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PROJECT 05-271

Prescribed burns and their effects on threatened and endangered species with emphasis on the Eastern Box Turtle (*Terrapene c. carolina*)

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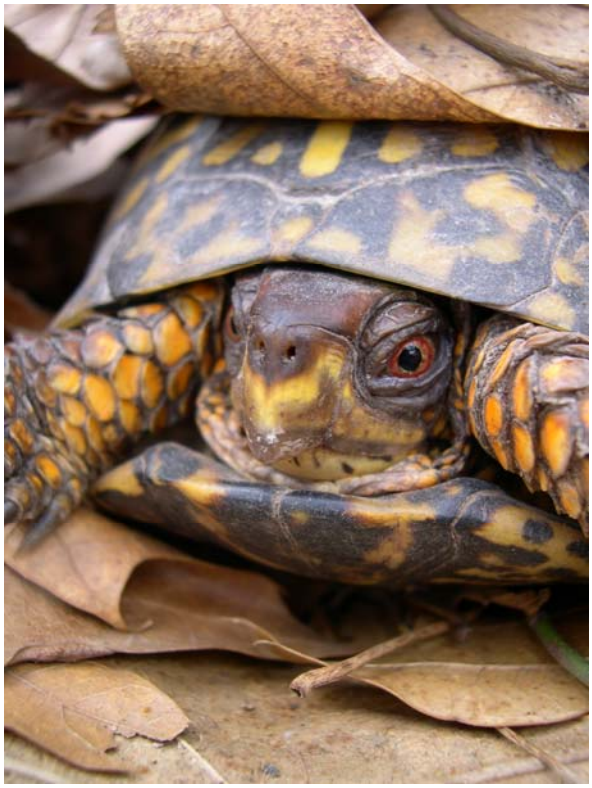
Ecological study of the Eastern Box Turtle (*Terrapene c. carolina*) as a representative herpetological species at Fort Custer Training Center, Michigan: Final Report and Management Recommendations

Project 05-271



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INTRODUCTION

This report summarizes preliminary findings from year one of field studies on the ecology of the Eastern Box Turtle (*Terrapene c. carolina*) on the Fort Custer Training Center (FCTC) in south central Michigan. This study was initiated to investigate the impacts of prescribed burning on resident herpetofaunal populations of FCTC by examining patterns of movement and habitat use of the Eastern Box Turtle using radiotelemetry.

Box turtles were considered an ideal study species for this project for several reasons: **1)** there is a relatively large population (Tobin 2005), so finding individuals to include in the study would not be difficult, **2)** the species has been observed to use all habitats on FCTC where burning has been employed, and **3)** surveys have highlighted possible scarring on several box turtles that could be attributable to fire. Additionally, this study serves to increase locally relevant knowledge of box turtle ecology, which is lacking despite noted population declines and its listing by many Midwestern states as a species of conservation concern (Michigan lists the Eastern Box Turtle as a species of Special Concern).

This report provides a discussion of data collected to date, as well as management recommendations intended to promote the conservation of the Eastern Box Turtle, as well as other herpetofaunal species found on the FCTC, including those that are listed as threatened and endangered. These species are likely to include the Eastern Massasauga Rattlesnake (*Sistrurus c. catenatus*), Spotted Turtle (*Clemmys guttata*), and Blanding's Turtle (*Emydoidea blandingii*).

A more detailed discussion on the effects of prescribed burning on the Eastern Box Turtle will be available at the conclusion of this study (in 2008). Funding for this study was provided by the Department of Defense Legacy Resource Management Program.

METHODS

Study site

The study site is located on the FCTC in south central Michigan. While the FCTC comprises approximately 7,500 acres, the study site was restricted to the western portion of this area (approximately 3,000 acres), and more specifically to Training Areas (TA's) 3 and 7. As the movements of the telemetered turtles in this study ultimately delineated the study area boundary, portions of TA's 4 and 5, as well as southern areas of the Fort Custer Recreation Area (FCRA), had also become part of the study area by the end of the first field season (see Figure 1). The study area is characterized by deciduous, hardwood forest interspersed with wetlands, streams, and natural and maintained prairie/grassland habitats. Additionally, agricultural fields (corn and soybean) comprise a small portion of the study area and were also utilized by turtles who ventured onto FCRA.

In 2002 FCTC started using prescribed fire to assist in the control of succession at designated high quality habitat areas within the study site. Since then, portions of TA's 4, 5, and 7 have been burned no more than once per year in early spring. FCRA also uses prescribed burning as a management tool. Exact burn dates at FCRA are unknown, but they were observed between late spring and early summer in 2006.

Radiotelemetry

Starting in spring 2006, we conducted intensive searches for box turtles to include in the radiotelemetry portion of the study. Once located, turtles were collected by hand and fitted with transmitters on-site. All turtles were sexed, aged, weighed, and morphometric data was collected prior to transmitter attachment. Any injuries, scars or abnormalities were noted, and the activity of the turtle was characterized. Sex was determined by a combination of four secondary characteristics: eye color, concavity of plastron, tail length, and hind limb nail morphology (Graham 1979). Turtles were classified as adult, juvenile, or hatchling based on number of annuli (Ewing 1939), plastron length (Legler 1960), and the presence of secondary sex characteristics. Morphometric data included carapace length and width (mm), plastron length and width (mm), shell height (mm), and mass (g). The activity of each turtle was noted as: walking, feeding, mating, resting (head and feet out, plastron in contact with ground), basking, disturbed (activity unknown – turtle frozen, disturbed by observer), retracted, partially buried in leaf litter, fully buried in leaf litter, or other. Additionally, to ensure the identification of individual turtles, a unique marking was notched on the marginal scutes of each turtle using a triangular file following the methodology of Cagle (1939).

Depending on mass, each individual was fitted with one of three sizes of RI-2BT transmitter (6g, 21x8mm; 10g, 24x10mm; 15g, 25x13mm; all with 240mm whip antennas, Holohil Systems, Ltd.). The transmitter was epoxied (using Devcon High Strength 5-minute epoxy gel) to the carapace above the hind leg, with the

antenna left to trail behind the turtle. Transmitter and epoxy did not exceed 6% of each turtle's total mass (Brander and Cochran 1971; Cochran 1980). After transmitter attachment, the epoxy was allowed to harden for approximately 30 minutes before each turtle was released at their point of capture.

An adult female with transmitter attached.
Photo by J. Gibson

Activity, Movements, and Spatial Ecology

Between May 30 and August 18, telemetered turtles were located on a rotational basis approximately three times per week. Prior to May 30, due to hunting season restrictions, locations averaged approximately once per week. After August, turtles were located at least once per month. Turtles were located using antenna and receiver, and locations were recorded with a handheld GPS unit.

Coordinates of relocations collected throughout the active season were imported into ArcGIS 9.2 (ESRI, Inc.) to facilitate the analysis of movement patterns and spatial

ecology. For each turtle, home range, activity centers, range length, and total distance moved were calculated. Home range was quantified by minimum convex polygon (MCP) analysis, and activity centers (or areas of "high" use) were quantified using 50% KD analysis. MCP and KD sizes were compared between sexes and age class using MANOVA and ANOVA. Additionally, range length, as well as total distance moved was also calculated. Range length was measured at the distance between the two furthest relocation points for each turtle, and total distance moved was calculated from the sum of distances between all consecutive relocation points. As with MCP and KD, data generated from these calculations were compared between sex and age class using MANOVA and ANOVA. Due to potential anomalies in their movements and activities, data collected from two female turtles were excluded from these analyses. These two turtles included a female from TA 4 who was sprayed with pesticides while on the FCRA, and a second female from TA 3 who had abscesses in both ears.

Habitat Use

We also classified the macrohabitat type for each turtle relocation. Categories for this classification included forest, open canopy prairie/grassland, wetland, road, and agriculture. In addition, we also recorded distance to ecotones/edges (m) within 15m (for example, forest-wetland edge), and we also noted whether the turtle was located in a burn area or not. Because of the preliminary nature of this report we have not included statistical comparisons of habitat use between sex and age classes at this time.

Mark-recapture

Mark-recapture surveys were conducted concurrently with radiotelemetry tracking. Surveys were standardized with the aim of covering specific survey areas uniformly and thoroughly (Stickel 1978). Surveyors walked in parallel lines throughout predetermined survey areas, actively searching around vegetation, logs and debris (Hallgren-Scaffidi 1986). Because of the rigors of continuous radio-tracking, mark-recapture surveys were conducted only as frequently as time allowed. To bolster these dedicated mark-recapture surveys, turtles found incidentally during telemetry efforts were also uniquely notched and included in the survey results. At this time we have not finished population estimates for the respective areas, and report only on capture numbers.

RESULTS

Radiotelemetry and Turtle Capture

A total of thirty-four turtles were fitted with radio-transmitters in 2006. Transmitters were deployed between April 14 and July 5, 2006. The study includes 28 adults (15 females and 13 males) and 6 juveniles. The initial study plan involved deploying ten transmitters in each of TA's 3, 4, and 7, however due to the difficulty of finding turtles in TA 4, we decided to concentrate on TA's 3 and 7 and increase the number of individuals in each of these two areas. We did find one female turtle in TA 4 early in the season, and this turtle was fitted with a transmitter and tracked for the entirety of the season. Given these parameters, the breakdown of turtles in each area includes:

eight females, seven males, and three juveniles in TA 3; six females, six males, and three juveniles in TA 7; and the previously mentioned female in TA 4. Table 1 provides the capture date and morphometric data for all telemetered turtles. Shell abnormalities, missing limbs, and general health comments are also detailed in Table 1.

Early search efforts (in April) for box turtles primarily focused on areas previously highlighted by Eric Tobin (Tobin 2005) as potential hibernation locations. In all three TA's (7, 3, and 4) these included regions of higher elevation. For example in TA 7 the ridge just to the north of the mesic prairie was targeted, in TA 3 higher elevation areas south of the northern open grasslands were targeted, and higher elevation areas south of the northern open grasslands in TA 4 were similarly targeted. Early search efforts in these areas produced predominately female turtles, and very few males. However, by tracking the telemetered female turtles we were able to continuously modify our search effort by focusing on those areas which were later frequented by female turtles. In mid to late spring these included more open canopy grasslands.

In TA 7, five of the seven telemetered female turtles were found very early in the season on the ridge north of the mesic prairie, and one male was found close by. The remaining seven adult telemetered turtles were found some distance away from the ridge, and all were encountered while tracking telemetered turtles. Five of these adult turtles were initially found in the mesic prairie, one was found crossing the road between TA's 5 and 7, and one was found in the large wetland area to the east of the mesic prairie. Two of the juvenile turtles from TA 7 were also found in the mesic prairie, and the third was found on the edge of a small wetland area west of the mesic prairie. Figure 2 provides the initial capture locations for all telemetered turtles from TA 7.

In TA 3 a small forest clearing on the eastern edge proved very productive for female turtles. Six of the seven telemetered female turtles were initially found here, as was one of the males. All other telemetered adult turtles in TA 3 (seven individuals: 6 males, 1 female) were initially found on the edge of the open maintained grassland areas in northern TA 3. The female was found in the large open grassland to the east of Medevac LZ3, five of the males were located in Medevac LZ3, and one male was located in the northeastern corner of TA 3. One juvenile was also found in Medevac LZ3. Another juvenile was located in the windsock field directly to the west of Medevac LZ3, and the third was initially found on the very eastern edge of the large open grassland in the northwest corner of TA 3. Figure 3 provides the initial capture locations for all telemetered turtles from TA 3.

Considerable survey effort was given to locating turtles for inclusion in the telemetry study from TA 4. An area of higher elevation on the eastern edge of TA 4 was intensively surveyed early in the season, and as spring progressed, the edges of the open grasslands along the northern end of TA 4 were targeted. A single female turtle was located in the small patch of forest between the road and the grass two-track just north of Lawler Pond (refer to Figure 3 for a map of the initial capture location of this female). However, as no other turtles were recovered after close to 50 hours of search effort, and turtles were more abundant and easily located in TA's 3 and 7, we decided discontinue search efforts in TA 4 and concentrate on TA's 3 and 7. The single female from TA 4 did however remain in the study.

Movements and Spatial Ecology

Several trends were apparent with the different groups of turtles tracked. The most striking difference was between females and the two other classes (males and juveniles). After transmitter attachment in early spring females made long-distance directed movements towards large open-canopy areas (for example, maintained open grasslands and agricultural fields). This trend was observed in all but three of the telemetered females. In TA 7, four of the seven telemetered turtles made directed movements north between early May and mid-June. Some of the movements were considerable, for example one female moved over 900m north onto the FCRA (see Figure 4). All four of the females remained in these northern open-canopy locations for between one to three weeks before returning to the area near where they were captured.

In TA 3, all seven telemetered females made considerable directed northerly moves to large open-canopy areas. Three individuals even ventured onto agricultural fields on the southern portion of the FCRA. These northerly moves were made between early May and early June and nearly all turtles moved back to the approximate locations where they were originally captured within three weeks (one turtle remained in an open grassland area until early August, however this anomaly was likely due to abscesses in both ears). As with the females in TA 7, the distance moved by these female turtles was considerable; for example the furthest distance moved by any of the telemetered females from TA 3 was over 900m (see Figure 5).

