Roosting ecology and human influences related to conservation of female wild turkeys in Kansas

by

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Abstract

Despite being considered a major conservation and restoration success, the culturally and economically significant wild turkey (*Meleagris gallopavo*) has experienced recent regional population declines. Proposed reasons for these declines include survival, recruitment, vegetation structure, and harvest management despite wild turkeys being considered habitat generalists. Potentially limiting factors must be identified for effective management to abate the population decline of wild turkey. My study occurred across a precipitation gradient across much of Kansas, USA, which was characterized by a unique, mostly privately owned grassland-dominated landscape with limited riparian areas with frequency of tree occurrence increasing from west to east. Wild turkeys are a tree-dependent species so availability of forested or wooded areas limits potential wild turkey habitat and space use, dictating where management can be applied. My primary objectives were to characterize tree- and landscape-level factors associated with roost-site selection and roost fidelity; evaluate whether female movement, space use, survival, and landownership use changed in response to spring hunting disturbance; and identify landowner characteristics and decision-making factors associated with intentions to manage habitat for wild turkeys. I evaluated female wild turkey roosting ecology and response to spring hunting disturbance across an east-to-west ecological gradient in Kansas by capturing and marking female wild turkeys (n = 400) using Iridium backpack-style transmitters during winter 2024 and 2025 across three study regions representing landscapes with differing availability of forest stands. For the roosting component, I collected characteristics of roosts used by female wild turkeys and random, available trees at multiple scales during the leaf-on (May-Aug) and leaf-off seasons (Nov-Feb) during 2024–2026. Roost-tree selection varied regionally, with diameter-at-breast-height identified as the strongest predictor of use. Across seasons and regions, roost use was best explained by larger diameter trees, reduced low understory cover, and more closed overstory canopy, suggesting that availability of roost trees is driven more by structure than by species. These structural requirements are needed within the context of a heterogeneous landscape providing other life-cycle requirements. Landscape-level selection analyses indicated that roosts were associated with greater forest cover, closer proximity to stream corridors, and lower developed land, shrubland, water, and cropland cover than available points. Availability of landcover and structural requirements influence the space use by wild turkeys. Estimated monthly home range area was similar among seasons and regions. However, female wild turkeys in the West Region had the largest home range during summer and the smallest during winter. Roost fidelity also varied regionally, with the highest fidelity in the West Region and the lowest fidelity in the East Region, consistent with a regional gradient in tree availability. Across years and regions, mean roost fidelity was 0.63 ± 0.20 during summer and 0.81 ± 0.16 during winter. Roost structure, landscape, and fidelity combined with wild turkey movements show that roost availability was limited in the West Region, especially during winter. To evaluate female response to spring hunting disturbance, I used a Before–After–Impact–Control design comparing survival and space use before (Mar), during (Apr–May), and after (Jun) the hunting season. I classified weekly dominant landownership (private vs. public) to test whether females shifted habitat use during the hunting season. Survival was slightly lower on public lands (Private: 0.65 ± 0.03; Public: 0.57 ± 0.04), but weekly survival did not differ among periods. However, mortality locations occurred on public lands more often than expected based on availability within pre-mortality use areas, suggesting that females using publicly accessible lands may experience elevated mortality risk. Females overwhelmingly used private land, with only ~3–5% of weekly locations on public land. Ownership switching was rare, with <15% of birds changing dominant landownership during the hunting season, peaking prior to firearm season. Space use increased during the hunting period for all birds but did not differ between ownership groups. Overall, I found limited evidence that the spring hunt altered female wild turkey behavior or survival, likely due to movement to private land prior to the season. Given the importance of private lands in this system, I surveyed 176 Kansas landowners who allowed wild turkey researchers access to their properties to evaluate private-land management potential using the Theory of Planned Behavior and audience segmentation in April and May of 2026. Attitudes, subjective norms, and perceived behavioral control positively predicted intentions to implement wild turkey management practices. Intention was best represented by three landowner clusters that differed in willingness across management practices. Clusters were also distinguished by age, property size, and land-use diversity, indicating that outreach should account for differences in landowner capacity and management context. These results indicate that landowner support for wild turkey conservation depends not only on general attitudes toward wildlife, but also on the specific practice being considered and how well that practice fits land-use goals, resources, and experience. Recognizing these differences can help agencies, extension, and conservation

partners develop more effective, locally relevant outreach strategies that support voluntary wild turkey management and broader private lands conservation in Kansas. In summary, these findings indicate that wild turkey management in Kansas will be most effective when habitat needs, behavioral responses, and private landowner decision-making are addressed simultaneously. Roost availability appears to be a limiting resource in portions of the state, particularly in western Kansas and during winter, making the protection and development of large-diameter open-branching trees in proximity to other life-cycle resource needs an important management priority. In contrast, spring hunting appeared to have limited influence on female behavior and survival, likely because females used private land extensively before and during the hunting season. Therefore, management actions focused solely on public lands or harvest regulations may have limited ability to influence female wild turkey populations in Kansas. Because most wild turkey habitat occurs on private working lands, conservation efforts should prioritize voluntary, locally relevant outreach to landowners, especially those already receptive to wildlife management. Overall, wild turkey management in Kansas will be most effective when roosting habitat, behavioral responses to disturbance, and private landowner decision-making are addressed together. Management should promote voluntary practices such as timber stand improvement, prescribed fire, and invasive vegetation control as habitat improvements that can be integrated into working lands.

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Chapter 1 - Physical Characteristics of Wild Turkeys Roost Trees

Introduction

Habitat availability shapes space use by wildlife species within a landscape. Often considered habitat generalists, wild turkeys (*Meleagris gallopavo*) use a wide range of vegetation types for foraging, nesting, brood-rearing, and seasonal movement. However, unlike many ground-foraging and ground-nesting birds, wild turkeys have a unique life-history requirement: they spend nearly every night in elevated roost trees. Elevated roosting reduces exposure to predators and environmental conditions, making roost trees a critical component of wild turkey habitat requirements (Lima and Dill 1990; Lima 1998). Although roost-tree characteristics have been described across many portions of the wild turkey range, roosting habitat is often assumed to be broadly available and therefore non-limiting, particularly in landscapes with extensive forest cover (Byrne et al. 2015; Bakner et al. 2022, 2024). In contrast, roosting habitat in semiarid and grassland-dominated landscapes is often concentrated in riparian corridors or isolated woody stands capable of supporting sufficiently large trees (Perlichek et al. 2009; Bakner et al. 2022). Therefore, this assumption may not apply in grassland-dominated portions of the Great Plains such as Kansas, USA, where forest cover is patchily distributed and roost trees are often restricted to riparian corridors and scattered woodland patches. In these grassland-dominated systems, the distribution of roost trees may limit potential space available to wild turkeys and shape daily movement, seasonal space use, and access to nesting, foraging, and escape cover.

Roost-tree availability may be especially important in landscapes where trees are spatially limited. In grassland-dominated or savanna systems, potential roost trees are not uniformly distributed across the landscape but instead occur in discrete forest patches (Perlichek et al. 2009; Bakner et al. 2022). Recent work suggests that roost sites can function as spatial anchors within female wild turkey home ranges, with females organizing movements around networks of hub and satellite roosts during the reproductive season (Bakner et al. 2024). Females must balance roosting, foraging, nesting, and predator avoidance within a relatively constrained area frequently using prospecting movements to identify locations with adequate resources for incubation and reproduction (Conley et al. 2016; Bakner et al. 2024). Therefore, nesting or foraging habitat may not be available if roost trees are absent or spatially separated from those resources.

Roost distribution may also affect how females respond to disturbance, because relocation may be limited when roost trees are patchily distributed (Wakefield et al. 2020; Roth et al. 2024). Disturbance associated with fire suppression, agricultural practices, woody encroachment, invasive species, and forest management may alter the abundance and distribution of available roosting habitat to the point that wild turkeys can no longer occupy affected landscapes (Flake et al. 1995; Martin et al. 2005). However, evaluating roost availability requires more than identifying where trees occur; it also requires understanding characteristics of trees used as roost sites.

Although tree species used for roosting vary geographically, many structural characteristics associated with roost selection are consistent across populations. Research has commonly identified tree height, diameter-at-breast-height (DBH), canopy structure, limb height, and branching patterns as important characteristics of used roost trees (Boeker and Scott 1969; Rumble 1992; Flake et al. 1995; Perlichek et al. 2009; Martin et al. 2025). For example, greater DBH and tree height were consistently associated with roost-tree selection across regions in Ontario, Canada (Adey et al. 2023). Other studies have suggested that lower understory density and relatively open conditions near roost trees may facilitate predator detection and flight access (Flake et al. 1995; Martin et al. 2005). Collectively, these findings suggest that wild turkeys often select large trees with structural characteristics that provide support, visibility, and access, even though the species of trees available for roosting differs among landscapes.

While these structural characteristics appear relatively consistent across populations, tree species selection largely reflects regional forest composition and local availability. Across the central portions (e.g., Great Plains) of the wild turkey range, commonly used roost species include eastern cottonwood (*Populus deltoides*), American basswood (*Tilia americana*), ponderosa pine (*Pinus ponderosa*), American elm (*Ulmus americana*), sycamore (*Platanus occidentalis*), live oak (*Quercus virginiana*), and sugar hackberry (*Celtis laevigata*; Jonas 1964; Hoffman 1968; Crockett 1969; Rumble 1992; Flake et al. 1995; Holdstock 2003; Swearingin 2007; Perlichek et al. 2009; Thompson et al. 2009). In Great Plains landscapes, where forested vegetation is less continuous than in eastern forests, species composition may be less important than structural requirements needed for safe and accessible roosting. Therefore, evaluating both used and available trees is necessary to determine whether wild turkeys are selecting specific tree characteristics or simply using the largest trees available within a region.

Seasonal conditions and life-history demands may influence roost-tree selection because both the protective value of vegetation and the resource needs of female wild turkeys change throughout the year. During winter, deciduous trees lose foliage, potentially reducing concealment and protection from adverse weather. At northern latitudes, winter roosts are often associated with vegetation that reduces wind exposure, snow accumulation, or thermal stress. For example, Kilpatrick et al. (1988) documented frequent use of dense softwood stands in Rhode Island, USA, whereas Ermer et al. (2005) observed selection for conifer stands with reduced wind exposure and shallower snow depths in Minnesota, USA. However, thermal protection may be less influential at mid and lower latitudes, where winter-roost studies have instead emphasized the availability of large, structurally suitable trees, adequate flight access, and nearby security and foraging resources. In south Texas, USA, winter roosts contained above-average-sized trees and were associated with relatively large stands, nearby clearings, brush cover, and permanent water, whereas studies in the Rolling Plains and Trans-Pecos regions of Texas emphasized tall, large-diameter trees within open-understory or riparian stands (Haucke 1975, Swearingin 2007, Perlichek et al. 2009). During spring and summer, female resource needs shift toward breeding, egg laying, nesting, and brood rearing. Before incubation, females prospect for reproductive habitat and move among roosts, potential nest sites, and foraging areas, suggesting that the spatial arrangement of roosts may influence access to resources required during reproduction (Bakner et al. 2024). Summer roosts may be smaller and contain fewer roost trees than communal winter roosts, but females and other wild turkeys continue to use large, mature trees that provide suitable branches, flight access, concealment, and potentially shade. Hoffman (1968) found that summer roost sites were smaller and contained fewer trees than winter sites, although summer roost trees remained among the largest and tallest trees available. Martin et al. (2025) similarly found that tree diameter predicted summer roost use more consistently than measured microclimatic conditions. Collectively, these studies indicate that seasonal roost-tree selection may reflect both changing environmental conditions and changing female resource needs, supporting evaluation across seasons and ecological regions.

Although some studies have examined wild turkey roosting ecology in the Great Plains, few have compared used and available roost trees across seasons and ecological regions for populations in mid-latitude landscapes of Kansas. Holdstock (2003) measured roost trees in the spatially limited woodlands of the Cimarron National Grassland in southwestern Kansas and on private lands in the Panhandle of Texas, USA. Used roost trees averaged 49.9 cm DBH, 13.6 m in height, and 3.4 m to the lowest limb. Eastern cottonwood represented the majority of used roost trees, although black locust (*Robinia pseudoacacia*) and netleaf hackberry (*Celtis reticulata*) were also commonly used. However, those findings were summarized across the annual cycle and did not evaluate how roost-tree selection may vary seasonally or across the east-to-west ecological gradient in Kansas. Accordingly, a regional and seasonal evaluation of roost-tree use and selection in Kansas are needed to better understand how roosting habitat may shape wild turkey space use in grassland-dominated systems.

Kansas provides an opportunity to examine roost-tree use and selection across ecological regions that differ substantially in precipitation, tree density, and vegetation composition. Therefore, my objective was to compare the physical and ecological characteristics of used and available roost trees across regions and seasons in Kansas. I hypothesized that female wild turkeys would select roost trees differently across an east-to-west precipitation gradient that included regional variation in tree availability, vegetation structure, and surrounding habitat composition. Specifically, I predicted that used roost trees would be larger in diameter, taller, and have greater limb height than available trees across all regions, but that the magnitude of the difference would be greatest in regions where trees were more limited. I also predicted that used roost trees would have relatively open understory or mid-story conditions and moderate surrounding canopy cover, which may facilitate flight access, predator detection, and structural support for roosting.

Study Area

My study area encompassed the eastern two-thirds of Kansas, spanning a longitudinal gradient divided into three regions: East (–96.96 to –95.50), Central (–98.49 to –96.96), and West (–100.15 to –98.49; Figure 1.1). These regions represent a pronounced east–west precipitation gradient and an associated transition from oak–hickory woodlands in the east to tallgrass, mixed-grass, and shortgrass prairies longitudinally moving westward along the precipitation gradient. Across all three regions, grassland is the dominant cover type in all study sites, with >65% of open prairie used for livestock grazing. Cropland and woodland cover vary regionally: cropland is most extensive in the West Region (31% of total area, primarily winter wheat and sorghum), intermediate in the Central Region (23%, primarily winter wheat with smaller amounts of sorghum, soybeans, corn, and alfalfa), and lowest in the East Region (11%, primarily soybeans). Forest cover is <5% in the Central and West regions but reaches ~15% in the East Region. Urban intensity is low statewide, though slightly larger in the East Region (1%) than in the Central (0.35%) or West Region (0.55%; Skidmore, 2026). Weather metrics during 2024–2026 study period were derived from county-level monthly weather averages from NOAA, Climate at a Glance, June 2026 (https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series). Regional extreme temperatures per each season was pulled from Kansas Mesonet (https://mesonet.k-state.edu/weather/historical/).

The East Region is comprised of five study sites (Riley, Morris, Chase, Osage, and Greenwood counties), which include tallgrass prairie and floodplain vegetation within the Flint Hills (28) and Osage Cuestas (40b) ecoregions (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). The Flint Hills Ecoregion contains the largest remaining expanse of intact native tallgrass prairie in the Great Plains, dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*). The Osage Cuestas Ecoregion represents a transition from tallgrass prairie in the west to oak–hickory woodlands in the east, with upland forests characterized by shagbark hickory (*Carya ovata*), bitternut hickory (*C. cordiformis*), red oak (*Quercus rubra*), white oak (*Q. alba*), and black oak (*Q. velutina*), with understory trees such as Ohio buckeye (*Aesculus glabra*), American bladdernut (*Staphylea trifolia*), and pawpaw (*Asimina triloba*).

During the leaf-on (May–Sep) season average precipitation from 1996–2026 in the East Region was 46.33 (SD = 1.27) cm. During 2024 it was a slightly dryer season at 43.73 (SD = 3.16) cm and in 2025 it was about average with yearly trend at 47.97 (SD = 8.18) cm. Average temperature from 1996–2026 was 23.3º C, with both seasons within typical range. In 2024, it was 23.6º C (7.3º C – 39.7º C) and 23.1º C (4.4º C – 38.4º C) in 2025. During the leaf-off (Nov-Feb) season average precipitation from 1996–2026 was 13.37 (SD = 1.50) cm. In 2024–2025 was a wetter season than average at 17.58 (SD = 1.56) cm but was slightly drier than typical in 2025–2026 at 11.41 (SD = 2.66) cm. Average temperature from 1996–2026 was 2.18º C, 2024–2025 was a colder season at 1.53º C (-25.7º C – 21.6º C) and a warmer season at 4.34º C (-22.6º C - 25.6º C) in 2025–2026.

The Central Region comprised of three study sites (Marion, McPherson, Dickinson, and Ellsworth counties), which includes the Smoky Hills (27a) and Wellington–McPherson Lowland (27d) ecoregions (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). Vegetation consists of tallgrass and mixed-grass prairie with floodplain forests along riparian corridors. Prairie vegetation communities are dominated by big bluestem, little bluestem, and Indiangrass, with switchgrass occurring in mesic sites. Riparian forests are dominated by plains cottonwood (*Populus deltoides*), black willow (*Salix nigra*), peachleaf willow (*S. amygdaloides*), hackberry (*Celtis occidentalis*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and black walnut (*Juglans nigra*), with bur oak (*Q. macrocarpa*) becoming less common westward.

During the leaf-on season average precipitation from 1996–2026 in the Central Region was 43.66 (SD =1.27) cm. There was typical precipitation in 2024 at 43.74 (SD = 4.56) cm but in 2025 it was a wet season at 52.56 (SD = 11.42) cm. Average temperature from 1996–2026 was 23.8º C and average temperature was typical both in 2024 at 24.0º C (4.2º C – 39.3º C) and 2025 at 23.3º C (2.8º C – 39.7º C). During the leaf-off season, average precipitation from 1996-2026 was 11.73 (SD = 0.41) cm. In 2024–2025 average precipitation was higher than typical at 16.40 (SD = 0.66) cm and lower in 2025–2026 at 9.19 (SD = 0.51) cm. Average temperature from 1996-2026 was 2.3º C, it was slightly cooler during 2024–2025 at 1.4º C (-25.5º C – 22.1º C) and warmer than typical at 4.4º C (-24.9º C - 25.3º C) in 2025–2026.

The West Region comprised of four study sites (Trego, Ellis, Ness, and Russell counties) is characterized by mixed-grass prairie with some shortgrass prairie, within the Rolling Plains and Breaks (27b) Ecoregion (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). Dominant grasses include little bluestem, blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), sideoats grama (*B. curtipendula*), and western wheatgrass (*Pascopyrum smithii*). Forested cover is largely restricted to riparian corridors.

During the leaf-on season average precipitation from 1996–2026 in the East Region was 33.7 (SD = 2.8) cm and precipitation was typical in both study years. During 2024, it was 34.5 (SD = 1.5) cm and in 2025 it was 33.8 (SD = 1.9) cm. Average temperature from 1996–2026 was

23.2º C, during 2024 it was 23.7º C (4.7º C – 42.5º C) and 23.0º C (2.6º C – 42.6º C) in 2025. During the leaf-off season average precipitation from 1996–2026 was 6.9 (SD = 0.7) cm. Conditions were wetter than typical in both leaf-off study seasons. In 2024–2025 average precipitation was 10.9 (SD = 1.5) cm and in 2025–2026 it was 7.9 (SD = 1.2) cm. Average temperature from 1996-2026 was 1.8º C, during 2024–2025 it was 1.2º C (-25.7º C – 24.4º C) and warmer at 4.4º C (-27.2º C – 26.9º C) in 2025–2026.

Methods

Capture

Female wild turkeys were trapped during January-March 2024 and 2025. Capture sites were stratified by ecoregion (Figure 1.1). Wild turkeys were captured by baiting with cracked corn and use of drop net, walk-in trap, or rocket net. Birds were removed from traps and placed into National Wild Turkey Federation approved wild turkey capture boxes. During processing, the head of each wild turkey was covered to minimize stress to the bird. Birds were sexed based on presence of spur, beard, and chest feather coloration. Age was determined by barring on outer primary wing feathers along with tail fan shape (Healy and Nenno, 1980; Schroder and Robb, 2005). Morphometric measurements of all birds include body mass (kg), tarsus length (mm), flattened wing cord (mm), and culmen (mm). When present, spur length (mm) and beard length (mm) were also recorded. Females >3.8 kg were considered for transmitter attachment. Captured females were fitted with 160-g Iridium GPS backpack transmitters (model G5-T2A, Advanced Telemetry Systems, Isanti, Minnesota, USA). Transmitters collected 6–12 daily location fixes, including nocturnal (i.e., roost; 0200 CST) locations. All birds received uniquely numbered riveted metal leg band for identification purposes (National Band & Tag Company, Newport, Kentucky, USA). Birds were released in groups at capture location. Capture and handling were conducted under State of Kansas Scientific, Education, or Exhibition Wildlife Permits (KDWP #980122568) and protocols were approved by the Kansas State University Institutional Animal Use and Care Committee (IACUC protocol 4906).

