ILLINOIS

PRAIRIE RESEARCH INSTITUTE

Illinois Natural History Survey
1816 S. Oak Street
Champaign, IL 61820

Wild Turkey Responses to Forest Management

Hoover, Jeffrey P.; Parker, Christine M.; Schelsky, Wendy M.; Benson, Thomas J.

INHS Technical Report 2017

Prepared for IDNR Division of Wildlife

Issued on 8/31/2017

Release online immediately;

Final Report for W-183-R-3

Wild Turkey Responses to Forest Management

(i) Project Information

a) Project Title: Wild Turkey Responses to Forest Management

b) Project Number: W-183-R-3

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 07/01/2016-06/30/2017

e) Due Date of the Final Report is 9/30/2017

f) Principle Investigator(s): Jeff Hoover, Avian Ecologist, Illinois Natural History Survey, University of Illinois, 1816 S. Oak Street, Champaign, IL 61820, 217-244-2922, j-hoover@illinois.edu; Thomas J. Benson, tjbenson@illinois.edu (217-265-6242); Wendy M. Schelsky, schelsky@illinois.edu (217-333-4712)

g) PhD student: Christine Parker, cmroy2@illinois.edu

h) IDNR Project Managers: Luke Garver, Luke.Garver@illinois.gov; Paul Shelton, Paul.Shelton@illinois.gov

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 (Nowacki and Abrams 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; Porter 1977, Badyaev et al. 1996a, Thogmartin 2001). 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 (e.g., 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.

To better understand the response of Wild Turkeys to forest management activities, the objectives of Segment 3 of the Wild Turkey Responses to Forest Management research project were to:

1) Use a combination of conventional and more-advanced telemetry to examine the effects of forest management, habitat and landscape features on Wild Turkey habitat use, survival and reproductive success in east-central and western Illinois (at least 2 study areas);

2) Use Global Positioning Systems (GPS) telemetry to understand variation in fine-scale movements and habitat use of up to 40 Wild Turkey hens (split among study areas) throughout their annual cycle;

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 (WITU) demographics (Badyaev 1995, Roberts and Porter 1996, Thogmartin 1999, Thogmartin and Schaeffer 2000, Spears et al. 2007, Fuller et al. 2013), our primary focus is on the movements, habitat selection and survival of WITU 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 a privately-owned site (Buckeye Creek). 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 WITUs during the breeding season. At Lake Shelbyville, oak, hickory and hard maple flourish in the uplands. Improvements to the forest which consist of thinning the trees to enhance mast production and understory growth (e.g. 40-160 ha per year), nesting cover establishment, 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. Hidden Springs, Siloam Springs and Buckeye Creek were all added this year because each has a decent turkey population along with the ongoing or past forest management (e.g., thinning, prescribed fire, non-managed forests) needed to study the effects of forest management on hen turkey habitat use throughout an annual cycle.

Capture and Tracking of Turkeys. We captured WITUs using magnetic-release drop nets at sites baited with cracked corn during winter (January – March) of 2017. 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; Dickson 1992). Each captured bird was weighed in a sling with a 10 Kg spring scale, and then fitted with a MiniTrack μGPS transmitter (Lotek Wireless Inc., Ontario, Canada). 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 configuration for transmitters, we expected the units to collect data for up to approximately one year. The location and activity data is stored on the transmitter, and may be uploaded remotely from a distance (at most approximately 500 m) allowing us to collect the data without disturbing nesting hens or influencing turkey movements. We released all birds at the capture site immediately after being processed. 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 approximately 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 2004) 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.

Hen activity data. We collected some observational data from domestic µGPS-tagged turkey hens to facilitate the identification of incubation versus recess behaviors from within the activity sensor data output. During fall of 2016, we tagged and video-recorded the behaviors of five domestic turkeys in a pen at Caveney Farm in Monticello, Illinois.

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.

Ongoing Data analyses. To calculate individual measures of incubation recess duration and frequency, we used machine learning algorithms to recognize and classify incubation patterns within activity data (Nathan et al. 2012, Brown et al. 2013). Behavioral observations and activity data collected from domestic turkeys was used to train and create the algorithm decision rules. We calculated daily measures, and an average (over all the days of a given nesting attempt), of incubation recess duration and frequency for each nesting hen.

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 includes one radioed hen from 2015 and six radioed hens from 2016 that had nests that made it to the brood stage. 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 (Team 2016).

Camera Trap Data. To evaluate the nest/hen predator community in burned and unburned areas within Forbes, we conducted trail-camera surveys during May 2017. Twenty-four cameras were deployed, each for a 4-week period, 12 within recently (winter/spring of 2016 or 2017) burned areas, and 12 at locations at least 300m from recently burned areas. Cameras were baited with fatty-acid tablets to attract mesocarnivores and other potential nest/hen predator species, and images were downloaded weekly.

Home-range analyses. We continue to work on these analyses and provide some sample information in the results section below. Just below in this section 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).

