north of Rapid River, Michigan

in the Hiawatha National Forest during 1969-1970. Schupbach (1977), after conducting extensive post-release field work during the winter of 1975-76, concluded that a viable population had not become established in the release area. Trapping pressure and emigration were considered important factors for the failure. Five pine marten were reintroduced on Stockton Island, Ashland County, Wisconsin in 1953 (Jordahl 1954). The reintroduction effort was considered a failure.

The USDA Forest Service and the WDNR reintroduced pine marten into the Nicolet National Forest of Wisconsin in 1975-76. The objectives of this study were to determine: 1) effects of various release methods, 2) post-release movements, 3) habitat selection, 4) survival, 5) cause of mortality, and 6) success or failure of the reintroduction program. Research was conducted from January 1, 1975 to June 30, 1976.

Study Area

Pine marten were released into the Fisher Management Unit (FMU) of the Nicolet National Forest (Fig. 1). The 216 sq. mi. (560 sq. km) area is closed to dry-set trapping and is semi-wilderness consisting mainly of large lowlands and dense hardwoods within the Pine River watershed of Forest County.

The economy of the surrounding area is based on tourism, lumbering, and a few wood-product industries. The human population in this area has declined during the last 30 years but has recently leveled off to a density of approximately 8 people per sq. mi. (20.72 people per sq. km).

Climate

Winters are long and severe and summers are short and cool. The

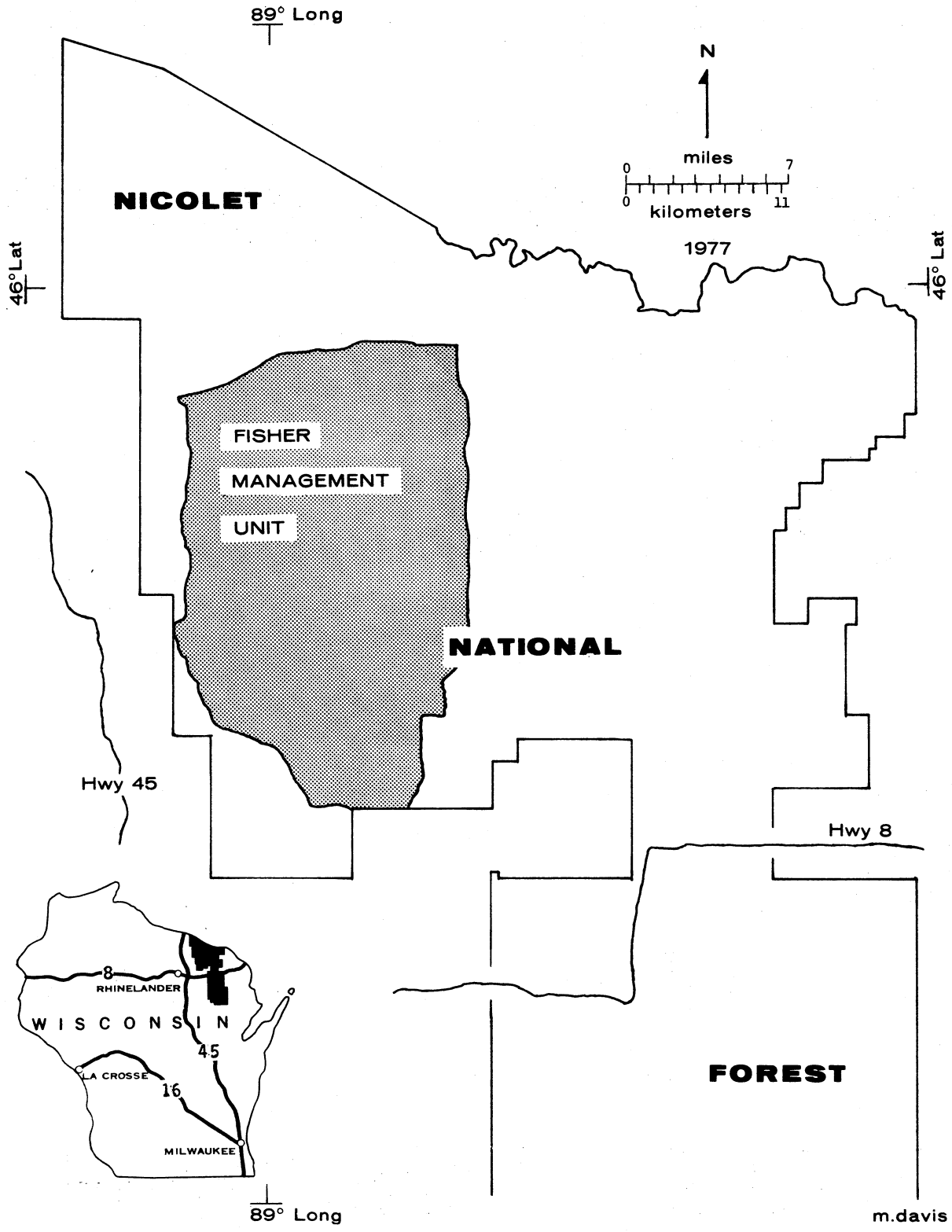

Fig. 1. Fisher Management Unit, Nicolet National Forest, Wisconsin.

precipitation norm is 30 in. (76.2 cm) per year and the average snow fall is 50-60 in. (127.0-152.4 cm). The average January temperature is 12.6°F (-10.8°C), the average July temperature is 66°F (18.7°C), and the average annual temperature is 39.7°F (4.3°C).

Vegetation

The FMU contains a variety of habitats differing in composition, age, and size. Large homogeneous stands are not characteristic of this area. Parallel northeast-southwest ridges are separated by lowlands. Mixed stands of aspen (Populus spp.), paper birch (Betula papyrifera), maple (Acer spp.) - beech (Fagus grandifolia) - birch (Betula spp.) (northern hardwoods), tamarack (Larix laricina), muskeg, white spruce (Picea glauca), black spruce (Picea mariana), lowland brush, white cedar (Thuja occidentalis), balsam fir (Abies balsamea), and white, jack and red pine (Pinus strobus, P. banksiana, P. resinosa) cover the area. (Nomenclature is according to Gleason 1952). The present distribution and condition of these stands are a result of extensive cutting and subsequent fires between 1870 and 1920.

Curtis (1959) described the original forest types (1840) of this area as follows:

> The wet land contained either conifer swamps dominated by tamarack, black spruce and white cedar, or hardwood swamps with black ash and yellow birch. The dry lands were dominated by pine, with jack and red pines on the lighter sands and white pine on the sandy loams. The heavier soils were typically covered by mixed conifer-hardwoods with white pine, hemlock, balsam fir, and white spruce as the conifers, and sugar maple, basswood, yellow birch, beech, American elm, red oak, and ironwood as the deciduous species. Some boreal forest stands of spruce and fir were found in the coldest localities.

Several investigators report the association of pine marten with

mature growths of mixed or coniferous composition (Thompson 1948, Marshall 1951a, deVos and Guenther 1952, Koehler et al. 1975). This relation is not well understood. Newby and Hawley (1954), working in Glacier National Park, found that:

> Although climax vegetation for most of the area is spruce-fir (Picea engelmanni-Abies lasiocarpa) very little of this vegetation is now present. Recurrent forest fires on various exposures have created a high degree of interspersion of seral stages and age classes.

Fire and logging are often cited as having caused the disappearance of the pine marten from much of its range. The affects of disturbance vary with the size and intensity of the disturbance. Koehler et al. (1975) believed that a diversity of forest communities may produce more pine marten over time.

METHODS

Capture to Release

One hundred thirty pine marten were transported by airplane from Ontario to Rhinelander, Wisconsin. Thirty-four pine marten (26 males: 8 females) were received by October 20, 1975; they were live-trapped in the Chapleau Crown Game Preserve (near Wawa, Ontario). Ninety-six pine marten (74 males: 21 females: 1 unknown) were obtained from the Algonquin Provincial Park between December 15, 1975 and April 2, 1976. Six animals (3 males: 2 females: 1 unknown) died in Rhinelander prior to release into the FMU. One hundred twenty-four pine marten (97 males: 27 females) were thus released into the FMU in ten separate releases between January 29, 1975 and April 3, 1976. The original stocking plan

called for the reintroduction of 100 pine marten (50 males: 50 females) into the FMU between January 1 and March 31, 1975.

Individual pine marten were held in captivity in Ontario for an unknown length of time. Many died before shipment to Rhinelander. The causes of mortality were unknown but poor husbandry practices were thought to have been a major facotr. The number and sex ratio of the animals that died was not known. An antibiotic (tetracycline) was sent to the Algonquin trapping operation, beginning with Release Number 8, for administration to the captive pine marten between the time of live-trapping and shipment to Rhinelander. It is not known whether the tetracycline reduced mortality.

All pine marten were ear-tagged within 24 hours of their arrival in Rhinelander. They were kept in an unheated garage when held overnight, and were watered and fed venison from road-killed deer; their bedding was changed if it was wet. Pine marten which appeared in poor health were held in captivity in pens in an unheated garage, fed as much food as they would eat, and administered tetracycline mixed with strawberry jam.

Pine marten were removed from their shipping cages by a person wearing heavy leather gloves and were placed in an animal handling cone. The animal was then weighed and tagged in each ear with return-tags. The National Band and Tag Co. (Newport, Kentucky) produced the tags (Jiffy wing bands #1005, size-3). Individual pine marten were named by a four-digit code; M=male or F=female and the last 3 digits were the right ear-tag number (e.g., M-001). Data recorded from each pine marten prior to release in the FMU were weight, age, sex, tooth wear, physical condition, date of arrival, date of release, type of release, and location of release.

Tooth wear was not used for age determination because of the unnatural wear which may have resulted from the animals gnawing on their shipping cages. Sex was determined by palpation for a baculum. Several investigators report that pine marten can be sexed by overall size and appearance. This technique was found unreliable and therefore was not used.

Reliable aging techniques for live pine marten are limited, especially for females. Attempts were made to separate females into juvenile and adult classes based on development of the sagittal crest. Marshall (1951b) reported that uncleaned female pine marten skulls, lacking the sagittal crest, were immature and those with a sagittal crest were adult. However, he suggests that not all adult females develop prominent sagittal crests. Males were aged on the basis of sagittal crest development and relative size of the baculum (Marshall 1951b).

Twenty-one pine marten, selected for radio-tagging, were anesthetized with ether while in the handling come. A 1-gallon (3.78 liter) plastic jar with puncture holes in the base, and containing cotton saturated with ether, was slipped over the handling cone. A plastic bag, taped to the rim of the jar directed the fumes to the pine marten. Animals were kept in the ether chamber until their legs offered no response to touch (approximately 3 min.). The pine marten were still conscious, but groggy, when removed from the cone.

Pulsing radio-tags (Model BU) were purchased from AVM Instrument Co. (Champaign, IL). The package contained a SB21V transmitter with a RM 660 mallory battery. The mean weight of the unfitted radio-tags was 0.05 lb. (21.6 g) (n=15) which was 2.8 percent of the mean male weight ($\bar{X}$=1.71 lb. [776.3 g]; n=97) and 4.1 percent of the mean female weight

($\bar{X}$=1.16 lb. [528.4 g]; n=27). The radio-tags were adjustable from 4.50 to 5.25 in. (11.4 to 13.3 cm) in circumference and fitted snugly around the neck of the animal. Once fitted, the collar was bolted together with a brass bolt and nut. Radio-tagged pine marten were allowed to completely recover from the anesthetic before release (2-3 hr.).

The bolt on the radio-tags was covered with dental acrylic on the seven animals (5 males: 2 females) radio-tagged in Release Numbers 1, 2, and 3. One of these pine marten (F-032) was live-trapped 161 days after attachment of the radio-tag. She had severe injury in the neck area because of irritation from the radio-tag. The brass antenna loop had been twisted and the protective padding slipped out from underneath allowing the edge of the antenna loop to cut into the neck of the pine marten. The radio-tag was removed and the wound treated with nitrofurazone. F-032 was kept in captivity until the wound healed (15 days)) and was then **released with an improved radio-tag.**

The bolt and entire brass antenna loop of the improved radio-tag, placed on F-032 and the radio-tags placed on all subsequent pine marten, was completely covered with dental acrylic, forming a solid one-piece loop. Four pine marten (M-132, F-088, F-158, and F-216) were live-trapped at the termination of the study to recover their radio-tags. The radio-tags had been attached for 113, 162, 73, and 71 days, respectively. No sign of injury to their necks was visible. However, the dental acrylic on the radio-tag attached for 113 days was cracked. Once cracked, the dental acrylic may readily chip off; allowing the brass antenna loop the flexibility to twist and potentially injure the neck.

Two temporary, short-life radio-tags (SM1 transmitter and RM 640 mallory battery) were constructed at the University of Wisconsin- Stevens

Point and placed on two pine marten radio-tagged in the first release.

Release

The reintroduced pine marten were set free by two techniques. "Quick-release" pine marten were released directly from their shipping containers at one of four quick-release sites (Fig. 2) within 24 hours of their arrival. Three carcasses of road-killed deer were planted at quick-release site-I prior to Release Number 1 and 2.

"Gentle-release" pine marten were retained in 3 ft. x 4 ft. x 6 ft. (0.91 m x 1.22 m x 1.83 m) holding pens which had been placed in select sites throughout the FMU (Fig. 2). Pens were placed in coniferous cover-types and the top of the pens were covered with tree branches if there was not 100 percent cover over the pens. Holding pens were constructed of chickenwire on a wood frame and contained a nest box filled with wood shavings. Pine marten were retained in the holding pens for approximately 7 days. They were watered, fed venison, and administered tetracycline mixed with strawberry jam. Food for at least 5 days was placed in the pens and cage doors were unlatched the day before release. Fishing line was tied to the doors so that they could be opened the next day without the animal observing any human activity. The pine marten opened the doors and released themselves in most instances.

All non-radio-tagged females were gentle-released beginning with Release Number 4. All non-radio-tagged males were quick-released except those that appeared in poor health. Eighty-nine males were quick-released and 8 males were gentle-released; 9 females were quick-released and 18 females were gentle-released.

Five quick-release males, 4 gentle-release males, 5 quick-release

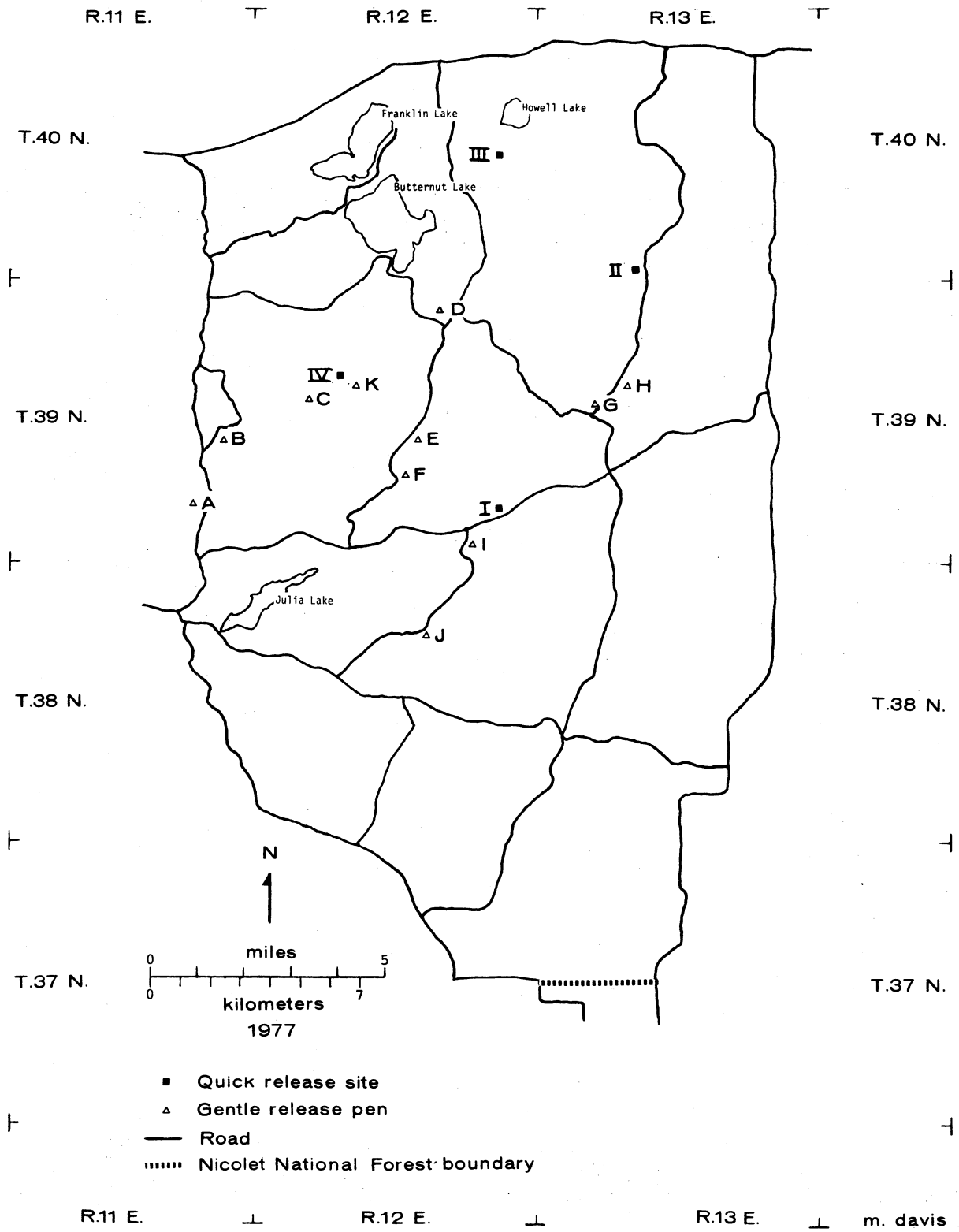

Fig. 2. Pine marten release sites in the Fisher Management Unit.

females and 6 gentle-release females were radio-tagged prior to release. One quick-release female (F-138) was radio-tagged when she was live-trapped 381 days after release. Post-release movements of the radio-tagged animals were compared 30 days after release to determine if gentle-release pens reduced post-release movements.