Roost Tree Measurements

Nocturnal roosts, defined as clusters of night locations used more than three times per month, were identified from GPS data and ground-truthed during leaf-on (May–Aug) and leaf-off (Dec–Feb) period. Roost trees were confirmed by presence of fecal droppings or feathers. At each roost site, the focal roost tree and three randomly selected available trees (DBH >7 cm) within 30–300 m in the same stand were sampled for comparison of multiple morphometric characteristics (Figure 1.2). I ensured that no tree was measured twice in a season.

Tree species were identified using Haddock and Freeman (2019) as the primary authority. Diameter-at-breast-height (DBH) was measured at 1.37 m above ground using a diameter tape. Tree height and height to the lowest live limb was measured with a clinometer or laser rangefinder. Canopy openness was quantified at 1-m and 10-m radii around the tree using a spherical densiometer. Understory vegetation cover was visually estimated in three strata: low (0–1.5 m), mid (1.6–4 m), and high (>4 m), following a modified pin-point method (Figure 1.3).

Stand density was estimated using a modified point-centered quarter approach (Cottam and Curtis, 1956). For each sampled tree, the nearest tree was searched for in each of four quadrants up to a maximum distance of 50 m. Quadrants in which no tree was detected within 50 m were treated as censored at the 50-m search distance rather than excluded from the calculation. To reduce the influence of clustered stems immediately adjacent to the focal tree, nearest-tree distances <0.5 m were set to 0.5 m prior to calculating density. Stand density was then calculated as 10,000 divided by squared mean corrected distance and expressed as trees per hectare.

Statistical Analyses

I conducted all statistical analyses in Program R. I limited analyses to trees associated with adult, non-brood-rearing female wild turkey roosts and randomly selected available trees. Trees were grouped by use status, season, and region. Used trees included trees classified as used roost trees; available trees included randomly selected trees sampled within the same stand as used roosts.

Genus Composition

I summarized tree genus composition by calculating counts and percentages of used and available trees within each region and season. To evaluate whether genus composition differed between used and available trees, I used Pearson's chi-square tests of independence separately for the leaf-on and leaf-off seasons. To reduce sparse cell counts, genera were grouped into common genera and an "Other" category prior to analysis. Common genera included *Celtis*, *Fraxinus*, *Juglans*, *Juniperus*, *Maclura*, *Populus*, *Quercus*, and *Ulmus*. I inspected expected cell counts to evaluate whether chi-square assumptions were met. Because expected counts were low for regional genus comparisons, I used the overall seasonal chi-square tests to evaluate genus composition and interpreted regional genus patterns descriptively using counts and percentages.

Seasonal Comparison of Used Roost Trees

To evaluate seasonal differences in characteristics of roost trees, I compared used roost trees between the leaf-on and leaf-off seasons within each region. I tested whether used-tree characteristics differed by season, region, or the season-by-region interaction using a factorial analysis of variance (ANOVA). I then compared leaf-on and leaf-off used roost trees within each region using two-sample *t*-tests. Variables included DBH, tree height, height to the lowest limb, canopy openness at 1 m and 10 m, low stratum cover, medium stratum cover, high stratum cover, and stand density.

Used versus Available Tree Characteristics

To compare used and available trees, I analyzed the leaf-on and leaf-off seasons separately. For each season, I used factorial ANOVA to test the effects of use, region, and use-by-region interaction on each tree characteristic. When the use-by-region interaction was significant, I interpreted used-versus-available comparisons within each region using *t*-tests. When the interaction was not significant, I interpreted the main effect of use across regions. I also evaluated regional differences using one-way ANOVA and used estimated marginal means for pairwise *t*-test regional comparisons when regional effects were significant.

Resource Selection Models

To evaluate which structural characteristics best predicted roost tree use, I used logistic regression with tree use as a binary response variable. I developed 11 *a priori* candidate models representing biologically relevant hypotheses of roost-tree selection based on structural characteristics of trees and surrounding vegetation. Candidate models represented hypotheses related to tree size (i.e., DBH), canopy openness, understory vegetation structure, and combinations of these variables associated with roost accessibility and predator detection. Competing models were ranked using Akaike's Information Criterion corrected for small sample size (AIC_c) to identify the best-supported predictors of roost selection.

Results

Roost tree sampling and seasonal species composition

During 2024–2026, I measured 602 roost trees used by adult, non-brood-rearing female wild turkeys and 1,773 randomly selected available trees across the West, Central, and East study regions. During the leaf-on (May-Sep) season, I measured 352 used roost trees and 1,046 available trees; including 95 used and 281 available trees in the West Region, 104 used and 316 available trees in the Central Region, and 153 used and 449 available trees in the East Region. During the leaf-off (Nov–Feb) season, I measured 250 used roost trees and 727 available trees; including 56 used and 164 available trees in the West Region, 62 used and 188 available trees in the Central Region, and 132 used and 375 available trees in the East Region.

Among used roost trees confirmed by presence of fecal droppings, DBH ranged from 13.1 – 198.0 cm across regions and seasons. Seasonal ranges were 13.1-198.0 cm during the leaf-on seasons and 18.4 – 163.0 cm during the leaf-off season. The most dominant tree genus used per region was consistent across both leaf-on and leaf-off seasons, although some differences between seasons were found in the second most dominant (Tables 1.1, 1.2). Tree-species richness and the number of species represented among used roost trees also varied by region and season. During the leaf-on season, 11 of 16 species in the West, 13 of 16 species in the Central Region, and 15 of 20 species in the East were used as roost trees. During the leaf-off season, roost-tree use included 4 of 8 species in the West, 10 of 18 species in the Central Region, and 13 of 16 species in the East. In the West Region, *Populus* (cottonwood) was the dominant genus with an average DBH of 87.27 (SD = 34.53) cm in the leaf-on season and 79.25 (SD = 26.37) cm in the leaf-off season. The second most used genus during the leaf-on season was *Ulmus* (elms) with a DBH of 52.64 (SD = 24.03) cm; whereas, in the leaf-off season *Gleditsia* (locust) with a DBH of 47.36 (SD =10.72) cm ranked second. *Populus* was also the most dominant genus in the Central Region for both leaf-on and leaf-off seasons, with average DBH of 83.31 (SD = 45.00) cm and 110.31 (SD = 31.52) cm, respectively. Again, the second-ranked species most used changed for leaf-on (*Celtis* [hackberry]; DBH = 46.60 cm, SD = 15.67) and leaf-off (*Quercus*

[oaks]; DBH = 81.08 cm, SD = 28.71) seasons. In the East Region, the dominant genus for leaf-on and leaf-off seasons was *Quercus* with average DBH of 50.76 (SD = 18.37) cm and 60.17 (SD = 23.43) cm, respectively, followed by *Celtis* with average DBH of 45.98 (SD = 14.21) cm and 59.88 (SD = 19.02) cm, respectively.

Used roost tree characteristics differed between leaf-on and leaf-off seasons, but seasonal patterns varied by region (Table 1.3). Season-by-region interactions were detected for DBH ($F_{2,596}$ = 5.22, P = 0.006), tree height ($F_{2,596}$ = 3.54, P = 0.03), lowest limb height ($F_{2,577}$ = 13.03, P < 0.001), canopy openness at 1 m ($F_{2,596}$ = 3.83, P = 0.02), canopy openness at 10 m ($F_{2,596}$ = 7.29, P < 0.001), low stratum cover ($F_{2,596}$ = 25.00, P < 0.001), medium stratum cover ($F_{2,596}$ = 5.79, P = 0.003), and high stratum cover ($F_{2,596}$ = 6.07, P = 0.002). Stand density did not have a season-by-region interaction ($F_{2,596}$ = 0.33, P = 0.72). Because most variables had significant season-by-region interactions, I interpreted seasonal differences within each region rather than across all regions combined.

In the West Region, leaf-off roost trees were taller with less open canopy and more understory obstruction than leaf-on roost trees. Stand density and DBH did not differ between seasons (Table 1.3). Few differences in the structure of used trees between seasons were found for the Central Region. Leaf-off roost trees had larger DBH, less low stratum cover, and denser forest stands than leaf-on roost trees. Height, canopy cover, medium and high stratum cover did not significantly differ between leaf-on and leaf-off seasons (Table 1.3). In the East Region, leaf-off roost trees were wider and taller, had slightly more open canopy at 1-m radius, reduced low stratum cover, and increased high stratum cover than leaf-on roost trees. Stand density, medium stratum cover, and canopy openness at 10 m was not significantly different between seasons (Table 1.3). Overall, seasonal differences were most pronounced in the West and East regions, with used roost tree characteristics in the Central Region similar between leaf-on and leaf-off seasons.

Leaf-on used versus available tree characteristics

During the leaf-on season, tree genus composition differed between used and available trees across all regions combined ($\chi^2_8 = 71.33$, $P < 0.001$; Figure 1.4). This pattern was driven primarily by disproportionate use of *Populus* in the West and Central regions. In the West Region, *Populus* accounted for 53.7% of used roost trees but 22.1% of available trees. In the Central Region, *Populus* accounted for 24.0% of used roost trees but only 3.8% of available trees. In the East Region, *Quercus* was the most frequently used genus, accounting for 31.4% of used roost trees and 28.1% of available trees.

During the leaf-on season, several tree characteristics had significant use-by-region interactions indicating that differences between used and available trees depended on region (Table 1.4). These included DBH, tree height, lowest limb height, canopy openness at 10 m from the tree, medium stratum vegetation cover, high stratum vegetation cover, and stand density. In the West Region during the leaf-on season, used roost trees were in denser stands and had greater height, DBH, denser canopy cover at 10 m, and more high stratum cover than available trees (Table 1.5). In the Central Region, used roost trees were taller, wider, and in sparser forest stands with less medium stratum cover than available trees (Table 1.5). In the East Region, used roost tree had greater DBH than available trees, although the absolute difference was small.
For variables without a significant use-by-region interaction, I interpreted the main effects of use and region. During the leaf-on season, used roost trees had greater canopy openness within 1 m than available trees (7.21 ± 0.67% and 5.61 ± 0.32%, respectively; $F_{1,1396} = 5.56$, $P = 0.019$) and less low-stratum vegetation cover (83.8 ± 1.37% and 88.2 ± 0.66%, respectively; $F_{1,1396} = 9.64$, P

= 0.002). Both characteristics also differed among regions. Mean canopy openness within 1 m decreased from the West Region (9.46 ± 0.66%) to the Central (4.93 ± 0.44%) and East regions (4.61 ± 0.43%; $F_{2,1395}$ = 26.33, P < 0.001). In contrast, low-stratum cover increased from the West Region (78.9 ± 1.53%) to the Central (86.7 ± 1.14%) and East regions (92.4 ± 0.56%; $F_{2,1395}$ = 43.64, P < 0.001).

Leaf-off used versus available tree characteristics

During the leaf-off season, tree genus composition differed between used and available trees across all regions combined, indicating that female wild turkeys did not use tree genera in proportion to availability (χ^2_8 = 78.40, P < 0.001; Figure 1.4). Regionally, this pattern was most apparent in the West and Central regions, where *Populus* represented a greater percentage of used roost trees than available trees. In the West Region, *Populus* accounted for 62.5% of used roost trees and 36.0% of available trees. In the Central Region, *Populus* accounted for 29.0% of used roost trees but only 2.7% of available trees. In the East Region, *Quercus* was the most frequently used genus, accounting for 36.4% of used roost trees and 28.0% of available trees.

During the leaf-off season, I found significant use-by-region interactions for DBH, tree height, and lowest limb height (Table 1.4). The interaction for medium stratum vegetation cover was marginal (Table 1.4). In the West, Central, and East regions, female wild turkeys used roost trees that were taller and had greater DBH than available trees (Table 1.6). Used roost trees also had higher lowest limbs than available trees in the West and East regions, but lowest limb height did not differ between used and available trees in the Central Region.

For variables without a significant use-by-region interaction, I interpreted the main effect of use and regions. During the leaf-off season, used trees had less canopy openness at 10 m and less low and medium stratum cover, but had greater high stratum cover (Table 1.7) than available. Across regions, trees had more open canopy conditions at 10 m in the West Region than the East Region (Table 1.8). Understory cover also differed among regions with Central Region tending to have less cover than West or East Region.

Resource selection

The two top-ranked models held all of the model weight when testing selection of roost trees by female wild turkey across regions and seasons (Table 1.9). The top-ranked model included DBH, 10-m canopy openness, and low stratum cover, while the next-supported model included only DBH and low stratum cover (ΔAICc = 4.31). Models containing DBH alone or DBH with canopy openness received substantially less support (ΔAICc > 13).

Roost-tree selection was most influenced by a combination of DBH, low understory vegetation cover, and canopy openness at the 10-m scale. Larger DBH trees were positively associated with roost use ($\beta = 0.94 \pm 0.06$ SE), whereas low stratum cover ($\beta = -0.20 \pm 0.05$ SE) and 10-m canopy openness ($\beta = -0.14 \pm 0.06$ SE) were negatively associated with roost use. The relative probability of roost-tree use increased with DBH during both leaf-on and leaf-off seasons (Figure 1.5).

Discussion

Female wild turkeys selected structurally distinct roost trees across Kansas, but the magnitude and characteristics of selection varied by region and season. Used trees were generally larger and taller than available trees, and roost-tree use was most strongly associated with greater DBH, reduced low-stratum vegetation, and greater surrounding canopy structure. Selection was most pronounced in the West and Central regions, where females disproportionately used large *Populus* and other mature trees within relatively limited wooded patches, whereas differences between used and available trees were less pronounced in the more heavily forested East Region. Seasonal comparisons also indicated greater use of larger or structurally developed trees during the leaf-off season, particularly in the Central and East regions. Collectively, these findings suggest that female wild turkeys selected a distinct subset of available trees and that the potential for roost-tree availability to constrain habitat use was greatest where large trees were less abundant and more spatially restricted.

Seasonal differences in used roost trees suggest that female wild turkeys placed greater emphasis on large or structurally developed trees during winter than during summer. In the Central and East regions, leaf-off roost trees had greater DBH than leaf-on roost trees, whereas leaf-off roost trees in the West and East regions were taller and had greater height to the lowest limb (Table 1.3). These patterns may reflect both seasonal changes in vegetation structure and winter social behavior. Wild turkeys commonly form larger flocks and use communal roosts during winter, potentially increasing the value of large trees and wooded stands that can accommodate multiple birds (Kilpatrick et al. 1988, Swearingin 2007). Larger trees may provide sturdier limbs, favorable branching arrangements, and more branches suitable for perching, although those characteristics were not measured directly in this study (Swearingin 2007, Martin et al. 2025). Thus, the greater DBH and height of winter roost trees in Kansas may partly reflect selection for trees capable of supporting communal roosting.

Female wild turkeys nevertheless continued to select structurally distinct trees during summer. During the leaf-on season, used trees in the West and Central regions were taller and had greater DBH and greater height to the lowest limb than available trees, whereas DBH was the only characteristic that differed between used and available trees in the East Region (Table 1.5). Across regions, used trees also had slightly more open canopy conditions within 1 m and less low-stratum vegetation cover than available trees, which may facilitate access to and departure from roost trees. Summer roost sites may support fewer birds than winter communal roosts, but this does not eliminate the importance of tree structure. Hoffman (1968) found that summer roost sites were smaller and contained fewer roost trees than winter sites, yet turkeys continued to select among the largest and tallest trees available. Similarly, Martin et al. (2025) found that large tree diameter predicted roost-tree use during both summer and winter. Collectively, these results suggest that females selected structurally suitable trees during both seasons, but that the function of those trees may differ seasonally. Winter roosts may need to accommodate larger flocks, whereas summer roosts provide secure nightly locations within breeding-season landscapes used for nesting and foraging.

Seasonal differences in canopy and understory measurements should also be interpreted carefully because measured vegetation structure changes between leaf-on and leaf-off periods. During winter, deciduous trees lose foliage and herbaceous vegetation becomes dormant, which can alter canopy openness, low stratum cover, and midstory visibility even if the woody structure of a site remains unchanged. In Kansas, winter roost trees often had greater high stratum cover and less low stratum cover, suggesting that females used roosts with overhead structure while maintaining relatively open conditions near the ground. This combination may provide concealment or thermal protection above the roost while preserving visibility and unobstructed flight access below. Previous studies have similarly emphasized the importance of large trees, open understory conditions, and adequate canopy or stand structure at wild turkey roost sites (Kilpatrick et al. 1988; Rumble 1992; Flake et al. 1995; Swearingin 2007; Perlichek et al. 2009; Adey et al. 2024; Martin et al. 2026).

Regional differences in used roost trees reflected the strong east-to-west gradient in tree availability and composition across Kansas. In the West Region, used roost trees were largely associated with riparian corridors and often *Populus* or other large trees occurring in otherwise open landscapes. This pattern is consistent with previous work in Great Plains and dryland systems where wild turkeys relied heavily on riparian or spatially restricted wooded areas for roosting habitat (Flake et al. 1995; Holdstock 2003; Perlichek et al. 2009). In western Kansas, roosting structure is concentrated in narrow wooded strips, making individual large trees especially important as there may be few alternatives. The Central Region appeared intermediate, with *Populus* still important but with somewhat greater diversity in available tree structure. In contrast, the East Region contained more continuous woodland and a greater diversity of hardwoods (Moser et al., 2008). Female wild turkeys in the East Region used *Quercus*, *Celtis*, and other hardwoods more frequently, which likely reflects the greater availability of upland woodland and forested habitat compared to western Kansas. Thus, female wild turkeys did not select a single tree genus statewide; instead, they selected locally available trees that provided seasonally required roosting structure within each region.

Comparisons between used and available trees further suggest that roost-tree limitation varied regionally. In the West Region, available trees were generally smaller, and used roost trees represented a more distinct subset of the available tree community. This pattern suggests that female wild turkeys in western Kansas rely disproportionately on large legacy *Populus* or other mature riparian trees. In the Central Region, used trees also differed from available trees, indicating continued selection for larger and more structurally complex trees. In the East Region, however, differences between used and available trees were often smaller or nonexistent. This does not mean roost trees are unimportant in eastern Kansas; rather, it may indicate that structurally adequate trees are more widely available and not limiting in the East Region. Because eastern Kansas has more forest cover and more upland hardwoods, females may have greater access to trees that meet roosting requirements, reducing the contrast between used and available trees. Similar patterns have been reported elsewhere, where wild turkeys used different tree species depending on local forest composition but consistently selected trees with adequate size, height, branching structure, or stand conditions (Boeker and Scott 1969; Rumble 1992; Flake et al. 1995; Holdstock 2003; Swearingin 2007; Thompson et al. 2009; Adey et al. 2024).

The resource-selection models supported the interpretation that roost-tree use was driven primarily by structure rather than tree identity alone. Roost use was positively associated with DBH, indicating that larger trees were more likely to be selected or limiting depending on study region. In contrast, low stratum cover and canopy openness at 10 m was trunk of tree were negatively associated with use, suggesting that females selected trees with less obstructive vegetation near the ground and greater surrounding canopy structure. These results are consistent with previous studies that identified tree diameter, tree height, canopy cover, basal area, and understory openness as important components of roost-tree or roost-site selection (Boeker and Scott 1969; Rumble 1992; Flake et al. 1995; Swearingin 2007; Perlichek et al. 2009; Adey et al. 2024; Martin et al. 2026). Large diameter trees likely provide stronger limbs, more stable perches, and branching architecture capable of supporting a large-bodied bird. Reduced low vegetation may improve visibility and reduce obstruction during flight into and out of roost trees (Flake et al. 1995; Swearingin 2007). Lower canopy openness at 10 m may indicate greater surrounding canopy structure, which could provide cover near the roost while still allowing access below. Together, these results reinforce the conclusion that female wild turkeys selected roost trees based on a combination of tree size, vertical structure, and access conditions.

These results also have implications for breeding-season habitat use. Female wild turkeys nest on the ground, but they continue to rely on elevated roosts before incubation and during egg laying, requiring breeding-season ranges to contain both nest vegetation and accessible roosting structure We did not estimate a distance threshold beyond which nesting habitat became functionally unavailable. However, where structurally suitable roost trees are sparse, females may have to travel farther between roosts and nesting or foraging areas, potentially affecting where breeding-season ranges can be established. Bakner et al. (2024) found that reproductive-season movements could be organized around networks of roost sites. Within these networks, hub roosts were highly connected sites that linked movements among several other roosts, whereas satellite roosts were less-connected sites associated with one or a few hub roosts. Recent work in Kansas also found that nest-site use was associated with proximity to trees even though most nests occurred in grassland land-cover patches (Skidmore 2026). In Kansas, where roost trees are patchily distributed, this relationship may be especially important. Grassland or shrubland vegetation may appear available for nesting, but females may be constrained if nearby roost trees are absent, isolated, or structurally insufficient. Thus, roost-tree distribution may influence not only where females sleep, but also where they can establish breeding-season ranges and access nesting, foraging, and escape cover.