Habitat and landscape characteristics. To evaluate how understory cover influences WITU habitat selection, we will survey visual obstruction twice per year, during summer (i.e., breeding) and winter (i.e., non-breeding) seasons. At least 30 locations were surveyed in each study area, and additional surveys may be added to ensure each management unit and areas used by turkeys are surveyed. Each survey location was ≥ 200 m from other survey locations in managed and non-managed units throughout each study area. At each survey location (similar to the nest-site cover surveys), we recorded visual obstruction at 15 m from the survey location using a density board, viewed from each cardinal direction (Nudds 1977). Visual obstruction was estimated at three height classes: 0-50 cm, 51 – 100 cm, and 101 – 200 cm using 6 categories: [1]

< 2.5%, [2] 2.5 – 25%, [3] 26 – 50%, [4] 51 – 75%, [5] 76 – 95%, and [6] > 95% (Badyaev 1995).

To determine the proportion of land cover categories and forest type within each UD, we used data from the National Agricultural Statistics Service (NASS) and Advanced Very High Resolution Radiometer (AVHRR) data. These data will facilitate classification of yearly land cover (NASS), and identify specific forest types (AVHRR). Forest management data for areas where fire-only, fire + thinning, and thinning-only occur were provided by Illinois Department of Natural Resources.

To determine the influence of acorn abundance on turkey habitat selection during the non-breeding season, we will conduct 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 will count all acorns on the ground (after acorn drop) within a 1 m^2 area located 25 m in a random direction from each vegetation cover survey point. We will conduct 5 of these counts at each survey point and will calculate 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 30 m of the survey location, we will count acorns in the canopy of each oak tree that is > 20 cm diameter at breast height (Perry and Thill 1999, Kozakai et al. 2011). 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.

Evaluating habitat selection. To evaluate habitat selection, we will compare proportions of used habitats to proportions of habitat available to turkey hens following (Aebischer et al. 1993) by using the R package 'adehabitatHS' (Calenge 2006). This process will allow us to determine whether or not hen turkeys prefer particular habitats relative to what is available at the scale of "landscape", and also whether or not hen turkeys prefer particular habitats relative to what is available within their own specific home range. Compositional analysis will be performed in several steps. First, we will define the area "available" to all hens with a 100% minimum convex polygon (MCP) that includes all hen locations. We will use geoprocessing tools in QGIS to calculate the proportion of land cover types within the MCP. Next, we will define used habitat for individual hens within the MCP using 95% UDs. After calculating the proportion of land cover types within each UD, we will rank habitat use in each UD relative to available habitat within the MCP (Equation 1). Then we will rank habitats by comparing the proportion of hen locations per habitat relative to habitat available within the 95% UD (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. Compositional analyses 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. To rank habitat selection by acorn availability during the non-breeding season, we will calculate the mean acorn abundance from acorn surveys located within the "available" and "used" habitat for each hen. 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).

Black Fly Monitoring. To document black fly presence and abundance, we deployed carbon dioxide baited CDC traps at each study site (non-nest) and near active turkey nests (King and Adler 2012). At each study site, non-nest traps were deployed two days per week (weather permitting), 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 trap sites were located adjacent to a persistent stream or river within the study site to increase the probability of capturing flies as they emerged from hatch-streams. 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 sampled black fly abundance at central and western sites. A 200-m distance should adequately sample fly abundance in the nesting habitat, given the proximity to the probable hatch source and distance that black flies are known to travel when seeking a host (up to 15 km; Adler et al. 2004). Traps were placed about one meter from the ground, operated without the light, and baited daily with dry ice (approximately two pounds; King and Adler 2012). 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). In this first attempt at monitoring black flies, our goal was to document how much black fly and turkey breeding seasons overlapped, and to determine if fly abundance differed between central and western Illinois sites. Ultimately, we will calculate daily and weekly mean abundance values for each study area using the mean value among all non-nest traps. Daily and weekly mean abundance values will also be calculated for each nest trap. We will use this data to study whether black flies are directly or indirectly causing hen mortality or nest failure, and whether black fly abundances are affected by habitat type and landcover composition.

(ii) Actual Accomplishments vs. Project Objectives

a) **Objective 1** – Use a combination of conventional and more-advanced telemetry to examine the effects of forest management, habitat and landscape features on Wild Turkey habitat use, survival, and reproductive success in east-central and western Illinois (at least 2 study areas).

This segment represents the third year of an ongoing project. We baited for turkeys at multiple locations at 5 sites and attempted to trap turkeys at multiple locations at 4 sites and were only able to capture 3 hen and 4 male turkeys despite our effort being more intensive and extensive than the 2 previous years where we had decent success. We attributed this to a mild winter, lots of acorns available, and a trapping season shortened by a week (extra youth hunting season added). We are getting 2-3 air-powered cannon net units to add to our drop nets to increase our chances of success the next year. In addition to monitoring the 7 birds captured and 12 still with radios from the previous year, 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 landcover in different management units at each site. We anticipate completing this objective during the next segment of this research project. With input from our IDNR project manager we added additional tasks and accomplished the following: deployment of 24 camera traps to assess predator activity during the typical turkey nesting season relative to prescribed fire treatments; analyses of accelerometer (motion) data to study incubation behavior (daily recesses) and nest failure, and loafing behavior during non-breeding periods; and deploying CO2 traps to assess black fly breeding season duration and abundance in both central and western Illinois. See results section below.

b) **Objective 2** – Use Global Positioning Systems (GPS) telemetry to understand variation in fine-scale movements and habitat use of up to 40 Wild Turkey hens (split among study areas) throughout their annual cycle.