Radio-tracking

Radio-tagged pine marten were followed using standard tracking techniques (Brander and Cochran 1971). Aerial locations of the pine marten were obtained using two four-element antennas, each mounted on a wing-strut of a Cesna 172 airplane. Antenna wires junctioned at a switch box, connected to a receiver, in the cabin of the airplane. The receiver (Model LA 12), the two antennas, and the switch box were purchased from AVM Instrument Co.

Aerial searches were conducted at 5000 ft. (1524 m) above ground level (AGL), and air-to-ground range was 4 to 10 mi. (6.44 to 16.09 km). Locations were obtained by flying aerial transects 5 mi. (8.04 km) apart radiating out from the previously known location. Aircraft altitude was decreased to 500 ft. (152.4 m) AGL once a signal was located. Decreasing concentric circles were then flown, keeping the signal on the same side of the aircraft.

Aerial locations varied in accuracy from 2 to 40 A. (0.81 to 16.19 ha) depending upon turbulence, cloud cover, distinguishable vegetative features at the location site, and experience of the pilot. Two hundred and eighty-nine hours were flown and 286 aerial radio locations were plotted.

Ground-to-ground locations were obtained using the null method

(Cochran and Lord 1963) with an 11 ft. (3.35 m), 8-element (HyGain Model 28) yagii antenna mounted on a 10 ft. (3.05 m) mast, set in a tripod on a truck bed. Range varied from 1 to 3 mi. (1.61 to 4.83 km) and locations were accurate to 26 A. (10.52 ha). Accuracy was determined by triangulating on radio-tagged pine marten at known locations. Error can partially be attributed to terrain, dense vegetative cover, animal activity and time lag between triagulation fixes (Tester and Siniff 1965).

Triangulation locations were selective for inactive animals. Signal intensity from the radio-tags fluctuated so much when the animals were active that reliable nulls could not be obtained. Two hundred fifty-seven successful ground locations were plotted by triangulation.

Visual observations of individual pine marten were obtained with a 3-element hand-held antenna (HyGain Model 23). One hundred four hand-held locations were determined.

Date, time (central standard), activity, signal quality, type of location (aerial, triangulation, hand-held), and weather conditions were recorded for the radio locations of each animal. Locations within the Nicolet National Forest were plotted on USDA Forest Service Timber Survey Maps which are cover-type maps of the public land within the National Forest boundaries.

Radio locations outside of the Nicolet National Forest were plotted on county maps, Wisconsin State Forest Maps, or Ottawa National Forest Timber Survey Maps. Distance from release site and distance from last location were also determined from these maps.

Initial post-release movements of the reintroduced radio-tagged pine marten were monitored by aircraft. Locations were obtained by ground triangulation after the individual pine marten appeared to settle down in

the FMU. Some locations were obtained by aircraft where road access was limited.

Tomahawk National live-traps (#206) were used to live-trap radio-tagged pine marten to replace spent batteries in the radio-tag and to remove radio-tags at the termination of the project. Venison was used for bait. Radio-contact was lost with 12 of the 21 radio-tagged pine marten, preventing removal of the radio-tag.

Analysis

Six hundred forty-seven radio locations were plotted on cover-type maps. Cover-type composition at the radio locations was analyzed by importance values (Cox 1976). The following modifications were made for calculating importance values:

1) Density = total number of times a particular cover-type occurred/total acres (ha) of all stands,

2) Dominance = total number of acres (ha) of a particular cover-type/total acres (ha) of all habitat types, and

3) Frequency = number of plots in which a particular cover-type occurred/total number of plots.

The 37 different cover-types on the survey maps were combined in two manners for pine marten habitat use analysis. Combined Habitat I was used to evaluate individual pine marten habitat use and grouped the 37 cover-types into nine distinct categories: hardwood, swamp conifer, spruce-fir, swamp-muskeg, private land, aspen, openings, pine, and water (Table 1). Combined Habitat II was used to delineate broad habitat types utilized by the reintroduced pine marten and grouped the same 37 cover-types into five general categories: deciduous, lowland conifer, upland conifer, miscellaneous, and open upland (Table 2).

Table 1. Combined habitat names and their component habitat types for Combined-Habitat I.

Combined habitat name	Component cover-types[a]
Hardwood	Paper Birch, Black Cherry, Swamp Hardwoods, Oak-Hickory, Pin Oak, Maple-Beech-Birch, Cove Hardwoods, Post, Blackjack or Bear Oak, Oak-Pine
Swamp Conifer	Mixed Swamp Conifers, Red or White Cedar, Tamarack, Black or Red Spruce
Spruce-Fir	Spruce-Fir, White Spruce, Hemlock
Swamp-Muskeg	Lowland brush, Sphagnum swamp, Muskeg
Private Land	Land not cover-typed, Gravel pit
Openings	Local use, Open, Upland brush, Clearcuts, Wildlife opening
Aspen	Aspen
Pine	Red Pine, White Pine, Jack Pine, Southern Pine
Water	Water

[a]Obtained from USDA Forest Service Timber Survey Maps.

Table 2. Combined habitat names and their component habitat types for Combined-Habitat II.

Combined habitat name	Component cover-types[a]
Deciduous	Aspen, Paper Birch, Black Cherry, Swamp Hardwoods, Oak-Hickory, Maple-Beech-Birch, Pin Oak, Cove Hardwoods, Post, Blackjack or Bear Oak, Oak-Pine
Lowland Conifer	Red or White Cedar, Mixed Swamp Conifers, Black or Red Spruce, Tamarack, Muskeg, Lowland brush, Sphagnum swamp
Upland Conifer	Spruce-Fir, White Spruce, Hemlock, Jack Pine, Southern Pine, Red Pine, White Pine
Miscellaneous	Water, Private land (not cover-typed), Gravel pit
Open Upland	Local use, Open, Upland brush, Clearcuts, Wildlife openings

[a]Obtained from USDA Forest Service Timber Survey Maps.

Survey maps from 1964 were used in the habitat analysis. The Forest Service had not completed the 1974 survey maps for the entire FMU at the time of this study. The area inhabited by F-032 had been resurveyed and the habitat types had not changed appreciably. Combined Habitat I importance values and ranks between that area inhabited by F-032 (n=156) on 1964 and 1974 surveys are almost identical (Fig. 3). Differences between the 1964 and 1974 surveys are less for Combined Habitat II for the area inhabited by F-032.

Habitat importance values and ranks were calculated for the radio locations of individual pine marten and for all radio locations combined. Locations were separated into two catagories; locations with snow cover on the ground (snow) and locations with no-snow cover on the ground (no-snow). Importance values and ranks were calculated from separate and combined snow and no-snow cover data. Importance values and ranks were calculated for all the radio locations between 1000 hrs. and 1500 hrs. and for those after 1500 hrs. and before 1000 hrs. Importance values and ranks were also calculated for those radio-locations less than or equal to 6 acres (2.43 ha) in size to reduce possible error induced by the increased number of different habitat types contained in larger radio-locations.

Habitat availability or expected habitat importance values and ranks in the FMU were determined from 96 random locations. The locations varied in size from 1 to 40 A. (0.40 to 16.19 ha) and were selected from line transects throughout the FMU. Pine marten habitat importance values and ranks were compared with expected importance values and ranks.

A T-test statistic was used to evaluate: 1) distance from release site, 2) mean of all distances from the release site, and 3) mean dis-

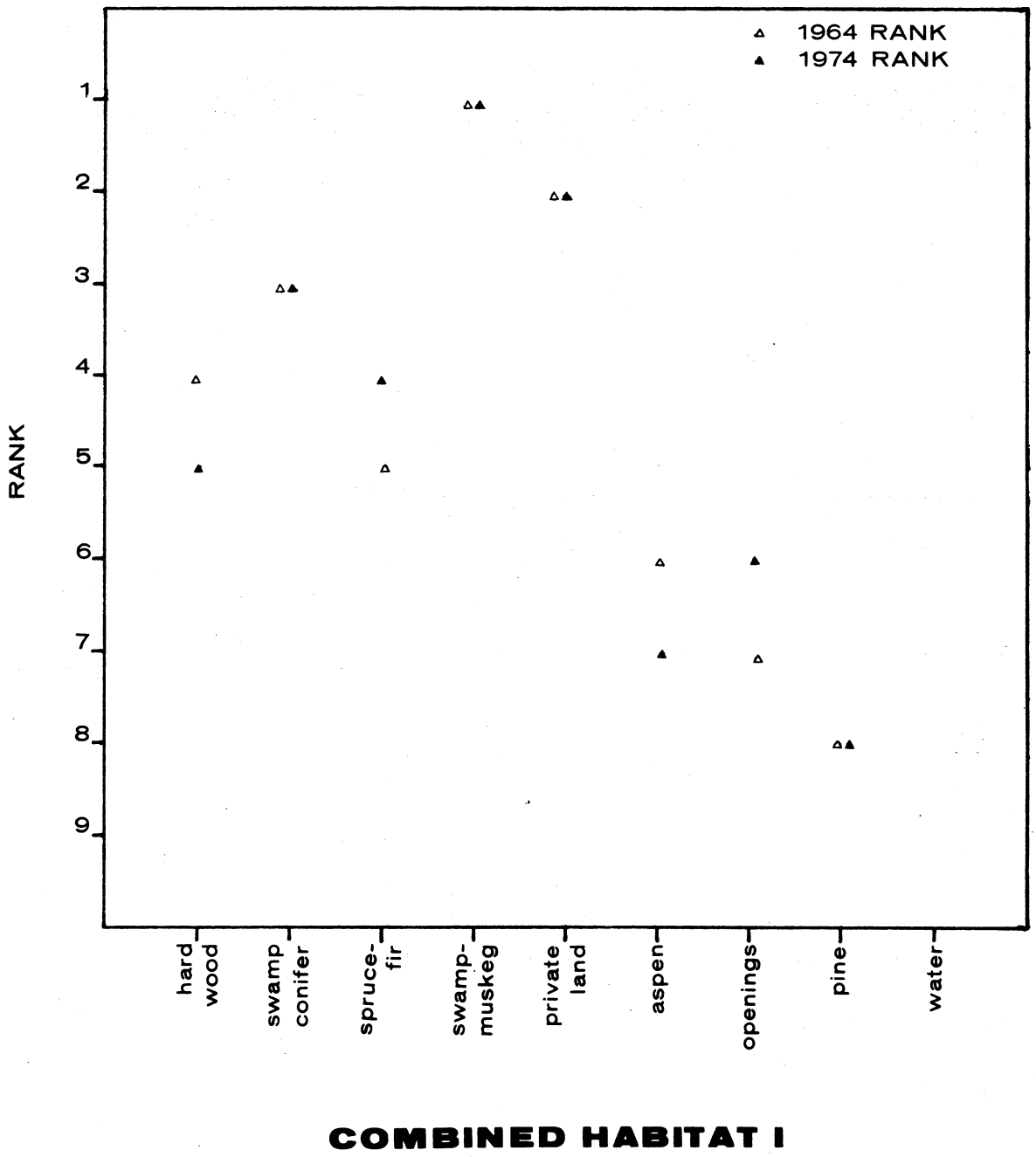

Fig. 3. Importance value ranks (Combined Habitat I) of habitat used by female pine marten F-032 from 1964 and 1974 Forest Service Timber Survey Maps.

tance from last location for gentle versus quick-released pine marten 30 days after release.

Home range was determined by connecting the outside points of location and measuring the area within with a planimeter (Mohr and Stumpf 1966, Hayne 1949, Hawley and Newby 1957, Cranford 1977).

RESULTS AND DISCUSSION

Physical Condition Prior to Release

The pine marten from the Chapleau Crown Game Preserve were in good health but the physical condition of the animals from the Algonquin Provincial Park was highly variable. Damaged dentition was noticed in the first shipment from Algonquin and subsequent pine marten were then examined for dental damage. Sixty-six of the 92 pine marten examined had canines which were broken or worn beyond that which was considered normal wear (Table 3). This dental damage is believed to have been caused by pine marten grinding their teeth on the welded wire Tomahawk National live-traps which were used for live-traps, holding cages, and shipping containers for the Algonquin shipments. Some game farm mink, in cages enroute to mink shows, damage their dentition so badly that they cannot be entered in competition (Geiger, personal communication, Geiger Mink Ranch, Mosinee, Wisc.). A pine marten's chances for survival are undoubtedly reduced by damaged or worn teeth.

Average weight for the 97 released males was 1.71 lb. (776.3 g) (S.D.= 0.25 lb. [114.4 g];Range= 1.17-2.35 lb. [531.0-1068.7 g]) and was 1.16 lb. (528.4 g) (S.D.= 0.24 lb. [106.8 g]; Range= 0.89-1.76 lb [404.2-800.0 g]) for the 27 released females (Table 4). Juveniles and

Table 3. Condition of the dentition for 124 pine marten released into the Fisher Management Unit of the Nicolet National Forest.

Code	Condition of dentition	Number of animals
1	good condition	26
2	1-2 canines worn or broken	18
3	1-2 canines worn and 1-2 canines broken or stubs	12
4	3-4 canines broken or worn to gums	17
5	canines gone; raw gums	13
6	all canines worn but intact	6
Unk[a]	condition of dentition not noted	32
		Total=124

[a]The pine marten were in good physical condition and were set free in Release Numbers 1,2,3, and 4.