The single female from TA 4 was also observed to make a long-distance directed move to an open-canopy area in late May. In fact, she traveled over 1350m to the agricultural fields on the southern portion of the FCRA (see Figure 6). However, unlike

the majority of other females, this turtle did not return to her capture location soon after this move (likely due to the fact that she was sprayed by pesticides).

After these directed movements, all females made considerably shorter movements and generally remained around where they were originally captured for the remainder of the summer (in more closed-canopy areas).

In contrast to females, no telemetered males were observed to make similar directed movements early in the season. In fact, the majority of telemetered males moved very little in comparison to females (refer to Figure 7). Long directed movements were however observed in males in TA 3 as they moved from Medevac LZ3 south to higher elevation forested habitat in early fall where they hibernated (see Figure 8).

Juveniles also did not make any directed movements similar to those of females early in the season. Overall they moved very little. However, as with the males, directed movement to higher elevation hibernation sites late in the season (early fall) was observed in several individuals.

A map of the locations of all telemetered turtles is provided in Figure 9a (covering TA's 3 and 4) and Figure 9b (covering TA's 5 and 7).

The observed trends in movements were also supported statistically. Estimates of home range and activity centers were significantly different between sex and age class with females having significantly larger home range and activity centers than both males and juveniles. Interestingly, there was no significant difference in home range and activity center size between males and juveniles. Home range and activity center data can be found in Table 2. In addition, to help visualize the differences between the home range sizes of females, males, and juveniles, we present a figure for each of TA's 3

(Figure 10) and 7 (Figure 11) depicting the home range of one female, one male, and one juvenile turtle.

Similar to home range and activity centers, range length and total distance moved were also found to be significantly different between the turtle sexes and age classes. Females had significantly larger range lengths and total distance moved than either males or juveniles. While no significant difference was found for range length between males and juveniles, there was a significant difference for total distance moved. After females, males were found to have greater total distance moved than juveniles. Range length and total distance moved data can be found in Table 2.

Nesting, Courtship and Mating

Courtship and mating of telemetered turtles was observed during all months: May (1 observation), June (3 observations), July (2 observations), August (4 observations), and September (1 observation). In addition, no affinity for mating in any particular habitat was observed. Turtles were observed displaying courtship behavior and mating in forest, open prairie/grassland, and wetland habitats. Three of the telemetered females and eight of the telemetered males were observed in either courtship behavior or copulation.

Based on the movements and activity of the female telemetered turtles from FCTC, nesting likely occurred between early May and late June. All but three of the telemetered turtles made significant directed movements to open-canopy locations during this period. All nesting locations were observed to have open-canopies and loose soils. It is interesting to note that many of the female telemetered turtles chose to nest in areas

that were at considerable distances from their hibernation locations, even though suitable looking nesting habitat was nearby.

Areas of prime nesting habitat in TA 3 include all of the northern open grassland areas. In TA 7, prime nesting habitat also includes northern open grassland habitat, as well as the mesic prairie, and the large oak barren to the east of the mesic prairie. Based on the movements of the telemetered juvenile turtles, and two more incidental juvenile captures, several additional nesting locations can be presumed. These include the large forest gap on the eastern edge of TA 3, three small forest openings west of the mesic prairie in TA 7, and the large open grassland on the northern edge of TA 5. A depredated nest located during a mark-recapture survey also highlighted nesting activity in an open grassland on the western edge of TA 7. Figures 12 and 13 highlight the locations of observed and presumed nesting locations on FCTC (for TA's 7 and 3 respectively).

Hibernation

Turtles were observed to enter hibernation between late September and late October. As turtles were being relocated approximately once per week during this period, we can only provide approximate dates of ingress into hibernacula. The earliest date of ingress was in the week before September 29 and the latest occurred in the week prior to October 28. Only two turtles were still above ground on October 14, but both were very close to where they ultimately entered hibernation by October 28. The hibernation locations of all turtles were reconfirmed on January 1, 2007, and no turtles had moved from their October 28 locations.

Hibernation locations were observed in mostly higher elevation locations, and all were observed in relatively loose soil. All of the telemetered turtles, except for one juvenile, were hibernating in forested habitat. This single juvenile was hibernating in a small shrub/tree clump on the eastern edge of the mesic prairie in TA 7. Interestingly, three of the telemetered turtles were hibernating within 10m of each other in TA 3, and two of them were within 1m of each other. A map of hibernation locations for each of TA's 7 and 3 is found in Figures 14 and 15 respectively.

Habitat Use

The majority of telemetered turtle locations occurred in forested habitat (62%), followed by open canopy prairie/grassland habitat (29%), and wetland habitat (9%). Turtles were also located in agricultural fields and on roads, but these habitats accounted for less than 1% of all relocations. During the nesting season, female telemetered turtles were observed in open canopy prairie/grassland habitats more often than in more closed-canopy habitats (such as forest).

Box turtles were observed to make considerable use of edge habitat. For those locations where turtles were in forest, 40% of these locations were within 15m of a habitat edge, whether this edge be a different habitat type (for example, forest – open prairie edge), or a gap within the forest. In open prairie/grassland situations, 75% of all turtle locations were observed to be within 15m of a habitat or structural edge (for example a shrub/tree clump). Similarly, in wetland habitats turtles were observed within 15m of an edge 37% of the time. All locations made on roads were within 15m of a

habitat edge, while roughly half of locations in agriculture fields were within 15m of an edge.

All telemetered turtles in area 7 were observed in habitat that had been burnt earlier in the year, and a total of 69% of all locations were made in identifiably burnt habitat. In area 3, three of the telemetered turtles had home ranges which overlapped areas that had been burnt in early 2006. In total, 2% of all locations of Area 3 turtles were within burnt habitat.

Mark-recapture

The turtles are very camouflaged and can be quite difficult to find. Photo by J. Gibson.

A total of 163 captures were made during the course of 2006. Of these, 127 were new captures and 36 were recaptures. A breakdown of number of turtles captured from each area is provided in Table 3. Only 24 of the total number of turtles captured were found during the roughly 120 hours spent conducting dedicated mark-recapture surveys. The majority of turtles (i.e., the remaining 139 turtles, or 85%) were located while radio-tracking telemetered turtles. A map containing the locations of all turtles found during mark-capture surveys as well as during radio-telemetry efforts can be found in Figure 16.

Abnormalities and injuries were relatively common. Of the total number of turtles located, 17 were observed to be missing a foot. This number is likely an

underestimate as many turtles stayed retracted while they were being processed making quantification of deformities impossible. Additionally, nine turtles were observed to have identifiable bites marks, seven appeared to have fire scarring (as evidenced by "melted" looking scutes), and nine had exposed bone on their carapaces. Three individuals also had some evidence of an upper respiratory tract infection (sneezing, runny nose, blowing bubbles from nose), two had very enlarged ear abscesses, and one individual had an enlarged eye and was possibly blind.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Patterns of Movement and Habitat Use

The telemetered turtles from FCTC, particularly the females, were observed to make considerable long-distance movements and they also maintained large home ranges. By employing radio-telemetry we observed that several turtles (one female from TA 7, one female from TA 4, and three females from TA 3) crossed from FCTC onto the FCRA. This highlights that fact that not only do activities occurring on FCTC have the potential to impact box turtles, but so do activities occurring on the FCRA.

Nearly all of the telemetered females made directed movements to open-canopy areas during the nesting season. On FCTC, the nesting season was observed to occur approximately between early May and late June. Open-canopy areas, including prairie/grassland, and agricultural fields (on FCRA) were observed as suitable nesting sites (refer to Figures 12 and 13 for a map of nesting areas in each of TA's 7 and 3 respectively).

RECOMMENDATION - Activities that reduce habitat used for nesting, or that form a barrier to the dispersal of females to these nesting areas could have detrimental affects on not only the FCTC box turtle population, but also other turtle species which were also observed to nest in similar sites to the box turtles. In particular, use of vehicles and burning should be avoided in these areas in May and June. In addition, to minimize disturbance to nests (and hatchlings) earthmoving activities (e.g. graders, logging) should be restricted until after the turtles have entered hibernation (after late October). Unfortunately, the FCRA employs an independent burn schedule to that used by the FCTC. A late season burn that occurred during the nesting season was observed in an open-canopy area on the FCRA in 2006. Interestingly, the female from TA 7 that crossed onto the FCRA is believed to have used this burned area to nest several weeks after the burn occurred.

As well as being extremely important for nesting areas, open-canopy grassland/prairie habitats were also important for male and juvenile turtles. In TA 3, all three juveniles and six of the seven telemetered males, as well as numerous other turtles captured incidentally, were observed to make extensive use of the northern open-canopy grasslands. In fact, the aforementioned telemetered turtles occupied these areas for much of their active seasons (i.e., between April and October). In TA 7, two of the telemetered juveniles and three of the six telemetered males made extensive use of the mesic prairie. The importance of the mesic prairie to box turtles was additionally highlighted by the fact that at least one third of all turtle captures from TA 7 were made there. The third juvenile from TA 7 also utilized open-canopy habitat for the majority of the active season.

However, in contrast to all other telemetered turtles, this individual made extensive use of maintained road-side habitat southwest of the mesic prairie.

RECOMMENDATION - Due to the extensive use of open-canopy grassland/prairie habitats, by both telemetered and non-telemetered turtles alike, high impact activities in these areas would prove detrimental to the FCTC box turtle population. For example, any development of these areas would certainly have significant negative impacts, as would grading activities, and high vehicular activity. Extensive use of roadside habitat by one of the juvenile box turtles, as well as frequent observed road crossings by box turtles and also Blanding's Turtles on FCTC highlight the importance of mowing practices that are conducted with the safety of turtles in mind. Mowing deck height should be a minimum of 25cm in height, and equipment which allows for all tires of the tractor to remain on roads, minimizing tire rollover hazards, should be used, if at all possible.

In addition to open prairie/grassland habitat, wetland habitat was also observed to be important to the telemetered turtles on FCTC. The wetland complex on the eastern side of TA 3 was utilized as a travel corridor for several of the females as they moved to and from the northern open grassland areas in northern TA 3. The wetland complexes on both the eastern and western sides of the ridge just north of the mesic prairie in TA 7 were also observed to be important for both telemetered and non-telemetered turtles alike. The western wetland complex was similarly used as a travel corridor for some of the telemetered females as they moved to and from the northern open grasslands in northern TA 7. Several additional non-telemetered turtles were located in this wetland complex while tracking the telemetered turtles in this study. The eastern wetland

complex in TA 7 was also used extensively by box turtles. Two of the telemetered male turtles utilized this area during the active season and several additional turtles were located while tracking there.

RECOMMENDATION - To ensure the safety of turtles as well as other herpetofaunal species utilizing these areas, burns should only be conducted in these wetland areas during the inactive season (i.e., when the turtles are hibernating).

Of all the habitats used by turtles on FCTC, forest was observed to be used most extensively. Additionally, forest openings (for example, old two-tracks, wind-blows) were observed to be extremely important for box turtles, with many observations of both telemetered and non-telemetered turtles alike occurring in these areas.

RECOMMENDATION - To ensure their continued suitability to box turtles, we recommend that these openings be actively maintained as open-canopy habitat (a map of several forest openings to be managed is found in Figure 17a for TA 7, and Figure 17b for TA 3). A strategy that enhances these open canopy areas within FCTC should be considered.

As box turtles made extensive use of forested habitat on FCTC, any burning of forested habitats must coincide with when the turtles are hibernating. While box turtles were observed as early as April 14 on FCTC, a nearby property observed box turtles as early as April 4 (Chris Hoving, pers. comm.). It is hoped that the telemetered turtles will provide for more accurate emergence data this spring (2007), and consequently a better "cease burn date" for 2007 may be applied.

All but one telemetered turtle was observed to hibernate in forested habitat. Additionally, while statistical procedures have not yet been applied, we observed no

pattern to turtle hibernation locations. Consequently, activities that result in significant ground disturbance (for example, grading and logging) in forested areas of FCTC have the potential to kill hibernating turtles, as well as other species of amphibians and reptiles, during the inactive season (October through April).

As mentioned, only three of the female turtles (all from TA 7) did not make long-distance directed movements towards large open canopy areas. One of these turtles is missing a foot, and consequently may be unable to make long-distance migrations. Another turtle was captured later in the season, so it is possible that we missed any directed movements. No explanation can be provided for the third turtle. She was transmittered early in the study, but no long-distance directed movements were observed. A possible explanation for all three turtles may be that they were not gravid in 2006, or that they nested in the open-canopy areas in southern TA 7 (for example in the mesic prairie – depredated box turtle nests were located there). It will be interesting to observe the movement patterns of these three turtles in 2007 to see if they differ from their 2006 movements.

Further Management Considerations

Raccoons

Numerous injuries were observed on turtles from FCTC. Missing limbs and bite marks are likely due to raccoons. Additionally, numerous depredated turtle nests were also likely a result of raccoon activity. Due to the known negative impacts of raccoons on turtle nest success rates, and consequently turtle populations, management activities that focus on significantly reducing the raccoon population on FCTC are strongly

recommended. A reduction in raccoon numbers on FCTC would likely not only positively benefit the box turtle population, but also the populations of other turtle species, such as the Blanding's Turtle.