Overall, roost-tree availability appears most likely to limit habitat use in western and portions of central Kansas, where trees are less abundant and more strongly associated with riparian corridors. In these regions, the loss of mature *Populus* or other large riparian trees could reduce available habitat even if surrounding grassland or cropland remains available. Similar concerns have been raised in the southwest Kansas and Rolling Plains of Texas, where potential roost sites were limited and Rio Grande wild turkeys used large riparian roost stands with the tallest and largest-diameter trees available (Holdstock, 2003; Swearingin 2007). Cottonwoods grow rapidly and can attain dimensions suitable for roosting relatively quickly, so the primary concern is not simply the time required for an individual tree to grow. Instead, cottonwoods are relatively short-lived, and successful natural recruitment depends on episodic environmental conditions that expose moist, bare substrates during seed dispersal allow seedlings to survive subsequent changes in river stage (Cooper 1990, Scott et al. 1997). Altered flow regimes, declining water tables, intensive grazing, competition from invasive vegetation, and removal of mature trees may therefore prevent new cohorts from becoming established before existing roost trees senesce or are lost (Holdstock 2003, Swearingin 2007). If this produces a gap in suitable roost structure, the number and spatial distribution of usable roost sites could decline. For wild turkey populations, fewer or more isolated roost sites could contract the area capable of supporting birds, concentrate use around remaining roosts, and increase the distance between roosts and nesting or foraging resources. Over time, these changes could reduce local carrying capacity or contribute to declining occupancy in otherwise suitable landscapes, although this study did not directly evaluate effects of roost availability on population growth.

Wild turkey management should prioritize preventing roost trees from becoming a limiting habitat component for female wild turkeys. Our results indicate that this concern is greatest in western and portions of central Kansas, where used roost trees represented a distinct subset of the available tree community and were concentrated within riparian corridors. In these regions, loss of mature *Populus* or other large trees may reduce the area that females can use, even when surrounding grassland, shrubland, or cropland continues to provide nesting and foraging cover. Management should therefore retain existing large roost trees and promote recruitment of replacement cohorts near areas used by wild turkeys. In western Kansas, this will often require maintaining riparian conditions that allow *Populus* establishment and survival, whereas management in central Kansas should retain both large riparian trees and mature hardwoods that increase the number and distribution of roosting options. In eastern Kansas, large trees appeared more widely available, suggesting that individual tree loss may be less likely to constrain habitat use, although retaining a diversity of large hardwoods remains important. Thus, the primary management implication of this study is that surrounding vegetation alone does not determine whether an area provides wild turkey habitat; an adequate number and distribution of roost trees must also be maintained so that roost availability does not restrict female space use or access to breeding-season resources. Although this study did not directly test whether roost-tree availability limited wild turkey populations, females selected a distinct subset of available trees, particularly in regions were large trees were less abundant and more spatially restricted. Loss of those trees could therefore reduce the number and distribution of roost sites and constrain the portion of the surrounding landscape available to females. This study therefore identified conditions under which roost trees may become limiting in grassland-dominated landscapes, particularly where large trees are uncommon and spatially isolated.

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Figures

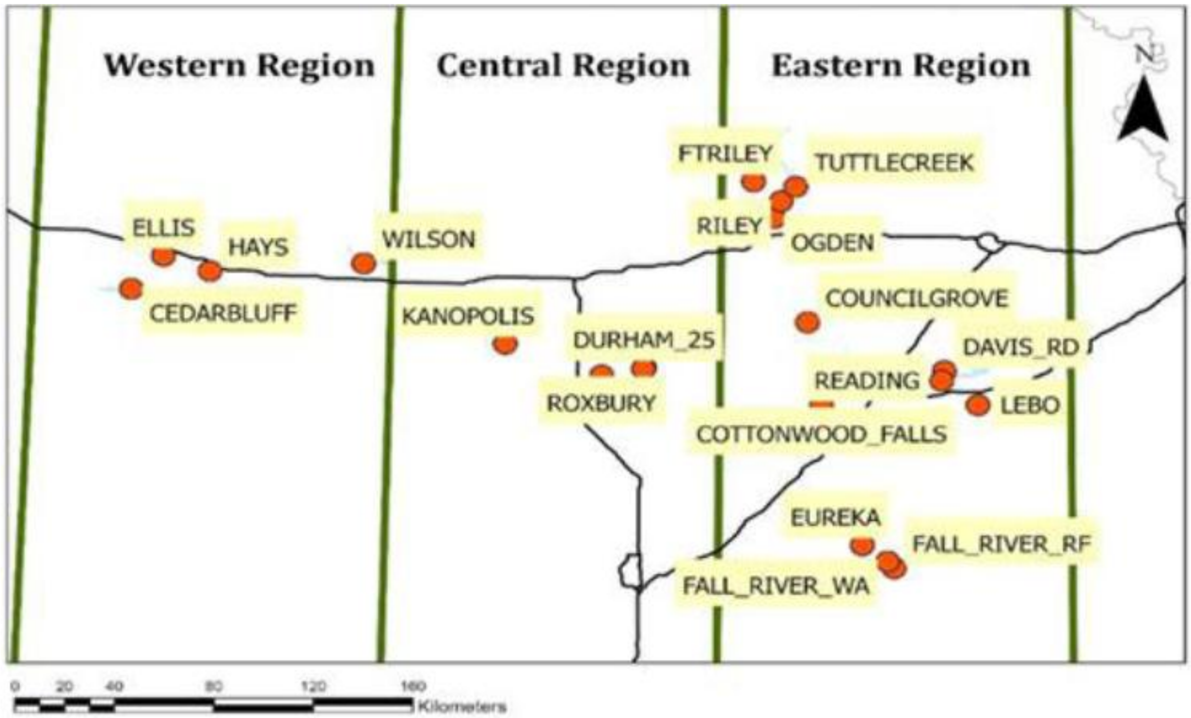

Figure 1.1. The study area split into three study regions (West, Central, and East) where wild turkeys were captured and marked with 140-gram G5-T2A Iridium backpack units with global positioning systems (GPS) and very high frequency (VHF) radio transmitter components. Captures occurred across 19 different sites in Kansas, 2024-2025.

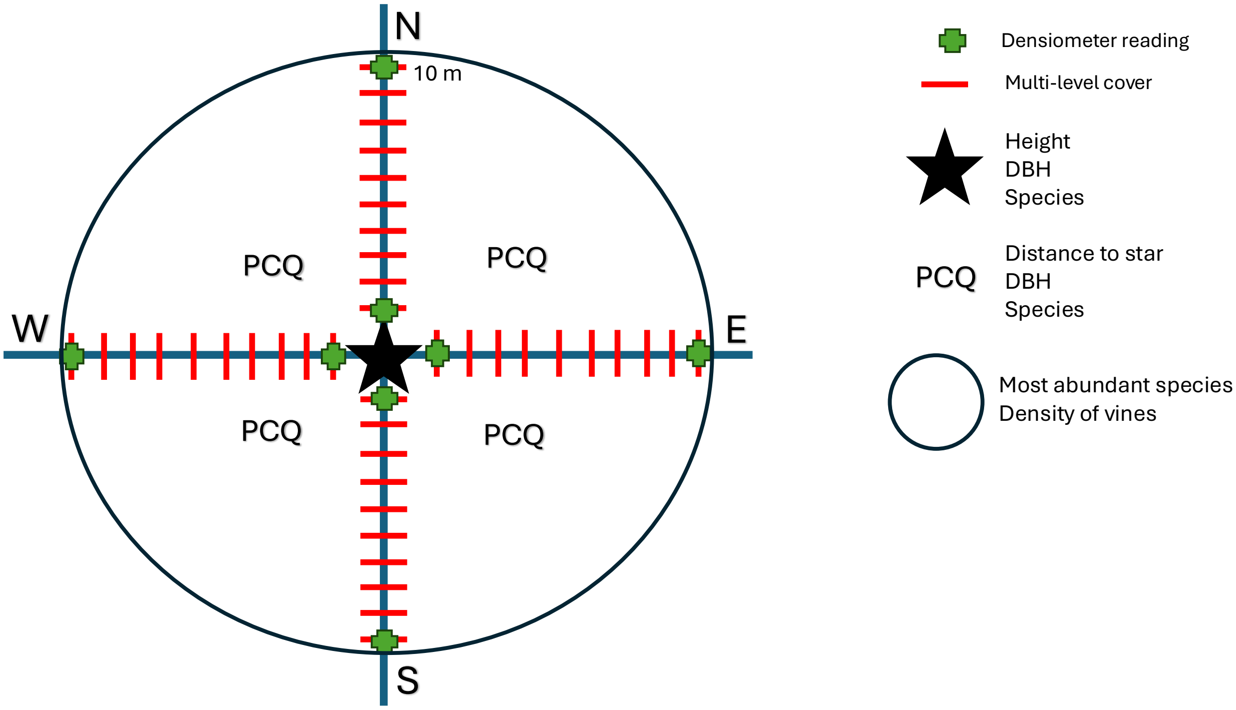

Figure 1.2 Example sampling scheme showing physical habitat characteristics are taken at each roost site for female wild turkeys in Kansas, USA, during 2024–2026. I recorded diameter-at-breast-height (DBH), total height, limb height, and species at the center location. Canopy cover was recorded at 1 m and 10 m from trunk along with presence/absence of cover every meter in 3 height strata (low [0–1.5 m], mid [1.6–4 m], and high [>4 m]) in each cardinal direction. A modified point-center quarter method was used to estimate tree stand density. Lastly, an overall dominant species in each height category including vines in recorded within 10-m radii of the center tree.

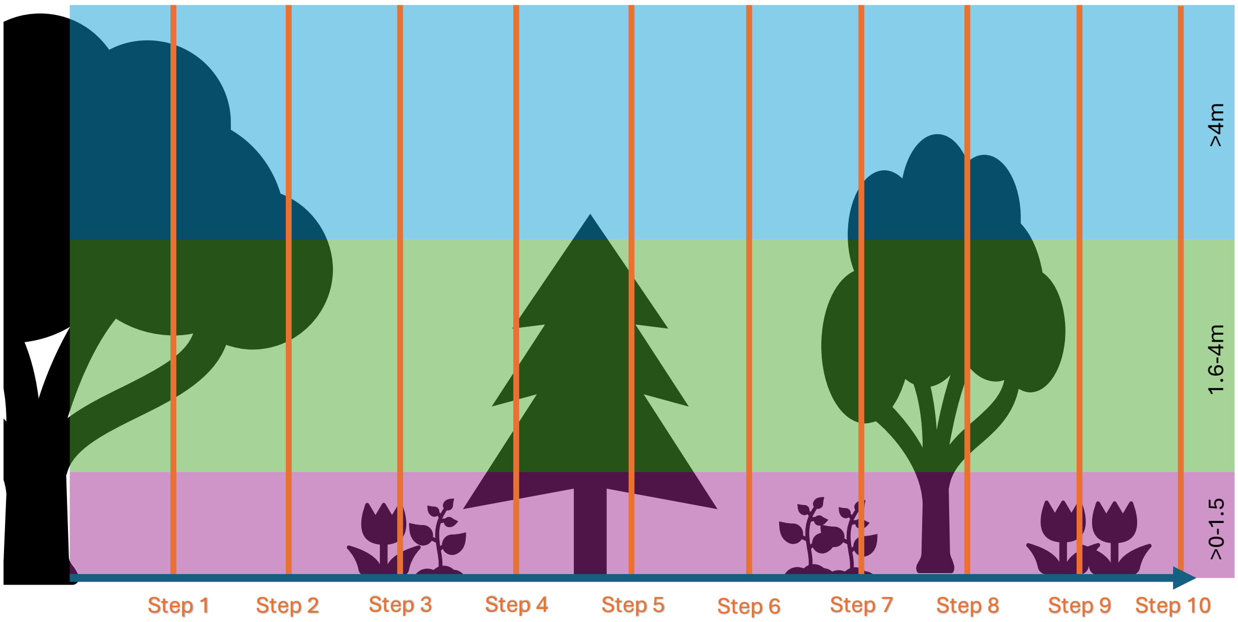

Figure 1.3 Depiction of sampling strategy for understory cover associated with roost tree locations used by female wild turkeys in Kansas, USA, during 2024–2026. Starting at 1 m out to 10 m in the 4 cardinal directions from the base of the tree, single point presence/absence of vegetation was recorded at 3 strata: low (>0-1.5 m), medium (1.6-4 m), and high (>4 m). If no vegetation was present at that point, then it was recorded as barren.

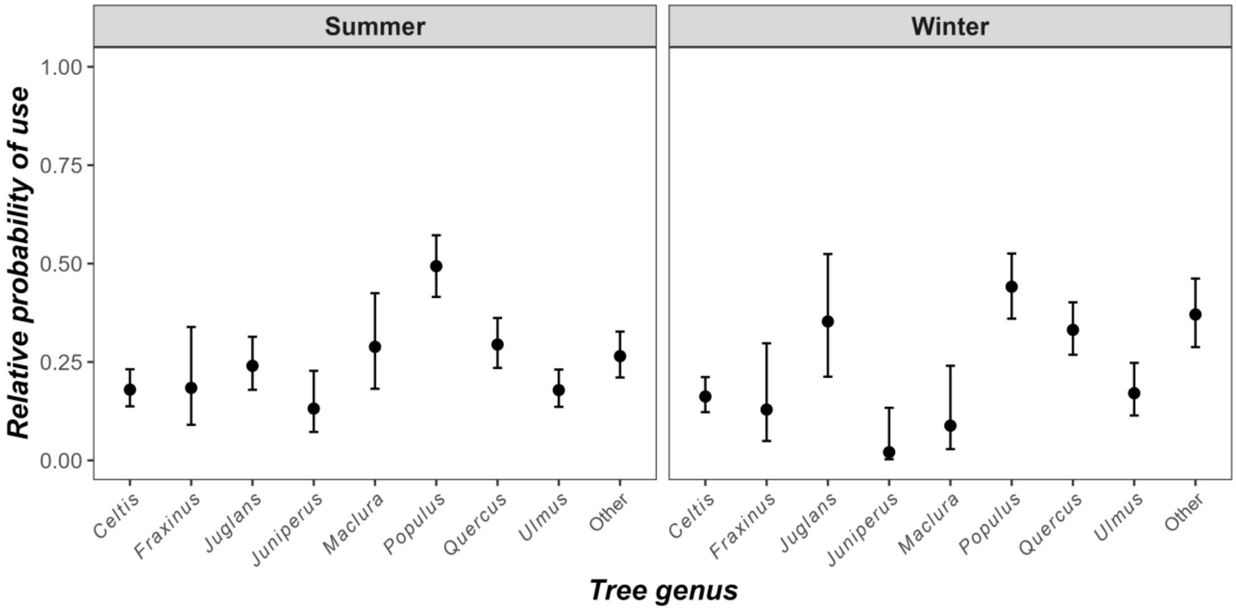

Figure 1.4 Relative probability of roost-tree use among tree genera by female wild turkeys during summer and winter in Kansas, USA, 2024–2026. Points represent estimates from season-specific binomial logistic regression models and error bars represent 95% confidence intervals. Tree genera not included among the eight primary genus groups were combined as Other.

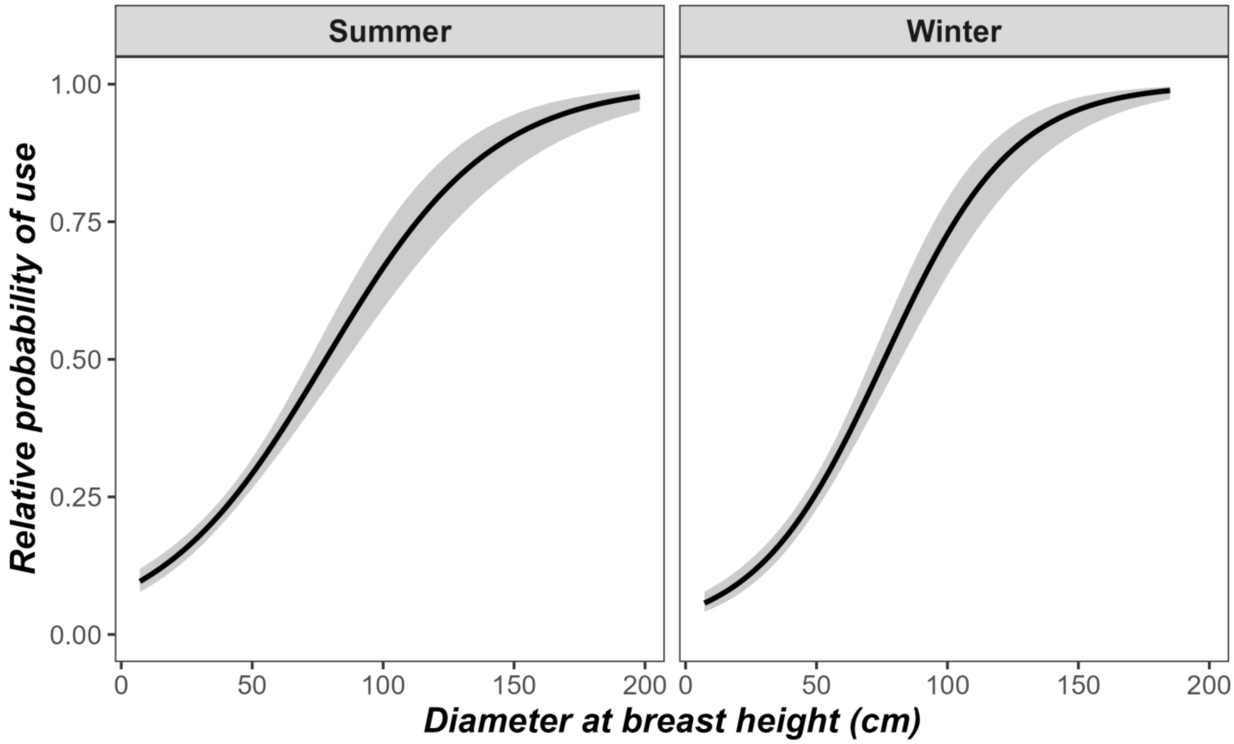

Figure 1.5 Relationship between diameter-at-breast-height (DBH) and relative probability of roost-tree use by female wild turkeys during summer and winter in Kansas, USA, 2024–2026. Solid lines represent predictions from season-specific binomial logistic regression models, and shaded areas represent 95% confidence intervals.

Tables

Table 1.1 Distribution (count [%]) of tree genus distribution per study region (West, Central, East) during leaf-on (May–Sep) 2024–2025 in Kansas, USA. Used trees were used at least three times by female wild turkeys and available trees were randomly selected within 30-300 m of used tree.

	Region					
	West		**Central**		**East**	
Genus	Used	Available	Used	Available	Used	Available
Acer	1 (1.1)	0	1 (1)	0	4 (2.6)	7 (1.6)
Carya	0	0	0	0	0	10 (2.2)
Catalpa	0	1 (0.4)	6 (5.8)	5 (1.6)	0	0
Celtis	8 (8.4)	55 (19.6)	16 (15.4)	79 (25)	22 (14.4)	76 (16.9)
Cercis	0	0	0	1 (0.3)	1 (0.7)	4 (0.9)
Fraxinus	0	14 (5)	3 (2.9)	9 (2.8)	4 (2.6)	8 (1.8)
Gleditsia	1 (1.1)	24 (8.5)	4 (3.8)	15 (4.7)	8 (5.2)	13 (2.9)
Gymnocladus	0	0	0	10 (3.2)	3 (2)	0
Juglans	2 (2.1)	5 (1.8)	15 (14.4)	32 (10.1)	20 (13.1)	80 (17.8)
Juniperus	5 (5.3)	40 (14.2)	0	6 (1.9)	5 (3.3)	20 (4.5)
Maclura	1 (1.1)	2 (0.7)	5 (4.8)	25 (7.9)	9 (5.9)	10 (2.2)
Morus	0	5 (1.8)	2 (1.9)	12 (3.8)	4 (2.6)	15 (3.3)
Other	0	1 (0.4)	0	0	0	0
Platanus	0	0	0	0	8 (5.2)	8 (1.8)
Populus	51 (53.7)	62 (22.1)	25 (24)	12 (3.8)	0	4 (0.9)
Quercus	1 (1.1)	0	9 (8.7)	13 (4.1)	48 (31.4)	126 (28.1)
Robinia	0	5 (1.8)	0	0	0	2 (0.4)
Salix	1 (1.1)	7 (2.5)	2 (1.9)	4 (1.3)	1 (0.7)	0
Snag	2 (2.1)	0	4 (3.8)	4 (1.3)	5 (3.3)	5 (1.1)
Tilia	0	0	0	0	0	2 (0.4)
Ulmus	22 (23.2)	60 (21.4)	12 (11.5)	89 (28.2)	11 (7.2)	58 (12.9)
Unknown	0	0	0	0	0	1 (0.2)

Table 1.2 Distribution (count [%]) of roost tree genus distribution per study region (West, Central, East) during leaf-off (Nov–Feb) 2024–2026 in Kansas, USA. Used trees were used at least three times by female wild turkeys and available trees were randomly selected withing 30-300 m of used tree.

