A Radiotelemetric Study of Home Range Size and Dispersal of the Marsh Rice Rat (*Oryzomys palustris*) in Southern Illinois: Progress Report

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The marsh rice rat (*Oryzomys palustris*) is of special interest in Illinois where it has been listed as a threatened species (Illinois Administrative Code, Title 17, Chapter I, subchapter c, part 1010.30, as amended 17 March 1989). Southern Illinois lies at the northern edge of the rice rat's range (Wolfe 1982) and, accordingly, this species has a restricted distribution within the state. Recent records for rice rats have been collected in only 11 of the southernmost counties in the state (Hofmann et al. 1990; Illinois Natural Heritage Database). Rice rats are also relatively uncommon in Illinois because they are dependent upon wetland habitats (Wolfe 1982); many southern Illinois wetlands have been lost to agriculture and development and the remaining wetlands are under continuing threat. Information about the life history and behavior of the rice rat is essential for its protection. This species is common throughout much of its range and has been the subject of several laboratory and field studies (Wolfe 1982). The only comprehensive ecological study of the rice rat, however, was conducted in a sedge-shrub community on the coastal dunes of Breton Island, Louisiana (Negus et al. 1961).

This study was designed to collect data on the ecology and behavior of rice rats in the emergent herbaceous wetlands of southern Illinois by means of radiotelemetry. One of the primary objectives was to determine home range sizes. Negus et al. (1961) found that males and females had mean home ranges of 0.33 ha (0.81 a) and 0.21 ha (0.51 a), respectively. In Florida, however, the mean home range of males (0.23 ha [0.56 a]) was slightly smaller than that of females (0.29 ha [0.72 a]; Birkenholz 1963). In a Maryland tidal marsh, the maximum distance between capture points for six rice rats trapped at least three times averaged 74.2 m (245 ft; Harris 1953); this information suggests that home range sizes were less than 0.4 ha (1.0 a). The second major objective was to investigate dispersal patterns. Dispersing individuals can move either short distances, establishing residency in unoccupied portions of the same habitat patch, or long distances, emigrating from one area and perhaps encountering another patch of suitable habitat. Adults may shift their home ranges, but dispersal is commonly associated with subadults leaving their birthplaces to establish their own home ranges or territories. Through dispersal, the area occupied by a population increases, previously unoccupied localities are colonized, and localities where populations have been extirpated are recolonized. There is little information on movements by rice rats. In Louisiana, two male rice rats moved 600 m and 300 m (2000 and 1000 ft) from their original home ranges (Negus et al. 1961). Seasonal movements of rice rats were documented in the Everglades where animals occupied hummocks during the wet season, but moved to low-lying mesic areas during the dry season (Smith and Vrieze 1979). The present study was designed to monitor home range shifts, dispersal of subadults, distances moved, use of travel corridors, and possible barriers to dispersal.

Because the small size and nocturnal habits of many mammals make direct observations of recognizable individuals difficult, indirect methods are used to monitor their space use and movement patterns. Long-term live-trapping studies can provide information on many individuals, but the information is not as precise as that obtained by radiotelemetry. Trapping may result in a few captures of an individual that provide locations from which home ranges and movements could be calculated; with radiotelemetry numerous readings of an animal's location can be taken at frequent time intervals. The placement of traps at fixed positions also limits the locations at which an animal can be recorded; with radiotelemetry any location visited by a free-ranging individual can be determined. Radiotelemetry has been used to study home range sizes, spatial relationships, nesting behavior, and dispersal of many rodents including Belding's ground squirrel (*Spermophilus beldingi*, Holekamp 1984), Merriam's kangaroo rat (*Dipodomys merriami*, Behrends et al. 1986), desert wood rat (*Neotoma lepida*, Thompson 1982), hispid cotton rat (*Sigmodon hispidus*, Cameron and Spencer 1985), prairie vole (*Microtus ochrogaster*, Hofmann et al. 1984), and meadow vole (*M. pennsylvanicus*; Webster and Brooks 1981, Madison et al. 1984, McShea and Madison 1984, Sherman 1984).

In addition to meeting the primary objectives of this study, radiotelemetry would make it possible to obtain incidental information about other aspects of the rice rat's life history. Nests can be located by determining the position of individuals during periods of inactivity. It was hoped that locating the nests of reproductively active females might provide information about litter size, length of the breeding season, and number of litters per year. Radiotelemetry can also shed light on daily activity patterns, mortality, and spatial and social relationships among individuals.

This report summarizes the results of radiocollaring rice rats at a wetland complex in southern Illinois during the summer of 1991. Because the effort was not entirely successful, possible flaws in the procedure are discussed and suggestions for future research are presented.

Study Area, Equipment, and Methods

This study was conducted at an expansive wetland complex located 5 km west of Harrisburg in Section 13, T9S, R5E in Saline County, Illinois (Figure 1). This area, where the hydrology had been altered through subsidence caused by underground mining, consists of open water interspersed with emergent, scrub-shrub, and forested wetlands. Portions of the complex were coded by the National Wetland Inventory (U.S. Fish and Wildlife Service, U.S. Department of the Interior; Figure 1) as PUBGh (diked/impounded pond), PUBGx (excavated pond), PEMA (temporarily flooded palustrine emergent wetland), PEMC (seasonally flooded palustrine emergent wetland), PSS1A (temporarily flooded broad-leaved deciduous scrub-shrub wetland), PSS1F (semipermanent broad-leaved deciduous scrub-shrub wetland), PFO1A (temporarily flooded broad-leaved deciduous forested wetland), and L1UBH (lake). The emergent wetland areas have a dense cover of common reed (*Phragmites australis*) and narrow-leaved cattail (*Typha angustifolia*). Illinois Route 13, a two-lane highway, runs through the complex and the wetlands are surrounded by residential areas, cropland, and abandoned cropland owned by Sahara Coal Company (Figure 2). This area was selected because of its large size, the presence of permanent standing water, and the existence of a large rice rat population. Live-trapping by the Illinois Natural History Survey during April 1987 and May 1988 had revealed that rice rats were abundant in emergent wetlands at this site, although by May 1990 their numbers had declined (Hofmann et al. 1990; Hofmann, unpublished data).

Rice rats were captured in Sherman live traps (8 x 9 x 23 cm) baited with a mixture of rolled oats and peanut butter. Traps were placed at approximately 10-m intervals in portions of the wetland complex where there was a dense cover of emergent herbaceous vegetation (Figure 2). Fifty traps were set along the edge of the large pond south of Route 13 (trapline A) and 26 were set along the south shore of the lake north of Route 13 (trapline C). A total of 50 traps was placed on both sides of Route 13 - 24 along the top of a roadside drainage ditch on the south side of the highway and 26 at the base of the highway embankment on the north side (trapline B). Traps were set during late afternoon on 4 June 1991 and checked early the following morning. The location, sex, reproductive condition, and weight (to the nearest gram) of each captured rice rat was recorded. The position of the testes (descended into the scrotum or abdominal) was used as a general indicator of male reproductive condition. Females were examined for signs of reproductive activity such as a perforate vagina, pregnancy (determined by palpation of the abdomen), or lactation (determined by inspection of the teats). Animals selected for radiocollaring (subadults or adults; only females who were not pregnant or lactating) were placed in wire mesh cages (22 x 22 x 37 cm) or back in the Sherman traps for transport to an abandoned farm shed just south of the wetland complex (Figure 2). Other animals were marked (small individuals had one toe clipped and larger individuals were fitted with numbered plastic collars) and released after the data had been recorded.

Rice rats were anesthetized by inhalation of Metofane (Methoxyflurane; Pittman-Moore); exposure to the vapor for 1 to 1.5 min induced anesthesia. Each animal was weighed to the nearest 0.1 gram on an Ohaus balance. Model MD-2 transmitters (Holohil Systems, Ltd., Woodlawn, Ontario, Canada), each emitting a unique frequency between 172.0 and 173.0 MHz, were attached to the animals with wire collars. These transmitters were connected to temperature sensing devices that monitor changes in body temperature and were covered with a waterproof coating. A wire whip antenna covered with plastic shielding extended approximately 8 cm from the collar. The batteries in the transmitter packages had an expected lifespan of four to six months. The average weight of the radiocollars was 3.95 g (range: 3.85 to 4.11 g). While the animals were still under anesthesia, one toe was clipped for permanent identification. Handling time for each individual was 5 min or less. The rice rats were then placed back in the cages or traps; after they had recovered completely from anesthesia, they were released at the trap stations where they had been captured.

Tracking was done with model TRX-1000S multi-channel receivers with a frequency range of 172.0 to 173.0 MHz (Wildlife Materials, Inc., Carbondale, Illinois) and series F172-3FB three-element Yagi antennas (AF Antronics, Inc., White Heath, Illinois).

At night, compass bearings (azimuth readings) were taken simultaneously (at half-hour intervals) by two observers (or teams of observers) at known positions. During the day, when rice rats are known to be inactive (Wolfe 1982), the radio signals were followed to find nest sites. Radiotracking was originally scheduled for three or four consecutive nights at six- or seven-week intervals over a six-month period.

The micro-computer software package TELEMPC (University of Missouri, Columbia) was used to determine the animals' locations from the sets of compass bearings and calculate home range polygons by the convex polygon, capture radius, non-circular, modified minimum area, and percent home range methods. The program was instructed to calculate locations for pairs of bearings separated by no more than 5 min and no less than 10°. Error polygons for each location were incorporated into the program and bogus readings were discarded.

Results

Trapping results for the morning of 5 June are presented in Table 1. Only one rice rat was caught in the 50 traps in line A; this species was much more abundant along the highway (trapline B) and the lake shore (trapline C). Eleven rice rats captured along line B and five from line C were kept as potential subjects for radiocollaring. Two of these individuals, both males, died after they had been collared and one animal escaped from the shed. Twelve individuals were successfully collared and released. The capture location, sex, reproductive condition, and weight of each of these rice rats are listed in Table 2; the capture locations are in Figures 3 - 14.

