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Wild Turkey Responses to Forest Management

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INHS Technical Report 2019 (23)

Prepared for IDNR Division of Wildlife

Issued on 8/31/2019

Release online immediately;

Final Report for W-183-R-5

Wild Turkey Responses to Forest Management

(i) Project Information

a) Project Title: Wild Turkey Responses to Forest Management

b) Project Number: W-183-R-5

c) Legal Name of Entity doing the Project: The Board of Trustees of the University of Illinois

d) Period of Time covered by this report is 07/01/2018-06/30/2019

e) Due Date of the Final Report is 08/31/2019

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Overview and Objectives

Lack of disturbance has led to the degradation of Illinois forests and open woodlands. As with forests throughout the Midwest, these historically oak-dominated systems are transitioning into closed-canopy forests that are dominated by shade-tolerant species such as maples. Much of this transition has been attributed to the exclusion of both anthropogenic and natural fires from contemporary landscapes (Abrams and Nowacki 2008). Beyond encroachment of shade-tolerant native species, the understory layers of many Midwestern forests and open woodlands have become encroached with exotic species such as honeysuckle (*Lonicera* spp.) or buckthorn (*Rhamnus* spp.). These large-scale alterations of forest and woodland ecosystems have adversely impacted numerous conservation-priority wildlife species that have historically depended on relatively open oak-dominated systems, including red-headed woodpeckers, whip-poor-wills, and wild turkeys.

Aside from being potential indicators of ecosystem health, wild turkeys are an economically important game species. Accordingly, considerable research attention has focused on understanding broad-scale habitat associations of turkeys and estimating demographic parameters. Forests or woodlands with mature trees are known to provide habitat that is preferred by turkeys for parts of their annual cycle (Miller et al. 1999), but turkeys have extensive and seasonally variable home ranges (e.g., <1 to 32 km^2; Thogmartin (2001), Badyaev et al. (1996a)). The importance of different habitat components is likely seasonally dependent, with food availability and safety from predators being important year-round, but with quality nesting and brood-rearing habitat being important during spring and summer. Aspects of vegetation structure and composition, including understory density, are known to influence nest-site selection and reproductive success (Badyaev 1995, Badyaev et al. 1996b, Locke et al. 2013), but quantitative information on important habitat characteristics during other stages of the annual cycle is generally lacking. Beyond influencing habitat use, the structure and composition of vegetation may influence the frequency and distance of movements, quantities negatively associated with survival (Hubbard et al. 1999). However, despite the numerous links between vegetation structure and aspects of wild turkey habitat use and demography, information on turkey responses to management actions is generally lacking. One additional factor, black flies (*Simulidae*), may play a role in limiting wild turkey reproductive success, particularly in western Illinois. While black flies have been documented reducing breeding success in some bird species (Smith et al. 1998, Solheim et al. 2013, Franke et al. 2016), their effect on wild turkey populations is unknown.

To better understand the response of wild turkeys to forest management activities and black flies, the objectives of Segment 5 of the Wild Turkey Responses to Forest Management research project were to:

1) Continue radio-tracking Wild Turkeys captured during the previous segment and capture and affix radios to up to an additional 40 hens enhance sample sizes across study sites;

2) Use micro-GPS telemetry to examine the effects of forest management, habitat and landscape features, and black flies on Wild Turkey habitat use, survival and reproductive success, emphasizing central and western Illinois sites;

3) Use micro-GPS telemetry, accelerometer data, and insect surveys during the breeding season to document potential effects of black flies on hen turkey incubation behavior, hen and nest mortality, and possibly poult survival;

4) Submit at least one manuscript for publication in a peer-reviewed journal and provide one popular article about this project to the Illinois Department of Natural Resources by the grant end date (popular article will be approximately 500 words in length with at least two pictures provided).

Methods

Given the importance of adequate nesting and brood rearing habitat to wild turkey demographics (Badyaev 1995, Thogmartin 1999, Thogmartin and Johnson 1999, Spears et al. 2007, Fuller et al. 2013), our primary focus is on the movements, habitat selection and survival of turkey hens throughout their annual cycle in areas where forests are actively being managed in ways that are intended to promote favorable nesting and brood rearing habitat.

Study Sites. We conducted this research at locations in central and western Illinois. Sites in central Illinois included Hidden Springs State Forest (Hidden Springs), Lake Shelbyville – U.S. Army Corp of Engineers land (Lake Shelbyville), and Ramsey Lake State Park (Ramsey Lake), while sites in western Illinois included four privately-owned sites (Buckeye Creek, McAllister Farm, Syrcle Farm, and Twin Rivers Sow Incorporated). Additional baiting occurred at an additional private property adjacent to Hidden Springs. At Hidden Springs, there has been forest management during the past decade (e.g. non-managed areas, and maple and exotic plant control with and without frequent fire) resulting in some prerequisite forest units needed to study the effects of forest management on hen turkey habitat use throughout an annual cycle. At Lake Shelbyville, oak, hickory and maple flourish in the uplands. Improvements to the forest consist of tree thinning to enhance mast production and understory growth (e.g. 40-160 ha per year), prescribed burning (e.g. 20-80 ha per year), and invasive species eradication (such as bush honeysuckle and autumn olive). The active management at Lake Shelbyville is distributed in small units spread out over a large area. At Ramsey Lake, there is a long and well-documented history of forest management, particularly prescribed fire and some thinning. This site also has a decent turkey population and some areas of forest that are not managed. We expected that the central Illinois sites would have few to no black flies present. We continued to work on private sites in western Illinois where turkeys had been captured in the previous season because we were still monitoring individuals from the previous year and turkey flocks were again observed on sites prior to or during the 2019 capture season. These privately-owned sites have had limited forest management historically (e.g., thinning, prescribed fire), and should have high numbers of black flies during the period of time when their emergence occurs.

Capture and Tracking of Turkeys. We captured turkeys using cannon nets (i.e. Netblasters) at sites baited with cracked corn during winter (mid-January - March) of 2019. Each captured bird was banded with an aluminum rivet leg band. Age of each captured individual was determined by evaluating the shape, wear, and barring on the 9^{th} and 10^{th} primaries (Leopold 1943), and sex was determined using a combination of morphological features (e.g., caruncle coloration, beard presence, leg spur presence and length, breast-feather coloration. Every hen and some males were fitted with a MiniTrack or PinPoint µGPS transmitter (Lotek Wireless Inc., Ontario, Canada). We released all birds at the capture site immediately after processing. Transmitters were programmed to record a location every 30 minutes during daylight hours (e.g. 0500-1900 hours) and one location at midnight (i.e., 28 locations daily) between time of capture till the end of June. After June, the transmitters were programmed to record a location every two hours during daylight hours and one location at midnight (i.e. 9 locations daily). Each µGPS unit is also equipped with a dual axis activity sensor which records forward-backward (x-axis) and left-right (y-axis) movements (Lotek user manual, revised 2018). Activity is measured simultaneously on each axis four times per second, and recorded as the difference in acceleration between consecutive measurements within a range of 0 to >800. These measurements (x and y) are averaged over one-minute intervals. Values < 20 are not considered active movement.

Based on this transmitter configuration, we expected the units to collect data for up to approximately one year. Remote download of the stored location and activity data on transmitters permits us to collect the data without disturbing nesting hens or influencing turkey movements. Each µGPS-marked bird was relocated every week during the breeding season and bi-weekly during the non-breeding season, using a 3-element Yagi antenna and a receiver (R-1000, 148-160 MHz, Communications Specialists Inc.). Upon relocation of a bird, we positioned ourselves within 500 m of each bird to facilitate use of a Handheld Command Unit (HCU; Lotek Wireless Inc., Ontario, Canada), and remotely downloaded location and activity data from the µGPS unit. Individual birds were monitored until death of the animal or the end of the life of the µGPS unit. These methods were approved by the University of Illinois at Urbana-Champaign Institutional Animal Care and Use Protocol (#15010).

<u>Nest, Hen, and Brood Survival</u>. We will use known-fate or other appropriate models (Allison 2011) to estimate the survival rates of hens and nests. In the results we currently report summaries of the fates of nests and radioed birds, and during the next segment we will continue to develop and complete the survival rate models for hens and nests and will provide those as they are completed.

Nest fate. We used location and activity data from µGPS-monitored hens to determine nest locations. Hatch dates were estimated based on the date when activity data first indicate a hen had low movement values (i.e., ≤ 15) for about 22-23 hours per day, indicating incubation had begun. After 28 days of incubation (Paisley et al. 1998), each nest was located to determine nest fate. Nests where egg shells remained mostly intact (i.e., not crushed or scattered) were classified as successful and attempts were then made to obtain visual confirmation of poults with the hen. Nests were classified as failed, and presumed predated, if egg shells were found smashed and scattered and no poults observed with the hen during the following week. If a hen terminated incubation early (< 28 days), the nest location was visited immediately to determine nest fate, and was classified abandoned if eggs were intact, or predated if eggs were destroyed.

Hen fate. During the breeding season, hens were monitored once weekly to download data and check for a mortality beacon. Each μGPS was programmed to emit a mortality beacon after 32 hours of inactivity. Unpublished data suggest that hens may sometimes remain on the nest for ≥ 24 hours during inclement weather which produces a false mortality signal. If a mortality signal was detected, hens were located, and intact carcasses collected for necropsy at the University of Illinois Veterinary Diagnostic Laboratory. Any signs observed at the carcass location, indicating predation by a specific animal (e.g., fur, feathers, tooth or claw marks, etc.), were noted. Due to the difficulty of identifying predator species without direct observation, we only seek to determine if predation was the cause of death.

Brood Surveys. For hens with successful nests, brood surveys were conducted weekly for up to 8 weeks. These hens were located via telemetry each week following a successful hatch. Each week hens were directly observed one time when possible to determine whether there were any poults with her (yes, no, uncertain) and to record the maximum number of individual poults observed.