We had too few new hens to study habitat use with 2017 birds, but were able to during this segment finally work through the database management, programming and modelling required to meet this objective. We ran initial analyses on the telemetry data from the 2015 hens at Forbes to look at annual habitat use of hens at 2 spatial scales relative to burn history (see results section below) and can now use this approach to model habitat use relative to forest management, and habitat and landcover configuration during discreet periods (i.e. seasons) within an annual cycle. We will continue completing analyses and modelling efforts during the next segment.

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.

As we accumulate more data with each year of our research, 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 2017 we baited and trapped at multiple locations at Hidden Springs, Lake Shelbyville, and at a privately-owned site (Buckeye Creek) in western Illinois. We also baited at Forbes and Siloam Springs, however, we were unsuccessful in capturing birds at Forbes and only males visited bait sites at Siloam Springs (so no traps were set up). Overall we had very poor success in capturing hens (despite intensive effort and success in previous years) and suspected that the mild winter in conjunction with super-abundant acorn mast availability contributed to the low number of birds captured. All captured birds were processed and received a rivet band on the leg, all captured birds were fitted with micro-GPS telemetry units, and all birds were released where captured.

Capture Information. We captured and banded a total of 7 turkeys during the 2017 trapping season. At Hidden Springs four adult males were banded and marked with µGPS units. At Buckeye Creek, three adult females were banded and marked with µGPS units. There were a number of hens (7 at Forbes and 5 at Lake Shelbyville) who had been captured during spring of 2016 and whose radios were still functioning. During the 2017 hunting season, 2 males were harvested from Forbes (both banded in 2015), three males were harvested from Lake Shelbyville (all banded in 2016), and one gps-tagged male was harvested from Hidden Springs. Going into our next segment of this ongoing research, we retained 37 units for deployment next year, and will order 25 new units.

Nesting Information. Turkeys initiated incubation of first nests primarily during late April and early May among south-central study areas (Forbes & Shelbyville), and through mid-May in western Illinois during 2017 (Tables 1 - 3). Of the 10 nests detected in 2017, none succeeded into the poult stage (poults observed with hen); 2 were classified as unknown (radios failed prior to incubation completion), 1 nest was abandoned with eggs intact, and 7 nests were predated. Two of the 10 attempts were unsuccessful renests, one in the Lake Shelbyville area and the other in western Illinois.

Table 1. Summary of first nest initiations by wild turkey hens in Stephen A. Forbes Recreation Area during 2015 - 2017.

Nesting parameter	2015	2016	2017
Mean first-nest initiation	8-May	1-May	19-Apr
Median first-nest initiation	6-May	2-May	19-Apr
Earliest first-nest initiation	21-Apr	19-Apr	19-Apr
Latest first-nest initiation	8-Jun	18-May	20-Apr

Table 2. Summary of first-nest initiations by Wild Turkey hens in Lake Shelbyville area during 2015 - 2017.

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

Table 3. Summary of first-nest initiations by wild turkey hens in Buckeye Creek during 2017.

Nesting parameter	2017
Mean first-nest initiation	17-May
Median first-nest initiation	17-May
Earliest first-nest initiation	24-Apr
Latest first-nest initiation	11-June

Survival. Among the 2017 male captures, there were two male mortalities, one due to capture myopathy and the other was harvested (see 'Nesting Information'), one male is of unknown status (presumably due to radio failure), and one is still being monitored (Table 4). No other mortalities occurred. The cumulative proportions of turkeys alive, dead, or of unknown status, at the end of each of 3 time periods are provided below for Forbes, Hidden Springs, Lake Shelbyville, and Buckeye Creek for 2017 (Table 4).

Table 4. 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 Stephen A. Forbes Recreation Area, Hidden Springs, Lake Shelbyville, and Buckeye Creek during 3 time-periods in 2017.

Date Ranges	**Forbes**			**L. Shelbyville**			**Hidden Springs**			**Buckeye Creek**		
Counts	A	D	U	A	D	U	A	D	U	A	D	U
1 Jan - 15 Mar	7	0	0	5	0	0	3	1	0	0	0	0
16 Mar - 15 Jun	6	0	1	4	0	1	1	1	1	3	0	0
16 Jun - 31 Aug	0	0	6	0	0	4	1	0	0	3	0	0
Cumulative Proportion												
1 Jan - 15 Mar	1.00	0.00	0.00	1.00	0.00	0.00	0.75	0.25	0.00	0.00	0.00	0.00
16 Mar - 15 Jun	0.86	0.00	0.14	0.80	0.00	0.20	0.25	0.50	0.25	1.00	0.00	0.00
16 Jun - 31 Aug	0.00	0.00	1.00	0.00	0.00	1.00	0.25	0.50	0.25	1.00	0.00	0.00

Camera Trap Data. To evaluate the predator community in burned and non-burned areas within Forbes during the nesting period, we conducted trail-camera surveys during May. Among the species detected, we found that raccoons were common in both habitats, and that opossums and foxes were detected at a higher rate in burned areas vs. non-burned areas (Fig. 1). These preliminary findings suggest that nest predators may be more abundant in areas managed with recent prescribed fire relative to non-managed areas.