Fire

Telemetered turtles on FCTC were observed to use areas that had been previously burned, and many of the turtles from TA 7 are hibernating in burned areas. Four turtles from TA 7 were observed with evidence of fire scarring on their carapaces ("melted" looking scutes). Interestingly, three turtles from TA 3 (an area of FCTC which has not been burned) were also observed with possible fire scarring on their carapaces. As turtles from FCTC were observed to move onto FCRA it is impossible to conclude where the fire scarring observed on these turtles was derived. The radio-tagged turtles will provide an excellent opportunity to observe any direct effects of fire on turtles if fire is used in 2007 in any of the areas where the telemetered turtles are currently hibernating.

Burn Calendar. Based on data collected on the telemetered box turtles in this study burning on FCTC should be restricted to the inactive season, approximately November through March. Prescribed fires outside of this period run the risk of injuring box turtles, as well as other herpetofaunal species. If upland areas are to be included in burning regimes these areas should be prioritized and burnt before other habitats.

At the end of the 2006 field season temperature data loggers were attached to all adult turtles, and were also buried at varying depths near several hibernation locations. It is hoped that these data loggers may provide more accurate information on emergence dates from hibernation, and consequently more reliable cease burn dates may be highlighted. Data from this aspect of the project will be available mid-2007.

Mark- Recapture

With the continuation of the study in 2007 we will be able to complete a population estimate for each area surveyed on FCTC. However, some preliminary comments can be made from data collected in 2006. Twice as many turtles were found in TA 7 compared to TA 3 (109 total captures in TA 7 compared to 54 in TA 3). While it is too early in the study to conclude that box turtle density is higher in TA 7 compared to TA 3, the difference in available habitats between the two areas may potentially contribute to the observed differences in turtle numbers: TA 7 contains a greater diversity of habitat types, in a smaller area, as compared to TA 3.

Only eight of the 163 total turtle captures were juvenile box turtles. Compared to the telemetered adults, the telemetered juveniles appeared to utilize relatively moist areas with greater levels of brush and ground cover. They also made considerable use of cover objects (such as down debris) compared to adults. Their propensity for areas of dense vegetation and debris certainly contributes to them being difficult to locate.

It is also interesting to note that very few turtles were located during dedicated mark-recapture surveys, compared to those located while radio-tracking. On several occasions we came across multiple turtles within a very short time period while tracking one of the telemetered turtles. Mark-recapture efforts in 2007 will continue to include turtles found incidentally during telemetry efforts as well as those located during dedicated mark-recapture surveys.

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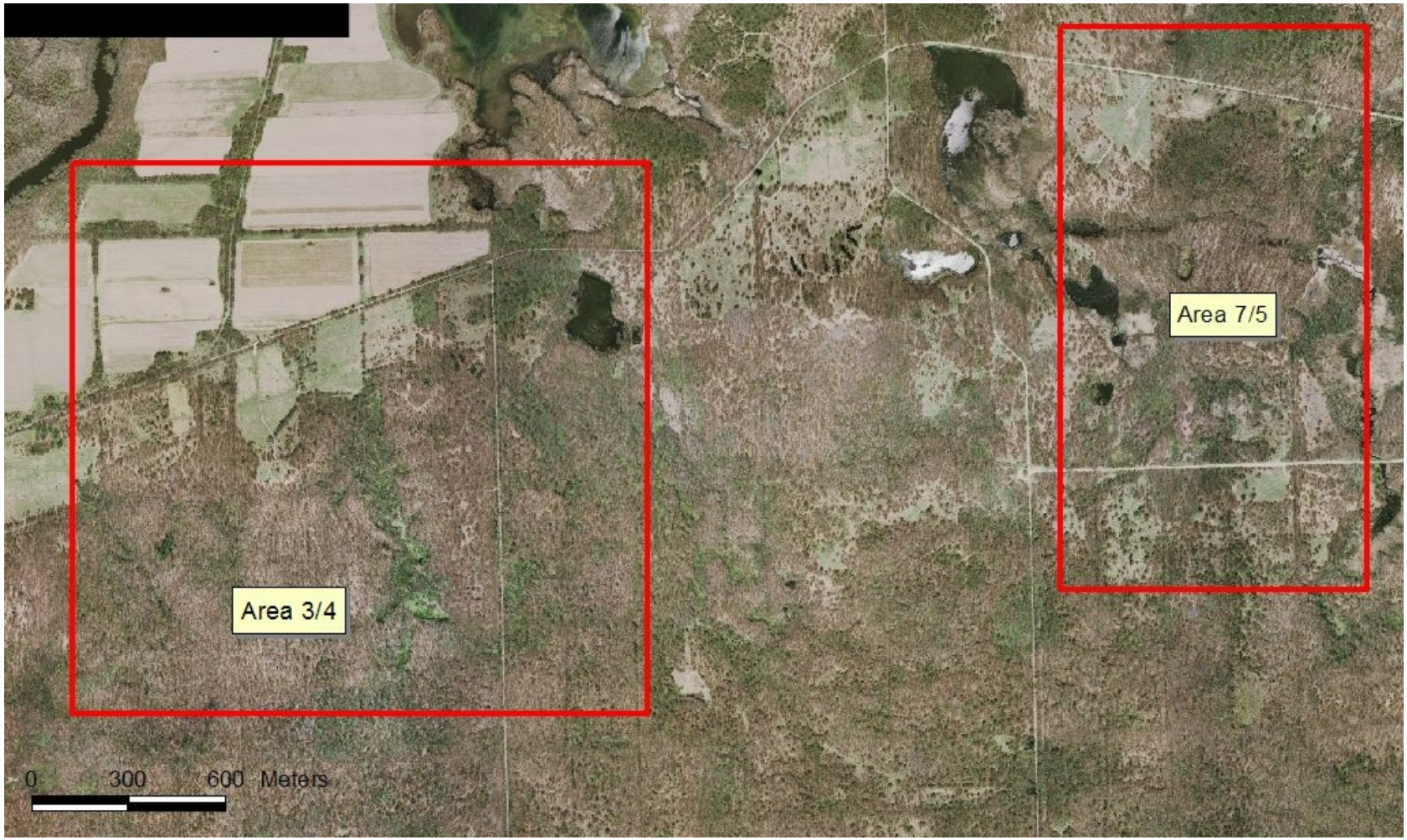

Figure 1. The study site on FCTC is comprised of two areas (delineated by red rectangles). One focuses on TA 3 and includes a small portion of TA 4 and the second focuses on TA 7 and includes a small portion of TA 5.

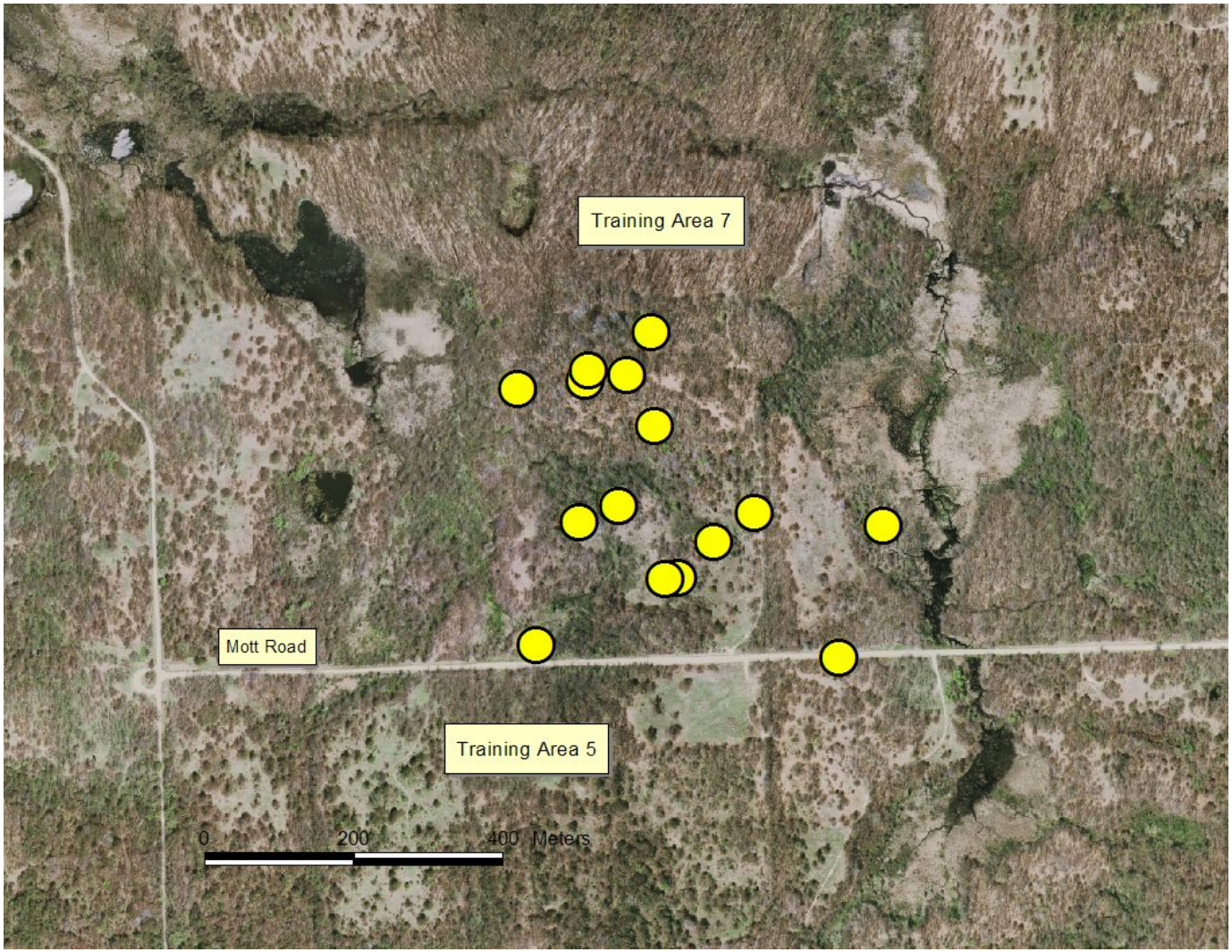

Figure 2. Initial capture locations for all telemetered turtles from TA 7

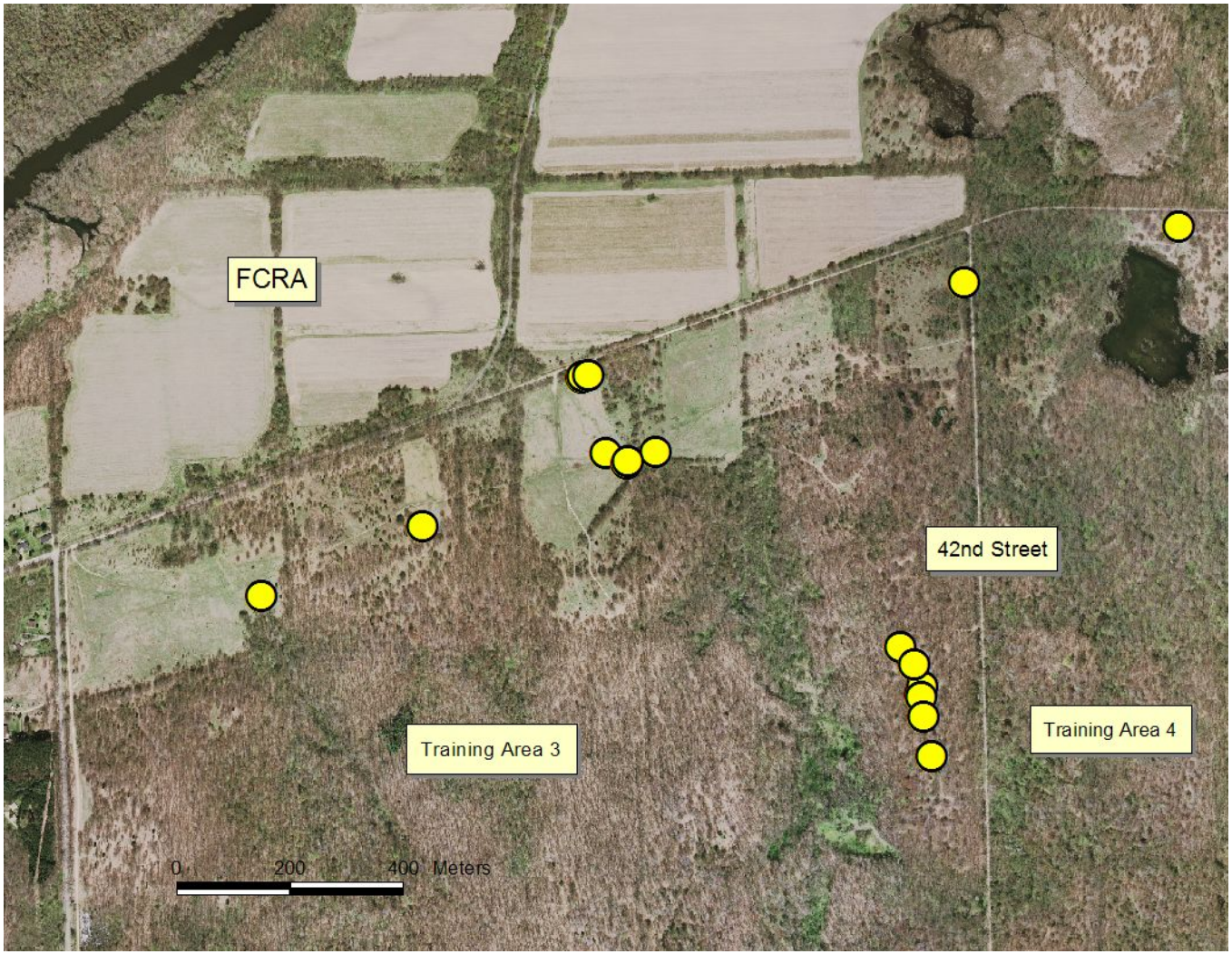

Figure 3. Initial capture locations for all telemetered turtles from TA 3 and TA 4

