2-1979

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by

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February 1979

[1] Final Report: This is the final report of the results of a study conducted by the U.S. Fish and Wildlife Service under Interagency Agreement EPA-IAG-D7-0449 between the Environmental Protection Agency (EPA) and the Fish and Wildlife Service (FWS).

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TABLE OF CONTENTS

Abstract: Under an Environmental Protection Agency (EPA) Interagency Agreement, we evaluated the hazards to wildlife associated with aerial 1080 (sodium monofluoroacetate) baiting for California ground squirrels (*Spermophilus beecheyi fisheri*). We conducted the study in Tulare County, in south-central California, in the eastern foothills of the San Joaquin Valley. Vegetation is annual range grasses and associated forbs, under open stands of oak (*Quercus* spp.), with cottonwood (*Populus* spp.), California sycamore (*Platanus racemosa*), and California buckeye (*Aesculus californica*) along stream bottoms. The study monitored a large-scale operational baiting program conducted in Tulare County by the Tulare County Agricultural Commissioner. During early June 1977, (in the vicinity of the study area) about 25,000 ha (60,000 acres) were spot-treated with 0.075 percent 1080-treated oat groats at about 6.7 kg/ha (6 lb per swath acre). The actual surface area baited was about 3.4 percent of the range. California ground squirrel populations were reduced about 85 percent following baiting. Primary hazards to seedeating birds appear minimal as indicated from intensive carcass searching and the results from 31 radio-equipped mourning doves (*Zenaida macroura*) and 10 radio-equipped California quail (*Lophortyx californicus*). One of two white-breasted nuthatches (*Sitta carolinensis*) found dead after treatment contained 1080 residue. One of two samples of dead ants also contained 1080 residue. Twelve cottontail rabbits (*Sylvilagus auduboni*) were found dead after treatment and four contained 1080 residue, indicating some primary hazard to this species. Secondary hazards to raptors and mammalian predators were evaluated by attaching radio transmitters to 24 raptors (red-tailed hawks, *Buteo jamaicensis*; turkey vultures, *Cathartes*

aura; a golden eagle, Aquila chrysaetos; great horned owls, Bubo virginianus; barn owls, Tyto alba; a screech owl, Otus asio; common ravens, Corvus corax; a common crow, Corvus brachyrhynchos) and 42 mammalian predators (bobcats, Lynx rufus; coyotes, Canis latrans; gray fox, Urocyon cinereoargenteus; badgers, Taxidea taxus; striped skunks, Mephitis mephitis; raccoons, Procyon lotor; and opossum, Didelphis marsupialis) and monitoring their movements before, during, and after treatment. Five of the six radio-equipped coyotes and three of the 10 radio-equipped bobcats (one bobcat was emaciated, possibly a result of a trap injury) were found dead after treatment. Three dead striped skunks (not radio-equipped) were also found dead after treatment and one contained 1080 residue. No other treatment-related mortalities were indicated among the remaining radio-equipped birds or mammals. Also, monitoring of 58 active raptor nests indicated no treatment-related mortalities.

In October 1976, officials of the U.S. Environmental Protection Agency (EPA), both from the Washington and San Francisco Regional Offices, met with representatives from several California agencies including the California Department of Food and Agriculture, the California Department of Fish and Game, the University of California at Davis, and the California Agricultural Commissioners Association. The purpose of this meeting was to review the possibility of conducting field studies designed to evaluate the effects on target and nontarget wildlife associated with 1080 baiting for controlling California ground squirrels. After considerable discussion it was agreed that the most appropriate approach would be an Interagency Agreement between EPA and the U.S. Fish and Wildlife Service (FWS). An Interagency Agreement was negotiated and signed on 13 January 1977. This agreement called for the Denver Wildlife Research Center of the FWS to conduct field evaluations of 1080-treated grain bait to control California ground squirrels.[1]

This report is concerned with the effects on the target species, ground squirrels, and with the primary and secondary hazards to wildlife (i.e., seedeating birds, rabbits, raptors, and mammalian predators) resulting from the use of 1080 bait for controlling the Fisher subspecies of the California ground squirrel.

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[1] Funds for this study were provided by the Environmental Protection Agency under Interagency Agreement EPA-IAG-D7-0449.

Acknowledgments

The cooperation of several groups is gratefully acknowledged: the California Department of Food and Agriculture; the California Department of Fish and Game; the University of California at Davis; the Environmental Protection Agency Regional Office, San Francisco; the Tulare County Agricultural Commissioner's Office, who supervised and conducted the baiting operations, and provided local guidance and assistance; the assistance of Fish and Wildlife Service personnel from Region 1 and colleagues from the Denver Wildlife Research Center; and the excellent cooperation of area ranchers and land managers on whose land we worked (without which the study could not have been conducted). The authors wish to extend a special thanks to Thomas Zikratch, Larry Lamper, Edward Fite, Richard Ockenfels, and Steve Loch who worked with us during the field phases of the study. Special thanks also go to the Section of Supporting Sciences (Denver Wildlife Research Center) who designed and built the transmitters and conducted the chemical residue analysis for 1080.

Study Area

The study area was located near Exeter, in Tulare County, California. The area ranges in elevation from about 125 m to about 1100 m (400 to 3500 feet) above sea level (Fig. 1). It is situated on the eastern side of the San Joaquin Valley in the foothills of the Sierra Nevada Mountains. The natural vegetative cover is annual range grasses and associated forbs, with open stands of oak. Along the stream bottoms, cottonwood, California sycamore, and California buckeye are also present. Vegetative

cover was below average because 1977 was the second consecutive year of below average precipitation.

Cattle ranching is the principal agricultural activity in the area. In the valley, various crops (citrus, nuts, olives, grapes, cereal, and row crops) are grown. However, most 1080 baiting takes place on rangeland.

Because of increasing concern about endangered species, the treated area was not in the known, defined range of the San Joaquin kit fox (Vulpes macrotis mutica) (Morrell 1975). However, on 6 September 1977, an adult male San Joaquin kit fox (a road kill) was found dead on a highway in the general study area. This is an eastward extension of their range of about 5 km (3 mi). In this area, the Friant-Kern Canal was previously considered the eastern limit of their range.

According to Koford (1953), Wilbur et al. (1974), Wilbur (1978), and S. Wilbur (personal communication), Tulare County is an area historically used by California condors (Gymnogyps californianus), as condors were present and seen by the earliest white settlers in the Sequoia National Park region. The county is now one of the main summer use areas for a majority (15-20 presumed nonbreeding birds) of the Sespe-Sierra condor population. Condors arrive from the south in March and April, reach peak numbers in July and August and most are gone again by October. Their feeding area is the eastern edge of the San Joaquin Valley at elevations between 150 m and 600 m (500 to 2000 feet). Roosting areas are in the adjacent Sierra Nevada foothills between 600 m and 2450 m (2000 and 8000 feet) elevation. Most feeding areas are on private lands, while the majority of roosting terrain is on federal, state and Indian reservation

lands (Wilbur 1978). We observed condors at the Blue Ridge Roost, about 6 km (4 mi) from the general study area. Condors were found regularly throughout the 1977 season at this roost, with a maximum of 7 seen on 29 June (Winter and Morlan 1977). We did not observe condors on the study area, but they have been observed in previous years (Ruth, personal communication and Clark, personal communication).

Treatment

The treated areas were made up of parts of several ranches and about 25,000 gross ha (60,000 acres) were treated. The gross treated acreage refers to the areas flown over by aircraft or ridden over on horseback. Most of the study area was treated by aircraft and in those areas only about 3.4 percent of the area actually had bait on the ground. Net acres are those areas that actually had bait on the ground. The gross and net treated areas for aircraft treatment are illustrated in Figure 2.

Other areas in Tulare County and in adjacent counties were also treated with 1080 bait for controlling ground squirrels; however, we concentrated our efforts in the general study area shown in Figure 1.

Most operational baiting was done by aircraft between 7 and 9 June 1977 and all procedures concerning application, notification of adjacent landowners, pilot safety, and handling, cleanup, and disposal of poison bait were governed by California Department of Food and Agriculture and Tulare County regulations, policies, and guidelines. The baiting was supervised and conducted by officials authorized by the Tulare County Agricultural Commissioner. The bait was applied by spot-broadcasting from aircraft over ground squirrel colonies at a rate of about 6.7 kg/ha

(6 lb/swath acre). A few smaller acreages were treated by hand application of this bait from horseback.

Bait

The bait was prepared by the Tulare County Agricultural Commissioner's Office to contain 0.075 percent 1080 on crimped oat groats (California State Registration No. 1122350022AA, EPA Est. No. 11224-CA-1). It contained a brilliant yellow dye (Auramine O concentrate) at 0.03 percent, the standard rate recommended by the Department of Food and Agriculture guidelines.

Bait samples were collected from the bait sacks before treatment and from the ground starting the day of treatment and periodically up to 185 days after treatment. Residues of 1080 found in bait samples are shown in Table 1. As expected, residues were highest in bait directly from the bait sack. After a few weeks on the ground, the 1080 residue in the bait was reduced, and after 135 days no detectable residues were present. Fresh bait was dyed a bright yellow, but after 3 to 4 days the dye had noticeably faded on bait surfaces exposed to the sun. After 2 weeks, the exposed surface of dyed bait was virtually indistinguishable from undyed oats unless turned over.

We did not attempt to measure the percent or amount of bait remaining on the ground after treatment. However, some bait, not consumed by ground squirrels or other animals, remained on the surface for 6 months (until December 1977) but became increasingly difficult to find. None was found after 10 months (April 1978).

Ants (Veromessor andrei and Liometopum occidintale) carried bait to their nests and left bait concentrated on the ground near the nest.

Marsh (1967) also noted that ants concentrated bait near their nests. Over a 54-day period, he found that invertebrates removed 34 percent of the bait kernels. Spencer (1945) recorded ants removing as much as 50 percent of 1080-treated grain within 2 h in New Mexico.

Keyes (1945) found that 35-40 percent of the bait remained on the ground and was not consumed by rodents after hand baiting ground squirrel colonies with 1080. After aerial baiting programs, Marsh (1967) found that between 55 and 98 percent of the bait remained on the ground.

Control Areas

Control areas consisted of several untreated portions of ranches in the general study area. We sampled ground squirrel populations and conducted carcass searches on these areas.

Effect of Treatment on Ground Squirrels

We used several methods to evaluate the efficacy of 1080 grain baits on California ground squirrels. They were (1) the closed-hole, (2) marked population survival, (3) total population survival, (4) generated population reduction, and (5) radio telemetry.

For the closed-hole method, we selected 10 colonies from areas scheduled to be treated and an additional 4 colonies from areas not to be treated. Within these colonies, we staked out and measured one or more plots in areas of greatest squirrel activity. The plots ranged in size from 0.3 ha to 2.2 ha for a total of 16 plots totaling 18.1 ha (Table 3).

To determine baseline activity on each plot, we closed the ground squirrel burrow entrances (holes) on 29 and 30 May 1977. We counted the

number of holes reopened 7 days later (immediately prior to treatment) and recorded this activity. Seven days after treatment we again closed all burrow entrances on all plots and recorded the number reopened 7 days later. We used the difference in hole opening activity pre- versus post-treatment to calculate the percent change in squirrel activity (Table 4). The efficacy, based on this activity index, varied on treated plots from 34.3 percent up to 91.6 percent, with a mean of 71.7 percent. Activity on the control areas varied from an increase in activity of 20.8 percent to a decrease of 34.8 percent with a mean reduction in activity of 8.1 percent. Paired t-tests showed a significant reduction in activity on the treated area ($P < 0.0002$) and no significant difference on the control plots ($P > 0.6$).

For the marked survival and total survival methods, we live-trapped and marked ground squirrels on 10 treated and 4 control plots beginning 1 month prior to treatment. We marked a total of 231 squirrels using a combination of colored ear tags and red rhodamine B dye on the front shoulders. We could easily observe these marks from 100 m with a 20X spotting scope without disturbing the above ground activity of most colonies. However, our preliminary observations indicated that ear tags were dropping off and the dye was fading on some of the squirrels from the first group of plots trapped. In addition, we could not approach some plots without disturbing squirrel activity because of the topography. Because of these problems, we were only able to use five treated plots to estimate ground squirrel populations. We counted squirrels once in the morning and once in the evening for 5 consecutive days ending 2 days before treatment. The squirrels were counted during 15-minute observation

periods in which we made several sweeps of the study plot with the spotting scope. The sweep with the highest number of squirrels was recorded and squirrel populations were estimated by a standard Lincoln Index, using the ratio of marked to unmarked squirrels observed. We made three to six population estimates for each plot and used the mean of these estimates to estimate the pretreatment populations (Table 5).

To estimate the total and marked populations that survived treatment, we collected squirrels by trapping and shooting (starting 2 weeks after treatment) from these five treated plots. Squirrels were collected for approximately 1 month (up to 6 weeks posttreatment) when we again closed the burrow entrances and observed the colonies for any remaining ground squirrel activity. We calculated treatment efficacy by comparing the total population that survived treatment with our pretreatment population estimates and by comparing the marked population surviving treatment with the population we originally marked on each plot (Table 6).

The calculated mean reduction using marked squirrel survival was 92.2 percent and total squirrel survival was 84.1 percent while the reduction using closed-hole data for the same five plots was only 61.4 percent (Table 7). The efficacy based on the marked squirrel survival data represents a maximum estimate, as some portion of the population may not have been recoverable because of such factors as emigration, predation, and estivation. While our efficacy estimates based on total population survival are influenced by these same factors, we feel they are more conservative because of additional factors such as immigration into the plots. We found that closed-hole estimates can be conservative with colonial burrowing rodents such as the California ground squirrel, since

one or two animals can open burrows posttreatment that were opened pretreatment by 5 to 10 individuals.

Based on hole and squirrel counts pre- and posttreatment, we found that the ratio of holes per squirrel changes. For example, the mean number of holes per squirrel posttreatment is about three times the mean holes per squirrel pretreatment (Table 8). If we extend these ratios of holes per squirrel pre- and posttreatment to all of the plots where hole counts were made, we can roughly extrapolate squirrel numbers pre- versus posttreatment and calculate the percent reduction based on these generated squirrel numbers (Table 9). The mean reduction in the generated population was 90.4 percent.

We live-trapped 10 ground squirrels from squirrel plot 2 (1 to 6 days before treatment) and equipped each with a 30-MHz transmitter. We tranquilized the squirrels using ketamine hydrochloride, ear-tagged them, and fitted each with a neck collar transmitter. After the squirrels recovered from the tranquilizer, we released them at the capture site and followed them daily for up to 5 days posttreatment. We found two radio-equipped squirrels dead on the surface approximately 12 h after treatment and both contained 1080 residue in their stomachs (Table 2, Samples 70 and 71). On 29 June, 22 days posttreatment, we recovered one live radio-equipped squirrel during our posttreatment trapping. We assumed that all other radio-equipped squirrels were dead in their burrows because: (1) the radio signal did not move, (2) their burrow entrances remained closed posttreatment, and (3) they were not recovered during posttreatment trapping. Based on this sample, reduction in the population equals the 90 percent mortality.

The mean for the five methods of determining efficacy was 85 percent.

To determine the percentage of the ground squirrels that died above ground and was therefore readily available to predators and scavengers, we used the radio-equipped squirrel population from squirrel plot 2 and the marked squirrel population from other squirrel plots. Based on radio telemetry 22.2 percent (2 of 9) died on the surface. By subtracting the marked survivors from the total marked population and using the number of marked squirrels found during carcass searches, we calculated percent surface kill at 8.3 percent (Table 10). This is a minimum estimate because plots were not searched daily and we may have missed some dead marked squirrels. Also, some may have been removed by other animals.

Residue Analysis

Bait and animal tissue samples were analyzed (by personnel of the Section of Supporting Sciences, Denver Wildlife Research Center) for 1080 residue by two gas chromatographic procedures. One (Peterson 1975) required relatively large amounts (100 g ideal) of sample material while the other (Okuno Unpublished) required only small (1 to 2 g) amounts of sample material. This procedure is summarized in Appendix 1. Those samples analyzed by the Peterson technique are summarized in Table 30. All other residue information in the text and tables of this report was determined by the Okuno technique.

Clean oat groats, oat groats with 0.075 percent (750 ppm) 1080 only, and oat groats with dye only were also prepared by the Tulare County Agricultural Commissioner's Office. These samples were analyzed to test the validity of the analytical techniques. Those samples known to

contain 1080 showed high residue levels while the rest showed no detectable 1080 residue (Table 1). Presumed control samples (animal tissue collected prior to treatment) were also analyzed for 1080 residue and results are summarized in Tables 2, 15, 16, 17, 18, 21, and 29. None of these samples contained detectable 1080 residue. Field personnel coded all samples with randomly assigned numbers and the analytical chemists did not know the identity of any sample.

Carcass Searches

We conducted intensive carcass searches starting the day of treatment and continuing for 2 weeks after treatment. We searched a total of 381.1 ha (941.7 acres) in treated areas (Table 11). A variety of habitats was searched, including open rangeland (56.2 ha), oak savannah (240.1 ha), stream bottoms (74.4 ha), and brushy areas (10.4 ha). Live animals observed during carcass searches were also recorded (Table 12). In addition to those found during scheduled carcass searches, a number of carcasses were collected for residue analysis during other research activities.

All of the ground squirrel plots were searched to determine the number of ground squirrels and other animals that died on the surface of the ground (Tables 13 and 14). These ground squirrel plots were searched on day 1 posttreatment, then searched again on day 7 while closing holes and on day 14 while counting the number of holes reopened by ground squirrels. During these searches, all 38 ground squirrel and 10 other rodent carcasses were found on the treated plots. No dead rodents were found on the control plots (Table 14).

We found 294 dead ground squirrels on the surface during the other carcass searches (Table 11). Fifteen (4.5%) of the 332 carcasses of dead ground squirrels found on the 400 ha searched (1.6% of the treated areas) were collected, labeled, and frozen for 1080 residue analysis (Table 2). Two of these carcasses were radio-equipped and 13 were marked. Five additional ground squirrel carcasses were collected from other areas for 1080 analysis; 4 were associated with a predator (2 with red-tailed hawks, 1 with a raccoon, and 1 with a rattlesnake), and the remaining carcass was found recently dead 22 days posttreatment (Table 2). All other ground squirrel carcasses, including the remaining 317 found during carcass searches as well as those on the rest of the entire treated area of 24,600 ha, were left undisturbed because of the need to evaluate the potential for secondary poisoning hazards. A sample of carcasses (every other one up to three from any one plot) of other rodents and rabbits was collected. All mammalian predator and bird carcasses found were collected for residue analysis.

Other Rodents

The 1080 bait killed rodents other than ground squirrels (Tables 11 and 14), including kangaroo rats (*Dipodomys heermanni*), deermice (*Peromyscus* spp.), harvest mice (*Reithrodontomys megalotis*), pocket mice (*Perognathus longimembris*) and wood rats (*Neotoma lepida*). Some of each of these species contained 1080 residue (Table 15). Two pocket gophers (*Thomomys bottae*) were found dead but they may have been road kills (Table 15). Marsh (1967) found that aerial 1080 baiting for California ground squirrels reduced deermouse populations in all cases studied.

Marsh (1967) reported kangaroo rats were also affected and to a lesser degree populations of wood rats occupying the same territory as the ground squirrels. Keyes (1945) found dead kangaroo rats, deermice, wood rats, and pocket mice during hand 1080 baiting operations for controlling California ground squirrels.

The LD_{50}'s of 1080 to most rodent species are relatively low: California ground squirrel--0.35; wood rat--1.5 mg/kg; kangaroo rat--0.33 mg/kg; deermouse--4.0 to 5.5 mg/kg; northern pocket gopher (Thomomys talpoides)--0.33 mg/kg (Denver Wildlife Research Center, Unpublished). In the past, 1080 has been used for controlling many of these species.

Rabbits

We found that 1080 baiting for California ground squirrels constitutes some hazard to cottontail rabbits. Ten dead cottontail rabbits were found during carcass searches (Table 11) and two more during other activities. Nearly all were found in rockpiles or heavy brush. Analysis of 10 of these 12 rabbits showed four contained 1080 residue in their stomachs (Table 16). Cottontail rabbit populations were probably not drastically reduced by treatment, as 55 live rabbits were seen during the carcass searches (Table 12). Marsh (1967) also reported that cottontail rabbit populations in localized areas suffered some loss but were not drastically reduced or permanently affected. He also stated that an occasional jackrabbit (Lepus spp.) consumed a lethal amount of bait. Keyes (1945), in a hand-baiting program for controlling California ground squirrels with 1080, also reported losses of cottontail rabbits and black-tailed jackrabbits (Lepus californicus).

Marsh (1967) and McNeill (1977) felt that rabbits were less vulnerable than rodents to aerial baiting because of the difficulty in picking up lethal amounts of widely scattered grain. However, the fact that 1080 can kill rabbits is not surprising, as 1080-carrot bait has been used to poison rabbits in Australia and New Zealand for many years (Rowley 1963, Poole 1963). The LD_{50} for European rabbits (Oryctolagus cuniculus) is < 0.8 mg/kg and the LD_{50} for black-tailed jackrabbits is 5.55 mg/kg (Atzert 1971).

Invertebrates

We found that two species of ants, Veromessor andrei (a harvester ant) and Liometopum occidentale, carried the 1080 bait back to their nests and left large amounts (sometimes several hundred up to 2000 kernels in 1 square meter) scattered around the ant mound. The ants generally cleared a large area around the nest of bait. Many of the ants died, apparently from 1080 poisoning, and could be found at the entrance to the nests. Residue analysis of two samples of dead ants showed one contained 1.4 ppm of 1080 and the other contained no detectable residue.

Marsh (1967) also reported that harvester ants (Pogonyrmex spp.) and darkling ground beetles of the Tenebrionidae family removed and consumed the 1080 bait. He reported that ants ultimately succumb to 1080 poisoning and sometimes leave bait concentrated on the ground near their nest.

The large number of treated kernels around these ant nests could present a hazard to seedeating birds. It is also possible that ants killed by 1080 constitute a hazard to insectivorous birds.

We found two dead white-breasted nuthatches that may have been killed by eating poisoned ants. One, sample number 91, contained about 1 ppm 1080 residue, while sample number 85 was negative (Table 17). Sibley (Unpublished) in 1966 also found two dead white-breasted nuthatches during a 1080 ground squirrel baiting operation conducted in August. He indicated that these birds had traces of grain in their stomachs but no 1080 residue analysis was conducted. Kalmbach (1945) theorized that burrowing owls (Speotyto cunicularia) may also receive a lethal dose by eating ants or other invertebrates killed by the bait.

Snakes

Live rattlesnakes (Crotalus spp.) were frequently seen during the carcass searches, but none were found dead. We did find ground squirrels in rattlesnake stomachs after treatment. One such ground squirrel (Sample 87, Table 2) was chemically analyzed but no 1080 residue was detected.

Radio Telemetry

Radio transmitters used in this study were designed and built by the Bioelectronics Unit, Section of Supporting Sciences, Denver Wildlife Research Center. Transmitter type and size varied depending on the species. All transmitters for nontarget species were in the 164 MHz band. Those for ground squirrels were in the 30 MHz band. Radio-tracking vehicles (for 164 MHz transmitters) were equipped with roof-mounted, dual yagi antennas. These antennas could be rotated from inside the vehicle and radio bearings were indicated on a 360^{o} protractor by a pointer

attached to the antenna mast. The pointer was aligned to the null of the antenna. Coaxial cables from the antenna were attached to a null-peak switch box (built by AVM Instrument Co., Champaign, Illinois)[1] which allowed switching from in phase (for maximum signal strength) to out of phase (for precise bearings) operation. We used model LA 12 receivers (built by AVM Instrument Co.)[1] for all 164 MHz radio-tracking. Hand-held loop and yagi antennas were employed for portable field use. Single yagi and whip antennas were used on aircraft during aerial tracking operations. Hand-held loop antennas and Johnson Messenger 3 receivers[1] were used for radio-tracking ground squirrels.

During early phases of the study, we did not follow movements of radio-equipped nontarget animals on a daily basis. We did, however, keep track of their general movements by trying to locate each of them every 2 to 3 days. During the 2 weeks prior to treatment and for 2 months after treatment, we attempted to locate each radio-equipped animal daily.

As described by Hegdal and Gatz (1978), we placed a beacon transmitter on a high hilltop near the center of the study area (Fig. 5). This transmitter put out a CW (continuous wave) signal and was designed to be on for 2 minutes and then off for 2 minutes throughout the study period. Radio-tracking stations were established along roads and marked with numbered rock cairns (Figs. 5 and 6). These were also located on a composite aerial photo. We had radio voice communication equipment in each vehicle to coordinate tracking efforts and obtain simultaneous or nearly simultaneous bearings. At a tracking station we recorded the

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[1] Reference to trade names does not imply Government endorsement.

bearing to the beacon transmitter and then to the animal transmitter. This method eliminated the need to orient the vehicle in any particular direction. These bearings were later converted to the angle at the tracking station between the animal and beacon, which allowed accurate plotting of the animal's location when we obtained bearings from two or more tracking stations. Those radio-equipped animals without mortality transmitters (especially doves and quail) were frequently walked out to determine their condition as well as their location. Those radio-equipped animals with mortality transmitters (coyotes, bobcats, badgers, and raccoons) were only occasionally walked out unless the mortality signal indicated they had died, in which case they were recovered as soon as possible. All radio-equipped animals that were recovered dead during the study were necropsied and tissues were preserved for chemical residue analysis. Telemetry allowed us to determine if instrumented animals actually used treated areas, as well as to recover any mortalities.

All figures illustrating movements of radio-equipped animals were constructed by connecting (with a straight line) consecutive points where the animal was located via telemetry.

HAZARDS TO MOURNING DOVES, CALIFORNIA QUAIL, OTHER PASSERINE BIRDS AND WATERFOWL

Mourning doves

Using Kniffin collapsible bait traps (Reeves et al. 1968) and 3-cell Potter traps, we captured and radio-equipped 31 mourning doves. We also attached a colored, numbered leg streamer (Guarino 1968) to these birds

to facilitate field identification if seen in groups. Attachment methods followed those of Hegdal and Gatz (1977).

Table 19 summarizes the results of the telemetry data on doves. Prior to treatment, we lost contact with eight doves and one was found dead 1 day after treatment but had died before treatment (Sample 205, Table 18). The remaining 21 doves were radio-tracked after treatment for at least 6 and up to 51 days. Figures 7 through 25 illustrate the movements of some of these birds.

Although doves (including some radio-equipped birds) were observed feeding in treated areas and at least picking up 1080-treated bait, all but one dove (Fig. 7) found dead after treatment were apparently killed by predators; analysis showed no 1080 residue in the stomach of the dove not killed by a predator (Sample 152, Table 18). During the carcass searches, we searched feeding and roosting areas and found no dead mourning doves (Table 11). Doves remained very numerous after treatment (Table 12).

We collected 10 mourning doves after treatment to determine if they were consuming sublethal levels of 1080 bait. However, examination of crop and stomach contents and residue analysis indicated they were not feeding on the 1080 bait (Table 18).

Doves will readily accept oats. For example, Hegdal and Gatz (1977) found dove mortalities (confirmed by strychnine residue analysis) in areas where undyed, strychnine-treated oats were used for controlling Richardson's ground squirrels (*Spermophilus richardsonii*). Tucker and Crabtree (1970) reported that the LD_{50} for 1080 to mourning doves is between 8.55 and 14.6 mg/kg, which indicates that they could be killed by the 1080 bait. Hunt and Keith (1962) reported an LD_{50} for mourning

doves of 7.8 mg/kg. Spencer (1945) reported only a few mourning doves found dead from 1080 hand-baiting in California and Colorado, even in areas with abundant dove populations. Keyes (1945) noted no reduction in the number of mourning doves during 1080 hand-baiting operations. Spencer (1945) observed that 1080 often acted as an emetic to mourning doves; of 18 doves offered 1080 bait for 24 h, only two died. Our telemetry data, combined with carcass search and residue data indicate that surface baiting with dyed 1080-treated oat groats presents little hazard to mourning doves. This generally agrees with the conclusions of Spencer (1945), Keyes (1945) and Welch (1945).

California quail

Using a variety of quail traps and mist nets we captured and radio-equipped 10 California quail. The transmitter design and attachment was similar to the one used on mourning doves. Prior to treatment, four quail were apparently killed by predation, one died of unknown causes, and two lost their radios. Table 20 summarizes the results obtained from radio-equipped quail. Figures 26 through 29 illustrate the movements of these birds.

No dead California quail were found during carcass searches even though we thoroughly searched brushpiles and gooseberry (Ribes spp.) patches where quail were known to roost (Table 11). Live quail were numerous before and after treatment (Table 12) and we noticed no change in numbers of quail in some of the frequently observed coveys. Quail appeared to be feeding heavily on gooseberries during the treatment period and did not eat the scratch grain (a combination of seeds

including milo, millet, and corn) that we put out before treatment while trying to trap them, so it is doubtful that they accepted the treated oats.

Dana (1971) refers to studies where aerially broadcast 1080 oat groats were completely ignored by California quail. He also reported that during carcass searches in treated areas, no dead birds were found that were attributed to the control program. Food habits analysis showed that none of the quail collected had oat groats in their crops. Green (1947) reported that Gambel's quail (Lophortyx gambellii), mourning doves, ducks, and Brewer's blackbirds (Euphagus cyanocephalus) had to be force-fed because taste or other factors caused them to refuse lethal doses under voluntary feeding. Marsh (1967) reported no detectable hazard to California quail during aerial 1080 baiting. Keyes (1945) noted no reduction in the numbers of mourning doves, California quail, horned larks (Eremophila alpestris), western meadowlarks (Sturnella neglecta) or other seedeating birds during a 1080 hand-baiting program for California ground squirrels. He also stated that no California quail were killed in pen tests with 1080 squirrel baits even when offered dyed baits after the color had faded away. Spencer (1945) also noted no reduction in ring-necked pheasant (Phasianus colchicus), Gambel's quail or California quail populations during 1080 baiting studies. He cited pen tests where Gambel's quail refused oats to the point of starvation. Spencer (1945) found that Gambel's quail were reluctant to consume grains not native to the local area or not available naturally at the particular season of treatment. However, food studies from areas outside the California quail's native range are suggestive of greater dependence on

food sources such as grain crops, legumes and weed seeds (Martin et al. 1951; Crispens 1960). Spencer (1945) added that adult Gambel's quail are quite resistant to 1080 with an LD_{40} of 20 mg/kg, and estimated the LD_{50} for immatures as 10 mg/kg. In contrast, LD_{50} values for California quail have been reported as low as 4.63 mg/kg by Tucker (unpublished data) and 2.6 mg/kg by California Fish and Game (1962). Sayama and Brunetti (1952) also concluded from laboratory results that 1080 is extremely toxic to California quail.

We collected nine California quail after treatment to determine if they were eating sublethal levels of 1080 bait. However, examination of crop and stomach contents and residue analysis indicated they were not feeding on the 1080 bait (Table 18).

These data indicate that surface baiting with dyed 1080-treated oat groats presents little hazard to California quail. This also generally agrees with the conclusions of previous authors.

Other seedeating and insectivorous birds

Spencer (1945) pointed out that at near minimum lethal doses, 1080 acts very slowly in producing death in birds and that some species have the habit of secreting themselves when affected. Furthermore, the prolonged reaction time permits birds to travel considerable distances from the area where bait was exposed. He summarizes that these facts make 1080 poisoned birds difficult to find and cautions that conclusions based solely on observed losses on treated areas may be unreliable. For these reasons, we intensively searched roosting and feeding areas of seedeating birds. We found very few bird carcasses (Table 11). One

white-breasted nuthatch (Sample 85, Table 17) found 2 days after treatment, an ash-throated flycatcher (Myiarchus cinerascens, Sample 105a, Table 17) found 4 days after treatment, a plain titmouse (Parus inornatus, Sample 175, Table 17) found 10 days after treatment and a sick scrub jay (Aphelocoma coerulescens, Sample 191, Table 17) picked up 19 days after treatment (died the next day) contained no 1080 residues. A starling (Sturnus vulgaris, Sample 144, Table 17) was possibly a pretreatment mortality and a western bluebird (Sialia mexicana, Sample 167, Table 17) was a possible road kill. We found three bird carcasses that contained detectable 1080 residues: a white-breasted nuthatch (Sample 91, Table 17) found 2 days after treatment, a Brewer's blackbird (Sample 158, Table 17) found 7 days after treatment, and an acorn woodpecker (Melanerpes formicivorus, Sample 187, Table 17) found plucked under a Cooper's hawk (Accipiter cooperii) nest 14 days after treatment. Again, our data indicate little hazard to populations of seedeating and insectivorous birds from surface baiting with dyed 1080-treated oat groats. However, in some situations 1080-treated bait can cause limited bird mortality.

In a "carefully monitored" operation in Grant County, Oregon, in 1975, only two dead starlings were found on 1500 baited acres (Anonymous 1975). However, no residue analysis was performed. Fish (1946) mentioned dead horned larks, McCown's longspurs (Rhynchophanes mccownii), chestnut-collared longspurs (Calcarius ornatus) and western meadowlarks during a 1080 baiting program for controlling Richardson's ground squirrels in Suffield, Alberta. Again, no residue analysis was conducted. Marsh (1967) referred to isolated instances of bird losses (e.g., yellow-billed magpies--Pica nuttalli, woodpeckers, one sparrow and a single towhee)

during 1080 programs as representing an infinitesimal portion of the total bird population in the area. Welch (1945) found two dead black-billed magpies (Pica pica) adjacent to 1080 plots. However, he noted no deaths among common ravens, blackbirds, and doves feeding in the same area. According to Spencer (1945), magpies suffered the heaviest casualties among birds from 1080 operations. He stated that all 1080 baiting projects reported kills with some of up to 30 percent of the resident magpie population. The LD_{50} of 1080 for magpies is 0.6-1.3 mg/kg (Atzert 1971). The LD_{50} of house sparrows (Passer domesticus) is 3.0 mg/kg (Tucker and Crabtree 1970) and Spencer (1945) stated that the lethal doses for song sparrows (Melospiza melodia) and vesper sparrows (Pooecetes gramineus) are similar. Spencer (1945) added that very few sparrows have been observed as victims of 1080 and attributes this to the repellency of the color-dyed bait used. No blackbird mortalities occurred during a June 1080 baiting program, but a few immature Brewer's blackbirds were killed during an August baiting program (Spencer 1945). In June, blackbirds ate 100 percent insects, which Spencer (1945) felt was the reason for the lack of mortalities; by August, they ate 100 percent plant matter.

Dodge (1968) found varied thrush (Ixoreus naevius), dark-eyed juncos (Junco hyemalis) and one California quail dead following a 1080 bait application (using 0.31 percent 1080 on wheat applied at 1/4 lb/acre). Subsequent analysis showed 0.75 ppm 1080 in a composite whole body sample of the quail and five varied thrush and 1.7 and 3.2 ppm in two different samples of the gastrointestinal tracts of four varied thrush. However, other samples showed endrin residues up to 134 ppm. In spite of the fact

that 1080 residues were found Dodge (1968) believed that 1080 was not responsible for the deaths because: (1) no mortalities of nontarget species were found up to 6 days after the 1080 application, (2) no remains of 1080-treated wheat were found in the stomach or gizzard of specimens examined, (3) many specimens did contain identifiable aluminum- and endrin-treated Douglas fir (Pseudotsuga menziesii) seed remnants and (4) the endrin residues. He added that varied thrushes were abundant both before and after the 1080 treatment, yet no mortalities were found until about 20 days after endrin-treated Douglas fir seed was applied. He concluded that while 1080 does not seem to constitute a serious threat to most forest-dwelling birds, this may not be entirely true for more deliberate-feeding birds such as quail.

Other seedeating bird mortalities reported during 1080 baiting by Welch (1945) and Spencer (1945) included immature Brewer's blackbirds (the LD_{50} is 2.0 - 3.0 mg/kg) and scrub jays. Spencer (1945) reported that each of two captive towhees readily hulled and consumed eight kernels of steam-rolled oats containing 0.062 percent 1080; both died within 18 h.

Kalmbach and Welch (1946) demonstrated a drastic decline in the number of birds killed when aniline dyes were added to strychnine bait. For example, in tests with uncolored bait, they recorded 85 mortalities among the following species: common grackles (Quiscalus quiscula), brown-headed cowbirds (Molothrus ater), red-winged blackbirds (Agelaius phoeniceus), yellow-headed blackbirds (Xanthocephalus xanthocephalus), mourning doves and horned larks. In contrast, only nine birds were killed with yellow bait and none with green bait. They concluded that the color of the bait deterred the birds. However, Davison (1962) found

that doves readily accepted grain dyed with tasteless food colorings, but refused grains of the same color treated with aniline dyes. Aniline dyes contain distilled oils that apparently give them a disagreeable taste (Davison and Sullivan 1963). Pank (1976) found differences in consumption between textured and untextured seed treatments which indicated that texture as well as color affected seed acceptance in dark-eyed juncos, varied thrushes and California quail. Of the agents tested, he concluded that Monastral Fast Green and animal charcoal would be the best bird repellents. According to Kalmbach and Welch (1946), yellow dye was considered second to green dye in deterring birds. The 1080 bait used in California contains a yellow aniline dye.

Nestler and Llewellyn (unpublished data) noted that bobwhite quail (Colinus virginianus) while being deterred by colored grains, would accept dyed grain under penned conditions when no naturally colored food was available. Nevertheless, the question remains--even though birds will avoid certain colors when choices are available, will they be repelled if only one color is available under field conditions?

Waterfowl

We did not attempt to radio-equip any waterfowl as their use of baited areas was negligible. However, some were occasionally observed on ponds in the study area; none were observed feeding in treated areas and no dead waterfowl were found during the carcass searches.

There is some data in the literature on hazards of 1080 to waterfowl. For example, the LD_{50} ranges from 2.9 mg/kg for young mallards (Anas platyrhynchos) and 3.0 mg/kg for the American wigeon (Anas americana) to

8-10 mg/kg for adult mallards and pintails (Anas acuta) (Cummings et al. 1973, Atzert 1971, and Tucker and Crabtree 1970). The LD_{50} of 1080 to snow geese (Chen caerulescens) is 3.5 mg/kg. That of white-fronted geese (Anser albifrons) is 5.9 mg/kg (California Fish and Game 1962). Twenty percent of a total of 3070 geese killed by poison grain in a rodent control program at Tule Lake National Wildlife Refuge contained 1080-treated oats, dyed yellow. (The remaining 80 percent of the geese contained undyed zinc phosphide treated oats.) The composition of the dead geese was as follows: 70 percent snow geese, 14 percent white-fronted geese, and 7 percent Ross' geese (Chen rossii). The 3070 dead geese totaled about 10 percent of the refuge goose population at the time (Federal Cooperative Extension Service 1959). Identification of the toxicants involved was apparently based on the color of the oats found in the geese and not on chemical analysis.

Hazards to Mammalian Predators

Laboratory studies have repeatedly shown the theoretical possibility of secondary poisoning of several species of wildlife, especially canids. The LD_{50} of most mammalian predators is low (canines are particularly susceptible) as shown in the following list from (1) Atzert (1971), (2) Schitoskey (1975), and (3) Denver Wildlife Research Center (Unpublished):

(1) Bobcat	<0.66 mg/kg
(1) Cat (*Felis domesticus*)	0.2 mg/kg
(3) Coyote	0.10(0.085-0.12) mg/kg
(1) Gray fox	0.3 mg/kg
(2) Desert kit fox (*Vulpes macrotis arsipus*)	0.22(0.15-0.34) mg/kg
(3) Dog (*Canis familiaris*)	0.06 mg/kg
(1) Badger	1.0-1.5 mg/kg
(1) Bear (*Ursus* sp.)	0.5-1.0 mg/kg

Carcasses of rats poisoned with 1080 remain toxic for 8-10 weeks (Pattison 1959) and dried carcasses may be toxic for a period of years (A. L. Ward personal communication). Field monitoring of the effects of 1080 grain baits on nontarget wildlife species has been conducted in the past by several authors (Marsh 1967; Keyes 1945; Spencer 1945; California Department of Food and Agriculture unpublished; Swick 1973; W. Griffith personal communication; Hagen 1972 and Sibley unpublished). No cases of secondary poisoning by 1080 (other than circumstantial evidence) were documented during those studies and McNeill (1977) (while not precluding the possibilities of some losses) stated that it is doubtful that significant losses have gone undetected considering the man-hours spent in the field. Nevertheless, coyotes, dogs, foxes, badgers, and skunks have been reported killed in operational baiting programs, particularly in times of restricted food supply when they eat poisoned squirrels or dig out dessicated carcasses (U.S. Army 1976). Spencer (1945) concluded that one or a very few poisoned rodents may be enough to kill a coyote.

In a hand-baiting program, Keyes (1945) cites 11 dead adult coyotes and three dead pups killed by eating 1080 poisoned rodents during one baiting program. Nine fox and one dog were found dead in the same operation. Another program reported "not less than" seven coyotes found dead (Keyes 1945). After aerial 1080 bait application, Marsh (1967) found a single dead coyote with circumstantial evidence pointing to secondary poisoning and one dead and one sick skunk (which later recovered), but the skunks may represent primary rather than secondary poisoning because skunks are known to consume oat groats occasionally.

Spencer (1945) reported finding a number of dead coyotes in California and Colorado, 50 dead farm dogs in Montrose, Colorado, and 10 dead desert kit fox in Kern County, California. Schitoskey (1975) killed a desert kit fox by feeding it one 1080-killed kangaroo rat containing 0.74 mg of 1080 (the amount of 1080 on 40-50 treated seeds).