Nest-site Vegetation Surveys. Several parameters were measured at each nest site as well as a paired "non-nest" location (80 m from each nest, in a randomly-determined direction) associated with each nest. To evaluate visual obstruction around turkey nests, we measured the distance to the nearest obstruction (e.g. foliage or stems) above the nest up to 5 m. Visual obstruction at 15 m from a nest was also recorded whereby a technician held a density board (Nudds 1977) at the nest bowl facing the direction of a 2nd technician located 15 m from the nest. The 2nd technician then estimated and recorded an index of vegetation cover for each height class represented on the density board, including 0-50 cm, 51-100 cm, and 101-200 cm above ground level. Cover index values are [1] < 2.5%, [2] 2.5 – 25%, [3] 26 – 50%, [4] 51 – 75%, [5] 76 – 95%, and [6] > 95%. This visual obstruction at 15 m survey was conducted in each the cardinal direction from the nest bowl.

To evaluate vegetation cover around turkey nests, we estimated and recorded cover (to the nearest 5%) for small (< 3 cm in diameter at 0.1 m height), and large shrubs (> 3 cm in diameter at 0.1 m height) within 15 m of the nest bowl. Within 1 m of the nest bowl, in each cardinal direction, we estimated vegetation cover ≤ 1 m high, to the nearest 5% (Fuller et al. 2013). Vegetation surveyed within 1 m was classified as either woody or herbaceous.

Black Fly Monitoring. Black fly monitoring from 2018 is discussed here because of the lag from when the fly data are collected and when the fly samples are processed, counted and summarized. To document black fly presence and abundance during 2018, we deployed four carbon dioxide baited CDC traps each at McAllister Farms and Srycle Farms, and two at Buckeye Creek (non-nest) in western Illinois, and also deployed traps near 6 active turkeys nests (King and Adler 2012). All traps were deployed two days per week (weather permitting), and non-nest traps were deployed from early-April through the end of June or until adult flies were no longer detected, to document the duration and intensity of the black fly breeding season. The non-nest traps were located 200 – 500m from a persistent stream or river within the study site. When nest incubation was detected, a nest-trap was deployed at a location between the nest and nearest body of moving water, at about 200 m from the nest to prevent potential nest abandonment. We expected that a 200-m distance from the nest should adequately sample fly abundance in the nesting habitat, given the proximity to the probable hatch source and the distance that black flies are known to travel when seeking a host (up to 15 km; Adler et al. (2004)). Trap nets were replaced daily to prevent loss of samples due to battery failure or weather (e.g., strong winds or flooding). Sampled flies were euthanized by exposure to dry ice for two hours, and then stored in 95% ethanol. Black flies were sorted from bycatch morphologically (Adler et al. 2004).

During mid-April – June 2019, we again sampled black flies among three study areas and at eight locations near (within 200m of) turkey nests in western Illinois and two locations near (within 200m of) turkey nests in south-central Illinois. We completed vegetation surveys at 2019 black fly trap locations following methods described in '*Nest-site Vegetation Surveys*' to permit evaluations of fly abundance as a function of habitat. In forthcoming analyses we will evaluate the relationship between wild turkey incubation behavior (recess frequency and duration), black fly abundance, and nest-site habitat.

<u>Camera Trap Data</u>. To evaluate the nest/hen predator community in the 3 study areas where turkeys were captured in 2019 (Hidden Springs State Forest, Twin Rivers Sow Farm, and Syrcle Farm), we conducted trail-camera surveys during June 2019. Twelve cameras (4 at Hidden Springs, 4 at Twin Rivers Sow Farm, and 4 at Syrcle) were deployed, each for 4 1-week periods between 31 May and 28 June corresponding with when the peak of turkey nesting and early poult rearing periods should occur. Camera trap locations on each site were established to maximize coverage and were placed within forest habitat at least 500 m apart from each other. Cameras were baited with fatty-acid tablets to attract mesocarnivores and potential nest/hen

predator species, and images were downloaded weekly. Cameras took heat/motion sensed images whenever triggered. For a given type of animal, once a capture event occurred, at least 30 minutes had to pass before a “new” capture event could be registered. Average daily capture rates were estimated for each type of animal at each camera. Mean capture rates were calculated and compared for each of the 3 sites for each species detected.

Home-range analyses. We continue to work on these analyses and will subsequently include the data collected with this current segment. We provide preliminary results below, which are based on location data for hens at Stephen A. Forbes State Recreation Area (Forbes) during 2015-2017, to show how the data are analyzed and what we can assess. Immediately below is a detailed description of our approach to the many aspects of home-range analyses. A spatial database has been created and designed to automate many time-consuming processes, such as the association of individual turkey attributes with GPS locations and environmental data. It is also designed for time-efficient data queries, which are otherwise very cumbersome with such large data sets.

Forbes is located in south-central Illinois (Fig. 1). Within the park boundary, Forbes land cover is comprised of: agricultural fields (43.7 ha), open water (220.4 ha and 29 km of shoreline), development (52.2 ha), deciduous forest (751.6 ha, of which approximately 465 ha are oak-hickory), grass-pasture (58.6 ha), and herbaceous wetlands (< 1 ha). To reduce invasive vegetation and encourage oak regeneration, prescribed fire was applied during the dormant season of each year and burns ranged in size from 1-105 ha.

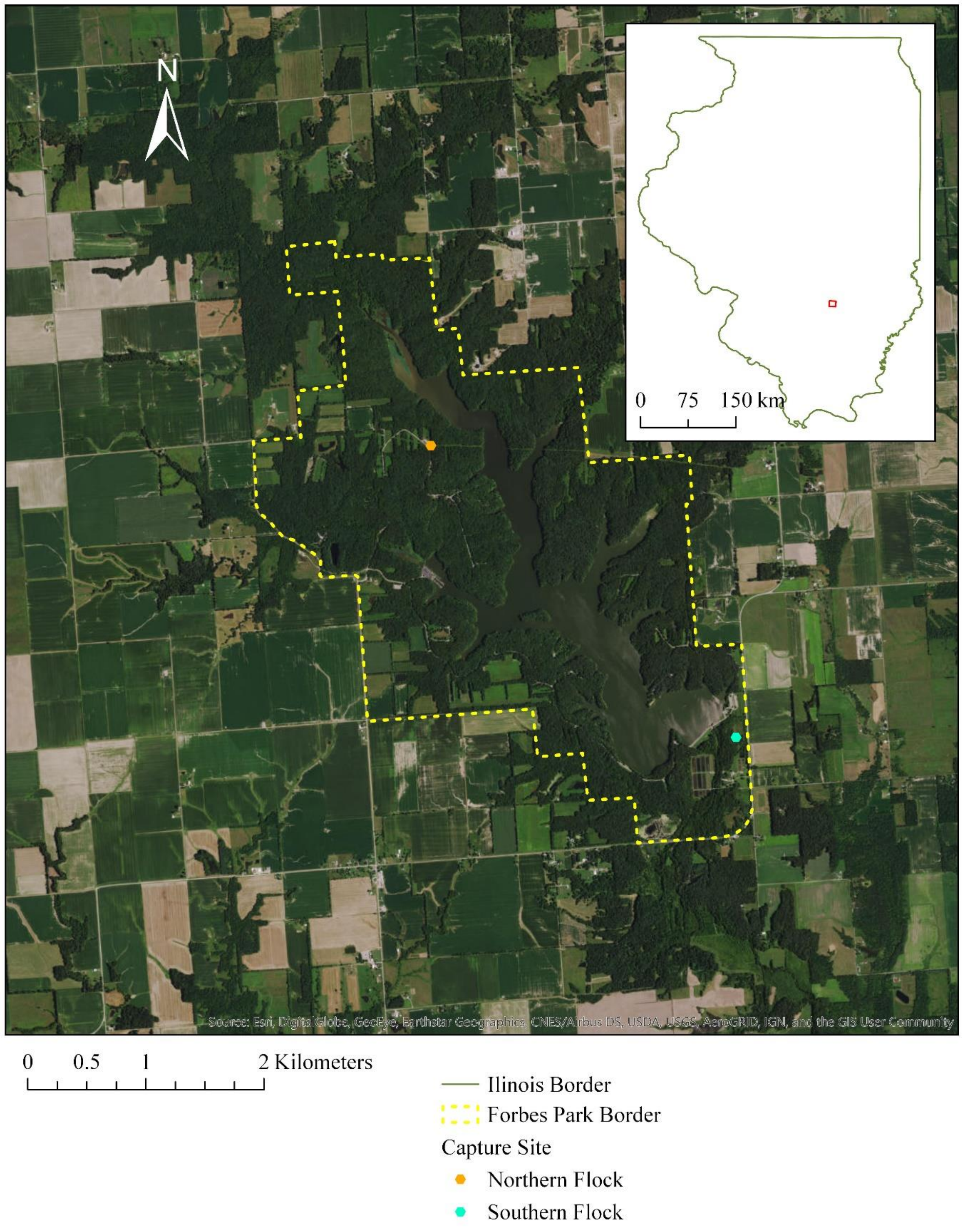

Figure 1. Boundary of Stephen A. Forbes State Recreation Area in Kinmundy, Illinois. Colored dots represent the locations where Northern & Southern turkey flocks were captured during 2015-2017. Inset map displays the park location within the state of Illinois.

Home-range calculation & composition. All location and activity data were managed using PostgreSQL 10 (Urbano and Cagnacci 2014), and all analyses were conducted using R (v3.5.1). All location data used in these analyses met two requirements: 1) location was recorded at a time between the capture/release date and the date of death (bird or μGPS) and 2) location was realistic relative to previous and successive locations, and within the landscape (i.e., not in open water). We categorized each location into one of three reproductive seasons that were defined by individual shifts in observed behavior throughout the year, including: egg-laying, incubation, and brood-rearing.

