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Wild Turkey Responses to Forest Management

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Wild Turkey Responses to Forest Management

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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 4 of the Wild Turkey Responses to Forest Management research project were to:

1) 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, with an added emphasis on western Illinois sites;

2) 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 poult survival associated with up to 60 wild turkey hens (split among study areas);

3) Use these results to inform/modify stand- and landscape-level forest and open woodland management plans and actions to benefit turkey populations in Illinois.

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 Stephen A. Forbes State Park (Forbes), Lake Shelbyville –U.S. Army Corp of Engineers land (Lake Shelbyville), and Hidden Springs State Forest (Hidden Springs), while sites in western Illinois included Siloam Springs State Park (Siloam Springs) and three privately-owned sites (Buckeye Creek, McAllister Farm, and Syrcle Farm). Additional baiting occurred at Wineberg-King State Park (Scripps Unit), Ray Norbut Sate Fish and Wildlife Area, and an additional private property that is adjacent to the McAllister Farm. Forbes is approximately 1256 ha of forest surrounding a large impounded lake, of which 465 ha are actively managed oak and hickory forest. Management at Forbes is focused on maintaining open woodlands with intact canopy through the use of prescribed fire and occasional selective (undesirable and mesic species) sapling removal, and beginning in 2016 some tree thinning as well. This management is intended to promote structure and composition of understory vegetation that is beneficial for wild turkeys during the breeding season. 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. Additional sites, private and public, were used this year because turkey flocks were observed just prior to or during the 2018 capture season. Owners or managers of these sites were currently or previously engaged in forest management (e.g., thinning, prescribed fire, non-managed forests) on the property, which would permit us to study the effects of forest management on hen turkey habitat use throughout an annual cycle.

Capture and Tracking of Turkeys. We captured turkeys using magnetic-release drop nets and cannon nets (i.e. Netblasters) at sites baited with cracked corn during winter (January – March) of 2018. 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; MiniTrack 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 two hours during daylight hours (e.g. 0500-1900 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 on 21 Aug 2014). 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 – 255. These measurements (x and y) are averaged over five minute intervals. Values < 15 are not considered active movement.

Based on this transmitter configuration, we expected the units to collect data for up to approximately one year, though recent models are lasting for >1 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).

Nest, Hen, and Brood Survival. 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 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 48 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 16 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 1.5 m, and outward (horizontally, in any direction) from 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. To document black fly presence and abundance during 2017, we deployed one carbon dioxide baited CDC trap at each study area (non-nest) in western (n = 3) and southern (n = 3) Illinois and also deployed a trap near active turkeys nests (n = 6; 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 expect 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 2018, we sampled black flies among three study areas and at seven locations near (within 200m of) turkey nests in western Illinois. At study areas where no turkeys were being monitored, two traps were deployed to collect additional fly data within the study region. Traps were placed using the same method as described for 2017 with one modification: non-nest traps were placed in varying degrees of canopy openness to determine the persistence of flies in forested areas occupied by turkeys. We completed vegetation surveys at 2018 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 sites (Buckeye Creek, McAllister Farm, and Syrcle Farm) where turkeys were captured in 2018, we conducted trail-camera surveys during May and June 2018. Ten cameras (2 at Buckeye, 4 at McAllister, and 4 at Syrcle) were deployed, each for 4 1-week periods between 7 May and 13 June corresponding with the nesting and early poult rearing periods. 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 passive images at a rate of 1 every 5 min, and heat/motion sensed images whenever triggered.

Home-range analyses. We continue to work on these analyses and provide preliminary results below. 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.

Utilization distributions. All location and habitat data will be managed in a spatial database developed in PostgreSQL (Urbano and Cagnacci 2014). To ensure quality, location data must meet two requirements: 1) locations were recorded between the release date of the transmitter and the date of death, or date of last known location of a hen; 2) locations occur in realistic locations - relative to previous and successive locations, and within the landscape (i.e., not in open water). To evaluate the seasonal and annual habitat selection by WITUs, we will use Brownian Bridge Movement Models (BBMM) using the 'adehabitatHR' package in R to calculate 95% and 50% utilization distributions (UDs) for each turkey (Calenge 2006). UDs created using BBMMs take into account the time elapsed between successive locations, location errors, and the mobility or speed of the animal to account for the fact that successive locations for some species may be correlated (Horne et al. 2007). To account for temporal and spatial errors, the parameters *sig1* and *sig2*, are included in BBMMs. *Sig1* represents the Brownian motion variance related to the speed of the individual animal, and will be calculated following Horne et al. (2007) and Calenge (2006). *Sig2* represents location error of the µGPS units; a value of 20 m will be used for all models based on manufacturer's specifications (Byrne et al. 2014). Using *sig1* and *sig2*, BBMMs predict the probability of use along a route between successive locations, and quantify UDs that are adjusted for error. UDs will be the focus of data analyses and will facilitate analyses of habitat selection, for specified seasons as well as annually, at various spatial scales including within the landscape (habitat in 95% UD compared to the larger local landscape), and within each home range (habitat in 50% UD compared to 95% UD).

Managed forest use. To evaluate how time-since-burn influences WITU habitat selection we compared proportions of used habitats and habitat available to WITU hens following Aebischer et al. (1993) using the R package 'adehabitatHS' (Calenge 2006). First, we defined the area "available" to all hens, within a given year, by a 95% home range that includes the area used by all hens (hereafter 'flock range'). We calculated the proportion of burn units, categorized by years-since-burned within the flock range. Next, we defined "used" habitat for individual hens within the flock range using individual 95% UDs (hereafter 'individual range'). After calculating the proportion of burn unit types within each individual range, we ranked habitat use in each individual range relative to habitat available within the flock range (Equation 1). Finally, we will also compare the proportion of hen locations per habitat relative to habitat available within the individual range to evaluate fine-scale habitat selection (Equation 2). The difference between y_{UD} and y_{MCP} represents the use of a habitat type within the UD relative to all habitat available within the MCP (Equation 3). For values of $d > 0$, use of the habitat type is greater relative to compared habitat type. This compositional analysis will be conducted for each hen during the breeding season, and will be pooled by flock during the non-breeding season.