	Region					
	West		Central		East	
Genus	Used	Available	Used	Available	Used	Available
Acer	0	0	5 (8.1)	6 (3.2)	2 (1.5)	5 (1.3)
Betula	0	0	1 (1.6)	0	0	0
Catalpa	0	0	1 (1.6)	2 (1.1)	0	0
Carya	0	0	0	0	0	2 (0.5)
Celtis	8 (14.3)	50 (30.5)	3 (4.8)	57 (30.3)	32 (24.2)	115 (30.7)
Cercis	0	0	0	0	0	1 (0.3)
Fraxinus	0	3 (1.8)	3 (4.8)	9 (4.8)	1 (0.8)	15 (4)
Gleditsia	10 (17.9)	18 (11)	2 (3.2)	6 (3.2)	2 (1.5)	4 (1.1)
Gymnocladus	0	0	0	5 (2.7)	0	0
Juglans	0	0	9 (14.5)	17 (9)	3 (2.3)	5 (1.3)
Juniperus	0	20 (12.2)	0	2 (1.1)	1 (0.8)	25 (6.7)
Maclura	0	1 (0.6)	0	18 (9.6)	3 (2.3)	12 (3.2)
Morus	0	0	0	1 (0.5)	1 (0.8)	1 (0.3)
Other	0	0	0	2 (1.1)	0	0
Platanus	0	0	0	0	16 (12.1)	10 (2.7)
Populus	35 (62.5)	59 (36)	18 (29)	5 (2.7)	7 (5.3)	12 (3.2)
Quercus	3 (5.4)	7 (4.3)	12 (19.4)	15 (8)	48 (36.4)	105 (28)
Robinia	0	0	0	1 (0.5)	0	0
Salix	0	0	0	1 (0.5)	0	2 (0.5)
Snag	0	0	0	1 (0.5)	0	0
Ulmus	0	6 (3.7)	8 (12.9)	40 (21.3)	13 (9.8)	56 (14.9)
Unknown	0	0	0	0	3 (2.3)	5 (1.3)

Table 1.3 Averages ($\bar{x}$ ± SE) of used roost tree characteristics by female wild turkeys compared between leaf-on (May-Sep) and leaf-off (Nov-Feb) seasons within three study regions (West, Central, East) across Kansas 2024–2026.

	Region											
	West				Central				East			
	Leaf-on	Leaf-off	*t*	*P*	Leaf-on	Leaf-off	*t*	*P*	Leaf-on	Leaf-off	*t*	*P*
DBH (cm)	67.31 ± 3.74	66.49 ± 3.76	0.15	0.88	58.64 ± 3.22	78.87 ± 4.21	-3.82	<0.001	47.15 ± 1.87	62.46 ± 2.32	-5.15	<0.001
Height (m)	15.78 ± 0.67	20.14 ± 0.97	-3.69	<0.001	19.36 ± 0.72	20.75 ± 0.98	-1.15	0.25	18.17 ± 0.55	23.22 ± 0.59	-6.26	<0.001
Limb Height (m)	3.44 ± 0.25	7.01 ± 0.71	-4.73	<0.001	6.03 ± 0.47	5.42 ± 0.44	0.95	0.34	4.76 ± 0.22	6.75 ± 0.29	-5.56	<0.001
Canopy 1 m %	11.70 ± 1.58	8.54 ± 1.06	1.65	0.10	6.67 ± 1.24	6.47 ± 1.28	0.11	0.91	4.78 ± 0.76	8.52 ± 1.35	-2.42	0.02
Canopy 10 m %	27.57 ± 2.99	15.50 ± 2.51	3.09	0.002	7.41 ± 1.22	8.01 ± 1.67	-0.29	0.77	9.62 ± 1.45	13.17 ± 1.95	-1.46	0.15
Low Stratum %	74.84 ± 3.31	91.34 ± 2.77	-3.82	<0.001	82.86 ± 2.81	58.06 ± 3.86	5.19	<0.001	90.11 ± 1.23	82.58 ± 2.15	3.04	0.003
Med Stratum %	59.71 ± 2.98	76.07 ± 3.26	-3.07	<0.001	55.84 ± 2.99	51.21 ± 3.26	1.05	0.30	43.33 ± 1.90	47.73 ± 2.27	-1.49	0.14
High Stratum %	84.34 ± 2.08	97.77 ± 0.60	-6.20	<0.001	91.30 ± 1.64	95.00 ± 0.99	-1.93	0.06	91.56 ± 1.16	96.12 ± 0.63	-3.44	<0.001
Stand density (trees/ha)	844.22 ± 192.25	969.16 ± 174.06	-0.48	0.63	457.70 ± 48.84	786.30 ± 109.50	-2.74	0.007	619.16 ± 84.01	799.32 ± 85.03	-1.51	0.13

Table 1.4 Results from testing for an interaction between tree type (used roost vs. available) and region (West, Central, East) in a factorial analysis of variance for wild turkeys in Kansas, USA, during leaf-on (May-Sep) and leaf-off (Nov-Feb) during 2024–2026.

	Season			
	Leaf-on		**Leaf-off**	
Variable	$F_{2, 1392}$	P	$F_{2, 971}$	P
DBH (cm)	49.580	<0.001	17.488	<0.001
Tree Height (m)	21.44	<0.001	3.226	0.040
Lowest Limb Height (m)	4.046	0.018	4.768	0.009
1 m Canopy (%)	1.692	0.185	0.870	0.419
10 m Canopy (%)	7.674	<0.001	0.909	0.403
Low Stratum (%)	0.352	0.704	1.533	0.216
Medium Stratum (%)	3.742	0.024	2.728	0.066
High Stratum (%)	13.183	<0.001	1.458	0.233
Stand Density (trees/ha)	13.480	<0.001	1.684	0.186

Table 1.5 Comparison of characteristics ($\overline{x}$ ± SE) exhibiting an interaction between study region (West, Central, and East) and tree use category (Used, Available) between trees used as roosts by wild turkeys (used) and available within three regions of Kansas, USA, during leaf-on (May–Sep) 2024 and 2025. Means between used and available trees for each region were compared using a *t*-test. Means among regions were tested separately for used and available trees using analysis of variance.

	Region				
Variable	West	Central	East	*F*	*P*
Tree Height (m)					
Used	15.78(0.67)^{B}	19.36(0.72)^{A}	18.17(0.55)^{A}	6.93	0.001
Available	9.39(0.30)^{C}	13.84(0.34)^{B}	17.21(0.30)^{A}	152.47	<0.001
t	-8.66	-6.96	-1.53		
P	<0.001	<0.001	0.13		
Limb Height (m)					
Used	3.44(0.25)^{C}	6.03(0.46)^{A}	4.76(0.22)^{B}	14.39	<0.001
Available	2.52(0.11)^{B}	4.53(0.16)^{A}	4.68(0.21)^{A}	36.81	<0.001
t	-3.35	-2.99	-0.28		
P	0.001	0.003	0.780		
DBH (cm)					
Used	67.31(3.74)^{A}	58.64(3.22)^{A}	47.15(1.87)^{B}	13.70	<0.001
Available	29.34(1.33)^{B}	29.79(0.98)^{B}	41.79(0.98)^{A}	46.41	<0.001
t	-9.56	-8.58	-2.53		
P	<0.001	<0.001	0.001		
1 m Open Canopy Cover (%)*					
Used	11.70(1.58)	6.67(1.24)	4.78(0.76)	9.54	<0.001
Available	8.71(0.70)	4.35(0.42)	4.55(0.52)	17.55	<0.001
t	-1.73	-1.78	-0.24		
P	0.09	0.08	0.81		
10 m Open Canopy Cover (%)					
Used	27.57(2.99)^{A}	7.41(1.22)^{B}	9.62(1.45)^{B}	30.01	<0.001
Available	41.75(2.22)^{A}	9.03(0.98)^{B}	10.09(1.00)^{B}	161.41	<0.001
t	3.81	1.03	0.27		
P	<0.001	0.303	0.788		

Low Stratum Cover (> 0 - 1.5 m; %)*					
Used	74.84(3.32)	82.86(2.81)	90.11(1.23)	11.05	<0.001
Available	80.32(1.71)	88.01(1.19)	93.16(0.61)	33.27	<0.001
t	1.47	1.69	2.21		
P	0.14	0.09	0.03		
Medium Stratum Cover (1.6 – 4 m ; %)					
Used	59.71(2.98)^{A}	55.84(2.99)^{A}	43.33(1.90)^{B}	12.51	<0.001
Available	56.49(1.63)^{B}	64.74(1.70)^{A}	45.77(1.15)^{C}	46.75	<0.001
t	-0.95	2.59	1.10		
P	0.345	0.010	0.274		
High Stratum Cover (>4 m ; %)					
Used	84.34(2.08)^{B}	91.29(1.64)^{A}	91.55(1.16)^{A}	6.18	0.002
Available	72.32(1.75)^{B}	93.35(0.70)^{A}	92.39(0.71)^{A}	114.49	<0.001
t	-4.42	1.15	0.62		
P	<0.001	0.252	0.538		
Stand Density (Individuals/hectare)					
Used	844.22±192.25^{A}	457.70±48.84^{A}	619.16±84.01^{A}	2.51	0.083
Available	333.23±35.66^{B}	742.02±51.30^{A}	725.77±48.25^{A}	20.61	<0.001
t	-2.61	4.01	1.10		
P	0.010	<0.001	0.272		

$^{A, B, C}$ Within each Used or Available category, regions that do not share an uppercase letter differed significantly. Regions sharing at least one letter were not significantly different. For example, a region labeled AB did not differ from regions labeled A or B.

* If no significant interaction between region and use was present ($\alpha = 0.05$) then variable was only evaluated for main effects and results reported in text.

Table 1.6 Comparison of characteristics ($\bar{x}$ ± SE) exhibiting an interaction between study region (West, Central, and East) and tree use category (Used, Available) between trees used as roosts by wild turkeys (used) and available within three regions of Kansas, USA, during leaf-off (Nov–Feb) 2024–2026. Means between used and available trees for each region were compared using a t-test. Means among regions were tested separately for used and available trees using analysis of variance.

Variable	West	Central	East	*F*	*P*
Tree Height (m)					
Used	20.14 ± 0.97^{B}	20.75 ± 0.96^{AB}	23.22 ± 0.59^{A}	4.80	0.009
Available	12.57 ± 0.46^{A}	13.04 ± 0.42^{A}	18.10 ± 0.37^{B}	57.86	<0.001
t	-7.05	-7.24	-7.30		
P	<0.001	<0.001	<0.001		
Limb Height (m)					
Used	7.01 ± 0.68^{A}	5.41 ± 0.43^{B}	6.75 ± 0.28^{A}	3.27	0.04
Available	4.00 ± 0.31^{B}	4.73 ± 0.20^{AB}	5.28 ± 0.17^{A}	8.01	<0.001
t	-3.85	-1.40	-4.41		
P	<0.001	0.167	<0.001		
DBH (cm)					
Used	66.49 ± 3.76^{AB}	78.87 ± 4.21^{A}	62.46 ± 2.32^{B}	6.93	0.001
Available	34.63 ± 1.88^{A}	31.72 ± 1.70^{A}	41.12 ± 1.16^{B}	11.77	<0.001
t	-7.59	-10.38	-8.24		
P	<0.001	<0.001	<0.001		
1 m Open Canopy Cover (%)*					
Used	8.54 ± 1.07	6.47 ± 1.28	8.52 ± 1.35	0.59	0.56
Available	11.63 ± 1.12	8.63 ± 1.03	8.32 ± 0.85	2.76	0.06
t	2.00	1.31	-0.12		
P	0.05	0.19	0.90		
10 m Open Canopy Cover (%)*					
Used	15.50 ± 2.51	8.00 ± 1.67	13.17 ± 1.95	2.34	0.10
Available	23.22 ± 2.05	12.94 ± 1.41	15.39 ± 1.24	9.30	<0.001
t	2.39	2.26	0.96		
P	0.02	0.03	0.34		

Low Stratum Cover (>0 – 1.5 m ; %)*					
Used	91.34 ± 2.77	58.06 ± 3.86	82.58 ± 2.15	28.85	<0.001
Available	91.86 ± 1.42	67.41 ± 2.10	87.40 ± 1.12	61.91	<0.001
t	0.17	2.13	1.99		
P	0.87	0.04	0.05		
Medium Stratum Cover (1.6 – 4 m; %)*					
Used	76.07 ± 3.26	51.21 ± 3.26	47.73 ± 2.27	25.01	<0.001
Available	77.39 ± 1.84	50.57 ± 2.07	57.15 ± 1.47	46.27	<0.001
t	0.35	-0.17	3.49		
P	0.72	0.87	<0.001		
High Stratum Cover (>4 m; %)*					
Used	97.77 ± 0.60	95.00 ± 0.99	96.12 ± 0.64	2.36	0.10
Available	93.78 ± 0.89	89.55 ± 1.13	94.06 ± 0.60	8.50	<0.001
t	-3.73	-3.62	-2.34		
P	<0.001	<0.001	0.02		
Density (Individuals/hectare)*					
Used	969.16 ± 174.06	786.30 ± 109.50	799.32 ± 85.03	0.62	0.54
Available	600.99 ± 73.51	971.90 ± 225.53	968.95 ± 63.06	2.51	0.08
t	-1.95	0.74	1.60		
P	0.06	0.46	0.11		

[A, B, C] Within each Used or Available category, regions that do not share an uppercase letter differed significantly. Regions sharing at least one letter were not significantly different. For example, a region labeled AB did not differ from regions labeled A or B.

* If no significant interaction between region and use was present ($\alpha = 0.05$) then variable was only evaluated for main effects and results reported in text.

Table 1.7 Results of main effect of tree characteristics ($\bar{x}$ ± SE) between used and available trees of female wild turkeys that did not have a significant interaction between use category and region in Kansas during leaf-off (Nov-Feb), 2024–2026.

Variable	Used	Available	$F_{1,975}$	P
1 m Canopy (%)	8.02 ± 0.816	9.15 ± 0.574	1.081	0.299
10 m Canopy (%)	12.4 ± 1.25	16.5 ± 0.881	6.051	0.014
Low Stratum (%)	78.5 ± 1.78	83.2 ± 0.92	6.388	0.012
Medium Stratum (%)	54.9 ± 1.77	60.0 ± 1.08	5.798	0.016
High Stratum (%)	96.2 ± 0.44	92.8 ± 0.48	15.75	<0.001
Stand Density (Individuals/hectare)	834 ± 65.2	887 ± 68.9	0.181	0.671

Table 1.8 Results of main effect of tree characteristics ($\bar{x}$ ± SE) among three study regions in Kansas during leaf-off 2024 – 2026.

Variable	Region			$F_{2,974}$	P
	West	Central	East		
1 m Canopy %	10.84 ± 1.00	8.10 ± 0.94	8.38 ± 0.66	2.57	0.08
10 m Canopy (%)	21.3 ± 1.53^{A}	11.7 ± 1.43^{B}	14.8 ± 1.01^{B}	10.84	<0.001
Low Stratum (%)	91.7 ± 1.60^{C}	65.1 ± 1.50^{A}	86.1 ± 1.06^{B}	89.3	<0.001
Medium Stratum (%)	77.1 ± 1.82^{A}	50.7 ± 1.71^{B}	54.7 ± 1.20^{B}	67.02	<0.001
High Stratum (%)	94.8 ± 0.78^{A}	90.9 ± 0.73^{B}	94.6 ± 0.52^{A}	9.78	<0.001
Stand Density (Individuals/hectare)	695 ± 71.1	926 ± 172	925 ± 51.7	1.60	0.20

$^{A, B, C}$ Differences among regions designated with different uppercase letters

Table 1.9 Ranking of models testing the relative influence of vegetation structure characteristics for prediction of female wild turkey roost-tree selection in Kansas, USA, 2024 – 2026.

Model	K[A]	AICc[B]	ΔAICc[C]	w_i[D]
DBH + 10 m Canopy + Low Stratum	4	2307.85	0.00	0.89
DBH + Low Stratum	3	2312.16	4.31	0.10
DBH + 10 m Canopy	3	2320.88	13.03	0
DBH	2	2324.78	16.93	0
Tree Height	2	2496.98	189.13	0
Low Stratum	2	2677.94	370.09	0
10 m Canopy	2	2679.64	371.79	0
High Stratum	2	2681.26	373.41	0
Medium Stratum	2	2685.15	377.30	0
Null	1	2691.07	383.22	0
1 m Canopy	2	2692.45	384.60	0

[A] Number of estimable parameters in the model.
[B] Akaike's Information Criterion corrected for small sample size.
[C] Difference in AICc between each candidate model and the highest-ranked model.
[D] Akaike model weight, representing the relative support for each model within the candidate model set.

Chapter 2 - Fidelity and Landscape Drivers of Roost Trees by Female Wild Turkeys

Introduction

Wild turkey (*Meleagris gallopavo*) roosts are not only individual trees selected for structural characteristics (Chapter I), but also reflect relationships with landscape features that may shape how individual birds use space and access necessary resources (Chamberlain et al. 2000; Thompson et al. 2009; Bakner et al. 2024). In forested landscapes where trees are broadly distributed, wild turkeys typically have many potential roosting options and greater flexibility in nightly roost placement. In contrast, grassland-dominated or semi-arid systems often contain roosting structures that are concentrated along riparian corridors, wooded draws, shelterbelts, or isolated tree patches (Boeker and Scott 1969; Perlichek et al. 2009; Byrne et al. 2015; Bakner et al. 2022). This patchy distribution may cause roosts to function as central resources around which females organize daily movements, seasonal home ranges, and access other habitat needs. Therefore, understanding wild turkey roost ecology in the Great Plains requires evaluating not only which trees are used, but also how repeatedly females use roosting areas and how those areas are positioned within the surrounding landscape.

Selection of roost sites is not independent of other resource needs. Although a roost provides a safe location for overnight refuge, its value may also depends on whether it occurs near foraging areas, water, nesting and brood-rearing cover, or other features that support daily and seasonal requirements (Chamberlain et al. 2000; Thompson et al. 2009; Adey et al., 2024; Bakner et al. 2024). For female wild turkeys, this landscape context may be especially important because habitat needs change throughout the annual cycle. During winter, females can benefit from roosting near reliable food and water sources, provided roost sites are stable, reliable, and contribute to thermal cover (Haucke 1975; Kilpatrick et al. 1988; Ermer et al. 2005). During spring and summer, roost placement may be influenced by reproductive behavior, nesting movements, brood-rearing habitat and need to balance resource access with predation risk (Lutz and Crawford 1987; Chamberlain et al. 2000; Bakner et al. 2024). Thus, roost use may reflect decisions based on a combination of roost availability, surrounding land cover, seasonal resource needs, and movement constraints.

Roost fidelity, defined as the repeated use of the same tree or group of trees, provides a useful behavioral measure for evaluating how wild turkeys respond to roost availability and landscape structure (Byrne et al., 2015; Wakefield et al., 2020; Bakner et al., 2024). Strong roost fidelity may indicate that roosting areas are limited, only certain roosts provide reliable access to important resources, or females are repeatedly returning to familiar locations that meet multiple habitat needs. Weak fidelity may suggest greater availability of roosts, greater behavioral flexibility, or seasonal shifts in resource distribution. Because fidelity reflects repeated use over time, it can reveal if roosts act as central organizing features within female wild turkey home ranges (Byrne et al. 2015; Bakner et al. 2024).