Joint investigations by the California Department of Food and Agriculture, the California Department of Fish and Game and cooperating agricultural commissioners in 1973 and 1976 concluded that proper use of 1080 for ground squirrel control does not have any significant effects on populations of the San Joaquin kit fox (Wallace 1976). Morrell (1975) states that the effect of rodent control programs on the kit fox is uncertain.

We did not observe mountain lion (Felis concolor) on the study area; however, a female and young were observed nearby (Kirkpatrick personal communication). Mountain lions have been recorded shifting their diet to ground squirrels during squirrel population peaks (Mountain Lion Workshop 1976). No LD_{50} or 1080 hazard data is available for mountain lions.

No chemical residue analysis was reported for any of the above mortalities and baiting programs prior to the late 1960's were usually related to hand or ground baiting procedures. Howard (personal communication to McNeill 1977) pointed out that the types of bait used and techniques of application were not refined to reduce secondary hazards to the degree they are today.

We captured and radio-equipped 6 coyotes, 10 bobcats, 2 gray fox, 4 raccoons, 9 badgers, 1 opossum, and 9 striped skunks. Most were trapped using No. 3 offset traps with tranquilizer tabs (Balser 1965). However, most skunks were netted according to procedures outlined by Adams et al. (1964). One young bobcat was darted with ketamine hydrochloride while in a tree. We also used ketamine hydrochloride (intramuscular), as necessary, as an immobilizing agent to restrain bobcats, badgers, raccoons, and skunks during radio instrumentation. Coyotes and fox were manually restrained during this process. All animals were ear-tagged, including those not radio-tagged. Animals were transported in canvas bags and some were held several hours to insure complete recovery from the tranquilizer. After the radio transmitter was attached, the animals were released at the capture site. Trapping for these animals started in early April and continued until shortly after treatment in early June. Mammalian predators that were recovered dead during the study were necropsied and tissues were preserved for chemical residue analysis.

Four of the six radio-equipped coyotes died within 1 week after treatment. Figures 30 through 33 illustrate the movements of these coyotes. A fifth radio-equipped coyote was found dead 30 days after treatment but had probably died within 3 weeks after treatment. We had

difficulty locating this animal 2-1/2 weeks after treatment (Fig. 34). Necropsies of these animals generally showed symptoms similar to those indicated for 1080 intoxication (Table 31). However, chemical analysis did not indicate 1080 residue in the stomach contents (Samples 86, 147, 150, 209 and 195, Table 21). The sixth radio-equipped coyote survived treatment, was tracked in the treated area, and was alive and well in early December about 6 months after treatment (Fig. 35). Results obtained from radio-equipped coyotes are summarized in Table 22. Two other coyotes (not radio-equipped) were found dead during the study. One was found 7 days after treatment but had been dead for some time and was probably dead prior to treatment (Sample 151, Table 21). The other was found dead 9 days after treatment. Again, necropsy indicated 1080 intoxication (Table 31) but chemical analysis did not show 1080 residue in the stomach contents (Sample 164, Table 21).

We conducted pre- and posttreatment predator scent post surveys according to procedures outlined by Linhart and Knowlton (1975). Our coyote indices were low compared to the mean 1977 indices for California (121) and the Western United States (99) (Roughton 1977). While our data are limited, confounded with time and not significantly different, they do show a reduction in the coyote abundance index after treatment (Table 23). However, after one year, the abundance index increased (Table 23).

We also conducted pre- and posttreatment coyote siren surveys according to procedures outlined by Wolfe (1974), and the results are summarized in Table 24. Again while limited, confounded with time, and not significantly different, these data show a reduction in the number of

coyotes responding after treatment with a return to near pretreatment levels 1 year later.

It is not surprising to find coyote abundance near pretreatment levels a year after treatment. Beasom (1974) found that intensive predator control (on a 9 sq mi area) reduced coyote numbers in Texas but that coyote numbers returned to near pretreatment levels about 6 months after intensive control efforts ceased. Connolly and Longhurst (1975) stated that a coyote population can maintain itself and even increase its numbers except at the very highest levels of control. Their simulation model predicted that if 75 percent of the coyotes are killed each year, the population can be exterminated in slightly over 50 years.

Neither coyotes nor gray fox were abundant on the study area prior to treatment. Two gray fox were radio-equipped during the study, but one lost its radio transmitter 19 days prior to treatment and the other one could not be located after 29 April 1977, 39 days before treatment. One domestic dog was reported dead 8 days after treatment by a landowner living within 450 m (1500 feet) of a treated area. Results of chemical analysis did not show 1080 residue (Sample 171, Table 21), but necropsy indicated symptoms similar to 1080 intoxication (Table 31). One San Joaquin kit fox was found dead on a highway on 6 September 1977, 3 months after treatment. This animal was an apparent road kill, and neither residue analysis nor necropsy (Table 31) indicated 1080 intoxication (Sample 208, Table 21).

Some bobcats were also apparently killed by the 1080 treatment, although they appear to be less susceptible than canines. Of the 10 radio-equipped bobcats, three died in the first 4 days after treatment.

While necropsies again indicated symptoms similar to 1080 intoxication, chemical analysis did not show 1080 residue in the stomach contents (Samples 69, 78, and 107, Table 21). Figures 36-38 illustrate the movements of these animals prior to their death. One of these bobcats (Sample 69, Fig. 36) had sustained a foot injury when trapped and was emaciated when found. The injury may have contributed to its death. The rest of the bobcats all survived treatment but one was found dead 5 months after treatment near a road and possibly had been shot (Fig. 39). The exact cause of death could not be determined because of the state of decomposition. Another one was killed when struck by a vehicle on a highway 6 months after treatment (Fig. 40) and another one was retrapped by a trapper 8 months after treatment (Fig. 41). The rest were all alive the last dates radio-tracked, which were 27 June, 14 September, 1 December 1977, and 24 April 1978 (Table 25 and Figs. 42-45). Table 25 summarizes results obtained from radio-equipped bobcats.

A landowner living within 450 m (1500 feet) of a treated area found one housecat dead after treatment. Again necropsy indicated symptoms similar to 1080 intoxication (Table 31) but chemical analysis did not show 1080 residue in the stomach contents (Sample 170, Table 21).

Two dead adult and one dead juvenile skunk were possibly killed by the 1080 treatment. The only mammalian predator that contained detectable 1080 residues was the juvenile skunk (Sample 55, Table 21) which contained 1.5 ppm of 1080. No grain was detected in the stomach. The two adult skunks did not contain detectable 1080 residue in their stomach contents (Samples 98 and 168, Table 21). Spencer (1945) and Marsh (1967) also reported finding dead skunks associated with 1080

baiting programs. We lost contact with five of the nine radio-equipped skunks prior to treatment. One of the remaining skunks apparently was consumed by a mammalian predator. The radio transmitter was found in what appeared to be raccoon feces and had apparently passed through the digestive tract of the raccoon (Fig. 46). Another skunk survived treatment and was alive and well 12 days after treatment, the last date tracked (Fig. 47). We had difficulty tracking the remaining two skunks but they apparently survived treatment and were last tracked on 5 July and 6 July (28 and 29 days posttreatment). Table 26 summarizes results obtained from radio-equipped skunks.

We found no indication of a hazard to badgers. No badger carcasses were found during the carcass searches and the three badgers that were radio-tracked during and after treatment all survived (Figs. 48-50). Table 26 summarizes results obtained from radio-equipped badgers. No dead badgers were found by Spencer (1945) or Keyes (1945) either, although badgers were present on treated areas they studied. Welch (1945) reported two badgers being killed by eating sick and dead ground squirrels.

Of the four radio-equipped raccoons, one died of unknown causes prior to treatment and we lost contact with one prior to treatment. The remaining two raccoons both survived treatment and were alive the last dates tracked which were 5 September 1977 and 24 April 1978 (Figs. 51 and 52). Table 26 summarizes the results obtained from radio-equipped raccoons. Raccoons were exposed to treatment. For example, a raccoon was observed eating a ground squirrel the night of treatment. This ground squirrel was

collected and preserved for chemical analysis, which showed it contained 13 ppm 1080 in the stomach contents (Sample 73, Table 2).

Marsh (1967) theorized that aerial application of bait might greatly decrease the secondary hazards of 1080 because individual rodents would consume less of the scattered bait. While this may be true, our results indicate that some hazards to mammalian predators, especially to coyotes, still exists with aerial 1080 baiting. Even though chemical analysis did not show 1080 residue in the stomach contents, the most likely cause of death, for most of the predators found dead, appears to be 1080 intoxication. Preliminary indications from recent laboratory and pen studies at the Denver Wildlife Research Center indicate that coyotes can be killed by consuming Richardson's ground squirrels that died after feeding on 1080-treated oat groats. Also, 1080 may not be detectable in these coyotes, with current technology, except at the highest levels. However, we had tagged some of the 1080-treated oat groats with coded plastic, microscopic particles that fluoresce and can be magnetically recovered. We detected these particles in the coyote digestive tract (after the coyote had died from consuming ground squirrels killed with the tagged bait).

Hazards to Raptors and Carrion-eating Birds

Most investigators report little or no secondary hazard to raptors from 1080 ground squirrel baiting programs. Rough-legged (*Buteo lagopus*), marsh (*Circus cyaneus*), Swainson's (*Buteo swainsoni*), red-tailed, Cooper's hawks, golden eagles, turkey vultures, and California condors have all been observed feeding on rodents killed by

1080 without any apparent adverse effects (Spencer 1945, Welch 1945, Keyes 1945, and Koford 1953). Keyes (1945) noticed no adverse effects of 1080 on three golden eagles and numerous red-tailed hawks feeding regularly on dead and dying ground squirrels. Spencer (1945) observed marsh, red-tailed, Swainson's, Cooper's and rough-legged hawks feeding on rabbits killed by 1080. A pair of red-tailed hawks was observed for 1 month in Colorado feeding repeatedly on 1080-killed prairie dogs (*Cynomys* spp.).

Koford (1953) even suggests that ground squirrel poisoning (by providing a food source) may be responsible for the northward extension of the California condors' range since the 1920's.

With the exception of the golden eagle (LD_{50} 1.25-5.0 mg/kg; Tucker and Crabtree 1970), the LD_{50} of 1080 to raptors is higher than that of most mammals and seedeating birds (Atzert 1971). For example:

Ferruginous hawk (*Buteo regalis*)	10 mg/kg
Rough-legged hawk	10 mg/kg
Marsh hawk	10 mg/kg
Great horned owl	10 mg/kg
Turkey vulture	20 mg/kg (LD_{71})
Black vulture (*Coragyps atratus*)	15 mg/kg

Raptors may be less susceptible to secondary poisoning than mammalian predators because of their higher LD_{50}'s and because of their refusal in captivity to consume large amounts of 1080 poisoned meats (Dana 1971). In addition, Spencer (1945) hypothesized that 1080 may cause emesis in hawks before lethal amounts are absorbed. Hawks were force-fed mice and received a dose of 25 mg/kg of 1080. They survived by

regurgitating the partially digested mouse. The secondary hazard may be further reduced by the fact that, when food was plentiful, both hawks and vultures eviscerated the carcass before eating it (Spencer 1945). We also observed hawks and vultures eviscerating carcasses. Neither the stomach nor the intestines of poisoned squirrels were eaten by red-tailed hawks observed by Welch (1945) or by captive marsh and rough-legged hawks (Spencer 1945). However, some raptors may consume stomach contents, for example when they swallow small rodents whole. Van Driesche (1975) suggested that young raptors in the nest would be more sensitive to 1080 poisoning because of their smaller size. Coulombe (personal communication to Zarn 1974) maintains that burrowing owls consume carrion available to them near their burrows and feels that secondary poisoning of burrowing owls is important in the foothills of the Central Valley of California. In addition to the possibility of secondary poisoning to burrowing owls, Butts (1973) asserts that the burrowing owl is dependent upon active rodent colonies and suffers from loss of habitat during poisoning programs. Keyes (1945) mentioned that "grain eating" burrowing owls were killed by 1080 bait on Camp Roberts Military Reservation, California. We have found no literature that supports this contention of grain in the diet of burrowing owls. Spencer (1945) was possibly referring to the same incident when he cites three burrowing owls found dead. Once again, no residue analysis was conducted.

Spencer (1945) suggests that burrowing owls may receive lethal doses of 1080 by consuming poisoned insects. As previously discussed, many cereal baits are removed and consumed by invertebrates. Burrowing owls are opportunistic feeders and their diet may include rodents, birds,

insects, crustaceans, reptiles, amphibians, carrion, and examples of cannibalism (Errington and Bennett 1935, Neff 1941, Hamilton 1941, Glover 1953, Robinson 1954, James and Seabloom 1968, Ross 1970, Thomsen 1971, Coulombe 1971, and Butts 1976). Most researchers noted an increase in the consumption of insects by burrowing owls during summer months.

Spencer (1945) found one dead and three sick "barred" owls (probably barn owls) at Camp Roberts, California. Two of the sick owls later recovered. In lab tests, he found owls regurgitated when fed 1080 poisoned rats; one of three great horned owls survived high levels of 1080.

Long-eared owls (Asio otus) and great horned owls were present during poisoning operations in Colorado but none were found dead (Spencer 1945). Although many owl species are primarily nocturnal in their feeding habits, ground squirrels do show up in great horned owl diets (Fitch 1947; Maser et al. 1970). More significant, however, are the high numbers of wood rats, kangaroo rats, pocket mice, and especially deermice that occur in the diets of great horned owls, barn owls, long-eared owls, and short-eared owls (Asio flammeus) (Smith and Hopkins 1937, Evans and Emlen 1947, Fitch 1947, Maser et al. 1970, and Clark and Wise 1974). We found these rodent species dead after treatment and residue analysis confirmed 1080 intoxication in many cases (Table 15). Marsh and Howard (personal communication to McNeill 1977) believe that of the nontarget rodents killed by 1080 baiting (wood rats, deermice, kangaroo rats, and pocket mice), deermice are probably the most affected. They state that this nocturnal species is most apt to be found in close association with ground squirrels, and that they are excellent foragers with a relatively

high preference for oats. Maser et al. (1970) found deermice to be the second most important prey species to great horned and long-eared owls during the summer in central Oregon. Evans and Emlen (1947) reported that deermice are important prey items of the barn owl during the spring and summer in Davis, California. The likelihood of poisoning deermice presents the possibility of secondary hazards to their major predators.

Welch (1945) observed five common ravens feeding on surface-killed ground squirrels. Two of these birds were seen to regurgitate undigested portions of rodents. However, he found no dead ravens.

Vultures and condors have been said to be relatively immune to 1080 (Hagen 1972, Spencer 1945). Vultures weighing 3 kg required 30 mg of 1080 to produce 1080 poisoning symptoms; Spencer (1945) felt that they could not consume enough rodents in one day to obtain a lethal dose. According to Koford (1953) a turkey vulture would have to eat as much as 40 times its own weight in poisoned ground squirrels before it would probably die. He adds that this amount would be less if the contents of the cheek pouches and stomachs were eaten or if the squirrels had ingested more than the minimum lethal dose. However, Keyes (1945) reports four "buzzards" (presumably turkey vultures) found dead following a 1080 baiting program. He located two of these within 120 m (125 yards) of a highway, but both were too decomposed for laboratory examination. Because of the otherwise stable "buzzard" population in the area he implied that these birds could have been shot. Miller et al. (1965) stated that carrion-feeding birds readily eat the viscera and cited Albitrie (personal communication) who observed condors feeding on 1080-poisoned kangaroo rats, which they swallowed one after the other.

While some investigators conclude that little or no hazard is presented to the California condor by 1080 ground squirrel baiting (S. Wilbur personal communication, Keyes 1945, Spencer 1945, and Hagen 1972), Koford (1953) stated that poisoned animals must be regarded as dangerous to condors until proven otherwise. Miller et al. (1965) suggested that this use of 1080 may be a contributing factor in condor mortality. No certain evidence exists that a condor has been poisoned in this manner, but 1080 ground squirrel poisoning is widespread in the condor feeding range. Also, condors have been reported eating poisoned ground squirrels (Koford 1953, Miller et al. 1965, and Hagen 1972). S. Wilbur (personal communication) and W. Clark (personal communication) indicated that with the general shift from ground to aerial application of 1080 bait in recent years, there appears to be considerably fewer ground squirrels dying above ground. Instead of a bait spot at each burrow, a light sprinkling of grain is spread in the treated area. Squirrels presumably eat enough to make them sick but they return to their burrow before dying. Therefore, fewer carcasses should be available to attract condors or other raptors. In our study, we found an average of 3.92 dead ground squirrels per hectare on the surface. Koford (1953) suggests that the physiological effect of the ingestion of sublethal doses of 1080 over a long period might well be harmful to condors. Hagen (1972) discusses an incident where a condor that was killed by flying into a power line showed a low level of 1080 residue in its digestive tract. He adds that there was no indication that 1080 contributed to the bird's death.

We captured and radio equipped six red-tailed hawks, one golden eagle, four great horned owls, two barn owls, one screech owl, five

turkey vultures, three common ravens, and one common crow. Figures 53 through 57 illustrate the movements of some of these birds. Table 27 summarizes the results of the telemetry data on raptors that were tracked through treatment.

Raptors were trapped using the bal-chatri trap (Berger and Mueller 1959, Berger and Hamerstrom 1962), the Swedish goshawk trap (Meng 1971), the Verbail trap (Stewart et al. 1945), mist nets and cannon nets. A few juveniles were captured by hand after they had left the nest. Raptors were banded and radio-tagged immediately after capture and released at the capture site. No tranquilizer or immobilizing agents were used. Some raptors that were captured but not radio-equipped were banded and released. Turkey vultures (not radio equipped) were equipped with patagial tags. Bands were not used on any turkey vulture because bands tend to trap excrement causing swelling and loss of the use of leg and/or foot as described by Henckel (1975).

Even though present on the study area, we did not instrument sharp-shinned hawks (Accipiter striatus), Cooper's hawks, prairie falcons (Falco mexicanus), American kestrels (Falco sparverius) or merlins (Falco columbarius). Reasons for not instrumenting these birds were varied, but generally included one or more of the following:

(1) Food habits information shows them likely to feed more on birds than on mammals.

(2) They are not summer residents in the area--only migrating through or winter residents.

(3) They generally feed on smaller rodents or insects and are less likely to be affected by the ground squirrel control program.

(4) We simply did not have the capacity to radio-track additional individuals.

Vet-wrap[1] (3M Co., Minneapolis, Minnesota) was used to restrain raptors during radio instrumentation and banding operations (Fuller 1975). Several species of raptors were still feeding young in the nest when the area was treated. Therefore, we checked nests to determine nesting success. However, we kept these activities to a minimum during critical periods to prevent nest abandonment as outlined by Fyfe and Olendorff (1976). We located 86 nest platforms, 58 of which were active in 1977 (Table 28). All nest locations were plotted (Fig. 58).

The number of young fledged from active nests (Table 32) compares favorably with that of other studies (Wiley 1973, Brown and Amadon 1968 and Fitch et al. 1945). Also, the 18 nests still active at treatment all successfully fledged young. There were 30 red-tailed hawks fledged from 15 nests, three golden eagles fledged from two nests, and four Cooper's hawks fledged from one nest.

Any raptors that were recovered dead during the study were preserved for necropsy and chemical residue analysis. We found a sick American kestrel 7 days after treatment that died 1 day later (Sample 148, Table 29) but it contained no detectable 1080 residue. A screech owl (Sample 181, Table 19) was found dead 11 days after treatment but it contained no detectable 1080 residue. Two dead vultures were picked up 37 and 135 days after treatment but the cause of death could not be determined. No

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[1] Reference to trade names does not imply endorsement by the Federal Government.

1080 residue was detected (Table 29, Samples 198 and 211). While it seems unlikely, the possibility that 1080 was involved in the death of these birds cannot be ruled out. The other carcasses picked up after treatment were very dry and the birds probably died before treatment.

Raptors were frequently observed feeding on ground squirrels and other rodents after treatment and were thus exposed to 1080. A ground squirrel (Sample 176, Table 2) dropped by a red-tailed hawk contained 1.7 ppm of 1080 and another ground squirrel found under a red-tailed hawk nest contained 1.6 ppm of 1080 (Sample 154, Table 2). However, this nest fledged all three young. A kangaroo rat (Sample 77, Table 15) dropped by an American kestrel contained no detectable 1080 residue. An acorn woodpecker (Sample 187, Table 17) found plucked under a Cooper's hawk nest contained 4.4 ppm 1080 residue. However, all four young were fledged from this nest.

Vultures and red-tailed hawks were numerous on the study area both before and after treatment, and we observed them eating and eviscerating ground squirrel carcasses. We observed no dead or sick birds at roosts or feeding areas after treatment.

One radio-equipped turkey vulture was observed 780 km southeast in Organ Pipe Cactus National Monument on 5 May 1978 (about 12 months after it was radio-equipped) (Table 27). One patagial-tagged turkey vulture was reportedly shot about 2500 km southeast in Mexico near Los Reyes, Michoacan, in mid-December 1978 (about 20 months after being tagged).

Even though raptors are exposed to poisoned carcasses and some frequently feed on ground squirrels, the secondary hazards to raptors from 1080 baiting for California ground squirrels appear to be relatively low.

Conclusions

The aerial application of dyed 1080-treated oat groats resulted in about an 85 percent reduction in the ground squirrel population. Other small rodents such as pocket mice, kangaroo rats, deermice, harvest mice and wood rats were also killed by the treatment but percent population reduction is unknown. There appeared to be some primary hazard to cottontail rabbits but the population was probably not significantly affected. There appeared to be little hazard to seedeating birds such as mourning doves and California quail. There is apparently some hazard to insectivorous birds such as acorn woodpeckers and white-breasted nuthatches, which could be caused by eating 1080-poisoned ants. However, the population of acorn woodpeckers did not appear to be significantly affected. Raptors, including red-tailed hawks, great horned owls, golden eagles and turkey vultures, did not seem to be affected by the treatment, although some were consuming poisoned rodents. Mammalian predators, especially coyotes, appeared to be the nontarget animals most affected. Three dead striped skunks (not radio equipped), five of six radio-equipped coyotes, and three of 10 radio-equipped bobcats were found dead after treatment under circumstances that implicate 1080. In spite of the initial reduction in the coyote population, scent post and siren surveys 11 months after treatment indicated population levels near pretreatment levels. However, data from these surveys are limited and confounded with time.

Even though chemical analysis did not show 1080 residue in the stomach contents of radio-equipped predators found dead, the most likely cause of death is 1080 intoxication. First, most deaths occurred in the

first week posttreatment, and none occurred after 3 weeks posttreatment. Second, necropsies on these animals showed symptoms similar to 1080 intoxication. Third, unidentified rodent remains were found in the stomachs of most dead predators. Also, it may be difficult to detect 1080 residues in animals that were killed by secondary poisoning because 1080 tends to exert an emetic action, especially on canines (Azert 1971). And, some 1080 is converted, in the primary species, to fluorocitrate, which is apparently the actual toxicant causing death (Atzert 1971, Goldman 1969 and Peters et al. 1953). Therefore, predators may be ingesting mostly fluorocitrate rather than fluoroacetate (1080). Fluorocitrate would not be detected by the methodology for fluoroacetate. Fluorocitrate is very unstable and current methodology is unsatisfactory for determining its presence at low levels in biological material (E. Kun personal communication). Preliminary indications from our studies with penned coyotes indicate that coyotes can be killed by consuming Richardson's ground squirrels that were killed by feeding on bait containing 0.075 percent 1080. Also, these preliminary tests indicate that any 1080 residue present in these same coyotes may not necessarily be detectable with current residue techniques. However, we tagged some of the bait with coded plastic, microscopic particles that fluoresce and can be magnetically recovered. We found these particles detectable in the coyote digestive tract (after the coyote died from consuming ground squirrels killed by the tagged bait).

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Table 1. 1080 residue analysis of bait samples.

Sample No.	Source of Sample	1080 Residue ppm
110	Bait from bait sack	700
112	Bait from bait sack	240
127	Bait from bait sack	280
138	Bait from bait sack	300
139	Bait from bait sack	210
140	Bait from bait sack	230
122	From ground immediately posttreatment	240
129	From ground immediately posttreatment	310
113	From ground 2 days posttreatment	160
128	From ground 2 days posttreatment	140
142	From ant mound 3 days posttreatment	210
143	From ant mound 7 days posttreatment	185
188	From ground 13 days posttreatment	82
186	From ground 15 days posttreatment	5
193	From ground 21 days posttreatment	152
196	From ant mound 33 days posttreatment	110
207	From ground 74 days posttreatment	5
210	From ant mound 135 days posttreatment	NLT 2[1]
212	From ground 185 days posttreatment	NLT 2
213	From ant mound 185 days posttreatment	NLT 2
199	Untreated oat groats	NLT 2
200	Untreated oat groats	NLT 2
201	Oat groats with dye only	NLT 2
202	Oat groats with dye only	NLT 2
203	Oat groats with 1080 but without dye	300
204	Oat groats with 1080 but without dye	730

[1] NLT - Not found, if present less than value indicated.

Table 2. 1080 residue analysis of ground squirrels shot before treatment as controls or collected after treatment.

Sample No.	Days post-treatment	Distance from treated area	Status	1080 Residue (ppm)
Pretreatment:				
45			Shot	NLT 2[1]
47a			Shot	NLT 2
47b			Shot	NLT 2
47c			Shot	NLT 2
Posttreatment:				
62	1	Within	Marked, found dead	22
67a	1	Within	Marked, found dead	2.2
67b	1	Within	Marked, found dead	6.3
68	1	Within	Marked, found dead	---
70	8 hrs.	Within	Radioed-found dead	11
71	8 hrs.	Within	Radioed-found dead	16
73	12 hrs.	30 m	Raccoon was eating it	13
74	1	Within	Marked, found dead	13
76a	2	Near	Marked, found dead	5
76b	2	Near	Marked, found dead	32
76c	2	Near	Marked, found dead	150
76d	2	Near	Marked, found dead	5
81	2	Within	Marked, found dead	29
83	1	Within	Marked, found dead	8.5
87	3	Within	Found within rattlesnake's stomach	NLT 2
99	4	Within	Marked, found dead	24
146	5	Near	Marked, found dead	1.2
154	3	Within	From under raptor nest	1.6
176	9	Within	Dropped by red-tailed hawk	1.7
194	22	Within	Found dead	NLT 10

[1] NLT - Not found, if present less than value indicated.

Table 3. Size of squirrel efficacy plots and number of burrow entrances on plots prior to burrows closing.

Plot	Hectares	No. Burrow Entrances	Burrow Entrances/Hectare
Treated			
1	2.2	229	104.1
2	1.4	148	105.7
3	1.1	173	157.3
4	0.4	72	180.0
5	0.8	147	183.7
6	1.6	265	165.6
7	1.1	167	151.8
8	0.3	96	320.0
9	0.8	127	158.8
10	1.1	174	158.2
11	1.1	229	208.2
12	1.9	306	161.0
Control			
13	2.0	202	101.0
14	1.3	264	203.1
15	0.6	56	93.3
16	0.4	93	232.5
Total	18.1	2748	
$\bar{X}$	1.1	171.8	151.8*

$$*\frac{\text{Total number burrow entrances}}{\text{Total hectares}}$$

Table 4. Percent change in activity of burrow entrances open by ground squirrels pre- and posttreatment.

Plot	Burrow Entrances Opened: Pre	Burrow Entrances Opened: Post	% Change in Activity[1]
Treated			
1	99	11	- 87.9
2	53	7	- 85.6
3	45	7	- 83.1
4	26	2	- 91.6
5	53	32	- 34.3
6	128	38	- 67.7
7	67	26	- 57.8
8	35	8	- 75.1
9	58	23	- 56.8
10	67	22	- 64.3
11	69	16	- 74.8
12	131	22	- 81.7
Total	831	214	
$\overline{X}$	69.2	17.8	- 71.7 ± 4.76
Control			
13	107	119	+ 11.2
14	66	43	- 34.8
15	24	29	+ 20.8
16	37	26	- 29.7
Total	234	217	
$\overline{X}$	58.5	54.3	- 8.1

[1] On the treated area, the % change in activity wad adjusted for the change in activity on the control areas as follows:

Adjusted percent control =

$$1 - \frac{\text{Number active posttreatment}}{\text{Number active pretreatment (1 - \% change on control area)}}$$

Table 5. Population estimates and pre-treatment densities of squirrels on five treated plots.

Plot	No. Marked Squirrels	No. Observations/Plot	Population $\overline{X}$*	(SE)	Hectares	Squirrels/ Hectare
3	24	3	38.67	(4.81)	1.1	35.2
5	23	4	54.15	(5.40)	0.8	67.7
6	33	6	82.90	(14.03)	1.6	51.8
7	19	5	46.48	(6.48)	1.1	42.3
10	16	6	50.22	(8.72)	1.1	45.7

* Based on Lincoln Index Formula:

$$\text{Population Estimate} = \frac{(\text{Total Observed})\ \ (\text{Total Marked})}{(\text{Marked Observed})}$$

Table 6. Percent control calculated for marked and total squirrel survival.

Plot	No. Marked	Population Estimate	Squirrel Survival		% Change	
			Marked	Total*	Marked**	Total***
3	24	39	0	1	- 100.0	- 97.4
5	26	54	4	10	- 84.6	- 81.5
6	33	83	4	24	- 87.9	- 71.1
7	19	46	1	9	- 94.7	- 80.4
10	16	50	1	5	- 93.8	- 90.0
$\bar{X}$	23.6	54.4	2	9.8	- 92.2	- 84.1

* Includes squirrels observed after ground squirrel removal.

** $1 - \frac{\text{Marked Recovered}}{\text{Total Marked}} \times 100$

*** $1 - \frac{\text{Total Recovered}}{\text{Population Estimate}} \times 100$

Table 7. Comparison of three estimates of efficacy on five treated plots.

Plot	Calculated Percent Change		Closed Hole
	Marked Survival	Total Survival	
3	- 100.0	- 97.4	- 83.1
5	- 84.6	- 81.5	- 34.3
6	- 87.9	- 71.0	- 67.7
7	- 94.7	- 80.4	- 57.8
10	- 93.8	- 90.0	- 64.3
$\bar{X}$	- 92.2	- 84.1	- 61.4

Table 8. Calculations of the number of holes per squirrel pre- and post-treatment.

	Pretreatment			Posttreatment		
Plot	No. Holes	No. Squirrels Estimated	Holes/ Squirrel	No. Holes	No. Squirrels Surviving	Holes/ Squirrel
3	45	39	1.2	7	1	7.0
5	53	54	1.0	32	10	3.2
6	128	83	1.5	38	24	1.6*
7	67	47	1.4	26	9	2.9
10	67	50	1.3	22	5	4.4
$\overline{X}$			1.3			3.8

* May have been lowered due to immigration into plot.

Table 9. Percent control calculated for generated population data corrected for changes in the number of holes per squirrel pre- and posttreatment.

Plot	Pretreatment No. Holes	Pretreatment No. Squirrels Generated	Posttreatment No. Holes	Posttreatment No. Squirrels Generated	% Change****
Control					
13	107	82.3*	119	91.5*	+ 11.2
14	66	50.8*	43	33.1*	- 34.8
15	24	18.5*	29	22.3*	+ 20.8
16	37	28.5*	26	20.0*	- 29.7
$\overline{X}$ =					- 8.1
Treated					
1	99	76.2*	11	2.9**	- 95.9
2	53	40.8*	7	1.8**	- 95.2
3	45	34.6*	7	1.8**	- 94.3
4	26	20.0*	2	0.5**	- 97.3
5	53	40.8*	32	8.4**	- 77.6
6	128	98.5*	38	10.0**	- 89.0
7	67	51.5*	26	6.8**	- 85.6
8	35	26.9*	8	2.1**	- 91.5
9	58	44.6*	23	6.1**	- 85.1
10	67	51.5*	22	5.8**	- 87.7
11	69	53.1*	16	4.2**	- 91.4
12	131	100.8*	22	5.8**	- 93.7
$\overline{X}$ =					90.4 ± 1.64

* Calculated at 1.3 holes per squirrel.

** Calculated at 3.8 holes per squirrel.

*** May be higher due to immigration into plot.

**** On the treated plots, percent change was adjusted to account for the % change on control plots as follows:

Adjusted percent change =

$$1 - \frac{\text{Posttreatment population}}{\text{Pretreatment population (1 - \% change on control areas)}}$$

Table 10. Percent surface kills calculated from marked squirrel carcasses found.

Plot	No. Marked	No. Marked[1] Survivors	No. Marked[1] Carcasses	% Surface Kill
1	17	0	0	0.0
3	24	0	1	4.2
4	22	0	1	4.5
5	23	4	0	0.0
6	33	4	6	20.7
7	19	1	3	16.7
10	16	1	1	6.7
11	7	0	1	14.3
12	7	2	0	0.0
Totals:	168	12	13	
$\bar{X}$				8.3[2]

[1] Found after treatment.

[2] $\bar{X}$ % Surface Kill = $\frac{\text{Total No. Marked Carcasses}}{\text{Total No. Marked - No. Marked Survivors}} \times 100$

Table 11. Dead animals found during carcass searches.

Area	Hectares Searched	Days Post-treatment	Ground Squirrel	Kangaroo Rat	Pocket Mouse	Other Rodents[a]	Rabbit	Skunk	Blackbird	White-breasted nuthatch
1	2.2	7 hrs.								
2	5.8	8 hrs.	2							
3	2.9	8 hrs.	3							
4	0.8	1	2							
5	3.4	1	2							
6	1.0	1								
7	14.4	1	6			1	1			
8	31.1	1	43	4	1					
9	24.8	1	16			1	1			
10	3.9	1	4		1					
11	10.4	1	5	1						
12	11.2	2	2							
13	14.2	2	5							1
14	44.8	2	19		1		1			
15	4.7	2	9				1			
16	26.0	2	18	1	2	1	2			1
17	13.5	3	1		1					
18	2.2	3	4							
19	22.5	3	20			1				
20	3.7	4				1				
21[b]	30.0	4	41						1	
22	3.0	4	15							
23	2.8	4	2	1		1				
24	12.6	4	15					1		
25	4.6	4	11							
26	0.7	4	5							
27	2.0	4	1			1				
28[c]	11.5	4	2			1	3			
29	2.9	5	4							
30	30.6	7	3						1	
31	4.0	8	7		1					
32	4.9	9	3							
33	10.1	9								
34	4.4	10	5							
35[b]	4.2	11	7							
36	3.6	11	4				1			
37[b]	5.7	12	8							
Totals	381.1		294	7	7	8	10	1	2	2

[a] Includes 4 deermice, 1 harvest mouse, and 3 woodrats.

[b] Numerous feathers found from acorn woodpecker.

[c] Ash-throated flycatcher carcass found.

Table 12. Live animals observed during carcass searches.

Area	Hectares Searched	Days Post-treatment	Ground Squirrel	Cotton-tail Rabbit	Mourning Dove	California Quail	Raptors[a]	Rattle-snake	Black-birds	Other
1	2.2	7 hrs.	2							
2	5.8	8 hrs.								
3	2.9	8 hrs.								
4	0.8	1								
5	3.4	1				25	8			
6	1.0	1				6				
7	14.4	1		6		~100				
8	31.1	1	3		1	~75		1	6	
9	24.8	1	4		1					2 ravens
10	3.9	1	5						6	
11	10.4	1			1					1 weasel
12	11.2	2	2	1	10		4			1 chipmunk
13	[illegible]4.2	2	3		1					2 ravens
14	[illegible]4.8	2	12	3	16	13				3 lark sparrows 1 meadow lark
15	4.7	2	1		8					
16	26.0	2	5	10	5	13	1		4	
17	13.5	3	1	4	13	20				
18	2.2	3	3		1	8		3		1 lark sparrow 1 woodrat
19	22.5	3	17	5	5	14	1			
20	3.7	4		2		6				1 bobcat
21	30.0	4		6	6	4	3		1	2 acorn wp 1 scrub jay 1 towhee
22	3.0	4		3	4					1 gopher 1 nuthatch
23	2.8	4	1		9			1		2 killdeer
24	12.6	4	5					1		1 crow
25	4.6	4	7							3 ravens
26	0.7	4								
27	2.0	4	3			2				
28	11.5	4	8	7	1	20	3			1 gopher 3 towhee 3 nuthatch 3 flicker
29	2.9	5	1	3	5	4		1		
30	30.6	7	6	2	~50	4	1		12	1 raven
31	4.0	8	1		17	12				
32	4.9	9	8							
33	10.1	9								
34	4.4	10								
35	4.2	11	7	2	1	16				
36	3.6	11		1						
37	5.7	12	2		2					
Total	381.1		107	55	158	342	21	7	29	

[a] Includes 13 turkey vultures, 3 red-tailed hawks, 2 American kestrels, 1 Cooper's hawk, 1 barn owl, and 1 great horned owl.

Table 13. Number of ground squirrel carcasses found above ground on plots within two weeks after treatment.

Plot No.	Size (Hectares)	Total No. Ground Squirrel Carcasses	No. Ground Squirrel Carcasses Per Hectare
1	2.2	8	3.6
2	1.4	6	4.3
3	1.1	0	0
4	0.4	9	22.5
5	0.8	0	0
6	1.6	6	3.8
7, 8, & 9	2.2	7	3.2
10	1.1	0	0
11	1.1	2	1.8
12	1.9	0	0
$\overline{X}$			3.92 ± 2.14

Table 14. Carcasses found on ground squirrel plots on the first, seventh and fourteenth days after treatment.

Plot No.	Treatment Date	Size (Hectares)	Days Post-treatment	California Ground Squirrels	Kangaroo Rats	Pocket Mice	Wood Rats	American Kestrels
Treated Plots								
1	6/7	2.2	1	8				
			7	0				
			14	0				
2	6/7	1.4	1	5	2			
			7	1				
			14	0				
3	6/7	1.1	1	0				
			7	0				1
			14	0				
4	6/7	0.4	1	6				
			7	3				
			14	0				
5	6/7	0.8	1	0				
			7	0				
			14	0				
6	6/7	1.6	1	2				
			2	3			1	
			7	1				
			14	0				
7,8 & 9	6/8	2.2	1	4	1			
			7	3	2			
			14	0	1	1		
10	6/7	1.1	1	0	1			
			7	0				
			14	0				
11	6/8	1.1	1	1	1			
			7	1				
			14	0				
12	6/8	1.9	1	0				
			7	0				
			14	0				
Total				38	8	1	1	1

Table 14 (continued). Carcasses found on ground squirrel plots on the first, seventh, and fourteenth days after treatment.

Plot No.	Treatment Date	Size (Hectares)	Days Post-treatment	California Ground Squirrels	Kangaroo Rats	Pocket Mice	Wood Rats	American Kestrels
Control Plots								
13	N.A.	2.0	1	0				
			7	0				
			14	0				
14	N.A.	1.3	1	0				
			7	0				
			14	0				
15	N.A.	0.6	1	0				
			7	0				
			14	0				
16	N.A.	0.4	1	0				
			7	0				
			14	0				
Total				0	0	0	0	0

Table 15. 1080 residue analysis of rodents (other than ground squirrels) collected before treatment or found dead after treatment.

Animal	Sample No.	Days Post-treatment	Distance from Treated Area (meters)	Status	1080 Residue Analysis (ppm)
Pretreatment:					
Deermouse	2			Dead in trap	NLT 2[1]
Deermouse	3			Dead in trap	NLT 2
Pocket Mouse	6			Dead in mist net	NLT 2
Kangaroo Rat	12			Probable road kill	NLT 2
Kangaroo Rat	43a			Dead in trap	NLT 2
Kangaroo Rat	43b			Dead in trap	NLT 2
Kangaroo Rat	43c			Dead in trap	NLT 2
Kangaroo Rat	46			Dead in trap	NLT 2
Posttreatment:					
Kangaroo Rat	56	1	6	Found dead	3
Kangaroo Rat	57	1	10	Found dead	7
Kangaroo Rat	58	1	Within	Found dead	NLT 2
Pocket Mouse	59	1	3	Found dead	13.6
Kangaroo Rat	60	1	Near	Found dead	NLT 4
Pocket Mouse	61	1	Within	Found dead	NLT 2
Wood Rat	64	1	3	Found dead	13
Wood Rat	65	1	15	Found dead	15
Kangaroo Rat	77	2	Near	Dropped by American Kestrel	NLT 2
Pocket Mouse	82	2	Within	Found dead	NLT 4
Pocket Mouse	84	3	6	Found dead	4.4
Wood Rat	88	3	None in immediate area	Found dead	NLT 4
Pocket Mouse	92a	2	Within	Found dead	2
Pocket Mouse	92b	2	Within	Found dead	76
Pocket Mouse	92c	2	Within	Found dead	26
Kangaroo Rat	93	2	Within	Found dead	NLT 2
Deermouse	96	4	Near	Found dead	46
Kangaroo Rat	97	4	Near	Found dead	3
Deermouse	100	4	Within	Found dead	6.4
Deermouse	104	4	Near	Found dead	17
Harvest Mouse	106	4	Within	Found dead	17.2
Kangaroo Rat	155	7	Within	Marked-Found dead	NLT 5
Pocket Mouse	166	8	Near	Found dead	25
Pocket Gopher	182	11	Within	Probable road kill	NLT 5
Kangaroo Rat	183	12	Within	Found dead	NLT 2
Kangaroo Rat	184	14	Within	Marked-Found dead	NLT 2
Pocket Mouse	185	14	Within	Found dead	NLT 2
Pocket Gopher	189	16	Within	Probable road kill	NLT 2

[1]NLT--Not found, if present less than value indicated.