Accelerometers within each μGPS record activity data that permitted us to determine, to the nearest hour, when incubation began and ended (C. Parker, *in prep*). We defined the start of the incubation period as the date when hens remained for at least three hours on the nest, and incubation terminated when hen activity data indicated movement throughout the day. We defined the egg-laying period as the 10 days prior to the first day of incubation. As we did not determine clutch sizes, we specified a mean clutch size of 10 eggs to estimate the egg laying period among all birds (Vangilder et al. 1987), but acknowledge the egg laying period varies as a function of actual clutch size. For each hen with a successful nest, we defined the brood-rearing as the period up to 112 days post-hatch, which was based on 16-week brood flushes during which poults were observed with hens. For unsuccessful nesting hens or hens that did not attempt a nest, a brood-rearing period was determined up to 112 days post-failure based on the mean incubation start and end dates of hens in the same capture flock. We evaluated habitat use by hens with unsuccessful or no nest attempts in the brood rearing analysis because hens often join other brood flocks if they do not reattempt nesting (Byrne et al. 2011). Therefore, the location data from unsuccessful hens may represent brood-rearing habitat. Non-nesting hen data were not included in egg laying and incubation analyses.

We used the 'adehabitatHR' package (Calenge 2006) to create Brownian Bridge Movement Models (BBMM) by year, and also by season within each year for each individual hen. Two parameters were specified in the models to account for known location errors (*sig 2* = 20) and motion variance related to the speed or mobility of the animal (*sig 1*= 1.5). From the BBMM's, we calculated flock ranges by year (95%), individual home ranges by year (95%), and seasonal core areas (50%) and home ranges (95%) for each individual.

We defined the management composition of each range by using ArcPRO v.2.2.4 to quantify management areas that overlapped with each annual and seasonal range. For each annual cohort of birds captured (i.e., 2015, 2016, 2017), year-specific management data were used to describe burn regimes. We obtained land cover data from the National Agricultural Statistics Service (https://nassgeodata.gmu.edu/CropScape/) for each study year. These datasets have a resolution of 30 m and included 24 categories of land cover in the landscape surrounding the study area. We selected and extracted only 'forest' categories from these datasets using the annual and seasonal ranges as masks. We contrasted the forest data with the forest management data to identify non-managed forest habitat. We classified other managed forest habitat by the number of growing seasons that occurred since burning (time-since-burn; 0-4 years), and by burn frequency (0-3 occurrences) within the prior 5 years.

Composition analyses. To evaluate habitat selection among managed areas by hens, we compared the composition of used and available managed habitat within home ranges following Johnson (1980; Table 1). We used the R package 'adehabitatHS' to evaluate the influence of management characteristics on habitat selection among hens at three levels of selection. To assess 2nd order habitat selection, we compared the composition of hen annual ranges (used habitat) to the composition of the flock annual range (available habitat; Fig. 2). To assess 3rd order habitat selection, we compared the composition of hen seasonal ranges (used habitat) to the composition of hen annual ranges (available habitat; Fig. 3). To assess 4th order habitat selection, we compared the composition of seasonal core areas (50% ranges; used habitat) to the composition of hen annual ranges (95%; available habitat). For each order of habitat selection we conducted three composition analyses to evaluate the influence of fire: 1) prescribed fire (burn vs. non-burn forest); 2) time-since-burn (non-burned -3 years); and 3) burn frequency (non-burned -3 occurrences within a 4 year period).

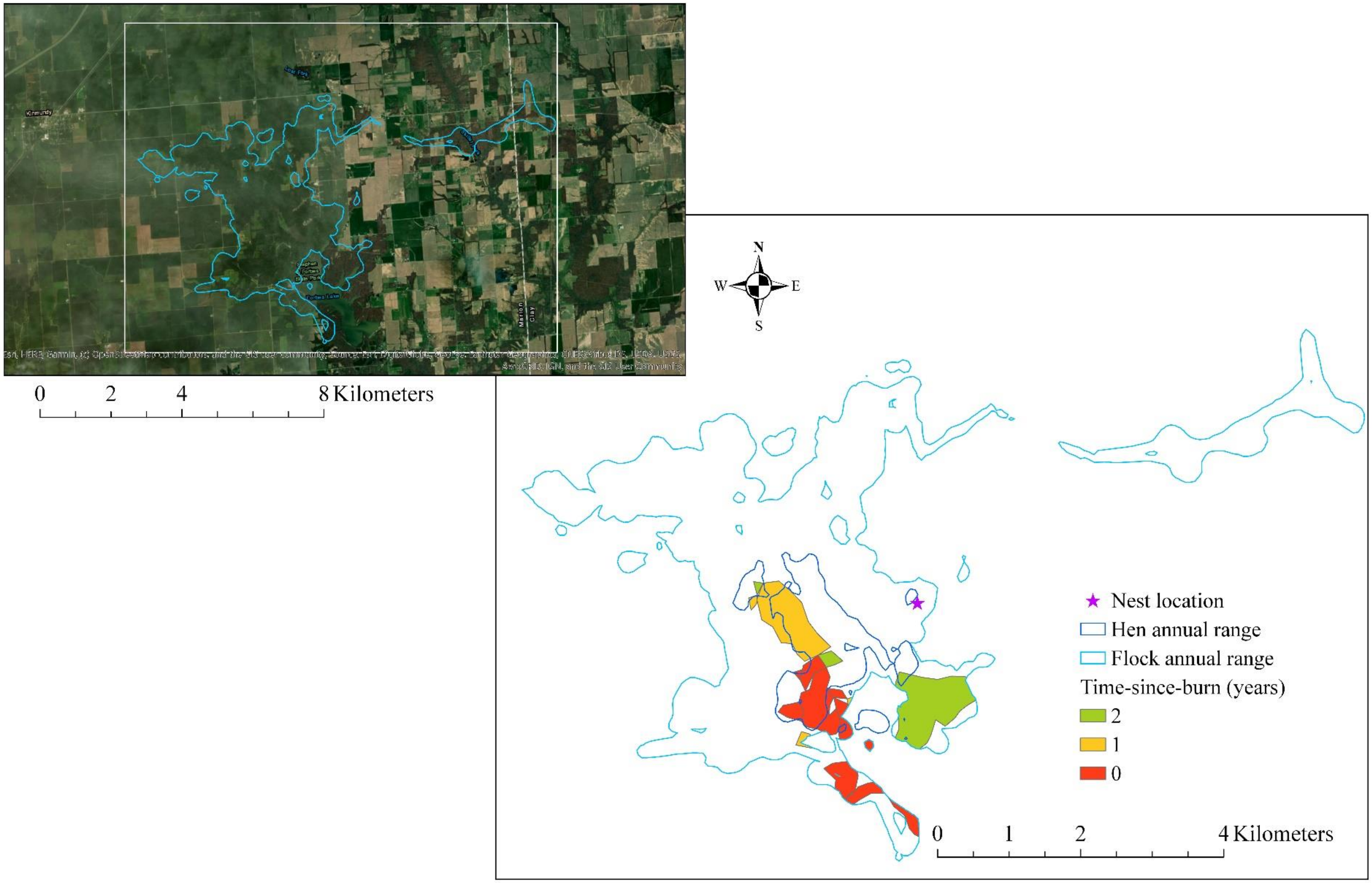

Figure 2. Time-since-burn (no. growing seasons) during 2015 and an example of a wild turkey hen annual home range (dark blue) and annual flock range (light blue) that was used in the 2nd order habitat selection analysis.