All collared rice rats were radiotracked on the nights of 5 and 6 June, 1991. On both nights, bearings for the four animals along the lake were taken by teams at two fixed locations. On 5 June the teams were in canoes at two stations on the lake marked by buoys (stations 3 and 4); the next night one team was at station 3, while the other team took bearings from the point of land that extends into the lake (station 5). On 5 June the positions of animals along Route 13 were determined by two trackers walking along the roadsides and triangulating in relation to the numbered stations along trapline B. The next night two fixed locations were used - one adjacent to the highway (station 2) and the other on top of a mound of subsoil created by the coal company (station 1). Locations of these five fixed monitoring stations are shown in Figure 2.

On the morning of 7 June the signals from the four animals south of the highway were followed to their origins. Female P151 was underground near station B7, while animals P250, P289 and P090 were all in the vicinity of B10. These locations and the original trapping locations were used in home range determinations together with the bearings taken during the two nights of radiotracking. Home ranges of the other animals were derived from original trapping locations and the bearings from 5 and 6 June.

Radiotracking was resumed on the nights of 15 and 16 July, but these bearings were not used in home range determinations. Daytime tracking on 17 July revealed that most of the animals had died or shed their collars. Nine of the 12 collars were recovered; five of these were found with skeletal remains. The "fate" of each of the collared rice rats is summarized in Table 3.

The mean home range size (± 1 SE), calculated by the convex polygon method, for 11 individuals was 0.73 ± 0.19 ha. These home ranges were derived from a minimum of five locations for each animal. Sizes varied greatly, from a minimum of 0.04 ha to a maximum of 1.63 ha. The home ranges of seven males averaged 0.68 ± 0.25 ha and those of four females 0.82 ± 0.38 ha. Given the large confidence limits (partly the result of small sample sizes), the difference between the mean home range sizes for males and females is not statistically significant. The home range size of each individual is listed in Table 4 along with the number of fixes (compass bearings or known positions) and the number of locations generated by the TELEMPC program. The locations for each individual are superimposed on the cover type map of the study area in Figures 3 - 13.

The TELEMPC program calculated an index of diversity for the shape of convex home ranges where 1.0 indicated a circular range. The home ranges for the four individuals on the south side of Route 13, where part of the wetland was a narrow linear strip of habitat, deviated more from circularity ($x = 1.91 \pm 0.23$, $n = 4$) than did those on the north side of the highway or along the lake shore ($x = 1.32 \pm 0.05$, $n = 7$) where the configuration of the habitat was not limiting.

Two of the rice rats captured along the lake, female P049 and male P171, spent time on the opposite side of Route 13, although most of the locations for these two individuals were, in fact, between the lake shore and the highway. Of the six locations calculated for P049 from radiotracking bearings, five were on the north side of the highway and one was on the south side (Figure 11). Within an hour on the night of 6 June this female apparently travelled approximately 60 m from a location just north of the highway to the south side of the highway and 180 m back up to the shore of the lake. For male P171 there were seven radiotracking locations between the lake shore and the highway and three on the opposite side of the highway (Figure 10). He was on the south side of the highway for the first three readings on 6 June and then returned to the north side. It can't be determined if these animals crossed the highway or swam through a culvert under the highway.

The transmitter package from female P151 and her skeletal remains were found in a surface nest 2 m west of station B7 and 2 m from the water's edge on the roadside between the highway and the ditch (Figure 4). The nest was a globular mass of finely-shredded plant material measuring 28 x 35 cm; it was covered with 30 to 35 cm of vegetation. This was the first rice rat nest to be described in Illinois. The collar from male P250 was recovered from a burrow system 3.5 m east of station B10 on the bank of the roadside ditch (Figure 3). The burrow opening found by tracking the radio signal measured 4 cm high x 5 cm wide. Excavation of this burrow revealed that several other underground burrows and chambers were connected to it. The burrow system must have had at least one underwater entrance because the collar slipped into the water during excavation.

Most collars were found in the vicinity of the trap stations where the rice rats had been captured originally, but two collars were found at relatively long distances from the animals' original locations (Figures 6 and 14). On 17 July male P090 was found dead in a dry patch of common reed in the abandoned cropland south of the wetland complex, approximately 310 m from the trap station where he had been captured on 5 June. The remains were found in what appeared to be a rudimentary surface nest so it is unlikely that the rice rat was dropped there by a predator. The transmitter package of female P070 was found on the north shore of the lake at a distance of approximately 600 m from her capture site. Because P070 may have dispersed within two days of being collared, a home range was not calculated for this individual. Both P090 and P070 had been caught along Route 13 and each remained on the same side of the highway during dispersal.

Discussion

The mean home range for rice rats determined during this study (0.73 ha) was much larger than those previously reported (weighted mean for males and females = 0.29 ha, Negus et al. 1961; 0.25 ha, Birkenholz 1963). Earlier results were based solely on grid trapping which sometimes underestimates home range size (Bergstrom 1988, Desy et al. 1989). Geographical location may also be a factor. The previous studies were conducted in a sedge-shrub community on Breton Island, Louisiana (Negus et al. 1961) and a marshy pasture near Gainesville, Florida (Birkenholz 1963). It is possible that these more southerly sites were richer in food resources and that smaller areas were, therefore, able to support rice rats.

The home range sizes reported here, calculated by the convex polygon method, may also underestimate the area used by the radiocollared rice rats. First, the home range sizes for 11 individuals were calculated from a small number of locations (n = 82) obtained during only two consecutive nights of radiotracking. There is a consensus among researchers using radiotelemetry that a larger number of locations is necessary to define a home range precisely. More locations from additional nights might have revealed that these rice rats used areas that they had not visited during the first two nights and had larger home ranges than shown in Table 3. It is also possible, however, that some of the outlying locations obtained during the first two nights were one-time excursions and that the area consistently used by an individual was smaller than the home range size calculated by the convex polygon method.

Second, the convex polygon method (also known as the minimum area method) is more conservative than the capture radius and non-circular methods that are also used by the TELEMPC program. For example, the home range calculated for animal P250 was 0.25 ha by the convex polygon method, 1.06 ha by the non-circular method, and 2.28 ha by the capture radius method. The capture radius is defined as the average distance from locations to the geometric center of activity; the home range area is calculated by using this value as the radius of a circular range. Rice rats did not exhibit a high degree of circularity in this study and it was felt that the capture radius method overestimated the area actually used by the animals. The non-circular method does not assume that the distribution of locations is circular and generates ellipses to indicate the regions of most intense utilization. This method has little bias due to either sample size or the assumption of circularity and represents linear home ranges fairly well. Therefore, the convex polygon method represents the minimum area used by an individual whereas the non-circular method may better represent the total area over which an individual travels during its normal activity. Because there were so few locations from which to determine regions of most intense use in this study, only home ranges sizes calculated by the convex polygon method were reported.

Two individuals in this study had extremely small ranges (0.04 and 0.05 ha; Table 3), but their lack of movement could have been an artifact of radiocollaring. The calculated home ranges for the other nine animals were all at least 0.1 ha (Table 3) which may represent the minimum amount of habitat needed to support a resident rice rat. In a previous study most rice rats in southern Illinois were captured in wetland areas larger than 0.1 ha, although some were found in a wetland patch estimated to be as small as 0.03 ha (Hofmann et al. 1990). Individuals in very small patches of habitat (< 0.1 ha) could be dispersers or "floaters" on the periphery of a core population in a larger wetland.

Because many southern Illinois wetlands have been lost to agriculture and development, remaining wetlands are often more isolated. Many of these wetlands are small areas which cannot support large populations of rice rats; accordingly, many individuals may need to disperse to find suitable habitat. Rice rats are apparently capable of traveling relatively long distances over a period of several days. In this study, two individuals, a male and female, had traveled approximately 310 and 600 m, respectively, from their original capture locations before dying or shedding the radiocollar. In comparison, the mean maximum distance between locations used to determine 11 home ranges was 115.7 m (SE = 36.6). In Louisiana two adult males were recaptured after several months approximately 300 and 600 m from their original capture locations (Negus et al. 1961). Additional information about the behavior of dispersers would be valuable and might indicate how important travel corridors connecting wetlands are for an increase in rice rat numbers and distribution in Illinois.

Although the plan had been to radiotrack the 12 rice rats over a six-month period (June - November), the project was suspended in July. Within six weeks, four individuals had shed their collars, five had died (the skeletal remains of five animals were found with their transmitter packages on 17 July), and one transmitter had apparently failed. Rather than endanger any more rice rats, no additional animals were fitted with radiocollars during 1991. Although rice rats have a relatively short life expectancy in the wild (longevity in Louisiana was estimated to be seven months; Negus et al. 1961), it seems unlikely that five collared individuals would have died from natural causes within the same short time span. Mortality could be explained by one or a combination of the following factors.

(1). Anesthetization. Although two animals died when anesthetized with Metofane, 12 rice rats had completely recovered prior to their release. This anesthetic has been used on hispid cotton rats (*Sigmodon hispidus;* Cameron and Spencer 1985) and Merriam's kangaroo rats (*Dipodomys merriami;* E.J. Heske, Illinois Natural History Survey, pers. comm., 23 December, 1991) with no apparent detrimental effects. An alternative anesthetic would be Ketamine hydrochloride (Parke, Davis, and Company); in rodents accidental overdoses of this drug merely result in heavier sedation (Frase and Van Vuren 1989).

(2). Stress. Prolonged stress has adverse physiological and immunological effects and can lead to increased mortality among mammals (Vaughan 1986). Capture and handling may have produced stress in radiocollared rice rats, although this effect cannot be documented. There is also no evidence that stress would have been severe enough to cause mortality. Individuals selected for radiocollaring were kept in captivity longer and handled more than rice rats that were trapped and released, but repeated trapping and handling to obtain home range data might actually produce more stress.

(3). Radiotransmitter size. The transmitter packages used in this study (mean weight 3.95 g) were equivalent to 6.1 to 10.0% of the rice rats' body weight (mean 8.2%). This load is within the commonly accepted weight limit used in radiotelemetry. The package, however, was somewhat bulky and may have affected an animal's activities. If rice rats were to be fitted with radiocollars again, a smaller version of the transmitter package should be considered.