Table 16. 1080 Residue analysis of cottontail rabbits collected before or after treatment.

Sample No.	Days Post-treatment	Distance from treated area (meters)	Status	1080 Residue (ppm)
Pretreatment:				
35			Shot	NLT 2[1]
51a			Shot	NLT 2
51b			Shot	NLT 2
51c			Shot	NLT 2
Posttreatment:				
63	1	Within	Found dead	20
66	1	15	Found dead	4.5
75	2	Within	Found dead	NLT 2
80	2	Within	Found dead	NLT 2
94	2	Within	Found dead	NLT 2
95	2	Within	Found dead	NLT 2
101	4	Near	Found dead	4
102	4	Near	Found dead	---
103	4	Near	Found dead	NLT 2
108	1	Within	Found dead	4.2
153	7	Near	Shot	NLT 2
157	7	Near	Found dead	NLT 2
163	6	Near	Shot	NLT 2
165	9	20	Shot	NLT 2

[1] NLT - Not found, if present less than value indicated.

Table 17. 1080 residue analysis of small birds other than dove and quail found dead or collected in and near treated areas.

Animal	Sample No.	Days Post-treatment	Distance from treated area (meters)	Status	1080 Residue (ppm)
Pretreatment:					
Bushtit	16			Dead in mist net	---[2]
Acorn Woodpecker	22a			Dead in mist net	NLT 2
Acorn Woodpecker	22b			Dead in mist net	NLT 2
Brewer's Blackbird	25			Dead in trap	NLT 2
Brown Towhee	28			Dead in mist net	NLT 2
Brown Towhee	29			Dead in mist net	NLT 2
Plain Titmouse	30			Dead in mist net	NLT 2
Lark Sparrow	31			Dead in trap	NLT 2
Scrub Jay	33			Dead in mist net	NLT 2
Brewer's Blackbird	44			Dead in trap	NLT 2
Lark Sparrow	50a			Dead in trap	NLT 2
Lark Sparrow	50b			Dead in trap	NLT 2
Posttreatment:					
White-breasted nuthatch	85	2	Within	Found dead[1]	NLT 2
White-breasted nuthatch	91	2	Near	Found dead	LT 1[3]
Ash-throated flycatcher	105a	4	Near	Found dead	NLT 5
Starling	144	4	None near	Probable pretreatment mortality	NLT 2
Brewer's Blackbird	158	7	30	Found dead	2
Brown Towhee	162	5	Near	Shot	NLT 2
Western Bluebird	167	6	Within	Dead on road	NLT 2
Lark Sparrow	173	10	Within	Shot	NLT 2
Plain Titmouse[4]	175	10	60	Found dead	NLT 2
Acorn Woodpecker	187	14	None near	Prey remains	4.4
Scrub Jay	191	19	None near	Sick; convulsing; died 6/27	NLT 2

[1] Found near ant mound with large numbers of dead ants and bait kernels.

[2] NLT--Not found, if present less than value indicated.

[3] LT--Present, but less than indicated value.

[4] Found plucked under Cooper's hawk nest; nest successful--4 young fledged.

Table 18. 1080 residue analysis of mourning doves and California quail collected before treatment as controls or shot after treatment.

Animal	Sample No.	Days Post-treat-ment	Distance from treated area	Status	1080 Residue (ppm)
Pretreatment:					
Dove	11			Died after convulsions	NLT 2[1]
Dove	14			Mist net casualty	NLT 2
Dove	24			Mist net casualty	NLT 2
Quail	32			Mist net casualty	NLT 2
Quail	37			Dead in trap	NLT 2
Dove	40			Raptor kill	NLT 2
Dove	48a			Shot	NLT 2
Dove	48b			Shot	NLT 2
Dove	48c			Shot	NLT 2
Quail	49a			Shot	NLT 2
Quail	49b			Shot	NLT 2
Dove	53			Dead in trap	NLT 2
Posttreatment:					
Quail	89a	3	Near	Shot	NLT 2
Quail	89b	3	Near	Shot	NLT 2
Quail	89c	3	Near	Shot	NLT 2
Dove	90a	3	Near	Shot	NLT 2
Dove	90b	3	Near	Shot	NLT 2
Dove	90c	3	Near	Shot	NLT 2
Dove	90d	3	Near	Shot	NLT 2
Dove	90e	3	Near	Shot	NLT 2
Dove	90f	3	Near	Shot	NLT 2
Dove	90g	3	Near	Shot	NLT 2
Dove	90h	3	Near	Shot	NLT 2
Dove	90i	3	Near	Shot	NLT 2
Dove	161	5	Within	Shot	NLT 2
Quail	172	10	Within	Shot	NLT 2
Quail	177a	11	Within	Shot	NLT 2
Quail	177b	11	Within	Shot	NLT 2
Quail	178	11	Within	Shot	NLT 2
Quail	179	11	Within	Shot	NLT 2
Quail	180	11	Within	Shot	NLT 2
Radioed:					
Quail	42	Pretreatment	---	Found dead	NLT 2
Dove	152	7	Near	Found dead	NLT 2
Dove	205	1	Within	Probable pretreatment mortality	NLT 4

[1] NLT--Not found, if present less than value indicated.

Table 19. Summary of results obtained from 22 radio-equipped mourning doves that were tracked after treatment.

Dove/ Number	No. of days tracked	Tracked in treated area	Date of last bearing	No. of days Posttreatment	Results
1B	3	X	6/9	1	Found dead, NLT 4 ppm [1] Sample 205
2B	23	X	6/27	20	Lost contact
2C	23	X	6/18	11	Radio only found
3D	18	X	6/13	6	Radio only found - shot by hunter, 9/17/77. 75 km southwest
4E	32	X	6/14	7	Radio found, predator kill?
5C	48	X	6/26	19	Radio found, predator kill?
5E	47	X	6/29	22	Radio found, survived-nested
5F	12	X	6/18	11	Radio found
6C	74	X	7/22	45	Radio found
6E	42	X	7/22	41	Radio found
7C	35	X	6/13	6	Radio found, predator kill
7D	36	X	6/16	9	Lost contact
7F	32	X	6/14	6	Found dead, NLT 2 ppm Sample 152
8C	15	X	7/25	48	Radio found, predator kill?
8E	48	X	7/24	47	Radio found
8F	78	X	7/29	51	Lost contact, survived
9C	27	X	7/8	30	Radio found
10B	17	X	7/27	49	Radio found, predator kill
10D	10	X	7/20	42	Radio found
10E	14	X	6/21	14	Lost contact, shot by hunter 9/3/78, 18 km northwest
10F	10	X	7/20	42	Radio found, predator kill
11C	9	X	7/22	44	Radio found, predator kill

[1] NLT - Not found, if present less than value indicated.

Table 20. Summary of results obtained from 4 radio-equipped California quail that were monitored before, during and after treatment.

Quail No.	No. of days tracked	Tracked in treated area	Date of last bearing	No. of days posttreatment	Results
1D	60	X	7/20	43	Found radio--probable survivor
4C	22	X	6/12	3	Found radio--probable predator kill
4F	13	X	6/3	0	Found radio--pretreatment
11B	55		7/10	33	Found radio--probable survivor

Table 21. 1080 residue analysis of predators collected before treatment or found dead after treatment.

Animal	Sample No.	Days Post-treatment	Distance from treated area (meters)	Status	1080 Residue (ppm)
Pretreatment					
Juvenile Skunk	15			Trap mortality	NLT 2[2]
Bobcat	19			Trap mortality	NLT 2
Skunk	23			Died of exposure	NLT 2
Bobcat	36			Trap mortality	NLT 2
Raccoon	41			Trap mortality	NLT 2
Bobcat	54			Trap mortality	NLT 2
Posttreatment:					
Juvenile Skunk	55	1	10	Found dead	1.5
Skunk	98	4	100	Found dead	NLT 5
Coyote	151	7	Within	Probable pretreatment mortality	NLT 2
Coyote	164	9	100	Found dead	NLT 5
Skunk	168	9	Within	Found dead	NLT 2
House cat	170	8	Near	Found dead	NLT 2
Domestic dog	171	8	Near	Found dead[1]	NLT 2
San Joaquin Kit Fox	208	95	300	Probable road kill	NLT 2
Radioed:					
Bobcat	69	1	Within	Found dead	NLT 2[3]
Bobcat	78	2	None near	Found dead	NLT 2
Coyote	86	3	Near	Found dead	NLT 2
Bobcat	107	4	None near	Found dead	NLT 2
Coyote	147	4	400	Found dead	NLT 10
Coyote	150	7	Within	Found dead	NLT 5
Coyote	195	30	800	Found dead	NLT 10
Coyote	209	4	400	Found dead	NLT 5

[1] Showed poisoning symptoms for 3 days before death.

[2] NLT--Not found, if present less than value indicated.

[3] Foot injury sustained when trapped; may have contributed to this animal's death.

Table 22. Summary of results obtained from 6 radio-equipped coyotes that were monitored before and after treatment.

Coyote No.	No. of days tracked	Tracked in treated area	Date of last bearing	No. of days posttreatment	Results
1F	19	X	6/12	5	Found dead NLT 10 ppm, Sample 147[1]
10B	11	X	6/4	7	Found dead NLT 5 ppm, Sample 50
10D	42	X	6/11	4	Found dead NLT 5 ppm, Sample 209
10F	49	X	7/7	30	Found dead NLT 10 ppm, Sample 195
11D	200	X	12/1	177	Survived
12D	47		6/10	3	Found dead NLT 2 ppm, Sample 86

[1] NLT - Not found, if present less than value indicated.

Table 23. Predator scent post survey abundance index.[1 2]

	Pretreatment 3/28 - 3/31/77		Posttreatment 9/21 - 9/24/77		Posttreatment 4/21 - 4/24/78	
Number of Operable Station Nights	179		200		148	
Species	No. Visits	Index	No. Visits	Index	No. Visits	Index
Coyote	4	22.3	0	0	6	40.5
Bobcat	2	11.2	2	10	1	6.7
Gray fox	1	5.6	2	10	1	6.7
Raccoon	4	22.3	4	20	3	20.3
Opossum	0	0	1	5	0	0
Striped skunk	5	27.9	8	40	4	27.0
Ring-tailed cat	0	0	2	10	0	0
Black bear	0	0	4	20	0	0

[1] $\text{Index} = \frac{\text{Total number of visits}}{\text{Total number of operable station nights}} \times 1000$

[2] Procedures for this survey are described by Linhart and Knowlton (1975).

Table 24. Number of coyotes responding on siren survey.[1]

	Pretreatment	Posttreatment		
	6/1/77	9/26/77	4/23/78	9/15/78
Number of stations	7	8	7	8
Number of active stations	2	0	1	4
Number of coyotes responding	4	0	2	7
Index[2]	57.1	0	28.6	87.5

[1] Procedures described by Wolfe (1974).

[2] $$\text{Index} = \frac{\text{Number of coyotes responding}}{\text{Number of stations}} \times 100$$

Table 25. Summary of results obtained from 10 radio-equipped bobcats that were monitored before and after treatment.

Bobcat No.	No. of days tracked	Tracked in treated area	Date of last bearing	No. of days posttreatment	Results
1B	17	X	6/27	17	Radio found (a glued-on radio on a young bobcat) Survived
3F	177	X	12/1	177	Survived, killed by vehicle on highway, 12/18/78
5D	12	X	6/9	2	Found dead NLT 2[1], Sample 78
9B	128	X	9/14	99	Survived
9E	218	X	12/1	177	Survived, found dead 12/1/78, possibly shot
9F	333	X	4/24/78	321	Survived
11C	16	X	6/11	4	Found dead NLT 2, Sample 107
11E	43	X	6/8	1	Found dead NLT 2, Sample 69 (Foot injury, emaciated)
12C	191	X	12/1	177	Survived, retrapped by trapper 2/8/78
12F	210	X	12/1	177	Survived

[1] NLT - Not found, if present less than value indicated.

Table 26. Summary of results obtained from nine radio-equipped mammaliam predators (not including coyotes and bobcats) tracked before and after treatment.

Species	Number	No. of Days Tracked	Tracked in Treated Area	Date of Last Bearing	No. of Days Post-treatment	Results
Striped skunk	2F	56	X	6/20	12	Probable survivor-lost contact
Striped skunk	5E	78	X	7/6	29	Probable survivor-lost contact
Striped skunk	6D	54	X	6/11	4	Apparently consumed by mammalian predator--transmitter was passed with feces
Striped skunk	6E	75	X	7/5	28	Probable survivor-lost contact
Badger	4F	22	X	6/28	21	Probable survivor-lost contact
Badger	11E	175	X	12/1	177	Survived
Badger	12E	82	X	7/19	42	Survived
Raccoon	4D	99	X	9/5	90	Survived
Raccoon	12B	339	X	2/24/78	321	Survived

Table 27. Summary of results obtained from ten raptors and carrion-eating birds tracked before and after treatment.

Species	Number	No. of Days Tracked	Tracked in Treated Area	Date of Last Bearing	No. of Days Posttreatment	Results
Red-tailed hawk	2C	221	X	12/1	177	Survived
Red-tailed hawk	6D	106	X	9/9	94	Survived
Red-tailed hawk	9C	70	X	8/19	73	Survived
Golden eagle	5B	29	X	6/23	17	Survived- probably left area
Great horned owl	2E	117	X	8/21	76	Survived
Turkey vulture	4B	96	before treatment only	7/19	42	Found dead, left area, Sample 19B, Table 29
Turkey vulture	4F	66	before treatment only	6/13	6	Lost contact, left area
Turkey vulture	1C	13	before treatment only	4/26	-	Lost contact, observed in Organ Pipe National Monument, Arizona 5 May 1978, 780 km southeast
Common raven	4B	45	X	6/21	14	Lost contact
Common raven	3C	33	X	6/9	2	Lost contact, collected alive by farmer, 2/12/78 13 km southwest

Table 28. Number of active raptor nests located on the study area and productivity during 1977.

Species	No. Active Nests	No. Active at Treatment	No. Young Known Fledged	No. Young Fledged/Nest [1]	Total Productivity
Red-tailed hawk	40	15	45	1.73	69.2
Cooper's hawk	1	1	4	4	4
Great horned owl	8		14	2.33	18.6
Barn owl	1		2	2	2
Golden eagle	3	2	3	1	3
Common raven	4				
Common crow	1				
Total	58	18	68		96.8

[1] Based on number of young fledged in nests where fledging young were counted. We did not obtain fledging data on 14 red-tailed hawk, 2 great horned owl, 4 common raven and 1 common crow nests.

Table 29. 1080 residue analysis of raptors found dead before and after treatment.

Animal	Sample No.	Days post-treatment	Distance from treated area (meters)	Status	1080 residue (ppm)
Posttreatment:					
Radioed:					
Great horned owl	26	Pretreatment	---	Found dead	---
Red-tailed hawk	39	Pretreatment	---	Found dead	---
Red-tailed hawk	149	6	400	Probable pretreatment mortality	---
Turkey vulture	198	37	800	Found dead	NLT 4[1]
Misc.:					
Red-tailed hawk nestling	109	4	Within	Probable pretreatment mortality	NLT 4
American kestrel	148	7	Within	In convulsions. Died 6/15.	NLT 2
Barn owl nestling	159	5	None nearby	Probable pretreatment mortality	NLT 4
Turkey vulture	174	10	800	Probable pretreatment mortality	NLT 4
Screech owl	181	11	Within	Found dead.	NLT 2
Turkey vulture	211	135	400	Found dead.	NLT 2

[1] NLT - Not found, if present less than value indicated.

Table 30. Results of residue analysis by the Peterson (1975) technique.[1]

Sample No.	Material (Animal Species)	Status	1080 Residue ppm
201	Clean oat groats		NLT 0.2 ppm[2]
204	Oat groats with 1080 (0.075%)		640
35	Cottontail rabbit stomach	Control	NLT 0.2 ppm
101	" " "	Found dead post-treatment	2.8 ppm[3]
36	Bobcat stomach	Control	NLT 0.4
40	" "	"	NLT 0.4
54	" "	"	NLT 0.4
69	" "	Found dead post-treatment	NLT 0.2[4]
78	" "	" " "	NLT 0.2
107	" "	" " "	NLT 0.4
151	Coyote stomach	Found dead post-treatment -- Probable pretreatment mortality	NLT 0.4
86	" "	Found dead post-treatment	NLT 0.2
147	" "	" " "	NLT 0.2
150	" "	" " "	NLT 0.2
164	" "	" " "	NLT 0.2
195	" "	" " "	NLT 0.2
171	Dog stomach	" " "	NLT 0.2

[1] Using this procedure, samples of 10 g or less provide invalid results and are therefore not included.

[2] NLT - Not found, if present less than the value indicated.

[3] Confirmed by mass. spectrophotometer analysis.

[4] Foot injury, sustained when trapped, may have contributed to this animal's death.

Table 31. Summary of results from necropsies of animals found dead. [1]

Species	Sample No.	Days Post-treatment	Results
Coyote	86	3	Extensive lung edema and hemorrhage, diffuse gastrointestinal purpura, petechial cardiac hemorrhage, general hyperemia, moderate fat in mesentery.
Coyote	209	4	Moderate lung edema and hemorrhage, general gastrointestinal purpura, slight kidney hemorrhage, moderate fat in mesentery.
Coyote	147	5	General lung hemorrhage, general gastrointestinal purpura, severe hemorrhage of stomach, petechial cardiac hemorrhage, extensive fat in mesentery.
Coyote	164	9	General gastrointestinal purpura, moderate fat in mesentery, decomposition somewhat advanced.
Coyote	50	7	Had been dead for 3 - 4 days, necropsy not conducted because of state of decomposition.
Coyote	195	30	Had been dead for about 10 days, necropsy not conducted because of state of decomposition.
Dog	171	8	Showed symptoms for 3 days prior to death, extreme nervousness, running, convulsions, necropsy--extensive edema and hemorrhage of lungs, general purpura of gastrointestinal tract, extensive fat in mesentery.
San Joaquin kit fox	208	95	Found dead on highway, skull crushed, neck broken, extensive hemorrhage of lungs, only one area of hemorrhage on stomach and gastrointestinal tract on side of apparent impact, mesentery fat moderate.
Bobcat	69	1	Emaciated, foot injury may have contributed to death, slight hemorrhage of lungs, no fat in mesentery, around heart or kidney--in very poor condition.
Bobcat	78	2	Extensive lung edema and hemorrhage, general gastrointestinal purpura, moderate hyperemia of most internal organs, moderate fat in mesentery.
Bobcat	107	4	Extensive lung edema and hemorrhage, slight gastro-intestinal hemorrhage, slight amount of fat in mesentery, slight hemorrhage in kidney.

Table 31 (continued). Summary of results from necropsies of animals found dead.

Species	Sample No.	Days Post-treatment	Results
Domestic cat	170	10	Very nervous and had convulsions for 2 days prior to death, slight lung edema and hemorrhage, slight gastrointestinal hemorrhage, fat in mesentery extensive.

[1] In most cases the symptoms described are similar to symptoms described in the following references. While these symptoms are not necessarily diagnostic for 1080 intoxication, they would be expected in animals killed by 1080 intoxication.

Cottral, G. E., G. D. Dibble and B. Winton. 1947. The effect of sodium fluoroacetate ("1080 rodenticide") on white leghorn chickens. Poultry Science. 26:610-613.

Pattison, F. L. M. 1959. Toxic aliphatic fluorine compounds. Elsevier Publishing Co. London. 227 pp.

Egyed, M. N. and A. Shlosberg. 1973. Diagnosis of field cases of sodium fluoroacetate and fluoroacetamide poisoning in animals. Refuah Vet. 30:112-115.

Table 32. Comparison of number of fledged from active nests.

Source	No. of young fledged/active nest Great horned owl	Red-tailed hawk
Study area, 1977	2.33	1.73
Wiley (1973)		1.64
Brown and Amadon (1968)		1.4
Fitch et al. (1945)		0.84[1]
Olendorff (1972)	2.00	

[1] High rate of abandonment possibly because of investigator activities.

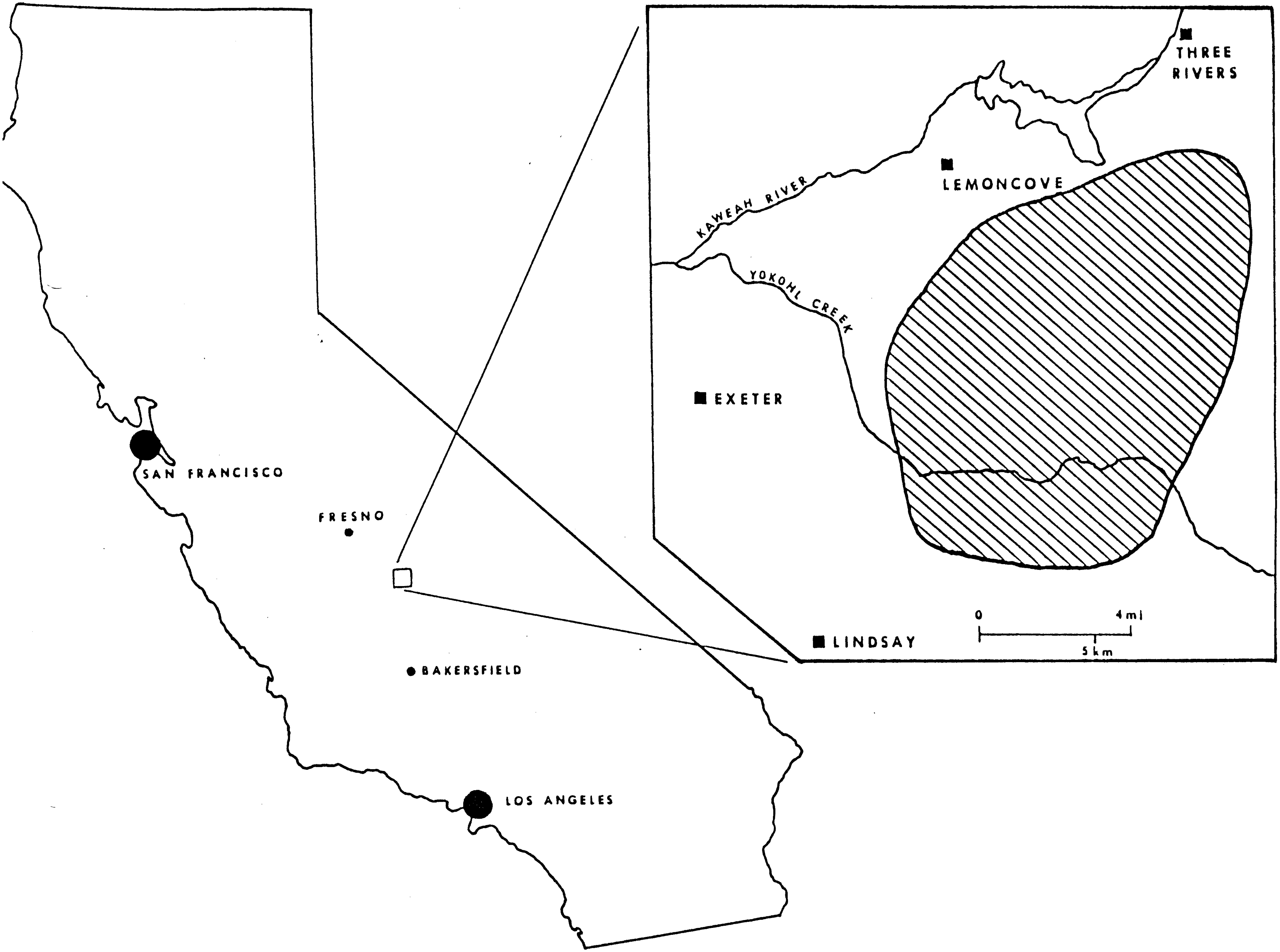

Fig. 1. Location of the study area in California.

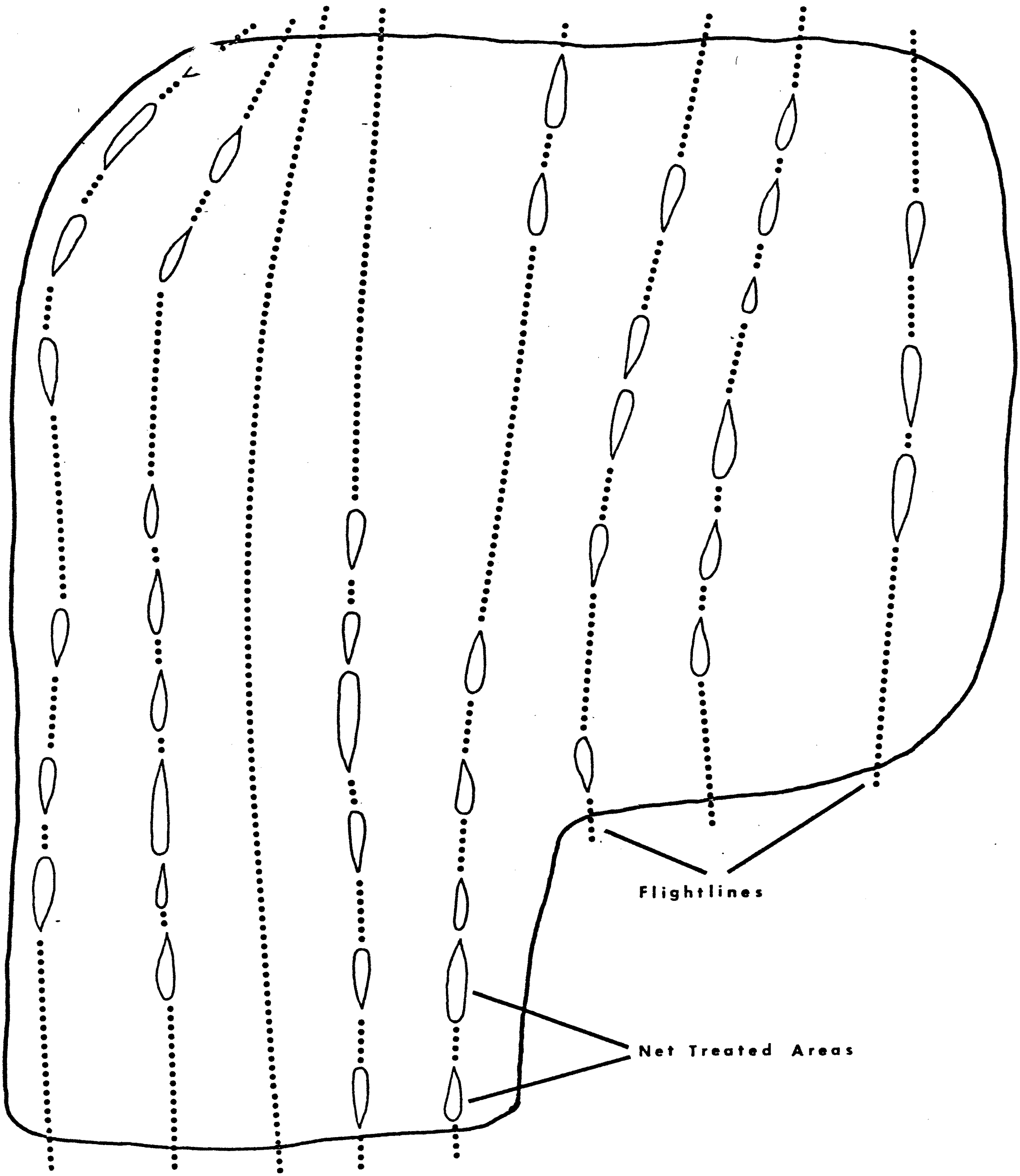

Fig. 2. A simulated example of a gross treated area of about 75 ha (185 acres). Net treated areas averaged 3.4% of the gross areas. Flightlines were approximately 100 m (300') apart.

Fig. 3. Location and pattern of gross treated portions of the general study area.

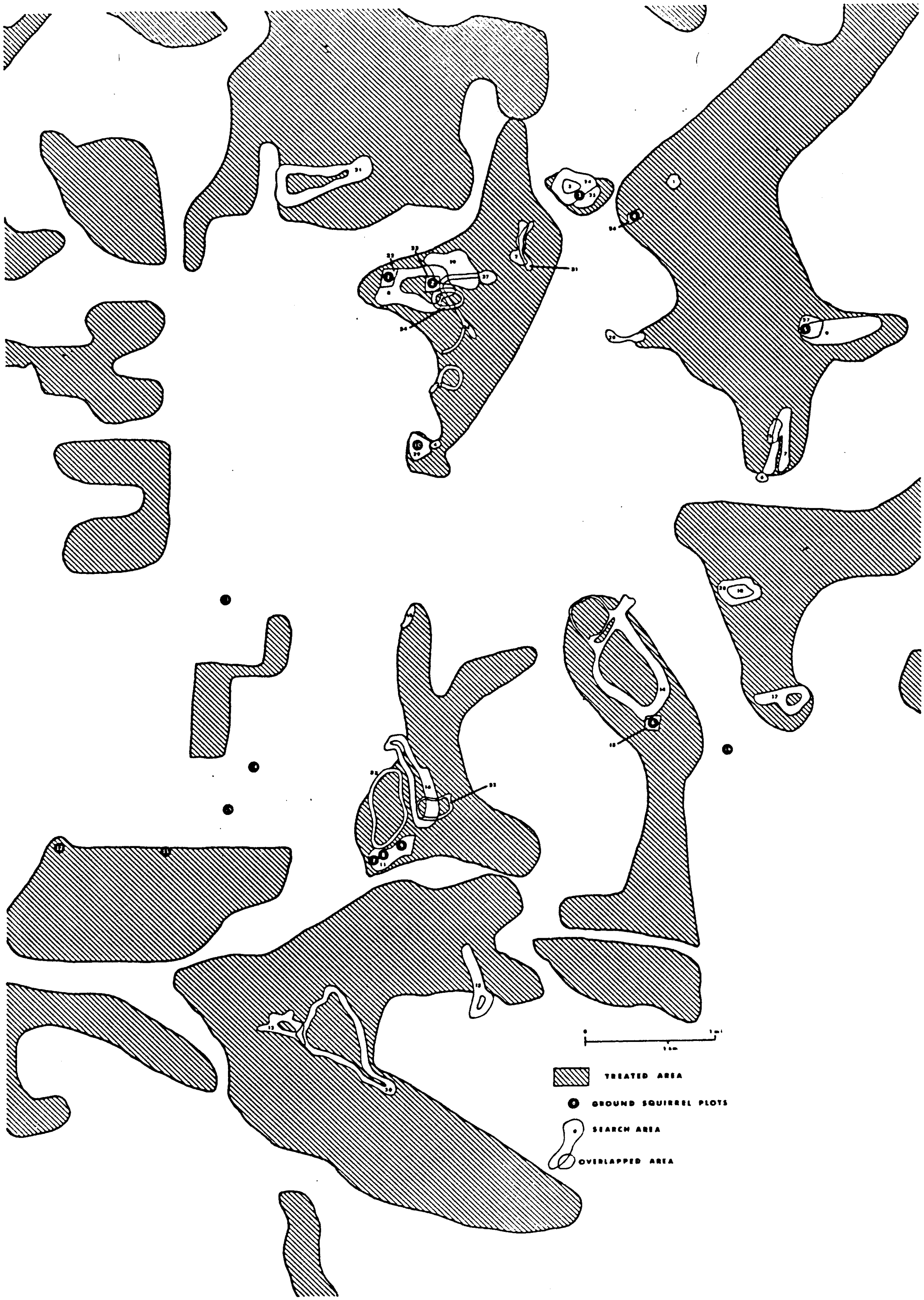

Fig. 4. Location of ground squirrel plots and carcass search areas.

Fig. 5. A radio-tracking vehicle at one of the tracking stations. Note the numbered rock cairn. The beacon transmitter is on top of the pointed hill in the background.

Fig 6. Location of the beacon transmitter and tracking stations along the roads in the study area.

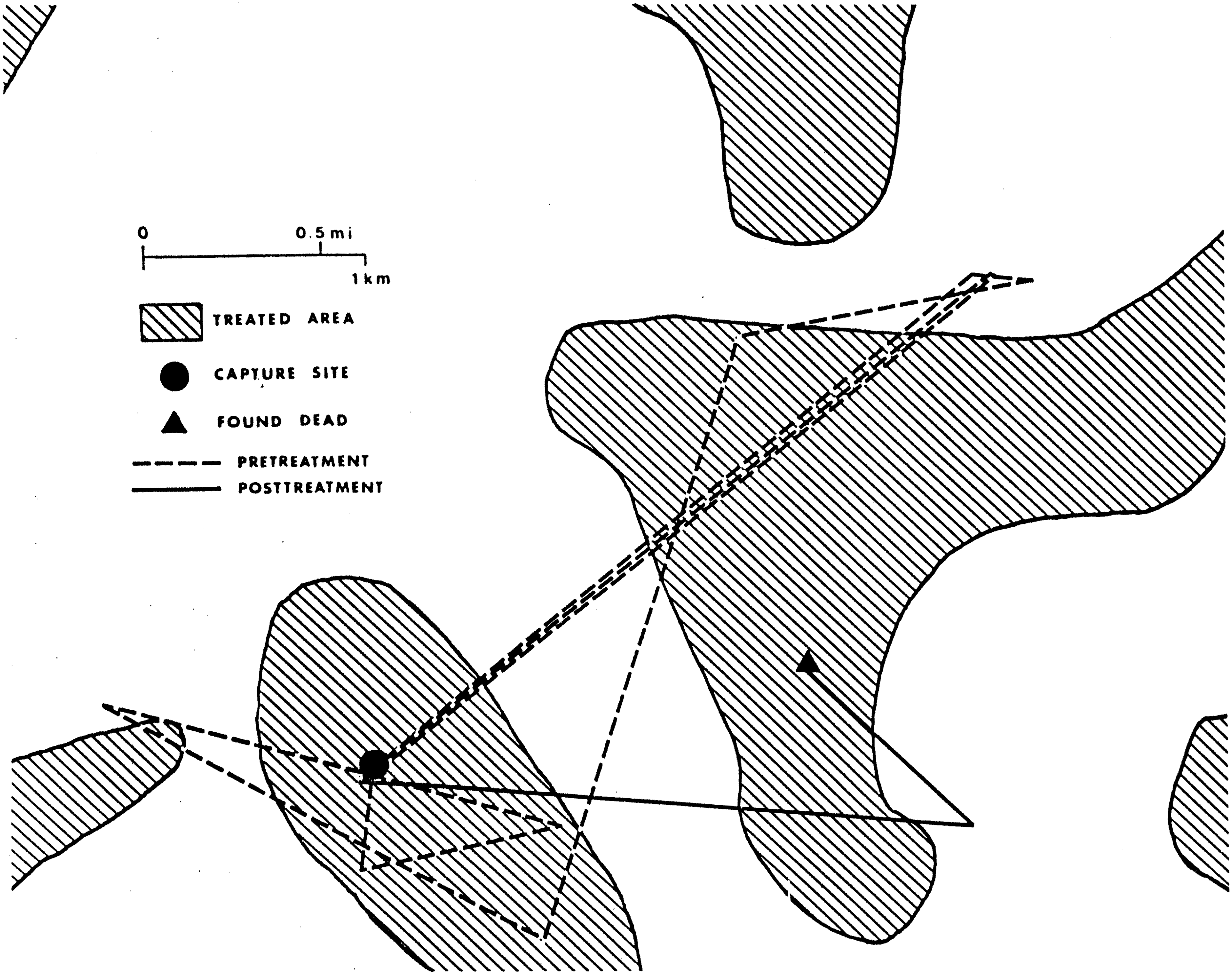

Fig. 7. Movements of 7F, an adult male mourning dove. Tracked from 5/12 to 6/14/77. Found dead--chemical analysis did not show 1080 residue in the crop contents (Table 18, sample 152).

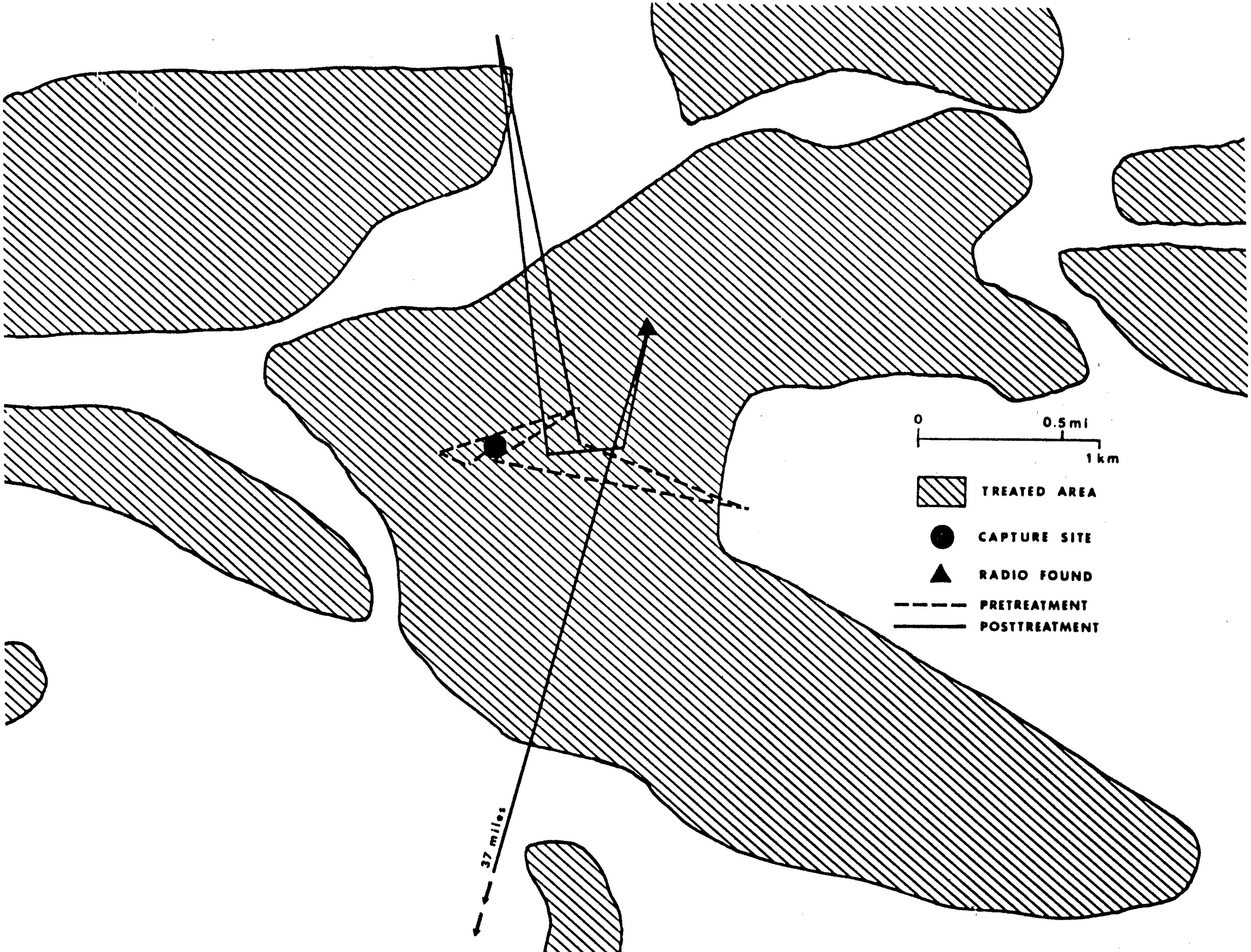

Fig. 8. Movements of 3D, an immature mourning dove. Tracked from 5/25 to 6/13/77. Radio only found. Shot on 9/17/77 by hunter, 60 km (37 mi) southwest.

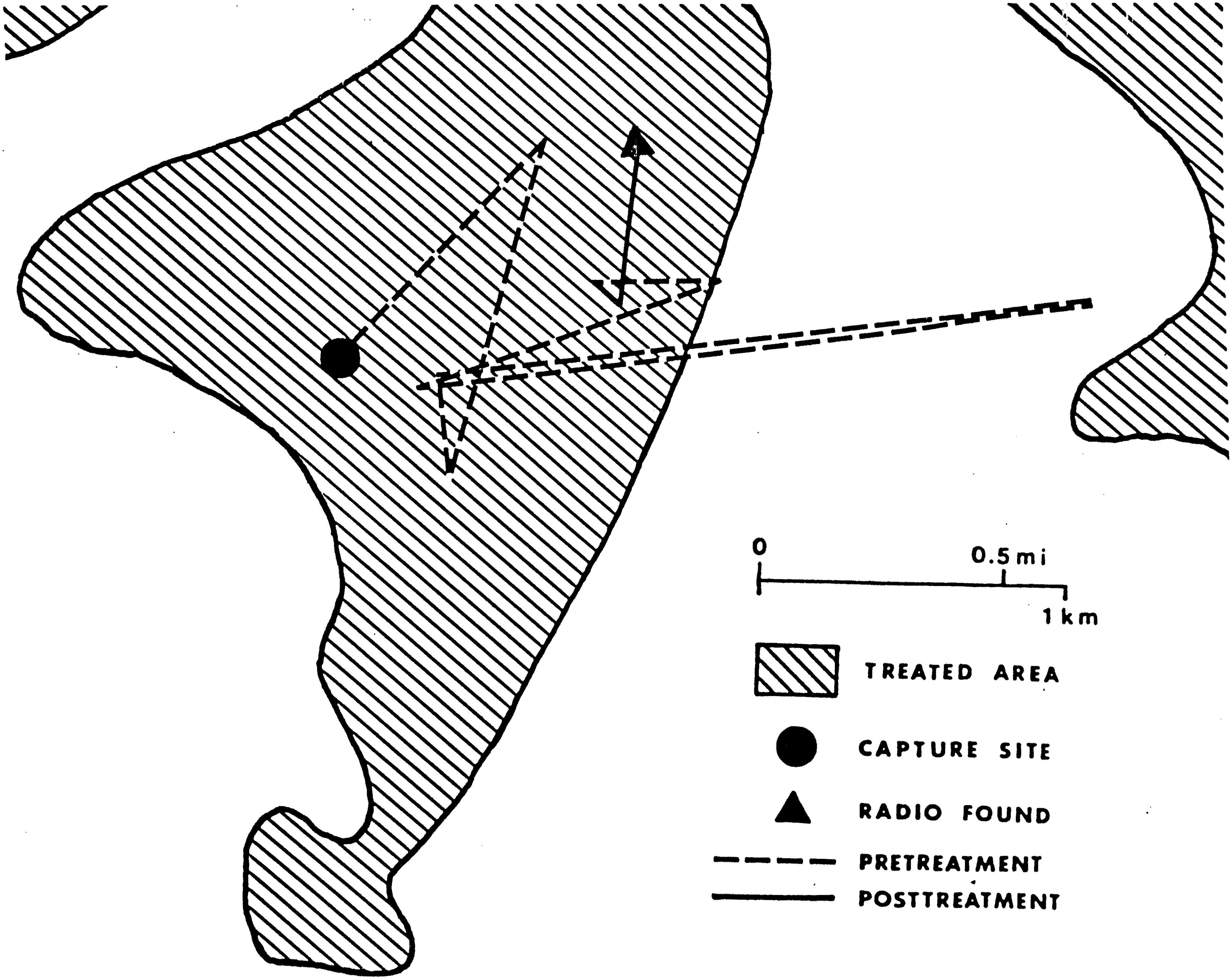

Fig. 9. Movements of 9C, an adult male mourning dove. Tracked from 5/13 to 6/8/77. Radio only found.