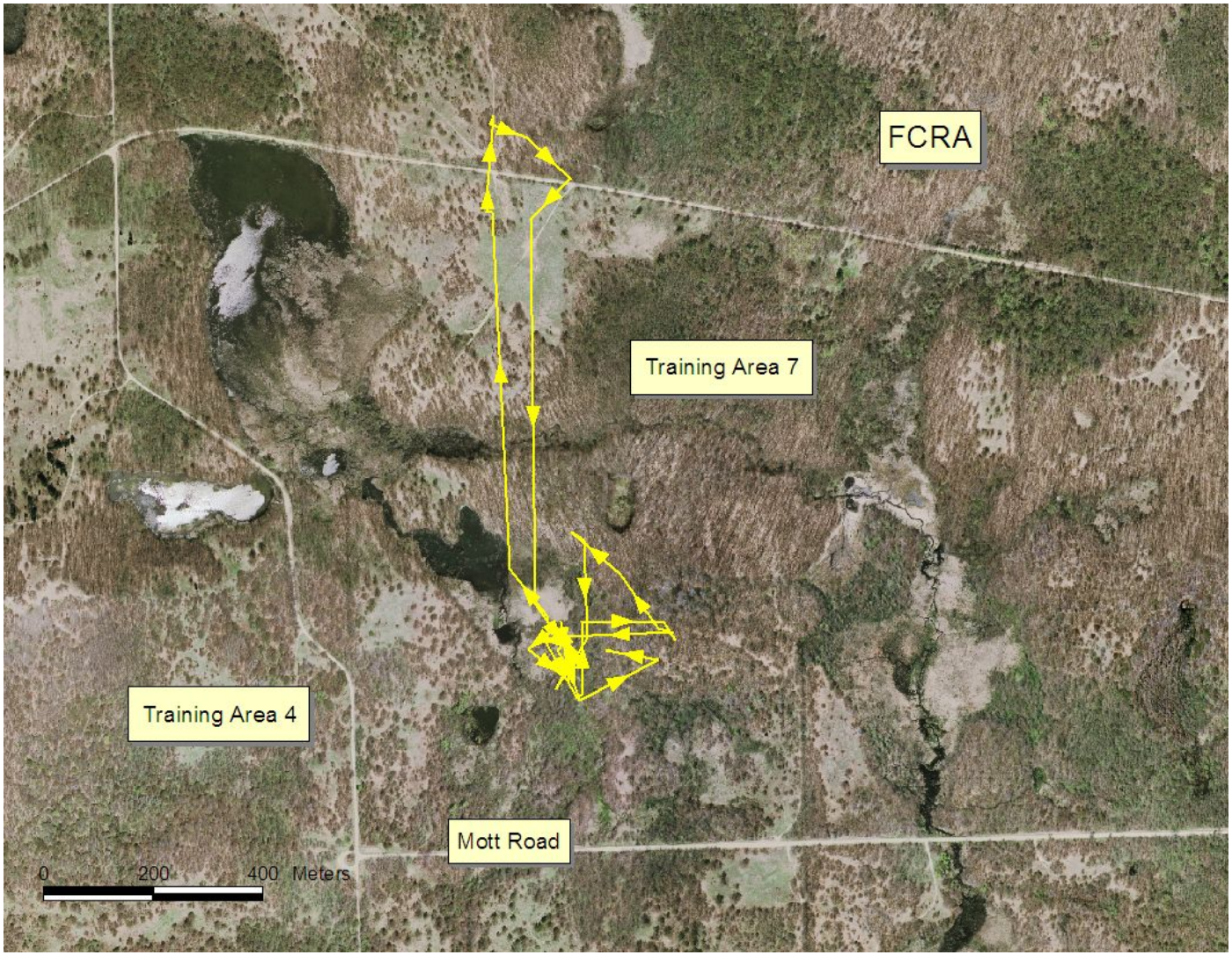

Figure 4. The seasonal movements of a telemetered female from TA 7. In spring 2006 directed movements of over 900m were made onto the FCRA.

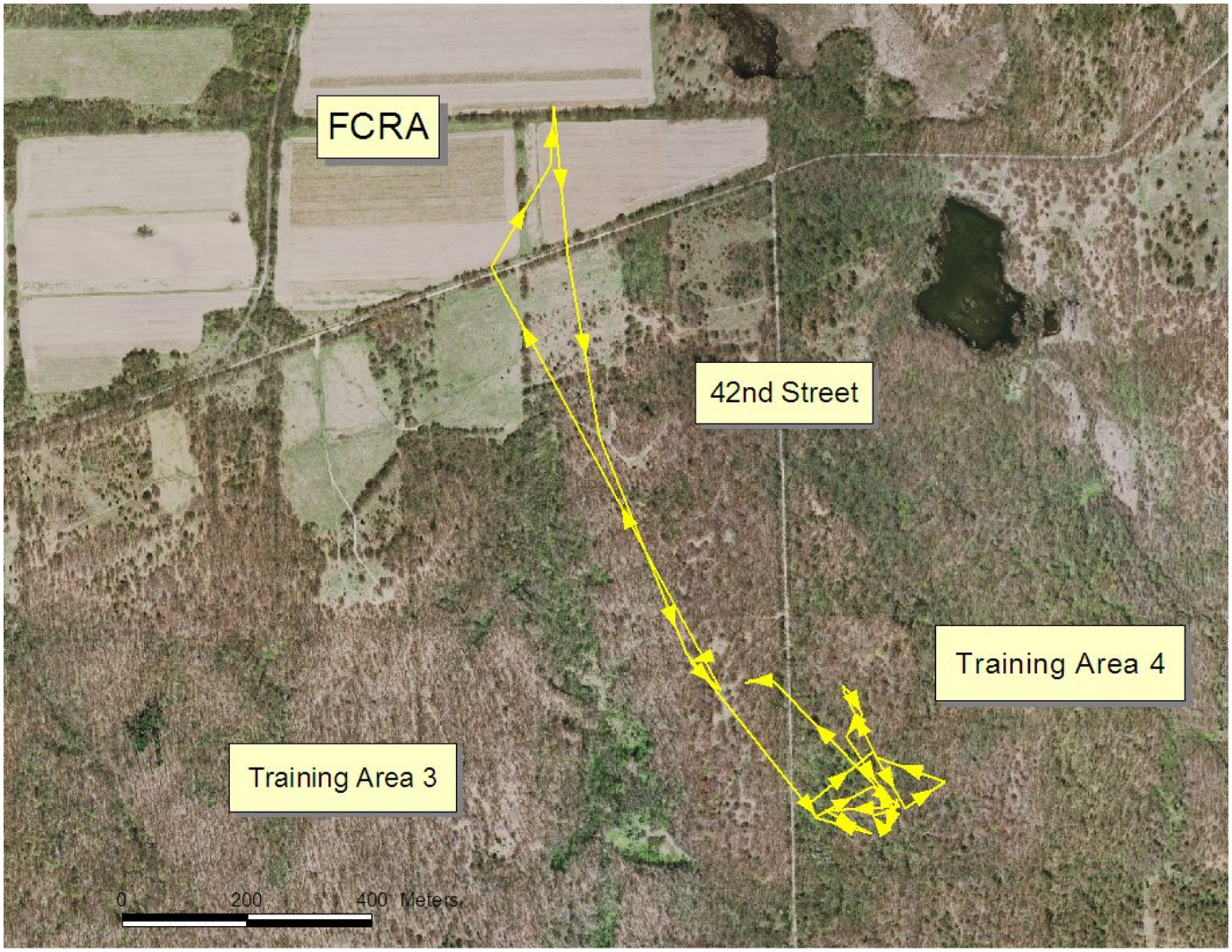

Figure 5. The seasonal movements of a telemetered female initially captured in TA 3. In spring 2006 directed movements of over 900m were made onto agricultural fields on the FCRA.

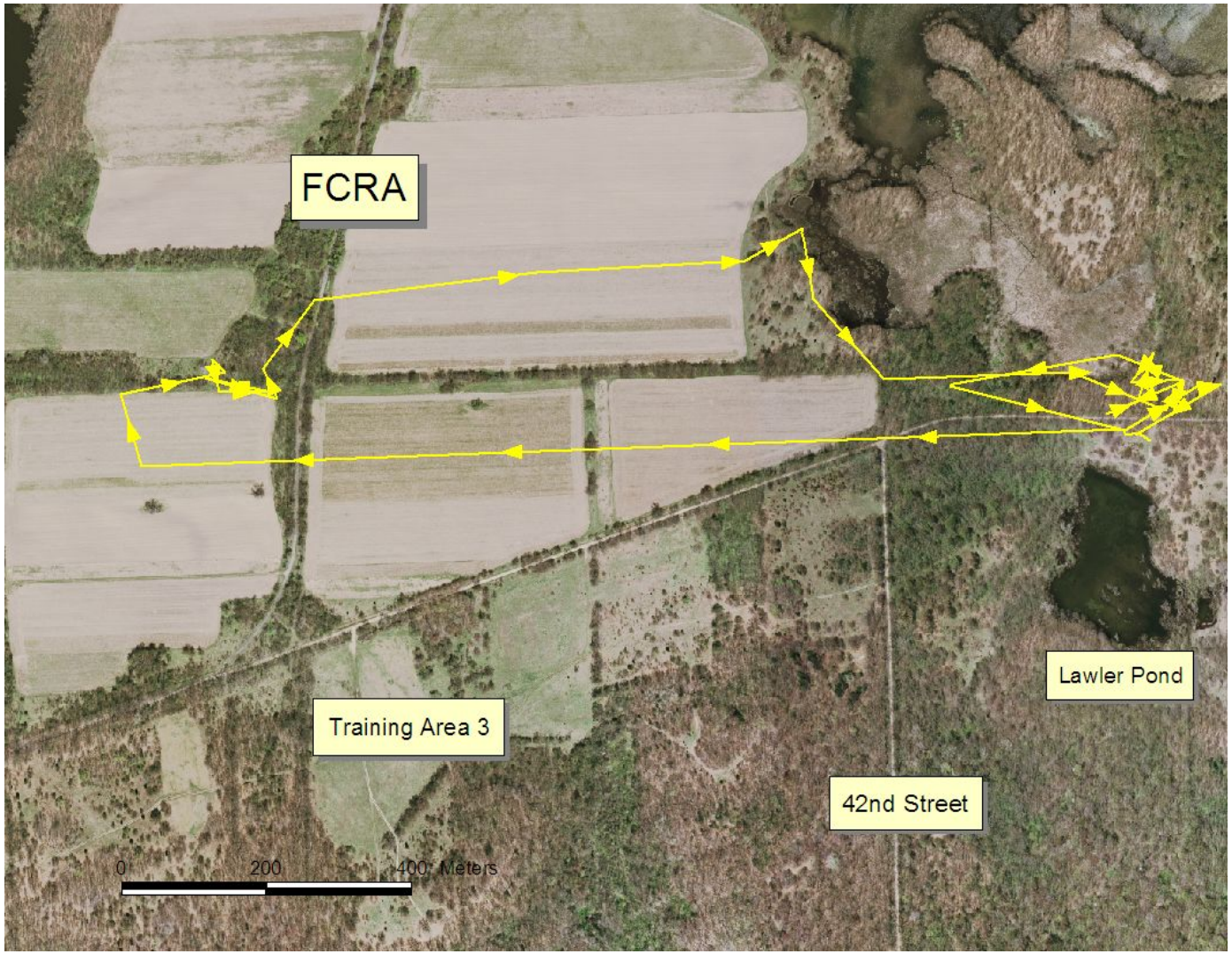

Figure 6. The seasonal movements of the single telemetered female from TA 4. In spring 2006 directed movements of over 1350m were made onto agricultural fields on the FCRA.