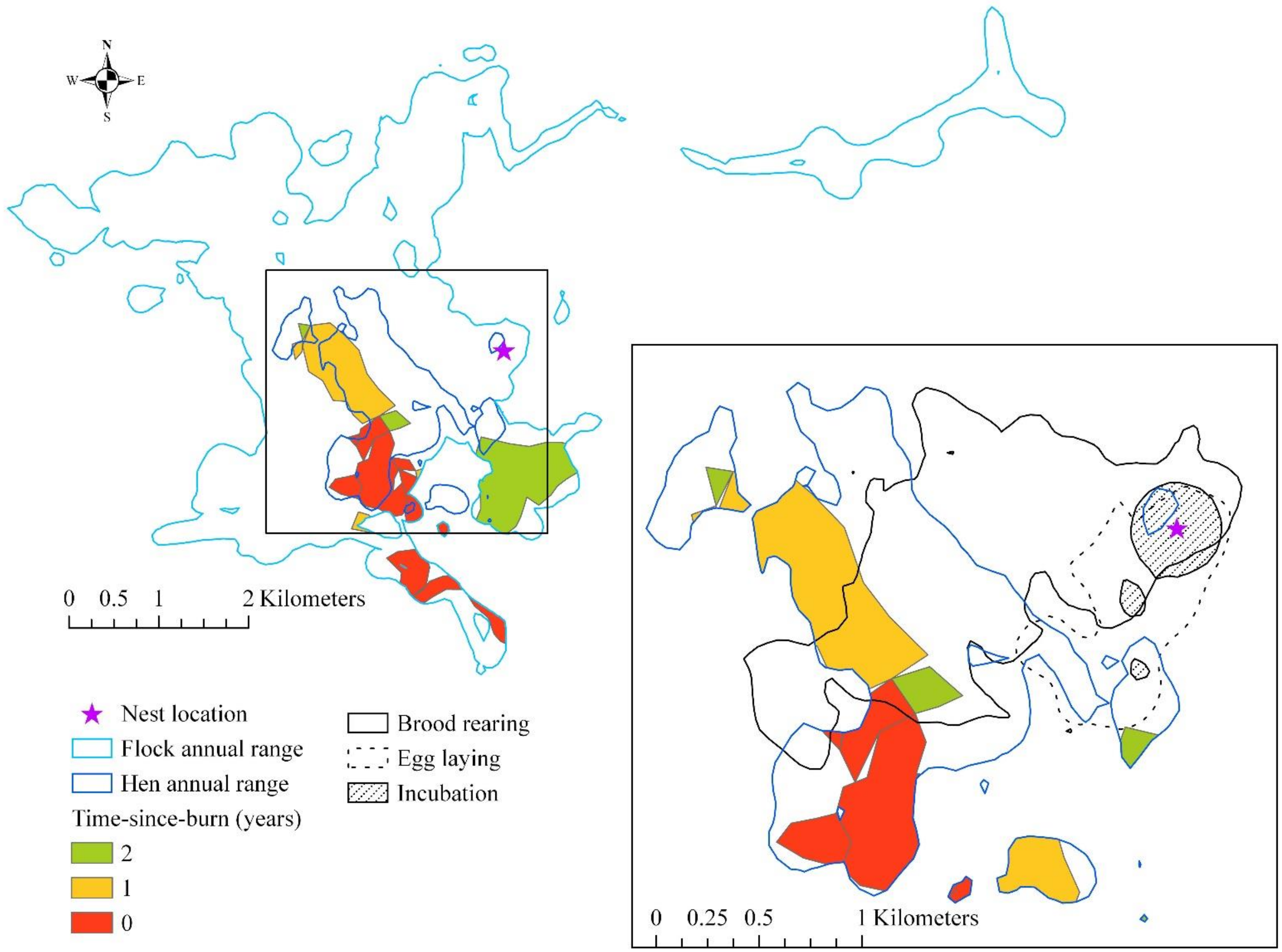

Figure 3. Time-since-burn (no. growing seasons) during 2015 and an example of a wild turkey hen annual home range and seasonal ranges that were used in the 3rd order habitat selection analyses. Notice the distance between the nest location and nearest burned area.

Acorn surveys. To collect data on acorn abundance at each site that can be used in subsequent winter habitat use and home range models, we conducted visual acorn counts at study sites where we hoped to capture turkeys in the upcoming trapping season during early fall while acorns were still on trees. Visual counts prior to acorn-drop are typically used as an indication of acorn availability in wildlife studies (Koenig et al. 1994, Kozakai et al. 2011). We collected this data at 10-12 point locations each at Lake Shelbyville, Siloam Springs, and the Pike County privately-owned sites. Acorn data was also collected at Forbes for comparison with the previous year's values. Within 25 m of each acorn survey location, we counted acorns in the canopy for up to five oak trees that are > 20 cm diameter at breast height (Perry and Thill 1999, Kozakai et al. 2011). We attempted to equally sample both red and white oak species as available within each survey area. Following Koenig et al. (1994), two observers selected different sides of the focal tree and then counted acorns for 15 s. The tree species and number of acorns counted by both observers were added together to yield the number of acorns counted per 30 s effort. Observers also estimated how much their view was obstructed by foliage or other vegetation so that values could be corrected for obstruction. Acorn numbers when collected at the same locations across multiple years can provide information on how much annual variation there is in acorn production and ultimately whether there are any patterns in acorn production over several years' time.

Ongoing data analyses. As databases are finally formalized, we will use model selection to evaluate the support for general linear mixed models of daily nest and hen survival (Burnham and Anderson 2002). These models will include the additive and interactive effects of nest-site vegetation characteristics and incubation behaviors. Study area, year, nest id, and management history of the nest location will be included as random variables. We will also evaluate landscape features (e.g., distance to edge) that may influence nesting mortality (i.e. death of hen or failure of nest). Once we have enough successful broods over time, we will use capture-recapture imperfect detection models (Lukacs et al. 2004) to estimate brood survival for the radioed hens that had broods. To date we now have had one hen from 2015, six hens from 2016, two hens from 2018, and three from 2019 that has broods/poults. All analyses will be conducted using R.

(ii) Actual Accomplishments vs. Project Objectives

a) **Objective 1** – Continue radio-tracking Wild Turkeys captured during the previous segment and capture and affix radios to up to an additional 40 hens enhance sample sizes across study sites.

This segment represents the fifth year of an ongoing project. We were able to continue monitoring during fall 2018 the turkeys with transmitters still working and had a successful capture season in winter 2019. We baited for turkeys among several sites and had good attendance by turkeys at bait locations in both south-central Illinois region and western Illinois. The two Netblasters that we had worked well and allowed us to capture 43 new turkeys during the winter 2019 capture season. These captured birds included 35 hens with 18 hens fitted with transmitters at Hidden Springs (south-central Illinois) and 17 at private sites in western Illinois.

b) **Objective 2** – Use micro-GPS telemetry to examine the effects of forest management, habitat and landscape features, and black flies on Wild Turkey habitat use, survival and reproductive success, emphasizing central and western Illinois sites.

During this segment we were able to get nearly identical numbers of hens in the two regions of study (one with many black flies and one with few) including at a site with ongoing forest management (Hidden Springs) so we should be able to meet this objective. The combination of having 35 total hens with transmitters and data from 33 nesting attempts will allow us to meet this objective with ongoing analyses.

c) **Objective 3** – Use micro-GPS telemetry, accelerometer data, and insect surveys during the breeding season to document potential effects of black flies on hen turkey incubation behavior, hen and nest mortality, and possibly poult survival.

We continued to work on counting black fly samples from 2018, collecting new black fly samples during 2019, managing databases, programming, and the modelling required to meet this objective. We are nearing completion of documenting incubation behavior in the absence of black flies for hens at Forbes, Lake Shelbyville and Hidden Springs. This past season we collected a second year of incubation behavior data for hens nesting in areas with many black flies (sites in western Illinois). We were able to document the duration and intensity of black fly emergence in 2018 (and will have the same kind of data from 2019) in conjunction with documenting the timing of breeding for hen turkeys in the same sites. The timing of black fly emergence overlaps substantially with the incubation and early poult rearing periods of the hens we monitored, so we know there is the potential for black flies to have an effect on hens and/or their poults. What we now have with this year's data, all in the same breeding season, hens nesting in sites lacking black flies and hens nesting in sites with abundant black flies.

d) **Objective 4** – Submit at least one manuscript for publication in a peer-reviewed journal and provide one popular article about this project to the Illinois Department of Natural Resources by the grant end date (popular article will be approximately 500 words in length with at least two pictures provided).

We have a draft of a manuscript that will be ready for submission this fall (on black flies to be submitted to the journal Parasites and Vectors) and hope to submit a second before the end of 2019 on turkey habitat use in relation to prescribed fire. Christine Parker wrote an article summarizing some of our turkey research for the IDNR 'Outdoor Illinois' online magazine (Feb 1st issue). A similar article was also published in the Illinois Audubon magazine.

Results and Discussion

General. During late January through March 2019, we baited and trapped at multiple locations at Ramsey Lake State Park, Hidden Springs, Lake Shelbyville, and at privately-owned sites in Pike county Illinois. Turkeys responded well to baiting efforts during the 2019 season. We believe snowy conditions increased attendance to bait sites; however, we were unable to capture turkeys at Ramsey Lake State Park, Lake Shelbyville or previously successful private land sites (e.g. Buckeye Creek and McAllister Farm). Flocks in different regions simultaneously visited their respective bait sites, so we made a decision to increase our efforts at forest managed sites (i.e. Hidden Springs) and sites where larger flocks attended consistently. We were able to use all trapping equipment this year, but the addition of a third Netblaster would increase our trapping success.

Capture Information. We captured 43 turkeys, and banded a total of 43 turkeys during the 2019 trapping season. At Srycle Farms, four juveniles (1 F; 3 M) and two adults (F) were banded and marked with µGPS units. At Twin Rivers Sow Incorporated, one juvenile male and 14 adult females were banded and marked with µGPS units. At Hidden Springs, 8 juveniles (4 F; 4 M) and 14 adult females were banded and marked with µGPS units.

Nesting Information. Turkeys initiated incubation of first nests during late April and early May among sites in 2019 (Table 1; Table 2). Eleven nests were monitored at Twin Rivers Sow Inc. (Figure 4). One nest attempt was observed at the Srycle Farm site (Figure 5). Twenty one nests were monitored at Hidden Springs (Figure 6). Of the 33 nests detected in 2019, three succeeded into the poult stage (poults observed with hen); six were classified as unknown (nest appeared successful, but we were unable to flush hen due to extenuating circumstances (e.g., land permission, local flood events). one nest was abandoned with eggs intact (flooding), two nests were abandoned due to livestock and mowing, and 13 nests were depredated. Eight of the

33 attempts were unsuccessful renests. A third attempt renest was successful. While nesting success rates were low, they are actually on par with or even higher than some other reported rates (e.g., Conley et al. 2016).

Table 1. Summary of first initiation of incubation dates (i.e., first day of incubation) by wild turkey hens in Pike County, Illinois during 2017-2019.

Nesting parameter	2017	2018	2019
Mean first-nest initiation	18-May	5-May	1-May
Median first-nest initiation	17-May	4-May	2-May
Earliest first-nest initiation	24-Apr	29-Apr	23-Apr
Latest first-nest initiation	11-Jun	16-May	10-May

Table 2. Summary of first initiation of incubation dates (i.e., first day of incubation) by wild turkey hens in Shelby County, Illinois in 2015-2017 and 2019.