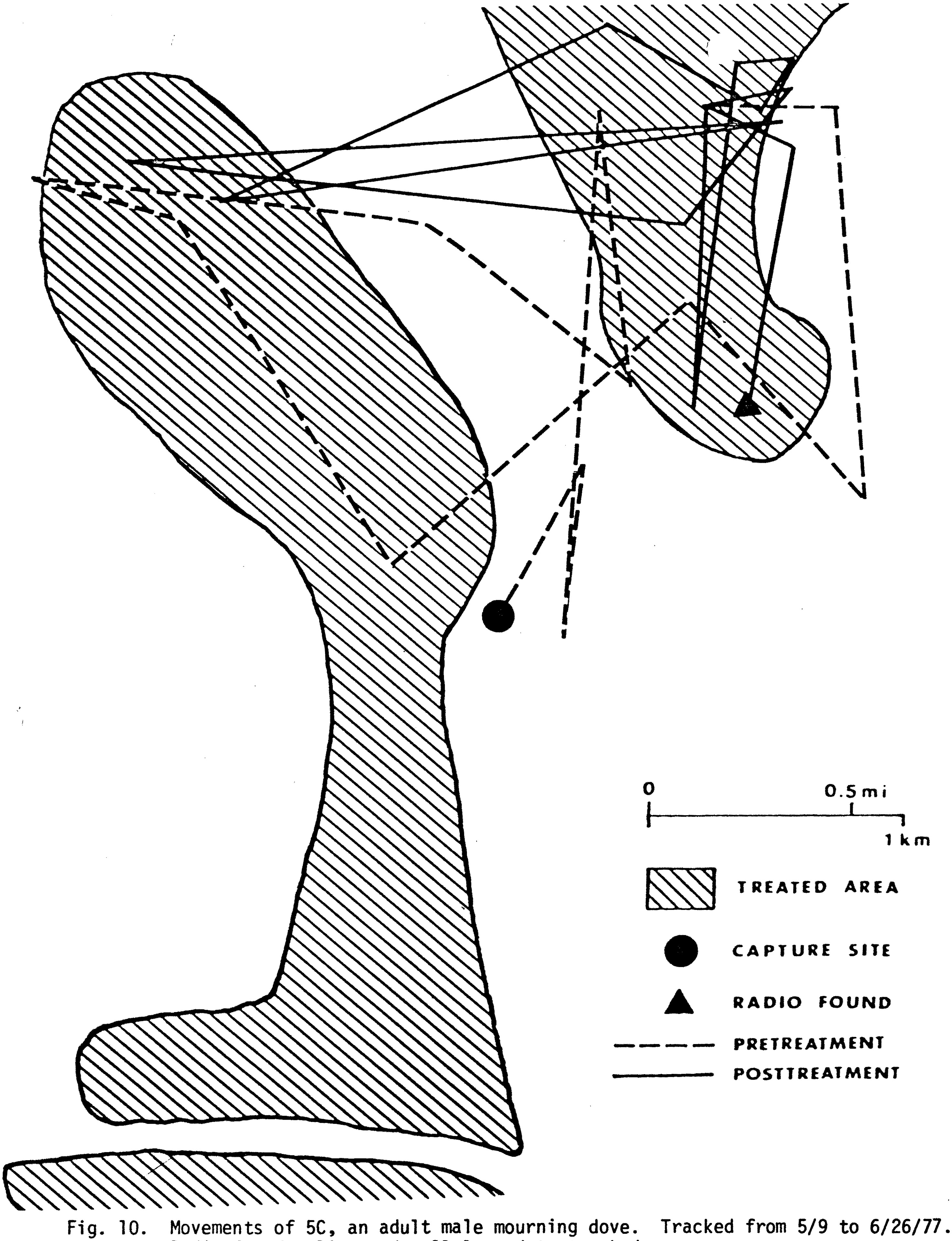

Fig. 10. Movements of 5C, an adult male mourning dove. Tracked from 5/9 to 6/26/77. Radio found--alive and well last date tracked.

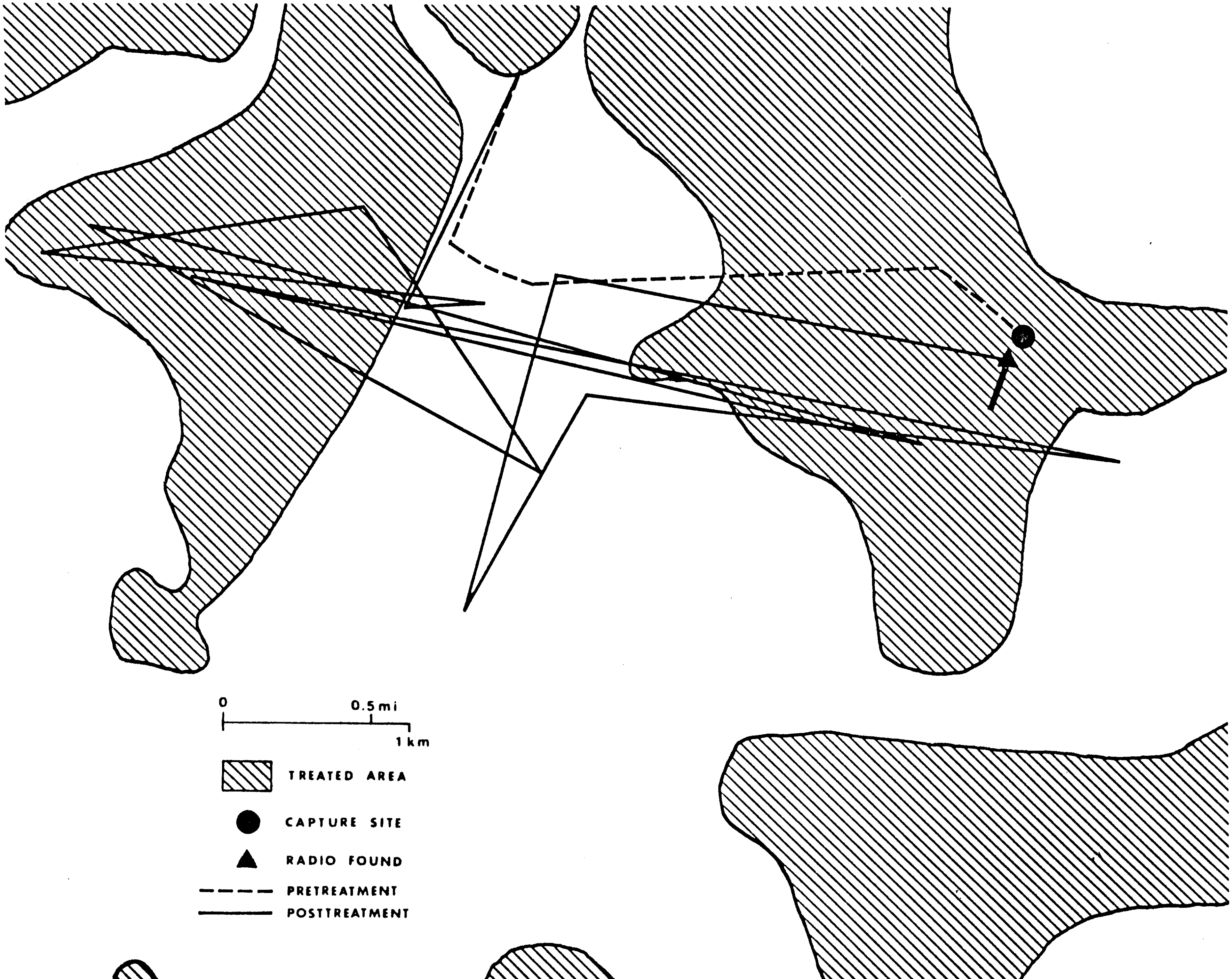

Fig. 11. Movements of 5E, an adult female mourning dove. Tracked from 5/13 to 7/3/77. Radio found near nest. Alive and well last date tracked.

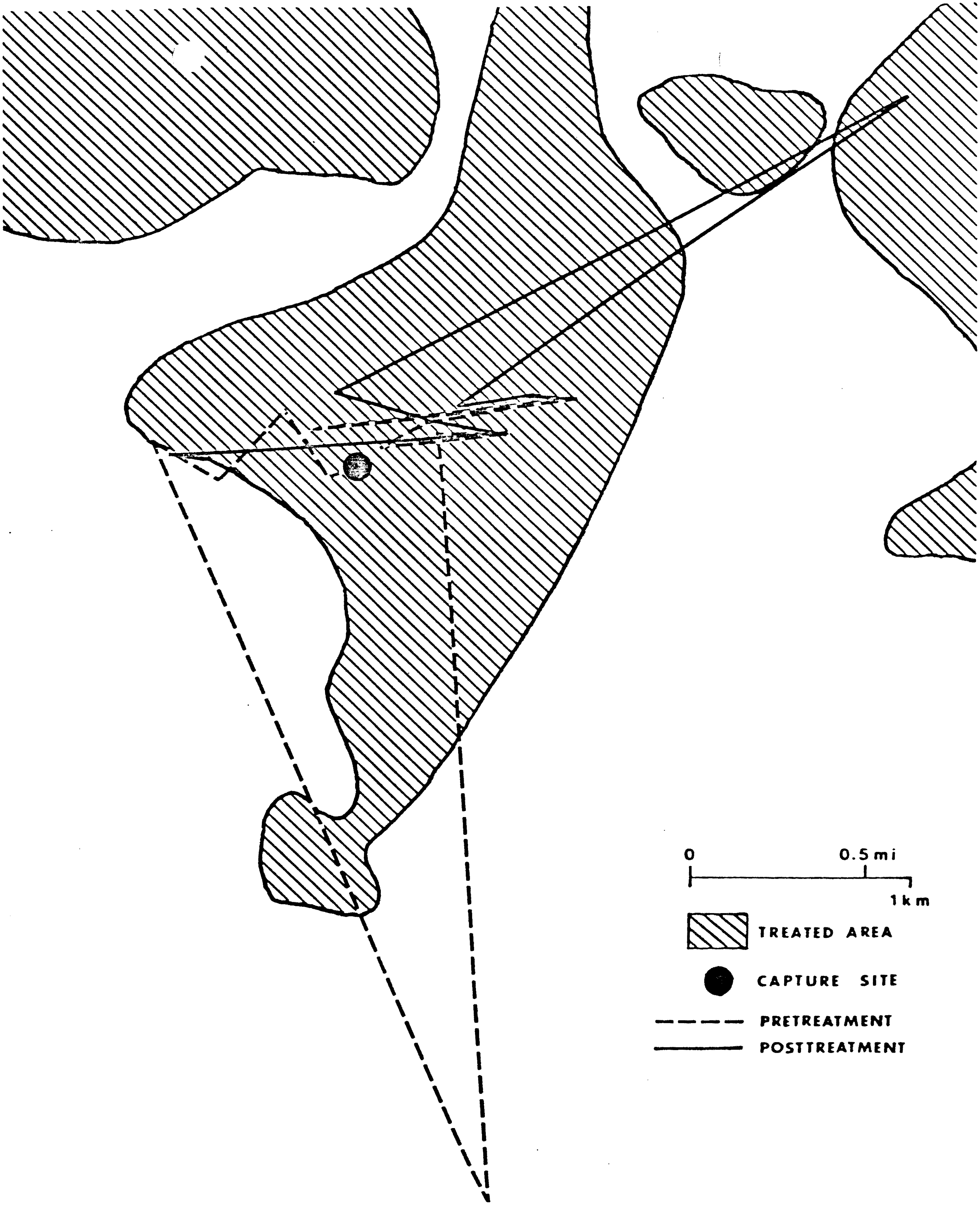

Fig. 12. Movements of 7D, a mourning dove. Tracked from 5/10 to 6/16/77. Lost contact, alive and well last date tracked.

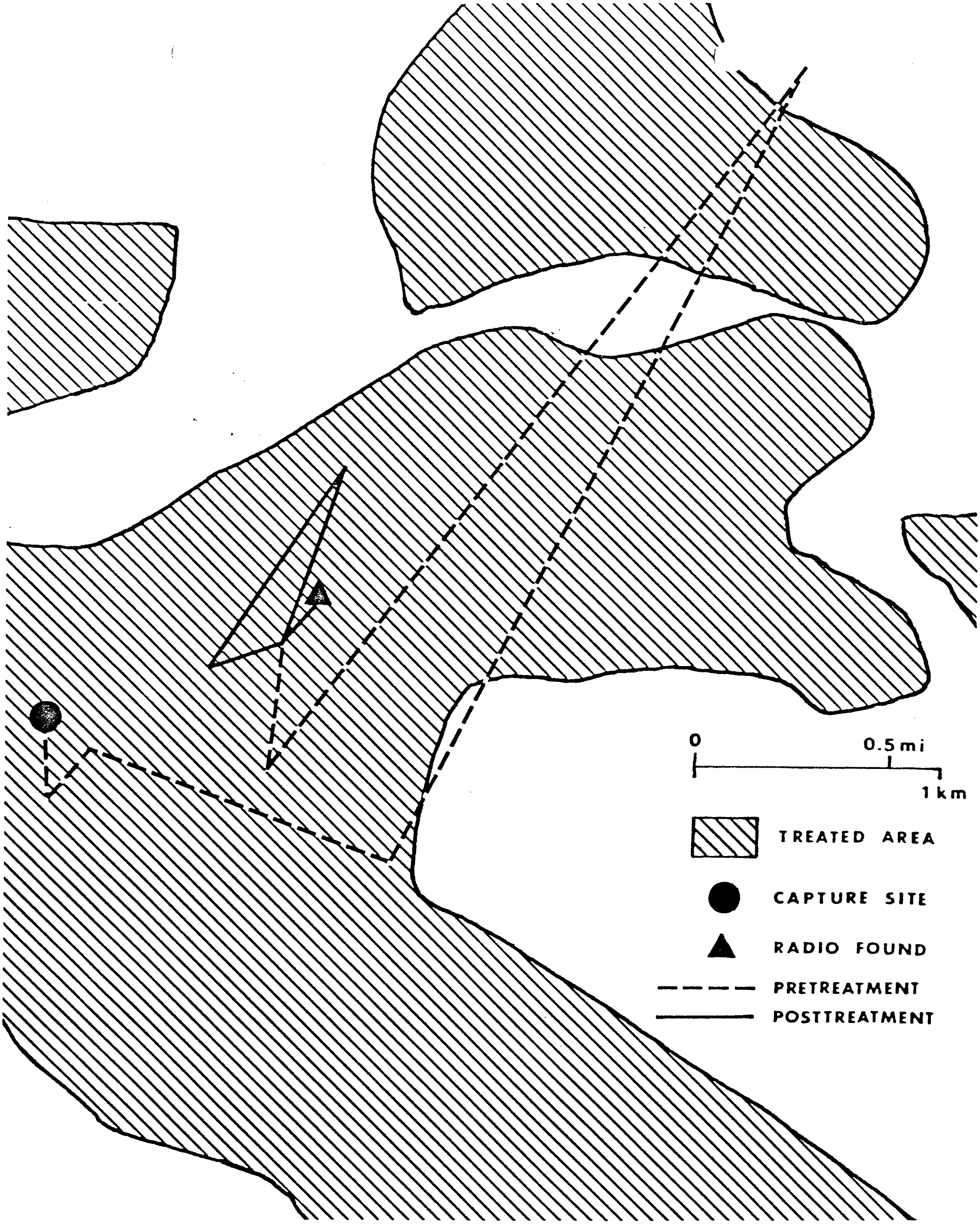

Fig. 13. Movements of 2C, an adult female mourning dove. Tracked from 5/26 to 6/18/77. Radio only found--alive and well last date tracked.

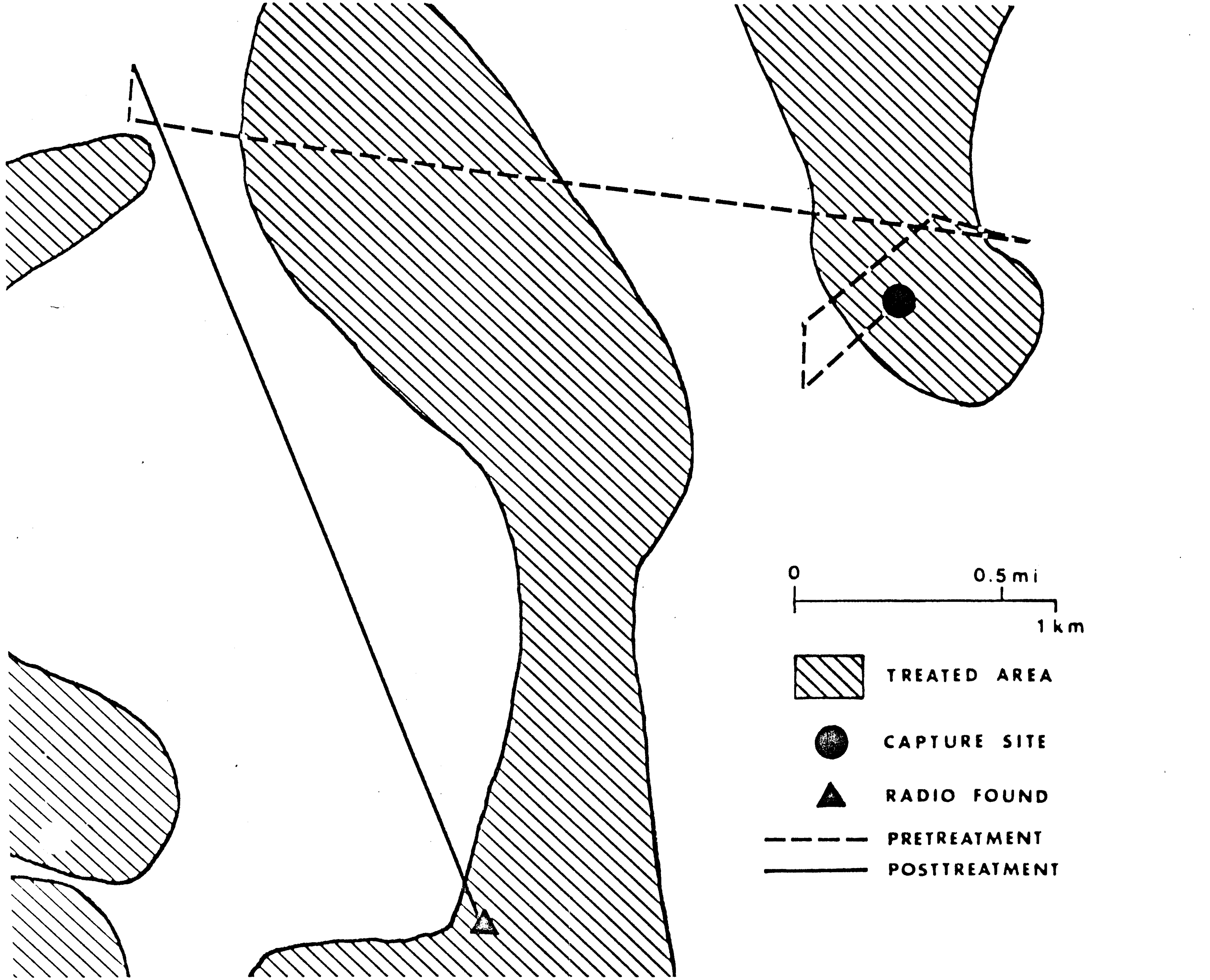

Fig. 14. Movements of 7C, an adult mourning dove. Tracked from 5/8 to 6/13/77. Radio found--alive and well last date tracked.

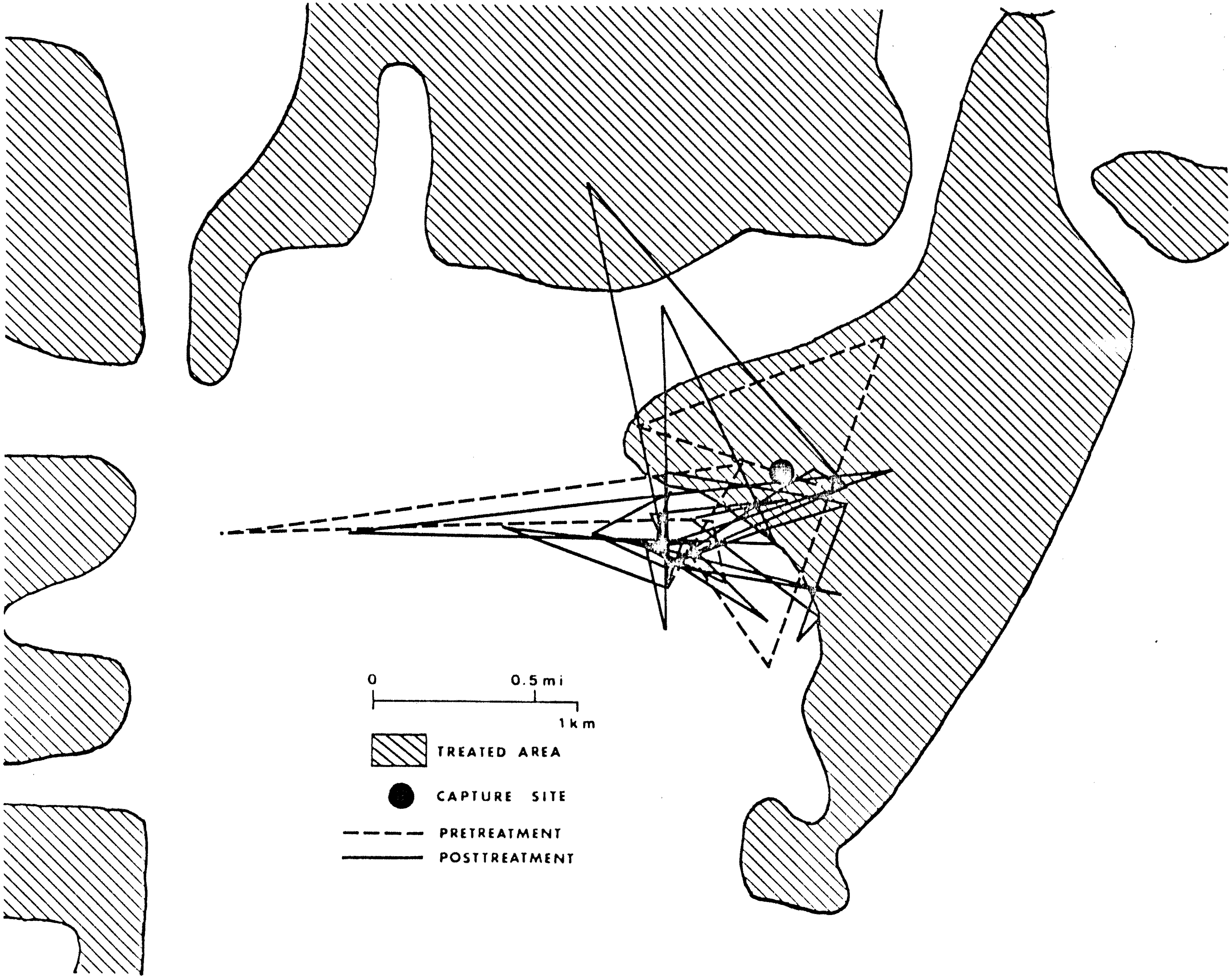

Fig. 15. Movements of 8F, an adult male mourning dove. Tracked from 5/11 to 7/28/77, Lost contact--alive and well last date tracked.

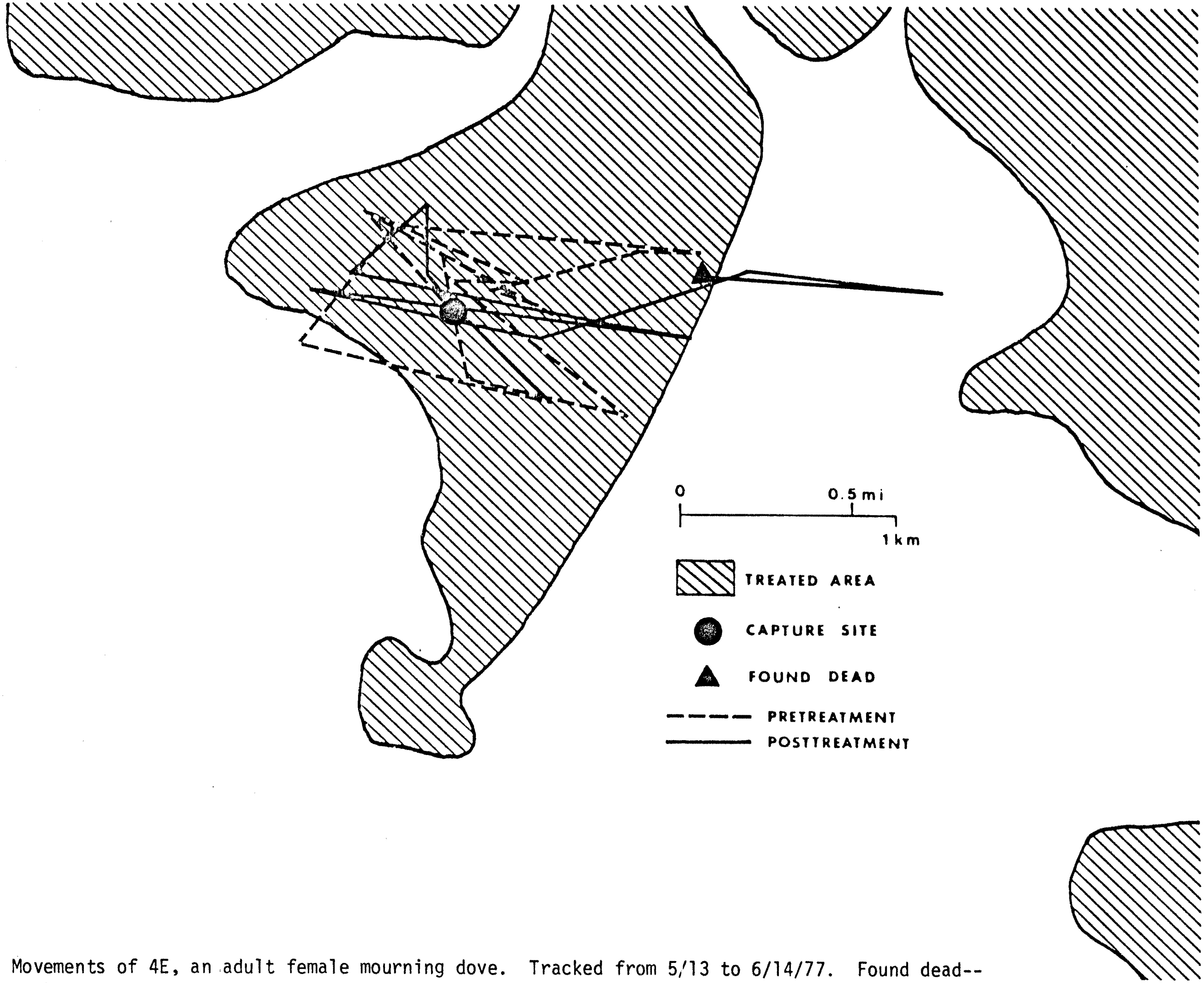

Fig. 16. Movements of 4E, an adult female mourning dove. Tracked from 5/13 to 6/14/77. Found dead--probable predator kill.

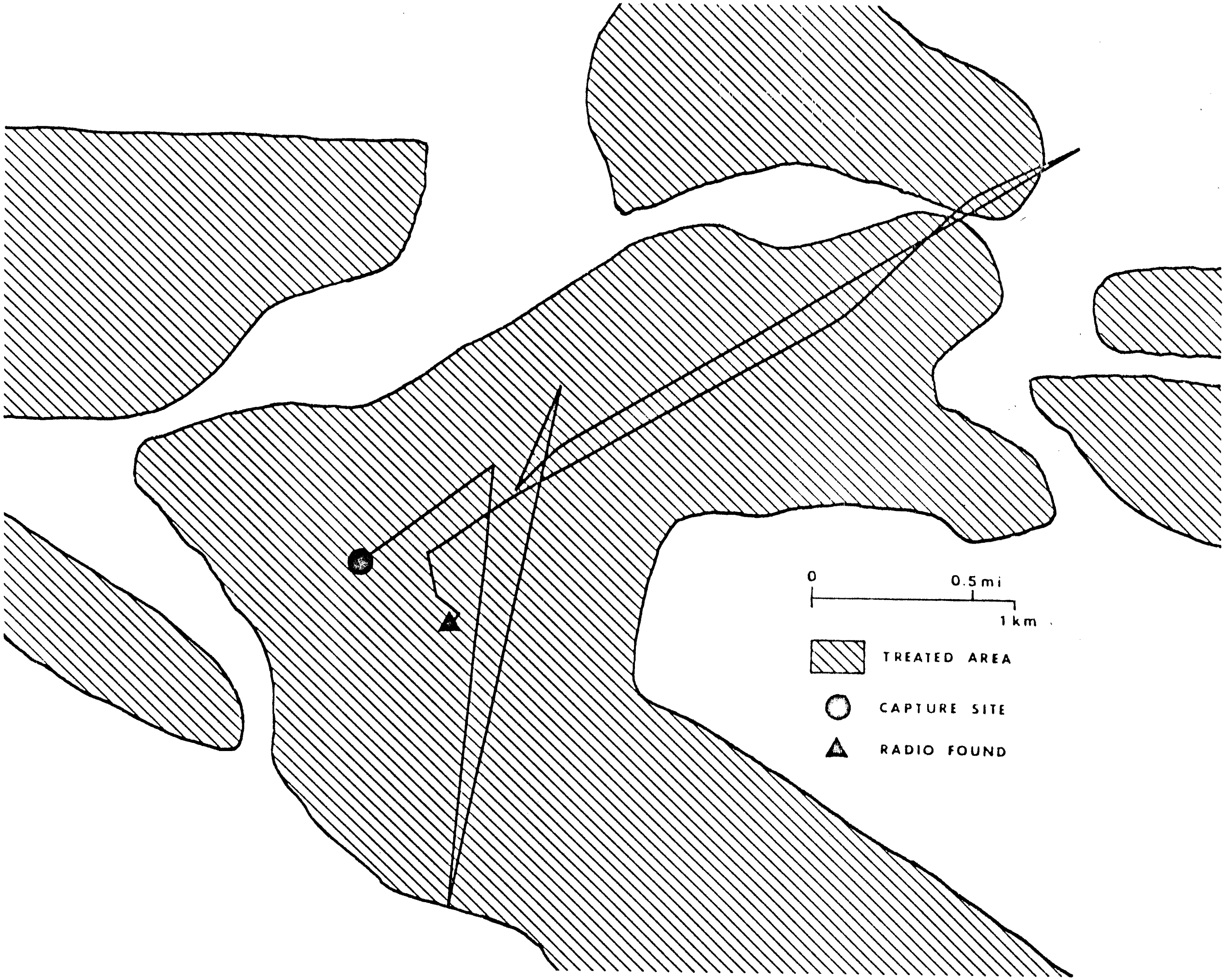

Fig. 17. Movements of 6E, an adult male mourning dove. Tracked from 6/6 to 7/22/77. Radio only found--alive and well last date tracked.

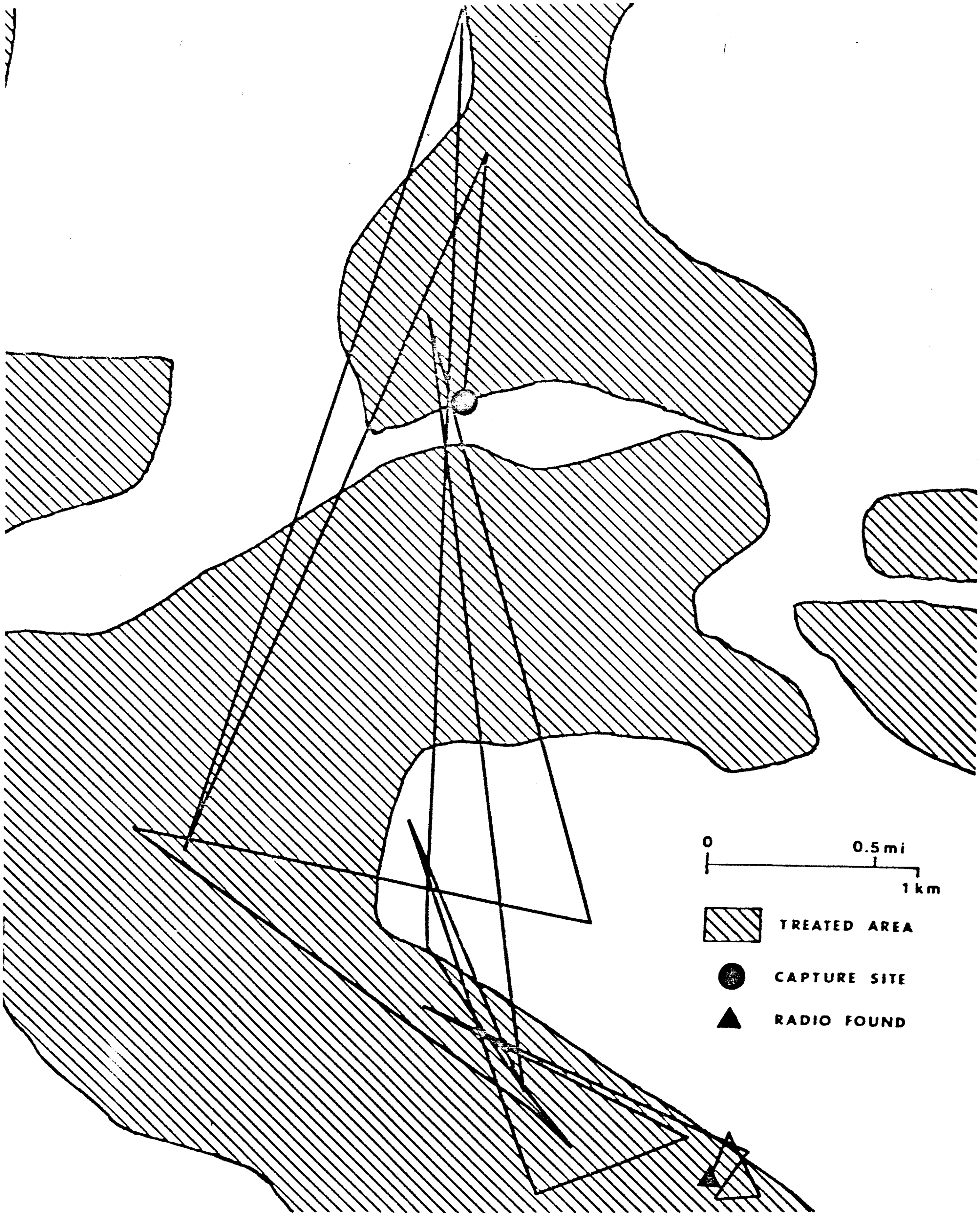

Fig. 18. Movements of 8E, an adult male mourning dove. Tracked from 6/6 to 7/17/77. Radio only found--alive and well last date tracked.

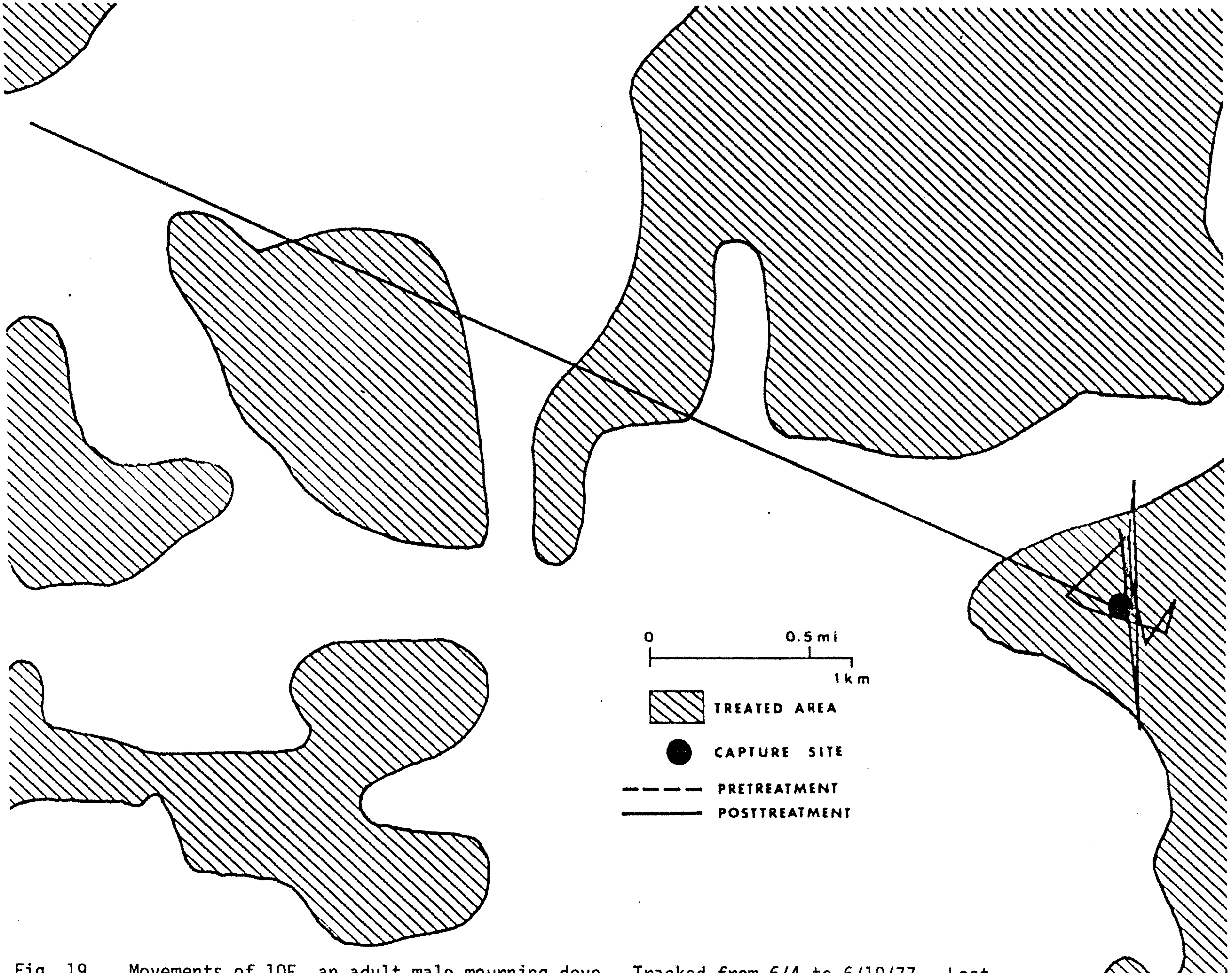

Fig. 19. Movements of 10E, an adult male mourning dove. Tracked from 6/4 to 6/10/77. Lost contact--alive and well last date tracked. Shot by hunter 9/3/78 (15 months later) 18 km northwest of last location.