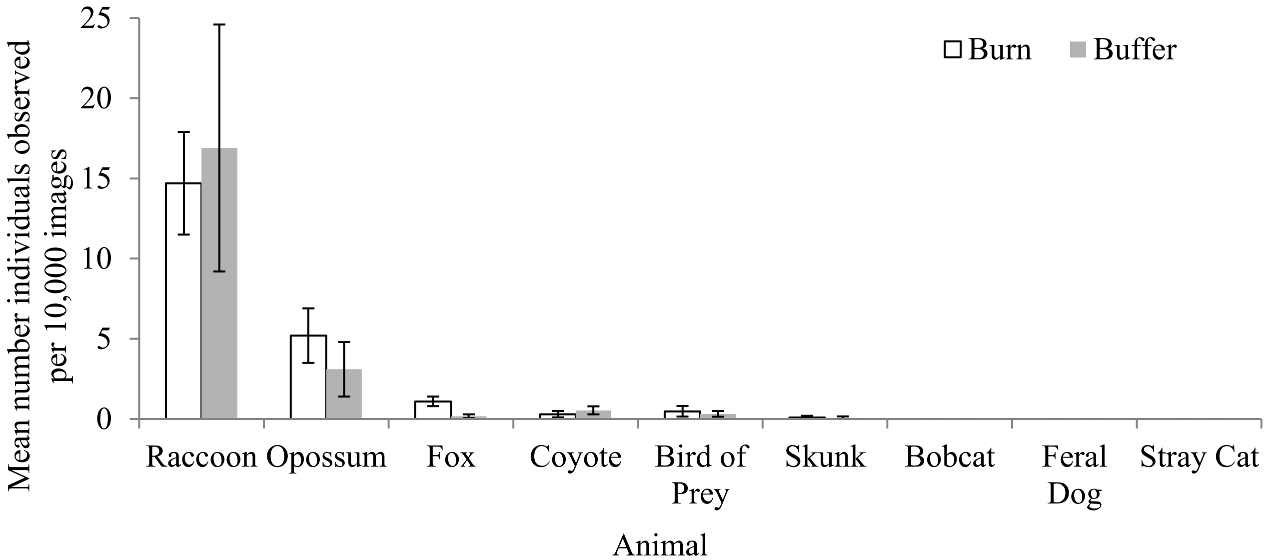

Figure 1. Mean + 1SE camera captures per camera trap of various animals that were photographed at camera traps during May 2017 in forests where prescribed fire has occurred (burn) or not (buffer) at Forbes. Total numbers of images screened were 116,450 and 118,735 in the burn and buffer areas, respectively.

Turkey Behaviors & Reproductive Success. As suggested in the previous year's report, we have the ability to virtually monitor and analyze the incubation behavior of wild turkeys using accelerometer data collected from µGPS units. The first step in this process involved a complex classification of activity data that allows us to extract characteristics of incubation and recess (off the nest) sessions, such as start/end times and session duration. From these characteristics, we determined the mean number of recesses that occurred daily, and their duration. We also determined the start and end dates of incubation for each nesting attempt. We conducted a preliminary analysis of nesting failure related to mean daily recess frequency. The analysis indicates that within the first ~ 20 days of incubation, hens taking more daily recesses were more likely to fail compared to their successful counterparts (Fig. 2).