(4). Radiotransmitter antenna. The plastic shielding on the wire whip antennas attached to the transmitters appeared to contribute to the mortality of collared rice rats. The plastic shielding had been chewed on eight of the nine transmitter packages that were recovered. The chewing often created small "hooks" of plastic which snared vegetation so that the antenna sometimes had a ball of matted vegetation attached to it. This situation may have made it difficult for a rice rat to move normally through thick vegetation . Removing the shielding and shortening the antenna would alleviate this problem.

(5). Radiocollar. The transmitters were placed on the rice rats' necks with narrow-gauge wire collars. It is difficult to achieve a correct fit with radiocollars. All of the rice rats were in good condition when released; however, if an individual grew afterwards, the collar could have become too tight and killed the animal. Some collars must have been too loose, because four were recovered without any skeletal remains. One of these collars had opened, but presumably rice rats had slipped out of the other three. Unfortunately it might be difficult to design an elastic collar that could accommodate growth because of the tendency of rodents to gnaw. An alternative would be either peritoneal or subcutaneous implantation of transmitters.

Radiotelemetry is an excellent method for obtaining information on home range size, activity patterns, and dispersal of small mammals. Even this short term project provided new information about the rice rat in Illinois. Home range sizes comparable to those determined by radiotracking can be obtained with a large number of captures on a live trapping grid; for prairie voles (*Microtus ochrogaster*) eight or more captures produced comparable results (Desy et al. 1989). There is no certainty that rice rats could be captured often enough to determine valid home range sizes or the use of space within the home range. Powdertracking with ultraviolet reflective powders is another effective method for determining home range size and movements (Jike et al. 1988), but it would not be practical for a semi-aquatic animal such as the rice rat.

Unfortunately, there was at least 50% mortality among the rice rats used in this study: two individuals died under anesthesia, skeletal remains of five individuals were found, and the fate of three individuals is unknown. The Illinois Department of Conservation's Division of Natural Heritage must decide if the additional information that could be obtained by radiotelemetry justifies further risk to individuals of this species. If radiotelemetry were resumed, serious consideration should be given to some modifications of the methods. The major problem in this project apparently was the design of the radiocollars. The transmitter package should include a smaller transmitter and a shortened antenna stripped of the plastic shielding. The radiocollar itself should be made somewhat elastic to allow for any growth of collared animals. If the radiocollars cannot be satisfactorily redesigned, implantation may be necessary even though this might reduce the range of the transmitters.

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Table 1. Results of live-trapping at a wetland complex in Saline County, Illinois, 5 June 1991. Refer to Figure 2 for location of traplines.

Trap line	Species	Number	M/F
A	*Oryzomys palustris*	1	1/0
	Peromyscus leucopus	3	2/1
	Microtus ochrogaster	2	0/2
	Mus musculus	9	8/1
B	*Oryzomys palustris*	18	12/5
	Microtus ochrogaster	1	0/1
	Mus musculus	6	*
C	*Oryzomys palustris*	7	4/3
	Mus musculus	1	*

**Mus musculus* were not sexed or weighed

Table 2. Capture location, sex, weight, and reproductive condition of 12 rice rats fitted with radiocollars at a wetland complex in Saline County, Illinois, 5 June 1991.

ID number*	Capture location	Sex	Weight (g)	Reproductive**
P250	B3	M	61.6	TS
P151	B5	F	43.4	NR
P289	B15	M	39.0	TA
P090	B17	M	43.0	TS
P030	B39	M	42.8	TS
P070	B42	F	51.3	NR
P109	B48	F	53.2	NR
P190	B49	M	63.4	TS
P171	C2	M	49.7	TS
P049	C8	F	49.1	NR
P131	C18	F	46.5	NR
P212	C24	M	48.8	TS

* ID number refers to the frequency of the transmitter with which the animal was fitted (e.g., number P250 = frequency 172.250 Mhz)

** TS = testes scrotal
TA = testes abdominal
NR = not pregnant or lactating

Table 3. Home range sizes (convex polygon method) of 11 rice rats fitted with radiocollars at a wetland complex in Saline County, Illinois, 5-7 June 1991. The number of locations generated by the TELEMPC program and the number of fixes entered into the program are also listed.

ID number	Home range (ha)	Locations	Fixes
P250	0.25	7	12
P151	0.05	7	12
P289	0.04	5	8
P090	0.10	6	8
P030	1.24	5	7
P109	0.53	5	11
P190	0.84	6	11
P171	1.63	11	21
P049	1.19	7	21
P212	0.66	13	25
P131	1.52	10	19

Table 4. Fate of radiocollars placed on 12 rice rats, Saline County, Illinois.

ID number	Fate
P250	Collar found in burrow on bank of roadside ditch 3.5 m east of station B10
P151	Collar and skeletal remains found in surface nest 2 m west of station B7
P289	Collar and skeletal remains found at station B9
P090	Collar and skeletal remains found south of wetland complex approximately 330 m from capture site
P030	Signal lost by 15 July; collar never recovered
P070	Collar found on north shore of lake approximately 660 m from capture site
P109	Collar found behind station B45
P190	Collar and skeletal remains found in surface nest 46 m north of station B43
P171	Signal failed before collar could be recovered
P049	Collar found between lake shore and Route 13
P212	Collar and skeletal remains found between lake shore and Route 13
P131	Signal failed before collar could be recovered

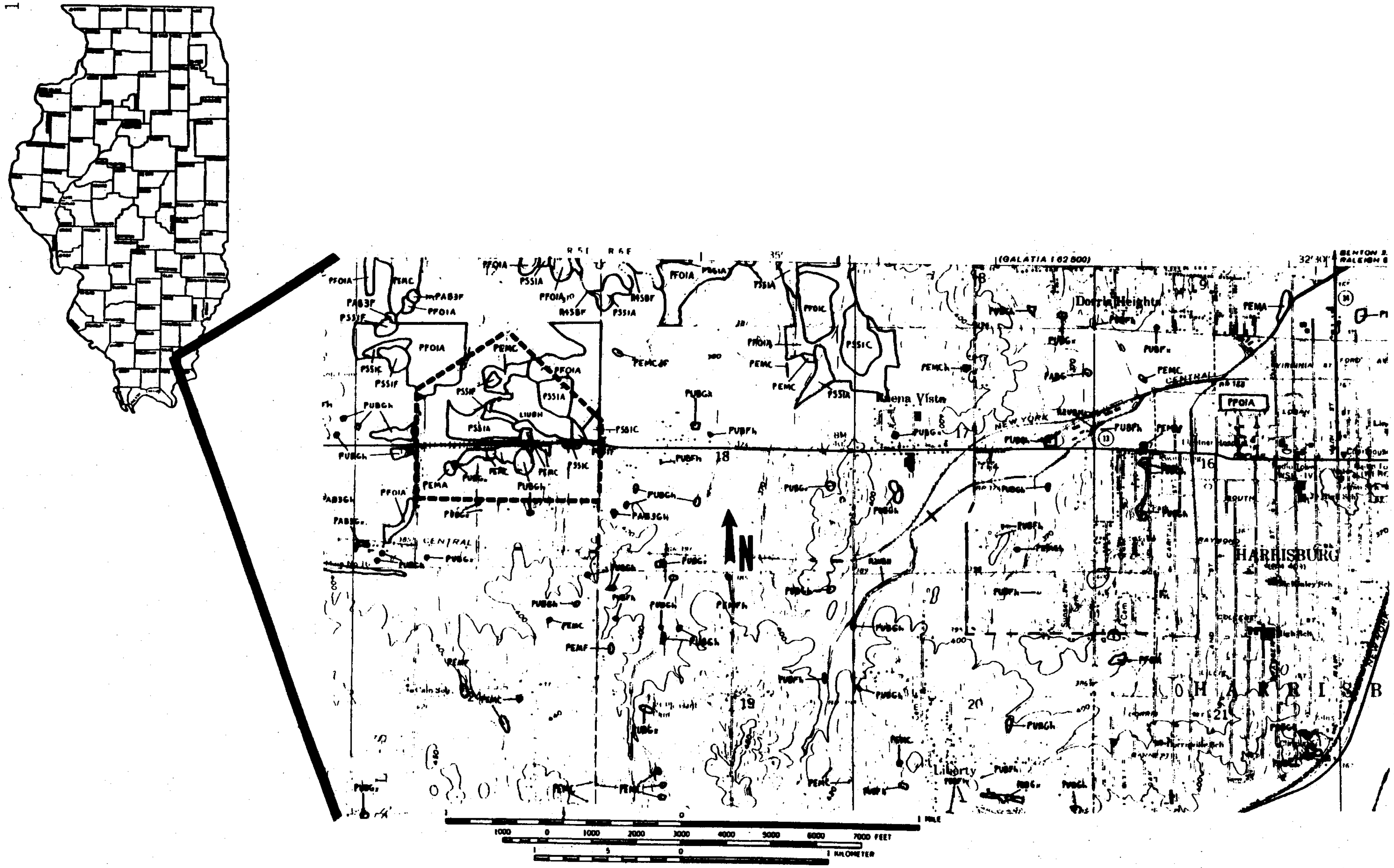

Figure 1. Location of rice rat radiotelemetry study area, Saline County, Illinois, showing National Wetland Inventory (U.S. Fish and Wildlife Service) codes. See text for definition of codes.