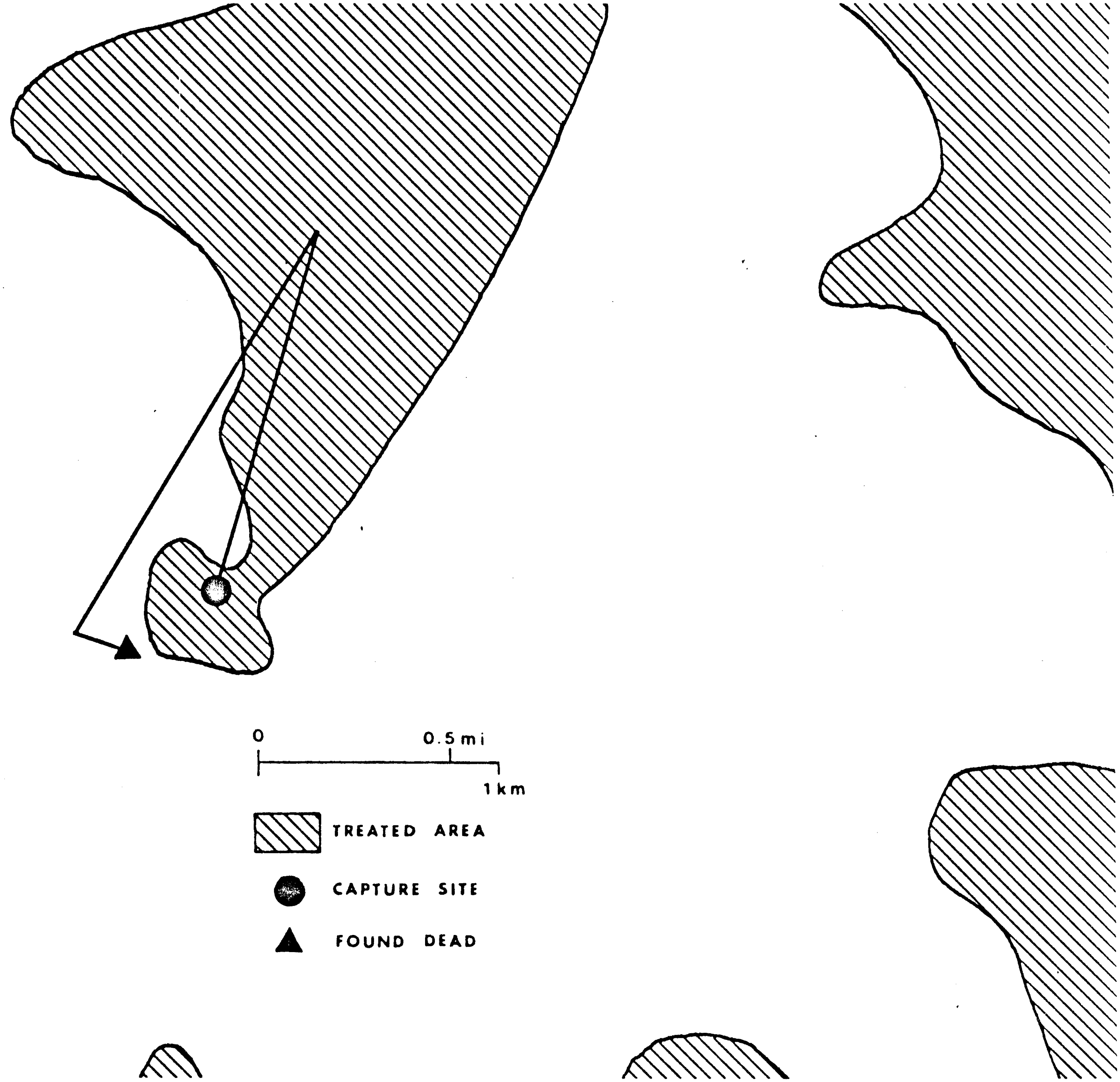

Fig. 20. Movements of 10D, an adult male mourning dove. Tracked from 7/10 to 7/20/77. Found dead--probable predator kill.

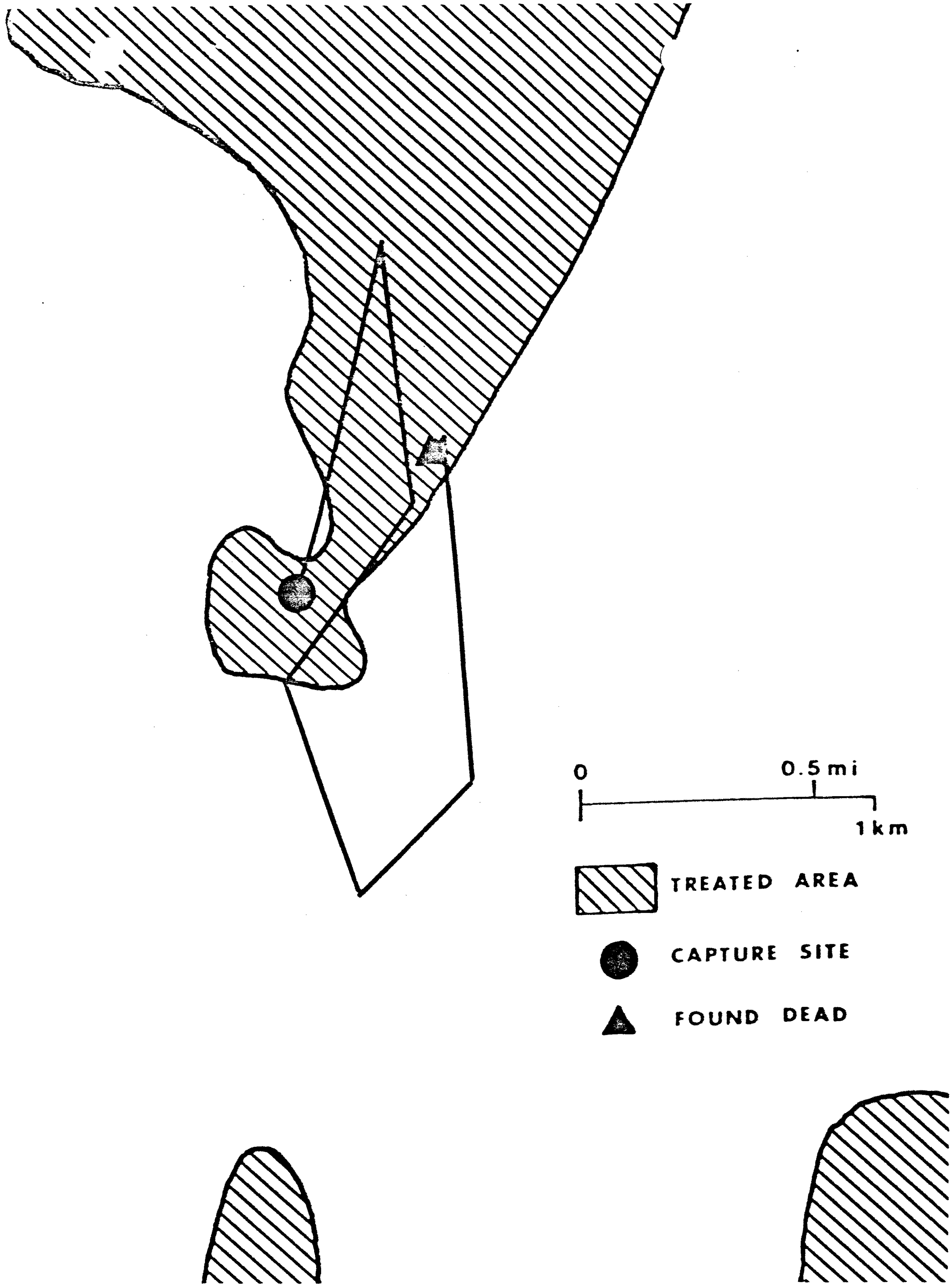

Fig. 21. Movements of 8C, an adult female mourning dove. Tracked from 7/10 to 7/25/77. Found dead--probable predator kill.

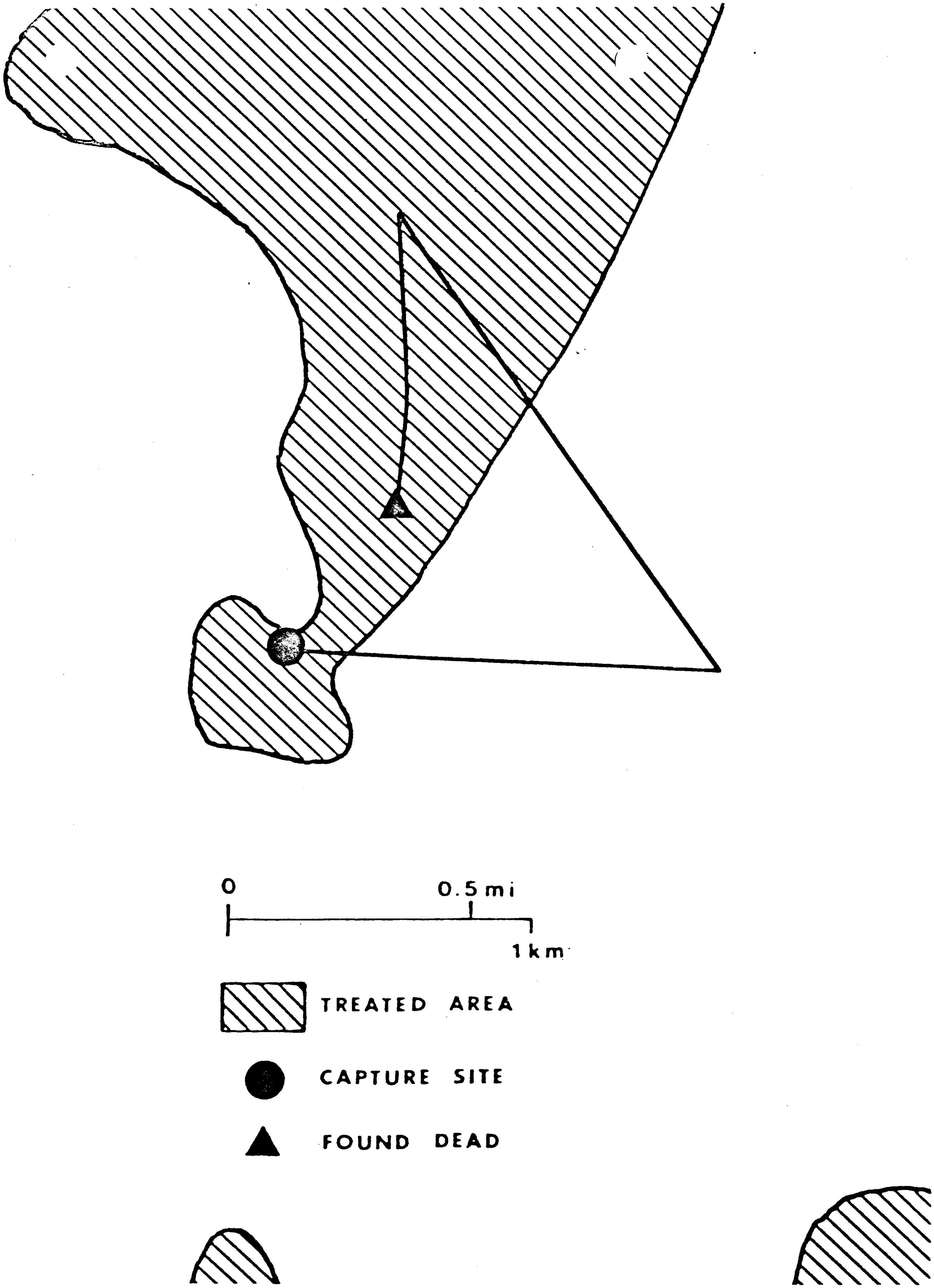

Fig. 22. Movements of 10F, an adult female mourning dove. Tracked from 7/10 to 7/20/77. Found dead--a probable predator kill.

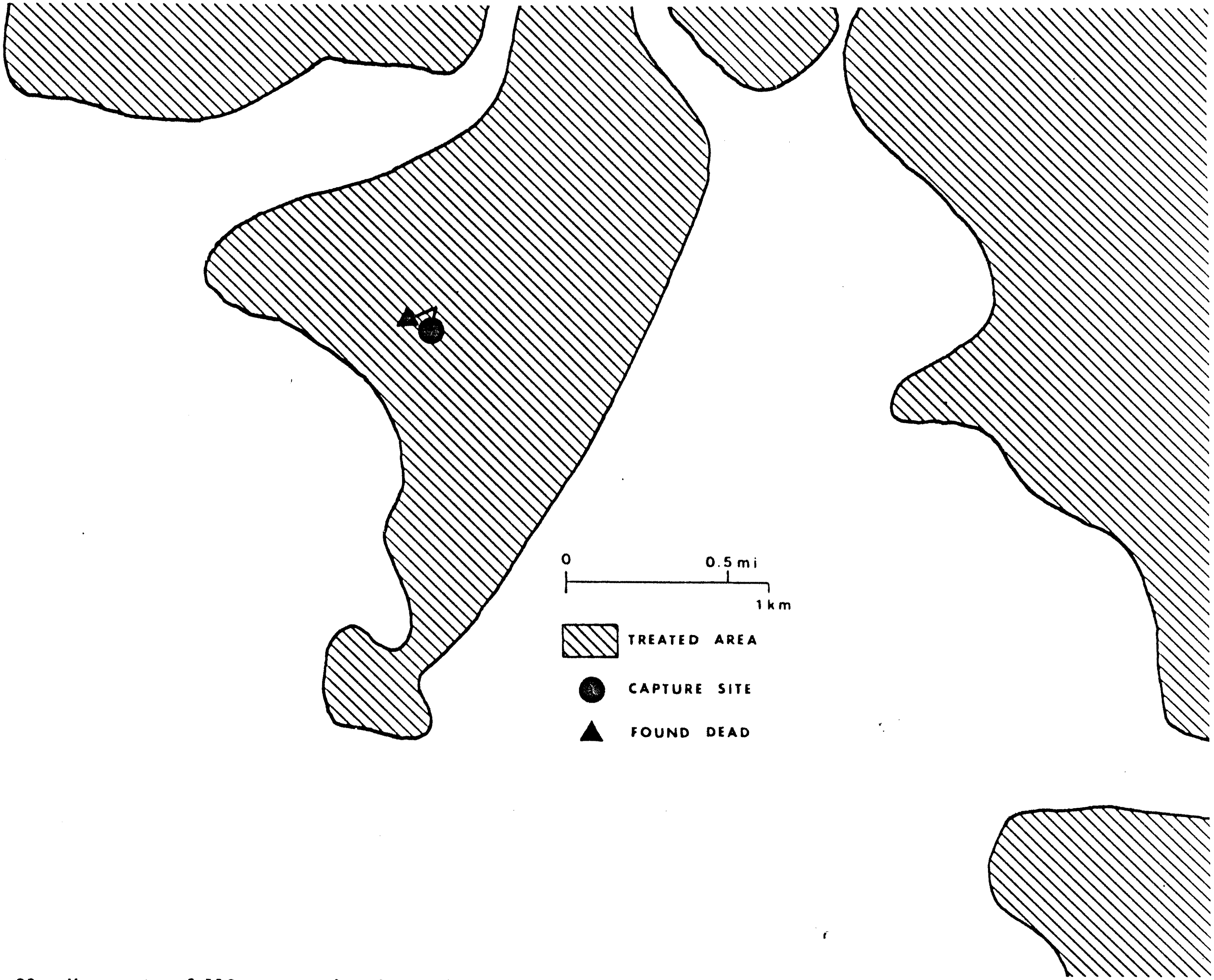

Fig. 23. Movements of 11C, a mourning dove. Tracked from 7/13 to 7/22/77. Found dead--probable predator kill.

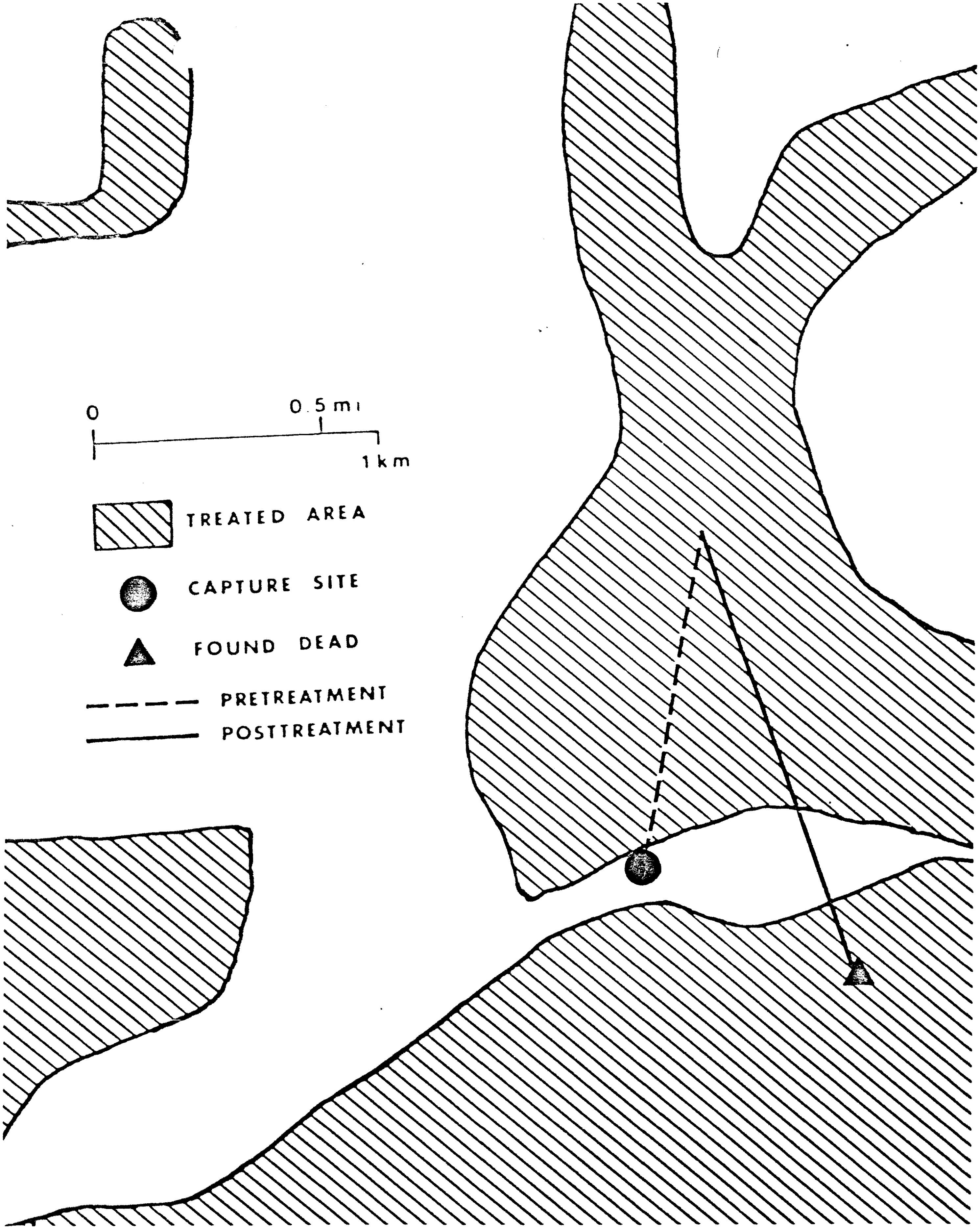

Fig. 24. Movements of 1B, an adult female mourning dove. Tracked from 6/6 to 6/9/77. Found dead--chemical analysis did not show 1080 residue in the crop contents (Table 18, sample 205).

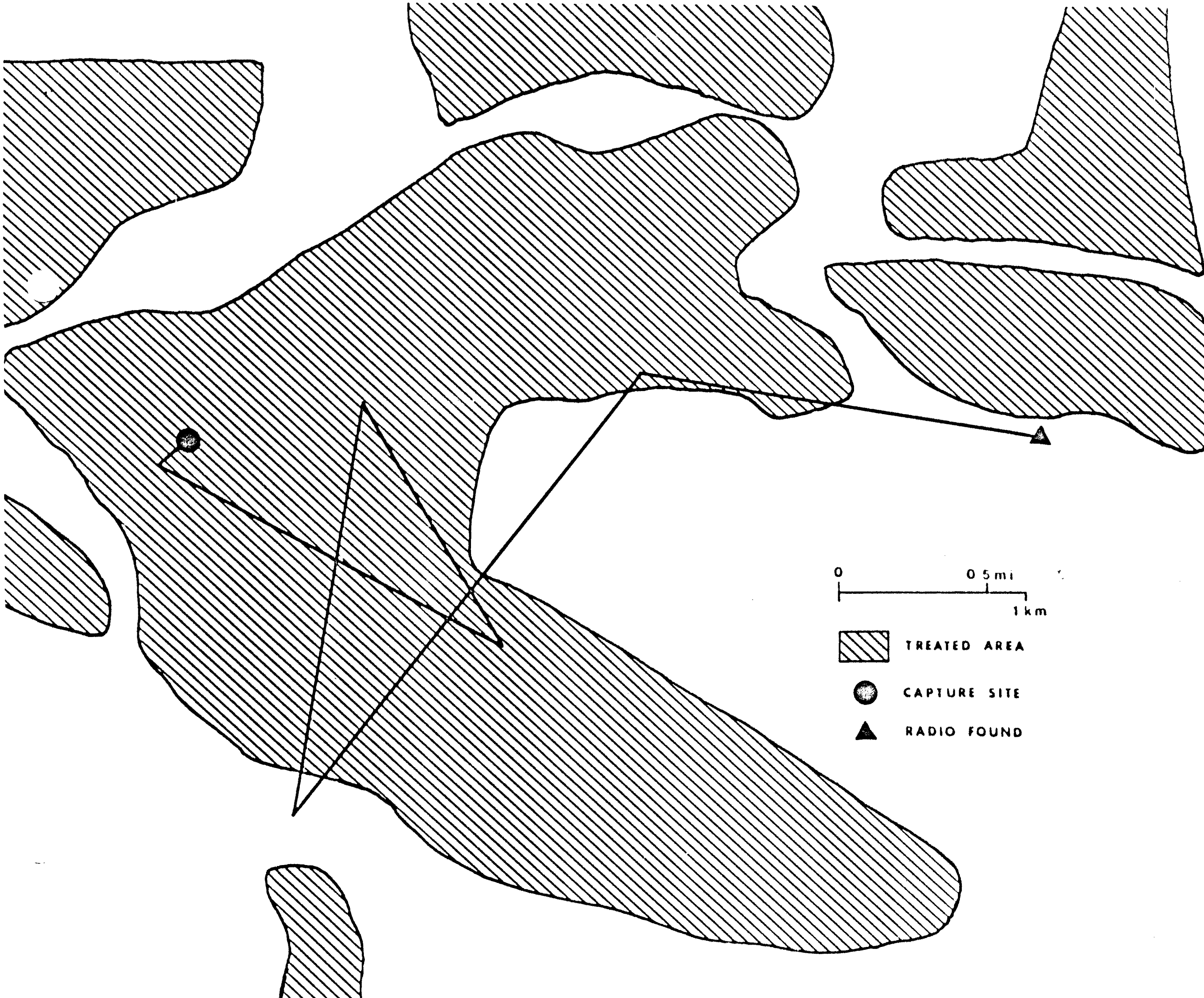

Fig. 25. Movements of 5F, an adult male mourning dove tracked from 6/6 to 6/18/77. Radio only found. Alive and well last date tracked.

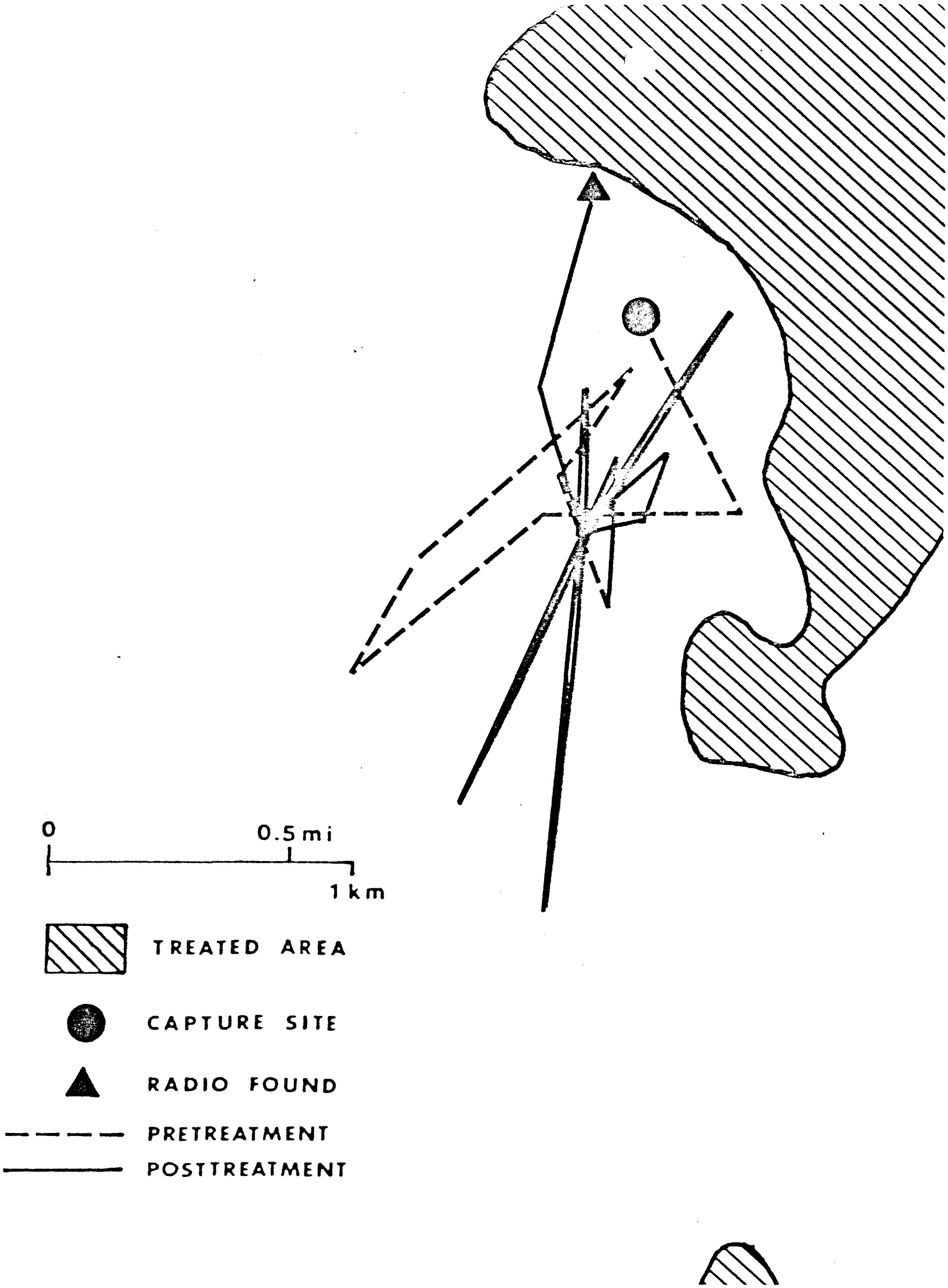

Fig. 26. Movements of 11B, an adult female California quail. Tracked from 5/16 to 7/10/77. Radio found--possible predator kill.

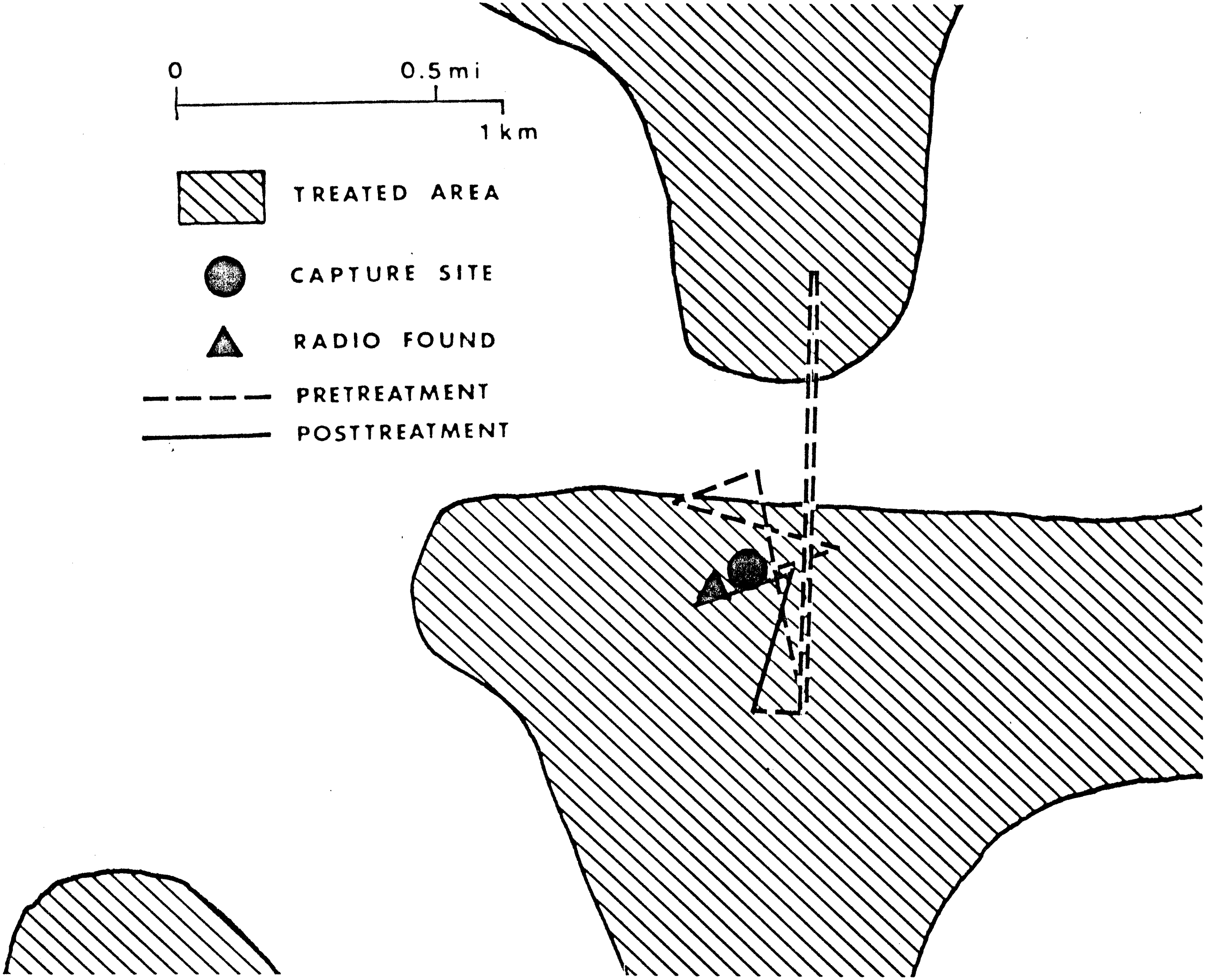

Fig. 27. Movements of 4C, an adult male California quail. Tracked from 5/21 to 6/12/77. Radio found--possible predator kill.

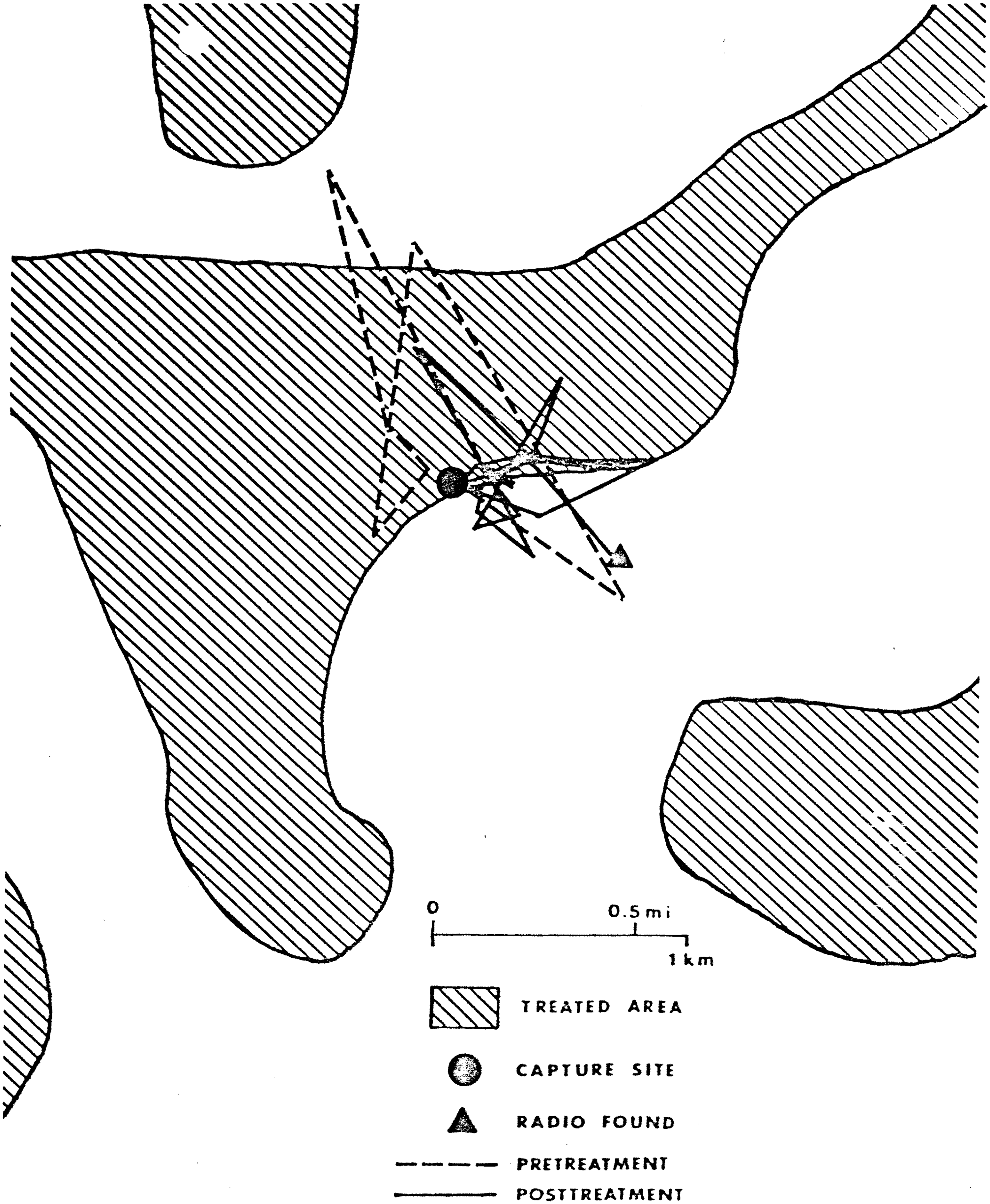

Fig. 28. Movements of 1D, an adult male California quail. Tracked from 5/21 to 7/20/77. Radio only found--alive and well last date tracked.

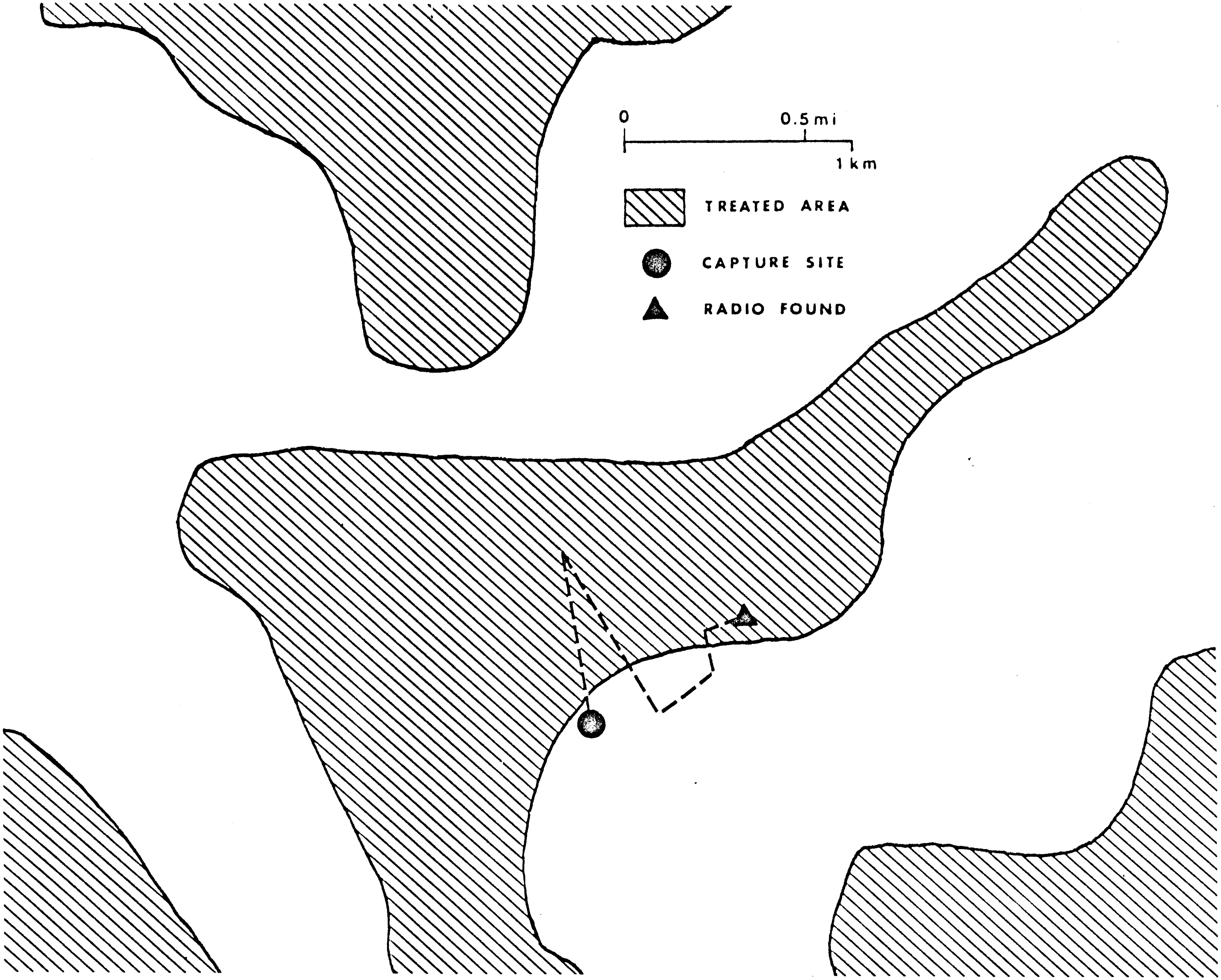

Fig. 29. Movements of 4F, an adult female California quail. Tracked from 5/21 to 6/3/77. Radio came off in brush pile while being tracked--alive and well last date tracked.

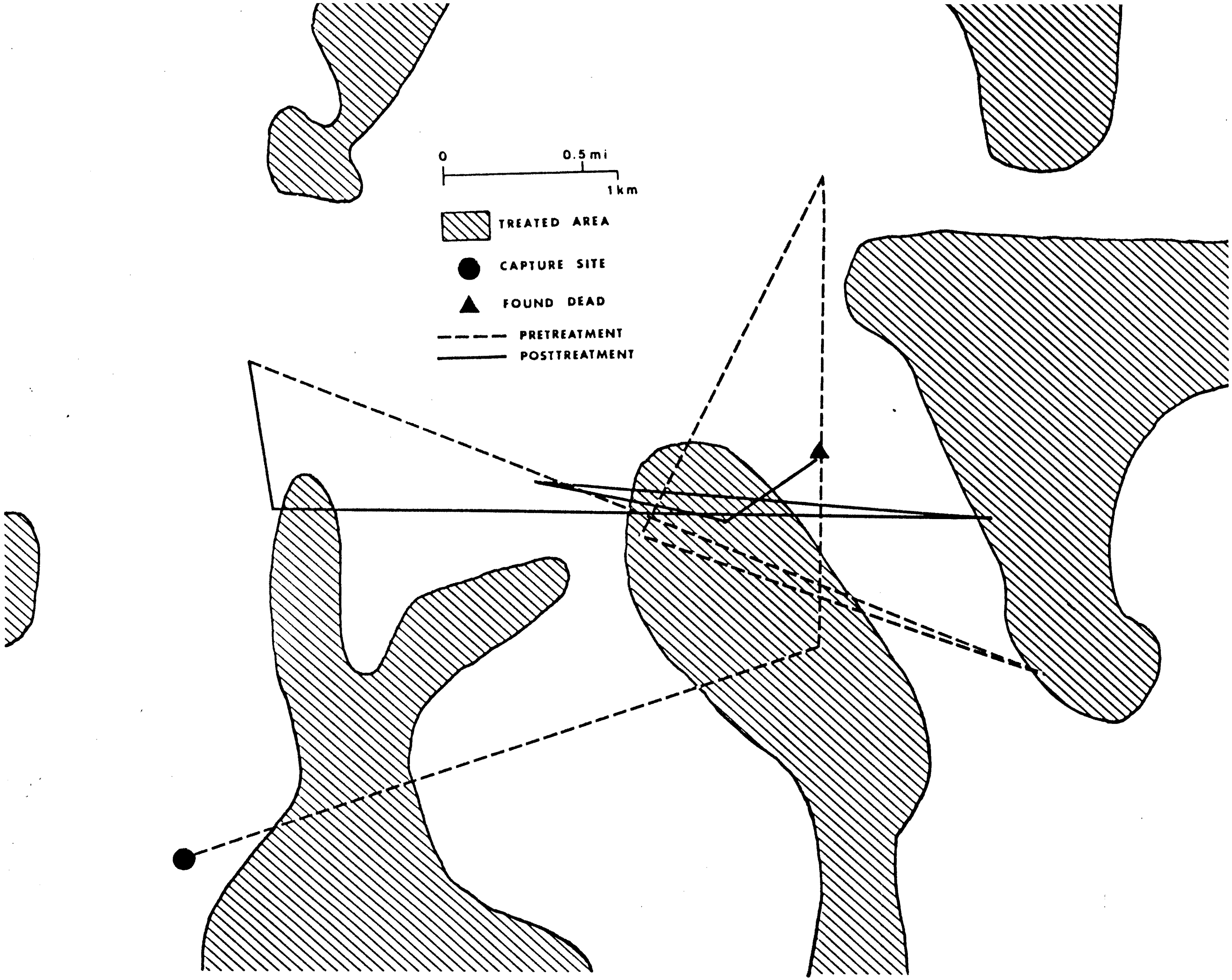

Fig. 30. Movements of 10D, an adult female coyote. Tracked from 4/30 to 6/11/77. Found dead, chemical analysis did not show 1080 residue in the stomach contents (Table 2[illegible], sample 209).