Nesting parameter	2015	2016	2017	2019
Mean first-nest initiation	22-Apr	29-Apr	24-Apr	6-May
Median first-nest initiation	22-Apr	28-Apr	22-Apr	6-May
Earliest first-nest initiation	12-Apr	15-Apr	20-Apr	24-Apr
Latest first-nest initiation	30-Apr	17-Apr	2-May	7-June

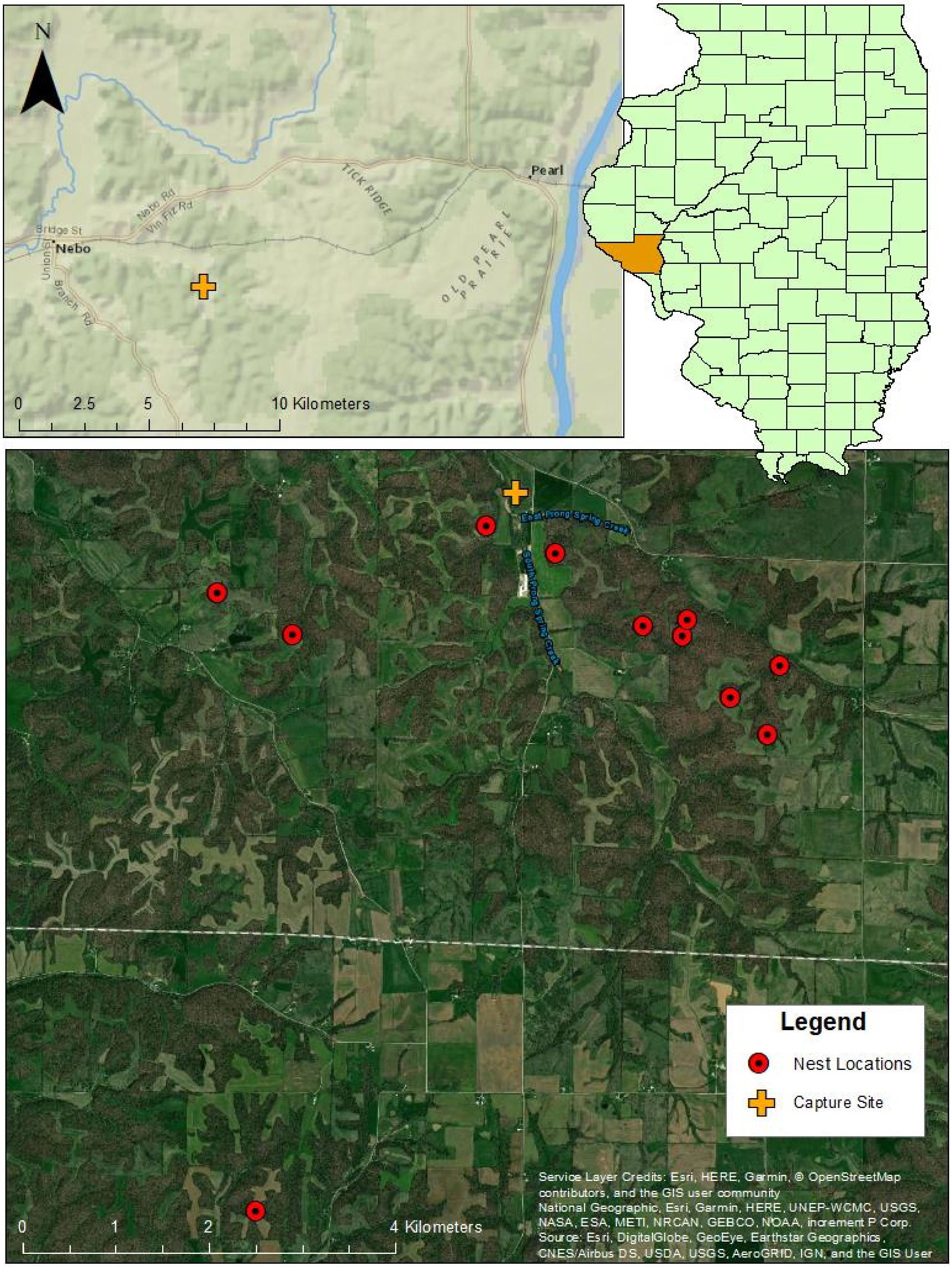

Figure 4. Eleven nests monitored during the 2019 season at the Twin Rivers Sow Inc. site in Nebo, Illinois, Pike County.

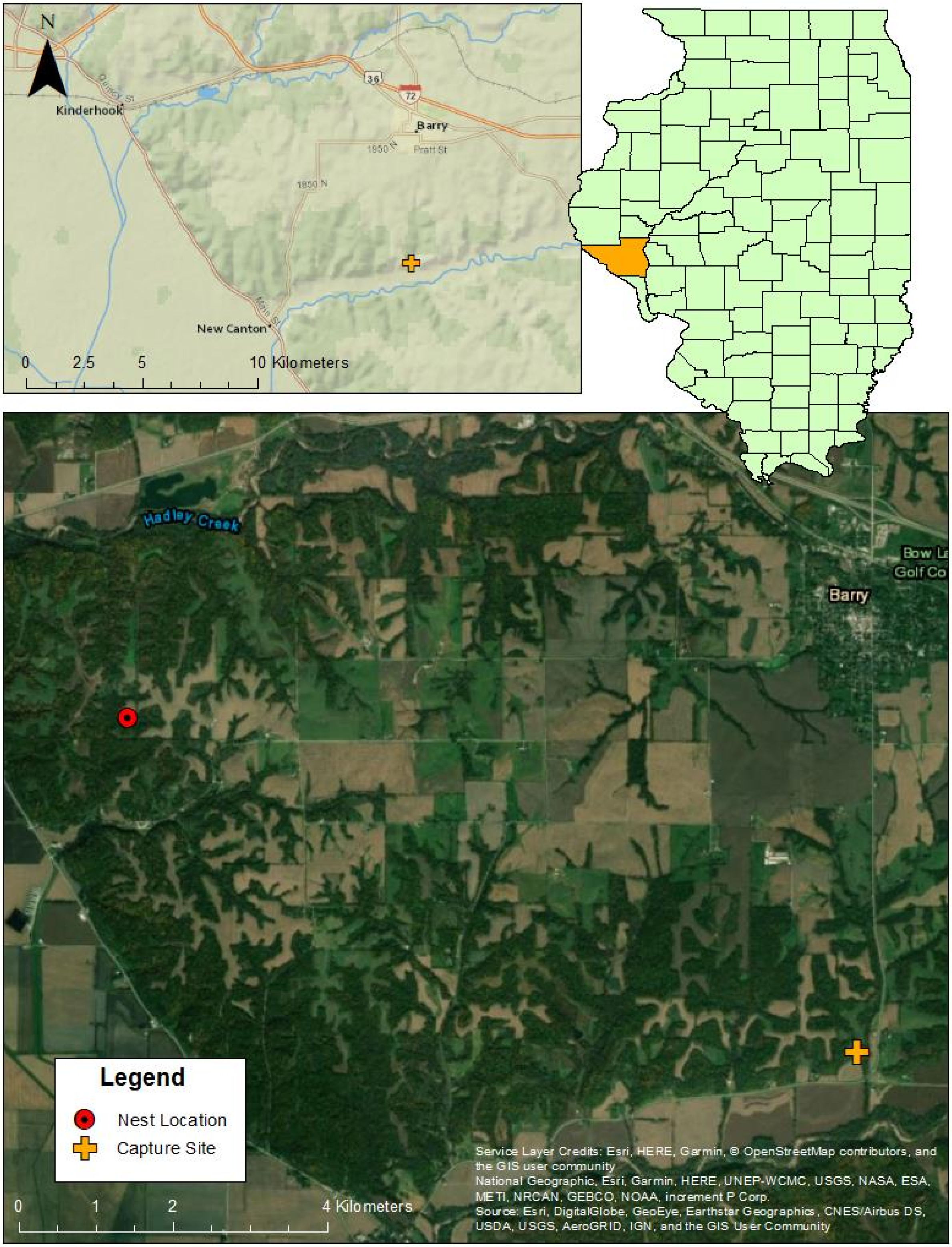

Figure 5. Monitored nest at the Srycle Farm Site during the 2019 season in Barry, Illinois, Pike County.