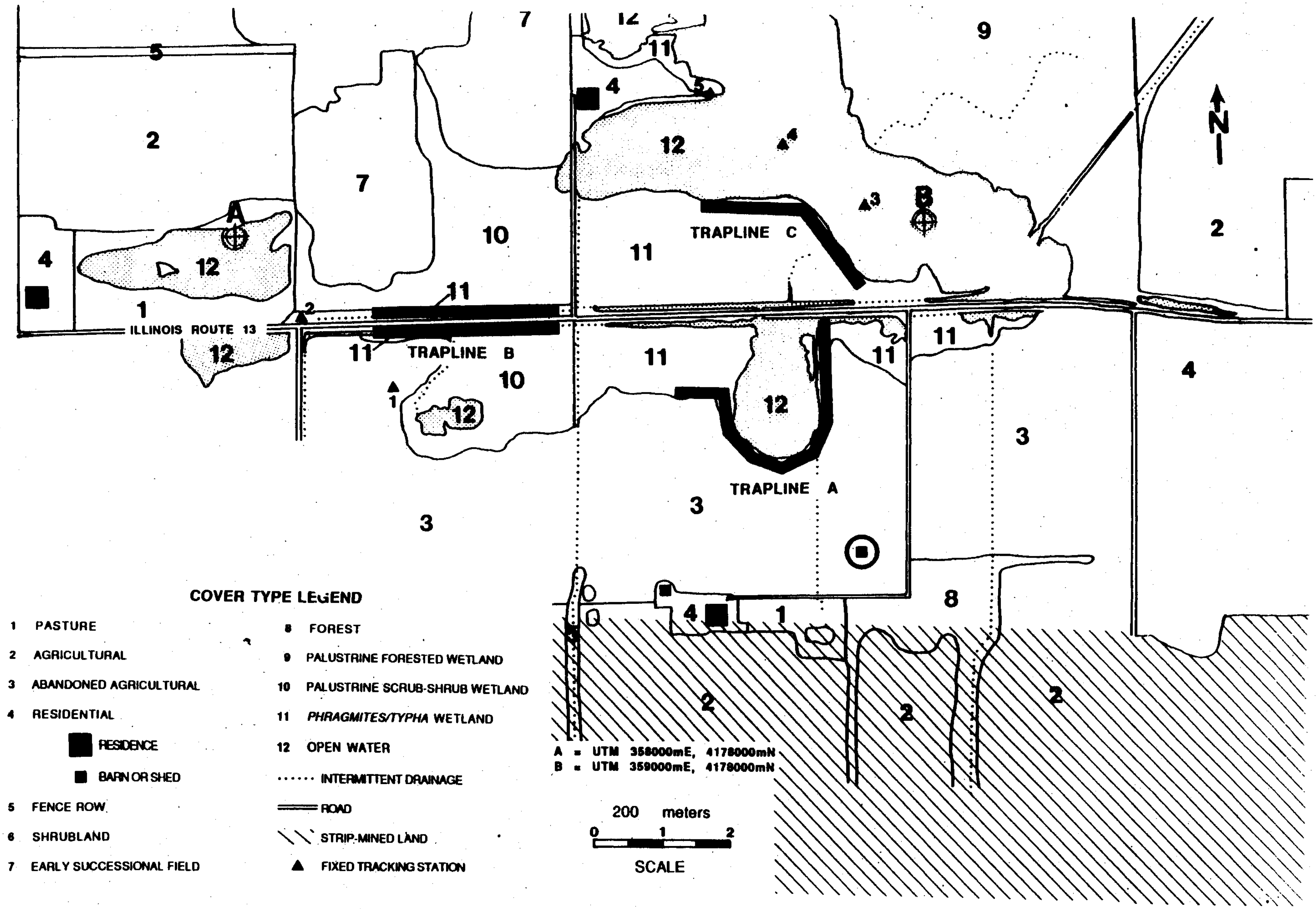

Figure 2. Cover type map of rice rat radiotelemetry study area, Saline County, Illinois, showing the locations of traplines, fixed radiotelemetry stations, and the shed (circled) where rice rats were fitted with radiocollars.

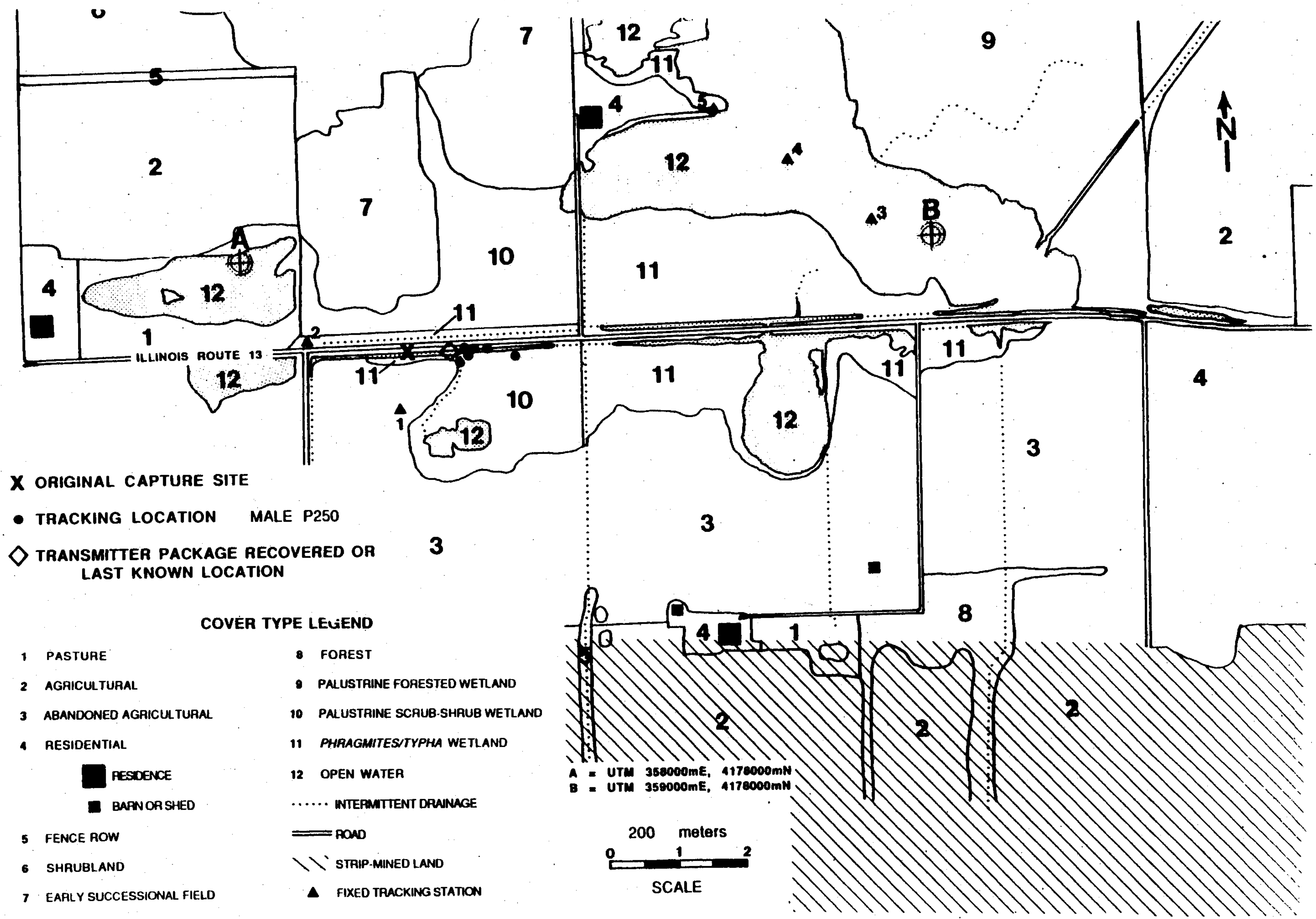

Figure 3. Locations of rice rat P250, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 7 June, 1991; collar recovery 17 July 1991.

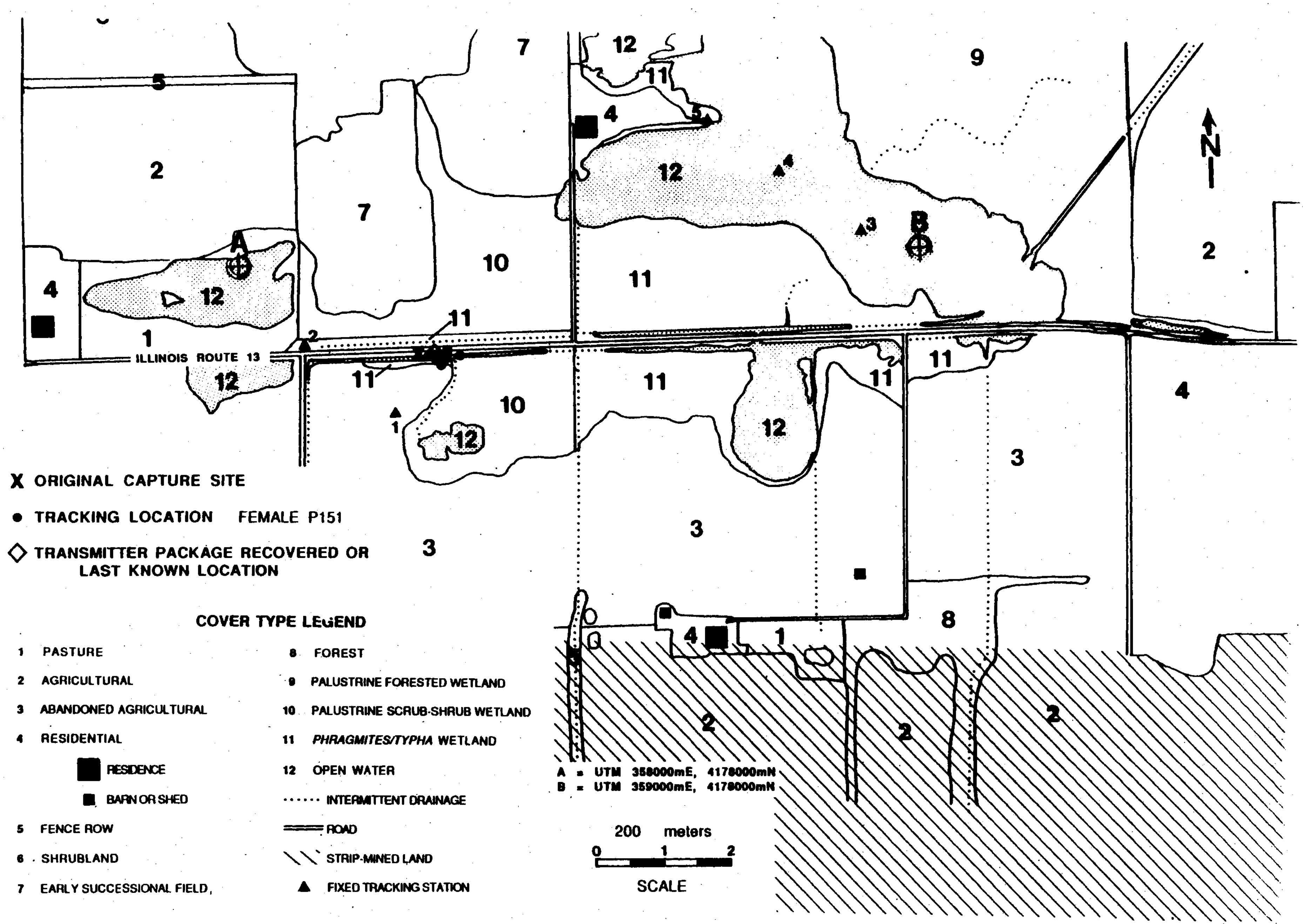

Figure 4. Locations of rice rat P151, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 7 June, 1991; collar recovery 17 July 1991.