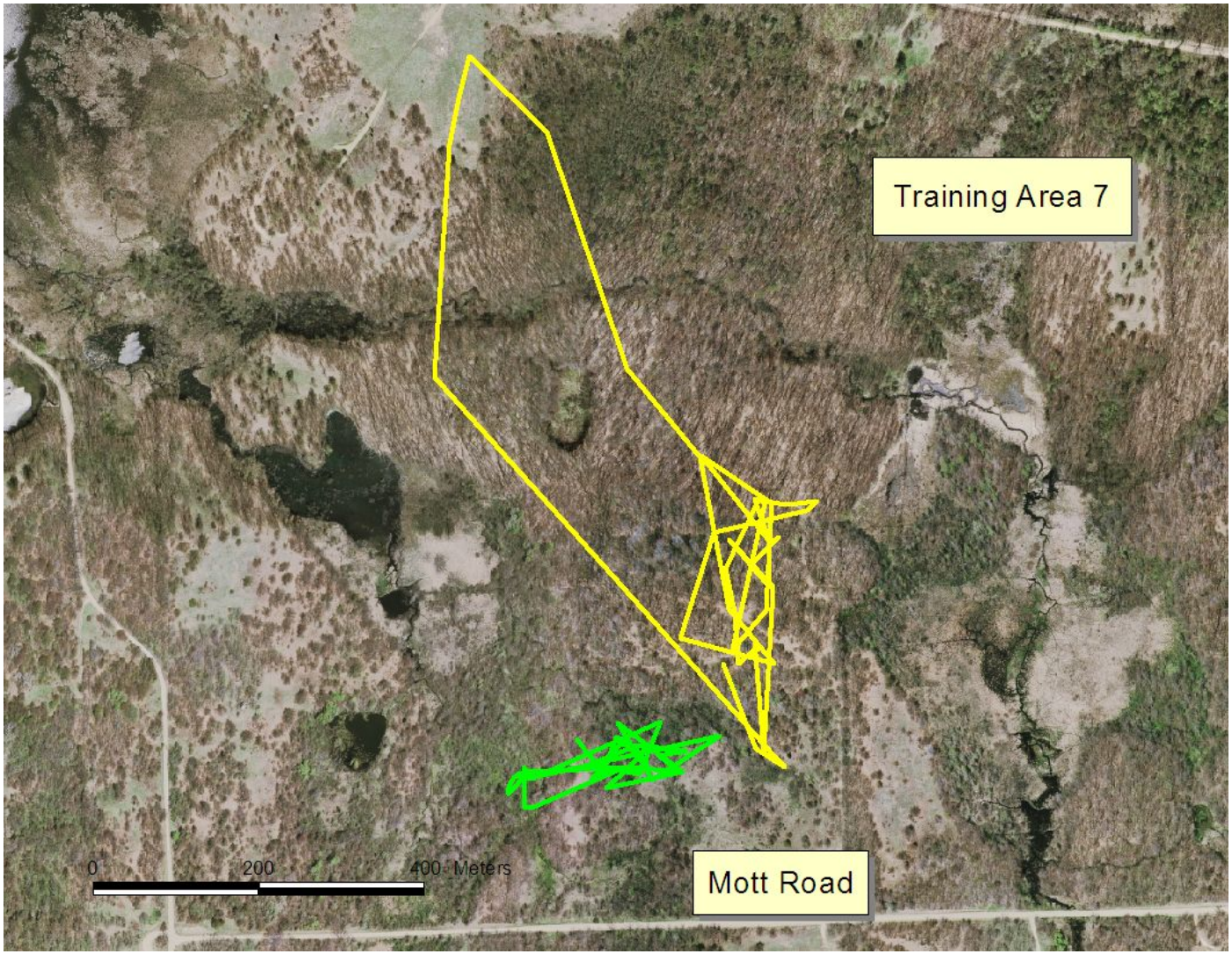

Figure 7. Comparison of movements of one female (in yellow) and one male (in green) turtle from TA 7. Males had significantly smaller home ranges than females.

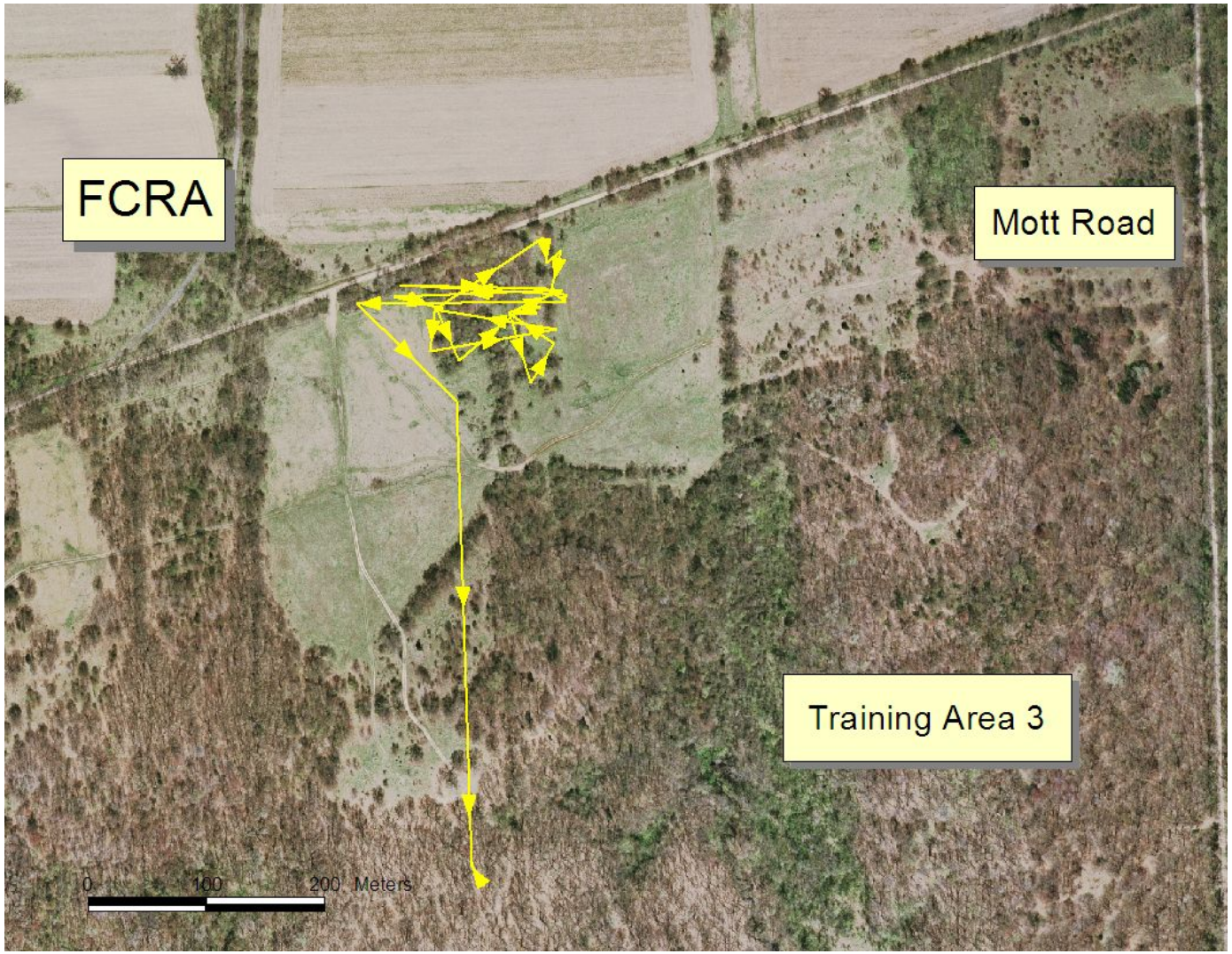

Figure 8. Long directed movements were made by several males in TA 3 as they moved south to hibernation locations in early Fall. Movements by one male is shown below.

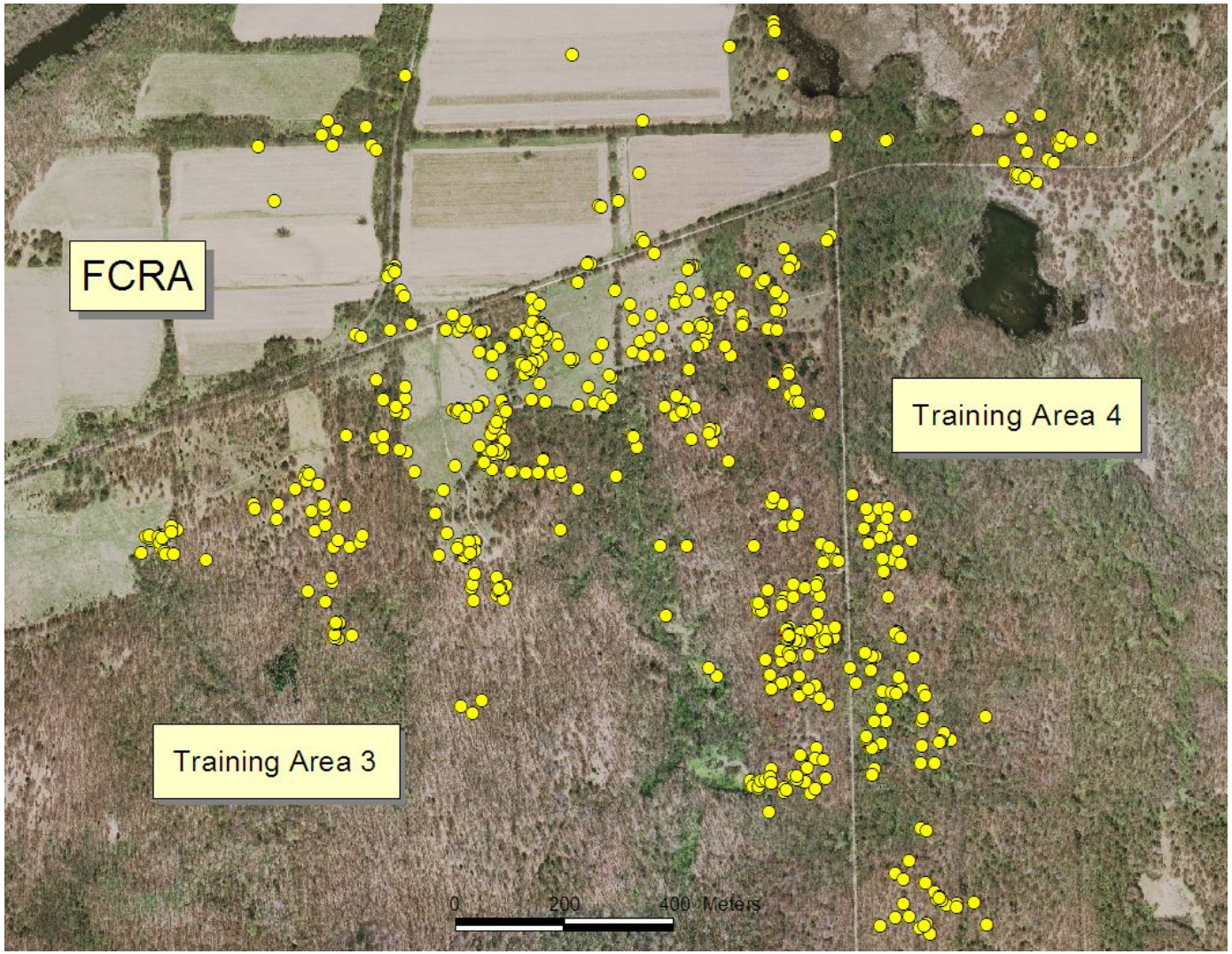

Figure 9a. All locations of telemetered turtles from TA 3 and 4 for 2006.