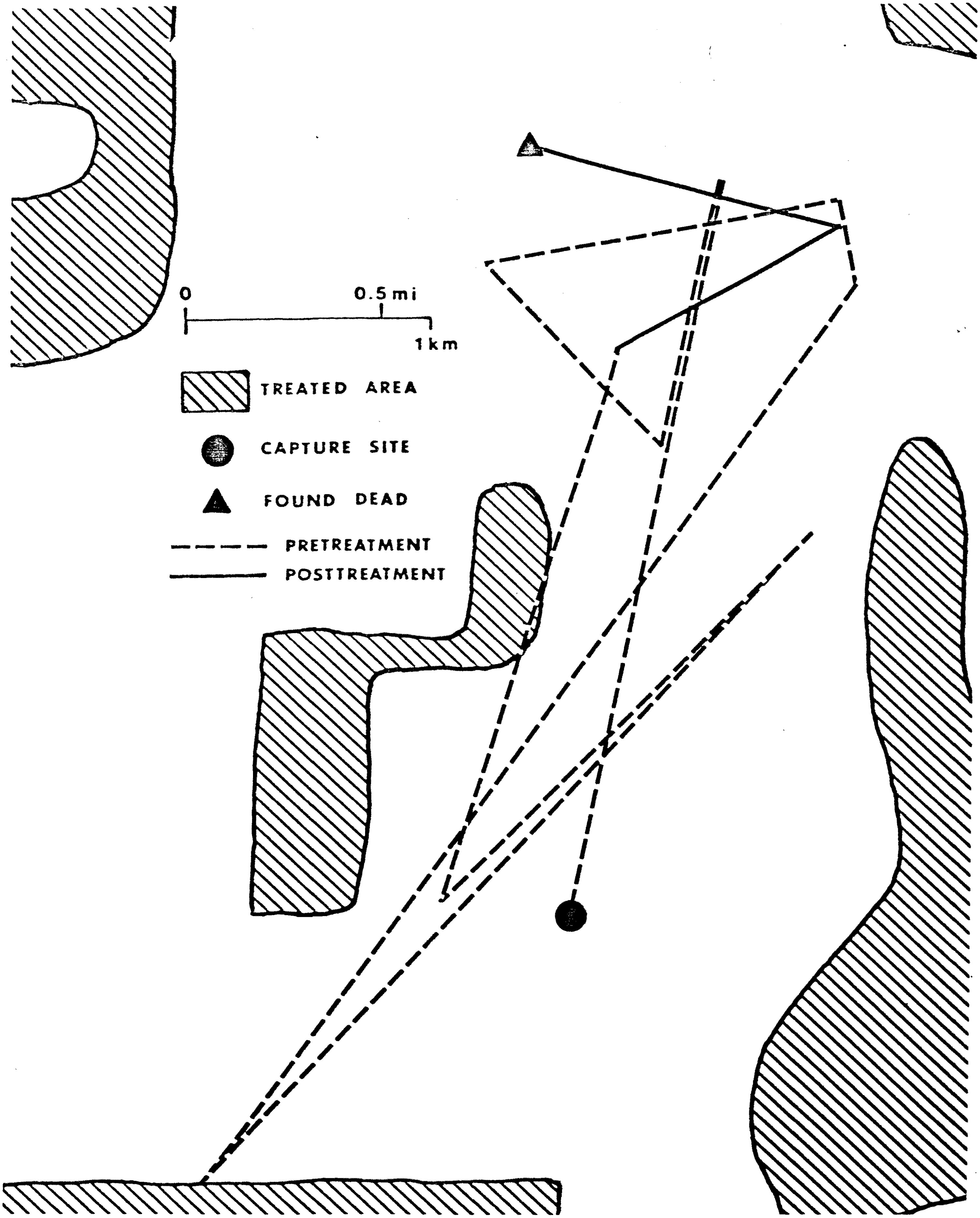

Fig. 31. Movements of 12D, an adult female coyote. Tracked from 4/24 to 6/10/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 86).

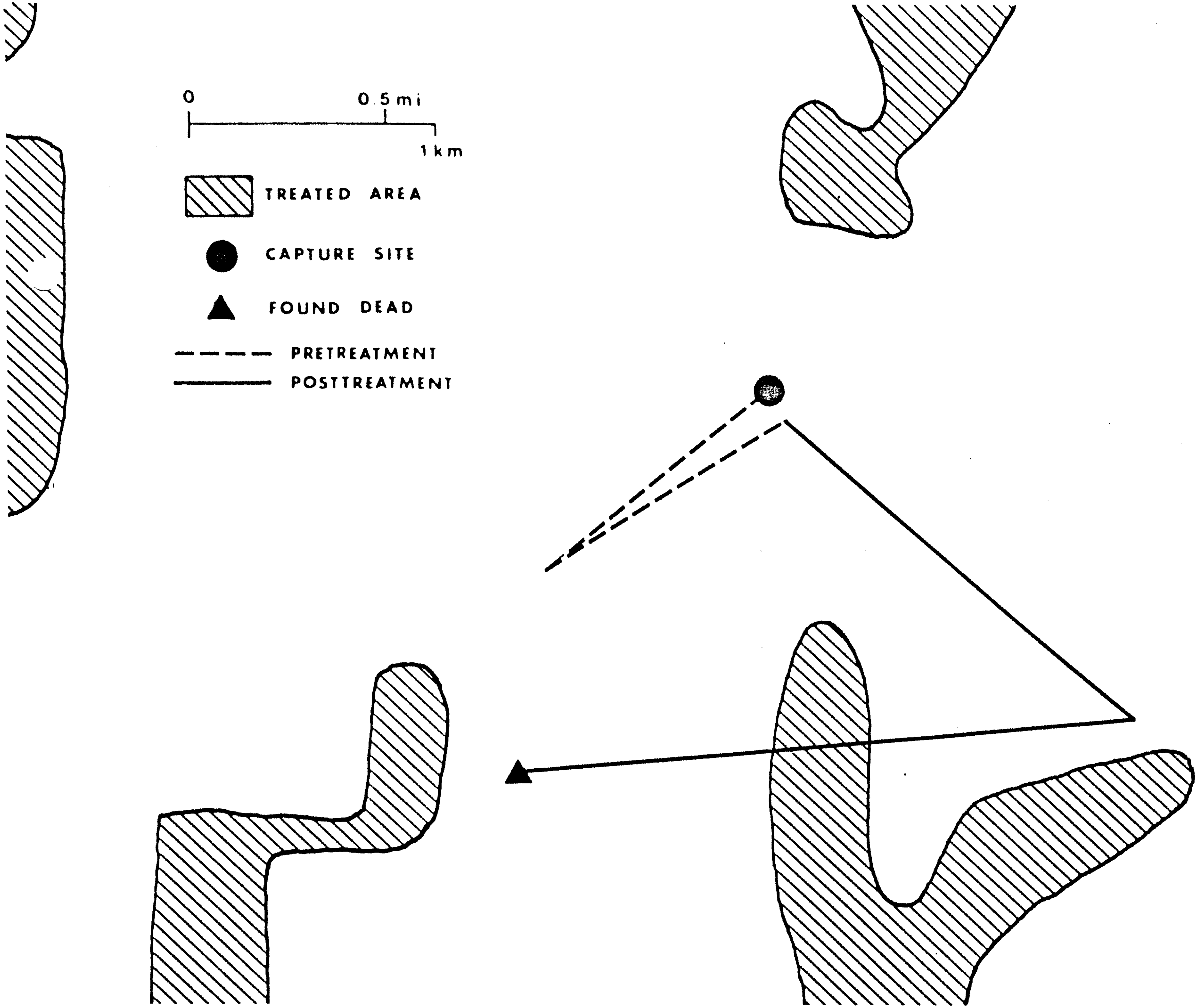

Fig. 32. Movements of 1F, an adult male coyote. Tracked from 5/24 to 6/12/77. Found dead--chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 147).

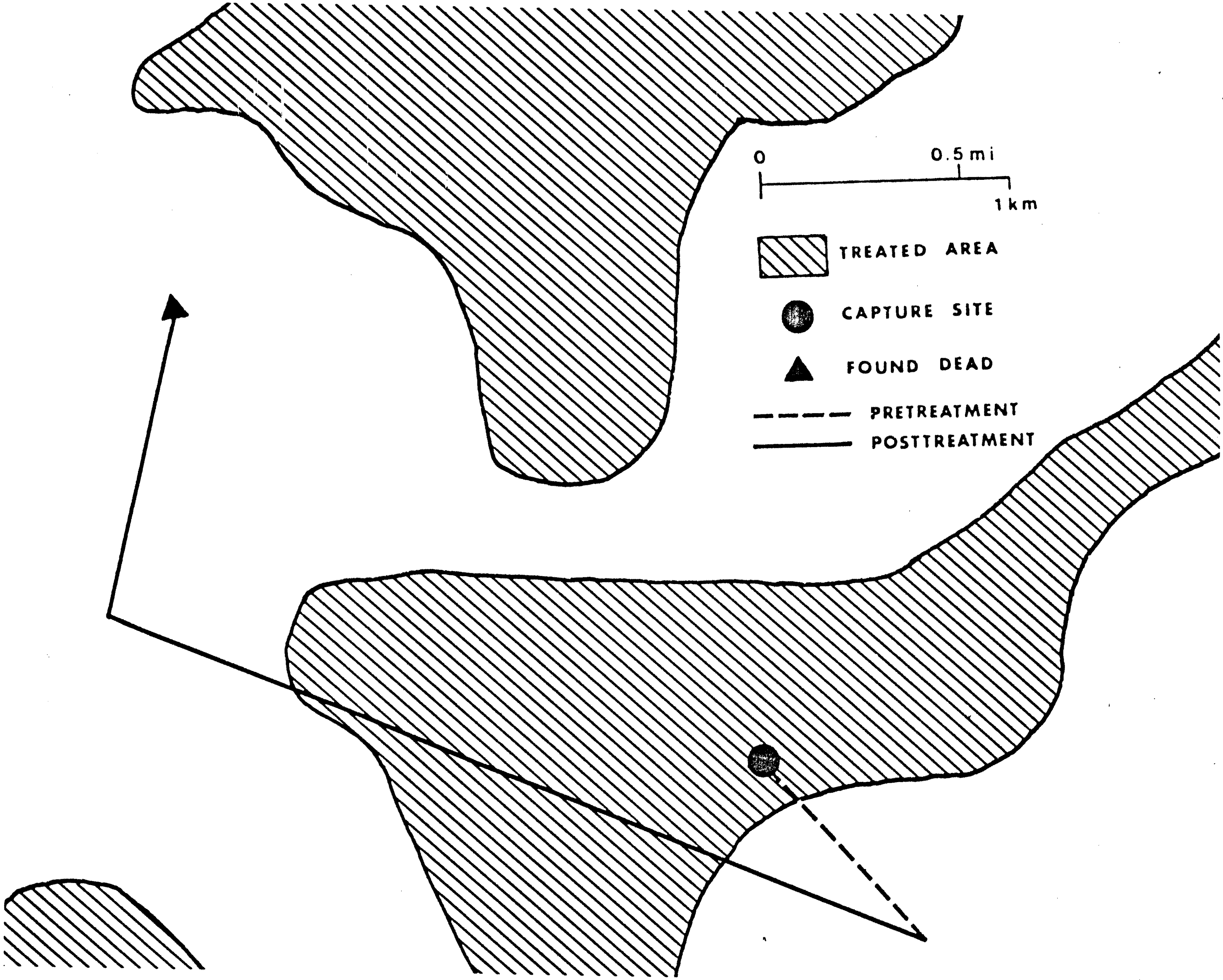

Fig. 33. Movements of 10B, an adult female coyote. Tracked from 6/3 to 6/14/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 150).

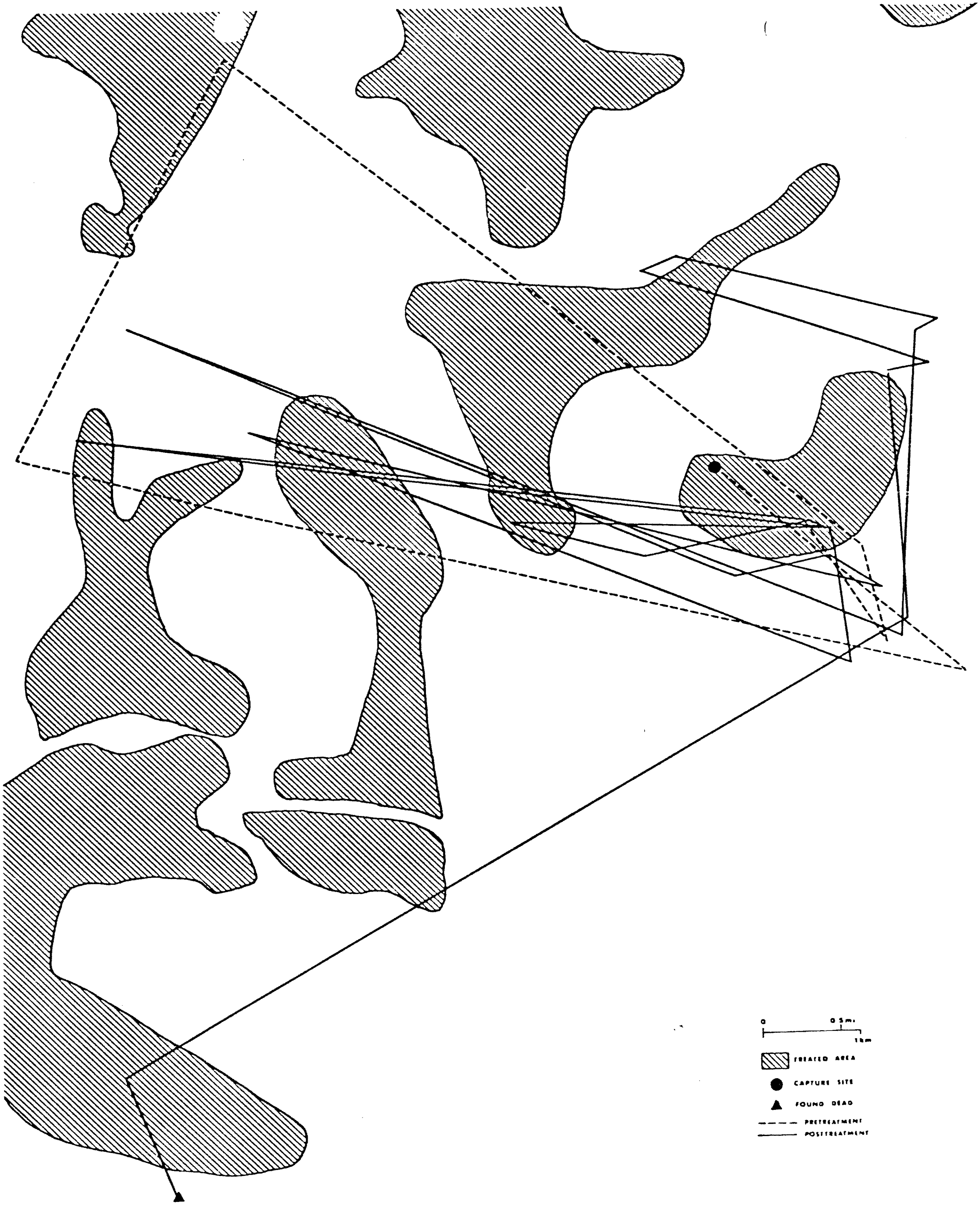

Fig. 34. Movements of 10F, and adult female coyote. Tracked from 5/19 to 7/8/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 195).

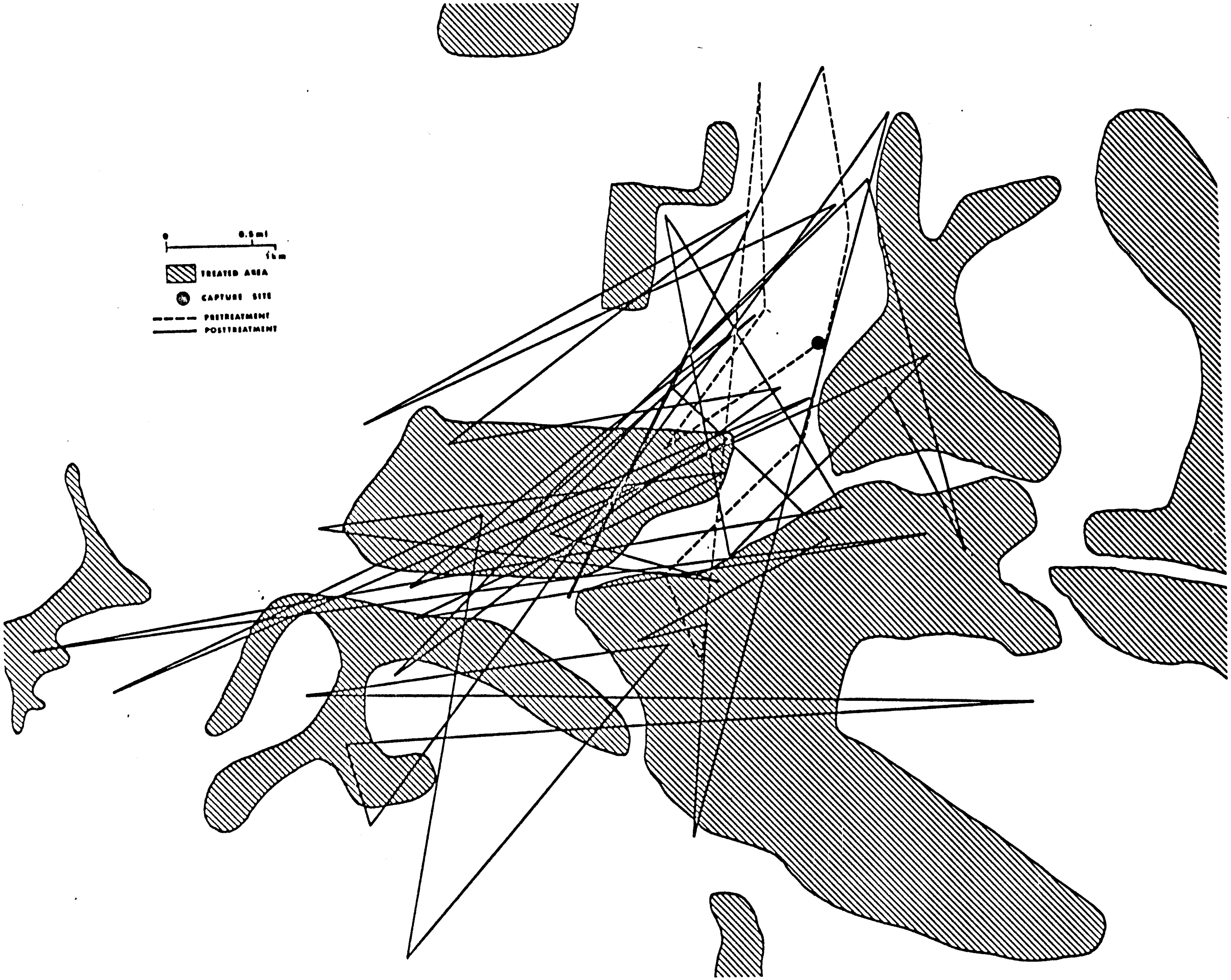

Fig. 35. Movements of 11D, an adult female coyote. Tracked from 5/5 to 12/1/77. Alive and well last date tracked.

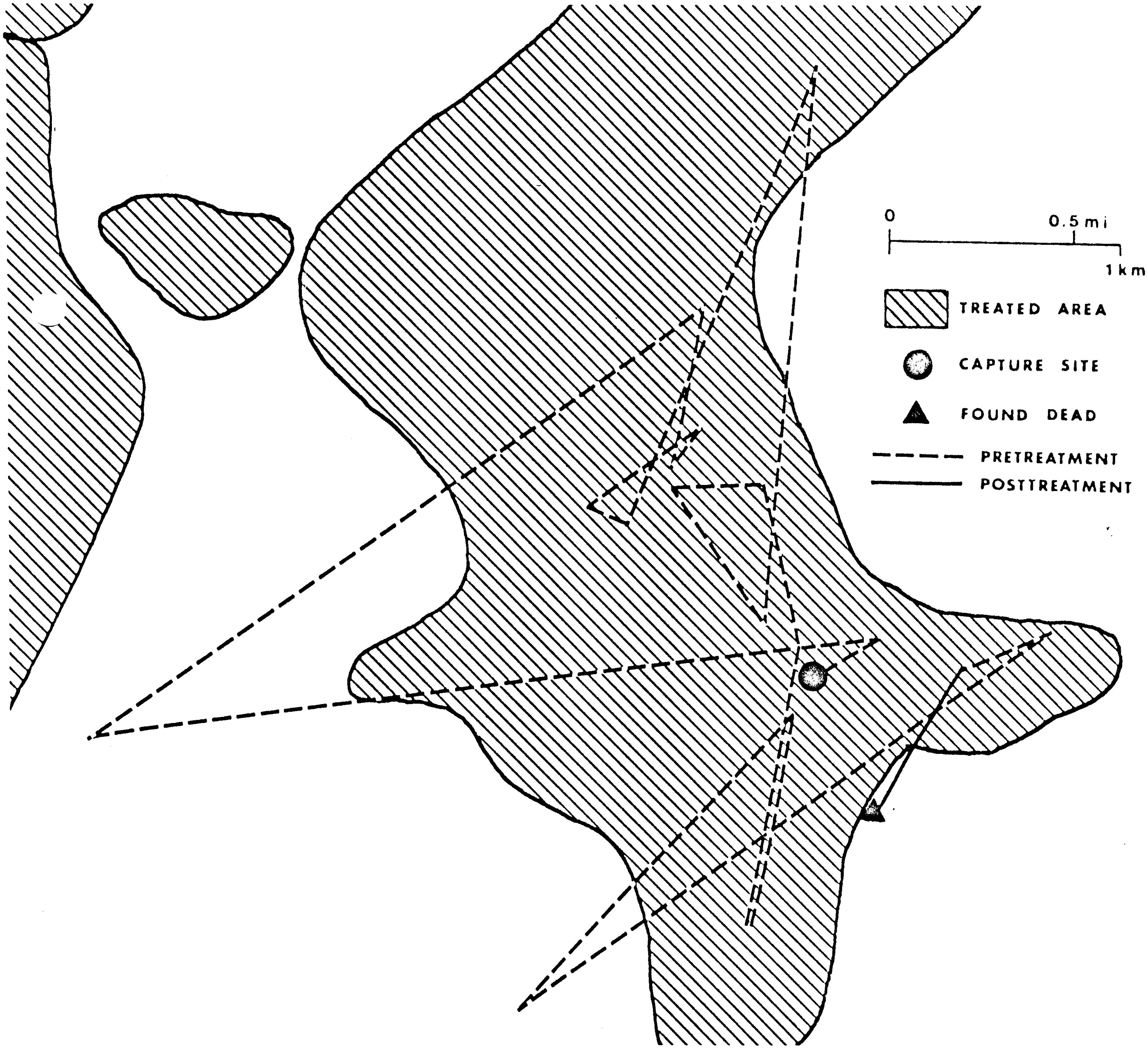

Fig. 36. Movements of 11E, an adult female bobcat. Tracked from 4/26 to 6/8/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 69). A foot injury sustained when trapped may have contributed to this animals death.

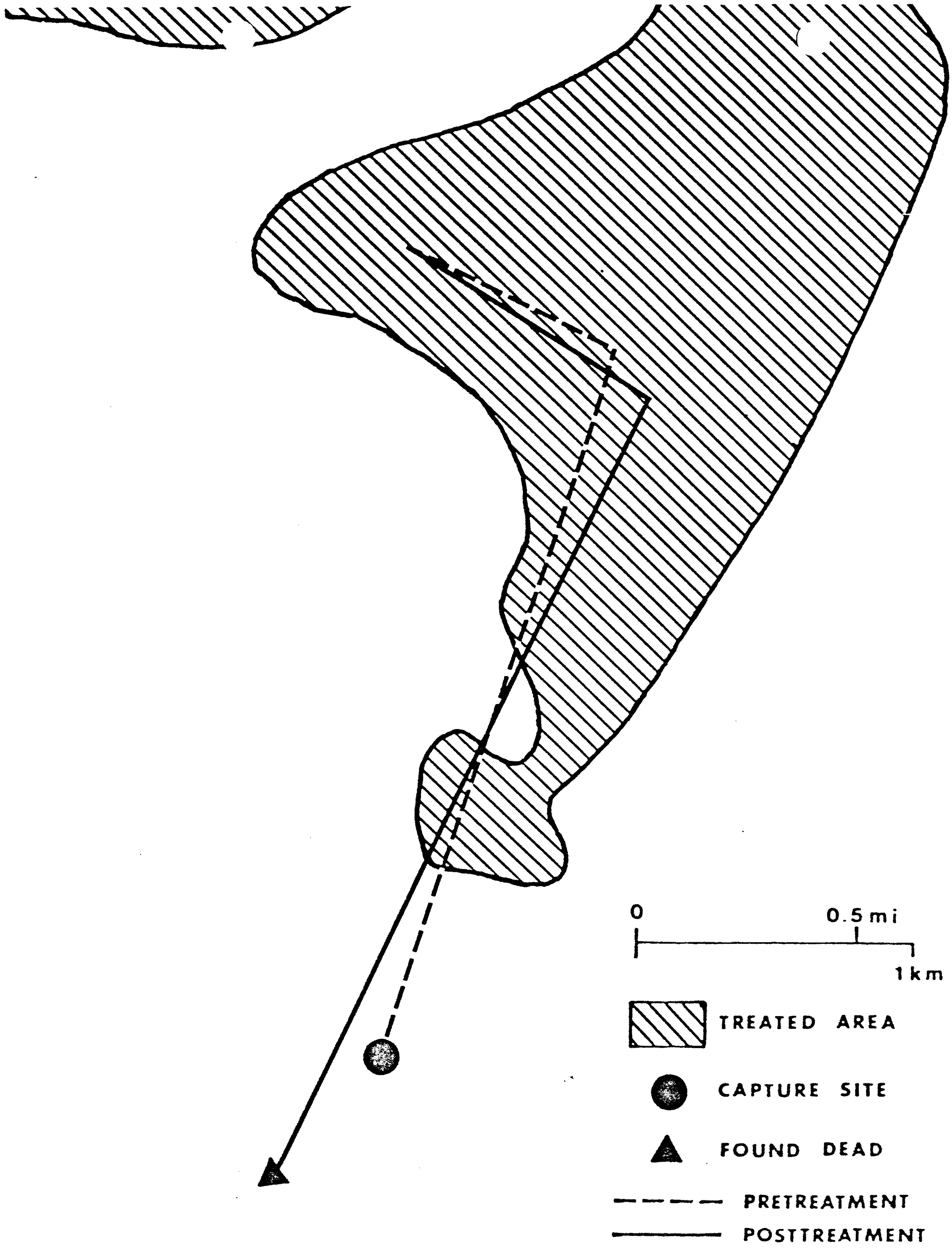

Fig. 37. Movements of 5D, an adult male bobcat. Tracked from 5/28 to 6/8/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 78).

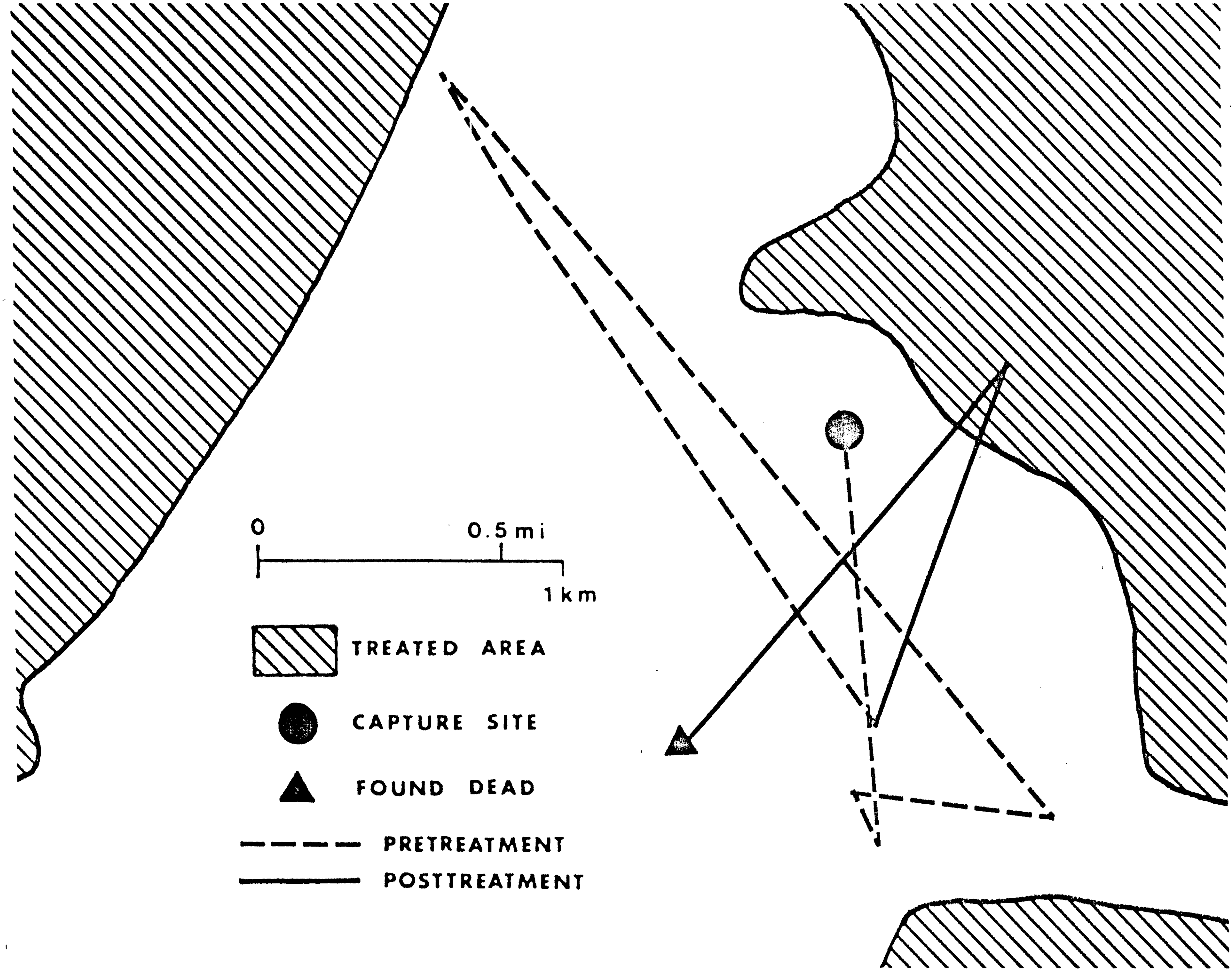

Fig. 38. Movements of 11C Bobcat, an adult female bobcat. Tracked from 5/26 to 6/11/77. Found dead. Chemical analysis did not show 1080 residue in the stomach contents (Table 21, sample 107).

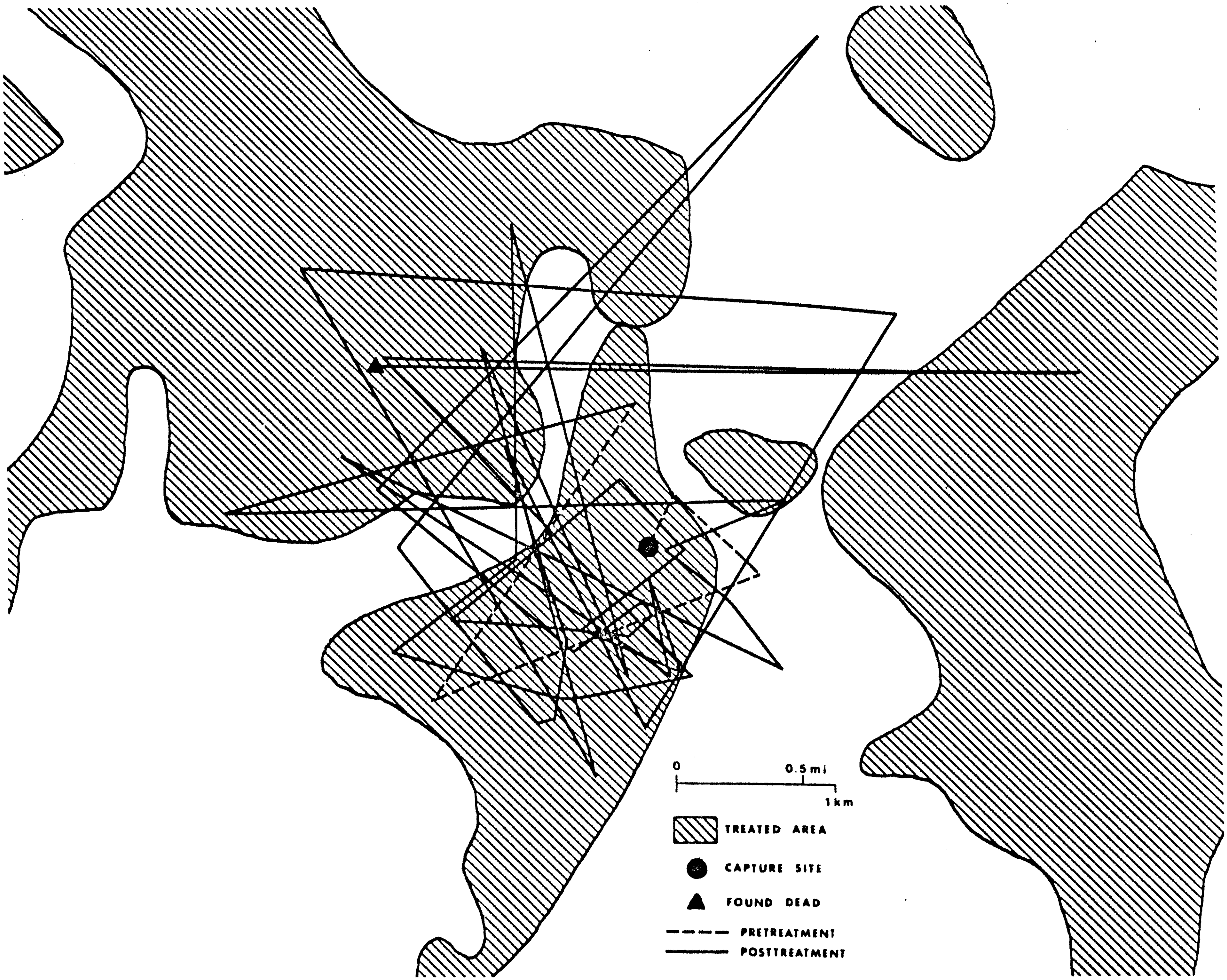

Fig. 39. Movements of 9E, an adult male bobcat. Tracked from 4/27 to 12/1/77. Found dead, possibly shot.

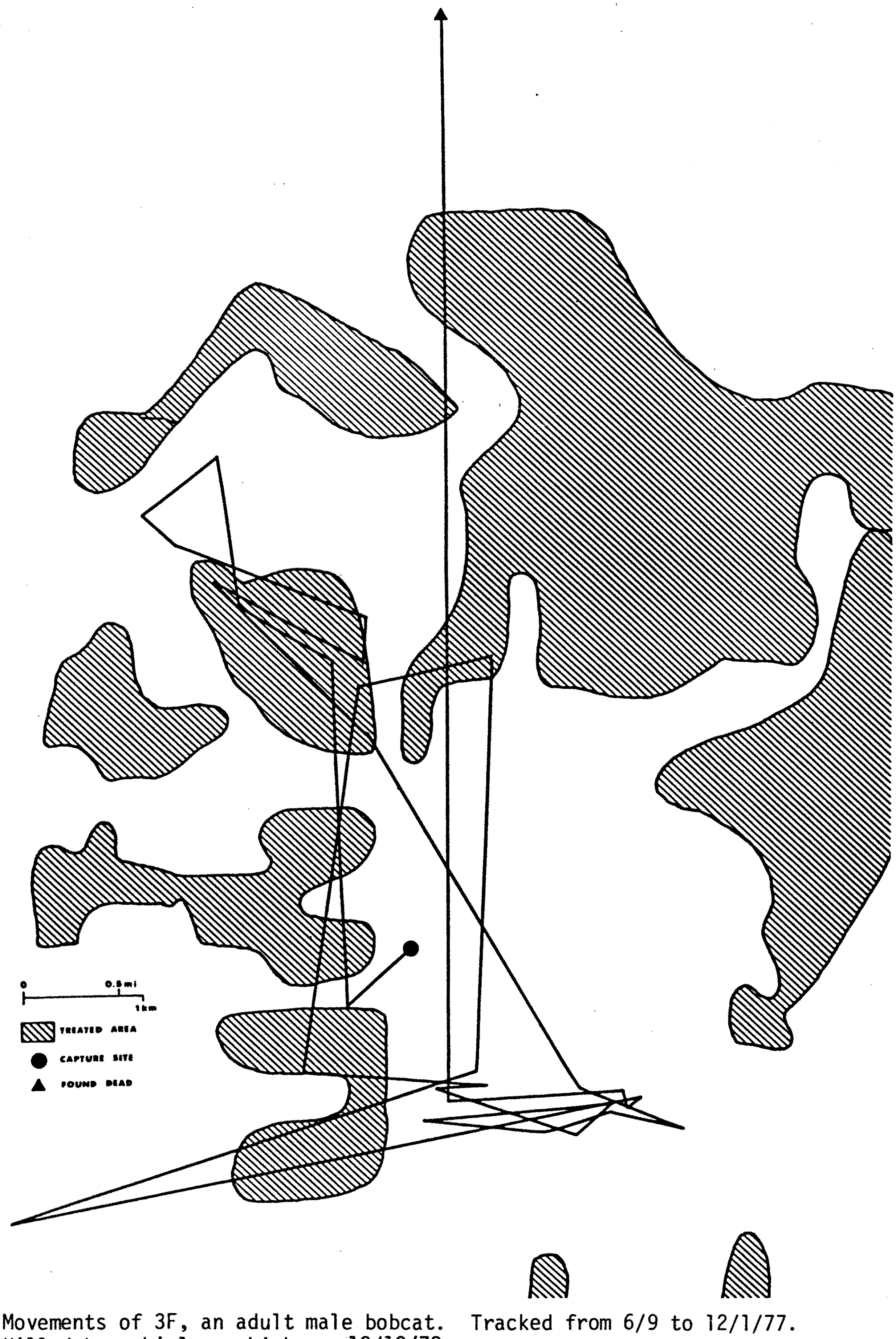

Fig. 40. Movements of 3F, an adult male bobcat. Tracked from 6/9 to 12/1/77.
Killed by vehicle on highway 12/18/78.

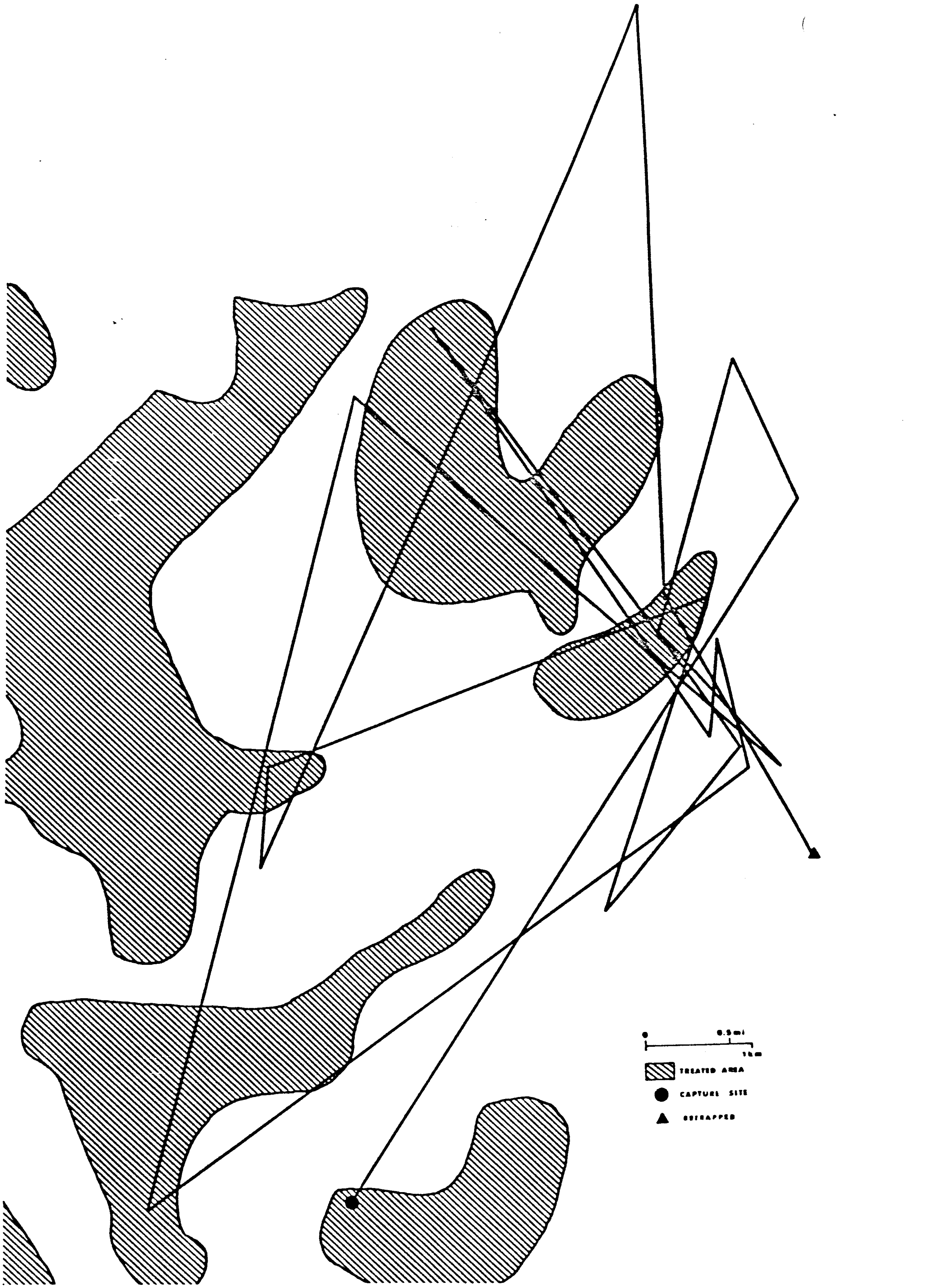

Fig. 41. Movements of 12C, an adult female bobcat. Tracked from 5/24 to 12/1/77. Retrapped by fur trapper on 2/8/78 who reported she was in good condition.