Previous research suggests that roost fidelity varies across landscapes, seasons, and behavioral states. Byrne et al. (2015) found that male wild turkeys exhibited lower roost fidelity during the reproductive season but increased reuse of specific roosts during summer, suggesting that fidelity can shift with seasonal behavior, resource availability, and space use. In sparsely forested or semi-arid systems, where roosting structures are limited, wild turkeys may show greater reuse of particular roost sites or roosting areas (Byrne et al. 2015; Bakner et al. 2022). More recent work has also suggested that wild turkeys may use networks of roosts, including primary “hub” roosts and secondary “satellite” roosts, rather than selecting isolated roost trees independently (Bakner et al. 2024). A network perspective may be particularly relevant in Kansas, USA, where trees are patchily distributed across a matrix of grassland, cropland, and riparian vegetation patches. In such landscapes, the spatial arrangement of roosts relative to food, water, cover, roads, and human-associated features may influence how often roosts are reused and how female wild turkeys move across the landscape.

Understanding roost fidelity in Kansas is important because roost sites may represent a limiting or structuring resource in Great Plains wild turkey populations. If females exhibit strong fidelity in regions where trees are sparse or concentrated, this may indicate dependence on a limited number of roosting areas that may limit access to potential resources. Alternatively, lower fidelity may suggest greater roost availability, greater behavioral flexibility, or shifting seasonal resource demands. Evaluating these patterns can improve understanding of how wild turkeys use patchy grassland landscapes and can inform habitat management by identifying landscape conditions that support reliable roosting opportunities.

I examined roost fidelity and landscape-scale drivers of roost use by female wild turkeys in Kansas. Specifically, I evaluated whether (1) roost fidelity differed among study regions and seasons, (2) low-, medium-, and high-intensity roosts differed in surrounding landscape features, and (3) landscape characteristics influenced roost selection. By shifting from the physical characteristics of individual roost trees (Chapter I) to the spatial context and repeated use of roosting areas, I further evaluated the influence of roost sites on the ecology and structure of female wild turkey space use in grassland-dominated landscapes of the Great Plains.

Methods

Study Area

My study area encompassed the eastern two-thirds of Kansas, spanning a longitudinal gradient divided into three regions: East (–96.96 to –95.50), Central (–98.49 to –96.96), and West (–100.15 to –98.49; Figure 1.1). These regions represent a pronounced east–west precipitation gradient and an associated transition from oak–hickory woodlands in the east to tallgrass, mixed-grass, and shortgrass prairies longitudinally moving westward along the precipitation gradient. Across all three regions, grassland is the dominant cover type in all study sites, with >65% of open prairie used for livestock grazing (Boryan et al. 2011). Cropland and woodland cover vary regionally: cropland is most extensive in the West Region (31% of total area, primarily winter wheat and sorghum), intermediate in the Central Region (23%, primarily winter wheat with smaller amounts of sorghum, soybeans, corn, and alfalfa), and lowest in the East Region (11%, primarily soybeans). Forest cover is <5% in the Central and West regions but reaches ~15% in the East Region. Urban intensity is low statewide, though slightly larger in the East Region (1%) than in the Central (0.35%) or West regions (0.55%; Skidmore 2026). Weather metrics during 2024–2026 study period were derived from county-level monthly weather averages from NOAA, Climate at a Glance, June 2026 (https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series). Regional extreme temperatures per each season were accessed from Kansas Mesonet (https://mesonet.k-state.edu/weather/historical/).

The East Region is comprised of 5 study sites (Riley, Morris, Chase, Osage, and Greenwood counties), which include tallgrass prairie and floodplain vegetation within the Flint Hills (28) and Osage Cuestas (40b) ecoregions (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). The Flint Hills Ecoregion contains the largest remaining expanse of intact native tallgrass prairie in the Great Plains, dominated by big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), and Indiangrass (*Sorghastrum nutans*). The Osage Cuestas Ecoregion represents a transition from tallgrass prairie in the west to oak–hickory woodlands in the east, with upland forests characterized by shagbark hickory (*Carya ovata*), bitternut hickory (*C. cordiformis*), red oak (*Quercus rubra*), white oak (*Q. alba*), and black oak (*Q. velutina*), with understory trees such as Ohio buckeye (*Aesculus glabra*), American bladdernut (*Staphylea trifolia*), and pawpaw (*Asimina triloba*).

During the leaf-on (May–Sep) season, average precipitation in the East Region from 1996–2026 was 46.33 (SD = 1.27) cm. During 2024, it was a slightly dryer season at 43.73 (SD = 3.16) cm and in 2025 it was about average with yearly trend at 47.97 (SD = 8.18) cm. Average temperature from 1996–2026 was 23.3º C, with both seasons within typical range. In 2024, it was 23.6º C (7.3º C – 39.7º C) and 23.1º C (4.4º C – 38.4º C) in 2025. During the leaf-off (Nov-Feb) season average precipitation from 1996–2026 was 13.37 (SD = 1.50) cm. It was a wetter season than average at 17.58 (SD = 1.56) cm in 2024–2025 but was slightly drier than typical in 2025–2026 at 11.41 (SD = 2.66) cm. Average temperature from 1996–2026 was 2.18º C, 2024–2025 was a colder season at 1.53º C (-25.7º C – 21.6º C) and a warmer season at 4.34º C (-22.6º C - 25.6º C) in 2025–2026.

The Central Region comprised of three study sites (Marion, McPherson, Dickinson, and Ellsworth counties), which includes the Smoky Hills (27a) and Wellington–McPherson Lowland (27d) ecoregions (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). Vegetation consists of tallgrass and mixed-grass prairie with floodplain forests along riparian corridors. Prairie vegetation communities were dominated by big bluestem, little bluestem, and Indiangrass, with switchgrass occurring in mesic sites. Riparian forests were dominated by plains cottonwood (*Populus deltoides*), black willow (*Salix nigra*), peachleaf willow (*S. amygdaloides*), hackberry (*Celtis occidentalis*), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and black walnut (*Juglans nigra*), with bur oak (*Q. macrocarpa*) becoming less common westward.

During the leaf-on season average precipitation from 1996–2026 in the Central Region was 43.66 (SD =1.27) cm. There was average precipitation in 2024 at 43.74 (SD = 4.56) cm but 2025 was wetter than average at 52.56 (SD = 11.42) cm. Average temperature from 1996–2026 was 23.8º C and average temperature was similar in 2024 at 24.0º C (4.2º C – 39.3º C) and 2025 at 23.3º C (2.8º C – 39.7º C). During the leaf-off season, average precipitation from 1996–2026 was 11.73 (SD = 0.41) cm. In 2024–2025 average precipitation was greater than typical at 16.40 (SD = 0.66) cm but lower in 2025–2026 at 9.19 (SD = 0.51) cm. Average temperature from 1996–2026 was 2.3º C, it was slightly cooler during 2024–2025 at 1.4º C (-25.5º C – 22.1º C) and warmer than typical at 4.4º C (-24.9º C - 25.3º C) in 2025–2026.

The West Region, comprised of four study sites (Trego, Ellis, Ness, and Russell counties), is characterized by mixed-grass prairie with some shortgrass prairie, within the Rolling Plains and Breaks (27b) Ecoregion (Kansas Native Plant Society, https://www.kansasnativeplantsociety.org/ecoregions/). Dominant grasses include little bluestem, blue grama (*Bouteloua gracilis*), needle-and-thread (*Hesperostipa comata*), sideoats grama (*B. curtipendula*), and western wheatgrass (*Pascopyrum smithii*). Forested cover is largely restricted to riparian corridors.

During 1996–2026, the leaf-on season average precipitation in the West Region was 33.7 (SD = 2.8) cm. Precipitation was similar in both study years. Precipitation was 34.5 (SD = 1.5) cm in 2024 and 33.8 (SD = 1.9) cm in 2025. Average temperature from 1996–2026 was 23.2º C, during 2024 it was 23.7º C (4.7º C – 42.5º C) and 23.0º C (2.6º C – 42.6º C) in 2025. During the leaf-off season, average precipitation from 1996–2026 was 6.9 (SD = 0.7) cm. Conditions were wetter than average in both leaf-off study seasons. In 2024–2025 average precipitation was 10.9 (SD = 1.5) cm and in 2025–2026 it was 7.9 (SD = 1.2) cm. Average temperature from 1996–2026 was 1.8º C, during 2024–2025 it was 1.2º C (-25.7º C – 24.4º C) and warmer at 4.4º C (-27.2º C – 26.9º C) in 2025–2026.

Capture and GPS Monitoring

Female wild turkeys were trapped during January-March 2024 and 2025. Capture sites were stratified by ecoregion (Figure 1.1). Wild turkeys were captured by baiting with cracked corn and use of drop net, walk-in trap, or rocket net. Birds were removed from traps and placed into National Wild Turkey Federation approved wild turkey capture boxes. During processing, the head of each wild turkey was covered to minimize stress to the bird. Birds were sexed based on presence of spur, beard, and chest feather coloration. Age was determined by barring on outer primary wing feathers along with tail fan shape (Healy and Nenno, 1980; Schroder and Robb, 2005). Morphometric measurements of all birds included body mass (kg), tarsus length (mm), flattened wing cord (mm), and culmen (mm). When present, spur length (mm) and beard length (mm) were also recorded. Females >3.8 kg were considered for transmitter attachment and fitted with 160-g Iridium GPS backpack transmitters (model G5-T2A, Advanced Telemetry Systems, Isanti, Minnesota, USA). Transmitters collected 6–12 daily location fixes, including nocturnal (i.e., roost; 0200 CST) locations. All birds received uniquely numbered riveted metal leg band for identification purposes (National Band & Tag Company, Newport, Kentucky, USA). Birds were released in groups at capture location. Capture and handling were conducted under State of Kansas Scientific, Education, or Exhibition Wildlife Permits (KDWP #980122568) and protocols were approved by the Kansas State University Institutional Animal Use and Care Committee (IACUC protocol 4906).

I used GPS locations recorded at 0200 or 0300 local time to represent nightly roost locations because the timing of the scheduled nocturnal fix shifted with daylight saving time. I retained one nocturnal location per female per date. Locations were limited to summer (May – Aug), and winter (Nov – Feb). Individual seasons were defined as summer 2024, winter 2024–2025, summer 2025, and winter 2025–2026. Additionally, I removed nocturnal locations that occurred during bird-specific reproductive ground-use windows. These windows began at the start of incubation and ended at nest failure or success. For successful nests, the ground end date included up to 14 days post-hatch because females with recently hatched broods roost on the ground rather than in trees.

Roost Fidelity

I projected nocturnal locations to Universal Transverse Mercator Zone 14N and identified unique roost sites separately for each female using density-based spatial clustering in the dbscan package in R (Hahsler et al., 2019). I used an 18-m neighborhood distance due to GPS-error scale and a minimum cluster size of one location, which allowed isolated locations to be retained as unique roost sites. I calculated roost fidelity for each female during each season as:

$$RF = 1 - \left(\frac{\text{number of unique roost sites}}{\text{number of usable roost nights}}\right).$$

Values closer to one indicated repeated use of relatively few roost locations, whereas values closer to zero indicated use of a different roost on most observed nights (Byrne et al.

2015; Wakefield et al., 2020; Bakner et al. 2024). I required at least 20 usable roost nights within a season to reduce the influence of bird-seasons with limited observations.

I used a linear mixed-effects model to evaluate differences in fidelity among regions and seasons. I included female identity as a random intercept because some females contributed observations during more than one season. I evaluated effects using a factorial analysis of variance to evaluate fixed effects.

Landscape characteristics of used and available roost sites

I evaluated landscape characteristics surrounding roost sites used at least three bird-nights. Roost sites were classified as summer or winter sites. I generated five random available locations for each used roost site. Available locations were located 30–4,000 m from the associated used roost and restricted to areas containing mapped tree cover in the acquired Kansas-specific EarthDefine 5-m tree layer (earthdefine.com). This layer was created using the 2021 National Agriculture Imagery Program imagery. Each available location was assigned the region and season of its corresponding used roost, and used and available locations were linked using a unique matched-choice-set identifier.

I summarized landcover composition within a 1-km-radius buffer surrounding each used and available location. Land cover compositions were based on Kansas Ecological Systems "Mapping Kansas Ecosystems" 2023 data layer. This layer was a 10 x10-m cell raster product created by the Kansas Biological Survey via remotely sensed data and field-based sampling sites to define landcover types across the state (Peterson and Moody 2024). Detailed landcover classes were combined into barren, cropland, developed, forest, grassland, shrubland, water, and wetland categories. I calculated the percentage of the buffer represented by each category. I also calculated the Euclidean distance from each location to the nearest road, cropland, small stream, and large stream. Landcover percentages summed to 100% for all locations, and all mapped landcover codes were assigned to a cover category.

Roost-Use Intensity

To evaluate whether landscape characteristics differed among roosts used at different intensities, I grouped used roosts into three use classes based on total bird-nights. Bird-nights were used because the same roost location could be used by more than one marked female or by the same female across multiple nights; therefore, bird-nights represent total observed use rather than the number of unique calendar nights. Low-use roosts were used 3–4 bird-nights, medium-use roosts were used 5–12 bird-nights, and high-use roosts were used ≥13 bird-nights. Landscape variables were summarized for each use class and included percent cover of major landcover classes (barren, cropland, developed, forest, grassland, shrubland, water, and wetland), and distance to roads, small streams, large streams, and cropland.

I evaluated each landscape characteristic separately within summer and winter using a linear model in which the landscape characteristic was the dependent variable and roost-use class and region were included as additive fixed effects. Thus, each model tested whether the mean value of a landscape characteristic differed among low-, medium-, and high-use roosts after accounting for regional differences. Landcover percentages were analyzed on their original scales, whereas distance variables were transformed using $\log(x + 1)$ before analysis because their distributions were right-skewed. I evaluated the overall effect of roost-use class using *F*-tests. Because I evaluated 12 landscape characteristics within each season, I adjusted *P*-values separately within summer and winter using the Benjamini–Hochberg procedure. I considered an effect of roost-use class supported when the Benjamini–Hochberg-adjusted *P*-value was <0.05.

For supported effects, I used Tukey-adjusted estimated marginal means to compare low-, medium-, and high-use roosts.

Used vs available roost site comparison

To describe regional differences between used and available roost locations, I compared landscape characteristics separately within each region and season. Because five available locations were associated with each used roost, I first averaged each landscape characteristic across the available locations within each matched choice set. I then used paired t-tests to compare the value at each used roost with the mean value of its associated available locations. I conducted separate comparisons for forest, cropland, developed, grassland, and shrubland cover and for distance to cropland, roads, small streams, and large streams. I report means ± SE, *t* statistics, and *P*-values for each comparison.

Landscape-scale roost selection

I evaluated landscape-level roost selection separately during summer and winter using conditional logistic regression. Each matched choice set contained one used roost and five associated available locations. Roost sites without matched available locations were excluded from the selection analysis.

I hypothesized that forest cover would be an important predictor of roost-site selection because woody vegetation provides the trees and protective cover required for nocturnal roosting, particularly in grassland-dominated landscapes where forest is spatially limited. I also predicted that selected roosts would occur closer to streams because riparian corridors often contain mature trees and connected woody cover, closer to cropland during winter because agricultural fields may provide concentrated food resources, and farther from roads and developed areas because these features may represent human disturbance. Because females also require access to open habitats for foraging, nesting, and brood rearing, I considered that selection might not increase continuously with forest cover and could instead be greatest at an intermediate level of forest cover.

I evaluated ten biologically defined candidate models during each season. These models represented forest cover; non-linear forest cover; distance to cropland; forest cover and distance to cropland; forest cover and distance to roads; distances to small and large streams; distances to cropland, small streams, and large streams; an anthropogenic model containing developed cover and distances to roads and cropland; a landcover model containing cropland, developed, forest, and shrubland cover; and a distance model containing distances to roads, cropland, small streams, and large streams. Forest cover and the other landcover predictors represented the percentage of each cover category within 1 km of each location and were derived from the 2023 Mapping Kansas Ecosystems layer. Forest cover and stream-distance variables were not included together in the same candidate model as forests were primarily associated with riparian areas. Grassland was omitted from the landcover model because landcover proportions summed to 100%, making grassland the compositional reference category.

I standardized all predictors separately within summer and winter to a mean of zero and standard deviation of one. Conditional logistic regression coefficients were estimated on the log-odds scale and converted to odds ratios by exponentiating each coefficient. Because predictors were standardized, each odds ratio represented the multiplicative change in the relative odds of roost-site selection associated with a one-standard-deviation increase in the predictor. For distance variables, odds ratios <1 indicated selection for locations closer to the feature, whereas odds ratios >1 indicated selection for locations farther from the feature.

I ranked candidate models using Akaike's Information Criterion (AICc) corrected for small sample size, with the number of matched choice sets treated as the independent sample size. I calculated differences in AICc from the best supported model and Akaike weights. Models with ΔAICc ≤2 were considered competitive. I report odds ratios, 95% confidence intervals, and *P*-values from the highest-ranked model for each season.

Results

Roost Fidelity

The final analysis included 646 bird-season observations from 264 females with at least 20 usable roost nights. Roost fidelity differed among regions ($F_{2,189.64} = 38.32$, $P < 0.001$) and was greater during winter than summer ($F_{1,398.75} = 72.74$, $P < 0.001$). Fidelity was also positively associated with the number of usable roost nights ($F_{1,622.50} = 103.89$, $P < 0.001$), whereas study year was not associated with fidelity ($F_{1,556.32} = 0.33$, $P = 0.57$). Evidence that seasonal differences varied among regions was limited because the region × season interaction was not significant ($F_{2,382.58} = 2.42$, $P = 0.09$).

Model-adjusted fidelity was greatest in the West Region, intermediate in the Central Region, and lowest in the East Region (Table 2.1). All pairwise regional comparisons were significant after Tukey adjustment. Across regions, adjusted fidelity was greater during winter (0.786 ± 0.008) than summer (0.709 ± 0.007).

Roost-Use Intensity

The roost-use intensity analysis included all 2,123 used roosts with at least three bird-nights. Summer included 503 low-use, 499 medium-use, and 447 high-use roosts. Winter included 238 low-use, 208 medium-use, and 228 high-use roosts.

After accounting for region and adjusting for multiple comparisons, none of the evaluated landscape characteristics differed among low-, medium-, and high-use roosts during either season (Table 2.2). During summer, distance to roads had the smallest unadjusted P-value, but the effect was not supported after correction ($F_{2,1444}$ = 2.78, unadjusted P = 0.06, adjusted P = 0.748). During winter, developed cover had the smallest unadjusted P-value, but the effect was not supported after correction ($F_{2,669}$ = 2.64, unadjusted P = 0.07, adjusted P = 0.34). Thus, the evaluated landscape characteristics did not distinguish roosts receiving low, medium, or high observed use.

Used vs available roost site comparison

During summer, used roost locations contained greater forest cover than matched available locations in all regions (Table 2.3). Used locations also contained less developed cover in all regions and were closer to large streams. Other landscape differences varied regionally, including cropland cover, shrubland cover, and distances to roads and small streams.

Differences between used and available locations were more pronounced during winter (Table 2.4). Forest cover was greater at used roosts in all three regions. Used winter roosts also contained greater cropland cover and were closer to cropland and large streams in all regions. Used locations were farther from roads in the Central and East regions but not in the West, and distance to small streams did not differ between used and available locations in any region. Forest cover was positively associated with relative probability of use during both seasons, with stronger relationships during winter (Figures 2.1 and 2.2).

Landscape-Level Roost Selection

Patterns of model support differed between summer and winter. During summer, the landcover model ranked highest (AICc = 4728.84, w_i = 0.65), although the quadratic forest-cover model was also competitive (ΔAICc = 1.26, w_i = 0.35; Table 2.5). All remaining models were ≥21.26 AICc units from the top-ranked model. Within the top summer model, the relative odds of roost selection increased with forest cover (OR = 1.30, 95% CI = 1.19–1.43, $P < 0.001$) and decreased with cropland cover (OR = 0.76, 95% CI = 0.69–0.83, $P < 0.001$), developed cover (OR = 0.72, 95% CI = 0.63–0.82, $P < 0.001$), and shrubland cover (OR = 0.82, 95% CI = 0.74–0.90, $P < 0.001$) relative to the omitted grassland reference category.

During winter, the quadratic forest-cover model received essentially all model support (w_i > 0.99; Table 2.6). The next-ranked model, containing linear forest cover and distance to cropland, was approximately 44 AICc units greater, providing strong support for a nonlinear relationship between forest cover and winter roost selection. Within the top winter model, the linear forest term was positive and the quadratic forest term was negative, indicating a hump-shaped relationship between forest cover and winter roost selection. Relative selection for winter roost sites reached 25% of its estimated maximum at approximately 15.1% forest cover within 1 km and continued to increase to a maximum at 31.5% forest cover (95% CI = 29.00–33.92%; Figure 2.3).