1. $y_{UD} = \ln\left(\frac{used(habitat\ A)}{used(habitat\ B)}\right) - \ln\left(\frac{available(habitat\ A)}{available(habitat\ B)}\right)$
2. $y_{MCP} = \ln\left(\frac{used(habitat\ A)}{used(habitat\ B)}\right) - \ln\left(\frac{available(habitat\ A)}{available(habitat\ B)}\right)$
3. $d = y_{UD} - y_{MCP}$

This approach can be applied/tailored to any time period of interest (e.g. breeding season, brood-rearing period for hens with poults, non-breeding period, etc.). We will conduct separate iterations of the compositional analysis to compare hen selection of managed versus non-managed areas, and to rank differently managed habitats selected by hens. The effect of age will be examined by conducting separate compositional analyses for adult and juvenile age classes and comparing the results. Finally, we will use a redundancy analysis to further examine relationships between habitat composition of turkey UDs with forest management, and landscape and habitat features (Ellison and Gotelli 2013).

Acorn surveys. To determine the influence of acorn abundance on turkey habitat selection during the non-breeding season at Forbes, we conducted two acorn counts: one during Sep - Oct, and another during the following January at the same locations where vegetation cover is surveyed. 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). Acorn counts on the ground conducted during the timeframe when they will be eaten by wildlife may be a more appropriate evaluation of availability for turkeys. Therefore, we counted all acorns on the ground (after acorn drop) within a 1 m^2 area located 25 m in each cardinal direction from vegetation survey points, for a total of five acorn surveys per vegetation survey point. We then calculated the average number of acorns per point.

To verify that fall and winter acorn counts on the ground adequately represent acorn availability, we will also visually count acorns in trees during Aug - Sep prior to acorn-drop. Within 25 m of the survey location, we will count acorns in the canopy of five oak trees that are > 20 cm diameter at breast height (Perry and Thill 1999, Kozakai et al. 2011). We will attempt to equally sample both red and white oak species as available within each survey area. Following Koenig et al. (1994), two observers will select different aspects of the focal tree and then count acorns for 15 s. The tree species and number of acorns counted by both observers will be added together to yield the number of acorns counted per 30 s effort. Analyses of the correlation between visual and ground counts, and of acorn abundances relative to turkey habitat selection during the winter will be forthcoming.

Hunter movement. During the spring, daily movements increase among male wild turkeys (Godwin et al. 1994, Gross et al. 2015). This increase in movement may increase mortality among male turkeys, and influence turkey management goals (Gross et al. 2015). The influence of hunting activity on turkey movement is growing in interest among biologists and land managers alike (Collier et al. 2006, Gross et al. 2015). We initiated a preliminary study seeking to determine if hunter presence influences turkey movement, which may subsequently influence fitness and survival. In addition to hunter presence, we expect that a number of other factors (e.g., food availability, age, forest management , etc.) may also influence movement among male turkeys (Collier et al. 2006).

To understand how spring hunting season influences space use by male turkeys, we attached transmitters to nine males captured in January – March 2018. We programmed the transmitters to record a location every hour during daylight hours and once at midnight. Male locations were remotely downloaded weekly. Two turkey hunters (hunting in the areas where male turkeys had been captured and equipped with μGPS units) volunteered to carry four transmitters (two during youth season; two during regular season) programmed to record a location every 10 minutes from 0600-1500. We retrieved the transmitters from the hunters at the end of the season. As this was a preliminary study, hunters were not required to document turkey observations or hunting success during the 2018 spring turkey season. However, if qualitative analyses of our preliminary data suggest an influence of hunters on movements of male turkeys, and we add this as a component in subsequent segments, then hunters will be asked to record any turkey observations and hunting success during each tracked hunting trip in the future.

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). We will use capture-recapture imperfect detection models (Lukacs et al. 2004) to estimate brood survival for the radioed hens that had broods, which included one hen from 2015, six hens from 2016, and two hens from 2018 to date. 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). All analyses will be conducted using R.

(ii) Actual Accomplishments vs. Project Objectives

a) **Objective 1** – 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, with an added emphasis on western Illinois sites.

This segment represents the fourth year of an ongoing project. We baited for turkeys among 9 areas, at a total of 15 sites and attempted to trap turkeys among 5 areas at 9 sites. While this was an improvement from the previous year, we still experienced low visitation to bait by turkeys, and technical difficulties (with a Netblaster that was finally functional near the end of the trapping season) additionally hampered our efforts. We are hoping to obtain an additional (third) Netblaster to increase our chances of success in 2019. In addition to monitoring the four birds with active radios that were captured in 2017, several tasks were completed that are essential to ultimately meeting this objective including general vegetation structure and composition surveys, acorn surveys, creation of GIS data layers for habitat and land cover in different management units at each site. We evaluated 2015 – 2017 telemetry data from hens at Shelbyville and Forbes using a compositional analysis to determine habitat preference as a function of time (years)-since-burn. We continue to work on this analysis and will be additionally conducting composition analyses for seasonal wild turkey ranges (i.e., pre-nesting, incubation, brood-rearing). We will continue to engage in analyses and modelling efforts during the next segment. We are nearing completion of the forest management/habitat use aspect of this objective and anticipate results will be available by the end of 2018.

b) **Objective 2** – 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 poult survival associated with up to 60 wild turkey hens (split among study areas).