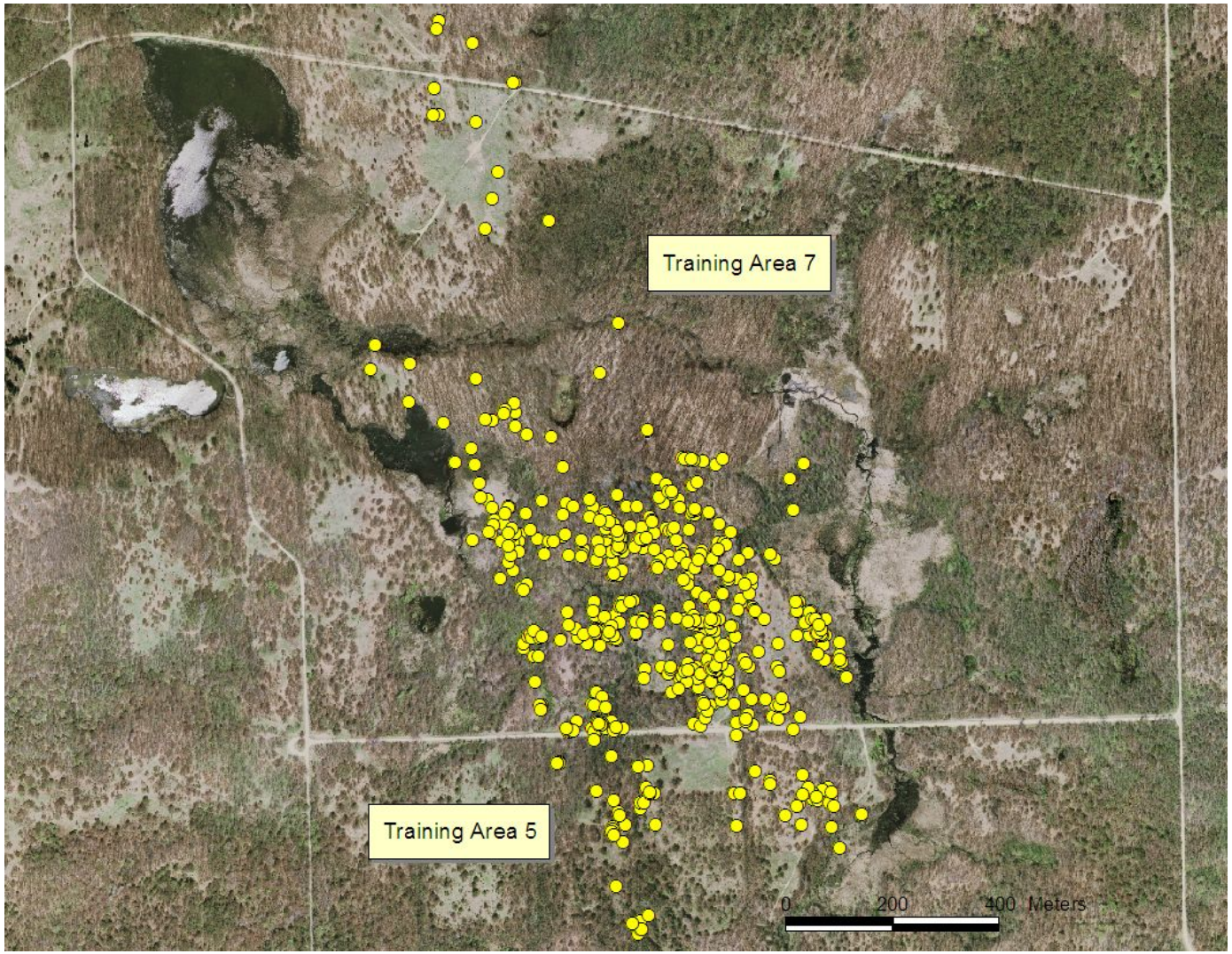

Figure 9b. All locations of telemetered turtles from TA 7 for 2006.

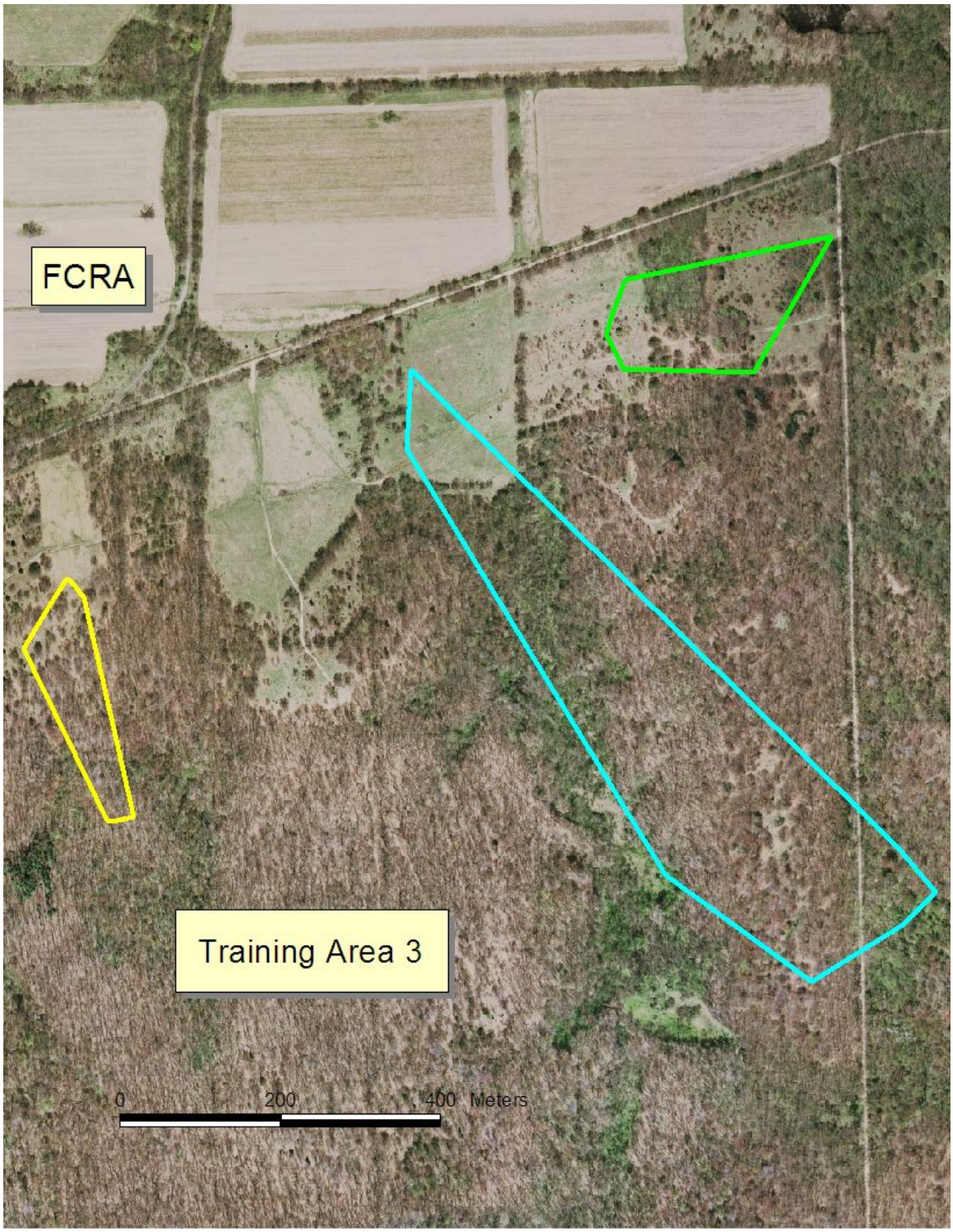

Figure 10. Comparison of home range size for one telemetered male (in green), female (in blue), and juvenile (in yellow) from TA 3.

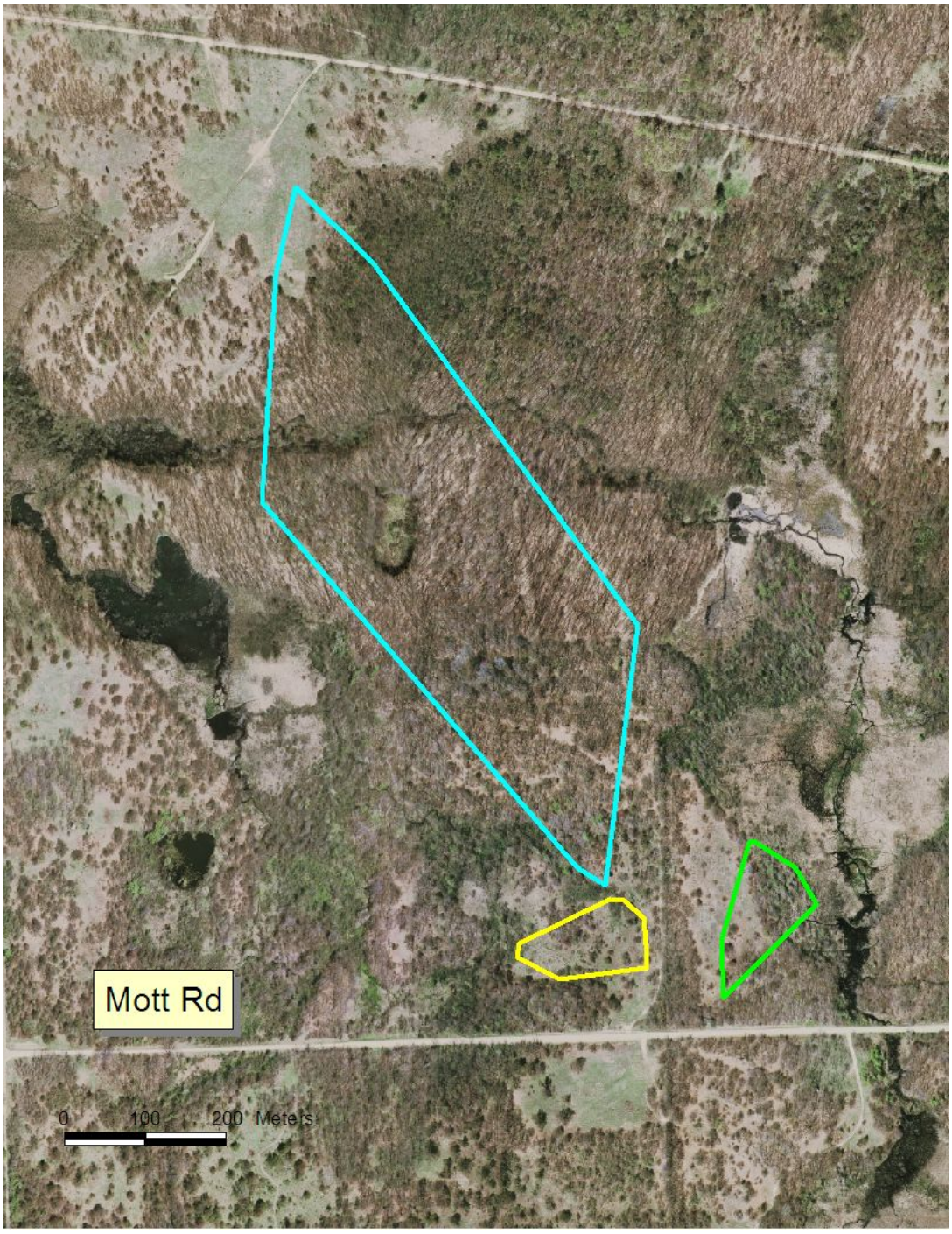

Figure 11. Comparison of home range size for one telemetered male (in green), female (in blue), and juvenile (in yellow) from TA 7.

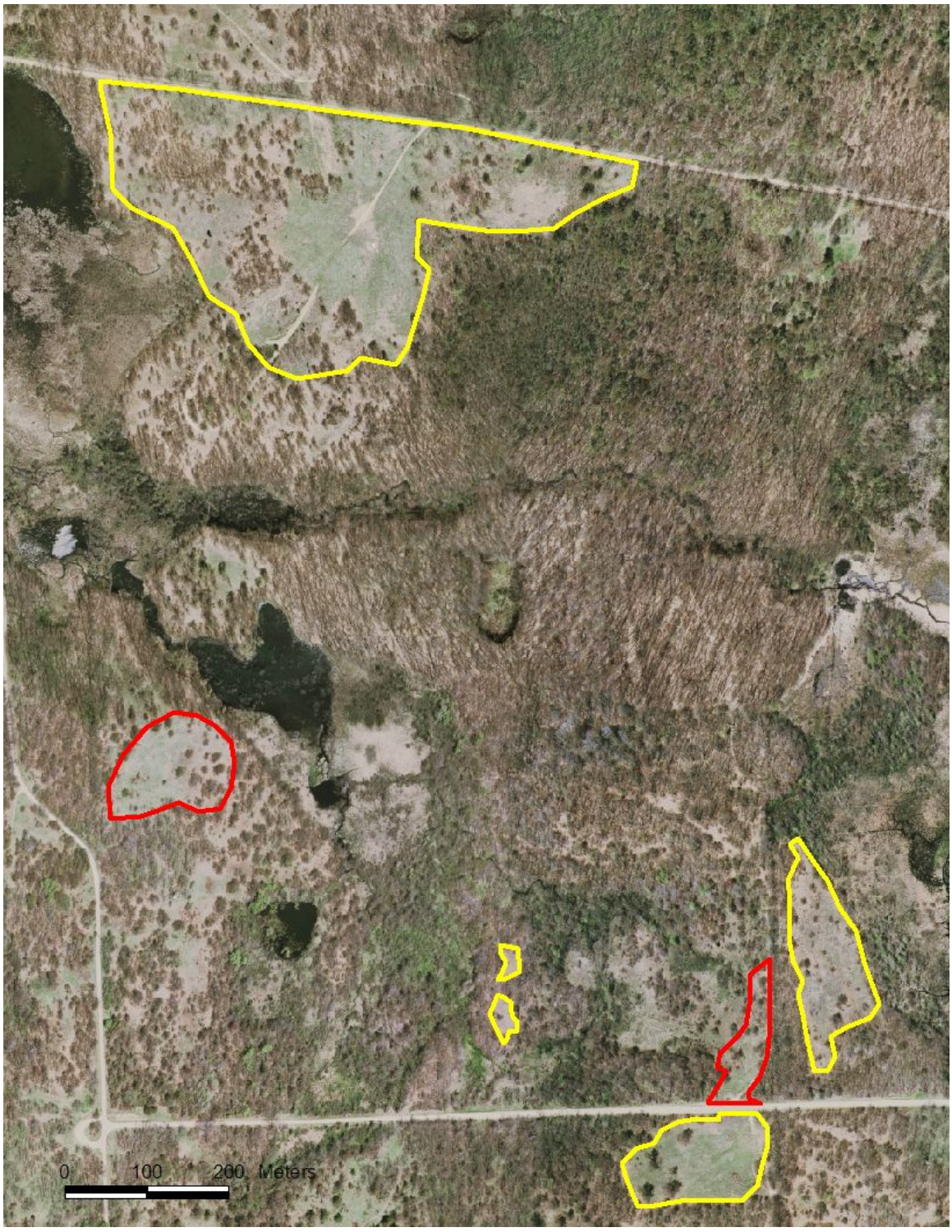

Figure 12. Observed (in red) and presumed (in yellow) nesting areas within the Study Area portions of TA's 7 and 5.