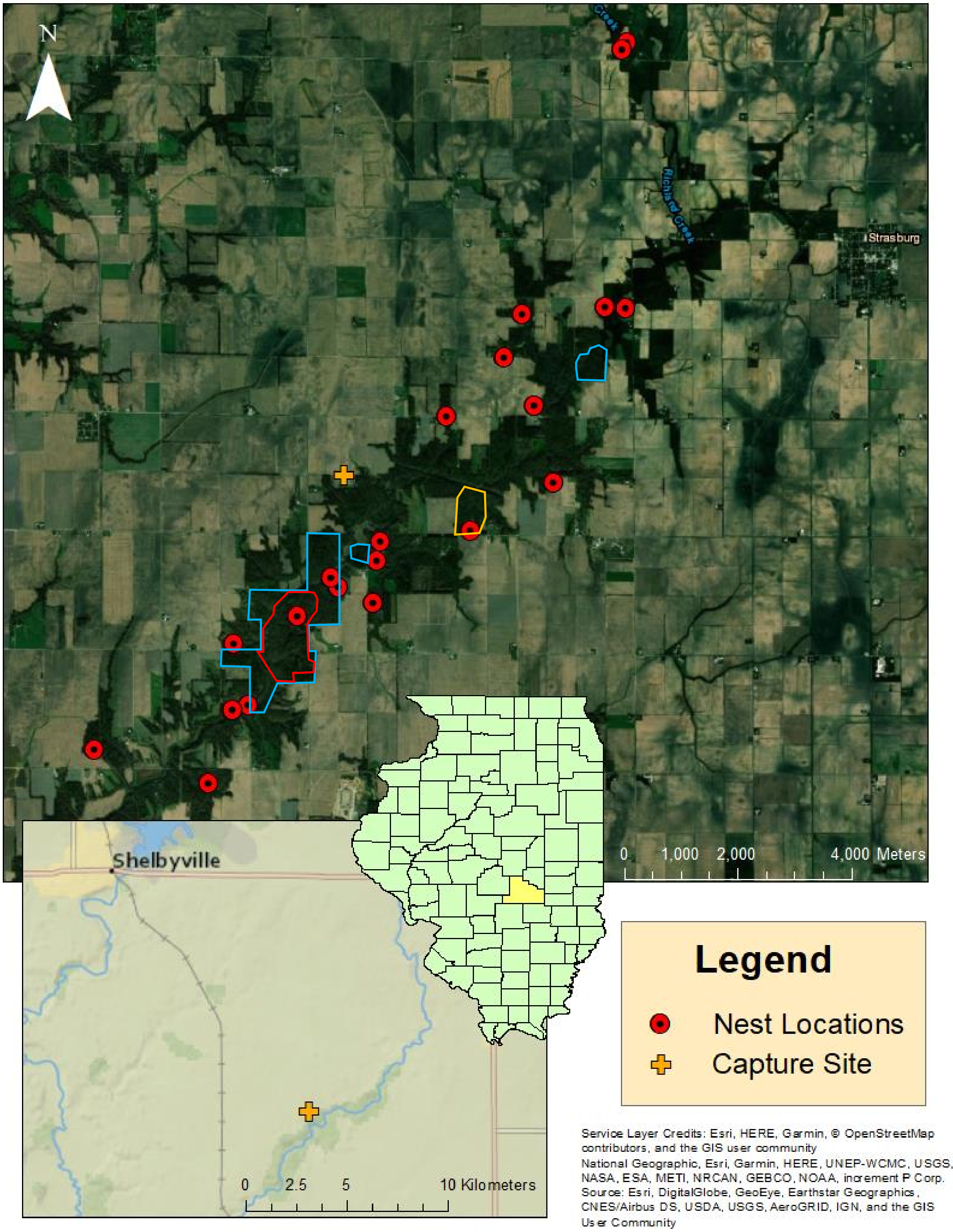

Figure 6. Twenty one nests monitored at Hidden Springs State Forest site during the 2019 season in Strasburg, Illinois, Shelby County. Blue outlines indicate maple and exotic plant control, red outlines indicate frequent fire, and orange outlines indicate recent prescribed fire.

Survival. There were 14 turkeys with active transmitters as of 1 July 2018 (from the 2018 capture season) and by the end of December there were 2 (males) remaining with active radios. The other 12 went into the “unknown” category because of radio battery depletion and not because of mortality. The fall and early winter remain periods of low turkey mortality. One banded female and four banded males were harvested during the 2019 spring turkey season; two 2-year old’s that were originally banded during 2018 at Srycle Farms, two 2-year old’s that were originally banded at Buckeye Creek Outfitters during 2018, and one adult bearded hen originally banded at Hidden Springs during 2019. As of March 2019 two GPS-tagged males captured in 2018 at Buckeye and Syrcle changed to “unknown” status (Table 3). Among the 2019 captures there were 13 female mortalities: (1) harvested (Hidden Springs), (4) depredated during nesting (Twin Rivers and Hidden Springs), and (8) depredated prior to incubation (Table 3; Syrcle & McAllister). One male captured at Twin Rivers was depredated during the 2019 season. Currently, 4 males and 21 females of the 25 GPS-tagged turkeys are still being tracked and their data downloaded. We currently have two females that are of unknown status (e.g. unable to download since capture; unable to hear signal since 22 June2019).

Table 3. Counts and cumulative proportions of micro GPS-tagged turkeys by status (A: alive, D: dead, or U: unknown) at the end of each date range in Hidden Springs and Western Illinois sites during three time-periods during 2018-2019.

Date Ranges	**Hidden Springs**			**Western Illinois**		
Counts	**A**	**D**	**U**	**A**	**D**	**U**
1 Jan- 15 Mar	22	0	0	17	1	2
16 Mar – 15 Jun	16	5	1	8	8	1
16 Jun – 31 Aug	15	1	0	9	0	0
Cumulative Proportion						
1 Jan- 15 Mar	1.00	0.00	0.00	0.85	0.05	0.10
16 Mar – 15 Jun	0.73	0.23	0.04	0.40	0.45	0.15
16 Jun – 31 Aug	0.68	0.27	0.05	0.45	0.45	0.10

Nest Site Vegetation. A summary of some vegetation characteristics associated with nests and randomly chosen points 80 m from each nest are given in Table 4. Hen turkeys did not place nests locally in locations with cover closer overhanging the nest. Hens did, however, place nests locally in locations providing more cover (i.e. concealment) from a distance of 15 m away. This concealment was not necessarily a function of shrub density within 15 m of the nest (Table 4) but rather was more likely a function of differences in the amount of ground cover (both woody and herbaceous) in the vicinity of nests.

Table 4. Vegetation characteristics for 2019 turkey nests (n=30) and paired random points 80 m away. Statistics are from paired *t*-tests (two-tailed).

	Mean			
Characteristic*	Nest	Non-nest	*t*	*P*
Distance (m) to nearest vegetation above	1.6	1.5	0.38	0.71
Obstruction (0-0.5 m up) from 15 m away	5.4	4.8	2.42	0.02
Obstruction (0.51-1.0 m up) from 15 m away	4.2	3.6	3.01	0.005
Obstruction (1.01-2.0 m up) from 15 m away	2.7	2.6	0.71	0.49
Number of shrubs (small and large combined w/in 15 m)	32.7	29.9	0.73	0.47

*Higher obstruction values represent higher amounts of cover

Black Fly Monitoring. The 2018 survey data indicate that black flies are present and abundant in western Illinois, proximate to the Mississippi and Illinois Rivers. In western Illinois during 2018, the data also suggest that black fly emergence occurs during the incubation and brood rearing period, with peak fly abundance occurring during late May and early June. Black fly samples from 2018 are nearly completely processed, and qualitatively we can say that emergence follows the same pattern observed in 2017 where emergence light in south-central Illinois and heavy in western Illinois, and began in early May, peaked during June, and diminished in early July. Western Illinois sites in 2018 did produce twice as many flies compared to samples from 2017.

During mid-April through the end of June of 2019, we sampled black flies among three study sites and at eight locations near (within 200m of) turkey nests across western and two locations near (within 200m of) turkey nets across south-central Illinois. We also conducted vegetation surveys at each 2019 trap site to investigate potential relationships between nest site habitat and black fly abundance. Over the next couple months, we will finish the 2018 samples and process the samples from the 2019 season. All results will be added as a supplement when completed. In forthcoming analyses we will evaluate the relationship between WITU incubation behavior (recess frequency and duration), black fly abundance, and nest-site habitat.

Camera Trap Data. Each week-long deployment of a camera yielded approximately 2,200 images. Raccoons, followed by opossums, had the highest detection rates among predators "captured" by camera traps (Fig 7). At Hidden Springs these were the only types of predators captured, whereas the other sites had two additional species captured (Twin Rivers: coyote and bobcat; Syrcle: skunk and feral cat; Fig 7). This result indicates that nesting hen turkeys may be particularly vulnerable to predation on the Twin Rivers site where the larger meso-predators (coyote and bobcat) were detected. A similar frequency of nest failure between Hidden Springs (81%) and Twin Rivers (83%) is likely related to the large numbers of raccoons and opossums (potential nest predators) present at each site whereas higher hen mortality (45%) at Twin Rivers (vs. 23% hen mortality at Hidden Springs) lends support to the idea that nesting hens at Twin Rivers may be the subject of greater predation pressure because of the presence of coyotes and bobcats.

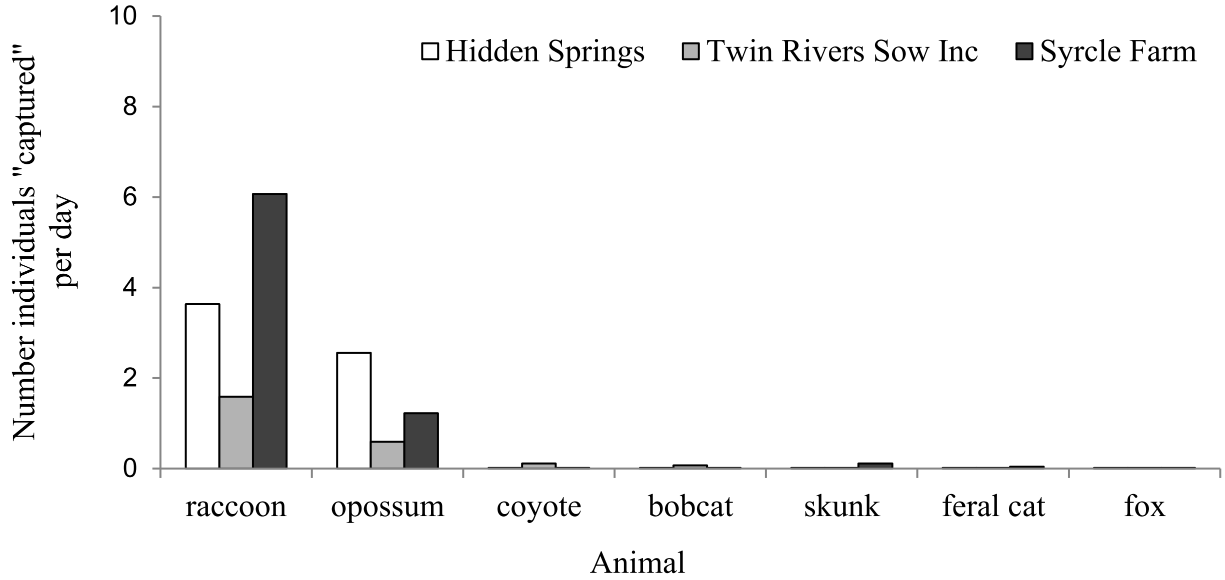

Figure 7. Detection rates for various potential predators of nest/hen/poult turkeys “captured” at camera traps deployed on three sites in Illinois during May 2019.