Discussion

Female wild turkeys did not use roosts as isolated trees distributed randomly across Kansas. Instead, roosting behavior reflected the availability of roosting areas, their surrounding landscape context, and seasonal access to other resources. Roost fidelity was greatest in the West Region, intermediate in the Central Region, and lowest in the East Region, and consistently greater during winter than summer. This regional gradient likely reflects differences in the availability and redundancy of roosting habitat. Forest cover is broadly distributed in eastern Kansas, whereas trees in the Central and West regions were concentrated within riparian corridors and isolated patches. Roosting habitat is similarly concentrated in riparian corridors and isolated woody areas in other grassland-dominated and semi-arid landscapes (Boeker and Scott 1969; Perlichek et al. 2009; Bakner et al. 2022). Consequently, western female wild turkeys may have fewer functionally interchangeable roosting areas within their seasonal ranges and may repeatedly return to the limited locations that satisfy structural, accessibility, and resource requirements. Eastern females may instead move among a larger set of suitable trees and forest patches. Similar differences have been observed between Rio Grande wild turkeys in sparsely wooded landscapes and eastern wild turkeys in more continuously forested systems, where roost availability appeared to exert a stronger influence in areas with less forest cover (Byrne et al. 2015). In addition to this regional pattern, seasonal changes in fidelity suggest that roost use was also shaped by shifting behavioral and resource requirements.

Greater winter fidelity across all regions indicates that females concentrated nocturnal activity into fewer locations during the nonreproductive period. Winter flock formation may increase the value of roosts capable of accommodating multiple birds and providing predictable access to food. Wild turkeys commonly form large communal flocks during winter, and winter roost selection has been associated with access to food, thermal cover, and other stable resources (Kilpatrick et al. 1988; Ermer et al. 2005; Adey et al. 2023). Adey et al. (2023), in particular, describes large winter flocks and the tendency for winter roosts to occur near dependable food sources. These patterns suggest that seasonal changes in social behavior and resource requirements influenced both the consistency of roost reuse and the landscape context of selected roosts.

Landscape-scale selection also varied seasonally. Summer selection was best explained by landcover composition, with selection increasing with forest cover and decreasing with cropland, developed cover, and shrubland relative to grassland. These results do not indicate that females completely avoided cropland, developed land, or shrubland. Instead, they indicate that these cover types were less prevalent relative to grassland in the landscapes surrounding selected roosts. This pattern likely represents selection for wooded patches embedded within grassland systems rather than selection for extensive forest because wild turkeys use open and early successional vegetation for foraging and brood-rearing while remaining dependent on trees for nocturnal roosting (Chamberlain et al. 2000; Bakner et al. 2024; Skidmore, 2026). Management should therefore emphasize the juxtaposition of dependable wooded roosting patches with nearby grassland and herbaceous habitats rather than maximizing forest cover within prairie landscapes. Together, these findings indicate that the landscape context of roost selection shifted from maintaining access to diverse summer habitats to balancing roost cover with predictable food resources during winter.

Winter selection was strongly associated with forest cover, but the relationship was nonlinear. Relative selection increased rapidly as forest cover increased, reached 25% of its estimated maximum at approximately 15.1% forest cover within 1 km, and peaked at 31.5% forest cover before declining at greater levels of forest cover. This pattern suggests that winter roost selection depended on an intermediate amount of woody cover rather than simply increasing with forest availability. Landscapes with very little forest may provide insufficient concentrations of suitable roosting habitat, whereas extensively forested landscapes may provide less of the juxtaposition between wooded roosting cover and open foraging habitats used by wild turkeys. Winter roost value may depend on maintaining sufficient wooded cover within a broader heterogeneous landscape rather than maximizing forest cover.

In contrast, the broad landscape variables evaluated here did not distinguish among low-, medium-, and high-use roosts. Forest cover and proximity to resources helped differentiate used locations from available tree locations, but these variables did not explain how frequently a selected roost was reused. Roost selection may therefore represent a two-stage process. Females first select areas that meet broad landscape requirements, after which repeated use depends on characteristics not fully represented by 1-km landcover composition or Euclidean distance. The tree-level findings from Chapter I complement this interpretation: landscape conditions may determine where roosting opportunities occur, whereas tree and stand structure may influence which opportunities receive repeated use.

Fidelity and intensity also represent different components of roosting behavior. Fidelity describes how concentrated an individual female's seasonal roost use was, whereas intensity represents bird-nights accumulated among several marked females at a shared location. A roost could have high population-level intensity because many females used it occasionally, even when no individual displayed strong fidelity. Conversely, a roost important to one female could remain in a low- or medium-intensity class. Together, these measures identify regions where individual females depended repeatedly on a limited set of sites and locations that received substantial collective use.

Management should therefore extend beyond protecting individual trees beside streams. In western and central Kansas, the primary concern may be loss of functional redundancy. Removal of a mature cottonwood stand, shelterbelt, or wooded drainage could eliminate an entire local cluster of roosting alternatives. Management should retain multiple mature roosting patches within daily movement distance, protect existing large trees, and encourage recruitment before older trees are lost. In eastern Kansas, where roosting options appear more widely distributed, management may focus on maintaining the quality, distribution, and connectivity of forest patches within the grassland matrix. The nonlinear winter relationship further suggests that management should maintain meaningful amounts of forest without necessarily maximizing forest cover. Relative selection reached 25% of its estimated maximum at approximately 15% forest cover within 1 km and was greatest near 31% forest cover. These values should be interpreted as landscape-scale selection benchmarks rather than minimum habitat requirements, but they suggest that maintaining forest within a heterogeneous landscape may be more valuable than either sparse tree cover or extensive continuous forest. During summer, a distributed network of wooded patches may allow females to shift roosts as nesting, brood-rearing, and foraging locations change.

Overall, female wild turkey roosting ecology in Kansas was shaped by the interaction of roost availability, seasonal behavior, and access to surrounding resources. Western females repeatedly used fewer roost locations, suggesting lower redundancy, whereas eastern females exhibited greater flexibility. Summer selection was primarily associated with landcover composition, whereas winter selection showed a strong nonlinear relationship with forest cover, with greatest relative selection at intermediate forest cover. Once a location was selected, however, broad landscape characteristics did not determine its intensity of use. Roosts should therefore be viewed as nodes within seasonal resource networks whose value depends on tree and stand structure, the availability of alternative roosts, proximity to daytime resources, surrounding landscape, and the behavioral processes that determine repeated use.

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Figures

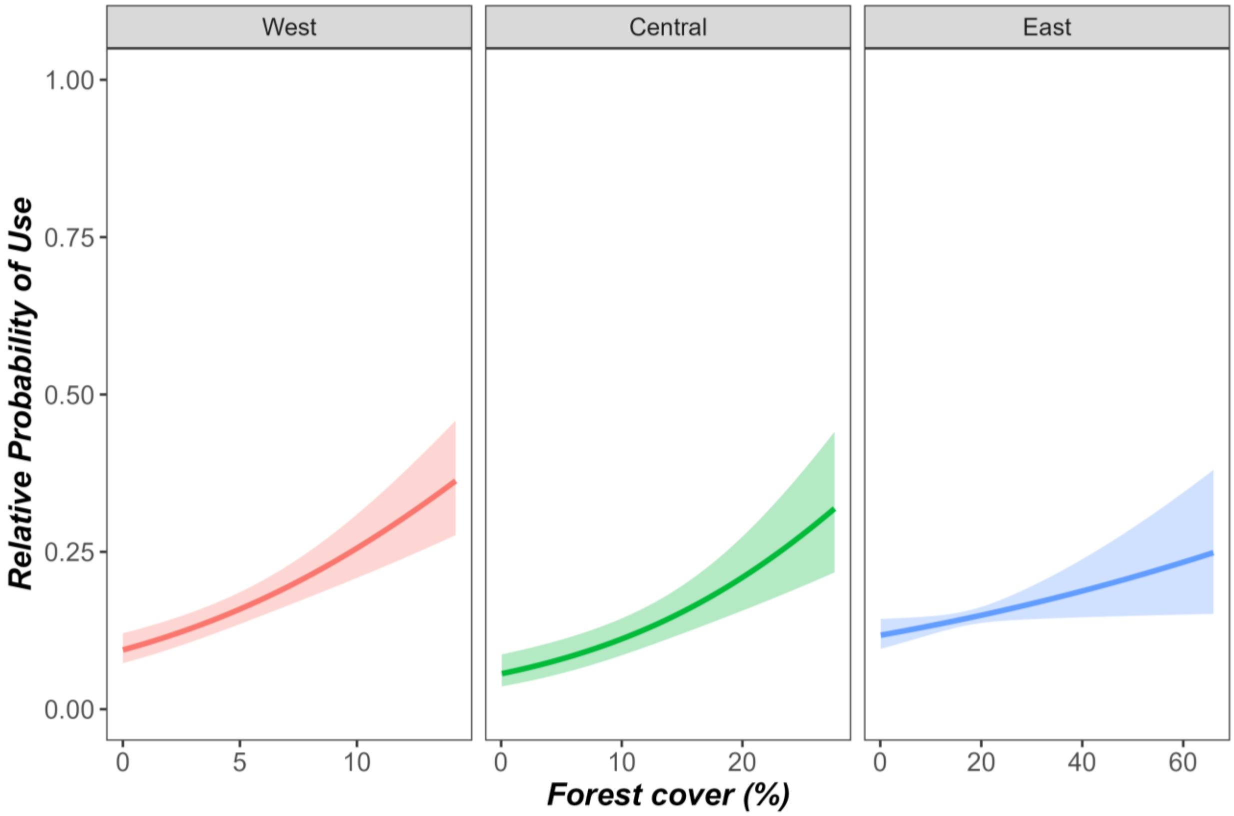

Figure 2.1 Relative probability of summer roost-site use in relation to percent forest cover within 1 km of used and available locations of female wild turkeys in the West, Central, and East regions of Kansas, USA, 2024–2025. Shaded areas represent 95% confidence intervals.

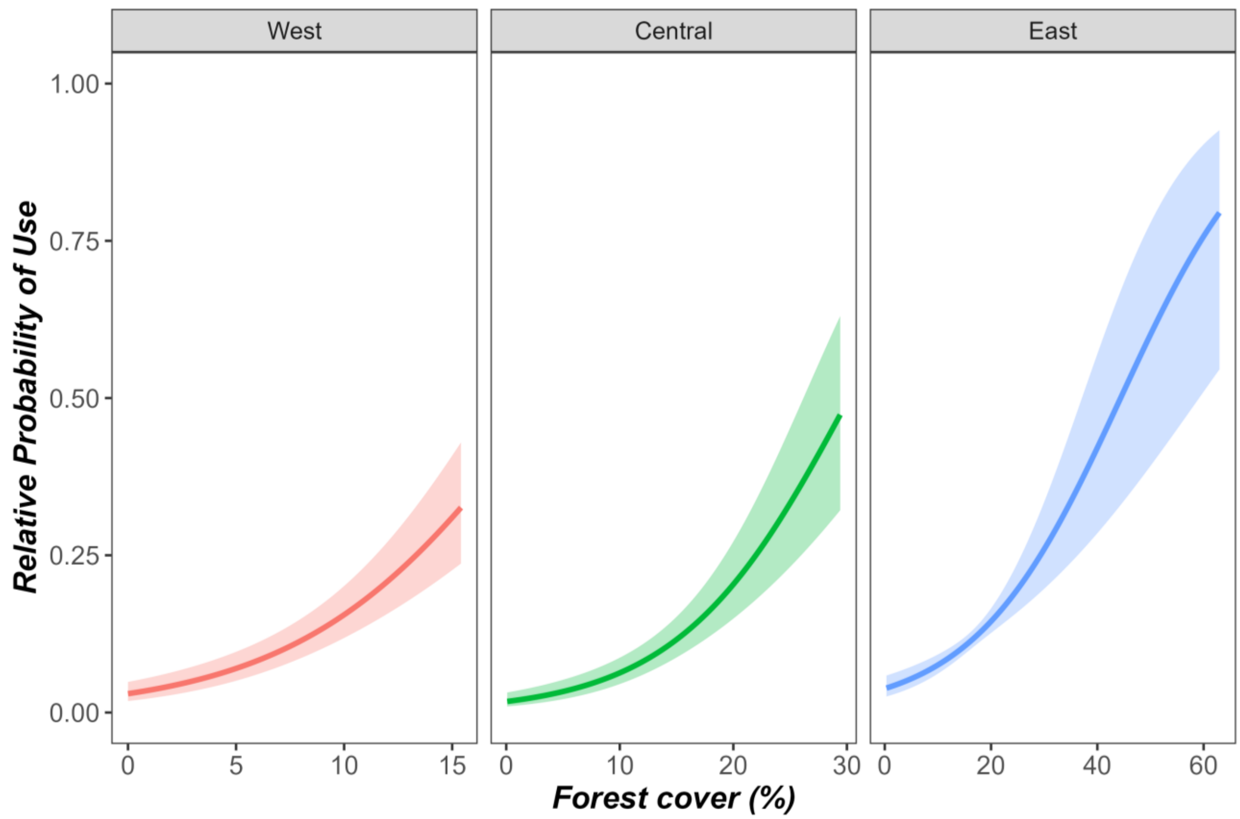

Figure 2.2 Relative probability of winter roost-site use in relation to percent forest cover within 1 km of used and available locations of female wild turkeys in the West, Central, and East regions of Kansas, USA, 2024–2025. Shaded areas represent 95% confidence intervals.

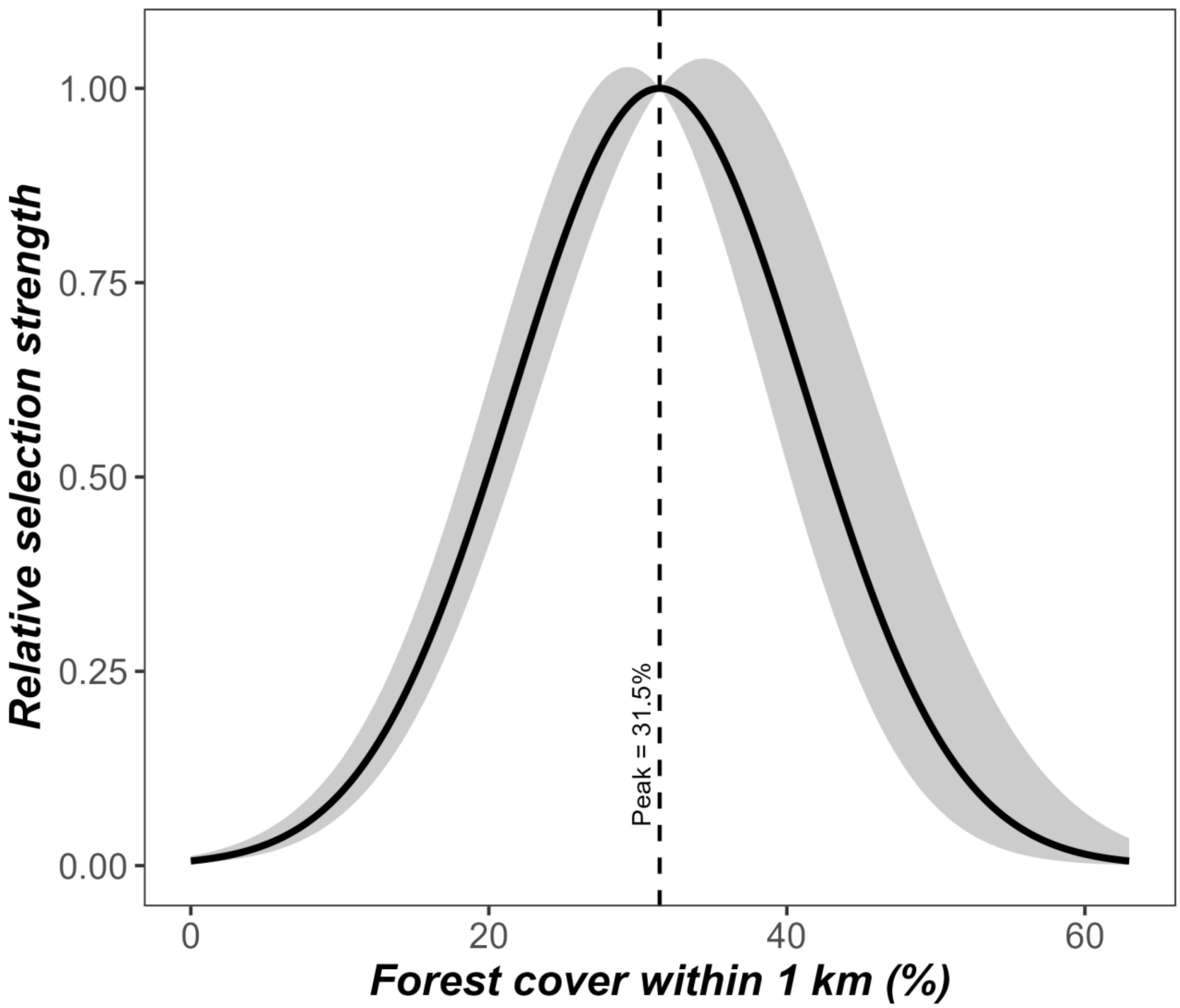

Figure 2.3 Relative selection strength of winter roost sites in relation to forest cover within 1 km for female wild turkeys in Kansas, USA, 2024–2026. The solid line represents the fitted quadratic relationship, the shaded area represents the 95% confidence interval, and the dashed vertical line indicates peak relative selection at 31.5% forest cover.

Tables

Table 2.1 Average roost fidelity ($\bar{x}$ ± SE) of female wild turkeys during summer (Jun-Aug) and winter (Nov-Feb) between three study regions in Kansas, USA, 2024–2026.

	Region					
	West		Central		East	
Season	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Summer	0.74	0.01	0.70	0.01	0.66	0.01
Winter	0.85	0.01	0.79	0.01	0.71	0.01
Overall	0.81	0.01	0.75	0.01	0.69	0.01

Table 2.2 Region-adjusted landscape characteristics ($\bar{x}$ ± SE) of low-, medium-, and high-use roosts used by female wild turkeys during summer and winter in Kansas, USA, 2024–2026.

	Summer						Winter					
Landscape characteristic	**Low use (n = 503)**	**Medium use (n = 499)**	**High use (n = 447)**	***F***	***P***	**Adjusted *P***	**Low use (n = 238)**	**Medium use (n = 208)**	**High use (n = 228)**	***F***	***P***	**Adjusted *P***
Barren cover (%)	1.53 ± 0.10	1.53 ± 0.10	1.32 ± 0.10	1.49	0.23	0.77	0.71 ± 0.06	0.76 ± 0.06	0.87 ± 0.05	2.36	0.10	0.34
Cropland cover (%)	18.40 ± 0.73	18.47 ± 0.72	18.03 ± 0.75	0.10	0.90	0.90	28.43 ± 1.13	26.21 ± 1.20	29.43 ± 1.11	2.20	0.11	0.34
Developed cover (%)	1.46 ± 0.17	1.43 ± 0.16	1.68 ± 0.17	0.66	0.52	0.77	2.37 ± 0.40	3.64 ± 0.43	2.96 ± 0.40	2.64	0.07	0.34
Forest cover (%)	12.55 ± 0.36	12.54 ± 0.36	12.01 ± 0.37	0.73	0.48	0.77	16.10 ± 0.56	15.24 ± 0.59	15.53 ± 0.55	0.67	0.51	0.51
Grassland cover (%)	62.08 ± 0.84	62.33 ± 0.83	63.29 ± 0.87	0.58	0.56	0.77	50.38 ± 1.23	51.66 ± 1.31	48.46 ± 1.21	1.77	0.17	0.34
Shrubland cover (%)	1.70 ± 0.10	1.58 ± 0.10	1.76 ± 0.11	0.81	0.45	0.77	1.72 ± 0.18	1.48 ± 0.19	1.75 ± 0.18	0.70	0.50	0.51
Water cover (%)	1.99 ± 0.30	1.85 ± 0.30	1.81 ± 0.31	0.11	0.90	0.90	0.23 ± 0.22	0.83 ± 0.24	0.70 ± 0.22	2.22	0.11	0.34
Wetland cover (%)	0.29 ± 0.09	0.27 ± 0.09	0.10 ± 0.10	1.19	0.30	0.77	0.06 ± 0.11	0.18 ± 0.12	0.29 ± 0.11	1.23	0.29	0.38
Distance to road (m)	203 ± 9	235 ± 10	220 ± 10	2.78	0.06	0.75	284 ± 15	279 ± 16	310 ± 16	1.16	0.31	0.38
Distance to cropland (m)	149 ± 12	154 ± 12	137 ± 11	0.55	0.58	0.77	92 ± 8	107 ± 10	90 ± 7	1.31	0.27	0.38
Distance to small stream (m)	67 ± 5	60 ± 4	59 ± 5	0.98	0.38	0.77	93 ± 10	77 ± 9	98 ± 11	1.27	0.28	0.38
Distance to large stream (m)	209 ± 22	227 ± 24	211 ± 23	0.20	0.82	0.90	64 ± 9	94 ± 15	74 ± 11	1.92	0.15	0.34

Table 2.3 Average landscape cover within 1-km buffer and distance to landscape feature of used and available roost locations of female wild turkeys during summer in Kansas, USA, 2024-2025.