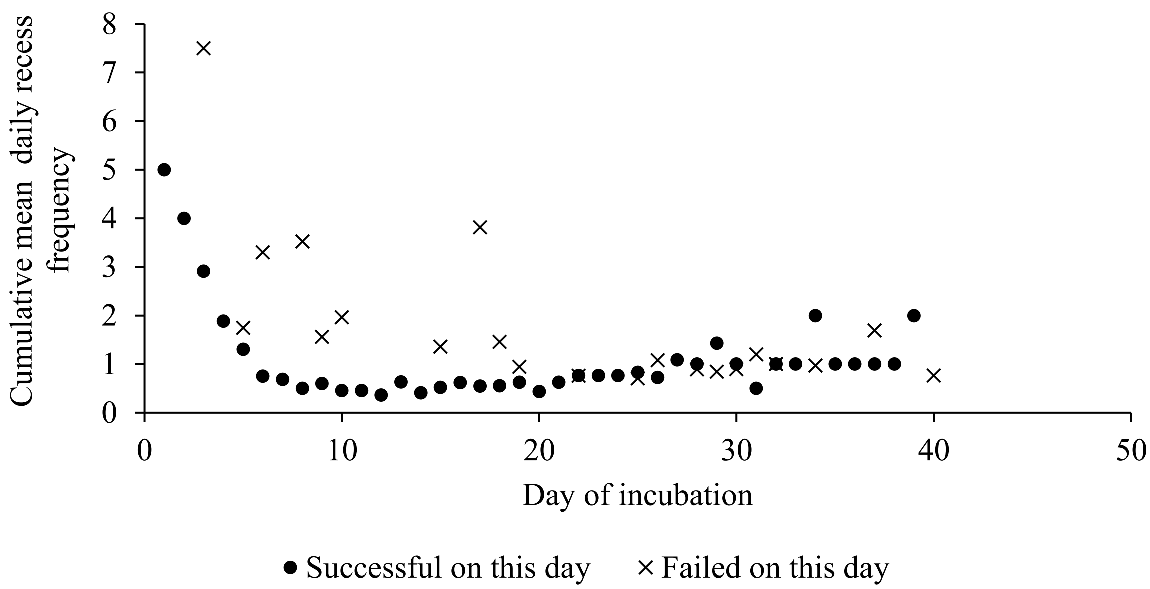

Figure 2. Cumulative mean daily recess rate for hens that were successful through a particular day of incubation (circle) and for hens that failed on a particular day of incubation (x), in Illinois 2015-2016.

We also used an analysis of accelerometer data to evaluate hen loafing (resting) behavior during the non-breeding season, a relatively unknown facet of wild turkey behavior. We found that mean loafing bout length varied among hens X^2=29580, df=14, $p < 0.001$. Furthermore, as we expected, bout length varies throughout the year $X^2 = 51049$, df = 9, $p < 0.001$, and throughout the day. During the year, longer bouts tended to occur when Illinois experiences peak temperature extremes (February & Aug). Within a given day, turkeys loafed longer and less frequently in the morning than in the afternoon. Results from this analysis were presented as a poster at the Midwest Fish & Wildlife Conference in Lincoln, Nebraska during February 5 – 8, 2017.

Habitat Selection. Due to the time-intensive nature of setting up and running home range models, we are still preparing the various layers of data needed to evaluate the relationships between habitat/landscape features and home ranges, incubation behavior, nesting success, and survival of hens. Those analyses will be forthcoming during the next segment of this project. We do, however, present preliminary results on habitat selection as a function of prescribed fire in Forbes. Among the 24 hens from 2015 for which we had sufficient data to conduct this analysis, we evaluated the proportion of their 95% and 50% utilization distributions that were forest managed with prescribed fire (Fig. 3). Based on the average difference in rankings among burn treatments we found that, within their 95% utilization distribution, hens preferred habitat burned 1-2 years previously relative to areas burned during the year of capture and this difference was statistically significant (Table 5; 2013 vs. 2014, $p = 0.83$; 2014 vs. 2015, $p < 0.05$; 2013 vs. 2015, $p = p < 0.05$). Among individual hens, use of burned areas varied in response to time-since-burn. Most hens avoided areas that were recently burned (< 1 year; $n = 13$), and few hens avoided areas that were burned 1 or 2 years previously (1 year: $n = 3$, 2 years: $n = 8$). However, results from the 3rd order selection analysis indicate that areas managed during the current year or two years prior were used more than expected within individual's 50% utilization distribution, although this difference was not statistically significant (Table 6; 2013 vs. 2014, $p = 0.15$; 2014 vs. 2015, $p = 0.33$; 2013 vs. 2015, $p = 0.62$).

Table 5. Results of 2nd order habitat selection for hens monitored during 2015 to early 2016, comparison of used managed areas within individual 95% utilization distributions relative to managed areas available within the 95% utilization distribution of the flock. Lower difference values indicate a stronger preference for an area.

	Mean Rank Values		
Year of burn	Used	Available	Difference
2013	2.34	3.00	-0.66
2014	1.30	2.00	-0.70
2015	2.36	1.00	1.36

Table 6. Results of 3rd order habitat selection for hens monitored during 2015 to early 2016, comparison of used managed areas within individual 50% utilization distributions relative to managed areas available within each individual's 95% utilization distribution. Lower difference values indicate a stronger preference for an area.

	Mean Rank Values		
Year of burn	Used	Available	Difference
2013	2.27	2.42	-0.15
2014	1.62	1.42	0.19
2015	2.12	2.15	-0.04