Table 4. Release data for 130 pine marten received from Ontario, Canada.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of release[b]	Release site/pen[c]
Release Number-1. (Pine marten received Jan. 28, 1975 from Chapleau Crown Game Preserve.)							
001[d]	002	M	0.90kg[e]	Unk	Unk	Quick	I
003	004	F	0.50kg	Unk	Unk	Quick	I
005	006	F	0.80kg	Unk	Unk	Quick	I
007	008	M	0.90kg	Unk	Unk	Quick	I
009	010	M	0.80kg	Unk	Unk	Quick	I
011	012	F	0.65kg	Unk	Unk	Quick	I
013	014	M	0.80kg	Unk	Unk	Quick	I
015[d]	016 138[f]	M	0.65kg	Unk	Unk	Quick	I
Release Number-2. (Pine marten received Feb. 27, 1975 from Chapleau Crown Game Preserve.)							
017[d]	018	M	0.80kg[e]	Unk	Unk	Quick	I
019	020	M	0.95kg	Unk	Unk	Quick	I
022	021	M	0.85kg	Unk	Unk	Quick	I
023	024	M	0.85kg	Unk	Unk	Quick	I
026	025	M	0.85kg	Unk	Unk	Quick	I
027	028	M	0.90kg	Juv	Unk	Quick	I
029	030	M	0.90kg	Juv	Unk	Quick	I
032[d]	031	F	0.50kg	Unk	Unk	Quick	I
033	034	F[g]	0.50kg	Unk	Unk	Quick	I
035	036	M	0.70kg	Unk	Unk	Quick	I
037	038	M	0.75kg	Unk	Unk	Quick	I
040	039	F	0.75kg	Unk	Unk	Quick	I

Table 4, Continued.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of release[b]	Release site/pen[c]
Release Number-3. (Pine marten received Apr. 3, 1975 from Chapleau Crown Game Preserve.)							
042	041	M	600.3g	Unk	Unk	Quick	IV
043[d]	044	M	775.6g	Unk	Unk	Quick	IV
046	045	M	779.2g	Unk	Unk	Quick	IV
048	047	M	886.2g	Unk	Unk	Quick	IV
050	049	M	705.6g	Unk	Unk	Quick	IV
051[d]	052	F	545.0g	Unk	Unk	Quick	IV
053[d]	054	M	831.4g	Unk	Unk	Quick	IV
Release Number-4. (Pine marten received Oct. 20, 1975 from Chapleau Crown Game Preserve.)							
056	055	M	1004.0g	Juv	4	Quick	III
058[d]	057	M	953.0g	Ad	Unk	Gentle	C
060[d]	061	F	627.6g	Juv	Unk	Gentle	B
062	063	M	700.1g	Juv	Unk	Quick	III
064	065	M	904.5g	Juv	Unk	Quick	III
066	067	M	913.4g	Juv	Unk	Quick	III
068	069	M	876.9g	Juv	Unk	Quick	III
Release Number-5. (Pine marten received Dec. 16, 1975 from Algonquin Provincial Park.)							
070	071	M	831.1g	Ad	1	Quick	II
072	073	M	628.5g	Ad	1	Quick	II
075	074	M	682.1g	Ad	5	Quick	II
076	077	M	729.6g	Ad	3	Quick	II
078[d]	079	F	652.3g	Ad	1	Gentle	E
080	081	M	722.7g	Ad	5	Quick	II
083[d]	082	F	404.2g	Juv	2	Gentle	A
084	085	M	627.8g	Ad	5	Quick	II
086	087	M	688.2g	Ad	3	Gentle	K

Table 4, Continued.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of release[b]	Release site/pen[c]
088[d]	089	F	439.5g	Juv	6	Gentle	B
090	091	M	834.3g	Juv	1	Quick	II
092	093	M	553.8g	Juv	1	Quick	II
095[d]	094	F	456.1g	Juv	3	Gentle	C
096	097	M	746.5g	Ad	6	Quick	II
098	099	M	719.3g	Juv	6	Quick	II
100	101	M	767.4g	Ad	6	Quick	II
102	103	M	664.6g	Ad	2	Quick	II
105	104	M	726.4g	Ad	6	Quick	II
106[d]	107	F	476.3g	Juv	4	Gentle	F
108[d]	109	M	632.7g	Ad	3	Gentle	D
110	111	M	698.4g	Juv	2	Quick	II
112	113	M	654.7g	Juv	2	Quick	II
		Unk[g]					
Release Number-6. (Pine marten received Jan. 16, 1976 from Algonquin Provincial Park.)							
115	114	M	614.5g	Ad	5	Gentle	B
116	117	M	577.2g	Juv	5	Gentle	C
118	119	M	612.9g	Juv	5	Gentle	K
		M[g]					
		M[g]					
		F[g]					
Release Number-7. (Pine marten received Feb. 12, 1976 from Algonquin Provincial Park.)							
120	121	M	531.0g	Juv	4	Quick	P-FMU
122	123	M	751.7g	Ad	2	Quick	P-FMU
124	125	M	719.3g	Ad	3	Quick	P-FMU
126[d]	127	M	745.0g	Ad	4	Gentle	F

Table 4, Continued.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of Release[b]	Release site/pen[c]
128	129	M	599.6g	Ad	3	Quick	P-FMU
130	131	M	976.5g	Ad	1	Quick	P-FMU
257[dh]	256	M	821.5g	Ad	1	Gentle	D
134	135	F	421.3g	Juv	2	Gentle	J
136	137	M	560.3g	Juv	2	Quick	P-FMU
Release Number-8. (Pine marten received Mar. 14, 1976 from Algonquin Provincial Park.)							
140	139	M	797.2g	Ad	3	Quick	III
142	141	M	726.3g	Ad	3	Quick	P-FMU
144	143	M	696.2g	Ad	3	Quick	IV
146	145	M	818.0g	Ad	3	Quick	P-FMU
148	147	M[g]	810.0g	Ad	4	Quick	
150	149	M	764.3g	Ad	1	Quick	IV
152	151	M	829.6g	Ad	2	Quick	IV
154	153	M	586.5g	Ad	4	Quick	P-FMU
156	155	M	731.2g	Ad	4	Quick	III
158[d]	157	F	596.0g	Juv	6	Quick	I
160	159	M	744.6g	Ad	5	Quick	IV
162	161	F	418.7g	Juv	1	Gentle	H
164	163	M	569.6g	Juv	4	Quick	IV
166	165	M	851.7g	Ad	5	Quick	IV
168	167	F	466.9g	Juv	4	Gentle	G
170	169	M	624.8g	Juv	4	Quick	III
172	171	F	491.7g	Juv	1	Gentle	I
174	173	M	815.3g	Juv	5	Quick	P-FMU
176	175	M	708.6g	Juv	5	Quick	P-FMU
178	177	M	772.8g	Ad	4	Quick	P-FMU
180[d]	179	F	474.8g	Juv	1	Quick	I
182	181	F	472.4g	Juv	1	Gentle	J

Table 4, Continued.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of release[b]	Release site/pen[c]
Release Number-9. (Pine marten received Mar. 25, 1976 from Algonquin Provincial Park.)							
184	183	M	735.4g	Juv	1	Quick	P-FMU
186	185	M	954.0g	Ad	5	Quick	P-FMU
188	187	M	815.6g	Ad	1	Quick	P-FMU
190	189	M	837.4g	Ad	1	Quick	P-FMU
192	191	M	776.6g	Juv	1	Quick	P-FMU
194	193	M	608.2g	Juv	1	Quick	P-FMU
196	195	M	937.3g	Ad	5	Quick	P-FMU
198	197	M	761.8g	Ad	2	Quick	P-FMU
200	199	M	737.5g	Juv	1	Quick	P-FMU
202	201	M	735.9g	Ad	1	Quick	P-FMU
204	203	M	826.2g	Ad	1	Quick	P-FMU
206	205	M	833.0g	Ad	2	Quick	P-FMU
209	207	M	793.9g	Ad	1	Quick	P-FMU
210	211	M	857.9g	Ad	2	Quick	P-FMU
212	213	F	414.3g	Juv	4	Gentle	F
214	215	F	449.4g	Juv	1	Gentle	E
216[d]	217	F	499.1g	Juv	2	Quick	I
218	219	F	473.4g	Juv	4	Gentle	D
220	221	F	469.5g	Juv	1	Gentle	B
Release Number-10. (Pine marten received Apr. 2, 1976 fron Algonquin Provincial Park.[i])							
222	223	M	743.6g	Juv	3	Quick	II
224	225	M	918.5g	Ad	2	Quick	II
226	227	F	534.1g	Juv	1	Gentle	G
228	229	M	800.0g	Ad	2	Quick	II
230	231	F	543.0g	Juv	2	Gentle	H
232	233	M	1068.7g	Ad	2	Quick	II
234	235	M	660.0g	Ad	3	Quick	II

Table 4, Continued.

Ear Tags Right	Ear Tags Left	Sex	Weight	Age	Condition of dentition[a]	Type of Release[b]	Release site/pen[c]
236	237	F	742.0g	Juv	4	Gentle	I
238	239	M	890.1g	Ad	4	Quick	II
241	240	M	970.4g	Ad	2	Quick	II
242	243	M	800.0g	Ad	4	Quick	II
244	245	M	934.5g	Ad	5	Quick	II
246	247	M	865.2g	Ad	2	Quick	II
248	249	M	821.2g	Juv	1	Quick	II
250	251	M	852.5g	Ad	4	Quick	II
252	253	M	935.8g	Ad	4	Quick	II
254	255	M	818.6g	Ad	1	Quick	II

[a]See Table 3 for explanation of dentition codes.
[b]Quick-release animals were released from their shipping containers within 24 hours of arrival; Gentle-release animals were retained in gentle-release pens for a minimum of 7 days after arrival.
[c]The locations of quick-release sites and gentle-release pens are shown in Fig. 2. The locations, for the males released along the periphery of the Fisher Management Unit (P-FMU), are not shown in Fig. 2.
[d]Radio-tagged.
[e]Weighed with a spring scale; accurate to 25g.
[f]A female pine marten was live-trapped 381 days after release; both ear-tags were ripped out. This animal was either F-003 or F-011 because the status an location of all other reintroduced females was known. The animal was re-tagged in the left ear, radio-tagged, and released at the trap site.
[g]Died before release.
[h]Orginal tags (Right = 132; Left = 133) were ripped out; re-tagged when radio-tag was removed at termination of study.
[i]Source of this shipment was unclear; some pine marten may have been from the Chapleau Crown Game Preserve.

adults were not separated in this calculation because all reintroduced animals were a minimum of 6 months old. Pine marten reach adult weight 3 months after birth (Brassard and Bernard 1939, Newby and Hawley 1954). There was a significant difference ($P < 0.001$) between male and female weights. Mean weight for the male pine marten was 47 percent more than the mean weight for females. Newby and Hawley (1954) found a 59 percent difference and deVos (1952) found a 55 percent difference between the mean weights of male and female pine marten in Montana and Ontario, respectively. The poor physical condition of many of the reintroduced pine marten may have caused the decrease in the percent difference between mean male and female weights.

The weight gains of pine marten held in pens because they appeared in poor health on arrival were phenomenal. M-108, M-141, and M-153 weree kept in captivity 15, 11, and 11 days, respectively. M-108 gained 0.41 lb. (187.9 g) (29.7 percent of his original body weight), and M-153 gained 0.22 lb. (100.8 g) (13.2 percent of his original body weight), and M-153 gained 0.82 lb. (371.6 g) (63.4 percent of his original body weight). Newby and Hawley (1954) report that an adult male lost 0.38 lb. (175 g) in one day and a juvenile male lost 0.44 lb. (200 g) during a 2-week period of frequent captures. Retaining reintroduced pine marten in gentle-release pens to replace depleted weight reserves may increase chances of survival after release. Gentle-release pens were inspected for signs of damage when the pine marten were fed and watered. Pine marten were promptly released to avoid additional tooth wear when kinked pen wire and teeth marks on the wood frame were observed.

The initial condition of some pine marten was poor, but most animals quickly recovered any weight loss. Three quick-release and two

gentle-release pine marten were weighed 71, 73, 113, 162, and 226 days after release. All showed at least a 16 percent increase in weight; the two gentle-release pine marten showed the largest percent increase (30.0 and 38.7 percent) (Table 5).

Twenty-six males were juveniles, 53 were adult, and 18 were not aged. Nineteen females were juveniles, 1 was adult, and 7 were not aged (Table 4). The unbalanced sex and age ratios of the reintroduced population was a product of a difference in vulnerability to live-trapping at different times of the year and mortality before shipment to Rhinelander.

The ears of seven pine marten were examined 71, 73, 113, 162, 226, 381, and 391 days after being tagged. The ears showed no sign of infection. Two animals, examined 113 and 381 days after attachment of the ear-tags, had ripped out both tags.

Post-release mortality

At least 5 pine marten died after release. The carcass of M-017 was recovered 40 days after release; he had been dead a maximum of 4 days when recovered. The head, feet, tail, and radio-tag were intact but the trunk of the animal was missing and the vertebral column had been picked clean. An owl pellet near the carcass and the condition of the vertebrae indicated an avian predator.

One female (F-060) was recovered 14 days after release. She was found, head down, in the cavity of a tree and had been dead a maximum of 4 days when recovered. A necropsy revealed that the animal had a broken neck and had died of a ruptured aorta, a condition not common in mammals. Her body condition was good at the time of death. She may have wedged

Table 5. Post-release weight changes for six pine marten released into the Fisher Management Unit of the Nicolet National Forest.

Pine marten	Initial weight lb.	Initial weight g	Date	Release method	Second weight lb.	Second weight g	Date	Weight change lb.	Weight change g	Weight change %[a]
M-132	1.81	821.5	Feb 12, 1976	Gentle	2.35	1068.1	Jun 4, 1976 (113)[b]	+0.54	+246.6	30.0
F-032	1.10	500.0[c]	Feb 27, 1975	Quick	1.28	580.0[d]	Oct 10, 1976 (226)	+0.18	+ 80.0	16.0
F-088	0.97	439.5	Dec 16, 1975	Gentle	1.34	609.5	May 26, 1976 (162)	+0.37	+170.0	38.7
F-158	1.31	596.0	Mar 14, 1976	Quick	1.53	695.5	May 26, 1976 (73)	+0.22	+ 99.5	16.7
F-216	1.10	499.1	Mar 25, 1976	Quick	1.38	626.5	Jun 4, 1976 (71)	+0.28	+127.4	25.5

[a]Percent difference between initial and second weight.
[b]Number of days since initial weight.
[c]Weighed with a spring scale - accurate to 25 g.
[d]Pine marten had an infected neck due to collar irritation.

the solid loop of the radio-tag in the cavity, broken her neck trying to free herself, and in the process, ruptured her aorta.

F-106 chewed her way out of a gentle-release pen. She was observed running across a road 0.32 mi. (0.52 km) from the release pen 5 days after confinement. I approached to within 20 ft. (6.10 km) and she appeared in good health. Her radio-tag was recovered 8 days later near a pile of slash, in a clear-cut operation, 2.71 mi. (4.36 km) from the release pen. No part of the pine marten was found and she was therefore assumed to be a victim of predation. The dental acrylic on the brass antenna loop of the radio-tag was chipped off and there were two dents on opposing sides of the antenna loop. This death was attributed to a canid.

Two non-radio-tagged males died. One (M-115) was shot by a local resident and one (M-160) died when live-trapped on the FMU during sub-zero weather.

Documented records of predation on native pine marten are scarce. Radio-tagged pine marten were vulnerable to raptor and canid predators. Predators killed 40 percent or two of the five pine marten recovered dead. Thus two of the 20 pine marten (10 percent) which were radio-tracked more than 2 days were killed by predators. Predation had a small impact on the entire reintroduction program.

Movements

Three post-release movement classifications, exploratory, wandering, and sedentary, are used in this study. Hawley and Newby (1957) stated that the composition of a native pine marten population in Montana continually changed through the loss and gain of individuals. They recognized three categories of animals based on movements deter-

mined by live-trapping:

1) Transients were present for no longer than 1 week,
2) Temporary residents were present over a period longer than 1 week but shorter than 3 months, and
3) Residents were present for 3 months or longer.

These three categories are analogous to the three post-release movement classifications (exploratory, wandering, and sedentary, respectively) used in this study.

Sedentary movements were those within a limited area called the home range. Stickel (1954), working with small mammals, observed that home ranges usually fall within a limited area but occasional movements are at extreme distances.

Exploratory movements in this study included 1) initial post-release movements before the pine marten established a home range, 2) occasional movements outside of the home range (Burt 1943), and 3) continued movements away from the home range. Exploratory movements were not used in the calculation of pine marten home range.

Movements that were not sedentary or exploratory in nature were classified as wandering. Wandering movements were not in a definable home range; each successive movement continued to increase the size of the ploygon home range estimate. All pine marten that exhibited wandering movements remained on the FMU.

Post-release movements of individual pine marten (Table 6) are discussed below according to animal sex and method of release; characteristic movement patterns are mapped.

Quick-release males

The quick-release males M-001, M-015, M-017, M-043, and M-053 were radio tracked for 38, 48, 41, 17, and 57 days, respectively. All, except M-015, made large exploratory movements. The movements of M-015

Table 6. Movements of 21 radio-tagged pine marten released into the Fisher Management Unit of the Nicolet National Forest. Distances are in miles with kilometers in parenthesis.