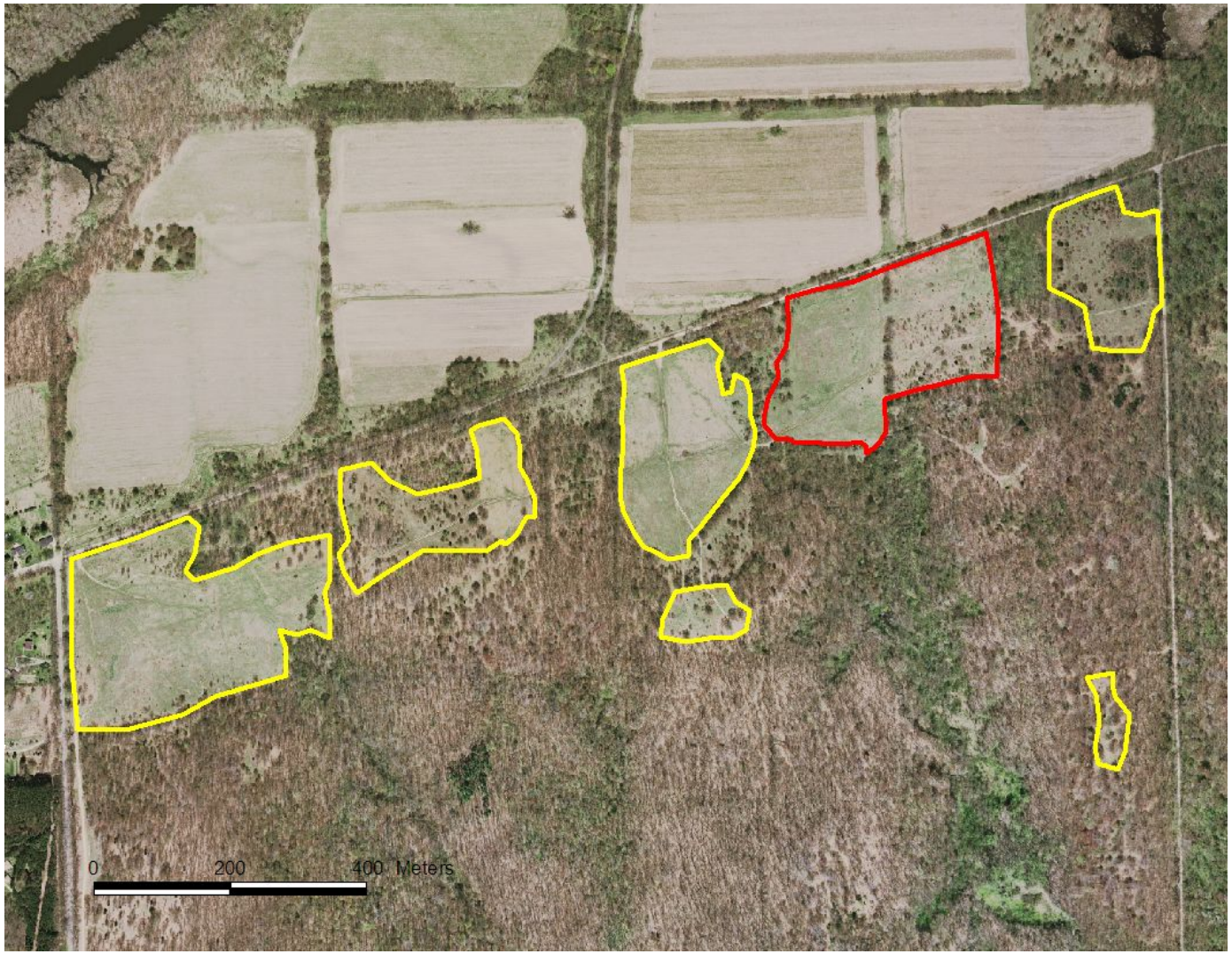

Figure 13. Observed (in red) and presumed (in yellow) nesting areas within the Study Area portions of TA 3.

Figure 14. Hibernation locations for all telemetered turtles from TA 7.

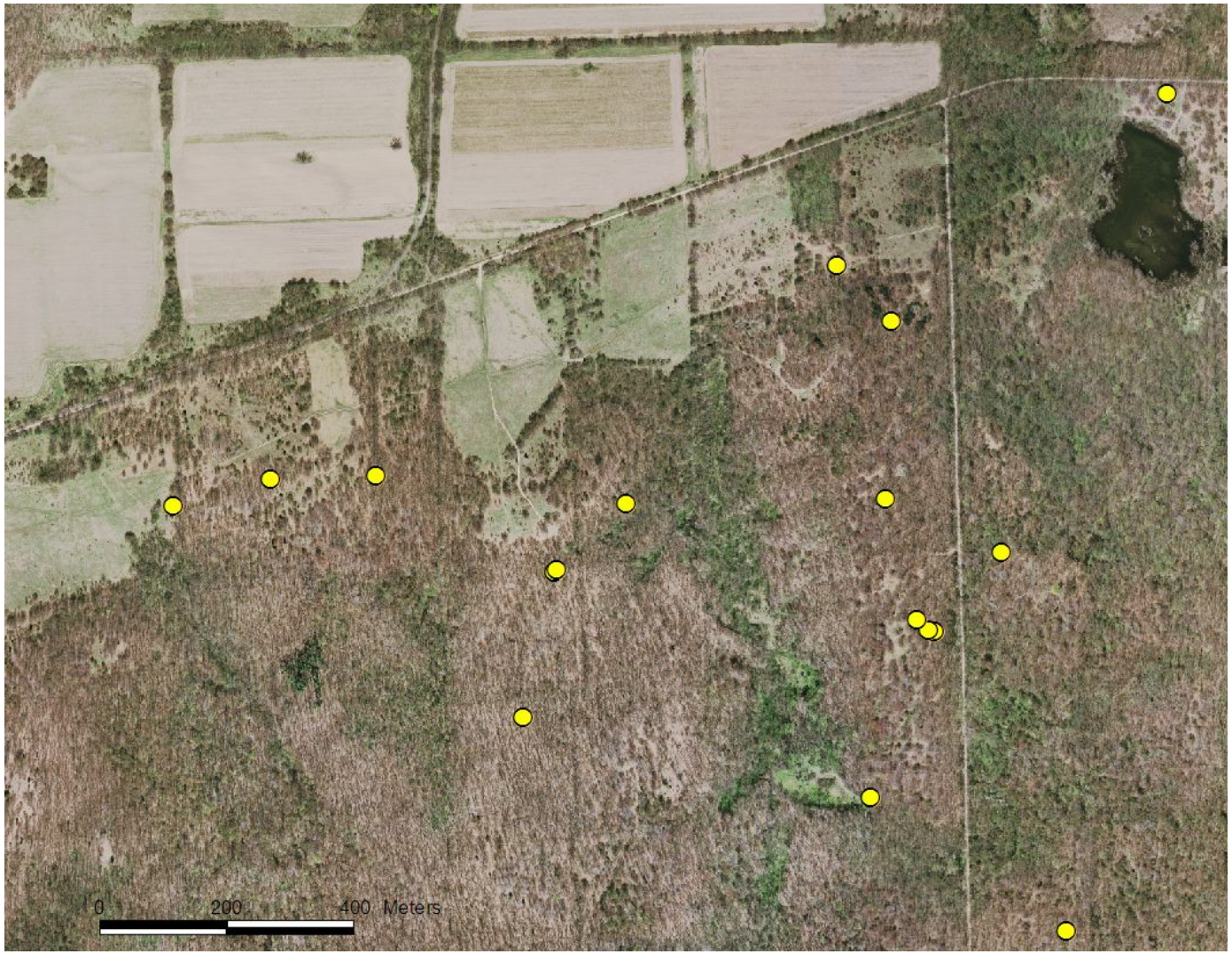

Figure 15. Hibernation locations for all telemetered turtles from TA 3 and 4.

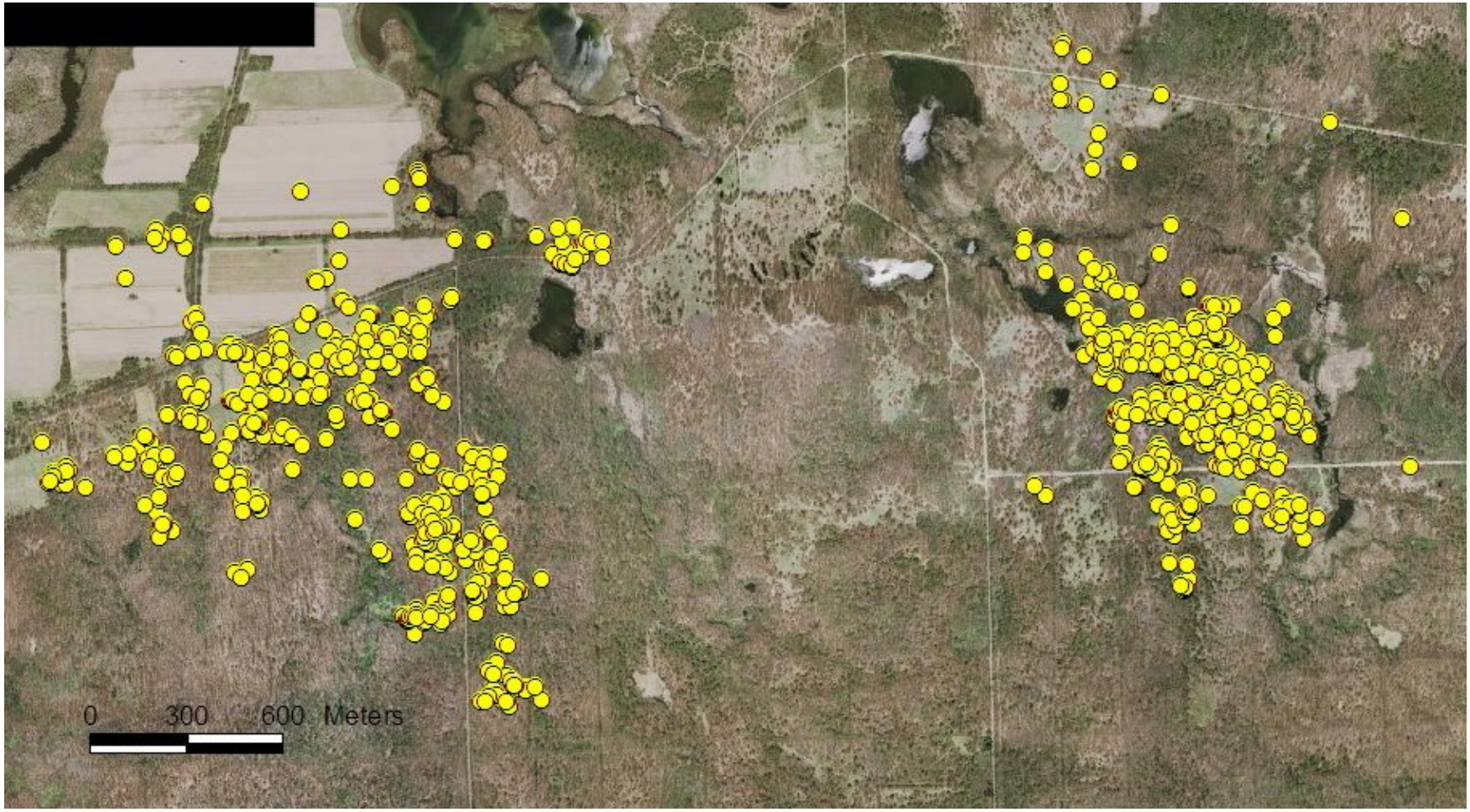

Figure 16. An overview of areas used by turtles in TA's 3, 4, 5, and 7. This map contains the locations of all turtles located during mark-recapture surveys, as well as all locations of the telemetered turtles.