During this segment we continued to work on counting black fly samples from 2017, collecting new samples from 2018, database management, 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 and Lake Shelbyville. This past season we collected new 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 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 need now is to have, all in the same breeding season, hens nesting in sites lacking black flies and hens nesting in sites with abundant black flies.

c) **Objective 3** – Use these results to inform/modify stand- and landscape-level forest and open woodland management plans and actions to benefit turkey populations in Illinois.

We are planning to meet with state biologists and land managers during the next segment to provide an overview of the results and progress that we have accrued since 2015. Additionally, grad students on the project (Christine Parker & Morgan Meador) have reached out to local fish and wildlife groups (NWTF and Mississippi Valley Hunter and Fishermen's Association) to share information about the research project and discuss volunteer opportunities for anyone interested in assisting with the project. As we accumulate more data, we will produce a series of publications and management recommendations valuable to site/habitat managers as well as turkey biologists.

Results and Discussion

General. During late January through March 2018, we baited and trapped at multiple locations at Siloam Springs, Hidden Springs, Lake Shelbyville, and at privately-owned sites in Pike county Illinois. Few turkeys responded to our baiting efforts on public lands in comparison to on private lands, and despite trapping attempts at public sites visited by turkeys we were more successful on private lands during 2018. All tagged birds were captured on privately-owned property in western Illinois (Buckeye Creek, McAllister Farm, and Syrcle Farm). In addition to low bait attendance by turkeys on public land, we experienced an equipment malfunction that left us with a single functioning Netblaster (for most of the season) to use among sites where drop-nets were not a feasible option.

Due to mild winter conditions during Jan-Feb, we observed more human activity among public areas, specifically shed-hunters, who began frequenting our bait piles which we assumed frightened away turkeys. On trap days in public areas (where possible), we asked hikers and shed-hunters to return at another time and explained our concern for their safety near our trapping equipment, and the importance of our research project. Unfortunately, these interactions typically occurred as the person(s) appeared walking to the site from the woods and were not followed by successful trapping events in the same day. We expect that with up to three Netblasters (functioning) and two drop-nets, we will see another rise in capture success during the 2019 season.

Capture Information. We captured 20 turkeys, including a same-season recapture, and banded a total of 19 turkeys during the 2018 trapping season. At Buckeye Creek, one adult and five juvenile males were banded, of which four of the juveniles and the adult were also marked with µGPS units. At McAllister Farm, four adults (F) and three juveniles (2 F; 1 M) were banded and marked with μGPS units. At Syrcle Farm, six adults (3 F; 3 M) were banded and marked with μGPS units.

Nesting Information. Turkeys initiated incubation of first nests during early May among sites in 2018 (Table 1). Of the seven nests detected in 2018, one succeeded into the poult stage (poults observed with hen); one was classified as unknown (nest appeared successful, but hen was depredated before poults could be observed), two nests were abandoned with eggs intact, and three nests were depredated. One of the seven attempts was an unsuccessful renest.

Table 1. Summary of first nest initiations by wild turkey hens in western, Illinois during 2017 and 2018.

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

Survival. Two banded males were harvested during the 2018 spring turkey season; a 3 year old that was originally banded during 2016 at Opossum Creek, and a 4 year old that was originally banded at Forbes during 2015. As of December 2017, the 3 hens captured at Buckeye during spring of 2017 were changed to "unknown" status, presumably due to radio failure, and by March 2018 a GPS-tagged male at Hidden Springs also changed to "unknown" status (Table 2). Among the 2018 captures there were 4 female mortalities: (1) capture myopathy (McAllister), (1) depredated during nesting (McAllister), and (2) depredated during brood rearing (Table 2; Syrcle & McAllister). Currently, 8 males and 5 females of the 18 GPS-tagged turkeys are still being tracked and their data downloaded. Based on activity and location data, one GPS-tagged male is presumed dead, and we are seeking permission to access the property to assess his condition.

Table 2. 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 2017-2018.

Date Ranges	**Hidden Springs**			**Western Illinois**		
Counts	**A**	**D**	**U**	**A**	**D**	**U**
1 Jan- 15 Mar	1	0	0	17	1	0
16 Mar – 15 Jun	0	0	1	14	3	0
16 Jun – 31 Aug	0	0	0	13	0	1
Cumulative Proportion						
1 Jan- 15 Mar	1.00	0.00	0.00	0.94	0.06	0.00
16 Mar – 15 Jun	0.00	0.00	1.00	0.78	0.22	0.00
16 Jun – 31 Aug	0.00	0.00	1.00	0.72	0.22	0.06

Black Fly Monitoring. During 2017, we conducted black fly surveys in three study areas and three nest locations in southern Illinois over a cumulative 2005.1 hours. In western Illinois, black fly surveys were conducted in four study areas and at two nest locations over a total 2076.8 hours (Fig 1). The 2017 survey data indicate that black flies are present and abundant in western Illinois, proximate to the Mississippi and Illinois Rivers, and were a rare occurrence in southern Illinois (Fig 2). In western Illinois during 2017, the data also suggest that black fly emergence occurs during the incubation and brood rearing period, with peak fly abundance occurring during

30 May – 01 June 2017 (week 22; Fig 2). Also, there appears to be a fair amount of variation in black fly abundance among western study areas (Fig 3).