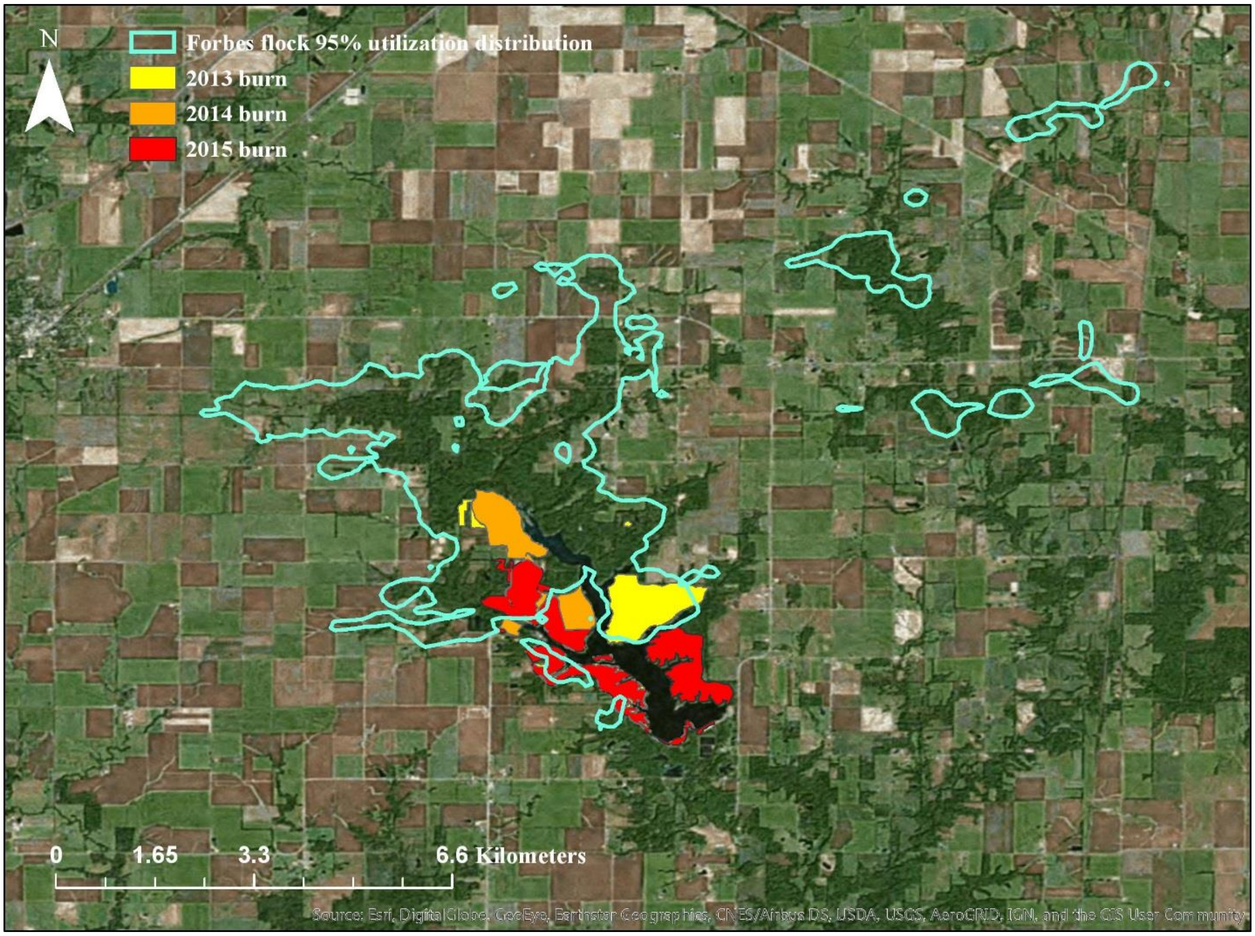

Figure 3. Illustration of the 95% utilization distribution of the Forbes flock during 2015, and areas managed with fire during 2013 - 2015.

Acorn Surveys. During the fall of 2016, we conducted ground surveys of acorns, and did not conduct visual surveys because most of the acorn crop dropped before we began surveys. During January of 2017, we conducted ground surveys again (with additional replications at survey points), and will conduct visual surveys during August 2017. Since there is likely a major difference in acorn production between years, we did not attempt to compare production between years. We will repeat the ground surveys again January 2017, and will compare those data with the data collected from visual surveys of August 2017 to document what how strong the correlation is between late-summer visual surveys of acorns on trees (August) and subsequent ground surveys in the same areas (January). From this comparison, we hope to determine the validity of acorn ground surveys, which are simple to conduct and easy to evaluate. Due to the strong relationship between acorn production and population growth of several wildlife species, this technique may be useful for making harvest predictions at the site-level or for land managers with interest in tracking food abundance for wildlife.

Black Fly Monitoring. During late April through the end of June of 2017, we sampled black flies among 7 study sites and 5 locations near (within 200 m of) turkey nests. Preliminary data indicated that black flies are present and abundant in Western Illinois, proximate to the Mississippi and Illinois Rivers, and were a rare occurrence in South-Central Illinois during 2017 (Fig. 4). We will continue to measure and compare daily incubation duration and recess frequency among nesting turkeys between two study regions where black flies are abundant and