<u>Habitat Selection.</u> Between two sites in the same Forbes study area (hereafter referred to as the ‘Northern’ and ‘Southern’ flocks), we captured 47 hens, which we monitored and collected data from during 2015-2017. We detected 31 nest attempts, of which 26 failed and 3 successfully hatched. For two nests, we were unable to determine the fate due to land access issues and µGPS malfunctions. Two unsuccessful nests were in forest that was burned during the previous year, and all other nests were located outside burn units. The mean annual home range size ($\bar{x}$ ± SE) of individual hens, both flocks combined, was 197.6 ± 13.5; of the Northern flock, was 205.7 ± 15.8 ha; and of the Southern flock, was 154.35 ± 8.5 ha (Fig. 8).

The mean home range sizes during the reproductive periods were 75.6 ± 6.7 ha (egg laying, n = 27), 55.5 ± 7.9 ha (incubation, n = 27), and 129.8 ± 9.9 ha (brood rearing, n = 33). Land cover within the combined flock ranges was composed of: agricultural fields (301.2 ha), open water (167 ha), developed land (101.1 ha), deciduous forest (1622.2 ha), grass-pasture (389.6 ha), woody wetlands (< 1 ha), and herbaceous wetlands (< 1 ha).

Habitat selection analyses indicated that hens were selecting habitat at multiple geographic and temporal scales, which confirms that hens may benefit from pyrodiversity within the landscape. We found that hens generally preferred non-burned habitat during the reproductive periods. This selection of non-burned habitat is noticeably absent in other studies of turkey habitat selection in fire-managed systems (Martin et al. 2012, Kilburg et al. 2015). This is likely due to the nature of the questions investigated, analytical design, and perhaps ecosystem differences. However, in their study of turkey reproductive ecology in upland hardwood forests, Pittman and Krementz (2016) detected differences in nest-site selection among hens and observed greater nest success among hens that nested in non-burned areas. The greater nest success observed in Missouri, and selection of non-burned habitat that we observed emphasizes the value of non-burned habitat for nesting turkeys. The exceptions to the preference for non-burned forest occurred as: 1) a function of burn regime, which did have some influence over selection, but only at the 3rd order of selection; and 2) 4th order selection appeared to have been random. It is important to note that our use of 95% seasonal home ranges included locations where hens traveled during incubation recess. Recesses occurred rarely throughout the day, and recess locations were unlikely to be recorded regularly due to a mismatch in timing between when recesses took place and when a location was recorded (i.e., every two hours during daylight). As a result, these rare location data were most likely eliminated from 50% core area calculations and could subsequently alter our understanding of habitat selection during the nesting period.

The habitat selection we observed among wild turkey hens within fire managed hardwood forests may not apply to male turkeys. Males generally remain in flocks throughout the entire year (Watts and Stokes 1971), and in central Mississippi did not exhibit variation in habitat use throughout the year (Miller et al. 2001). Due to the ability of wild turkeys to use a diversity of habitat and food types, we would not expect males to exhibit shifts in habitat use except during the reproductive season to locate females. In the subsequent sections we describe 2^{nd}-4^{th} order habitat selection that we detected among wild turkey hens.

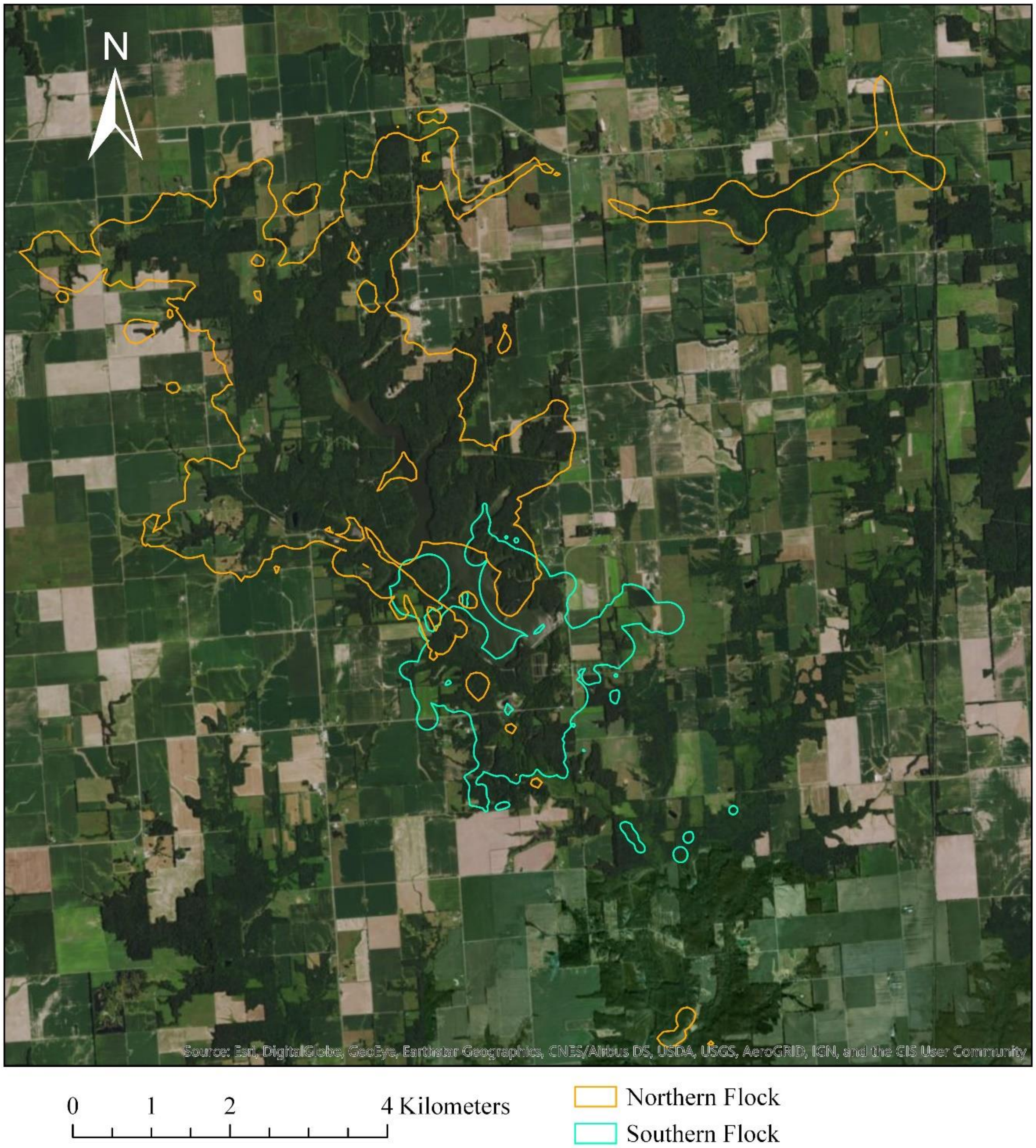

Figure 8. Overview of 95% annual home ranges of wild turkey flocks at Forbes in Kinmundy, Illinois during 2015-2017. Annual flock ranges were merged to represent each flock's entire range during 2015-2017.

Fire influence on second-order habitat selection. Within their annual ranges, hens favored non-burned areas relative to what was available to them within the flock range ($p = 0.05$). Hens did not select habitat randomly as a function of time-since-burn ($p < 0.01$) or burn frequency ($p < 0.01$), and data indicated a preference for non-burned forest. Among burned areas, hens preferred areas with one growing season over older burns and areas that had not completed a growing season since burning (Table 5). Following non-burned forest, hens preferred more frequently burned forest within their annual range (Table 6).

Table 5. Pair-wise comparison of *2nd order habitat selection* by turkey hens among categories of time-since-burn and non-burned (NB) habitat at Stephen A. Forbes State Recreation Area, Illinois, 2015-2017. Within rows, a + indicates that the habitat was used more than the habitat in the column relative to availability, and a – indicates that the habitat was used less than the habitat in the column relative to availability. Triple signs indicate statistical significance of the relationship at $\alpha = 0.05$.

Time-since-burn (years)	NB	0yr	1yr	2yr	3yr
NB	0	+++	+	+++	+
0yr	---	0	---	+	---
1yr	-	+++	0	+++	+
2yr	---	-	---	0	---
3yr	-	+++	-	+++	0

Table 6. Pair-wise comparison of *2nd order habitat selection* by wild turkey hens among categories of burn frequency (no. times burned within previous 4 years) and non-burned (NB) habitat at Stephen A. Forbes State Recreation Area, Illinois, 2015-2017. Burned areas are represented by the number of burns that have occurred within a four-year period (i.e., burn frequency). Within rows, a + indicates that the habitat was used more than the habitat in the column relative to availability, and a – indicates that the habitat was used less than the habitat in the column relative to availability. Triple signs indicate statistical significance of the relationship at $\alpha = 0.05$.

Burn frequency (# times burned within previous 4 years)	NB	1	2	3
NB	0	+++	+++	+++
1	---	0	-	---
2	---	+	0	-
3	---	+++	+	0

Fire influence on third-order habitat selection. Hens demonstrated selective use of non-burned habitat within their seasonal ranges associated with breeding (egg laying: $p < 0.01$; incubation: $p < 0.01$; brood rearing: $p < 0.01$). The selection of non-burned habitat during these reproduction periods was not influenced by burn regime, however, time-since-burn (Table 7) and burn frequency (Table 8) did influence hen selection among burned areas throughout the reproductive season. Specifically, hens generally selected older burns over younger burns during each breeding season (e.g. two years post-burn vs. current year; Table 7), although habitat selection at a significant level was only selected during the egg-laying ($p = 0.02$) and brood-rearing periods ($p = 0.03$). Selection among categories of burn frequencies varied among reproductive seasons, but habitat selection at a significant level was only detected during the brood-rearing period ($p = 0.02$; Table 8).