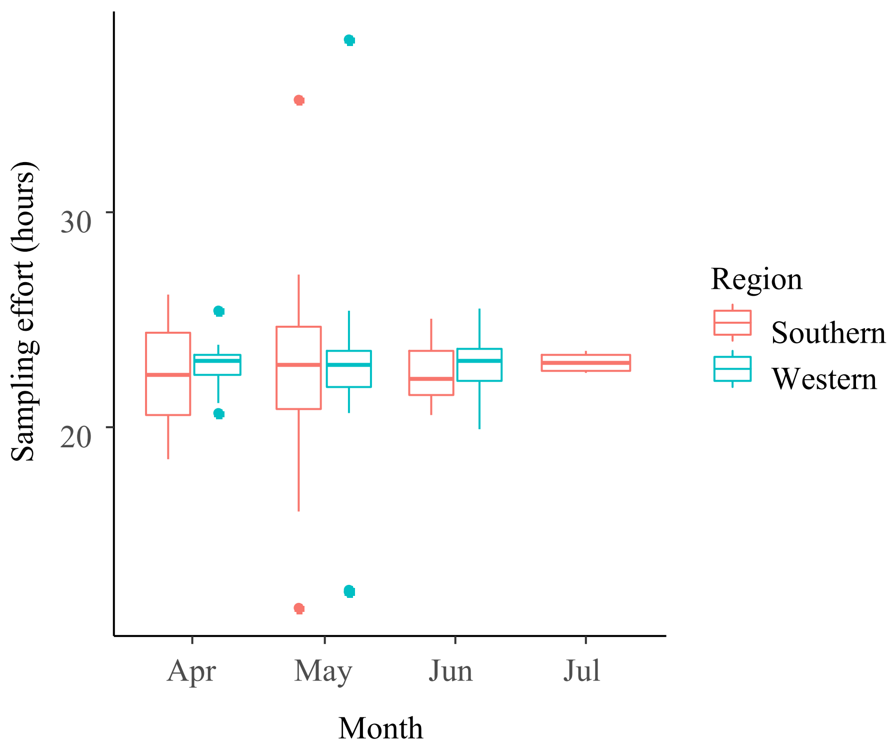

Figure 1. Black fly trapping effort during 2017 in western and southern Illinois.

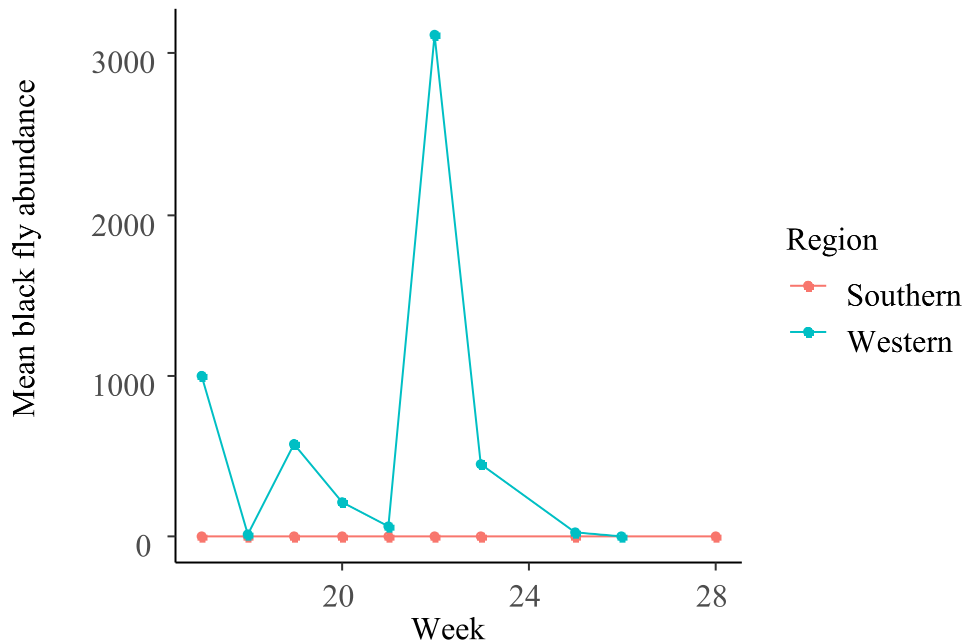

Figure 2. Weekly mean abundance of black flies in southern and western Illinois during 2017. Includes data from both nest and non-nest traps.