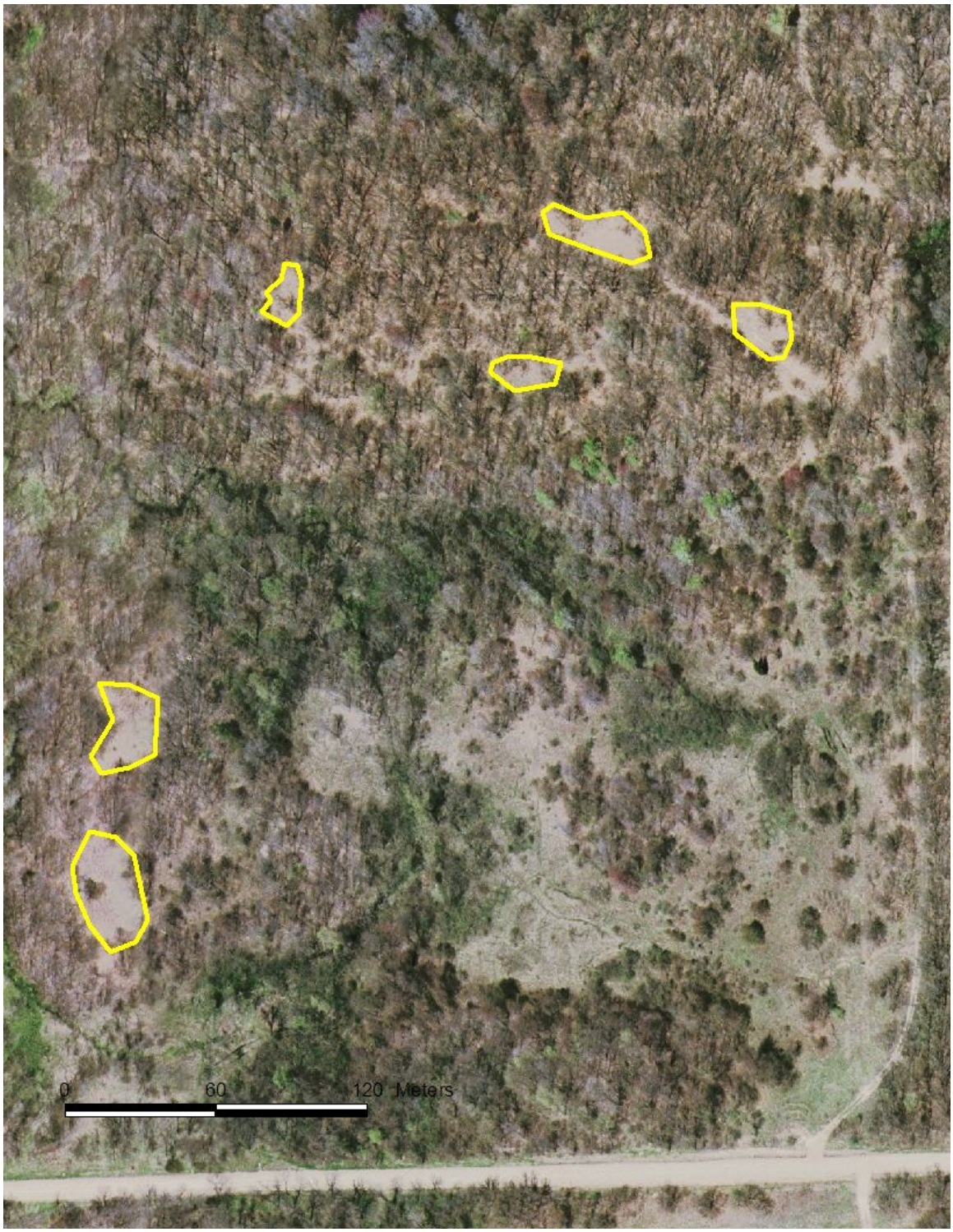

Figure 17a. Forest openings to be actively managed in TA 7. The four northern polygons are on and around the ridge north of the mesic prairie, and the two southern openings are directly west of the mesic prairie.

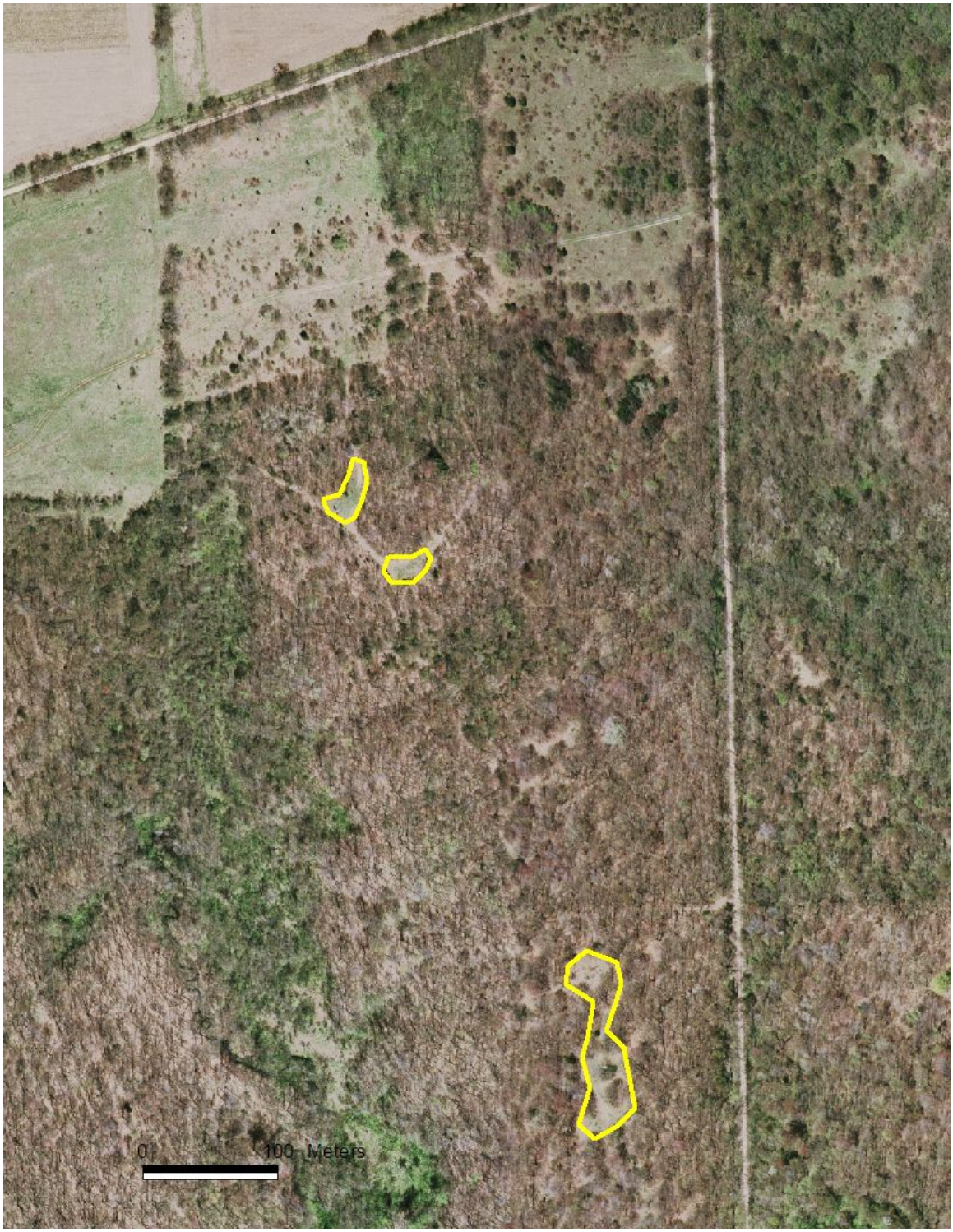

Figure 17b. Forest openings to be actively managed in TA 3. All three of these areas in on the eastern edge of TA 3.

Table 1. Capture date and morphometrics data for all 2006 telemetered turtles

Date	Area	Turtle #	Turtle Id (notch)	Sex	Annuli	Carapace length (mm)	Carapace width (mm)	Plastron length (mm)	Plastron width (mm)	Shell height (mm)	Mass (g)	Comments
4/14/2006	7	10	1-2	Female	14	118	91	127	65	71	480	Nail polish evident on rump, but cannot distinguish numbers.
4/15/2006	7	27	3-2	Female	16-20	142	112	147	83	71	590	Nail polish evident on rump, but cannot distinguish numbers.
4/15/2006	7	33	3-8	Female	21-22	134	109	134	73	71	600	
4/15/2006	7	34	3-3	Female	17	134	100	135	77	69	540	
4/22/2006	3	7	0-9,10	Female	18	137	116	135	69	62	535	Front of shell looks melted, all of the front marginals are deformed.
4/22/2006	3	25	9-9	Female	18-20	137	107	132	71	65	480	11 marginals on each side.
4/22/2006	3	26	2-2	Female	16	146	120	150	87	70	665	
4/23/2006	7	28	0-1,2	Male	20+	155	110	148	78	68	605	234 in red nail polish on hind carapace. Knicks on plastron, can see bone. 12th marginals on each side broken off. Middle toe, left front foot is very short. Previously notched by Kelly.
5/8/2006	3	9	3-9	Female	15+	134	101	137	74	73	560	Sneezed a lot when processing.
5/10/2006	7	8	10-9	Male	15+	149	108	139	81	61	545	26 written in red nail polish on rump. Very gnarly guy. Both carapace and plastron are quite irregular.
5/10/2006	7	12	9-11	Female	17+	135	98	133	76	62	480	Carapace too warn to count annuli.
5/10/2006	7	21	2-9	Male	20+	149	109	144	84	73	585	Possibly 224 in red nail polish on rump. Right front foot missing 4th nail from center; left front foot missing 2nd and 3rd nail from center.
5/10/2006	7	24	3-10	Male	18+	152	105	133	79	60	510	Front marginals broken off.
5/14/2006	4	13	2-3	Female	17+	134	95	130	70	70	520	Bone exposed on 4th pleural on both sides.
5/14/2006	3	19	2,2-0	Male	16+	134	100	134	75	68	545	11 marginals. Missing two outer nails on front left and missing middle nail on front right. Beak looks gnarly.
5/16/2006	7	32	1-11	Male	18+	140	103	132	76	64	480	Red nail polish on rump; could not make out number.
5/19/2006	3	14	2-11	Female	16+	148	114	142	73	71	600	
5/22/2006	7	11	8-2	Female	16	132	102	129	71	72	505	11 marginals on both sides. Nice looking female.
5/23/2006	7	22	3-12	Female	15+	155	115	149	71	79	760	Missing hind right foot. 8 in red nail polish on rump.
5/24/2006	7	17	2-1	Female	12	125	98	123	75	71	485	
5/24/2006	3	20	Did not notch	Female	14+	127	110	125	67	70	485	99 in red nail polish on rump? All marginals are damaged, so did not notch. Front left foot - around toes is a bit deformed - does not have all 5 toes. Missing 2 or 3 and one of nails is weird - doubled up? Abscesses in both ears.
5/24/2006	3	23	8-3	Male	15+	145	111	135	76	83	500	11 marginals on left; 12 on right. Handsome, very orange head and forelimbs.
5/31/2006	7	31	0-2,10	Male	22+	181	136	152	83	73	640	Red paint, but can't read the numbers
6/1/2006	7	2	Did not notch	Juvenile	6	97	81	105	61	57	190	First three marginals on each side look melted.
6/6/2006	7	4	Did not notch	Juvenile	4	95	74	93	57	50	167	Nice looking little turtle.
6/13/2006	3	3	Did not notch	Juvenile	6	108	85	110	61	51	165	Missing front left foot. Right ear abscessed.
6/13/2006	3	29	12-9	Male	13+	140	119	140	81	66	535	Missing part 1st marginal (right) and half of cervical. Half of first marginal on each side looks melted.
6/13/2006	3	30	12-8	Male	23+	151	117	142	83	67	550	Cervical scute missing. Very yellow turtle - hardly any black.
6/19/2006	3	16	10-2	Male	16+	148	111	138	79	74	555	Evidence of nail polish on rump (can't read the number).
6/21/2006	3	15	0-2,11	Male	14+	154	105	137	77	67	530	13 marginals on each side.
6/21/2006	3	18	2,8-0	Male	15+	144	103	137	84	70	560	11 marginals on each side.
6/28/2006	3	5	Did not notch	Juvenile	6	91	67	91	52	46	133	Shell in excellent condition.
6/28/2006	3	6	Did not notch	Juvenile	6 or 7	85	75	82	58	52	145	Quite a lot of damage to plastron. Carapace - front left 2 marginals missing - looks like bite marks. Front 2 marginals on each side missing.
7/5/2006	7	1	Did not notch	Juvenile	6	88	73	89	50	47	133	

Table 2. Means and data range (parentheses) of home range, activity center use, range length and total distance moved. Columns marked with an asterisk indicate significant differences between turtle classes as determined by MANOVA for that parameter.

Turtle class	Home Range	Activity Center	Range length (m) *	Total distance moved(m) *
	MCP (ha) *	50% KD (ha) *		
Female	16.18 (3.59 - 27.04)	2.59 (0.76 - 5.82)	876 (347 – 1343)	3644 (2106 – 4858)
Male	4.52 (1.14 - 11.36)	0.91 (0.17 - 3.54)	386 (180 – 693)	2323 (1294 – 3755)
Juvenile	1.66 (0.40 – 4.04)	0.49 (0.05 - 1.13)	267 (119 – 570)	968 (591 – 1296)

Table 3. Numbers of new and recaptured turtle by sex from each area for 2006.

Area	Sex	New Captures	Recaptures	Total New Captures	Total Recaptures	Total captures
3 and 4	Male	13	1	48	6	54
	Female	31	5			
	Juvenile	4	0			
5 and 7	Male	26	9	79	30	109
	Female	49	21			
	Juvenile	4	0			