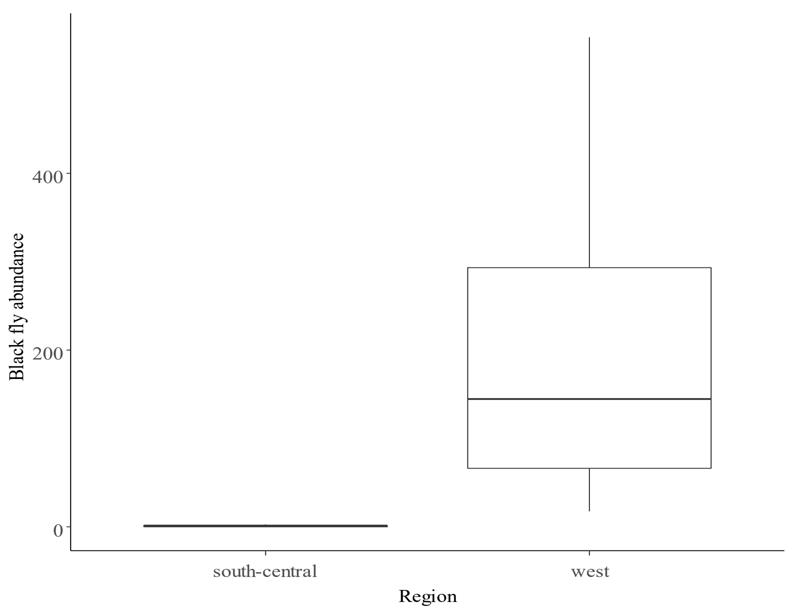

Figure 4. Black fly abundance among study sites and nest sites located in western Illinois and south-central Illinois, 2017.

where they are rare; to determine if there are any differences in incubation behavior exhibited by turkeys between these regions.

Continued Monitoring of Radioed Birds. Turkeys with active µGPS units will continue to be monitored every 2 weeks. Moving forward, we will calculate season-specific UDs to further investigate the turkey space use in managed habitats. We will continue to evaluate habitat selection among hens as a function of management, landscape cover, and other relevant landscape and habitat characteristics. We will then proceed to relate habitat selection to reproductive parameters (e.g., nest success, poult survival) and turkey behavior (e.g., incubation, loafing). As results of survival, nest-site selection and habitat use analyses are completed, we will provide those results to our IDNR project managers.

(iii) Reasons Estimated Goals Were Not Met

As mentioned above, we did not meet our primary goal of capturing and intensively monitoring up to 40 hens during this segment because we were only able to capture 3 hen and 4 male turkeys. This was despite our baiting and capture effort being more intensive and extensive than the 2 previous years where we had decent success. We attributed this to a mild winter 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. In addition, we realized that the objectives as written for this segment are more overall objectives for the multiple years we hope this project runs rather than as segment specific objectives. In future segments we will better define what the segment specific objectives (vs. overall longer-term objectives) are.

(iv) Additional Pertinent Information

The additional tasks completed during this segment (e.g. acorn surveys, camera traps, accelerometer data analyses, black fly trapping) are all important components of the longer-term objectives of this research. The black fly and accelerometer data in particular provided a proof of concept for what we plan to do during the next segment. 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.

Literature Cited

Adler, P. H., D. C. Currie, and D. M. Wood. 2004. The black flies (*Simuliidae*) of North America. Cornell University Press.

Aebischer, N. J., P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology 74:1313-1325.

Badyaev, A.V. 1995. Nesting habitat and nesting success of Eastern Wild Turkeys in the Arkansas Ozark highlands. Condor 97:221-232.

Badyaev, A.V., W.J. Etges, and T.E. Martin. 1996a. Ecological and behavioral correlates of variation in seasonal home ranges of Wild Turkeys. Journal of Wildlife Management 60:154–164.

Badyaev, A.V., T.E. Martin, and W.J. Etges. 1996b. Habitat sampling and habitat selection by female Wild Turkeys: ecological correlates and reproductive consequences. Auk 113:636–646.

Brown, D. D., R. Kays, M. Wikelski, R. Wilson, and A. P. Klimley. 2013. Observing the unwatchable through acceleration logging of animal behavior. Animal Biotelemetry 1:20.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multi-model inference: a practical information-theoretic approach. Springer.

Byrne, M. E., J. Clint McCoy, J. W. Hinton, M. J. Chamberlain, and B. A. Collier. 2014. Using dynamic Brownian bridge movement modelling to measure temporal patterns of habitat selection. Journal of Animal Ecology 83:1234-1243.

Calenge, C. 2006. The package “adehabitat” for the R software: A tool for the analysis of space and habitat use by animals. Ecological Modelling 197:516-519.

Dickson, J. G. 1992. The wild turkey: biology and management. Stackpole Books.

Ellison, A. M., and N. J. Gotelli. 2013. A primer of ecological statistics.

Fuller, A. K., S. M. Spohr, D. J. Harrison, and F. A. Servello. 2013. Nest survival of wild turkeys Meleagris gallopavo silvestris in a mixed-use landscape: influences at nest-site and patch scales. Wildlife Biology 19:138-146.

Horne, J. S., E. O. Garton, S. M. Krone, and J. S. Lewis. 2007. Analyzing animal movements using Brownian bridges. Ecology 88:2354-2363.

Hubbard, M.W., D. L. Garner, and E.E. Klaas. 1999. Factors influencing Wild Turkey hen survival in southcentral Iowa. Journal of Wildlife Management 63:731–738.

King, R. S., and P. H. Adler. 2012. Development and evaluation of methods to assess populations of black flies (Diptera: *Simuliidae*) at nests of the endangered whooping crane (*Grus americana*). J Vector Ecol 37:298-306.

Koenig, W. D., J. M. H. Knops, W. J. Carmen, M. T. Stanback, and R. L. Mumme. 1994. Estimating acorn crops using visual surveys. Canadian Journal of Forest Research 24:2105-2112.