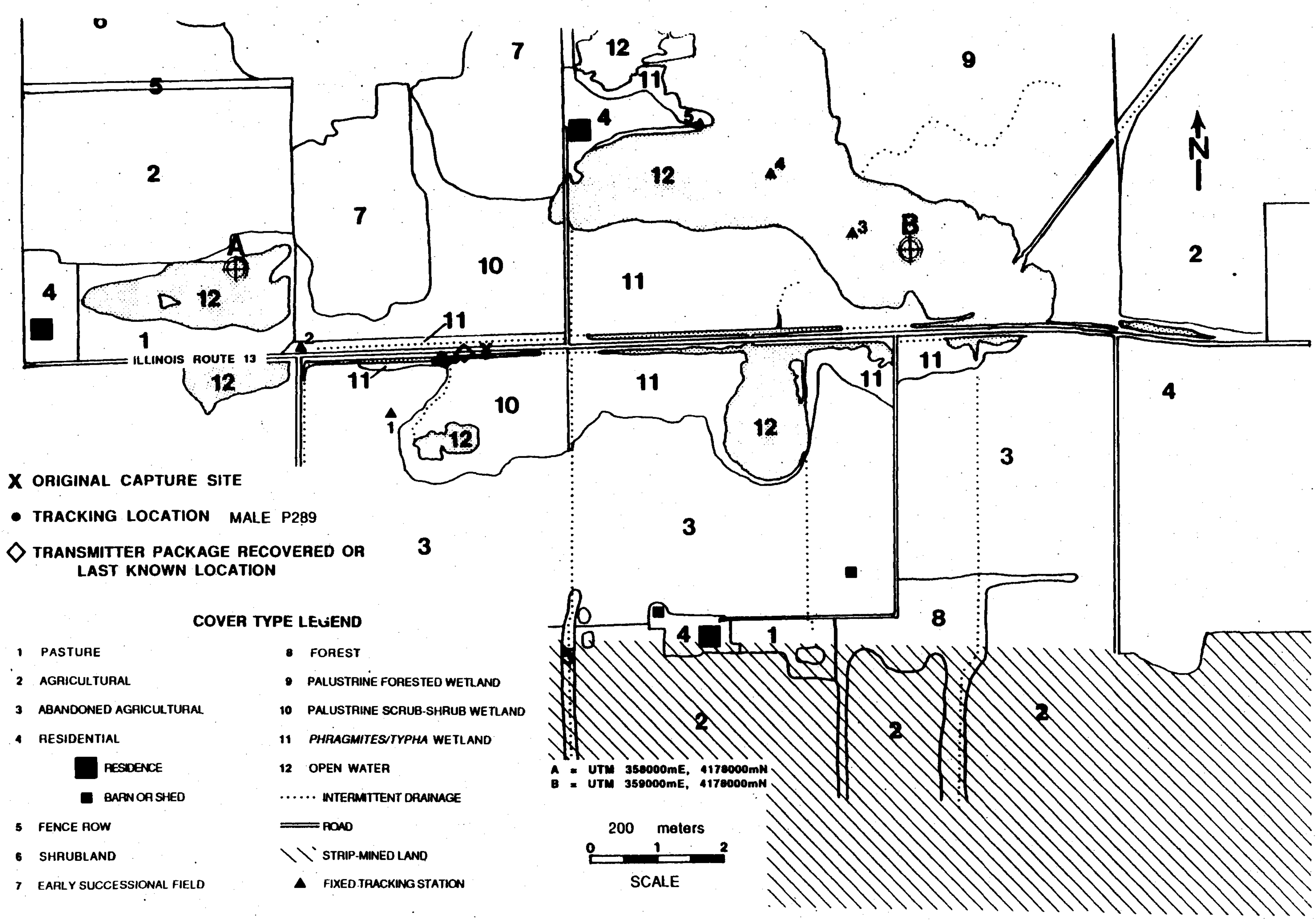

Figure 5. Locations of rice rat P289, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 7 June, 1991; collar recovery 17 July 1991.

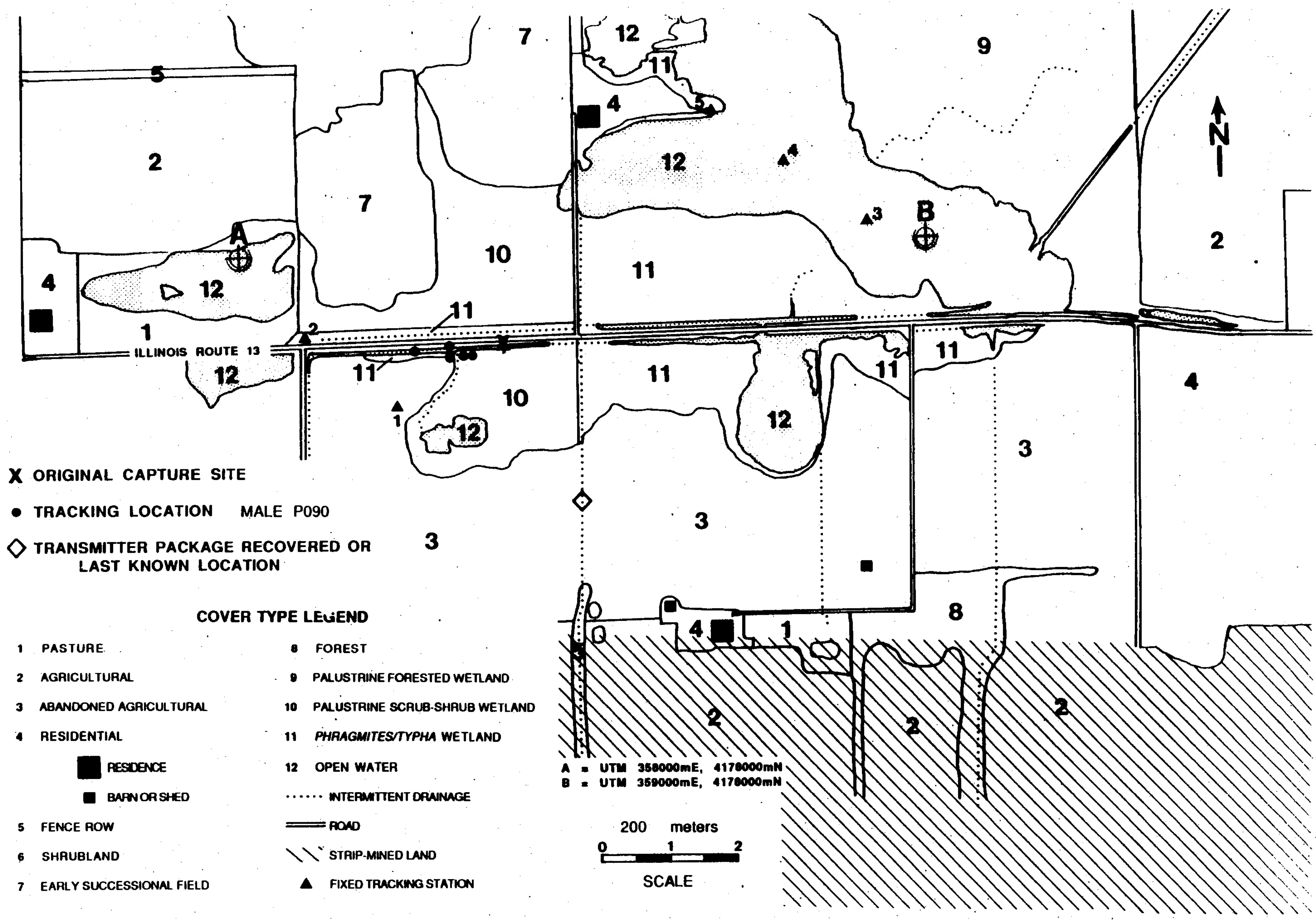

Figure 6. Locations of rice rat P090, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 7 June, 1991; collar recovery 17 July 1991.