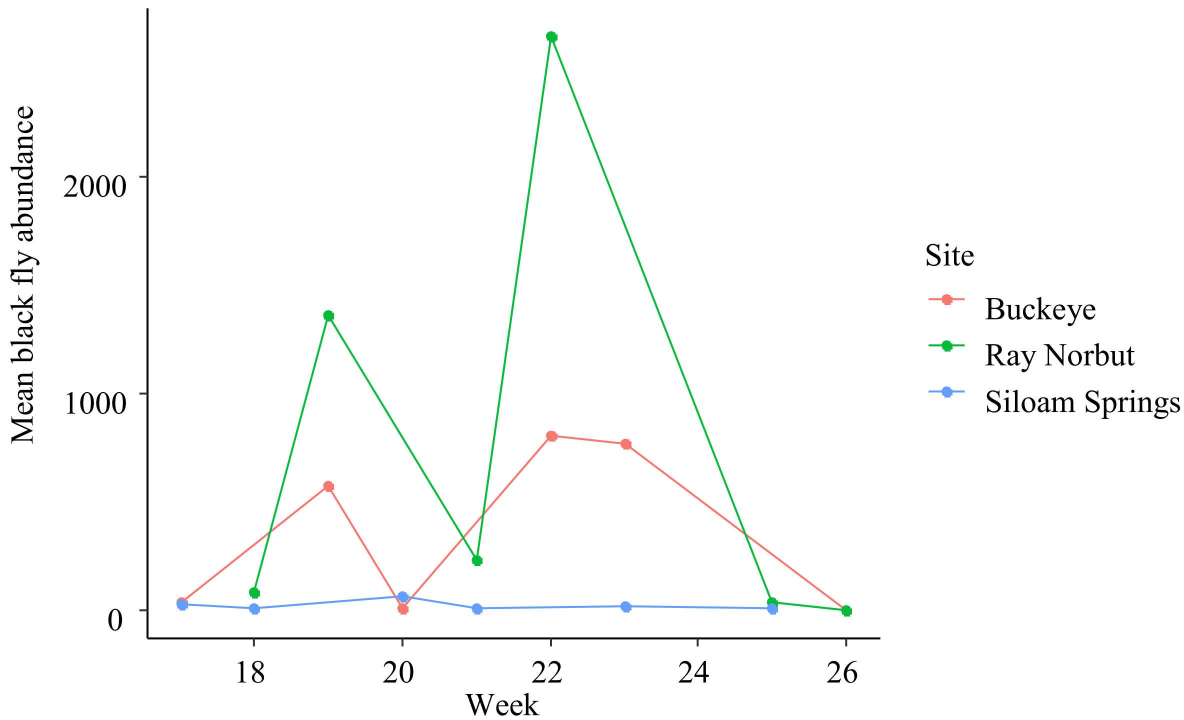

Figure 3. Mean black fly abundance among sites in western Illinois during 2017. Buckeye was the only site with GPS-tagged hens.

During mid-April through the end of June of 2018, we sampled black flies among three study sites and at seven locations near (within 200m of) turkey nests across western Illinois. We also conducted vegetation surveys at each 2018 trap site to investigate potential relationships between nest site habitat and black fly abundance. 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 4). Two of the study sites had detections of just a single type of predator, whereas the third site (McAllister Farm) had detections of several types (Fig 4). This result indicates that nesting hen turkeys, along with their nests and poults, may be particularly vulnerable to predation on the McAllister Farm site. A greater number of nest (n = 2) and hen (n = 2) predations at McAllister Farm (vs. 1 nest / 1 hen predation at Syrcle Farm) add support to the idea that nesting hens at McAllister may be the subject of greater predation pressure.

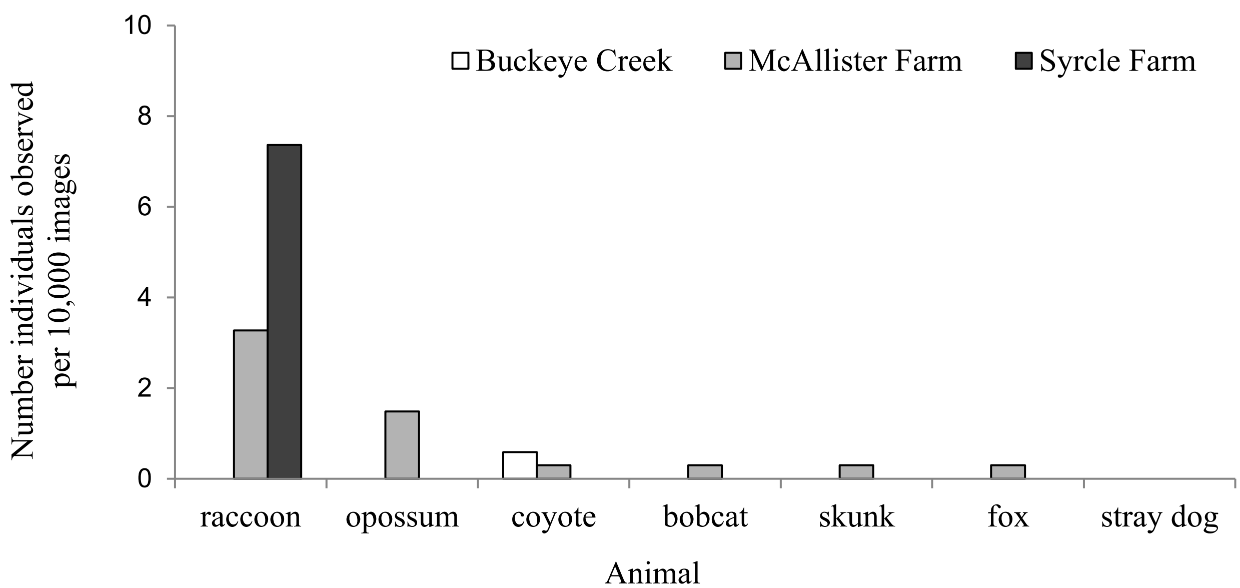

Figure 4. Detection rates for various potential predators of nest/hen/poult turkeys "captured" at camera traps deployed on three sites in western Illinois during April through early May 2018.

Habitat Selection. Home range sizes at Forbes ranged in size from 78.2 – 696.9 ha, and 91 – 405.5 ha at Shelbyville. Home range size remained fairly stable in the Shelbyville and varied by year at Forbes (Fig 5). Home range sizes varied among seasons as we expected. Space use during incubation and egg laying periods was lower than brood-rearing and flocking periods (Fig 6). We did not detect a difference in seasonal home range size between sites ($p = 0.91$). The changes in range size among years at Forbes, although not statistically significant, may be a function of cumulative area burned, which was largest in 2016. We surmise that size of active management areas, particularly during the nesting season, may restrict space use by hens as they appear to prefer nesting in areas further away from recently active burns. However, more recent burns represented a larger proportion of the burned habitat within individual ranges (Fig 7), indicating that hens are using recently managed habitat. We expect that forthcoming analyses of seasonal space use as a function of forest management will reveal more about this relationship.