Kozakai, C., K. Yamazaki, Y. Nemoto, A. Nakajima, S. Koike, S. Abe, T. Masaki, and K. Kaji. 2011. Effect of mast production on home range use of Japanese black bears. The Journal of Wildlife Management 75:867-875.

Leopold, A. S. 1943. The molts of young wild and domestic turkeys. The Condor 45:133-145.

Locke, S. L., J. Hardin, K. Skow, M. J. Peterson, N. J. Silvy, and B. A. Collier. 2013. Nest site fidelity and dispersal of Rio Grande Wild Turkey hens in Texas. Journal of Wildlife Management 77:207–211.

Lukacs, P.M., V.J. Dreitz, F.L. Knopf, and K.P. Burnham. Estimating survival probabilities of unmarked dependent young when detection is imperfect. Condor 106:926-931.

Mäkeläinen, S., H. J. de Knegt, O. Ovaskainen, and I. K. Hanski. 2016. Home-range use patterns and movements of the Siberian flying squirrel in urban forests: Effects of habitat composition and connectivity. Movement Ecology 4:1-14.

Miller, D.A., G.A. Hurst, and B.D. Leopold. 1999. Habitat use of Eastern Wild Turkeys in central Mississippi. Journal of Wildlife Management 63:210–222.

Nathan, R., O. Spiegel, S. Fortmann-Roe, R. Harel, M. Wikelski, and W. M. Getz. 2012. Using tri-axial acceleration data to identify behavioral modes of free-ranging animals: general concepts and tools illustrated for griffon vultures. J Exp Biol 215:986-996.

Nowacki, G.J., and M.D. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. BioScience 58:123–138.

Nudds, T. D. 1977. Quantifying the vegetative structure of wildlife cover. Wildlife Society Bulletin (1973-2006) 5:113-117.

Paisley, R. N., R. G. Wright, J. F. Kubisiak, and R. E. Rolley. 1998. Reproductive ecology of eastern wild turkeys in southwestern Wisconsin. Journal of Wildlife Management 62:911-916.

Perry, R. W., and R. E. Thill. 1999. Estimating mast production: an evaluation of visual surveys and comparison with seed traps using white oaks. Southern Journal of Applied Forestry 23:164-169.

Porter, W.F. 1977. Home range dynamics of Wild Turkeys in southeastern Minnesota. Journal of Wildlife Management 41:434–437.

Roberts, S.D., and W.F. Porter. 1996. Importance of demographic parameters to annual changes in wild turkey abundance. Proceedings of the National Wild Turkey Symposium 7:15-20.

Spears, B.L., M.C. Wallace, W.B.Ballard, R.S. Phillips, D.P. Holdstock, J.H. Brunjes, R. Applegate, M.S. Miller, and P.S. Gipson. 2007. Habitat use and survival of preflight Wild Turkey broods. Journal of Wildlife Management 71:69-81.

Team, R. C. 2016. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Thogmartin, W.E. 1999. Landscape attributes and nest-site selection in Wild Turkeys. Auk 116:912-923.

Thogmartin, W.E. 2001. Home-range size and habitat selection of female Wild Turkeys (*Meleagris gallopavo*) in Arkansas. American Midland Naturalist 145:247–260.

Thogmartin, W.E., and B.A. Schaeffer. 2000. Landscape attributes associated with mortality events of wild turkeys in Arkansas. Wildlife Society Bulletin 28:865-874.

Urbano, F., and F. Cagnacci. 2014. Spatial database for GPS wildlife tracking data. Springer.

Wigley, T. B., J. M. Sweeney, M. E. Garner, and M. A. Melchiors. 1986. Wild turkey home ranges in the Ouachita Mountains. Journal of Wildlife Management 50:540-544.

(v) Significant Developments

Not Applicable

(vi) Executive Summary

a) We continued to document locations and fates and nesting attempts of 12 Wild Turkey hens captured in the winter/spring of 2016 whose radios continued to function into the spring of 2017.

b) During the winter/spring of 2017 we captured and banded only 7 Wild Turkeys across 5 study sites and fitted each of the 3 hens captured (at Buckeye Creek) with a µGPS transmitter. This was far short of our goal of having up to 40 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 and habitat (i.e. forest) management affect the nesting success, survival, and habitat selection of hen turkeys.

d) Of the 15 hens monitored, none suffered mortality. This was different from the previous 2 years where several females died from predation following the onset of incubation during the nesting season. Overall, hen turkeys are particularly vulnerable to predation during the incubation phase of the nesting period, but not necessarily in every year.

e) Each of 10 nests failed to make it to the poult stage. Seven nests were depredated, one abandoned, and two could not be monitored to the end of incubation because of radio failure (associated with 2 females whose radios had lasted more than a year). Suspected nest predators include raccoons, opossums, coyotes and foxes based on visitation to baited camera traps.

f) Accelerometer data (index of hen turkey motion collected every 5 minutes) from the radios on hens 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.

g) Preliminary results indicate that black flies are very abundant in western, but not central, Illinois, and are emerging and seeking blood meals during the nesting season of Wild Turkeys. This sets the stage to determine whether there are any direct or indirect effect of black flies on hen and turkey nest survival.

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).