	West (N=281)				Central (N=382)				East (N=685)			
	Used $\bar{x}$ ± SE	Available $\bar{x}$ ± SE	*t*	*P*	Used $\bar{x}$ ± SE	Available $\bar{x}$ ± SE	*t*	*P*	Used $\bar{x}$ ± SE	Available $\bar{x}$ ± SE	*t*	*P*
Landscape cover (%)												
Forest	3.53 ± 0.18	3.1 ± 0.13	2.85	0.005	11.14 ± 0.25	9.83 ± 0.15	5.59	<0.001	21.79 ± 0.34	20.44 ± 0.26	3.97	<0.001
Cropland	18.5 ± 1.21	18.47 ± 0.97	0.05	0.96	22.79 ± 0.81	25.73 ± 0.79	-5.08	<0.001	14.46 ± 0.53	16.37 ± 0.46	-4.72	<0.001
Developed	2.06 ± 0.32	4.81 ± 0.81	-4.42	<0.001	0.63 ± 0.04	0.86 ± 0.05	-3.89	<0.001	2.07 ± 0.14	2.62 ± 0.15	-3.7	<0.001
Grassland	69.15 ± 1.29	64.32 ± 1.1	6	<0.001	61.89 ± 0.86	59.57 ± 0.77	3.34	<0.001	55.9 ± 0.63	53.95 ± 0.44	3.36	<0.001
Shrubland	1.31 ± 0.12	1.36 ± 0.11	–0.70	0.49	1.77 ± 0.07	1.56 ± 0.05	3.59	<0.001	2 ± 0.1	2.49 ± 0.12	-5.43	<0.001
Distance (m)												
Crops	489.06 ± 36.58	503.69 ± 24.43	-0.53	0.6	270.8 ± 24.14	278 ± 14.8	-0.37	0.71	674.91 ± 36.81	641.78 ± 25.95	1.39	0.16
Roads	303.09 ± 17.11	322.15 ± 12.23	-1.06	0.29	335.61 ± 14.1	305.15 ± 6.69	2.07	0.04	325.23 ± 9.25	294.45 ± 5.24	3.32	<0.001
Small stream	195.94 ± 11.56	213.94 ± 6.42	-1.69	0.09	136.73 ± 9.68	159.42 ± 5.5	-2.22	0.03	162.99 ± 8.15	195.1 ± 4.03	-3.91	<0.001
Large stream	1184.93 ± 95.34	1284.4 ± 80.75	-2.33	0.02	1052.76 ± 66.6	1171.97 ± 47.51	-2.79	0.006	789.1 ± 36.77	1014.09 ± 26.73	-7.82	<0.001

Table 2.4 Average landscape cover within 1-km buffer and distance to landscape feature of used and available roost locations of female wild turkeys during winter in Kansas, USA, 2024-2025.

	West (N=119)				Central (N=156)				East (N=327)			
	Used	Available			Used	Available			Used	Available		
	$\bar{x}$ ± SE	$\bar{x}$ ± SE	*t*	*P*	$\bar{x}$ ± SE	$\bar{x}$ ± SE	*t*	*P*	$\bar{x}$ ± SE	$\bar{x}$ ± SE	*t*	*P*
Landscape cover (%)												
Forest	6.24 ± 0.29	4.18 ± 0.21	8.56	<0.001	15.29 ± 0.38	10.73 ± 0.27	12.59	<0.001	23.76 ± 0.47	19.66 ± 0.34	9.43	<0.001
Cropland	29.27 ± 1.58	26.19 ± 1.45	3.04	0.003	35.46 ± 1.58	31 ± 1.32	3.91	<0.001	21.89 ± 0.81	18.5 ± 0.63	5.18	<0.001
Developed	6.44 ± 1.11	11.01 ± 1.8	-4.29	<0.001	0.58 ± 0.04	0.76 ± 0.07	-2.87	0.005	2.15 ± 0.23	2.98 ± 0.24	-3.45	<0.001
Grassland	55.23 ± 1.82	54.24 ± 1.81	0.89	0.37	46.54 ± 1.64	54.92 ± 1.36	-7.00	<0.001	47.46 ± 0.84	53.38 ± 0.61	-7.54	<0.001
Shrubland	1.33 ± 0.22	1.06 ± 0.18	2.25	0.03	1.34 ± 0.09	1.35 ± 0.07	-0.1	0.92	2.4 ± 0.17	2.72 ± 0.20	-1.91	0.05
Distance (m)												
Crops	255.24 ± 37.53	321.14 ± 26.99	-2.44	0.02	86.35 ± 9.34	203.89 ± 14.62	-7.17	<0.001	262.04 ± 27.6	456.93 ± 27.42	-7.63	<0.001
Roads	321.92 ± 23.15	289.02 ± 17.6	1.47	0.15	412.81 ± 17.39	310.1 ± 8.87	5.19	<0.001	378.93 ± 11.93	294.88 ± 8.03	6.99	<0.001
Small stream	276.52 ± 26.29	252.58 ± 10.87	1.06	0.29	202.09 ± 19.54	177.87 ± 9.28	1.34	0.18	192.71 ± 10.50	188.87 ± 5.41	0.34	0.73
Large stream	552.55 ± 93.00	754.72 ± 75.38	-3.49	<0.001	581.04 ± 91.94	1019.7 ± 69.02	-7.23	<0.001	514.24 ± 51.05	956.07 ± 37.52	-10.8	<0.001

Table 2.5 Candidate model comparison for landscape-level roost selection in summer by female wild turkeys in Kansas, USA, 2024–2026.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]
Landcover[e]	4	4728.84	0	0.65
Forest^{2}[e]	2	4730	1.26	0.35
Distance[e]	4	4750.11	21.26	0
Crop + streams[e]	3	4755.11	26.26	0
Streams[e]	2	4755.24	26.40	0
Forest + roads[e]	2	4797.87	69.03	0
Anthropogenic[e]	3	4798.13	69.29	0
Forest + crop[e]	2	4802.64	73.79	0
Forest[e]	1	4802.98	74.13	0
Crop + Distance[e]	1	4832.09	103.24	0

[a] Number of estimable parameters in the model.
[b] Akaike's Information Criterion corrected for small sample size.
[c] Difference in AICc between each candidate model and the highest-ranked model.
[d] Akaike model weight, representing the relative support for each model within the candidate model set.
[e] Forest^2: linear and quadratic terms for percent forest cover; Forest: Forest cover; Forest + Crop: forest cover and distance to cropland; Forest + roads: forest cover and distance to road; Streams: distance to small and large streams; Crop + Stream: distance to crops, small streams, and large streams; Anthropogenic: developed cover and distance to roads and crops; Landcover: cropland, developed, forest and shrubland cover; Distance: distance to crops, roads, small and large streams

Table 2.6 Candidate model comparison for landscape-level roost selection in winter by female wild turkeys in Kansas, USA, 2024–2026.

Model	K[a]	AICc[b]	ΔAICc[c]	w_i[d]
Forest^{2}[e]	2	1887	0	0.99
Forest + Crop[e]	2	1931.24	44.1	0
Distance[e]	4	1932.19	45.0	0
Forest + Roads[e]	2	1946.48	59.3	0
Landcover[e]	4	1958.88	71.7	0
Crop + Stream[e]	3	1993.62	106.0	0
Forest[e]	1	1995.47	108.0	0
Anthropogenic[e]	3	2010.45	123.0	0
Streams[e]	2	2028.38	141.0	0
Crop + Distance[e]	1	2086.72	200.0	0

[a] Number of estimable parameters in the model.
[b] Akaike's Information Criterion corrected for small sample size.
[c] Difference in AICc between each candidate model and the highest-ranked model.
[d] Akaike model weight, representing the relative support for each model within the candidate model set.
[e] Forest^{2}: linear and quadratic terms for percent forest cover; Forest: Forest cover; Forest + Crop: forest cover and distance to cropland; Forest + roads: forest cover and distance to road; Streams: distance to small and large streams; Crop + Stream: distance to crops, small streams, and large streams; Anthropogenic: developed cover and distance to roads and crops; Landcover: cropland, developed, forest and shrubland cover; Distance: distance to crops, roads, small and large streams

Chapter 3 - Female Wild Turkey Response to Hunting Disturbance in Kansas

Introduction

Human disturbance can alter wildlife behavior through both consumptive and non-consumptive pathways. Beyond direct mortality, disturbance associated with hunting activity may influence animal movement, habitat selection, vigilance, and survival through changes in perceived predation risk. Laundré et al. (2001) proposed that prey species exist within a "landscape of fear," where behavioral decisions are shaped by spatial and temporal variation in risk. Although this framework was initially developed in the context of predator-prey interactions, humans can similarly function as predators capable of eliciting behavioral responses in wildlife. Responses to human disturbance have been documented across numerous taxa and may result from direct hunting pressure, nontarget hunting activity, or nonlethal recreational disturbance (Mohlman et al., 2019, Mysterud et al. 2026).

Behavioral responses to hunting disturbance have been documented in a variety of avian species. Northern bobwhite (*Colinus virginianus*) exposed to elevated hunting pressure altered space use and foraging behavior relative to populations experiencing reduced disturbance (Mohlman et al., 2019). Similarly, waterfowl and other ground-associated birds exhibit changes in movement patterns, habitat selection, and energetic expenditure in response to hunting activity and human presence (Madsen and Fox, 1995; McDuie et al., 2021; Beatty et al., 2025). These responses may occur even in nontarget individuals and species, indicating that disturbance associated with hunting can influence wildlife populations through indirect ecological pathways in addition to direct harvest mortality (Bechet et al., 2004; Milner-Gulland, 2008; Ciuti et al., 2012).

Research evaluating hunting disturbance in wild turkeys (*Meleagris gallopavo*) has primarily focused on males which are targeted during spring hunting seasons. Male wild turkeys reduce gobbling activity, alter roost-site selection, and avoid areas associated with elevated hunting pressure, particularly near roads and public access points (Wakefield et al. 2020, Wightman et al. 2023). Roth et al. (2024) further demonstrated that males temporarily avoided high-risk areas during periods of peak hunting pressure before returning to pre-season movement patterns later in the spring. However, findings across studies remain inconsistent. Gross et al. (2015) and Williams et al. (1978) reported minimal changes in male space use associated with hunting activity, suggesting that responses may vary among regions, habitat configurations, and hunting intensity levels. In north-central Kansas, USA, male survival also differed among public-land areas managed under different harvest regulations, demonstrating that the effects of hunting may vary considerably among management settings (Chipault 2011). Although male behavioral responses to hunting disturbance are increasingly understood, comparatively little research has evaluated how female wild turkeys respond to hunting activity during the reproductive season.

Female wild turkeys may respond to disturbance related to hunting activities differently than males because spring hunting seasons overlap with mating, nesting, and incubation. Females experience substantial energetic demands during reproductive behaviors while simultaneously exhibiting increased site fidelity and reduced mobility associated with nest selection and attendance (Bakner et al., 2019). The Predation Risk Allocation Hypothesis predicts that individuals experiencing prolonged periods of risk may reduce avoidance behaviors when constrained by competing energetic or reproductive demands (Lima and Dill, 1990). Consistent with these constraints, female wild turkeys in the southeastern United States continued to use areas with relatively high hunting probability during late spring, particularly near roads, rather than consistently avoiding them (Roth et al., 2024). Similarly, a behavioral model developed by Quance (2025) predicted that incubating females at hunted sites would remain away from their nests for longer consecutive periods than females at non-hunted sites, suggesting that females may prioritize their own survival while increasing risk to their nests. Together, these findings suggest that females may not consistently avoid hunting-related disturbance and may instead alter their behavior in ways that transfer risk from the adult female to the nest.

Spring hunting also overlaps with a period of elevated vulnerability for female wild turkeys. White et al. (2022) found that only 52.5% of breeding female wild turkeys survived the spring reproductive period in Texas, USA, with mortality heavily concentrated during incubation. Similarly, Skidmore (2026) estimated reproductive-period survival of female wild turkeys in Kansas at 49.5%, compared with 82.7% during the nonbreeding period, with 79.4% of all mortalities occurring during the reproductive period. Although females are not legal harvest targets during spring in Kansas, USA, disturbance associated with hunting activity may therefore indirectly influence female survival and reproductive success through altered movement, reduced nest attendance, nest abandonment, or elevated predator exposure.

The potential effects of hunting-related disturbance on female wild turkeys are unlikely to be distributed evenly across the Kansas landscape. Greater than 98% of land in Kansas is privately owned, whereas public hunting opportunities are concentrated on a comparatively small area of publicly owned land (1.5%) and privately owned properties enrolled in the Walk-In Hunting Access (0.6%; WIHA) program administered by Kansas Department of Wildlife and Parks. Despite the limited extent of this publicly accessible land base, approximately 30% of spring wild turkey hunters in 2025 reported hunting on public or Walk-In Hunting Access properties; these properties accounted for 19% of reported harvest (Durbin, 2025). Previous Kansas survey results also indicated that hunters perceived hunting pressure to be greater on publicly owned properties than on WIHA properties (Pittman, 2011). Females occupying publicly accessible lands were therefore expected to encounter hunters and associated disturbance more frequently than females occupying exclusively private lands. Hunting disturbance on private lands was expected to be lower on average because access is controlled by individual landowners, although the intensity of disturbance likely varied among properties according to the number of hunters granted access and how hunting was managed. Accordingly, land ownership was used as an index of relative expected hunting disturbance rather than as a direct measure of hunter activity.

Kansas provides an ideal system for evaluating female wild turkey response to hunting disturbance because the state contains limited public land availability, extensive private ownership, and a strong east-west ecological gradient in the availability and distribution of roost trees. In regions where roost trees are limited to riparian corridors females may be concentrated around these features during the reproductive period. Consequently, hunting disturbance near roosting, nesting, or movement corridors could affect a relatively large proportion of females even when hunting activity is spatially localized. Public hunting access is concentrated within publicly owned properties and WIHA areas managed by Kansas Department of Wildlife and Parks, potentially creating localized areas of elevated hunting pressure. Previous work documented that activity of spring wild turkey hunters is strongly associated with roads and public access corridors (Gerrits et al. 2020), which may spatially overlap with nesting and brood-rearing habitats. Alternatively, density of females could be greater on private than public lands because these areas provide greater habitat heterogeneity, reduced disturbance, or increased resource availability during reproduction. Understanding how females respond to hunting activity among a mosaic of landownership and intensity of hunting disturbance is important for evaluating the ecological implications of current spring harvest frameworks on female wild turkey behavior.

My objective was to evaluate the influence of spring hunting activity on female wild turkey behavior, space use, and survival in Kansas. Specifically, I evaluated whether females altered movement behavior, home range area, and landownership use during periods of elevated hunting activity and whether survival differed among landownership categories during the spring season. I predicted that females using public lands would exhibit increased movement rates, larger home ranges, and lower survival during the hunting season relative to females using private lands due to greater exposure to hunting disturbance and human activity.

Methods

Study area

My study area encompassed the eastern two-thirds of Kansas and was composed of 13 unique capture locations spread from -100° to -97° W (Figure 3.1). The significant precipitation gradient across the study area was correlated with a dominant vegetation structure shift from short-grass prairies in the west, transitioning through mixed-grass and tallgrass prairies eastward to eventually grassland savannas as the percent cover by woody plants increased dramatically in the eastern portion of the study area. Average precipitation from 1996–2026 was 53.90 (SD = 5.08) cm in the west and 82.27 (SD = 7.62) cm to the east (https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series). Across these highly modified landscapes, wild turkeys mainly occupied grasslands, wooded edges, and intermixed croplands.

All wild turkey capture locations were grassland dominant, with the majority (>65%) of grasslands used for livestock grazing throughout the state (Boryan et al. 2011). Grasses common to the entire study area included little bluestem (*Schizachyrium scoparium*), side-oats grama (*Bouteloua curtipendula*), and switchgrass (*Panicum virgatum*). Common forbs include ragweed (*Ambrosia psilostachya*), yellow sweet clover (*Melilotus officinalis*), Illinois bundleflower (*Desmanthus illinoensis*), and annual sunflower (*Helianthus annuus*). Species most often comprising Kansas riparian areas were bur oak (*Quercus macrocarpa*), hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), American elm (*Ulmus americana*), rough-leaf dogwood (*Cornus drummondii*), coral berry (*Symphoricarpos orbiculatus*), and Virginia wild rye (*Elymus virginicus*; Haddock 2024). Croplands were predominantly planted to corn (*Zea mays*), soybeans (*Glycine max*), sorghum (*Sorghum bicolor*), wheat (*Triticum aestivum*), and alfalfa (*Medicago sativa*). Kansas is a predominantly privately owned state with only 1.5% of land cover publicly owned (state or federal). To support public access, the Kansas Department of Wildlife and Parks enters into lease agreements with landowners to allow hunter access to private land via the WIHA programs during hunting seasons. These areas add another 0.6% of publicly accessible land (Figure 3.2).

<u>Capture</u>

Female wild turkeys were captured during January-March 2024 and 2025 by baiting with cracked corn and use of drop net, walk-in trap, or rocket net (Austin et al. 1973, Davis 1994). Approximately 65% of birds were captured on private land and 35% on public land. Birds were removed from traps and placed into National Wild Turkey Federation approved wild turkey capture boxes. During processing, the head of each wild turkey was covered to minimize stress to the bird. Birds were sexed based on presence of spur, beard, and chest feather coloration. Age was determined by barring on outer primary wing feathers along with tail fan shape (Healy and Nenno, 1980; Schroder and Robb, 2005). Morphometric measurements of all birds included body mass (kg), tarsus length (mm), flattened wing cord (mm), and culmen (mm). When present, spur length (mm) and beard length (mm) were also recorded. Females >3.8 kg were considered for transmitter attachment and fitted with 160-g Iridium GPS backpack transmitters (model G5-T2A, Advanced Telemetry Systems, Isanti, Minnesota, USA). Transmitters collected 6–12 daily location fixes, including nocturnal (i.e., roost; 0200 CST) locations. All birds received uniquely numbered riveted metal leg band for identification purposes (National Band & Tag Company, Newport, Kentucky, USA). Birds were released in groups at capture location. Capture and handling were conducted under State of Kansas Scientific, Education, or Exhibition Wildlife Permits (KDWP #980122568) and protocols were approved by the Kansas State University Institutional Animal Use and Care Committee (IACUC protocol 4906).

Landownership was classified as two primary categories: private land and public land. Landownership was assigned to each GPS location based on layers provided by Kansas Department of Wildlife and Parks as public or WIHA (Figure 3.1). Any locations not within polygons of those shape files were considered private land. Public land included state, federal, and other publicly accessible conservation lands, as well as WIHA properties. I grouped WIHA lands with public lands because they represent areas available for public hunting access during spring wild turkey hunting season.

To evaluate the response of female wild turkeys to hunting disturbance, I employed a before–after–control–impact (BACI) design (Green, 1979; Haukos, 2013). I monitored GPS-marked females from March through June of 2024 and 2025, encompassing the youth (April 1–15), archery (April 7–15), and firearm (April 16–May 31) hunting seasons, as well as one month before (March) and one month after (June). I assumed hunting pressure to be highest on public lands, lowest on private lands, and intermediate on WIHA lands. Private properties therefore served as experimental controls, while public and WIHA sites represented treatment levels of hunting disturbance. Comparisons were made across temporal phases (before, during, and after hunting season) to assess effects of disturbance due to hunting on female wild turkey survival, movements, and space use.

Movement

I compared female movement and space use patterns among landownership groups (public, private, WIHA) and across temporal periods (pre-season, hunting season, and post-season). Prior to estimating home range areas, GPS locations were projected to a metric coordinate system and duplicate spatial points (e.g., nests) were removed for individual birds to improve estimator performance.

Step length and displacement

To evaluate potential behavioral responses to spring hunting disturbance, I tested whether female wild turkeys altered their movements among pre-hunting, hunting, and post-hunting periods and whether these patterns differed between females using predominantly public or private lands, where exposure to hunting activity may differ. Each GPS location was assigned to a public- or private-land category based on spatial intersection with land-ownership layers. Wildlife areas open to public hunting were combined with other public lands. For each bird-day and bird-week, I calculated the proportion of GPS locations occurring on private and public lands. Bird-days and bird-weeks with >50% of locations on private land were classified as private-dominant, whereas all other intervals, including equal proportions of private and public locations, were classified as public-dominant.