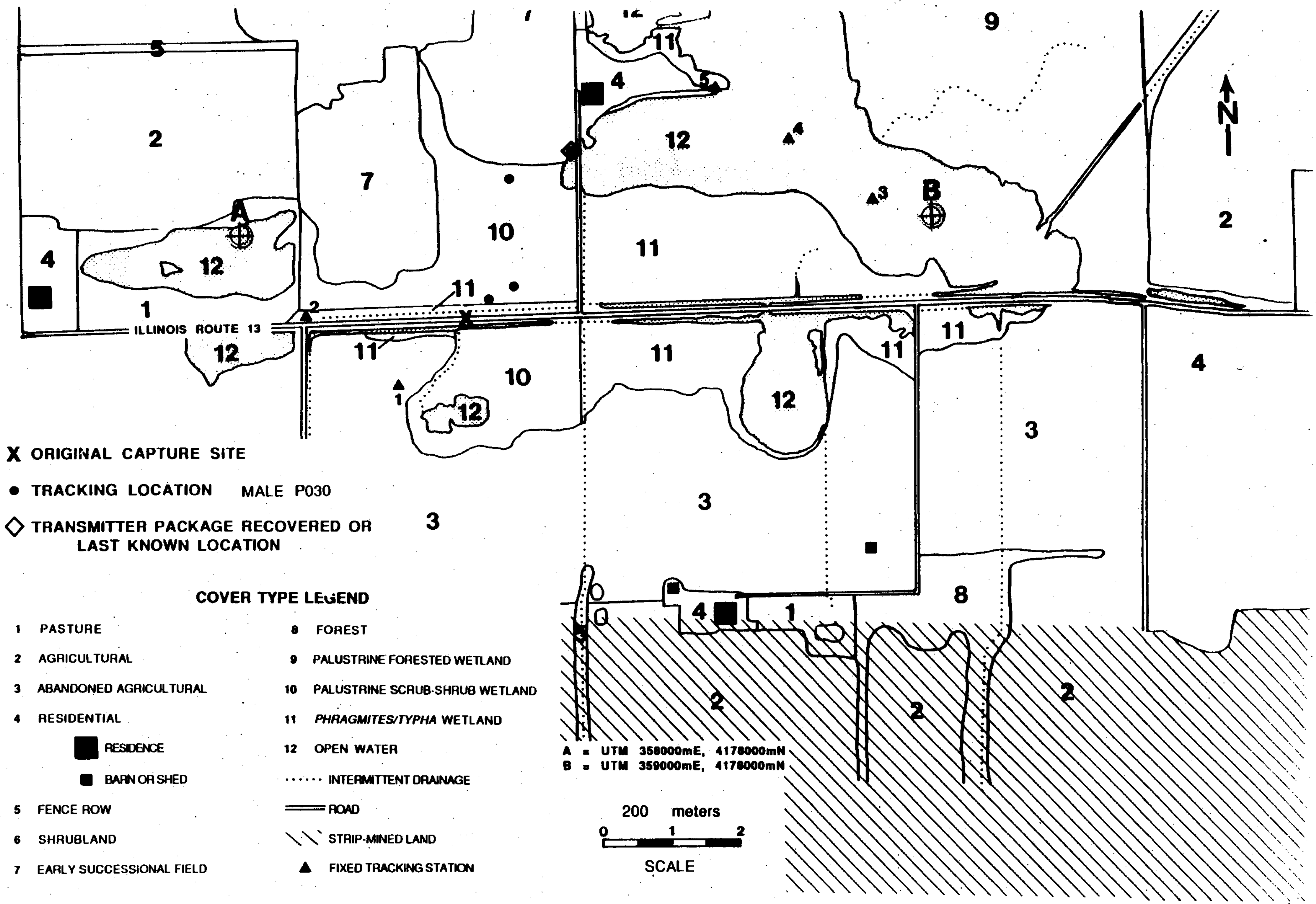

Figure 7. Locations of rice rat P030, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991.

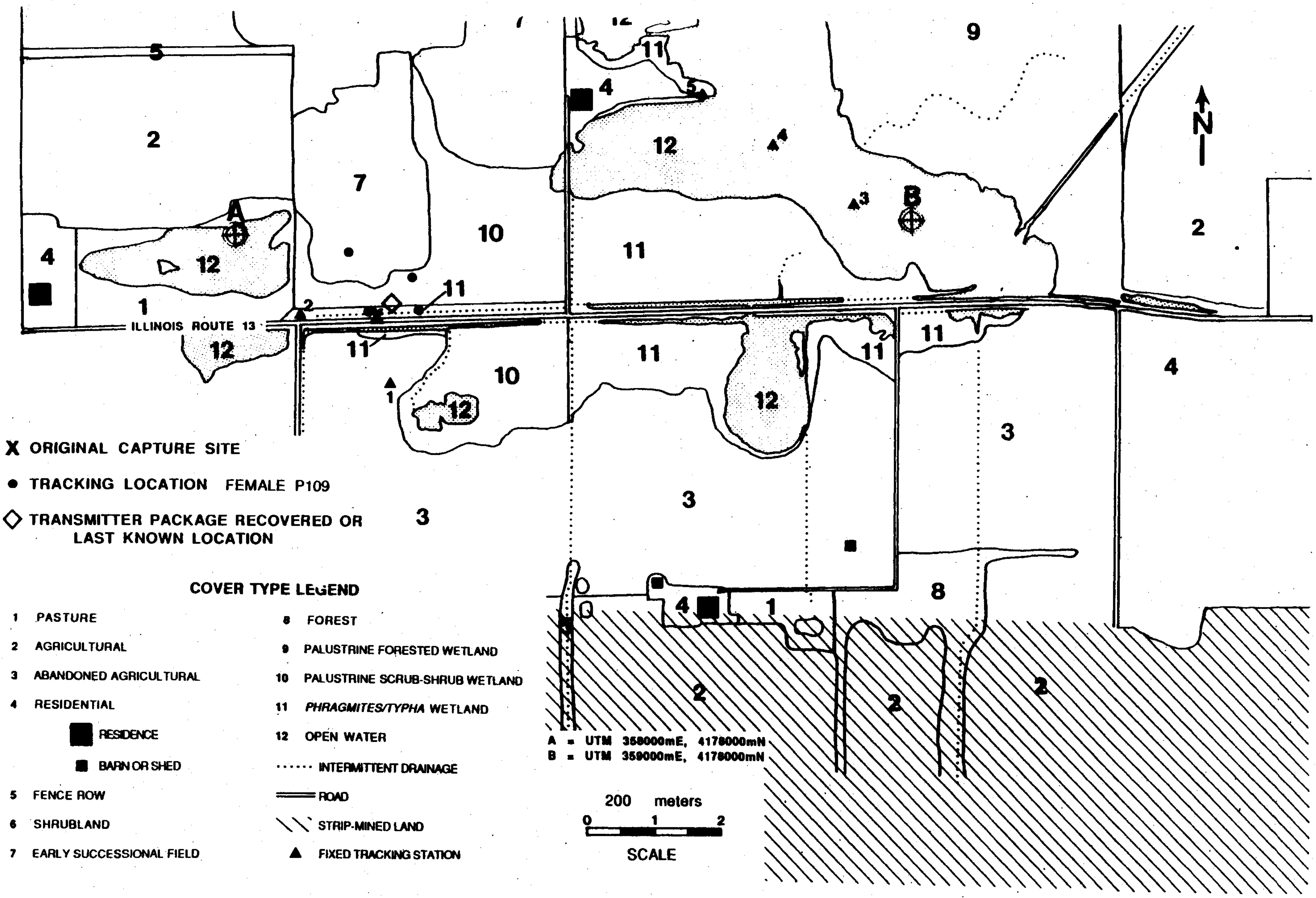

Figure 8. Locations of rice rat P109, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991; collar recovery 17 July 1991.

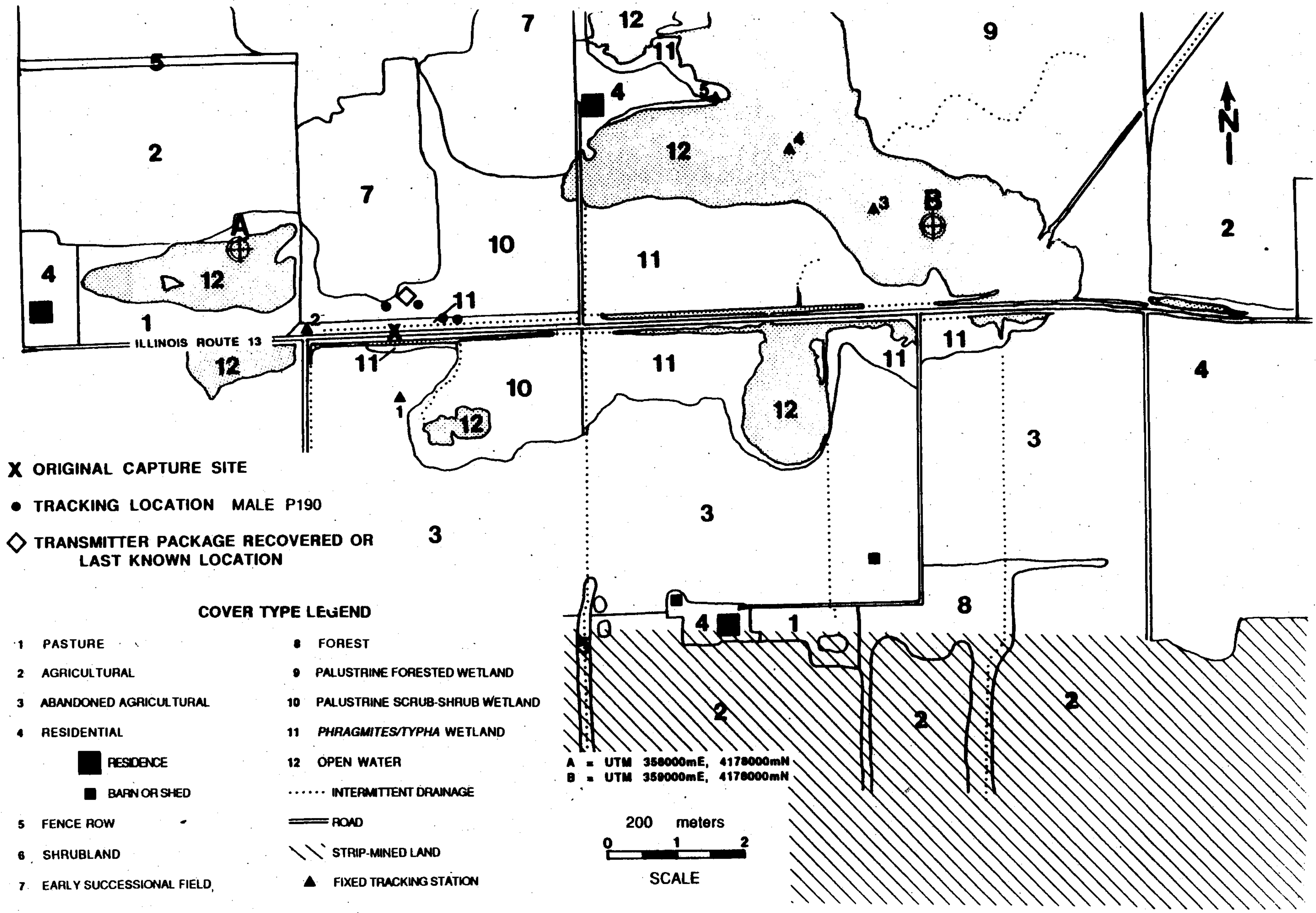

Figure 9. Locations of rice rat P190, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991; collar recovery 17 July 1991.