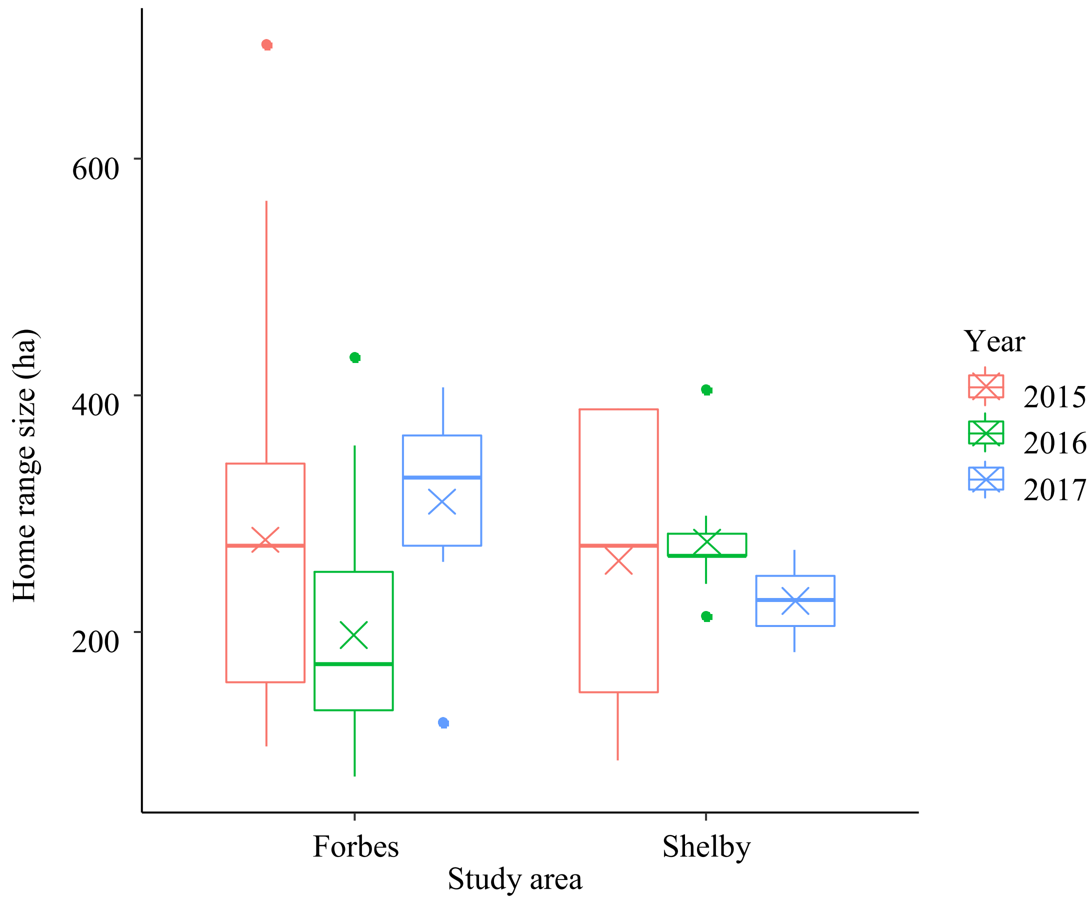

Figure 5. Individual home range sizes (95%) of WITU hens in Illinois during 2015-2017.

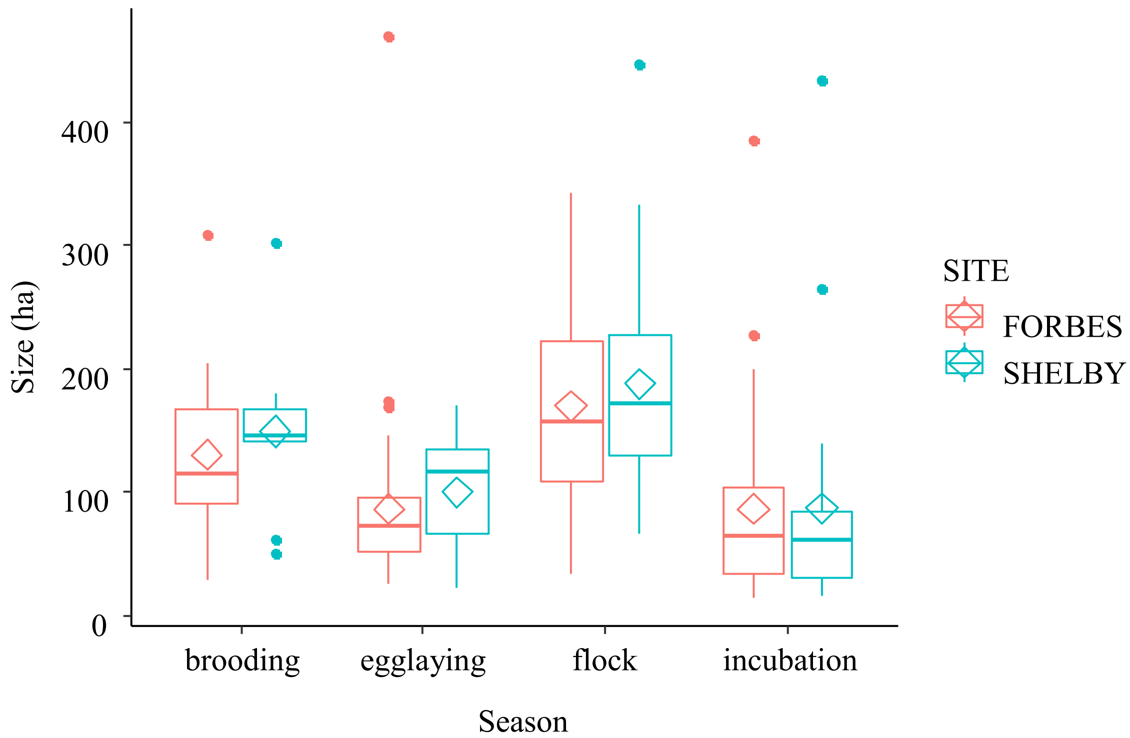

Figure 6. Seasonal home range sizes (95 %) of WITU hens in Illinois during 2015 - 2017.