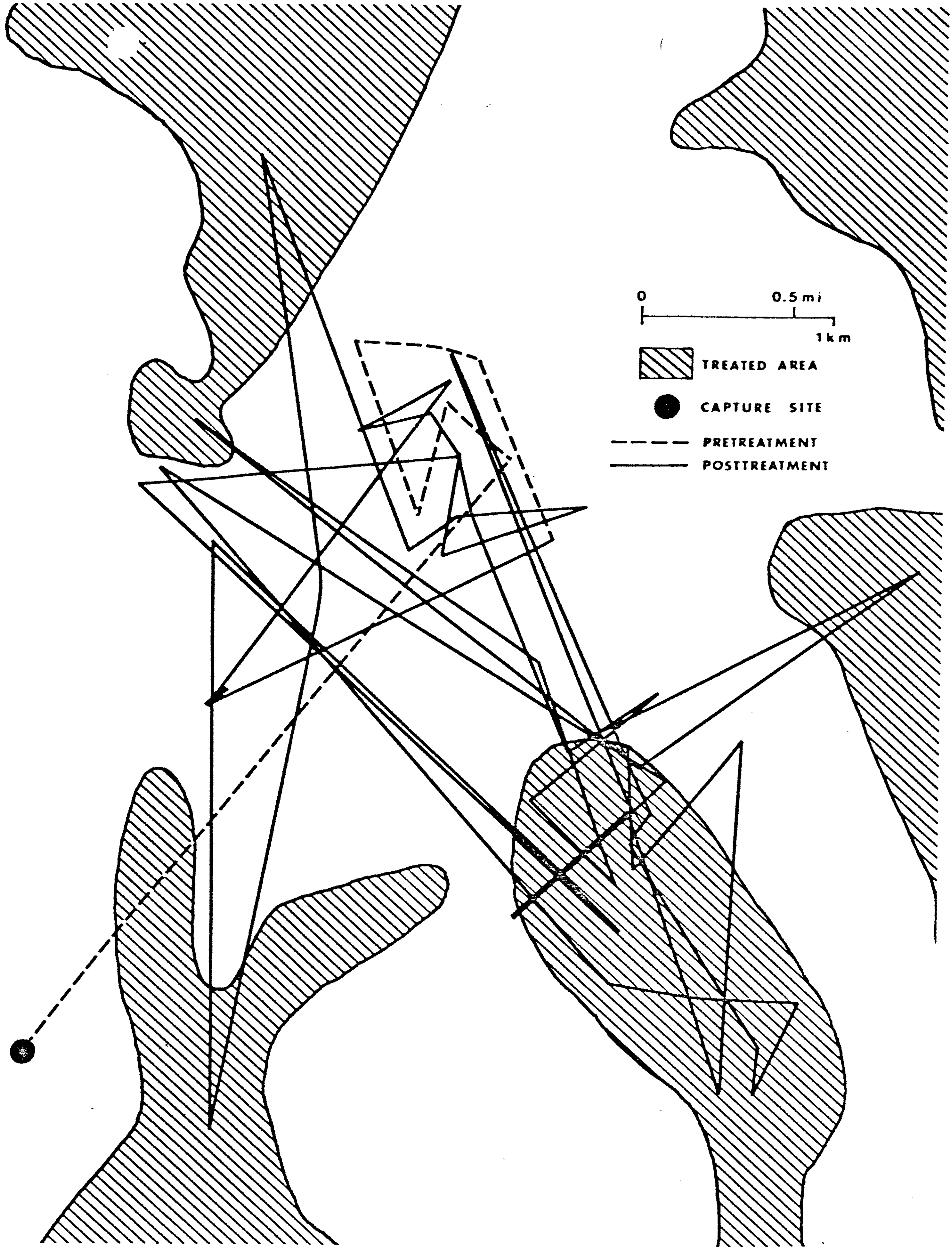

Fig. 42. Movements of 9B, an adult male bobcat tracked from 5/9 to 9/14/77. Alive and well last date tracked.

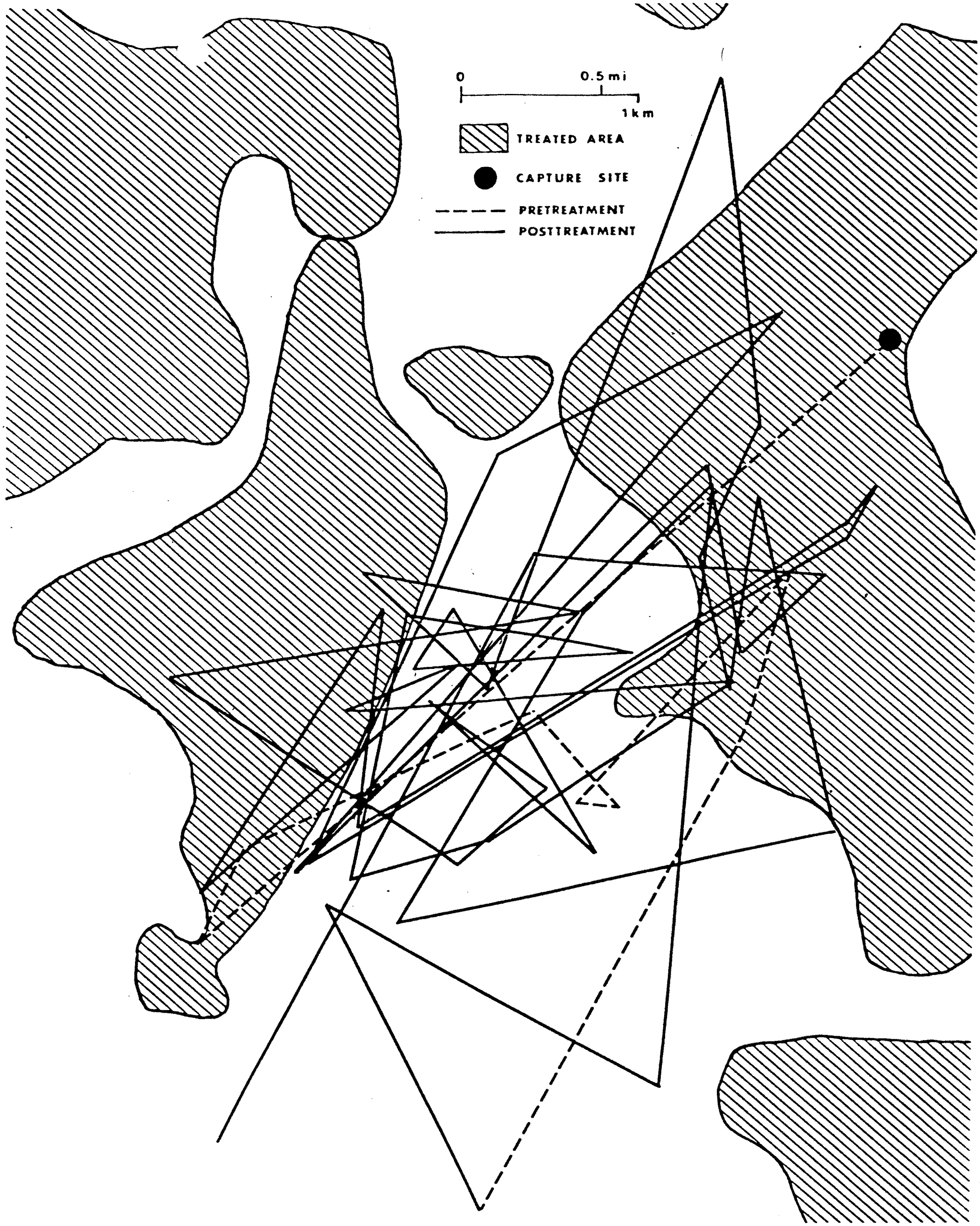

Fig. 43. Movements of 12F, an adult female bobcat. Tracked from 5/16 to 12/1/77. Alive and well last date tracked.

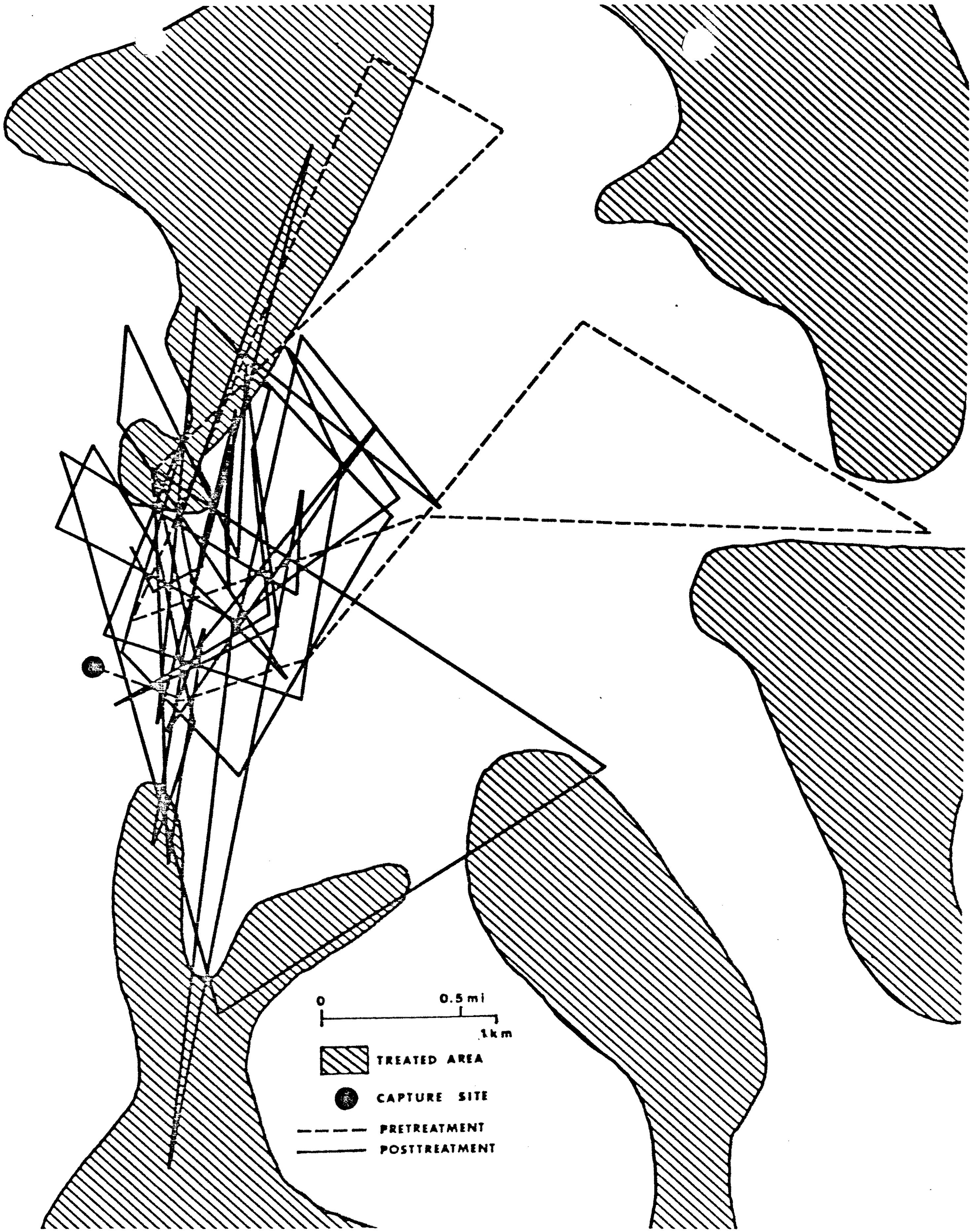

Fig. 44. Movements of 9F, an adult female bobcat. Tracked from 5/16/77 to 4/24/78. Alive and well last date tracked.

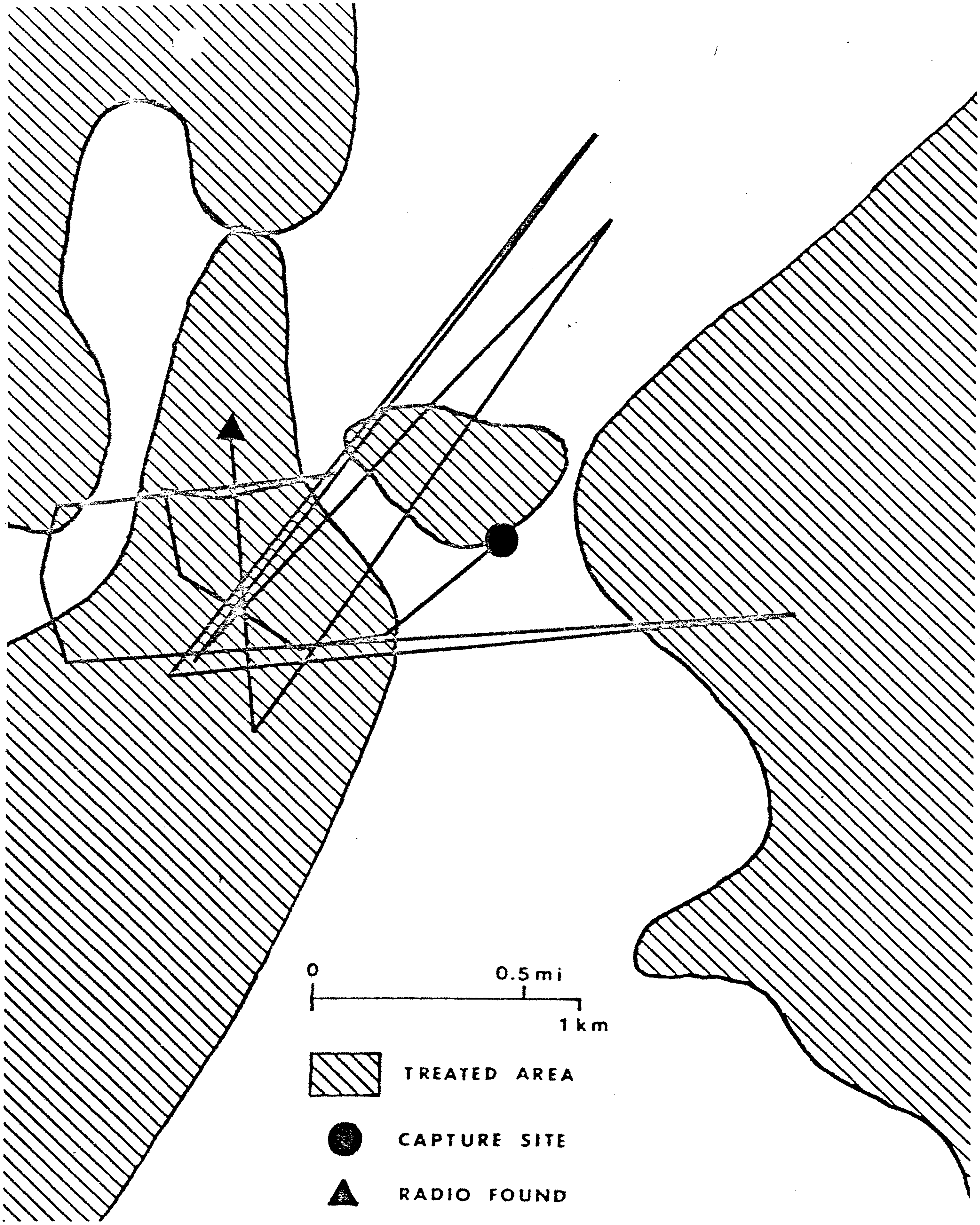

Fig. 45. Movements of 1B, an immature bobcat. Tracked from 6/10 to 6/27/77. Radio only found. Alive and well last date tracked.

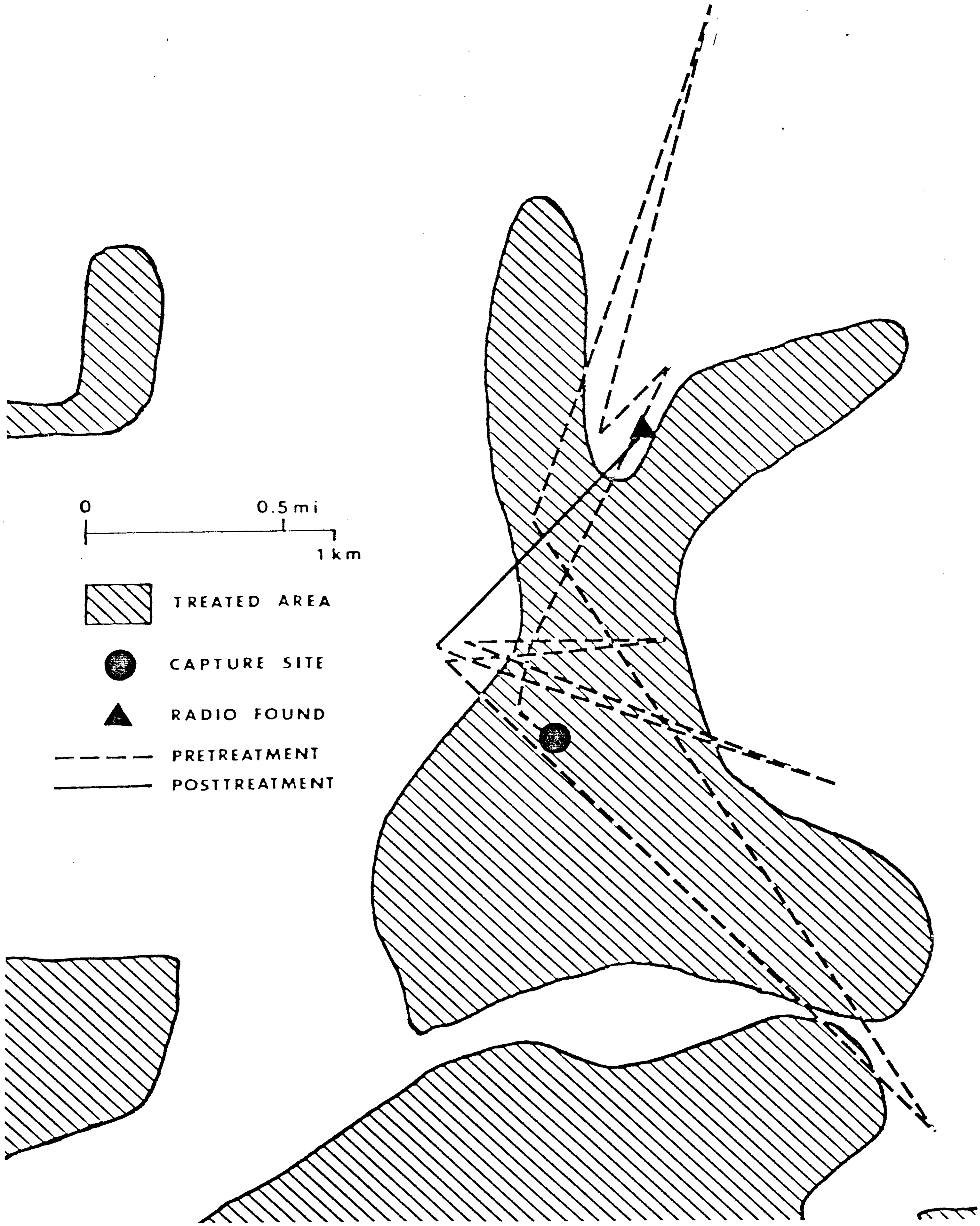

Fig 46. Movements of 6D, an adult male striped skunk. Tracked from 4/18 to 6/11/77. Radio only found in raccoon feces. May have been dead pretreatment.

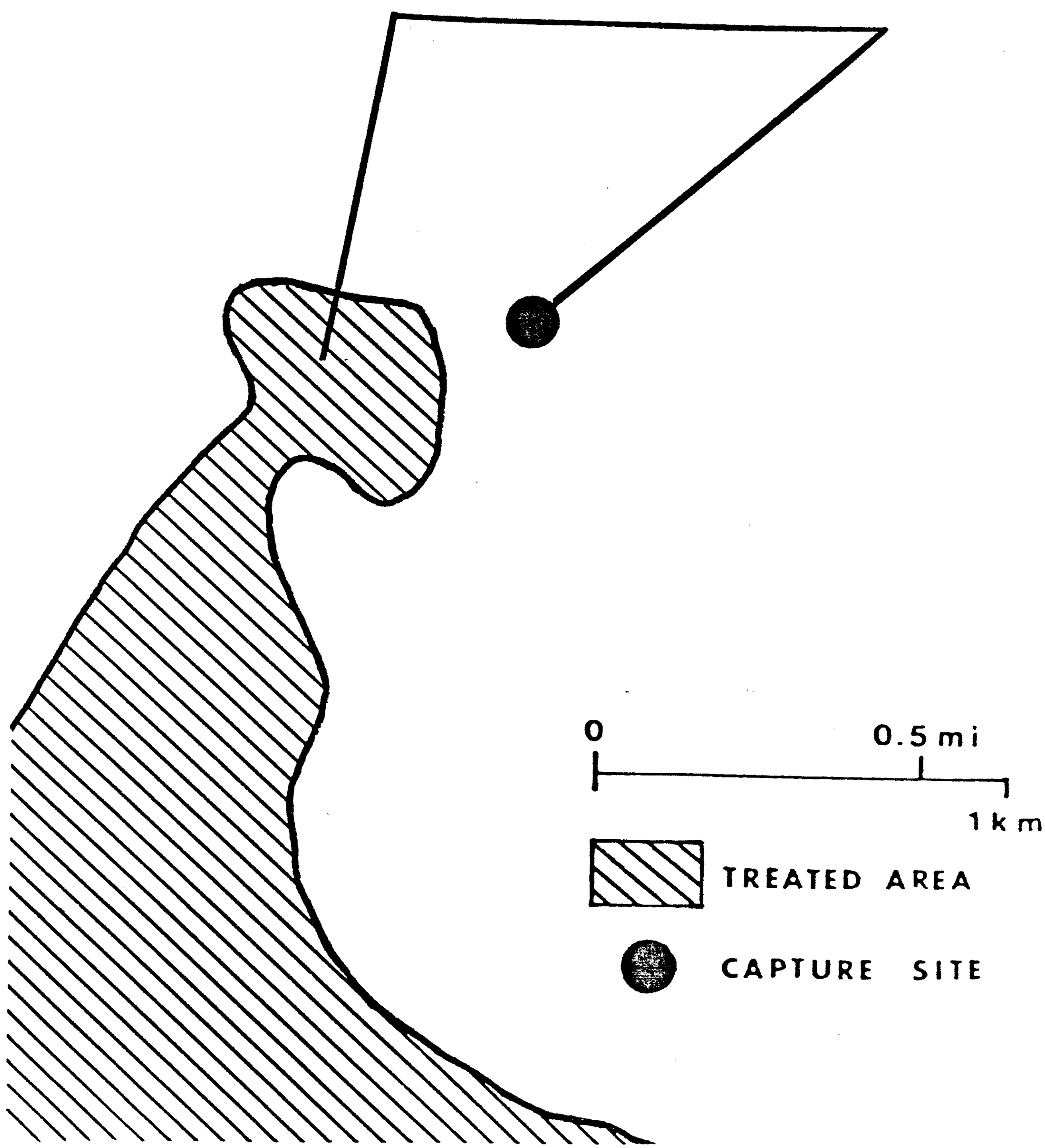

Fig. 47. Movements of 2F, an adult male striped skunk. Tracked from 4/25 to 6/20/77. Lost contact, alive and well last date tracked.

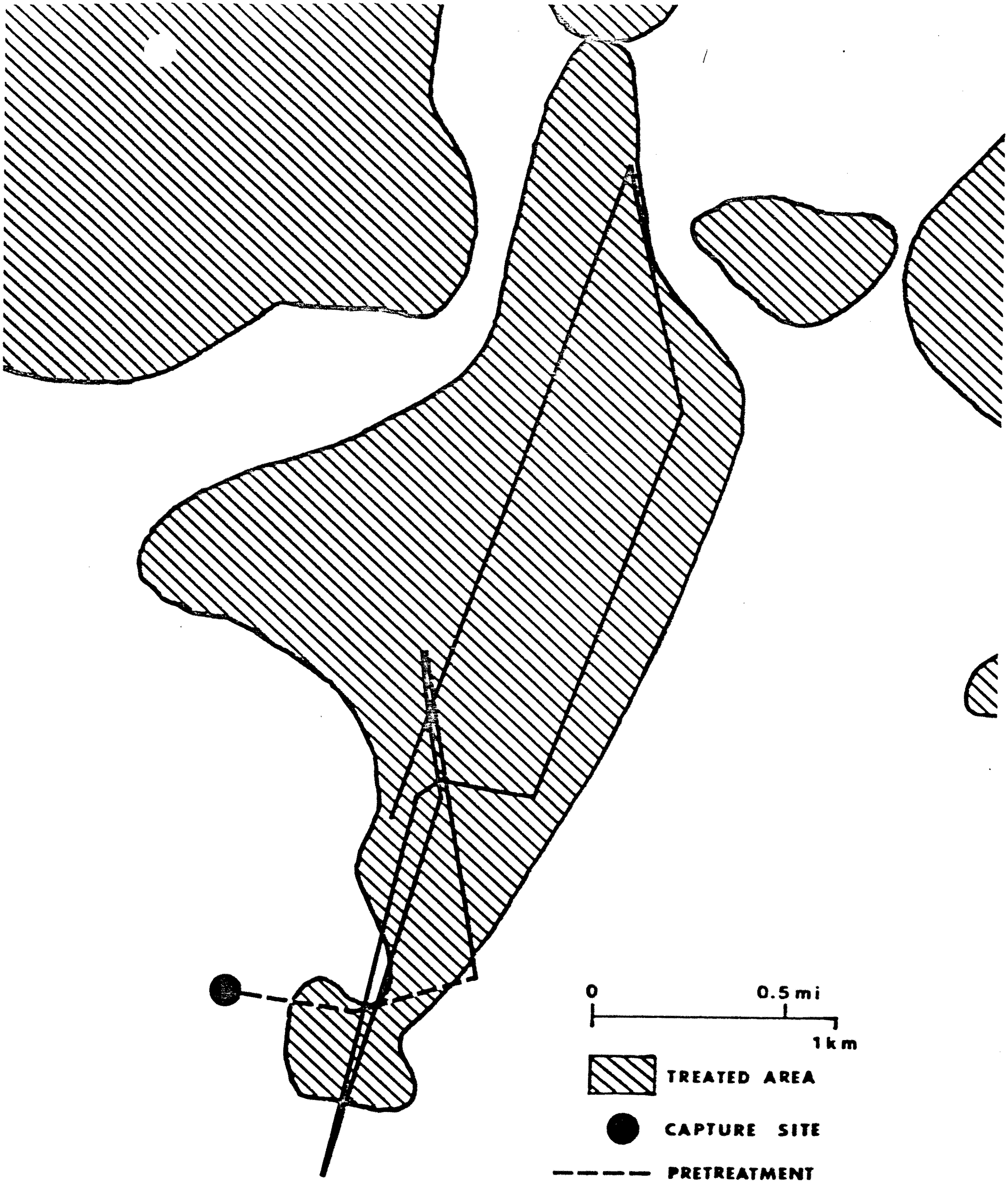

Fig. 48. Movements of 12E, an adult male badger. Tracked from 5/8 to 7/14/77. Lost contact, alive and well last date tracked.

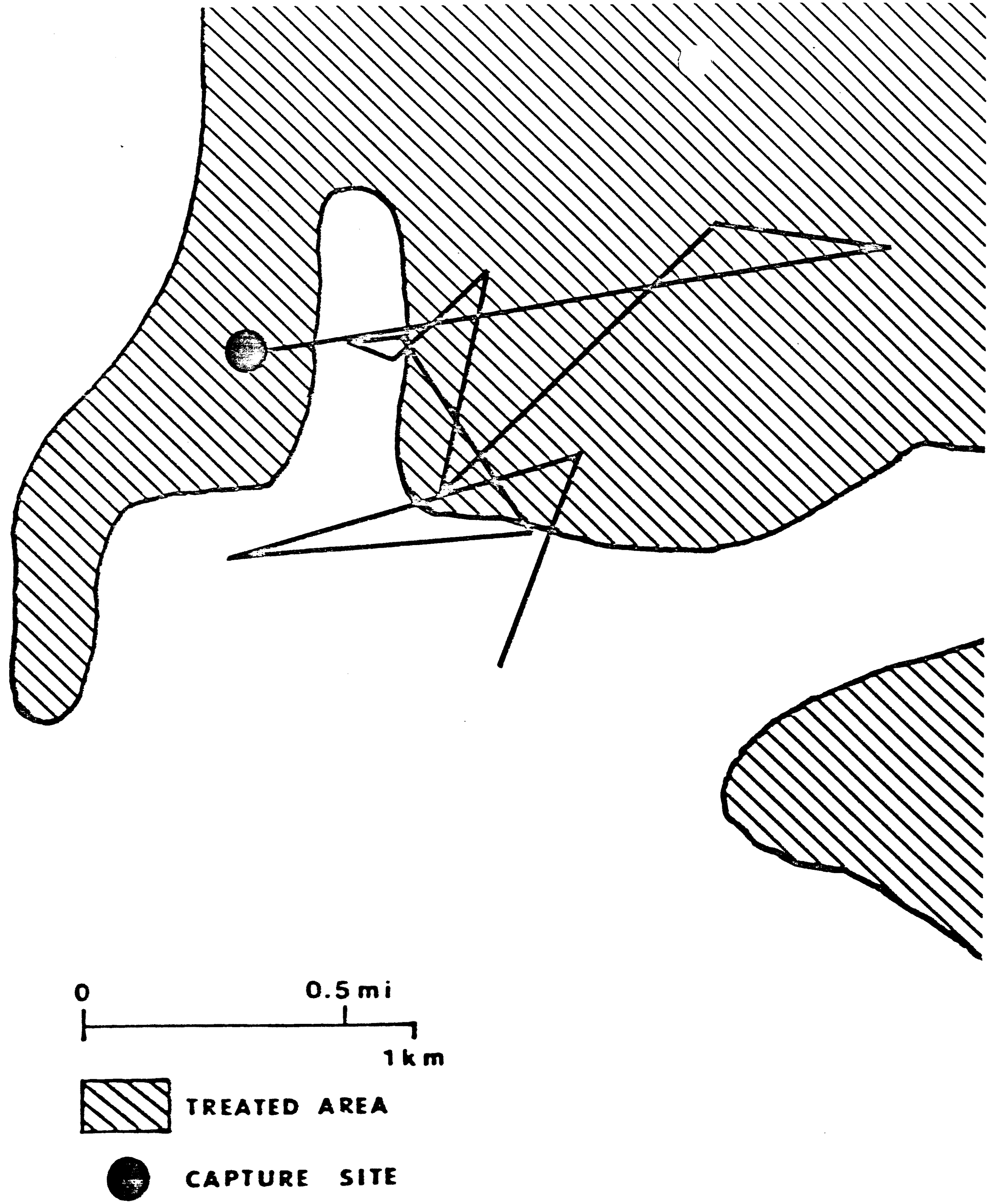

Fig. 49. Movements of 4F, an adult female badger. Tracked from 6/6 to 6/28/77. Lost contact. Alive and well last date tracked.

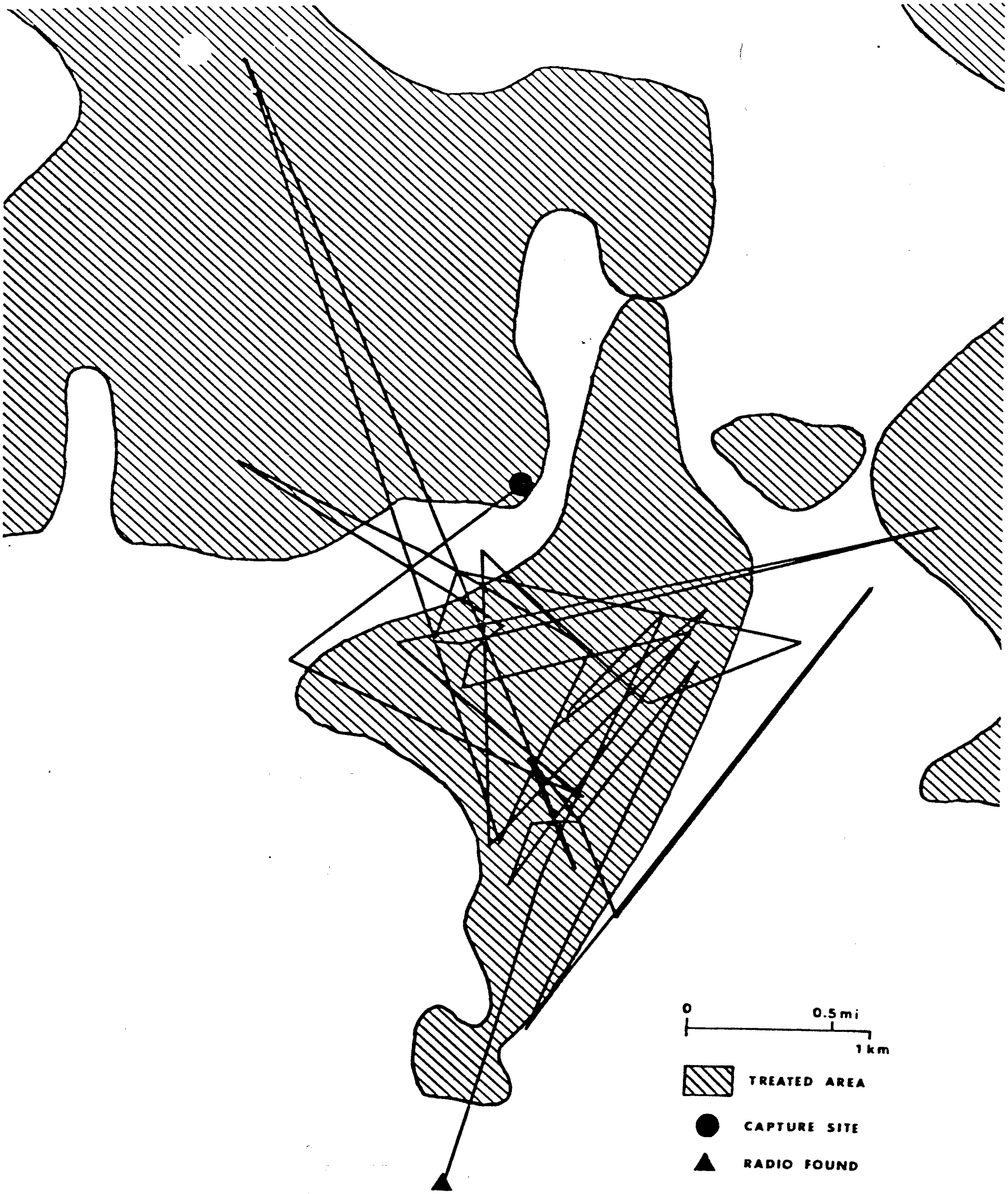

Fig. 50. Movements of 11E, an adult male badger. Tracked from 6/9 to 12/1/77. Radio found, alive and well last date tracked.

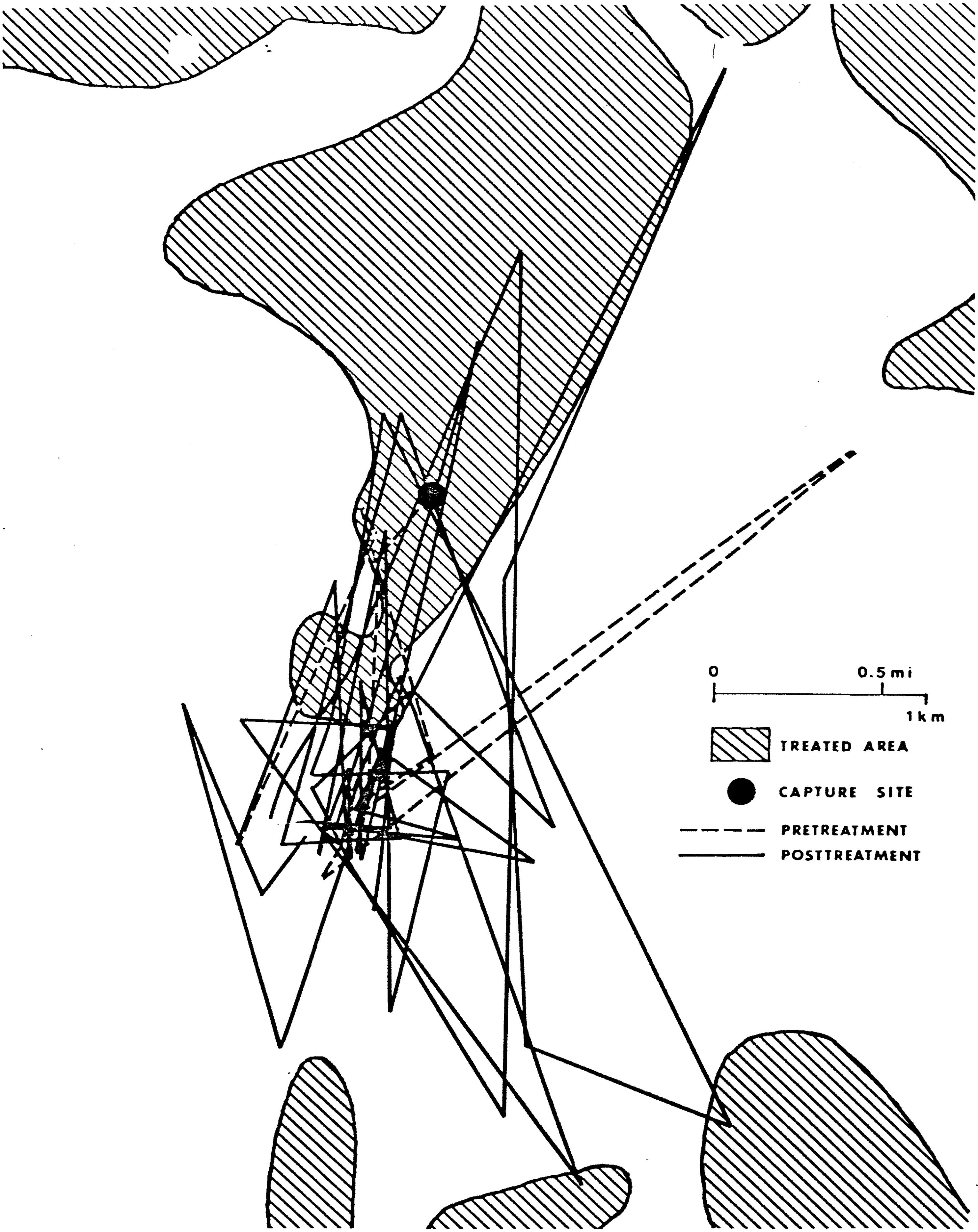

Fig. 51. Movements of 12B, an adult female raccoon. Tracked from 5/20/77 to 4/24/78. Alive and well last date tracked.