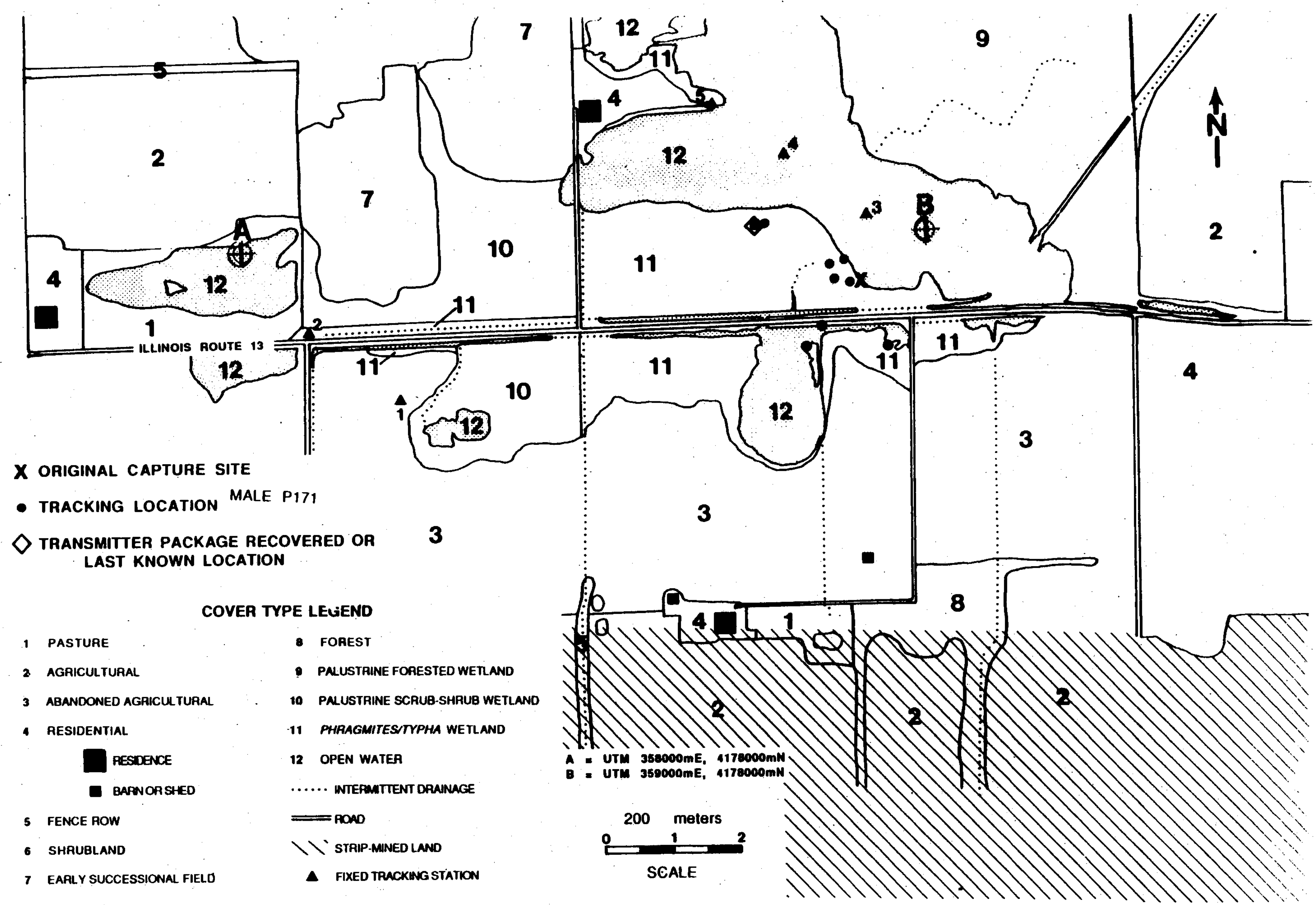

Figure 10. Locations of rice rat P171, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991.

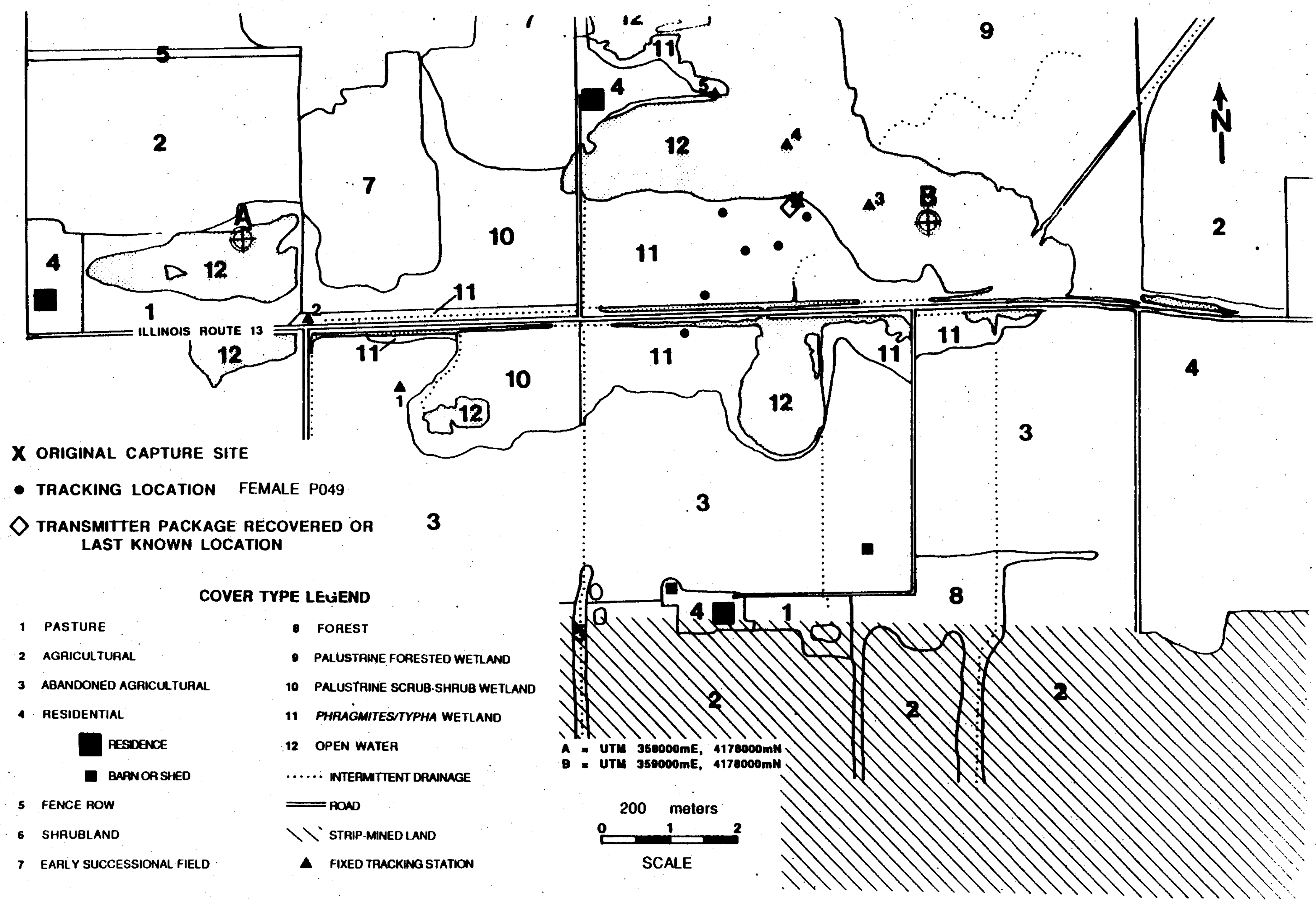

Figure 11. Locations of rice rat P049, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991; collar recovery 17 July 1991.