There was insufficient data to conduct a composition analysis of burned habitat preference in Shelbyville during all years, and in Forbes during the 2017. During 2015, habitat burned during the previous year (y1) was most preferred and habitat burned two years prior (y2) was avoided among wild turkey hens in their annual home range (Table 3). Areas burned during the current year of habitat use were preferred over areas burned two years prior (y2), and were used less than areas burned during the previous year (y1). Habitat burned three years prior was not included in this analysis because it was not available within the range of the 2015 flock. During 2016, habitat burned during the current year was preferred over habitats burned two and three years prior (Table 4). Habitat burned during 2015 was removed from this analysis because did not occur within the range of the 2016 flock. Habitat burned three years prior was used less than burns in the current year and two years prior. Habitat burned during the second year was used less than current-year burns, however the difference was not statistically significant.

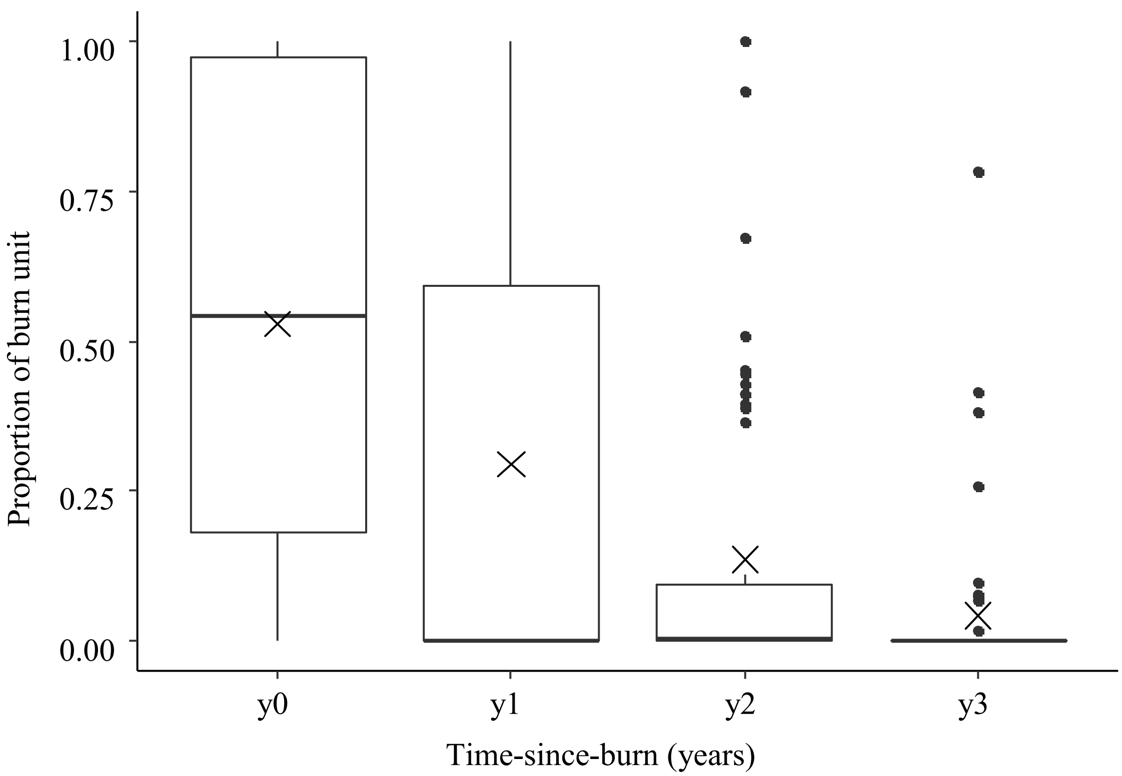

Figure 7. Proportion of burn units within individual ranges of wild turkey hens at Forbes in Illinois during 2015 - 2017. Time-since-burned is expressed as years since burned: Y0: current year; Y1: previous year; Y2: two years prior; Y3: three years prior.

Table 3. Habitat selection ranking matrix of burn units used within individual WITU ranges relative to availability within the flock range during **2015** (n = 19). (+) indicates burn unit type was preferred to other, and (-) indicates burn unit was not preferred over the other. Three signs (+++ or ---) indicate statistical significance at p < 0.05. y0 = 2015; y1 = 2014; y2 = 2013

	y0	y1	y2
y0	0	---	+++
y1	+++	0	+++
y2	---	---	0

Table 4. Habitat selection ranking matrix of burn units used within individual WITU ranges relative to availability within the flock range during **2016** (n = 25). (+) indicates burn unit type was preferred to other, and (-) indicates burn unit was not preferred over the other. Three signs (+++ or ---) indicate statistical significance at p < 0.05. y0 = 2016; y2 = 2014; y3 = 2013

	y0	y2	y3
y0	0	+	+++
y2	-	0	+++
y3	---	---	0

Acorn Surveys.

Our ground surveys of acorns indicated that abundance varied among years at Forbes (Fig 8). While abundance during 2016 and 2017 remained fairly stable (p = 0.57), we observed an increase in 2018 (p < 0.01). During the fall of 2017, we also surveyed acorns visually to compare with the abundance calculated using ground survey data. Analysis of these data revealed a mean difference of 30.9 acorns between methods, with ground surveys producing higher abundance values (p < 0.0001). Due to the large difference in results between methods, we have decided to use the visual survey method. Additional benefits for using the visual method include: 1) shorter survey times per location (visual: < 5 min; ground: 10 + min), 2) reduced risk of over estimation due to accumulation of acorns over time.