Pine marten	Length of radio contact	Number of successful radio locations	Maximum distance from release site	Distance from release site at termination of radio contact	Direction of release site at termination of radio contact	Largest one day movement	Fate
M-001	Jan 29,1975 - Mar 8,1975 (38 da)	6	11.56 (18.60)	2.41 (3.88)	159°	0.26 (0.42)	radio contact lost
M-015	Jan 29,1975 - Mar 18,1975 (48 da)	14	1.49 (2.40)	1.08 (1.74)	334°	0.05 (0.08)	radio-tag cracked and fell off
M-017	Feb 28,1975 - Apr 9,1975 (40 da)	20	21.28 (34.24)	21.00 (33.79)	65°	0.59 (0.95)	killed;radio-tag recovered
F-032	Feb 28,1975 - Aug 8,1975 (161 da)	153	2.55 (4.20)	0.70 (1.13)	283°	n/a[a]	live-trapped;radio-tag recovered
	Oct 24,1975 - Dec 7,1975 (44 da)	17	1.89 (3.04)	1.89 (3.04)	268°	n/a[a]	radio contact lost
M-043	Apr 4,1975 - Apr 21,1975 (17 da)	14	22.97 (36.96)	22.97 (36.96)	352°	13.69 (22.03)	radio contact lost
F-051	Apr 4,1975 - May 31,1975 (57 da)	30	31.19 (50.18)	16.25 (26.15)	21°	9.47 (15.24)	radio contact lost
M-053	Apr 4,1975 - May 11,1975 (37 da)	21	46.80 (75.30)	46.80 (75.30)	10°	8.25 (13.27)	radio contact lost
M-058	Nov 2,1975 - Jan 17,1976 (76 da)	21	2.53 (4.07)	1.70 (2.74)	260°	1.81 (2.91)	radio contact lost
F-060	Nov 2,1975 - Nov 16,1975 (14 da)	8	1.55 (2.49)	1.55 (2.49)	213°	0.08 (0.13)	killed;radio-tag recovered
F-078	Jan 1,1976 - May 22,1976 (142 da)	55	45.00 (72.41)	40.12 (64.55)	307°	14.48 (23.30)	radio contact lost
F-083	Jan 1,1976 - Apr 1,1976 (90 da)	25	7.27 (11.70)	7.27 (11.70)	278°	2.81 (4.52)	radio contact lost
F-088	Dec 24,1976 - May 26,1976 (154 da)	53	6.34 (10.20)	4.34 (6.98)	44°	3.91 (6.29)	radio-tag removed
F-095	Jan 1,1976 - Apr 8,1976 (98 da)	27	31.36 (50.46)	31.36 (50.46)	351°	n/a[a]	radio contact lost
F-106	Dec 20,1975 - Dec 30,1975 (10 da)	5	2.71 (4.36)	2.71 (4.36)	132°	0.82 (1.32)	killed;radio-tag recovered
M-108	Jan 7,1976 - Apr 15,1976 (99 da)	28	8.37 (13.47)	5.87 (9.45)	179°	0.15 (0.24)	radio contact lost
M-126	Feb 22,1976 - May 22,1976 (90 da)	29	4.94 (7.95)	4.94 (7.95)	9°	0.13 (0.21)	radio contact lost
M-132	Feb 22,1976 - Jun 4,1976 (103 da)	30	10.36 (16.67)	4.41 (7.10)	212°	9.61 (15.46)	radio-tag removed
F-158	Mar 15,1976 - May 26,1976 (72 da)	31	5.16 (8.30)	2.92 (4.70)	152°	2.17 (3.49)	radio-tag removed
F-180	Mar 15,1976 - Mar 19,1976 (2 da)	2	0.25 (0.40)	0.25 (0.40)	194°	n/a[a]	radio-tag fell off
F-216	Mar 25,1976 - Jun 4,1976 (71 da)	24	9.19 (14.79)	3.99 (6.42)	22°	1.16 (1.87)	radio-tag removed
F-138[b]	Feb 14,1976 - Jun 8,1976 (115 da)	42	3.37 (5.42)	2.12 (3.41)	256°	1.64 (2.64)	radio contact lost

[a]Not applicable; no consecutive daily movement locations were obtained.
[b]Radio-tagged when live-trapped 381 days after release; original ear tags were ripped out. This animal originally was F-003 or F-011 because the status and location of all other reintroduced females was known.

were sedentary and never exceeded 1.49 mi. (2.40 km) from his release site.

M-017 made exploratory movements for 16 days (n=5) and traveled a minimum of 35.75 mi. (57.52 km) (straight line mapped distance between successive movement locations) before becoming sedentary 20.75 mi. (33.39 km) from the release site. M-017 was killed by a predator 24 days after he became sedentary.

M-001, M-043, and M-053 made continuous large exploratory movements. M-001 initially traveled a mimimum of 9.48 mi. (15.25 km) south from the release site but was 2.41 mi. (3.88 km) from the release site when radio contact was lost (n=6). M-043 traveled a minimum of 119.02 mi. (191.50 km) (n=14) in 17 days and was 22.97 mi. (36.96 km) from the release site when radio contact was lost (Fig. 4). M-053 moved a minimum of 88.03 mi. (141.64 km) (n=21) in 38 days and was 46.80 mi. (75.30 km) from the release site when radio contact was lost.

Non-radio-tagged M-009 was live-trapped August 25, 1975, February 16, and February 24, 1976, 0.76 mi. (1.23 km), 0.85 mi. (1.37 km) and 0.80 mi. (1.29 km), respectively, from his release site. The trap sites were within 0.23 mi. (0.37 km) of each other. He was trapped 208, 383, and 391 days after his quick-release from Release Site I (Fig. 5).

Gentle-release males

The gentle-release males M-058, M-108, M-126, and M-132 were radio tracked for 76, 99, 90, and 103 days respectively. M-058 was sedentary throughout the 76 days of radio contact (n=21). No movements exceeded 2.53 mi. (4.07 km) from gentle release pen B.

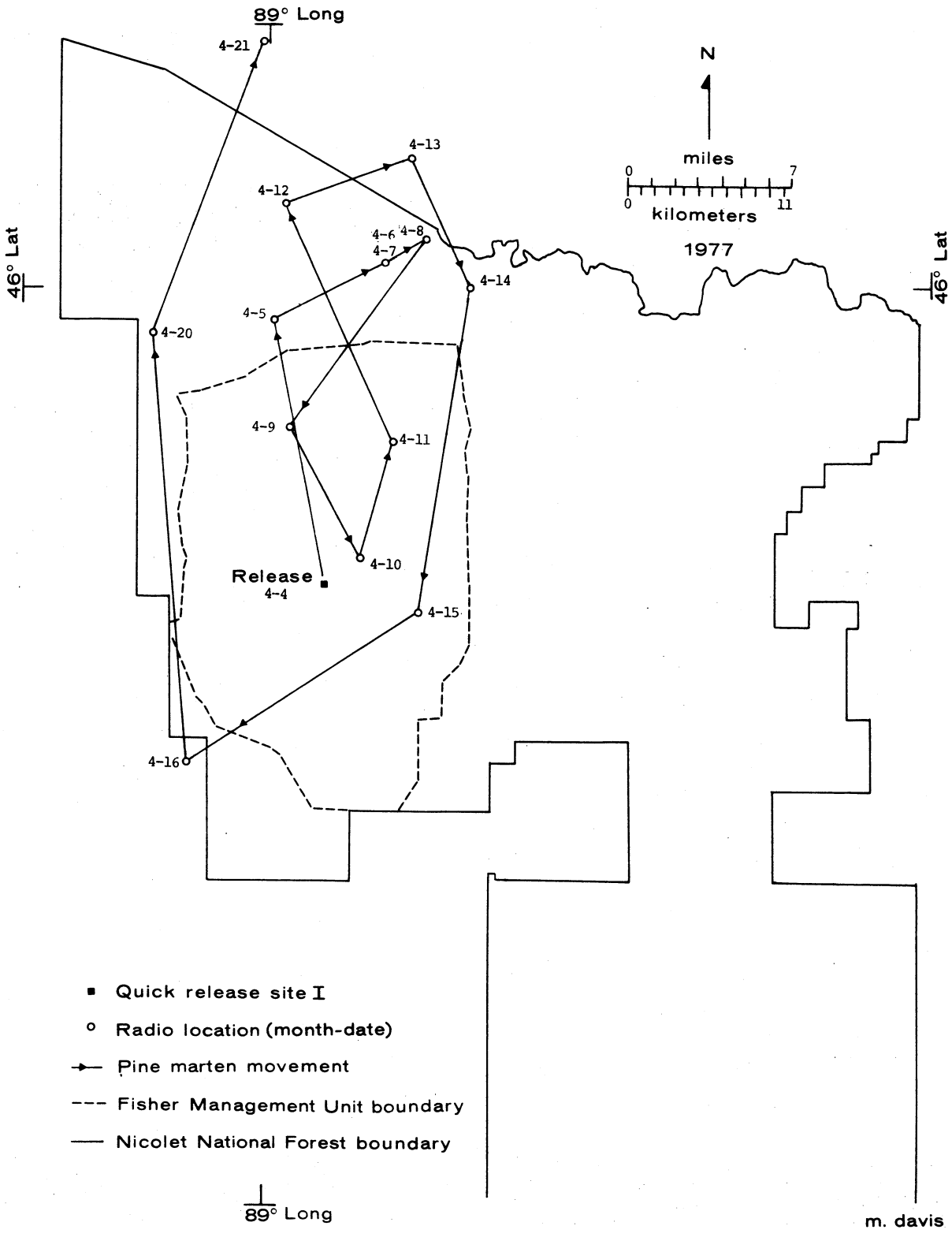

Fig. 4. Post-release movements of radio-tagged male pine marten M-043 from April 4 to April 21, 1975.

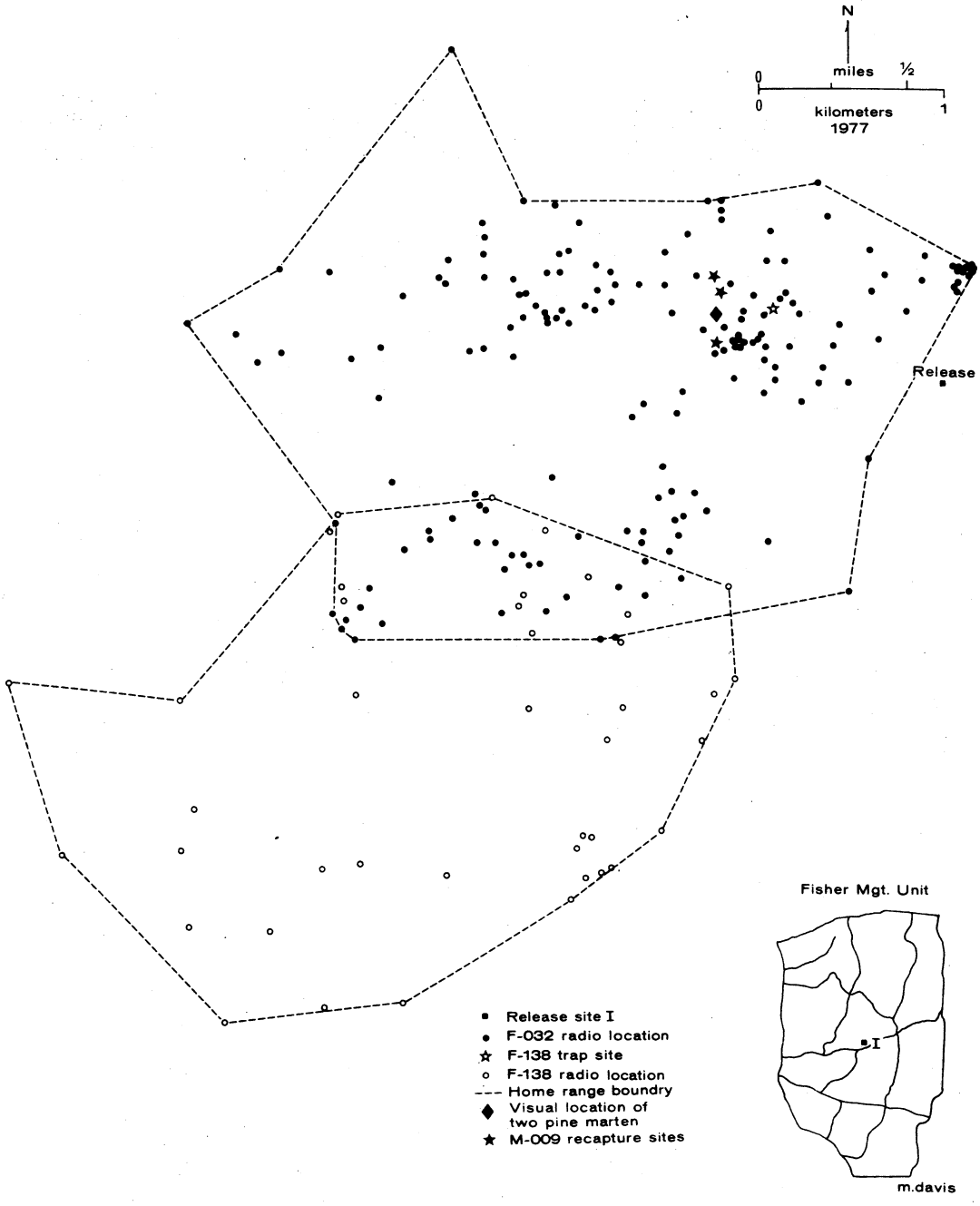

Fig. 5. Post-release locations and home range for two radio-tagged female pine marten (F-032 and F-138) and recapture sites for one non-radio-tagged male pine marten (M-009).

M-126 made four, and M-132 made one exploratory movement before beginning wandering movements (Fig. 6,7). M-132 made three exploratory movements of 6.93 mi. (11.15 km), 7.20 mi. (11.59 km) and 2.75 mi. (4.42 km) after initiating the wandering movement.

M-108, immediately after release occupied a den in the ground that was within 50 ft. (15.24 m) of the gentle release pen; he continued to feed on the meat and jam in the pen for 8 days. He then moved 5.89 mi. (9.48 km) southeast and made wandering movements in the east central portion of the FMU until loss of radio contact (n=28) (Fig. 8).

The physiological condition of the pine marten and the environmental conditions at release were different for each of the radio-tagged males; the nine animals were released at six separate times of the year. All except one of the five quick-released radio-tagged males made continuous exploratory movements and three were outside of the FMU when radio contact was lost. The four gentle-release radio-tagged males remained in the FMU although three made wandering movements. The gentle-release technique appears to have prevented the large exploratory movements regardless of the time of year; the gentle-release did not prevent wandering movements. However, the non-radio-tagged quick-release male that was live-trapped three times, remained near his release site longer than any of the reintroduced males (381 days), and one radio-tagged, quick-release male made sedentary movements near the release site.