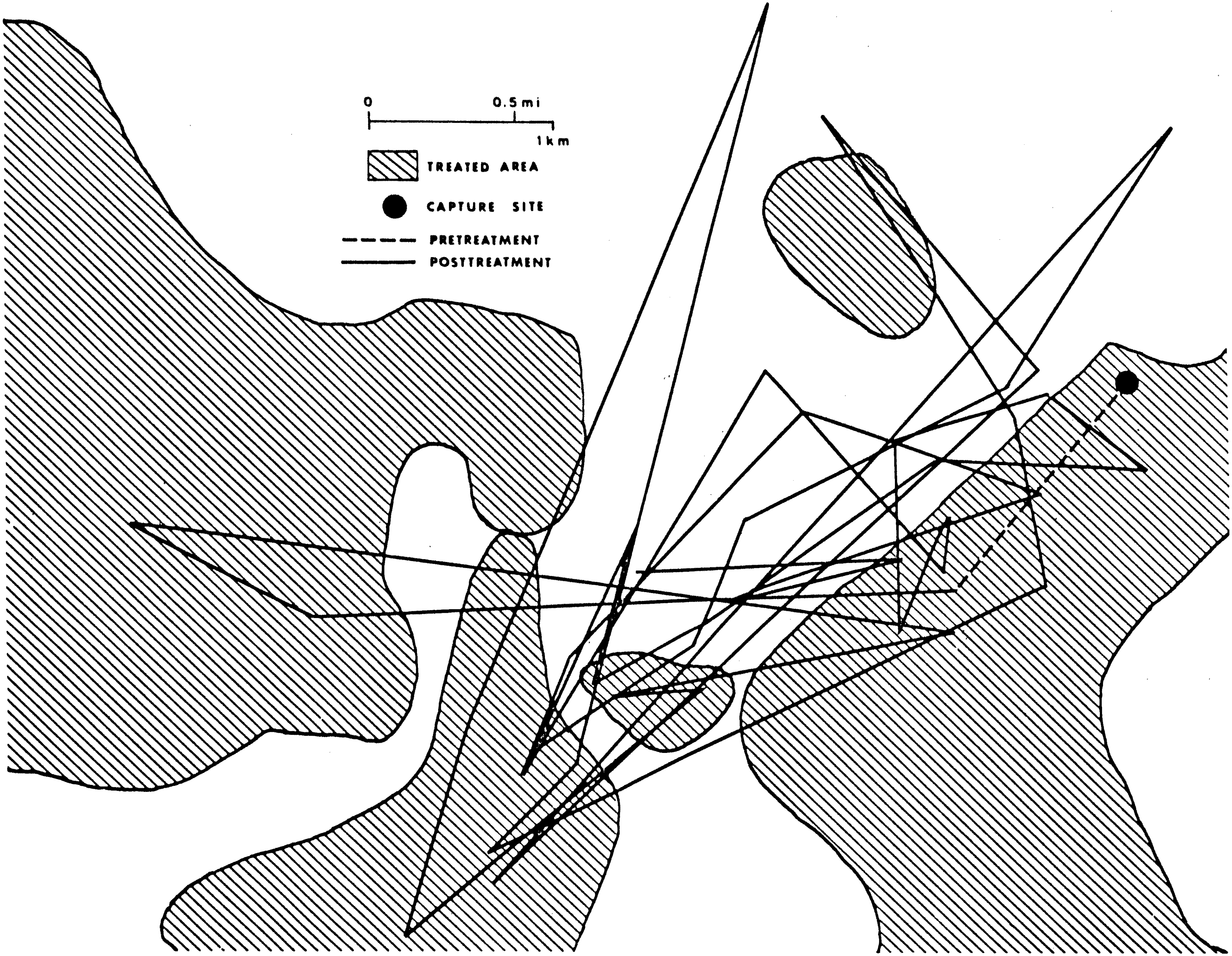

Fig. 52. Movements of 4D, an adult male raccoon. Tracked from 5/29 to 9/5/77. Lost contact, alive and well last date tracked.

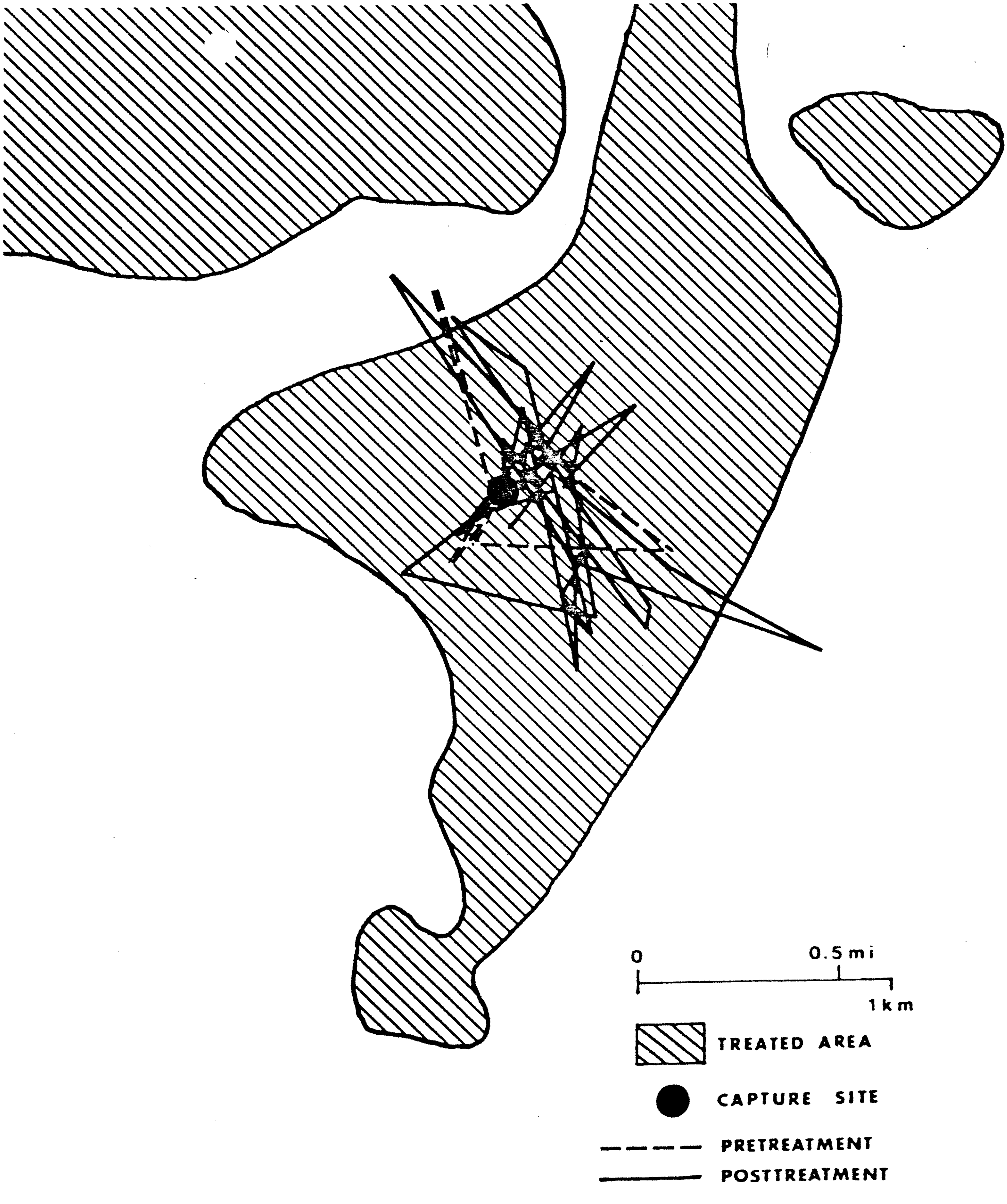

Fig. 53. Movements of 2C, an adult male red-tailed hawk. Tracked from 4/24 to 12/1/77. Lost contact--alive and well last date tracked.

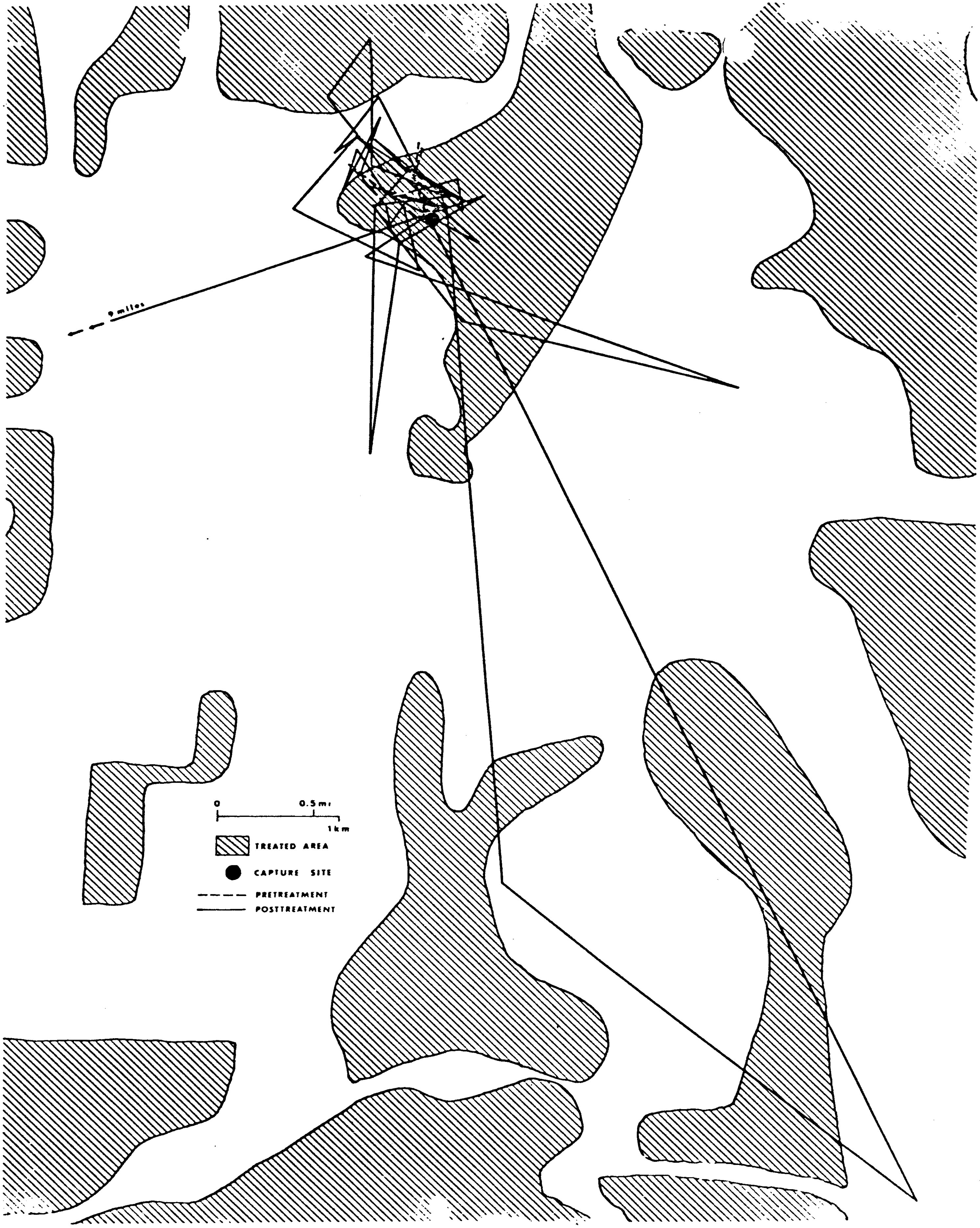

Fig. 54. Movements of 6D, an immature, red-tailed hawk. Tracked from 5/26 to 9/9/77. Lost contact--alive and well last date tracked.

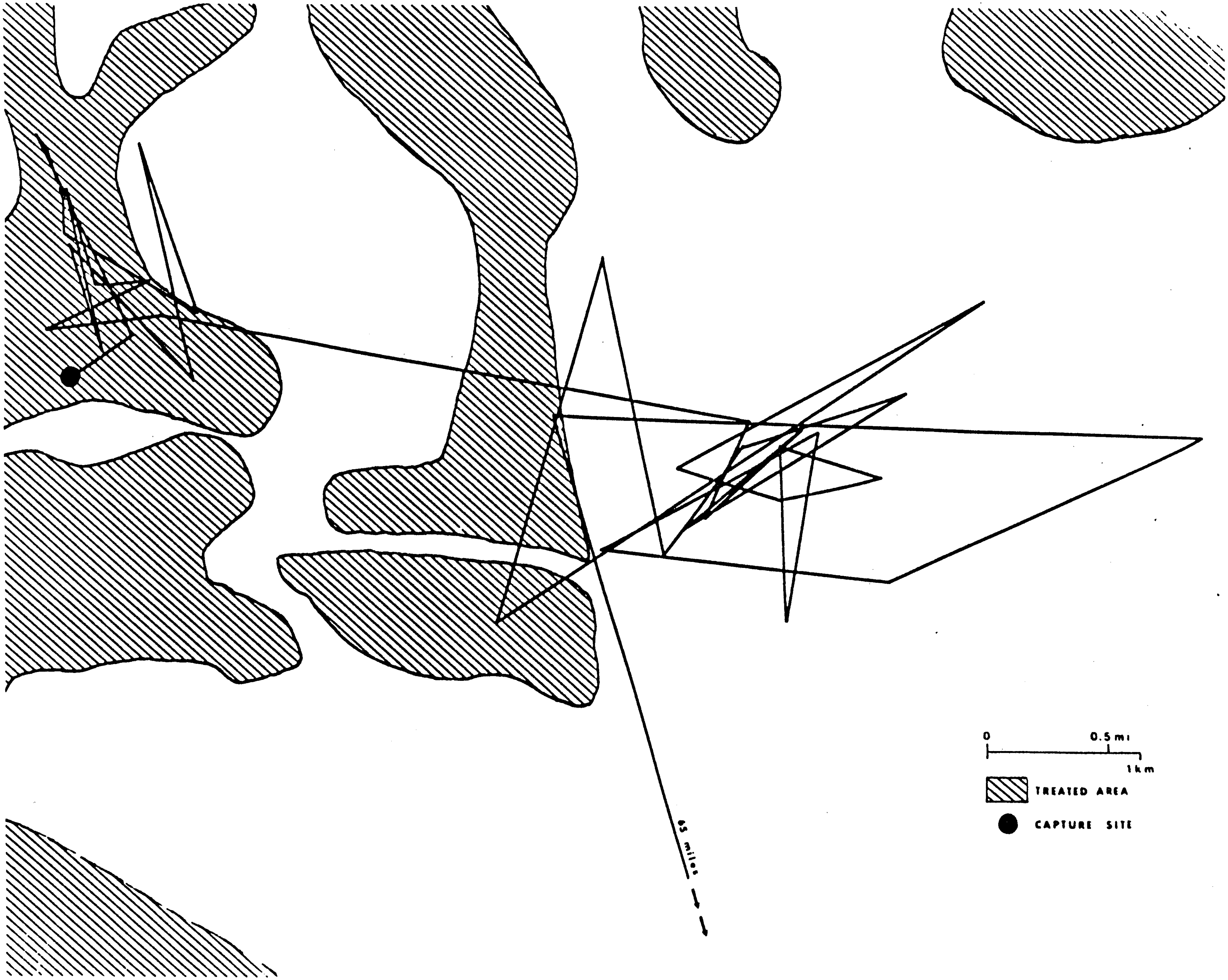

Fig. 55. Movements of 9C, an immature red-tailed hawk. Tracked from 6/10 to 8/19/77. Lost contact--alive and well last date tracked.

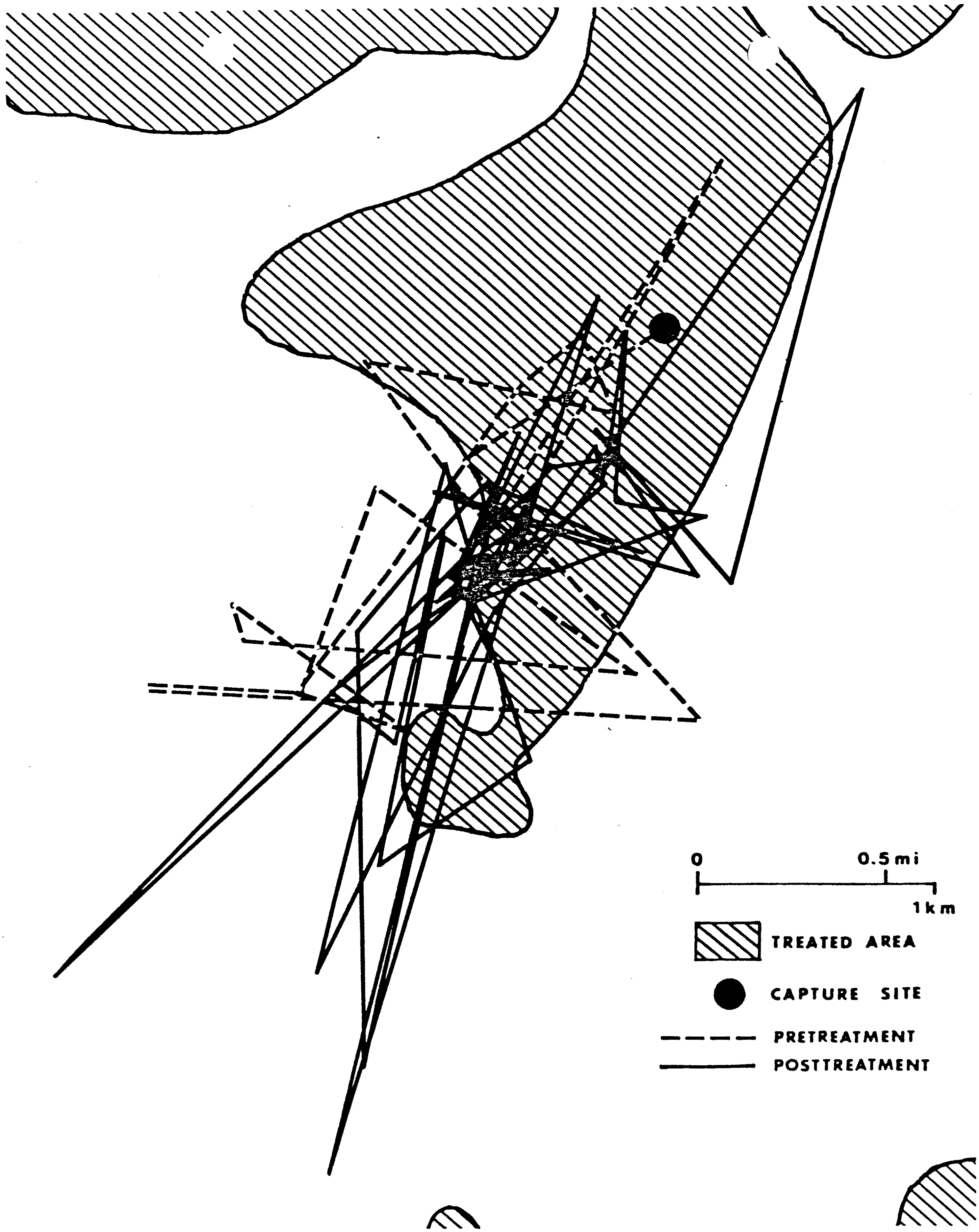

Fig. 56. Movements of 2E, an adult female great horned owl. Tracked from 5/8 to 8/21/77. Lost contact--alive and well last date tracked.

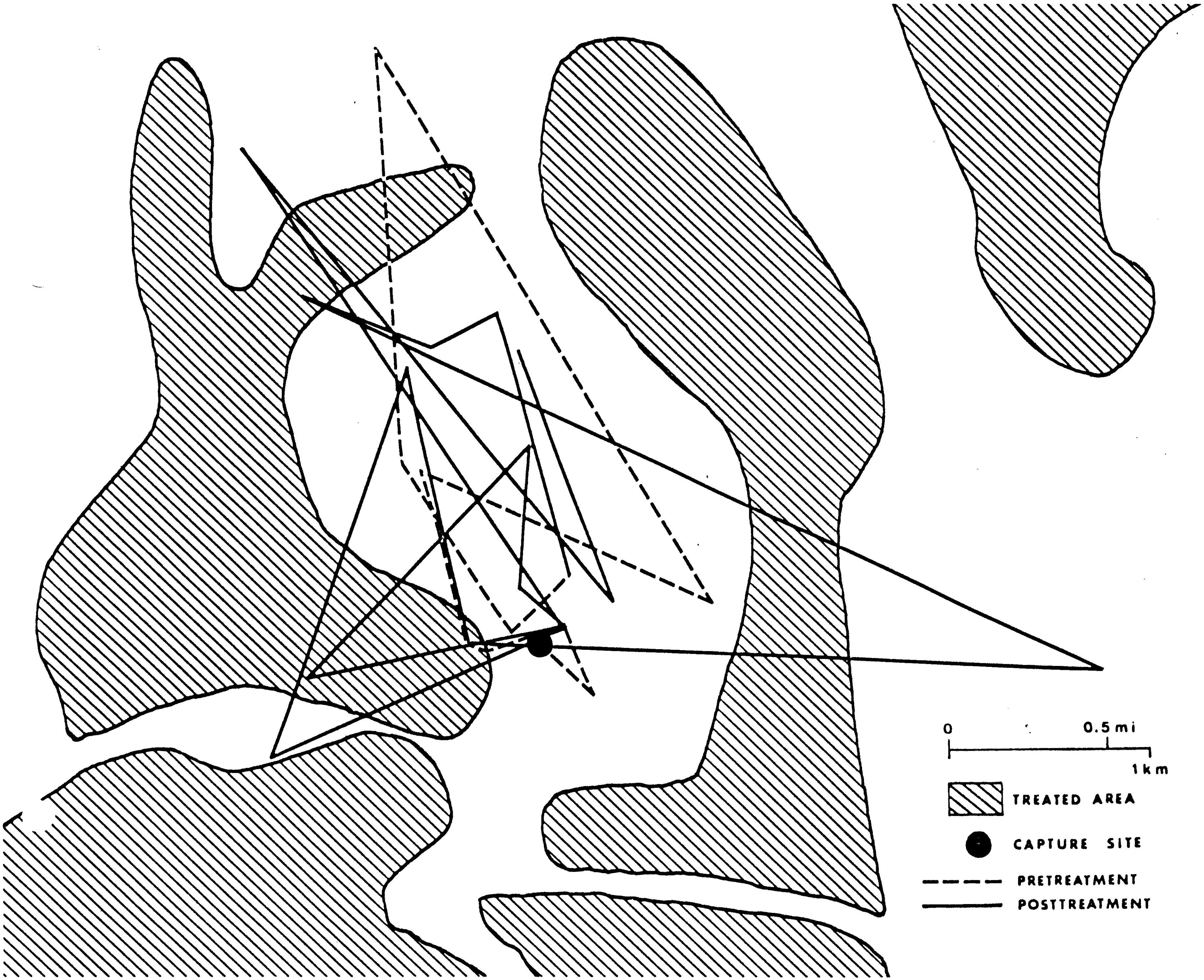

Fig. 57. Movements of 5B, an immature golden eagle. Tracked from 5/26 to 6/23/77. Lost contact--alive and well last date tracked.

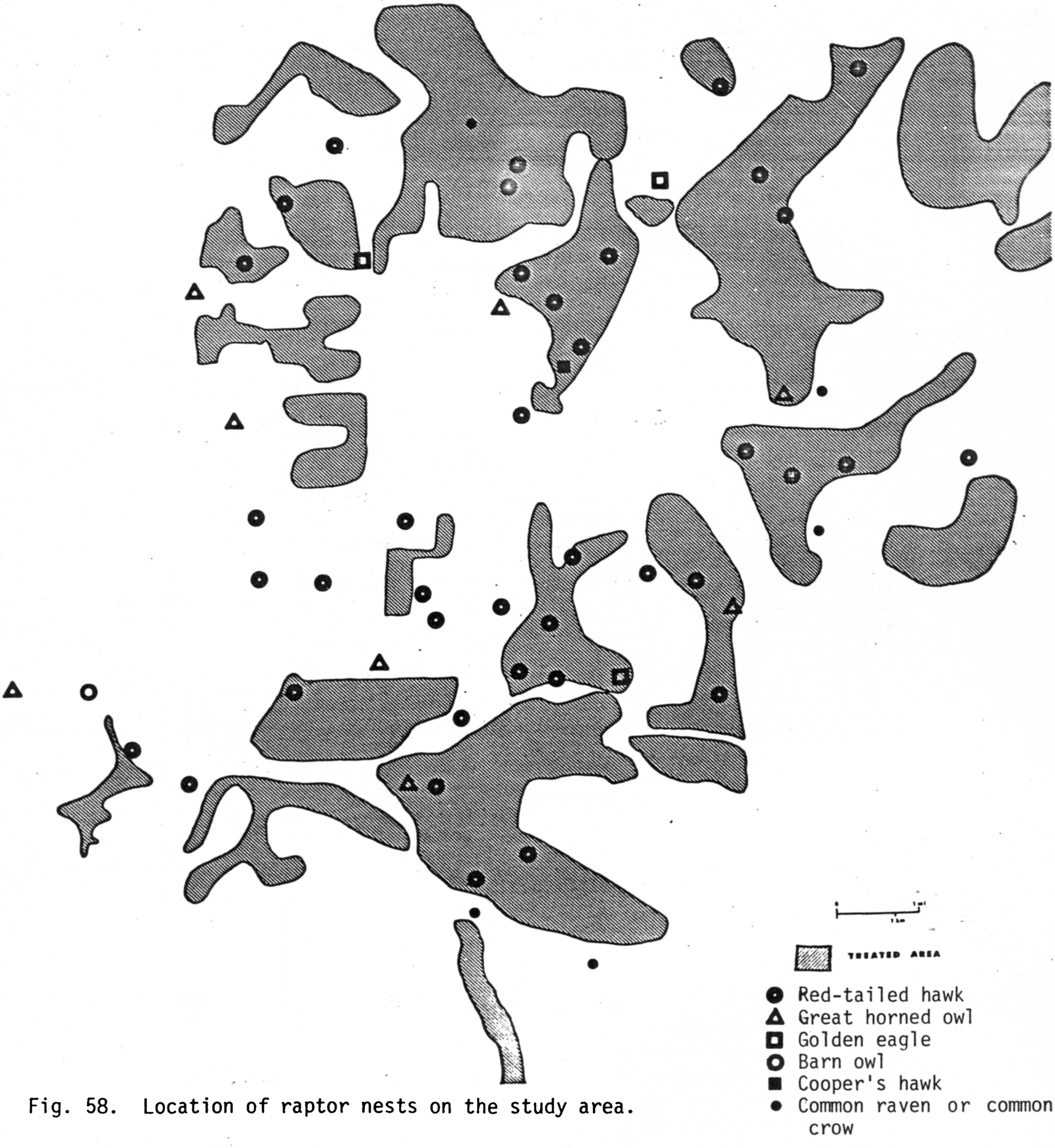

Fig. 58. Location of raptor nests on the study area.

SUMMARY OF ANALYTICAL METHOD FOR 1080

The 1080 analytical method used in this study was developed at the Denver Wildlife Research Center. Previously developed methods were not suitable because they lacked specificity or required large quantities of sample for adequate sensitivity. The method involved extraction of a 1-5 g sample with acetone, and cleanup of the sample extract with silica gel. Following dēsorption from the silica gel, the sample was cleaned up further by a micro distillation procedure. The volatilized fluoracetic acid was collected, then derivatized with pentafluorobenzyl bromide (α-bromo-2,3,4,5,6 - pentafluorotoluene) to form the pentofluorobenzyl ester. The ester is detectable in picogram quantities by electron capture gas chromatography, but the sensitivity of the method varies with the nature of the sample including type and freshness of the tissue. Two dissimilar columns, an OV-1 and QF-1, were used in the gas chromatographic analysis to ensure reliable qualitative identification. Recoveries of 1080 from fortified sample of stomach tissue from ground squirrels averaged 20% at levels ranging from 2 to 10 ppm.

Iwao Okuno
November 6, 1978

COMPOUND 1080 RODENT POISON GRAIN BAIT

POISON

Active Ingredient: Sodium Fluoroacetate .... .075%
Inert Ingredients: 99.925%

POISON

FIRST AID TREATMENT: If swallowed, immediately induce vomiting by giving a tablespoonful of salt in a glass of warm water and repeat until vomit fluid is clear. Then give two tablespoonfuls of Epsom salt in water. Have victim lie down and keep warm and quiet. Call a physician immediately.

WARNING: Harmful if swallowed. May cause secondary poisoning in other animals. Keep pets and domestic animals away from baited areas. Do not contaminate feed and foodstuffs. Spilled bait should be cleaned up immediately. Wash hands after using.

Keep Out of Reach of Children, Domestic Animals and Wildlife

(Over)

INSTRUCTIONS FOR USE: Possession of this bait material is unlawful. This poison bait shall be applied only under the supervision of the County Agricultural Commissioner in accordance with directions outlined in the Vertebrate Pest Control Handbook. See attached instructions for use on container in addition to label.

STATE REGISTRATION NO.: 11223 50022 AA E.P.A. Est. NO.: 11224-CA-1

Permit No.________________ Date Mixed:________________

Net Weight________________ lbs.

Prepared by Tulare County Agricultural Commissioner
Agricultural Bldg., Main & Woodland, Visalia, Calif. 93277

APPENDIX 2. LABEL FROM 1080 BAIT APPLIED ON THE STUDY AREA.

APPENDIX 3

List of birds observed in or near the study area. Period of observations: early February, mid-March to early October. Birds are classified during this period as A = Abundant, C = Common, U = Uncommon and R = Rare. They were not necessarily present during the entire period as some are migrants. Breeding status is also indicated: B = evidence of breeding, b = presumed breeding. This is not a complete listing of all species present. It only includes species identified during this study in 1977.

Occurrence	Breeding	Common Name	Scientific Name
U		Pied-billed grebe	Podilymbus podiceps
U		Great blue heron	Ardea herodias
R		Whistling swan	Olor columbianus
U	b	Mallard	Anas platyrhynchos
U		Green-winged teal	Anas carolinensis
U		Cinnamon teal	Anas cyanoptera
U		American wigeon	Anas americana
U		Lesser scaup	Aythya affinis
U		Common merganser	Mergus merganser
C	b	Turkey vulture	Cathartes aura
R		California condor	Gymnogys californianus
U	b	White-tailed kite	Elanus leucurus
U		Sharp-shinned hawk	Accipiter striatus
U	B	Cooper's hawk	Accipiter cooperii
C	B	Red-tailed hawk	Buteo jamaicensis
C	B	Golden eagle	Aquila chrysaetos
U		Bald eagle	Haliaeetus leucocephalus
U	b	Marsh hawk	Circus cyaneus
R		Osprey	Pandion haliaetus
U		Prairie falcon	Falco mexicanus
U	B	American kestrel	Falco sparverius
A	B	California quail	Lophortrx californicus
U		American coot	Fulica americana
C	B	Killdeer	Charadrius vociferous
U		Greater yellowlegs	Tringa melanoleucra
U		Common snipe	Capella gallinago
U		Ring-billed gull	Larus delawarensis
U		Band-tailed pigeon	Columba fasciata
A	B	Mourning dove	Zenaida macroura
U	b	Greater roadrunner	Geococcyx californianus
C	B	Barn owl	Tyto alba
C	b	Common screech owl	Otus asio
R		Flammulated owl	Otus flammeolus
C	B	Great horned owl	Bubo virginianus
U	b	Northern pygmy owl	Glaucidium gnoma
R		Burrowing owl	Speotyto cunicularia

APPENDIX 3, (Continued)

Occurrence	Breeding	Common Name	Scientific Name
R		Poorwill	Phalaenoptilus nuttallii
R		Black swift	Cypseloides niger
U		White-throated swift	Aeronautes saxatalis
C	b	Black-chinned hummingbird	Archilochus alexandri
C	b	Anna's hummingbird	Calypte anna
C		Rufous hummingbird	Selasphorus rufus
C	b	Common flicker	Colaptes auratus
A	B	Acorn woodpecker	Malanerpes formicivorus
R		Lewis' woodpecker	Melanerpes lewis
U	b	Hairy woodpecker	Picoides villosus
U	b	Downy woodpecker	Picoides pubescens
U	b	Nuttall's woodpecker	Picoides nuttallii
C	b	Western kingbird	Tyrannus verticalis
U	b	Ash-throated flycatcher	Myiarchus cinerascens
C	b	Black phoebe	Sayornis nigricans
U		Say's phoebe	Sayornis saya
U		Western flycatcher	Empidonax difficilis
U		Western wood pewee	Contopus sordidulus
U	b	Horned lark	Eremophila alpestris
U		Violet-green swallow	Tachycineta thalassina
U		Tree swallow	Iridoprocne bicolor
U		Rough-winged swallow	Stelgidopteryx ruficollis
C		Barn swallow	Hirundo rustica
C	B	Cliff swallow	Petrochelidon pyrrhonota
U		Stellar's jay	Cyanocitta stelleri
C	b	Scrub jay	Aphelocoma coerulescens
C	B	Common raven	Corvus corax
C	B	Common crow	Corvus brachyrhynchos
C	b	Plain titmouse	Parus inornatus
C	b	Bushtit	Psaltriparus minimus
U	b	White-breasted nuthatch	Sitta carolinensis
U	b	Wrentit	Chamaea fasciata
C	b	House wren	Troglodytes aedon
U	b	Bewicks' wren	Thryomanes bewickii
C	b	Canyon wren	Catherpes mexicanus
U	B	Rock wren	Salpinctes obsoletus
U	b	Mockingbird	Mimus polyglottos
R		California thrasher	Toxostoma redivivum
R		Sage thrasher	Oreoscoptes montanus
U	b	American robin	Turdus migratorius
C	B	Western bluebird	Sialia mexicana
U		Mountain bluebird	Sialia currucoides
U		Blue-gray gnatcatcher	Polioptila caerulea
U		Ruby-crowned kinglet	Regulus calendula
U		Water pipit	Anthus spinoletta

Occurrence	Breeding	Common Name[1]	Scientific Name[1]
U		Cedar waxwing	Bombycilla cedrorum
C	b	Phainopepla	Phainopepla nitens
U	B	Loggerhead shrike	Lanius ludovicianus
C	B	Starling	Sturnus vulgaris
C		Yellow warbler	Dendroica petechia
C		Yellow-rumped warbler	Dendroica coronata
U		Black-throated gray warbler	Dendroica nigrescens
U		Townsend's warbler	Dendroica townsendi
R		Hermit warbler	Dendroica occidentalis
U		MacGillivray's warbler	Oporornis tolmiei
C		Common yellowthroat	Geothlypis trichas
U		Wilson's warbler	Wilsonia pusilla
C	B	House sparrow	Passer domesticus
U	b	Western meadowlark	Sternella neglecta
U	B	Red-winged blackbird	Agelaius phoeniceus
R		Tri-colored blackbird	Agelaius tricolor
U	b	Northern oriole	Icterus galbula
C	b	Brewer's blackbird	Euphagus cyanocephalus
U		Brown-headed cowbird	Molothrus ater
U		Western tanager	Piranga ludoviciana
U		Black-headed grosbeak	Phencticus melanocephalus
C	B	House finch	Carpodacus mexicanus
U		American goldfinch	Spinus tristis
U	b	Lesser goldfinch	Spinus psaltria
R		Lawrence's goldfinch	Spinus lawrencei
R		Green-tailed towhee	Chlorura chlorura
U		Rufous-sided towhee	Pipilo erythrophthalmus
C	b	Brown towhee	Pipilo fuscus
C	b	Lark sparrow	Chondestres grammacus
R		Rufus-crowned sparrow	Aimophila ruficeps
U		Dark-eyed junco	Junco hyemalis
C		White-crowned sparrow	Zonotrichia leucophrys
C		Golden-crowned sparrow	Zonotrichia atricapilla

[1] Reference:

American Ornithologists' Union. 1957. Check-list of North American Birds, 5th ed. American Ornithologists' Union. Baltimore, Maryland. 691 pp. (Plus supplement

APPENDIX 4

List of mammals observed in or near the study area. Period of observation: early February, mid-March to early October. Mammals are classified as: A = Abundant, C = Common, U = Uncommon and R = Rare. This is not a complete listing of all species present. It only includes species identified during this study in 1977.

Occurrence	Common Name[1]	Scientific Name[1]
U	Opossum	Didelphis marsupialus
A	Bat	Myotis spp.
A	Cottontail rabbit	Sylvilagus audubonii
U	Black-tailed jackrabbit	Lepus californicus
A	California ground squirrel	Spermophilus beecheyi fisheri
A	Botta pocket gopher	Thomomys bottae
C	Little pocket mouse	Perognathus longimembris
C	Heerman's kangaroo rat	Dipodomys heermanni
U	Western harvest mouse	Reithrodontomys megalotis
A	Deermouse	Peromyscus spp.
C	Desert wood rat	Neotoma lepida
C	Coyote	Canis latrans
R	San Joaquin kit fox	Vulpes macrotis mutica
U	Gray fox	Urocyon cinereoargenteus
U	Black bear	Ursus americanus
R	Ring-tailed cat	Bassariscus astutus
C	Raccoon	Procyon lotor
C	Badger	Taxidea taxus
C	Striped skunk	Mephitis mephitis
R	Mountain lion	Felis concolor
C	Bobcat	Lynx rufus
U	Pig (feral)	Sus scrofa
C	Mule deer	Odocoileus hemionus

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[1] Reference:

Hall, E. R. and K. R. Kelson. 1959. The mammals of North America. Ronald Press Co. New York. Vol. I and II. 1083 pp.

Ingles, L. G. 1965. Mammals of the Pacific states. Stanford Univ. Press. California. 506 pp.

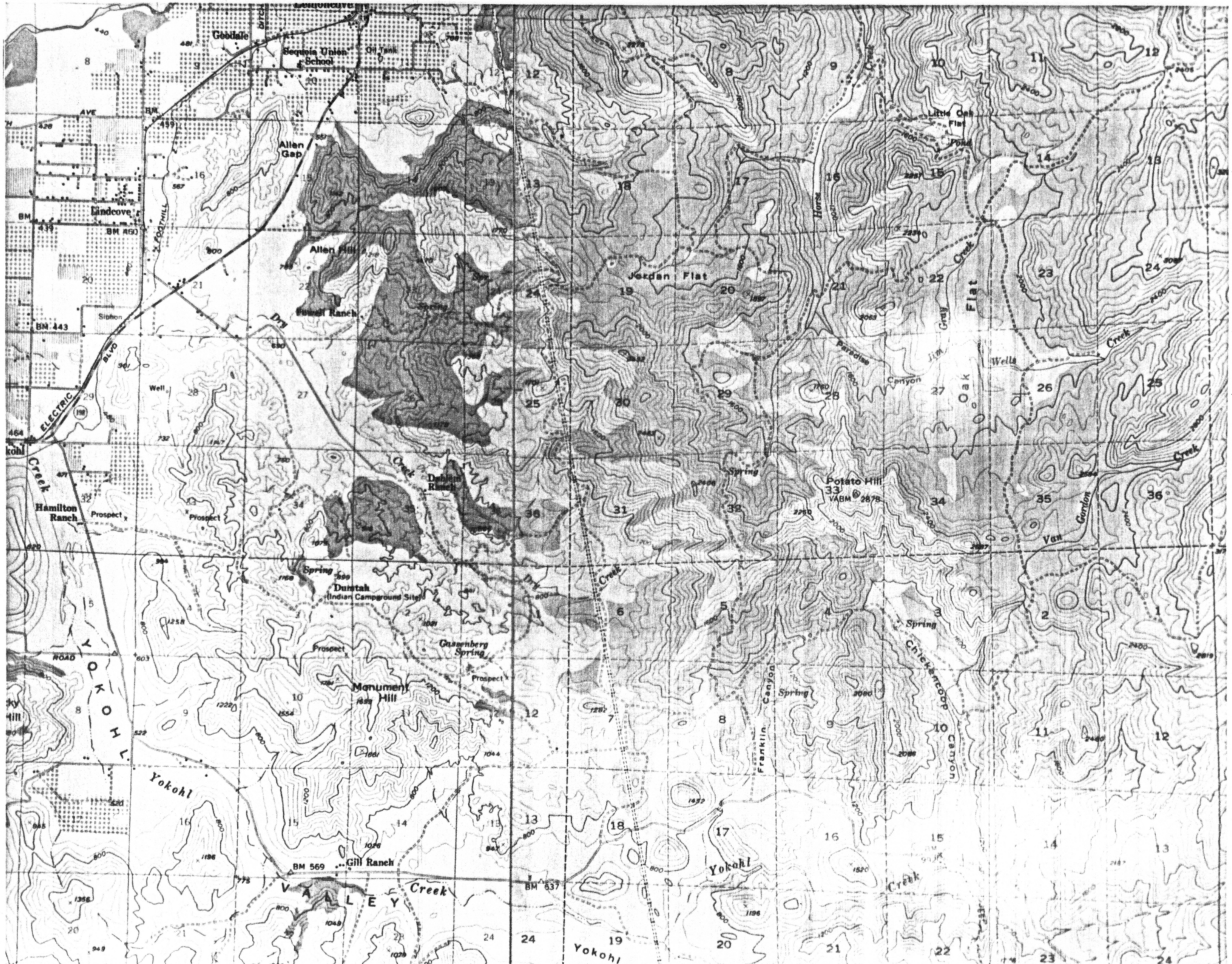
APPENDIX 5

List of reptiles and amphibians observed in the study area. Period of study: early February, mid-March to early October. These animals are classified as: A = Abundant, C = Common, U = Uncommon and R = Rare. This is not a complete listing of all species present. It only includes species identified during this study in 1977.

Occurrence	Common Name[1]	Scientific Name[1]
U	California slender salamander	Batrachoseps attenuatus
U	Pacific treefrog	Hyla regilla
C	Bullfrog	Rana catesbeiana
C	Western pond turtle	Clemmys marmorata
A	Western fence lizard	Sceloporus occidentalis
C	Gilbert's skink	Eumeces gilberti
R	Pacific rubber boa	Charina bottae bottae
U	California striped racer	Masticophis lateralis lateralis
C	Pacific gopher snake	Pituophis malanoleucus cantifer
U	California kingsnake	Lampropeltis getulus californiae
C	Western terrestrial garter snake	Thamnophis elegans
C	Western aquatic garter snake	Thamnophis couchi
C	Northern pacific rattlesnake	Crotalus viridis oreganus

[1] Reference:

Stebbins, R. C. 1966. A field guide to western reptiles and amphibians. Houghton Mifflin Co. Boston. 279 pp.



Appendix 6. Topography of the general study area.