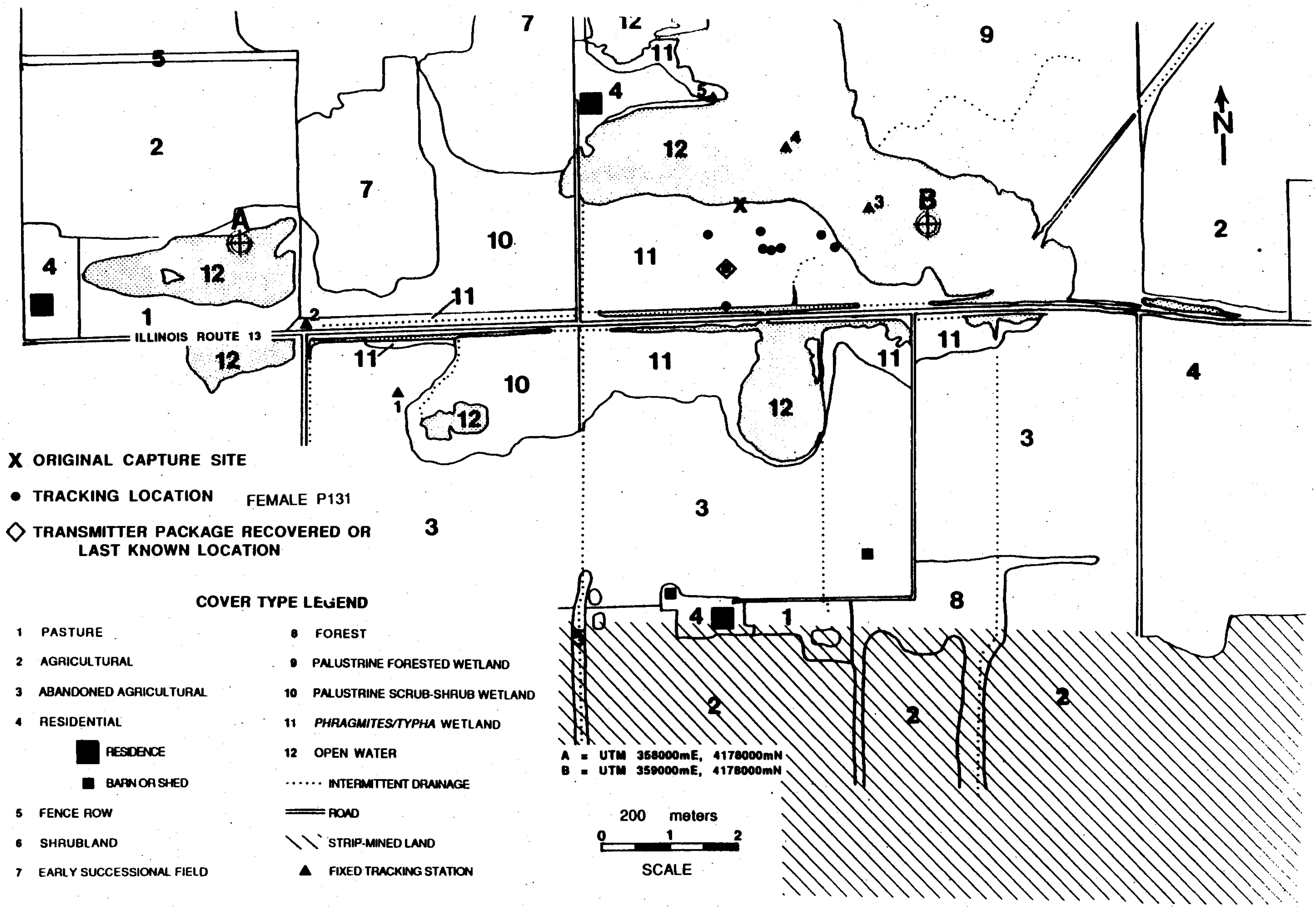

Figure 12. Locations of rice rat P131, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991.

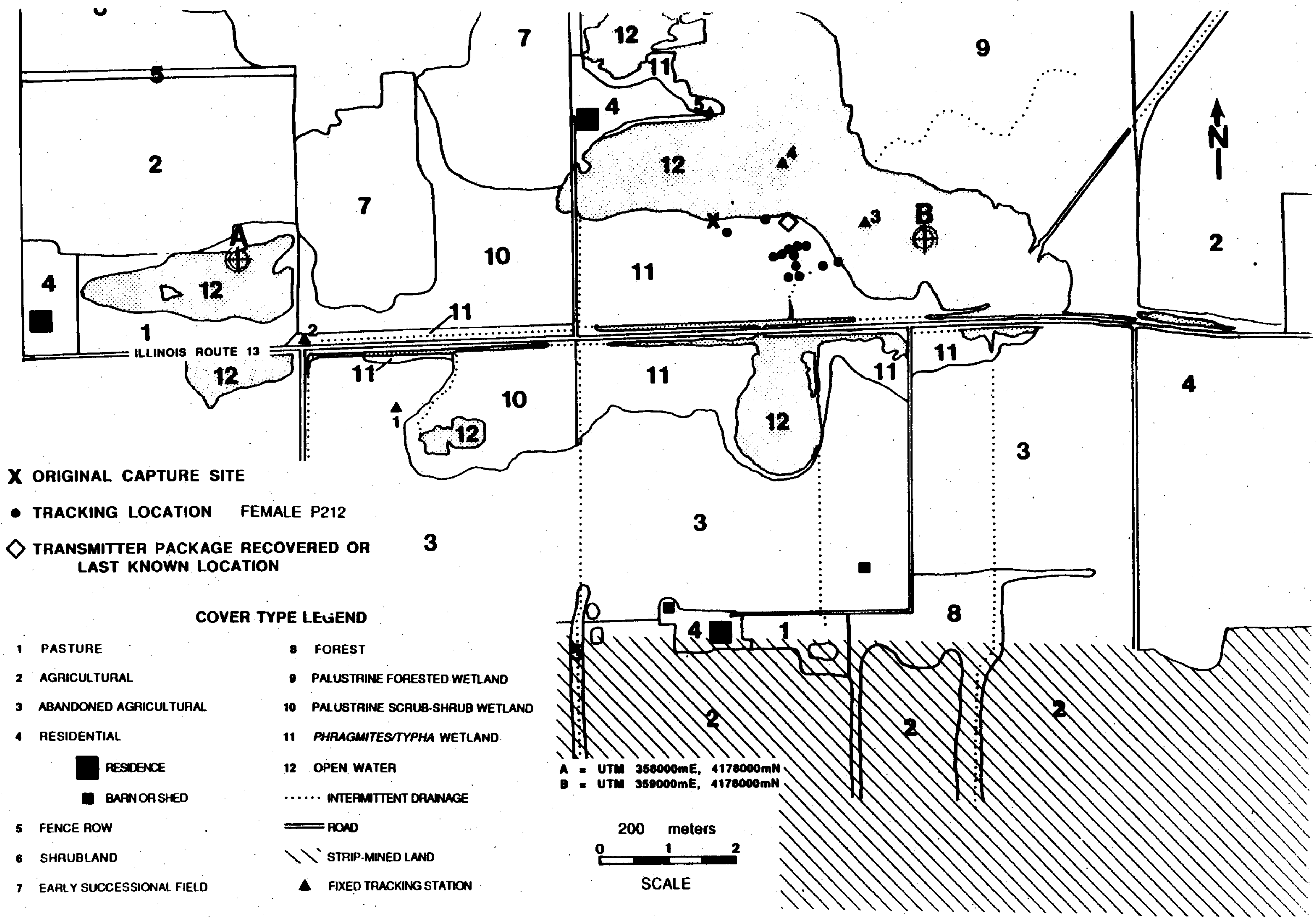

Figure 13. Locations of rice rat P212, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991; collar recovery 17 July 1991.

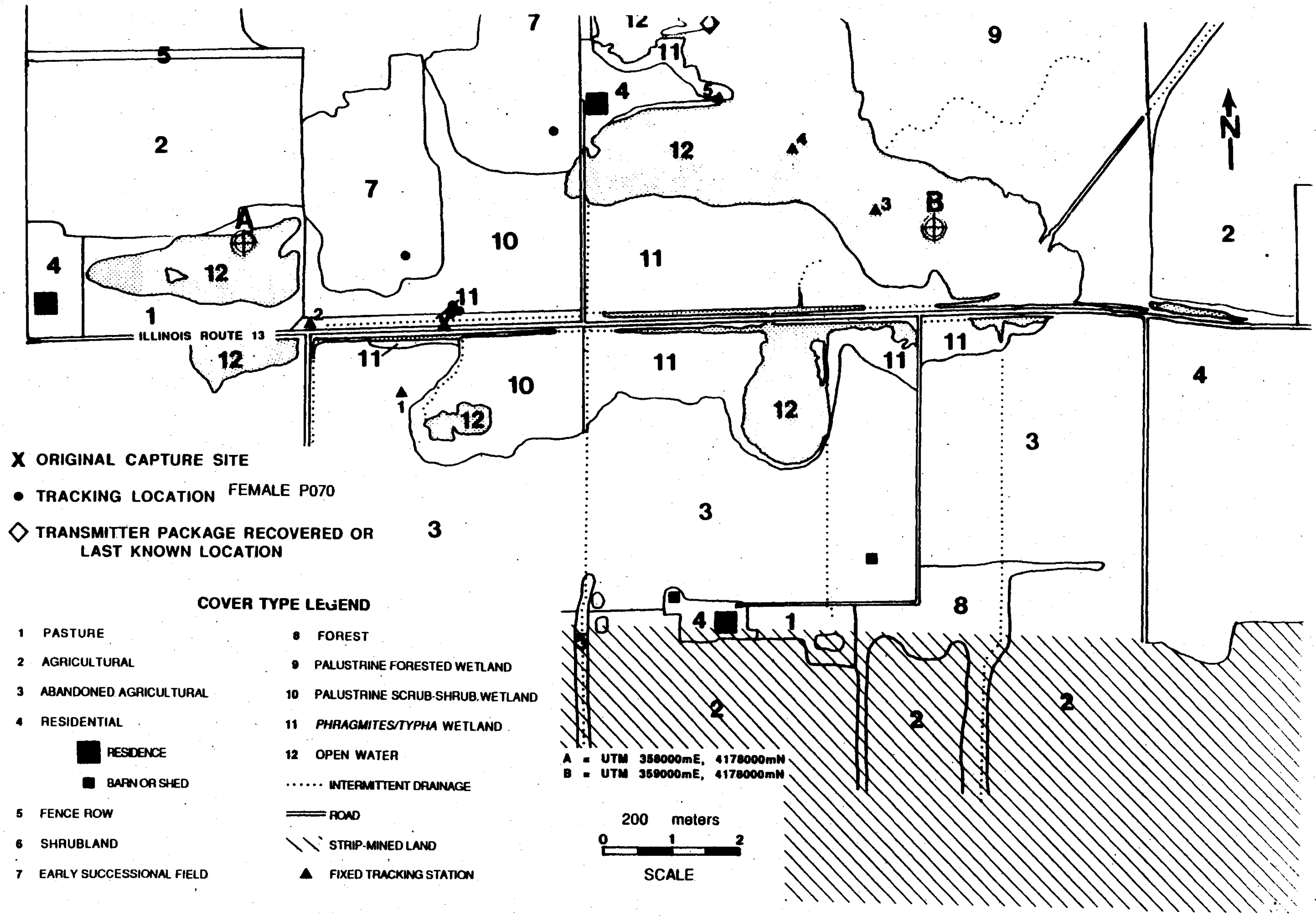

Figure 14. Locations of rice rat P070, Saline County, Illinois: capture location 5 June, 1991; radiotracking locations 5 - 6 June, 1991; collar recovery 17 July 1991.