Quick-release females

The quick-release females F-032, F-051, F-158, F-180, F-216 and F-138 were radio tracked for 205, 57, 72, 4, 71, and 115 days respectively. F-032 was the most intensively monitored pine marten. She fed

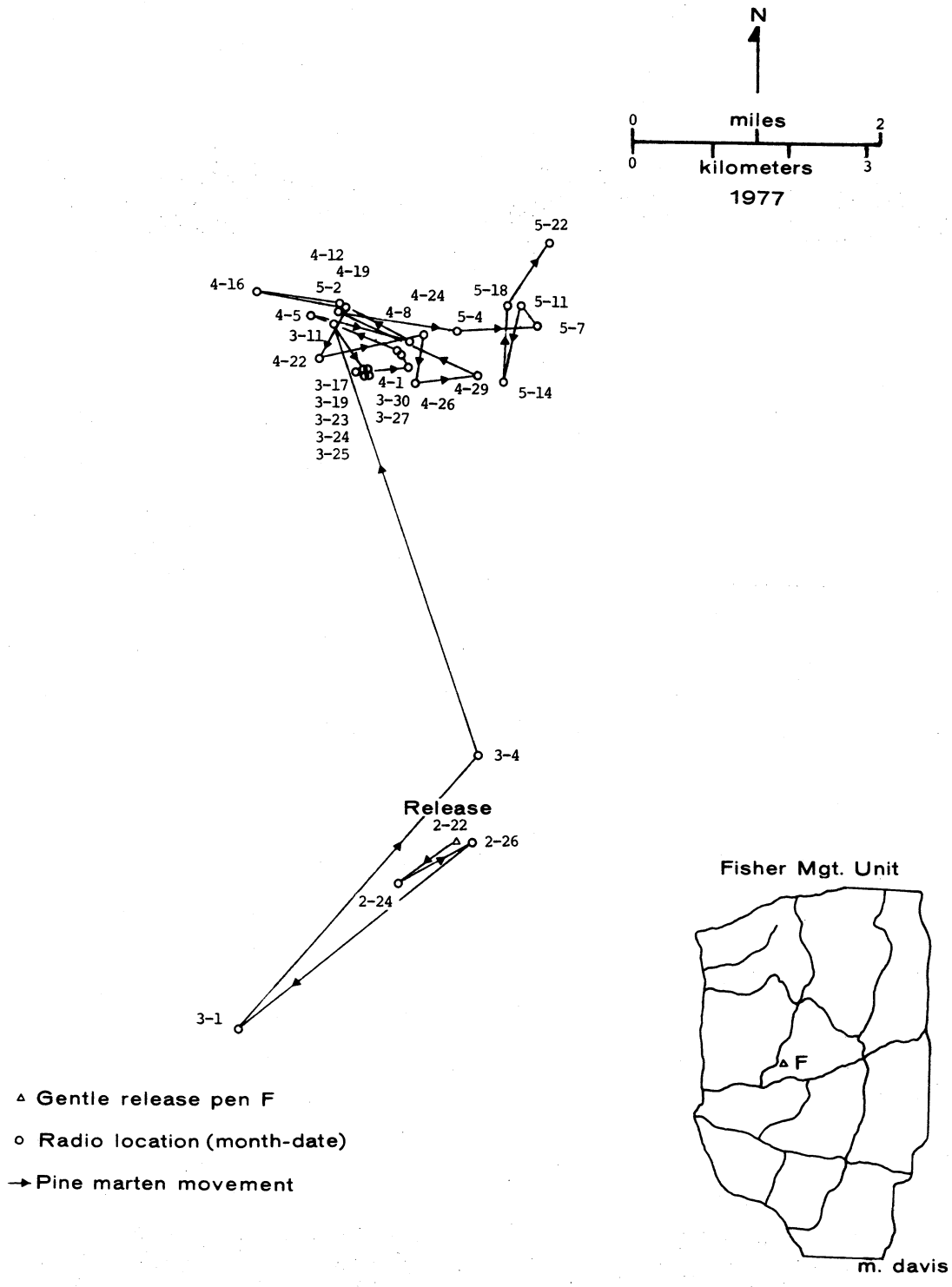

Fig. 6. Post-release movements of radio-tagged male pine marten M-126 from February 22 to May 22, 1976.

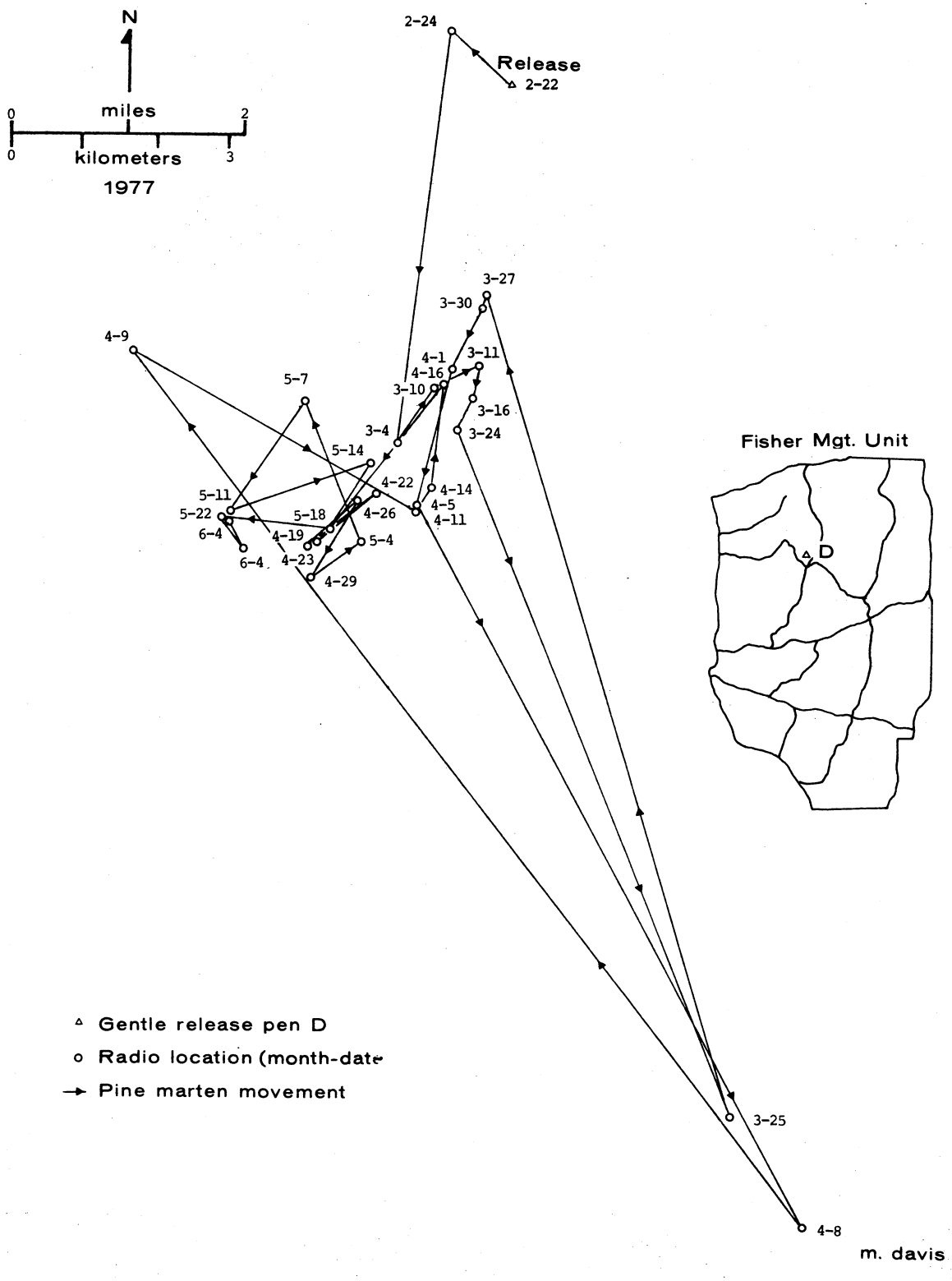

Fig. 7. Post-release movements of radio-tagged male pine marten M-132 from February 22 to June 4, 1976.

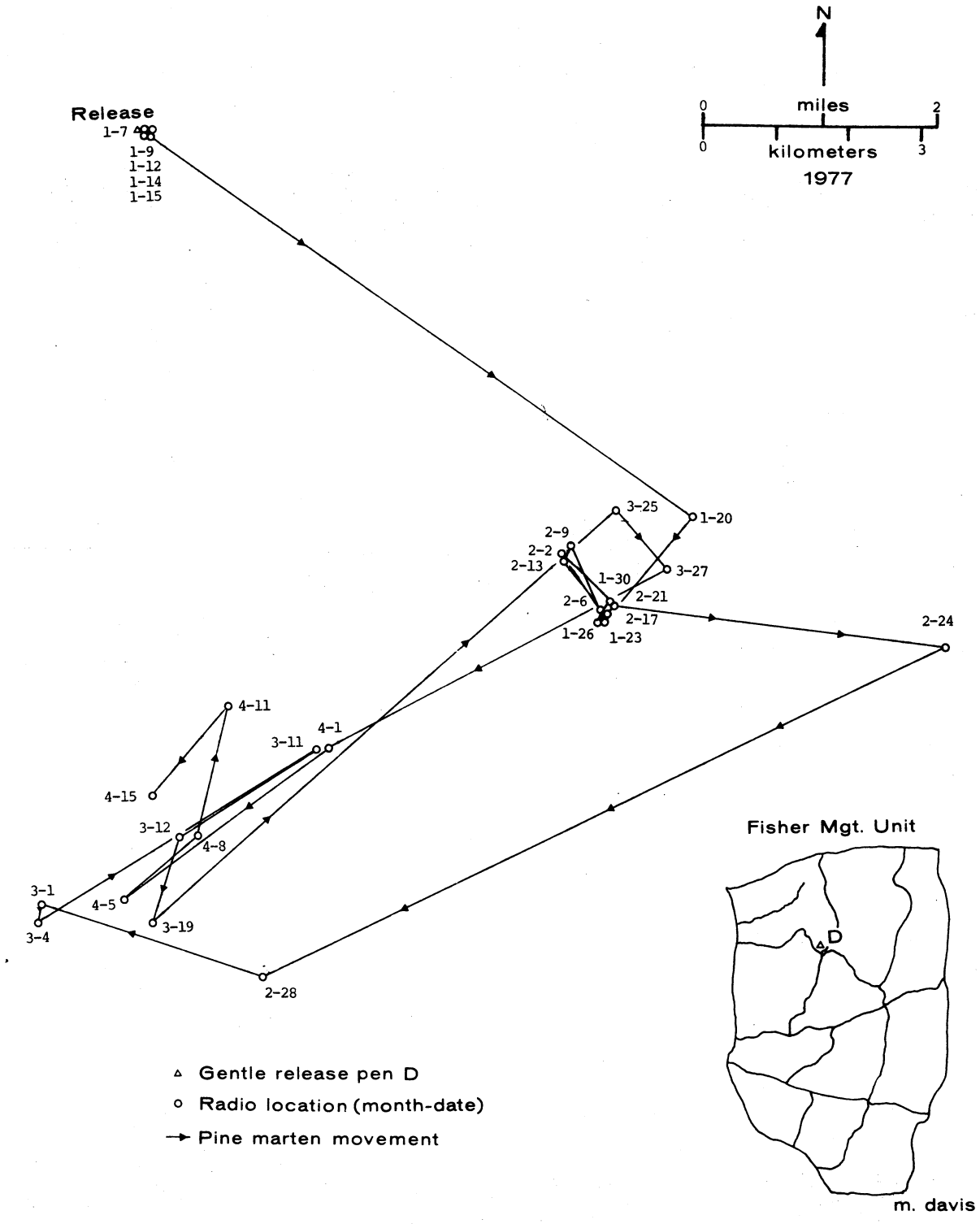

Fig. 8. Post-release movements of radio-tagged male pine marten M-108 from January 7 to April 15, 1976.

initially on a deer carcass planted at quick-release site-I for 13 days. One hundred seventy locations were plotted in 205 days. She was sedentary throughout this entire period and never moved farther than 2.55 mi. (4.10 km) from her release site (Fig. 5).

F-051 behaved similarly to quick-release males M-001, M-043 and M-053; making continuous exploratory movements. She traveled a minimum of 103.9 mi. (167.18 km) (n=30) in 57 days and was 16.25 mi. (26.15 km) from the release pen when radio contact was lost. Maximum distance from the release pen was 31.19 mi. (50.18 km).

All of the movements of quick-release F-158 and F-216 were wandering in nature and within the FMU (Fig. 9,10). F-158 was radio tracked for 72 days (n=31); the maximum distance from release site was 5.16 mi. (8.30 km). F-216 was radio tracked for 71 days (n=24); maximum distance from release site was 9.19 mi. (14.79 km).

The radio-tag placed on F-180 was recovered 4 days after release 0.25 mi. (0.40 km) from the release site. It had been fitted too loosely and F-180 was able to slip it over her head.

A non-radio-tagged, quick-release female pine marten was live-trapped February 14, 1976 (381 days after release), 0.64 mi. (1.03 km) from release site-I. Both ear tags were ripped out. This animal was either F-003 or F-011 because the status and location of all other reintroduced females was known. The animal was re-tagged (F-138), radio-tagged, and released at the trap site. She was radio tracked for 115 days (n=42). Her movements were sedentary and never exceeded 3.37 mi. (5.42 km) from her release site (Fig. 5).

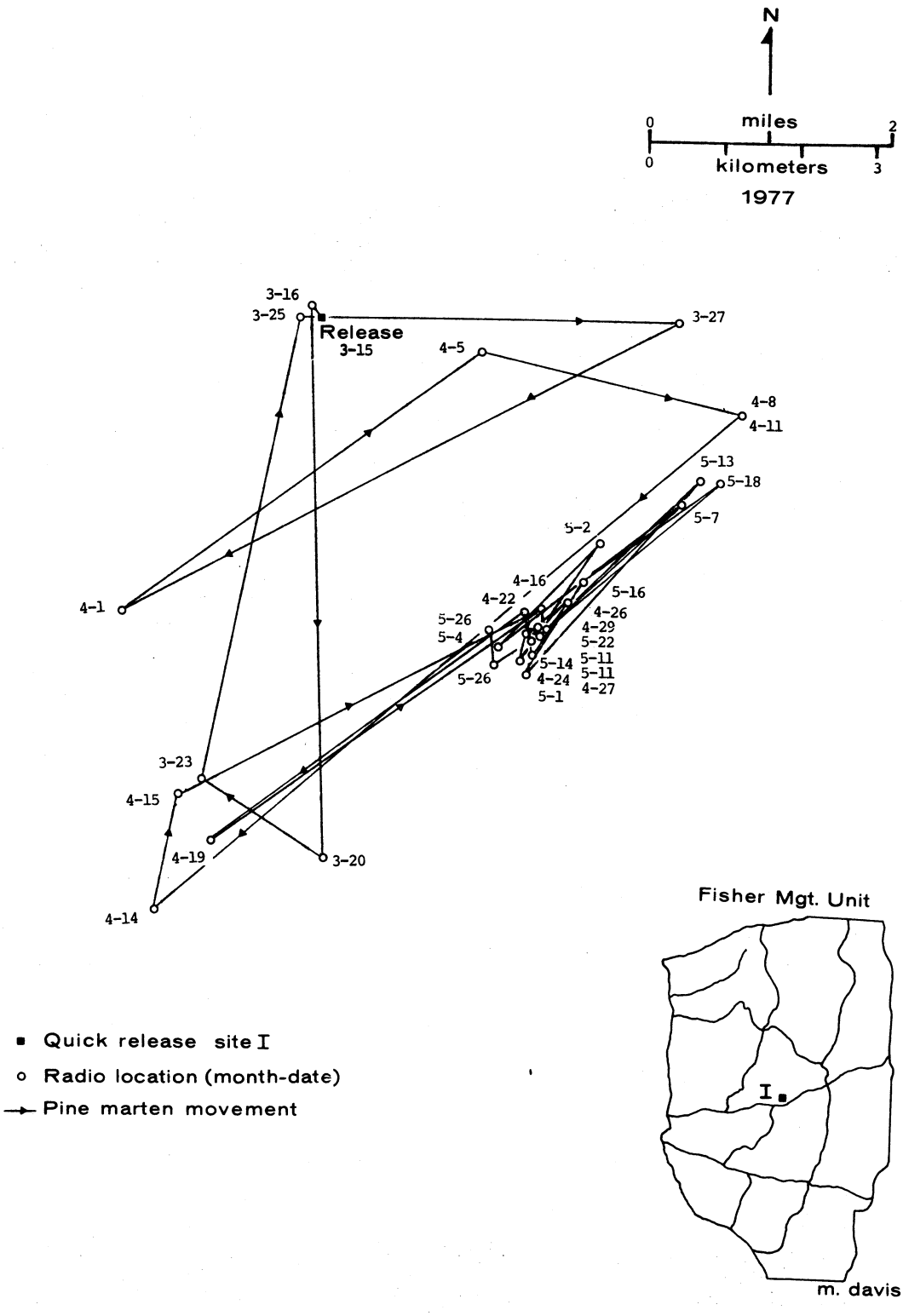

Fig. 9. Post-release movements of radio-tagged female pine marten F-158 from March 15 to May 26, 1976.