We detected notable exceptions to the general theme of 3rd order habitat selection of non-burned areas, specifically as a function of time-since-burn. During the egg-laying and incubation periods, selection among burned areas indicated that hens favored 1-3 yr old burns and that burns that occurred in the current dormant season (0yr) were the least preferred. This “avoidance” of current year burns is contrary to the idea that hens would be attracted to the areas by the flush of new growth in spring that follows a dormant season burn. In North Carolina, white-tailed deer also avoided current-year burns during the lactation period (Lashley et al. 2015). Lactating deer with young, and nesting hens, seek areas with enough cover from predators. Yet recently burned areas may be unsuitable habitat with fewer live shrubs and reduced understory foliage (1.5 – 10m; Blake and Schuette 2000). In fact, during our research we observed only two nest attempts (both unsuccessful) in areas managed with fire during the previous year. The area had experienced a full growing season prior to the year in which nesting occurred.

Table 7. Pair-wise comparison of 3^{rd} *order habitat selection* by wild turkey hens among categories of burned (time-since-burn) and non-burned (NB) habitat at Stephen A. Forbes State Recreation Area, Illinois, 2015-2017. Within rows, a + indicates that the habitat was used more than the habitat in the column relative to availability, and a – indicates that the habitat was used less than the habitat in the column relative to availability. Triple signs indicate statistical significance of the relationship at α = 0.05.

Egg laying	0yr	1yr	2yr	3yr	NB
0yr	0	-	---	---	---
1yr	+	0	-	-	-
2yr	+++	+	0	+++	-
3yr	+++	+	---	0	-
NB	+++	+	+	+	0
Incubation	**0yr**	**1yr**	**2yr**	**3yr**	**NB**
0yr	0	-	---	-	-
1yr	+	0	-	-	+
2yr	+++	+	0	+	-
3yr	+	+	-	0	-
NB	+	-	+	+	0
Brood rearing	**0yr**	**1yr**	**2yr**	**3yr**	**NB**
0yr	0	+++	-	+	-
1yr	---	0	-	---	---
2yr	+	+	0	+	-
3yr	-	+++	-	0	-
NB	+	+++	+	+	0

Table 8. Pair-wise comparison of *3rd order habitat selection* by wild turkey hens among categories of burn frequency (no. times burned within previous 4 years) and non-burned (NB) habitat at Stephen A. Forbes State Recreation Area, Illinois, 2015-2017. Burned areas are represented by the number of burns that have occurred within a four-year period (i.e., burn frequency). Within rows, a + indicates that the habitat was used more than the habitat in the column relative to availability, and a – indicates that the habitat was used less than the habitat in the column relative to availability. Triple signs indicate statistical significance of the relationship at $\alpha = 0.05$.

Egg laying	NB	1	2	3
NB	0	+++	+	+++
1	---	0	-	+
2	-	+	0	+
3	---	-	-	0
Incubation	**NB**	**1**	**2**	**3**
NB	0	+	+	+
1	-	0	-	-
2	-	+	0	+
3	-	+	-	0
Brood rearing	**NB**	**1**	**2**	**3**
NB	0	+	+++	+
1	-	0	+++	-
2	---	---	0	---
3	-	+	+++	0

Fire influence on fourth-order habitat selection. Data indicated that hens used burned and non-burned forest in proportion to their availability within core areas during the breeding season (egg laying: $p = 0.62$; incubation: $p = 1.0$; brood rearing: $p = 0.75$). Burn regime, specifically time-since-burn, did influence habitat selection by hens within their core areas relative to their annual range. During the incubation period non-burned and most recently burned forest were least preferred, and areas that had experienced at least one growing season were most preferred (Table 9). Habitat availability was not different from zero for more than two animals in the burn frequency data therefore we were only able to analyze data from the brood rearing period and found that habitat selection was random. As we mentioned previously, the absence of selection within core areas is likely a function of limiting the data to the areas that contain 50% of the locations for individuals. By limiting the data in this way, particularly during reproductive periods when space use becomes restricted, it is not surprising that we did not detect habitat selection within core areas.

Table 9. Pair-wise comparison of 4^{th} *order habitat selection* by wild turkey hens among categories of burned (time-since-burn) and non-burned (NB) habitat at Stephen A. Forbes State Recreation Area, Illinois, 2015-2017. Within rows, a + indicates that the habitat was used more than the habitat in the column relative to availability, and a – indicates that the habitat was used less than the habitat in the column relative to availability. Triple signs indicate statistical significance of the relationship at α = 0.05.

Egg laying	0yr	1yr	2yr	3yr	NB
0yr	0	-	---	---	---
1yr	+	0	-	---	-
2yr	+++	+	0	+	-
3yr	+++	+++	-	0	-
NB	+++	+	+	+	0
Incubation	0yr	1yr	2yr	3yr	NB
0yr	0	-	-	-	+
1yr	+	0	+	-	+
2yr	+	-	0	---	+
3yr	+	+	+++	0	+
NB	-	-	-	-	0
Brood rearing	0yr	1yr	2yr	3yr	NB
0yr	0	+	-	-	-
1yr	-	0	-	---	-
2yr	+	+	0	+	+
3yr	+	+++	-	0	-
NB	+	+	-	+	0

Acorn Surveys. Our fall aerial surveys of acorns indicated that abundance varied quite a bit among sites, with some sites having 4x as many as others (Table 10). Trail of Tears State Forest Data is included as an example of a southern Illinois upland oak/hickory forest (but we are not doing turkey work there). We now have two years of acorn data from Forbes and numbers of acorns at Forbes were up some in fall 2018 compared to fall 2017. This was the first year of aerial surveys at most sites in what we hope to be a long-term effort to document acorn mast annually to determine annual and site-to-site variation in acorn numbers and whether heavy mast years are cyclical. We intend to survey the same point locations at each site each year and possibly add sites or point locations at sites as warranted (e.g. if we have radioed turkeys at a new site in a subsequent segment. Benefits for using the visual method of counting acorns (rather than counting acorns on the ground) include: 1) shorter survey times per location (visual: < 5 min; ground: 10 + min), 2) reduced risk of over estimation due to accumulation of acorns on the ground over time, and 3) reduced risk of underestimation due to animals eating acorns off of the ground.

Table 10. Acorn summary for sites visited during fall 2018 (acorn crop available for 2019 winter, spring, summer).

Site	Points surveyed	Points with oaks	Avg. acorns obs./oak tree/30 sec
Trail of Tears SF	12	10	8.0
Lake Shelbyville	12	11	8.2
Forbes SRA	10	10	6.9
Siloam Springs SP	12	10	1.4
W. IL Private lands	10	10	1.4
Forbes SRA (fall 2017)	23	23	4.6

(iii) Reasons Estimated Goals Were Not Met

Not Applicable.

(iv) Additional Pertinent Information

Turkeys with active µGPS units will continue to be monitored every 2 weeks. The additional tasks completed during this segment (e.g. acorn surveys, camera traps, accelerometer data collection, and black fly trapping) are all important components of the longer-term objectives of this research. Continuing to have two Netblasters, and possibly a third added, will allow us to be as successful as we can be at capturing hens during the relatively brief winter capture season. Examples of presentations and posters given at conferences, as well as other forms of public outreach, were provided in the Quarterly Progress Reports during this segment.

(v) Significant Developments

Not Applicable

(vi) Executive Summary

a) We continued to document locations and fates and nesting attempts of 2 wild turkeys captured in the winter/spring of 2018 whose radios continued to function into the spring of 2019.

b) During the winter/spring of 2019 we captured and banded 43 wild turkeys among 3 study sites and fitted 35 hens (at various sites) and 5 males (at various sites) with a µGPS transmitter. This was good success relative to the prior two years.

c) On average each active transmitter has recorded over 1,500 locations to date that are accurate enough to allow us to know where and when hens were nesting, the fates of those nests, and seasonal habitat use at finer- and larger-scales. This will allow us to model how land use and forest management (at Hidden Springs) affects the nesting success, survival, and habitat selection of hen turkeys.

d) Of the 35 hens monitored, 13 suffered mortality: (1) harvested, (4) depredated during nesting, and (8) depredated prior to incubation. Overall, hen turkeys are particularly vulnerable to predation during the lead up to nesting and during incubation phase of the nesting period.

e) Thirty of 33 nests failed to make it to the poult stage. Three succeeded to the poult stage (poults observed with hen); three were classified as unknown (nest appeared successful, but we were unable to observe hens due to extenuating circumstances). One nest was abandoned with eggs intact, two nests were abandoned due to livestock and mowing, and 13 nests were depredated. Eight of the 33 attempts were unsuccessful renests. One renest was successful. Based on visitation to baited camera traps, suspected nest predators include raccoons, opossums, coyotes and skunks.

f) Accelerometer data from western Illinois sites (where black flies were abundant) are currently being analyzed for comparison to south-central Illinois sites (where black flies were relatively uncommon) to see if black flies influence incubation behavior.

g) Data confirm that black flies are very abundant in western, but not south-central Illinois. Peak black fly abundance occurred during the nesting season of wild turkeys. Future analyses of turkey incubation behavior and nest survival as a function of black fly abundance will permit us to determine whether there are any direct or indirect effects of black flies on wild turkey reproductive success.

h) Finally, the programming and database structure are now in place to allow us to begin using all of the data collected to date to assess the effects of land-cover configuration, forest structure and composition, and forest management history on hen and nest survival rates as well as seasonal and annual habitat selection at multiple scales (e.g. home ranges within landscapes, and activity hotspots within home ranges).

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