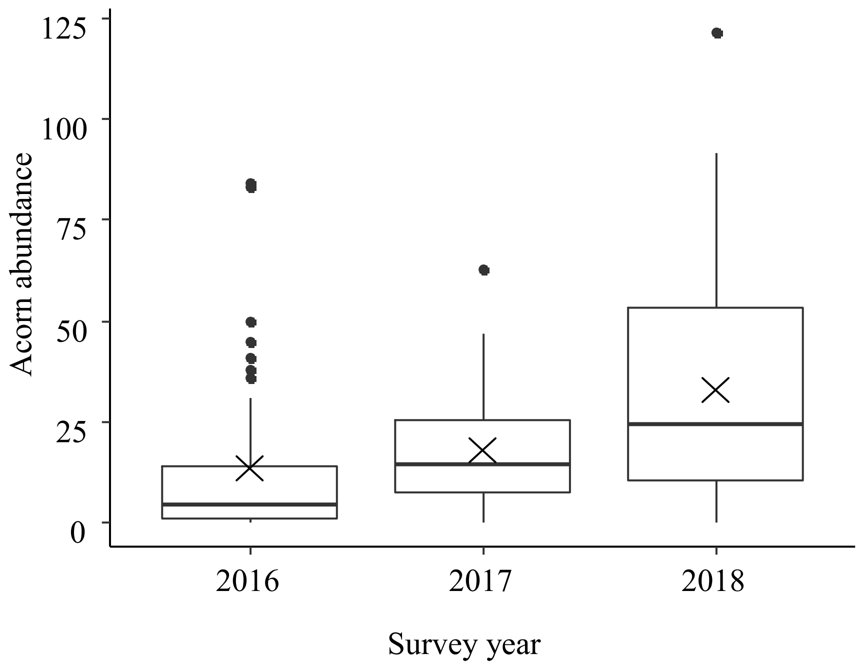

Figure 8. Acorn abundance at Stephen A. Forbes Recreation Area during 2016 - 2018. These data were collected using ground surveys.

Hunter movement. The data we described here was collected only at Buckeye Creek because the area has turkeys with active transmitters. Hunter locations (n = 2 hunters) were recorded during both youth seasons over 6 hunting trips. During the regular turkey season, hunter locations (n = 2 hunters) were recorded over 12 trips. A total of 77 GPS points were collected during the youth season, and 235 were collected during the regular season. On average, hunters spent about 4.5 hours in the field during both the youth and regular seasons, although hunters tended to start hunting about an hour earlier during the regular season. Moving forward we will evaluate the Buckeye-turkeys location data to determine if hunter presence in an area influences turkey space use.

(iii) Reasons Estimated Goals Were Not Met

As mentioned above, we did not meet our primary goal of capturing and monitoring up to 60 hens during this segment. While our capture success was greater this year, we faced a serious setback without the use of the 2nd Netblaster. Use of the drop-net was not feasible at most of the locations where we baited and turkeys were observed this year. Furthermore, frequent hiker activity likely contributed to our lack of capture success on public lands. We also experienced another fairly mild winter (little snow) combined with lots of acorns available to turkeys so that the turkeys showed little interest in the corn bait, and an already short trapping season shortened by a week. Because we were unable to capture birds on state- or federally-owned sites, we did not get data during this segment to assist in our modelling of turkey habitat use relative to forest management. With a full complement of Netblasters and some additional planned surveillance during the fall and early winter we feel poised to have a good capture season during the next segment and are expecting to capture birds at sites where forests are being managed (e.g. Hidden Springs, Lake Shelbyville, Siloam Springs) and also at sites with (e.g. Siloam Springs, and privately-owned in western Illinois) and without (Hidden Springs, Lake Shelbyville) black flies.

(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 analyses, black fly trapping, hunter movement tracking) are all important components of the longer-term objectives of this research. By adding cannon nets to our research tool box (and with some help in the form of a more typical winter with some snow cover) we are hoping to have a much more successful trapping season again this next year and have up to 60 hens equipped with µGPS units. 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 4 wild turkeys captured in the winter/spring of 2017 whose radios continued to function into the spring of 2018.

b) During the winter/spring of 2018 we captured and banded 20 wild turkeys among 3 study sites and fitted 9 hens (at various sites) and 9 males (at Buckeye Creek) with a µGPS transmitter. This was far short of our goal of having up to 60 new females fitted with µGPS units.

c) On average each transmitter has recorded over a thousand 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 affects the nesting success, survival, and habitat selection of hen turkeys.

d) Of the nine hens monitored, four suffered mortality: (1) capture myopathy, (1) depredated during nesting, and (2) depredated during brood rearing. Overall, hen turkeys are particularly vulnerable to predation during the incubation phase of the nesting period, but also during the early brood rearing period when poults are unable to fly.

e) Six of seven nests failed to make it to the poult stage. One succeeded to the poult stage (poults observed with hen); one was classified as unknown (nest appeared successful, but hen was depredated before poults could be observed), two nests were abandoned with eggs intact, and three nests were depredated. One of the seven attempts was an unsuccessful renest. Based on visitation to baited camera traps, suspected nest predators include: raccoons, opossums, coyotes and foxes.

f) Accelerometer data (index of hen turkey motion collected every 5 minutes) from the radios on hens monitored prior to this year (where black flies are absent) allowed us to determine that hens taking more daily incubation recesses are more likely to see their nest fail compared to hens taking fewer daily incubation recesses. New data from western Illinois sites where black flies were abundant are currently being analyzed for comparison to see if black flies influence incubation behavior.

g) Data confirm that black flies are very abundant in western, but not 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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