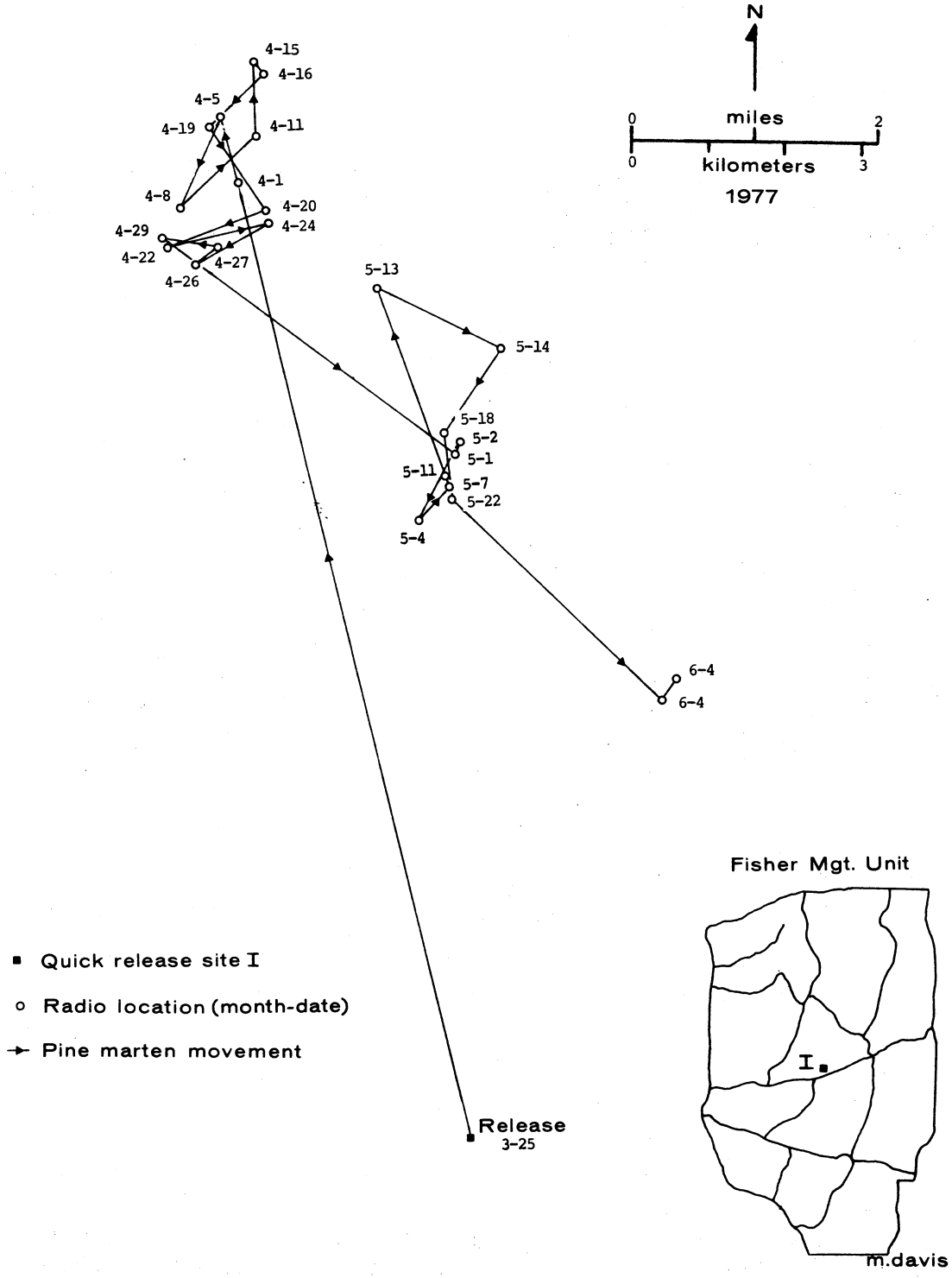

Fig. 10. Post-release movements of radio-tagged female pine marten F-216 from March 25 to June 4, 1976.

Gentle-release females

The gentle-release females F-060, F-078, F-083, F-088, F-095, and F-106 were radio tracked for 14, 142, 90 154, 98, and 10 days respectively. F-060 was recovered dead 1.55 mi. (2.49 km) from her gentle-release pen and F-106 was recovered dead 2.71 mi. (4.36 km) from the gentle-release pen.

F-078, F-083, and F-095 remained in the immediate vicinity of their gentle-release pens for 98, 54, and 54 days, respectively. During this time, maximum distance from the gentle-release pen was 1.96 mi. (3.15 km) for F-078 (n=34), 0.42 mi. (0.68 km) for F-083 (n=14), and 0.96 mi. (1.54 km) for F-095 (n=13). F-078 made one exploratory movement of 7.45 mi. (11.99 km) during this time but returned to the gentle-release pen area 2 days later. All three began making continuous exploratory movements after this initial sedentary period. Relatively small exploratory moves were followed by large daily movements. F-095 traveled a minimum of 106.59 mi. (171.50 km) (n=7) in 25 days. She was a minimum of 20.25 mi. (32.58 km) south of the release pen at one time, and was 31.36 mi. (50.46 km) northeast of the release pen when radio contact was lost (Fig. 11).

F-078, the only adult female, began making large daily exploratory movements after April 8, 1976 (98 days after release) and traveled a minimum of 165.33 mi. (226.02 km) (n=21) in 44 days. She was 43.40 mi. (69.83 km) north and 43.20 mi. (69.51 km) south of the release pen during this time. F-078 became sedentary April 24, 1976 (114 days after release) for a minimum of 10 days (n=4) in the midst of her exploratory movements, 44.04 mi. (70.86 km) from the release pen. She resumed making large exploratory movements by May 11, 1976. F-078 was 40.12 mi.

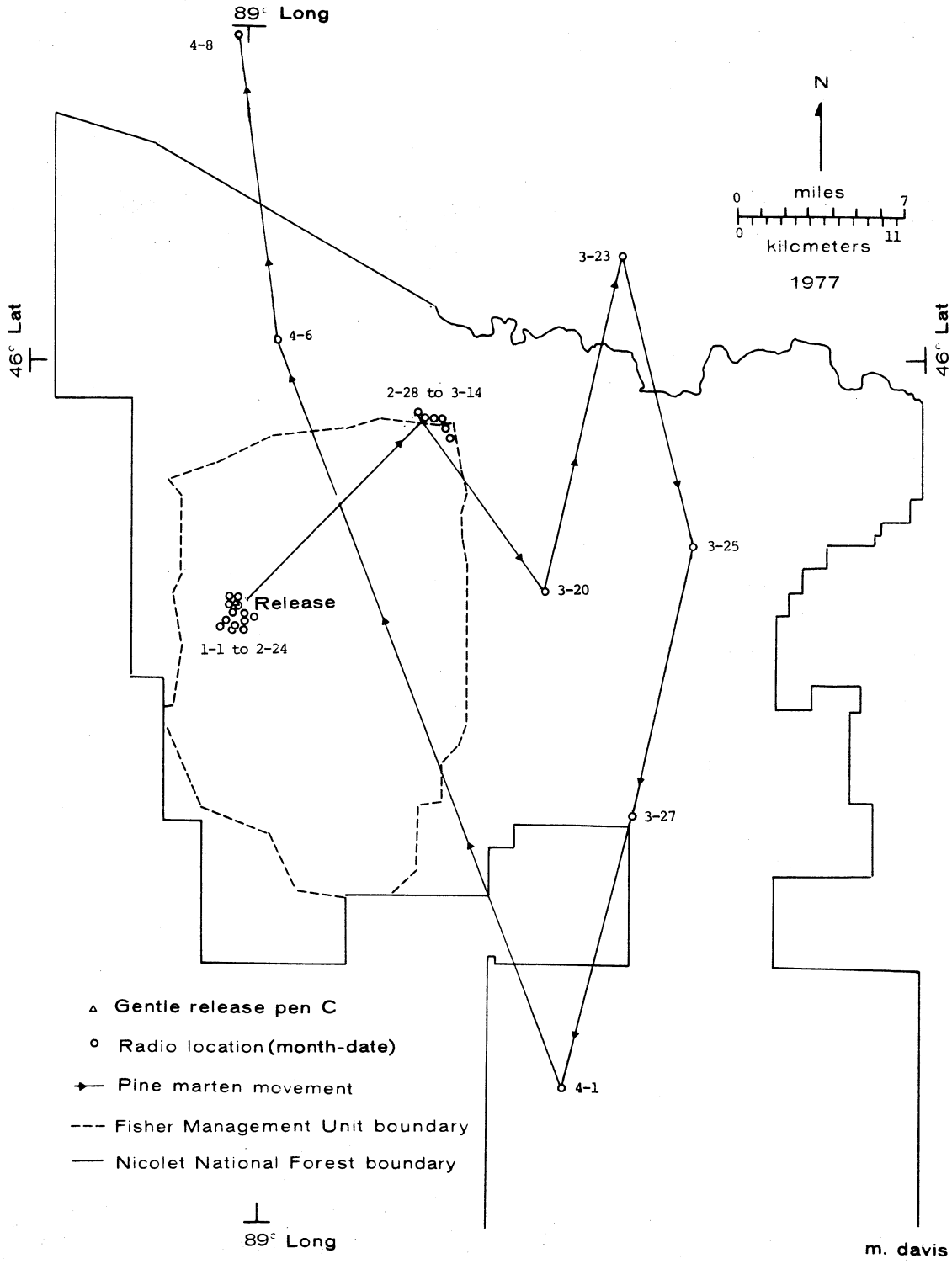

Fig. 11. Post-release movements of radio-tagged female pine marten F-095 from January 1 to April 8, 1976.

(64.55 km) from her gentle-release pen when radio contact was lost.

F-083 remained within 0.42 mi. (0.68 km) (n=14) of her gentle-release pen for 54 days. She then traveled to the northeast making 5 consecutive exploratory moves; maximum distance from the release pen was 2.20 mi. (3.54 km). Twenty-five days later she returned to the vicinity of her gentle-release pen. She remained near the pen for 5 days (n=2) and then made two consecutive exploratory movements in a 3-day period that were 2.97 mi. (4.78 km) north and 2.67 mi. (4.30 km) east of the release pen. Within 3 days of the last of these two exploratory moves, she again returned to the vicinity of the release pen. The next day she moved 7.27 mi. (11.70 km) east of the release pen. Radio contact was lost at this point.

F-088 escaped from the gentle release pen while being fed, 7 days after confinement. She remained at the release pen site for at least 7 days (n=2) and then moved 5.16 mi. (8.30 km) northwest. She made wandering movements (n=51) until removal of the radio-tag. Maximum distance from the release pen was 6.34 mi. (10.20 km) and she was 4.34 mi. (6.98 km) northeast of the release pen when the radio-tag was removed (Fig. 12).

The relationship between release techniques and post-release behavior of the radio-tagged females is unclear. The five quick-release females (excluding the one that lost her collar) were released at different times of the year. Two quick-release females made wandering movements in the FMU; one made exploratory movements and was outside of the FMU when radio contact was lost; one was radio-tagged when live-trapped near her original release site 381 days after release; and one remained sedentary for a minimum of 205 days. This animal initially fed on a

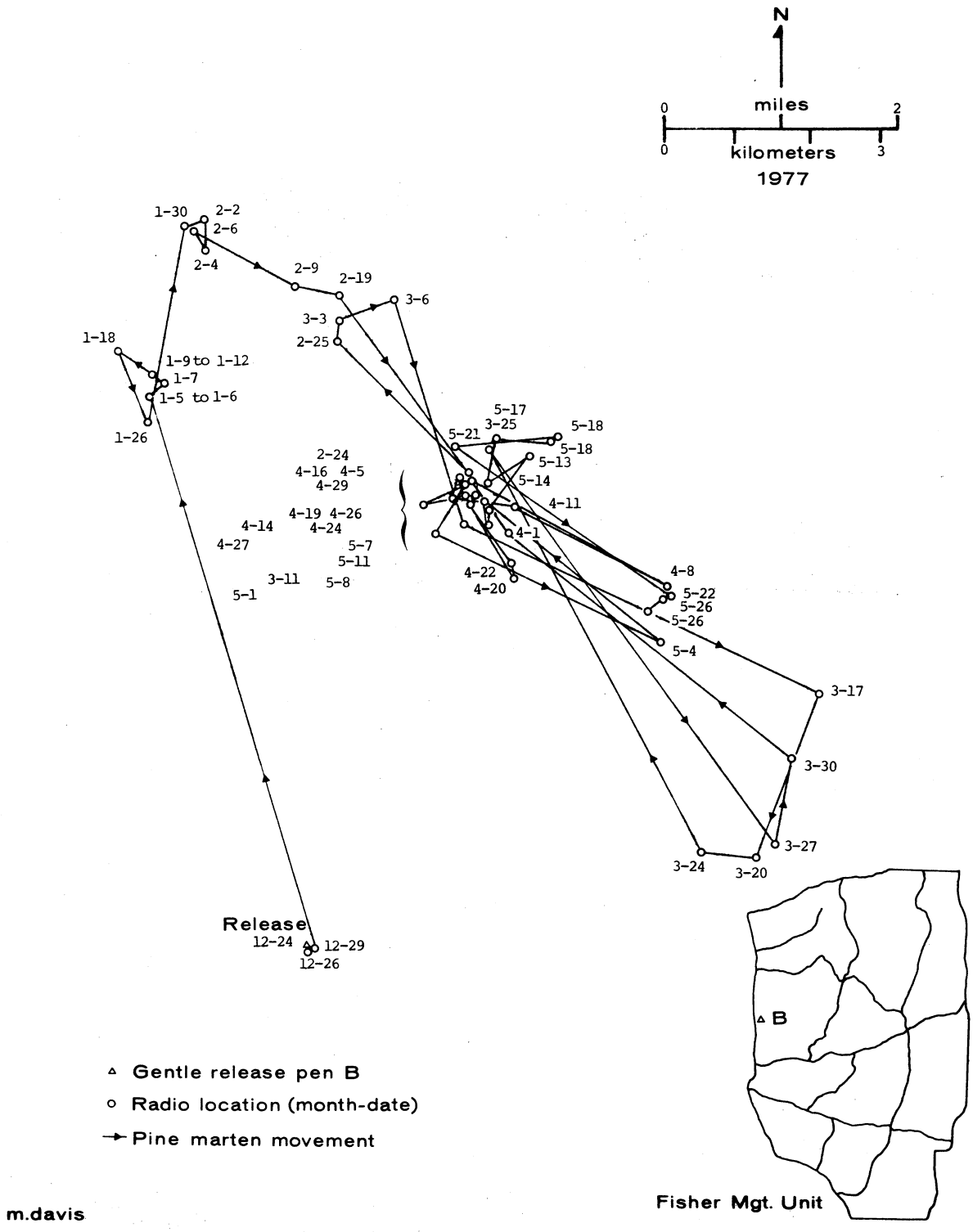

Fig. 12. Post-release movements of radio-tagged female pine marten F-088 from December 24, 1975 to May 26, 1976.

deer carcass for the first 13 days after release. The planted deer carcass provided the pine marten with a readily accessible food source during the winter months. A food source may reduce the tendency for reintroduced pine marten to make large exploratory movements. There is a risk that released pine marten will not find the planted food. One of four radio-tagged pine marten, released where deer carcasses were present, found the food. The gentle-release radio-tagged female pine marten (excluding the two that died) were released between December 24, 1975 and January 1, 1976; their behavior was similar. One made wandering movements in the FMU and three made sedentary movements near their release pens. The three sedentary pine marten began exploratory movements after this sedentary phase and were outside of the FMU when radio contact was lost. The exploratory movements began after mid-February and may have been related to the breeding cycle or a change in environmental conditions. The behavior of the non-radio-tagged quick-release female which was live-trapped 381 days after release, and the exploratory behavior of the three gentle-release females, indicates that other factor besides release method do influence post-release behavior.

Quick versus Gentle-release

Gentle-release pine marten remained closer to their release points than quick-release pine marten. There was a significant difference between gentle (n=8) and quick-release (n=9) radio-tagged pine marten in distance from the release site (DRS) ($P < 0.02$), the mean of all the distances from the release site (MDRS) ($P < 0.02$), and the mean distance from last location (MDLL) ($P < 0.04$) 30 days after release (Table 7). The use of gentle-release pens increased the chances of a successful rein-

Table 7. Post-release movements of quick and gentle-released radio-tagged pine marten; 30 days after release. Distances are in miles with kilometers in parentheses.

	Release date	Distance from release site	Mean of all distances from release site	Mean distance from last radio location	Number of radio locations in 30 days
Quick-release pine marten [a]					
M-001	Jan 29, 1975	11.57 (18.62)	10.14 (16.32)	2.51 (4.04)	5
M-015	Jan 29, 1975	1.25 (2.01)	1.29 (2.08)	0.36 (0.58)	8
M-017	Feb 28, 1975	21.28 (34.24)	18.15 (29.20)	2.87 (4.62)	13
M-043[b]	Apr 4, 1975	22.97 (36.96)	11.89 (19.13)	8.47 (13.63)	14
M-053	Apr 4, 1975	17.16 (27.61)	9.89 (15.91)	3.32 (5.34)	17
F-032	Feb 28, 1975	1.19 (1.91)	0.81 (1.30)	0.38 (0.61)	27
F-051	Apr 4, 1975	28.75 (46.26)	14.54 (23.39)	2.81 (4.51)	17
F-158	Mar 15, 1976	3.53 (5.68)	2.55 (4.10)	2.98 (4.79)	9
F-216	Mar 25, 1976	7.85 (12.63)	8.37 (13.47)	1.43 (2.31)	10
Gentle-release pine marten[c]					
M-058	Nov 2, 1975	2.36 (3.80)	1.09 (1.75)	0.65 (1.05)	9
M-108	Jan 7, 1976	5.22 (8.40)	3.17 (5.10)	0.88 (1.42)	9
M-126	Feb 22, 1976	3.84 (6.18)	2.43 (3.91)	1.34 (2.16)	8
M-132	Feb 22, 1976	2.65 (4.26)	2.28 (3.67)	1.10 (1.77)	5
F-078	Jan 1, 1976	1.66 (2.67)	0.54 (0.87)	0.39 (0.63)	10
F-083	Jan 1, 1976	0.42 (0.68)	0.19 (0.30)	0.12 (0.19)	7
F-088	Dec 24, 1975	5.46 (8.79)	3.93 (6.32)	0.70 (1.13)	8
F-095	Jan 1, 1976	0.74 (1.19)	0.43 (0.69)	0.27 (0.43)	9

[a]Released from their shipping containers within 24 hours of arrival.
[b]Radio contact lost 17 days after release.
[c]Retained in gentle-release pens for a minimum of 7 days after arrival.

troduction by reducing the influences of variability in habitat conditions, food availability, sexual development, and time of release (diurnal and annual) that each reintroduced pine marten is confronted with upon release.

There was a significant difference ($P < 0.05$) in DRS and in MDRS between gentle-release males (n=4) and quick-release males (n=5) 30 days after release. No significant difference ($P < 0.05$) was found in MDLL between gentle and quick-release males. No significant difference ($P<0.05$) was found in DRS, MDRS, and MDLL between gentle-release females (n=4) and quick-release females (n=4). The lack of significant differences between the movements of the quick and gentle-released female pine marten is attributed to the small sample size; the differences in the movements of the quick and gentle-release males was large enough to show significant difference even though the sample size was small.

Gentle-release pens returned pine marten to as near a natural condition as possible without actual release. They permit the pine marten to : 1) recover from the trauma of being handled while sexed, aged, weighted, and radio-tagged, 2) regain weight, and 3) become accustomed to their new environment.

Home Range

Only two pine marten exhibited sedentary movements which could be considered a home range. F-032's minimum home range was 3.16 sq. mi. (8.18 sq. km) during 205 days of radio tracking (n=170). F-138 had a minimum home range of 2.96 sq. mi. (7.67 sq. km) during 115 days of radio tracking (n=42). The home range of both animals was circular and overlapped each other by about one third. Although the two animals were not

radio-tracked at the same time, I believe F-138 and F-032 occupied the overlapping home range simultaneously. The history of F-032's movements for the previous 11 months, and the lack of evidence that she left her home range, indicates that the loss of contact (December 7, 1975) was a product of radio failure. Therefore, F-032 continued to occupy her home range when F-138's movements overlapped February 14 to June 8, 1976 (Fig. 5).

Hawley and Newby (1957) concluded that the home ranges of native pine marten of the same sex were evenly distributed with little overlap. However, an exception was noted in the complete overlap of two adult males. Mech and Rogers (1977) reported home ranges of two radio-tagged males overlapped considerably. However these individuals were studied during different periods. M-009, F-032, and F-138 had simultaneously overlapping movements.

Hawley and Newby (1957) found that the home range of a male often included the home range of one or more females. Non-radio-tagged M-009 was live-trapped within the boundaries of F-032's home range three times.

Individual researchers report the home range of pine marten varying from 0.27 sq. mi. (0.70 sq. km) to a circle 25 mi. (40.22 km) in diameter. The home range estimates of 4.05, 6.41, and 7.68 sq. mi. (10.5, 16.6, and 19.9 sq. km) for males and 1.66 sq. mi. (4.3 sq. km) for females (Mech and Rogers 1977) were based on 11, 26, 18, and 10 radio locations respectively. The two home range estimates for F-032 (3.16 sq. mi.) and F-138 (2.96 sq. mi.) were considered comparable to home range estimates of native pine marten; F-032 was sedentary for almost 1 year and F-138 was radio-tagged 0.64 mi. from her release site 381 days after her initial release into the FMU.

The minimum number of radio location movements necessary to estimate home range of native or reintroduced pine marten is unknown. Cranford (1977), working on wood rats (Neotoma fuscipes), determined that a minimum of 100 locations was necessary to estimate 95 percent of the known home range. Odum and Kuenzler (1955) found that the size of avian territories does not significantly increase after 25 to 90 observations, depending on the species involved.

Several reintroduced pine marten failed to become sedentary for unknown reasons. The wandering pine marten may have been analogous to the temporary residents, and the exploratory pine marten analogous to the transients that Hawley and Newby (1957) found in a native population. Pine marten did not exist in the FMU at the time of this reintroduction, so intraspecific competition could have only been from other reintroduced pine marten. Interspecific competition between fishers and pine marten is minimal, except during periods of food shortages (Clem 1975). The wandering and exploratory movements may have been caused by inadequate food and cover. However, the weight gains experienced by several reintroduced pine marten, and the sedentary behavior of M-009, F-032, and F-138 and the other pine marten that extablished themselves in specific areas for short periods of time, indicates that food and cover were adequate. The wandering pine marten may have been looking for a familiar part of their original home area and the exploratory animals may never have recovered from the human contact and handling at release.

Reproduction

No evidence of reproduction was found. Two females (Juv.) were

radio-tracked during April 1975 and six females (1 Ad.:5 Juv.) were radio-tracked during April 1976. Parturition date for captive pine marten is mid-April and newly born kits do not open their eyes until 39 days after birth (Brassard and Bernard 1939). Movements of a female pine marten with young would be concentrated in the immediate area around the natal den during this period.

The adult female (F-078) behaved differently than the other radio-tagged females during the month of April. She ceased making large exploratory movements on April 24, 1976. She may have reproduced but did not successfully raise the young because by May 11, 1976 she was making large daily movements. Three juvenile females (F-088, F-158, and F-216) were examined in late May-early June when their radio-tags were removed. No evidence of lactation was observed.

F-032 was observed with a non-radio-tagged pine marten on June 30, 1975 (Fig. 5). The sex of the non-radio-tagged pine marten is unknown; however a male (M-009) was live-trapped on August 25, 1975, 0.10 mi. (0.16 km) from where the two pine marten were observed. I observed these two pine marten running together in a stand of northern hardwoods and was able to approach to within 10 ft. (3.05 m) of them. They ascended a white cedar and one of the animals was continually making a "clucking sound" that Markley and Bassett (1942) heard from captive pine marten during the July-August estrous period. The two pine marten descended the tree and ran towards a tag alder (Alnus rugosa) thicket 27 minutes after they were first observed. F-032 was a minmum of 15 months old when the two pine marten were observed together. Female pine marten can breed at 15 months and produce their first litter at 24 months (Jonkel and Weckwerth 1963). Verification of mating was precluded when radio contact was lost with F-032 in December 1975.

The reproductive potential of the entire reintroduced population is unknown. All of the females released into the FMU should have mated during the previous summer in Canada if they were sexually mature. However, determining sexual maturity was difficult because of unreliable aging techniques. Although only one reintroduced female was considered an adult, some juveniles may have been adult. Any pregnant pine martenn may have shed their blastocysts during the trauma of the reintroduction process.

Potential Number of Females Remaining in the FMU

Radio contact was lost with six of the 12 radio-tagged females; radio-tags were therefore not removed. Four of the six were outside of the FMU when radio contact was lost. Three of these four females, or 50 percent of the gentle-release radio-tagged females, began exploratory movements and moved out of the FMU after an initial non-exploratory period of at least 30 days. The fourth female which was lost outside of the FMU, was quick-released and represented 20 percent of the quick-release females radio-tagged at release. One female (F-060) died from injuries inflicted by the radio-tag. Predators killed one female (F-106) or 8 percent of the radio-tagged females.

The number of female pine marten potentially available for reproduction in the FMU in April 1977 can be extrapolated from the above radio telemetry data. Losses and movements out of the FMU are as follows:

1) Two females are known to be dead. (27-2=25).
2) Four radio-tagged females were outside of the FMU when radio contact was lost. (25-4=21).
3) Predation may take 8 percent (2) of the remaining 21. (21-2=19).

4) Fifty percent (6) of the 12 gentle-release non-radio-tagged females would probably move off the FMU at least 30 days after release. (19-6=13).

5) Twenty percent (1) of the 3 quick-released non-radio-tagged females would probably move off the FMU. (13-1=12).

Twelve female pine marten may still be on the FMU as of June 1976. The two females that were on the FMU when radio contact was lost may face a premature death because of radio-tag inflicted injuries. Additional natural losses from predation (a minimum of 8 percent per year) can be expected before parturition occurred in April 1977. The total number of females available for reproduction would also be influenced by another unknown factor; the actual age of the females at the time of release.

Habitat Utilization

The 11 radio-tagged pine marten, with a minimum of 20 non-exploratory locations (wandering and sedentary) each utilized a wide variety of habitat types. M-058 preferred pine; M-108, M-126, and M-132 preferred hardwoods; F-032 and F-138 preferred swamp-muskeg; F-083 preferred spruce-fir; and F-078, F-088, F-158, and F-217 preferred hardwoods based on importance values and ranks for Combined Habitat-I. The individual diversity of habitat use by the reintroduced pine marten may be attributed to one or more of the following: 1) insufficient number of radio locations for individual pine marten, 2) the different times of the year pine marten were monitored, 3) the wandering nature of the pine marten, or 4) accuracy (size) of the larger radio locations.

Habitat was not a limiting factor for the reintroduced population. Reintroduced radio-tagged pine marten did not select one specific habi-

tat; they utilized the habitat that was available to them when all the non-exploratory movements for each radio-tagged pine marten were combined and analyzed together. Combined Habitat-II analyses, which grouped the cover-types on the timber survey maps into five broad catagories, showed that pine marten habitat use was identical to the available habitat when snow and no-snow cover movements (n=512) were combined and analyzed together (Fig. 13). Combined Habitat-I analyses, which grouped the cover-types into nine catagories, and are therefore more precise, showed: 1) that hardwood ranked number-one in availability and use throughout the year, 2) a selection for spruce-fir and pine habitat during snow cover (n=251), and 3) a selection for swamp-muskeg habitat during no-snow cover (n=261) (Fig. 14). Spruce-fir and swamp-muskeg ranked third and fourth, respectively, in availability. Analysis by accuracy (radio-locations less than or equal to 6 acres [2.43 ha] in size) and daily activity periods did not indicate selection for a specific habitat.

The habitat utilized by F-032 and F-138 may be a more accurate representation of pine marten habitat requirements in the FMU because of their sedentary behavior. F-032 preferred lowland conifer stands throughout the year. Figures 15 and 16 show the close relationship between snow (n=37) and no-snow (n=119) habitat use for Combined Habitat-I and II, respectively. The habitat F-032 occupied while feeding on the planted deer carcass was not included in the analysis. Devos and Guenther (1952) state that pine marten may use the cedar swamps because of the abundance of food. Habitat utilization did not change when the locations were analyzed by accuracy (radio-locations less than or equal to 6 acres [2.43 ha] in size) and daily activity periods. F-138 preferred swamp-muskeg during no-snow cover; use of other habitat types correlated with that which was available. Habitat use during snow

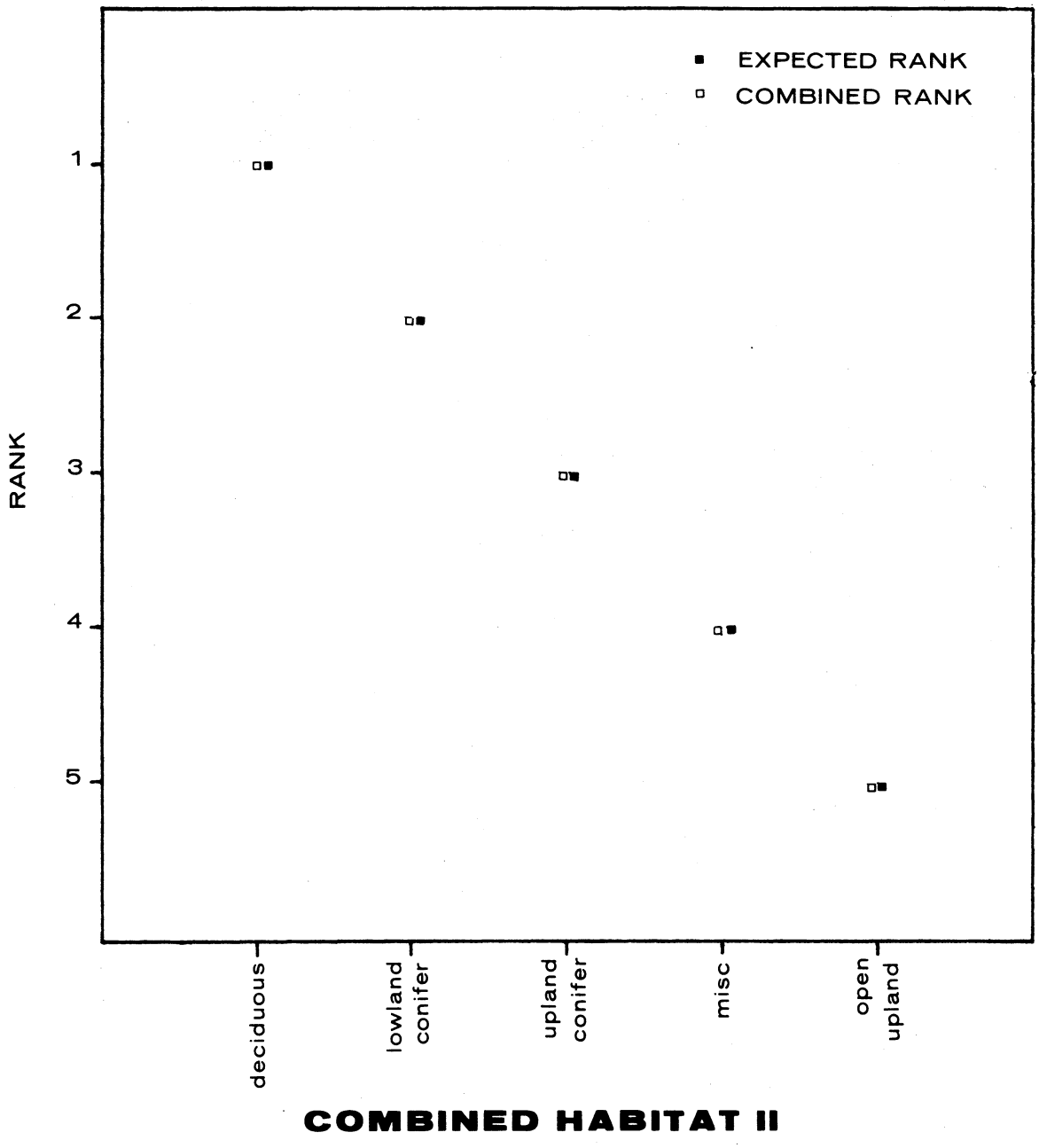

Fig. 13. Importance value ranks (Combined Habitat II) of all non-exploratory radio locations (Combined) and importance value ranks of available (Expected) habitat.

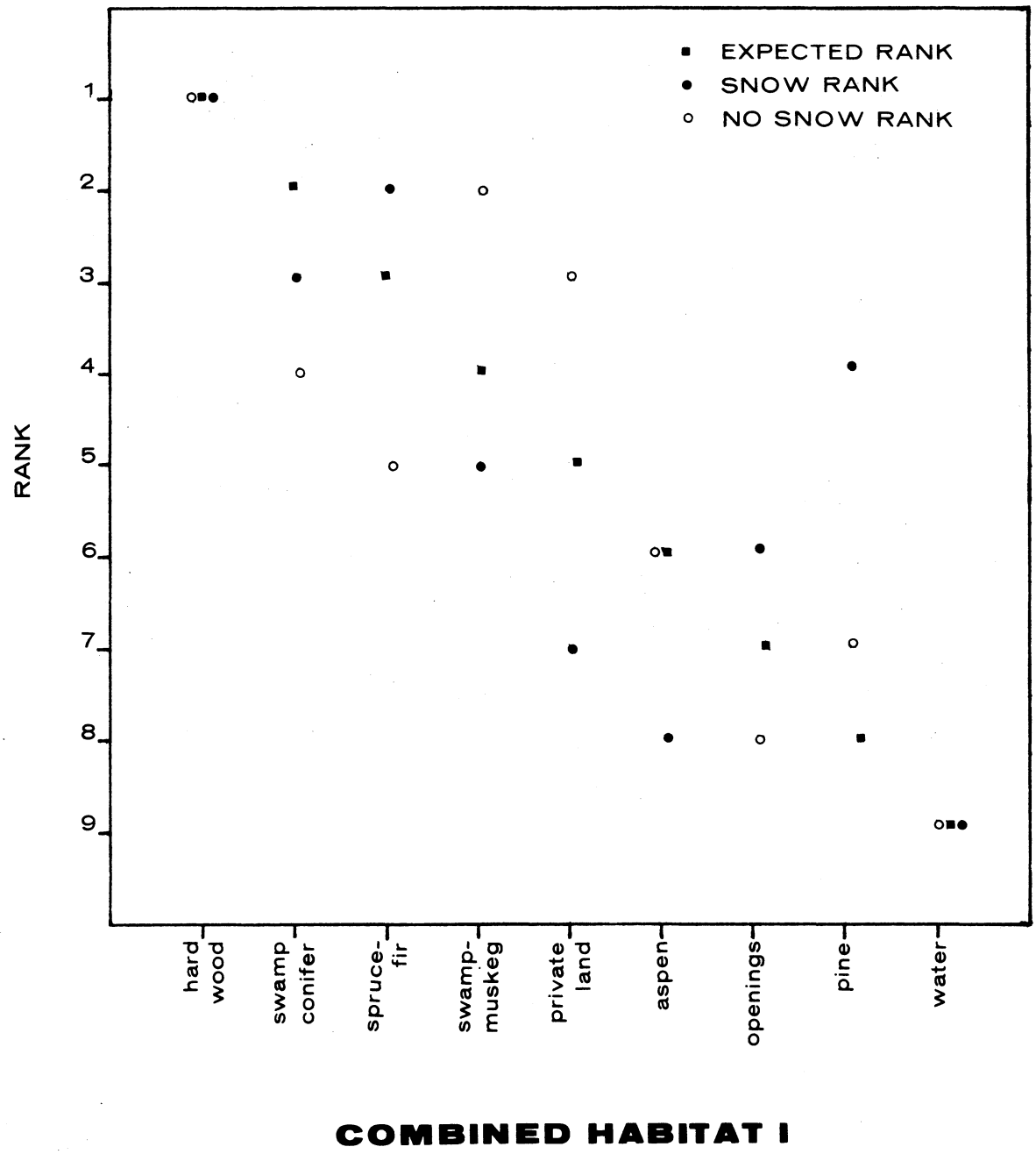

Fig. 14. Importance value ranks (Combined Habitat I) of all non-exploratory radio locations (Combined) and importance value ranks of available (Expected) habitat.

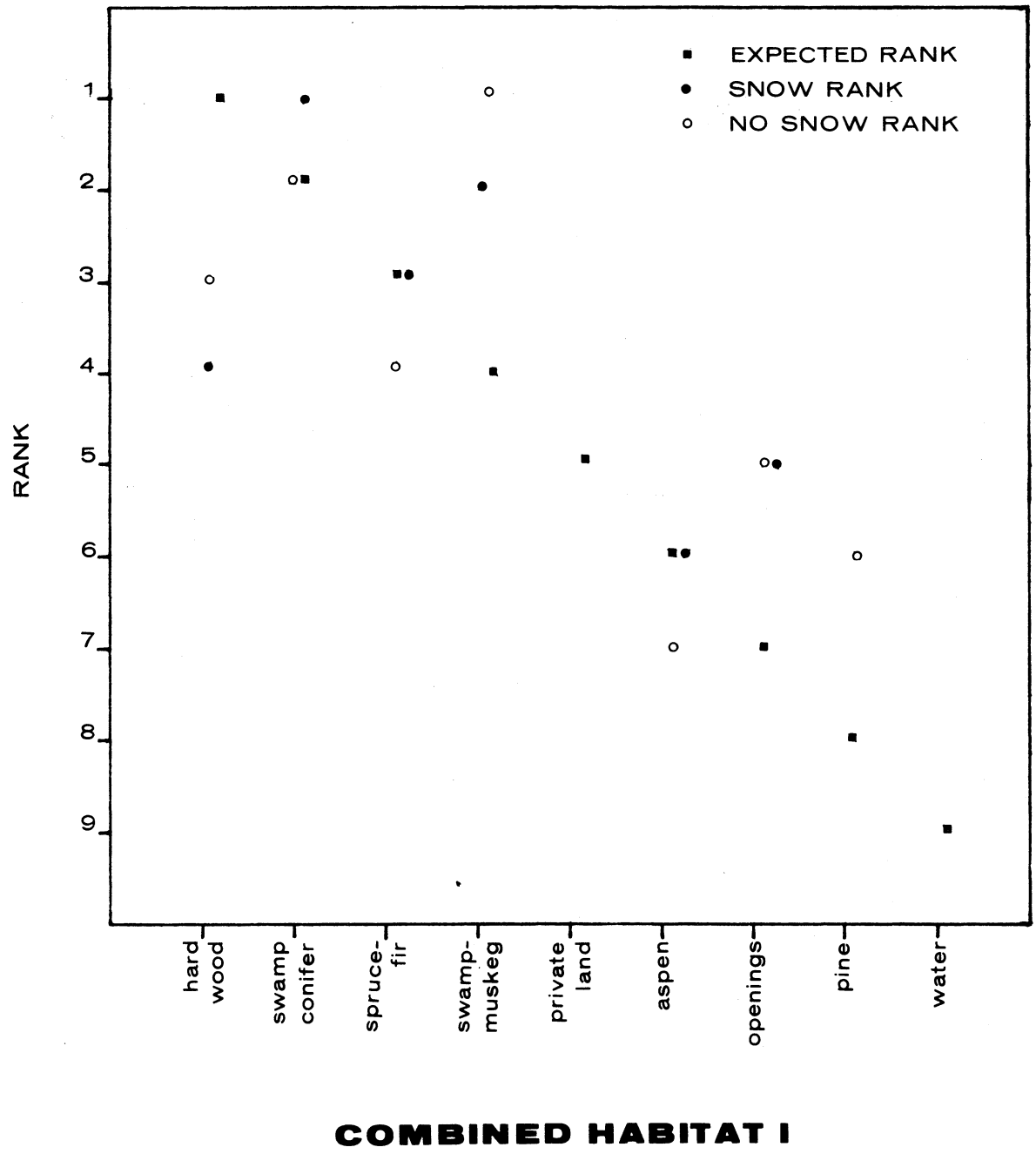

Fig. 15. Importance value ranks (Combined Habitat I) of habitat used by female pine marten F-032 and importance value ranks of available (Expected) habitat.

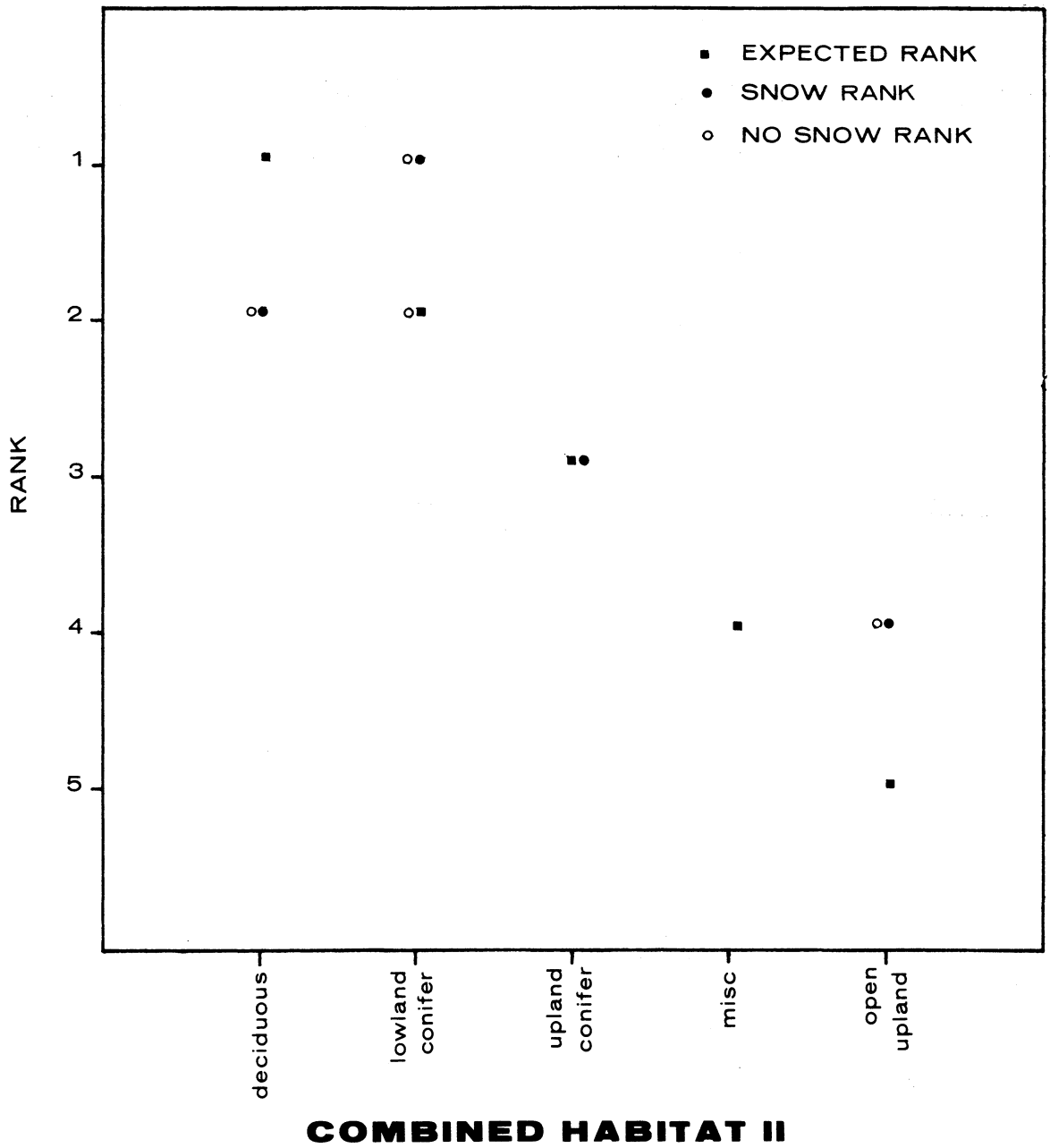

Fig. 16. Importance value ranks (Combined Habitat II) of habitat used by female pine marten F-032 and importance value ranks of available (Expected) habitat.

cover was not determined for F-138 because only six locations were obtained during snow cover. The lowland conifer habitat, utilized by the two sedentary pine marten, is second only to hardwoods in availability.

Behavior

Five of the 10 gentle-release radio-tagged pine marten returned to their release pens at various times up to 8 days after release. F-060 was observed from a blind when she left her gentle-release pen. She did not exit the pen immediately after the door was opened. She first stuck her head out of the door, and left a few minutes later. She was startled when she was approximately 3 ft. (0.91 m) from the door, and quickly returned to the nest box in the pen. She slowly left the pen again (15 minutes after the door was initially opened) and made a quick jump to a nearby balsam fir. She was still grooming and climbing in the trees when I left the blind 1 hr. after the door of the pen was opened.

Weather did not appear to influence pine marten activity. Movements were observed during all weather extremes. Two hundred twenty-four consecutive day-to-day movements were recorded; twelve of the 41 consecutive day-to-day movements that exceeded 2 mi. (3.22 km), exceeded 8 mi. (12.87 km). Maximum straight-line movement in a 24 hr. period was 13.69 mi. (22.02 km); maximum straight-line movement in a 30 hr. period was 14.48 mi. (23.30 km).

Pine marten do not establish a home den throughout most of the year. They rest in any convenient cavity or stump. Little is known about natal den requirements. Radio-tagged pine marten were observed in hollow cedar stumps, cavities in windfalls and standing trees, and in vegetative nests in trees when snow cover was lacking. F-032 was observed

nine times in eight different nest between May 17 and August 6, 1975. Nests were spherical, usually had two entrances, and were in balsam fir or black spruce trees. They were composed of grasses, moss, and conifer needles. Red squirrels (Tamiasciurus hudsonicus) were abundant in the vicinity of the nests, and although red squirrels were not observed in the nests, they are assumed to be red squirrel nests. Murie (1961) found that pine marten often lodge in the choicest available red squirrel nests. F-088 was also observed in a leaf nest on May 8, 1976 that is assumed to have belonged to a red squirrel.

Pine marten behavior varied with the presence or absence of snow cover. Sixty-four of 104 hand-held locations were obtained during the period of snow cover. Pine marten were noted to have climbed trees only twice during this time. They hunted around the base of windfalls and trees, and often caught their prey by tunneling under the snow. They usually traveled through several different cover-types while hunting. Two snowshoe hares (Lepus americanus), cached by two different pine marten, were located. Hunting behavior of radio-tagged pine marten conformed with that described by Marshall (1951a), Murie (1961), and Koehler et al. (1975). Pine marten utilize trees during the summer but they do most of their hunting and traveling on the ground.

CONCLUSIONS AND RECOMMENDATIONS

Pine marten are associated with wilderness because they are vulnerable to habitat alterations and overharvest in regions that are easily accessable to man; only populations in rugged and remote areas survive.

Northern Wisconsin is not wilderness but it is sparcely populated by man and it can support a pine marten population if the pine marten are protected from uncontrolled and indiscriminate trapping.

The FMU provides trapping protection to the reintroduced pine marten and will enable a population to become established and then emigrate into the surrounding parts of the state. Low human populations, diversity of habitat, and present-day small-scale logging practices in northern Wisconsin will insure the mixed coniferous-hardwood forests that pine marten require.

I recommend that an additional 20 to 30 adult female pine marten be released into the FMU as soon as possible to enhance the possibility of a successful reintroduction program. The following techniques should be used in future pine marten releases in the FMU:

1) Hold and ship pine marten in cages that will preclude them from damaging their teeth,
2) Administer an antibiotic to reduce mortality if the pine marten are to be held in captivity for more than 3 days prior to shipment,
3) Gentle-release all females to reduce post-release movements,
4) Saturate quick-release sites with food (e.g. road-killed deer) if the gentle-release is not possible, and
5) Quick-release surplus males along the periphery of the FMU to reduce the chances of competition with the male pine marten released during 1975-76.

Results of the 1975-76 pine marten reintroduction study suggests that adequate food and habitat are available in the FMU of the Nicolet National Forest. The radio telemetry data, summer observations, and winter track counts shows that pine marten are still present. The

final outcome of the reintroduction remains undetermined because of the relatively few numbers of females released, emigration, and there being no documentation of reproduction.

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