I estimated daily movement distance by calculating Euclidean step lengths between consecutive GPS locations for each female within each calendar day. I ordered GPS locations chronologically, with coordinates projected to the NAD83 / Conus Albers coordinate reference system before calculating distances. Steps were not allowed to cross calendar-day or spring-period boundaries. Daily step lengths were summed to estimate the total distance moved by each female per day. Bird-days with fewer than two GPS locations were excluded.

I estimated weekly movement distance by summing daily movement distances within seven-day intervals. Weekly intervals began at the start of each spring period, with the pre-hunting period beginning 1 March, the hunting period beginning 1 April, and the post-hunting period beginning 1 June. Only intervals containing seven days of movement observations were retained in the weekly analysis. Locations recorded during nesting and brood rearing were retained in the daily and weekly movement analyses because these behaviors represented components of spring movement.

Roost-to-roost displacement was calculated as the straight-line Euclidean distance between nighttime GPS locations recorded on consecutive calendar dates. Only intervals with nighttime locations exactly one day apart and within the same spring period were retained. Known nesting dates were removed from the roost dataset before displacement was calculated. Females were retained before and after nesting, but an interval was excluded when either nighttime location occurred during a known nesting interval because incubating females were located at nests rather than at roost sites.

I used linear mixed-effects models to evaluate variation in daily movement distance, weekly movement distance, and roost-to-roost displacement. Each response was log transformed before analysis. Models included dominant ownership category, spring period, and their interaction as fixed effects, with female identity included as a random intercept. I used Type III analysis of variance with Satterthwaite approximations for denominator degrees of freedom to evaluate overall fixed effects. When appropriate, I used estimated marginal means and asymptotic pairwise contrasts to compare private- and public-dominant observations within each spring period.

Home Range

I estimated period-specific space use by female wild turkeys using minimum convex polygons (MCP) and kernel density estimation (KDE). Before estimating space use, I excluded GPS locations recorded during known nesting intervals and, for successful nests, during the first 14 days of brood rearing. Bird-period combinations with fewer than 30 unique relocations remaining after these exclusions were removed to improve estimate reliability and maintain a consistent inclusion criterion between methods. Coordinates were projected to NAD83 / UTM Zone 14N (EPSG:26914) before estimating MCP and KDE areas. I calculated 95% minimum convex polygons (km^2) for each bird-year-period using the adehabitatHR package in Program R (Calenge 2024). Minimum convex polygon area was estimated separately for the pre-hunting, hunting, and post-hunting periods and reported in square kilometers. I also estimated period-specific utilization distributions using fixed kernel density estimation with the reference bandwidth method (href). I extracted the 95% KDE isopleth (km^2) for each qualifying bird-year-period.

Landownership use and switching

In addition to movement and home-range analyses, I summarized weekly ownership use to describe how female wild turkeys used private, public, and WIHA lands through time. Each bird-week was summarized as the mean proportion of fixes occurring on private, public, and

WIHA lands. Public and WIHA were then combined into a single public/WIHA category for classification purposes. Each bird-week was assigned a dominant ownership category based on the ownership class with the greatest proportional use. I summarized the percentage of birds classified as private-dominant or public/WIHA-dominant for each week. I also calculated mean weekly percentage of locations occurring on private, public, and WIHA lands to describe ownership composition without converting use to a dominant category.

To evaluate ownership switching, I ordered bird-weeks sequentially for each bird-year and counted the number of times each individual changed dominant ownership category between consecutive weeks. I summarized the total number of switches per bird, the percentage of birds that switched ownership category at least once, and week of each bird's first ownership switch. I also classified the direction of the first switch as either private to public/WIHA or public/WIHA to private. Switching rates were calculated as the number of switch events divided by the number of bird-weeks. Finally, I compared ownership at capture to the primary ownership category used during the spring by classifying each bird according to whether most of its bird-weeks were private-dominant or public/WIHA-dominant.

Spring mortality locations

To evaluate whether final spring pre-mortality locations occurred on publicly accessible lands disproportionately to their availability, I restricted the analysis to females with recorded mortality dates between 1 March and 30 June. For each female, I retained GPS relocations from 1 March of the mortality year through the recorded mortality date. I excluded females with fewer than 30 valid relocations during this period. I then generated a 99% MCP from each female's retained locations to represent the pre-mortality spring use area (Mohr 1947). I intersected each MCP with public-land and WIHA spatial layers provided by the Kansas Department of Wildlife and Parks. I calculated the area and proportion of each MCP classified as public land and WIHA and calculated private-land area as the remaining portion of the MCP. Public land and WIHA were combined as publicly accessible land for statistical analysis.

I identified the final valid GPS location recorded on or before each female's mortality date and classified it as publicly accessible or private. Under the null hypothesis that final pre-mortality locations occurred randomly with respect to landownership, the probability that a female's final location occurred on publicly accessible land was equal to the proportion of publicly accessible land within her individual pre-mortality MCP. Because this probability differed among females, I summed the individual probabilities to obtain the expected number of final locations on publicly accessible land. I then compared the observed and expected numbers using a two-sided normal approximation to the Poisson-binomial distribution (Hong 2013). I also calculated observed-to-expected ratios for publicly accessible and private land by dividing the observed number of final locations in each ownership category by its expected number based on individual availability (Manly et al. 2002). Ratios greater than 1 indicated that final locations occurred in an ownership category more often than expected, whereas ratios less than 1 indicated that they occurred less often than expected.

Survival Analysis

Kaplan-Meier cumulative survival analysis

I used Kaplan-Meier survival analysis with staggered entry and Cox proportional hazard models in Program R to compare weekly spring survival of female wild turkeys between ownership groups. Each bird was considered an individual per each spring season of 2024 and 2025. Individuals were classified as public- or private-land users based on their dominant ownership classification during the week prior to start of hunting season (week 4) of the spring monitoring period. Cumulative survival was measured in weeks from 1 March through 30 June, with each individual female wild turkey assigned an exit week corresponding to mortality. I estimated Kaplan-Meier survival functions separately for public- and private-land users using the survival package in R (Kaplan and Meier, 1958; Therneau, 2026). I used a log-rank test to evaluate whether survival distributions differed between ownership groups. To estimate the relative hazard of mortality associated with ownership, I fit a Cox proportional hazards model with landownership as the predictor variable (Therneau and Grambsch, 2000). I evaluated the proportional hazards assumption using Schoenfeld residuals.

Known-fate cumulative survival analysis

I estimated weekly survival of female wild turkeys using the known-fate framework in Program MARK (White and Burnham 1999). Females were classified as private- or publicly accessible-land birds based on dominant landownership use during week 4 (March 20). Publicly accessible lands included public and Walk-In Hunting Access properties. Females that died or were censored before week 4 were classified using all available locations before death or censoring. Encounter histories included 18 weekly intervals divided into pre-hunting, hunting, and post-hunting periods.

My candidate model set tested effects of hunting period, landownership, and age on weekly survival. Models included constant survival, period and ownership effects alone, additive and interactive effects of ownership and period, and models that included age as an additive covariate. I ranked models using Akaike's Information Criterion (AICc) corrected for small sample size and considered models with ΔAICc ≤ 2 competitive (Burnham and Anderson 2002). I used the age-adjusted ownership-by-period model to estimate weekly survival and compare private- and publicly accessible-land females within each period. Because the periods differed in duration, cumulative survival was compared only between ownership groups within the same period.

Results

During 2024, I captured and fitted transmitters to 297 female wild turkeys, including 168 females captured on private land and 129 captured on public land. During 2025, I captured and fitted transmitters to an additional 102 females, of which 87 were captured on private land and 15 were captured on public land. Across both study years, the dataset included 399 annual capture records (65.5% captured on private land). Females that survived and remained in the study for both years contributed data during each year and were treated as separate bird-year observations in annual analyses. Thus, the number of bird-year observations (n = 499) exceeded the number of unique individual females monitored during the study.

Daily movement distance

The daily movement dataset included 48,146 individual-day observations from 358 female wild turkeys. Results from analysis of variance of the log-transformed linear mixed model indicated that daily movement differed by dominant ownership category ($F_{1,30402} = 14.74$; $P < 0.001$) and spring period ($F_{2,48052} = 186.05$; $P < 0.001$). The interaction between dominant ownership and period was also significant ($F_{2,48020} = 10.41$; $P < 0.001$), indicating that the relationship between ownership and daily movement varied among spring periods. Daily movement did not differ between ownership categories during the pre-hunting or hunting periods, but the private-public contrast was significant during the post-hunting period (Table 3.1).

Weekly movement distance

The weekly movement dataset included 6,207 complete individual-week observations from 348 female wild turkeys. Weekly movement differed among spring periods ($F_{2,6069} = 38.94$; $P < 0.001$), with females moving the greatest weekly distances during the hunting period, slightly shorter distances during the pre-hunting period, and the shortest distances during the post-hunting period. However, weekly movement did not differ overall between private- and public-dominant females ($F_{1,2882} = 0.26$; $P = 0.61$), and the interaction between dominant ownership and period was not significant ($F_{2,6136} = 1.76$; $P = 0.17$; Table 3.2).

Roost-to-roost displacement

After excluding nighttime locations recorded during known nesting intervals, the roost-to-roost displacement dataset included 37,487 consecutive-night intervals from 355 female wild turkeys. Roost-to-roost displacement was greater for private-dominant females than for public-dominant females ($F_{1,14130} = 43.42$; $P < 0.001$) and differed among spring periods ($F_{2,37385} = 112.62$; $P < 0.001$). However, the interaction between dominant ownership and period was not significant ($F_{2,37101} = 1.20$; $P = 0.30$), indicating that the relationship between ownership and roost-to-roost displacement was similar among periods. (Table 3.3).

Landownership use

Across all weekly classifications, female wild turkeys were most commonly classified as private-land dominant. Of 7,273 bird-weeks, 5,314 bird-weeks were classified as private-dominant and 1,959 were classified as public/WIHA-dominant, representing 73.1% and 26.9% of bird-weeks, respectively. Weekly patterns were generally consistent through time, with the proportion of public/WIHA-dominant birds ranging from 20.1% in week 17 to 32.0% in week 10. Conversely, the proportion of private-dominant birds ranged from 68.0% to 79.9% across weeks. These patterns were similar between years, with public/WIHA-dominant bird-weeks comprising 27.4% of bird-weeks in 2024 and 26.4% in 2025.

Landownership switching

Although most birds remained in the same dominant ownership category across the study period, ownership dominance was not completely static. Of 499 individual birds-years, 315 birds, or 63.1%, never changed dominant ownership category, whereas 184 birds, or 36.9%, switched ownership dominance at least once. Among all birds, the mode number of switches was zero. The number of switches ranged from zero to seven. Among birds that switched at least once, the average number of switches was 2.16, with a mode of two switches. Most switching birds changed ownership dominance only once or twice; 82 birds switched once, 50 birds switched twice, and 52 birds switched more than twice. The proportion of birds switching ownership dominance in a given week was relatively low across the study period. Weekly switching ranged from 3.3% to 9.1% of bird-weeks. The highest weekly switching occurred during week 7 (April 10), when 42 of 464 bird-weeks, or 9.1%, involved a change in dominant ownership category. Switching was also relatively elevated during weeks 4 (March 20) and 6 (April 3), when 7.5% and 7.8% of bird-weeks changed ownership category, respectively. In contrast, the lowest weekly switching occurred during week 16, when 11 of 330 bird-weeks, or 3.3%, involved a change in dominant ownership category.

The first ownership switch most often occurred during the earlier portion of the monitoring period. Among birds that switched, the mean week of first switch was 6.3, and the median week of first switch was 6. First switches ranged from week 2 (March 6) to week 18 (June 26). Direction of first switch was slightly more common from private to public/WIHA than from public/WIHA to private. Of the 184 birds that switched, 108 birds, or 58.7%, first switched from private to public/WIHA, whereas 76 birds, or 41.3%, first switched from public/WIHA to private. Birds that first switched from private to public/WIHA did so earlier on average, with a mean first-switch week of 5.5 and median of week 5 (March 27). Birds that first switched from public/WIHA to private switched later on average, with a mean first-switch week of 7.3 and median of week 6 (April 3). The timing of many initial ownership switches corresponded with the onset of the spring hunting period, with the youth season beginning during week 5, the archery season during week 6, and the regular firearms season during week 8. The timing of these switches generally preceded the primary nesting period for most females. Skidmore (2026) reported that mean laying and incubation dates occurred later in spring, although the earliest documented incubation began on 6 April, suggesting that switches during weeks 5–6 likely preceded nesting for many females but may have overlapped with early reproductive activity for some individuals.

Home Range

After excluding GPS locations recorded during known nesting intervals, the MCP dataset included 1,253 bird-period observations from 357 female wild turkeys. Results indicated that 95% MCP area did not differ between private- and public-dominant females ($F_{1,730} = 0.70$, $P = 0.40$), but differed among periods ($F_{2,1029} = 48.06$, $P < 0.001$). The interaction between dominant ownership and period was not significant ($F_{2,1115} = 1.73$, $P = 0.18$), indicating that temporal patterns in MCP area were consistent between ownership categories. Across ownership categories, MCP area was greatest during the hunting period, intermediate during the pre-hunting period, and lowest during the post-hunting period (Table 3.4).

After excluding GPS locations recorded during known nesting intervals, the 95% kernel density estimate dataset included 1,253 bird-period observations. Kernel density estimate home-range area did not differ overall between private- and public-dominant females ($F_{1,720}$ = 1.72; P = 0.19), but differed among spring periods ($F_{2,1031}$ = 33.62; P < 0.001). The interaction between dominant ownership and period was not significant ($F_{2,1118}$ = 0.46; P = 0.63), indicating that temporal changes in KDE area were similar for private- and public-dominant females. Across ownership categories, KDE area did not differ between the pre-hunting and hunting periods but was greater during both periods than during the post-hunting period (Table 3.5).

Spring mortality and landownership availability

The analysis included 174 female wild turkeys with at least 30 valid GPS relocations between 1 March and their recorded spring mortality date. Of these, 54 females (31.0%) had final locations on publicly accessible land, whereas 39.38 locations (22.6%) were expected based on the proportion of publicly accessible land within each female's pre-mortality MCP. Final locations occurred on publicly accessible land more frequently than expected based on individual availability (normal approximation to the Poisson-binomial distribution: z = 3.81; P < 0.001). The observed-to-expected selection ratio for publicly accessible land was 1.37, indicating that final locations occurred on publicly accessible land approximately 37% more often than expected. Conversely, 120 final locations occurred on private land compared with 134.62 expected, producing a selection ratio of 0.89.

Survival

Kaplan-Meier

I included 489 unique birds alive during some portion of the spring period in the Kaplan-Meier survival analyses: 179 birds died during the spring period. Eleven birds did not survive until week 4 so landownership classification was based on dominate landownership type until death. I utilized the Kaplan-Meier survival analysis to estimate the cumulative survival of both private and public landownership wild turkeys with staggered entry (Figure 3.3). Birds classified as private landownership had an estimated cumulative survival of 0.64 ± 0.03 while public birds had 0.56 ± 0.04. Utilizing a log-rank test, public birds had a larger observed mortality than expected (1.83) while private birds had a lower than expected observed mortality (0.60). However, survival curves did not differ significantly between ownership groups based on a log-rank test ($\chi^2_1 = 2.5$, $P = 0.10$).

The Cox proportional hazards model indicated that landownership was not a significant predictor of female survival during the study period. Females associated with public lands had an estimated 1.29 times greater hazard of mortality than females associated with private lands, but this effect was not statistically significant and the confidence interval overlapped 1.0 (HR = 1.29, 95% CI = 0.94–1.77, $P = 0.12$). Schoenfeld residuals indicated no violation of the proportional hazards assumption for ownership ($P = 0.98$), suggesting that the relative hazard between ownership groups was consistent through time.

Known-Fate

The known-fate dataset included 489 annual encounter histories from 356 female wild turkeys. Of these histories, 395 were from adults and 94 were from juveniles. Females classified as private-land birds contributed 358 histories, whereas publicly accessible-land females contributed 131 histories. The dataset contained 7,203 monitored weekly intervals and 179 mortality occasions.

Model selection provided the greatest support for the additive age, ownership, and period model, $\hat{S}(\text{age} + \text{owner} + \text{period})$, which had an AICc weight of 0.26 (Table 3.6). However, five models were within 2 AICc units of the top model, and no single model received dominant support. Models including age and period, ownership and period, period alone, and the age-adjusted ownership-by-period interaction were all competitive with the top model. In contrast, the ownership-only and constant-survival models received essentially no support. All competitive models included spring period, indicating that temporal variation was the most consistently supported component of weekly survival.

In the top additive model, weekly survival was lower during both the hunting period ($\beta = -1.31$, SE $= 0.27,\ 95\%$ CI $= -1.83$ to $-0.79,\ P < 0.001$) and the post-hunting period ($\beta = -1.01$, SE $= 0.30,\ 95\%$ CI $= -1.60$ to $-0.43,\ P < 0.001$) relative to the pre-hunting period. Publicly accessible-land females had lower estimated survival than private-land females, although the ownership coefficient was imprecise and its confidence interval included zero ($\beta = -0.26$, SE $= 0.16,\ 95\%$ CI $= -0.58$ to $0.06,\ P = 0.11$). The estimated age effect was also uncertain $\left(\beta_{\text{juvenile}} = 0.34\right.$, SE $= 0.21,\ 95\%$ CI $= -0.07$ to $\left.0.74,\ P = 0.11\right)$.

To directly evaluate whether survival differed between ownership groups during each spring period, I examined estimates from the competitive age-adjusted ownership-by-period model. During the pre-hunting period, estimated weekly survival was $0.99(\pm 0.0024$ SE) for private-land females and 0.98 (± 0.0066 SE) for publicly accessible-land females. The estimated public-private difference was -0.01 (± 0.0070 SE), and the 95% confidence interval narrowly excluded zero (95% CI $= -0.03$ to $-0.0004,\ P = 0.04$).

During the hunting period, estimated weekly survival was $0.97(\pm 0.0033$ SE) for private-land females and $0.96(\pm 0.0061$ SE) for publicly accessible-land females. The public-private difference was small and imprecise $\left(\widehat{\Delta S} = -0.0046\right.$, SE $= 0.0069,\ 95\%$ CI $=$ -0.0195 to $\left.0.0078,\ P = 0.49\right)$.

During the post-hunting period, estimated weekly survival was $0.98(\pm 0.0044$ SE) for private-land females and $0.97(\pm 0.0090$ SE) for publicly accessible-land females. The estimated difference also included zero $\left(\widehat{\Delta S} = -0.0071, \text{SE} = 0.0100,\ 95\%\ \text{CI} = -0.0301 \text{ to } 0.0093,\ P = 0.43\right)$.

Although the pre-hunting ownership contrast narrowly excluded zero, the interaction terms describing changes in the ownership difference during hunting and post-hunting were not supported. The public-by-hunting ($P = 0.10$), and public-by-post-hunting interactions ($P = 0.22$) were not statistically significant. Thus, results did not indicate that the difference in weekly survival between private- and publicly accessible-land females increased during the hunting period. Instead, the estimated ownership difference was present before hunting and remained small during the hunting and post-hunting periods.

Cumulative survival estimates were calculated only for ownership comparisons within the same period. Estimated cumulative pre-hunting survival was 0.98 for private-land females and 0.93 for publicly accessible-land females. During the hunting period, cumulative survival was estimated as 0.75 for private-land females and 0.72 for publicly accessible-land females. Post-hunting cumulative survival was estimated as 0.89 and 0.86 for private- and publicly accessible-land females, respectively. These estimates were not compared directly among periods because the pre-hunting, hunting, and post-hunting periods contained different numbers of weekly intervals.

Discussion

Spring hunting activity appeared to exert limited influence on female wild turkey ecology in Kansas during the study period. Although females exhibited minor changes in space use and landownership patterns during periods of peak hunting activity, these responses were relatively weak and did not translate into substantial changes in movement behavior or survival. Instead, female spatial ecology appeared to be more strongly influenced by habitat distribution, reproductive constraints, and the predominance of private land across the Kansas landscape. However, because land ownership represented an index of expected hunting disturbance rather than a direct measure of hunter activity, these results should be interpreted as limited evidence of a response to expected disturbance rather than evidence that hunting activity had no effect.

Contrary to predictions, females did not substantially increase movement distances or home range area during the hunting season. Space use increased modestly during the hunting period for both ownership categories, but these differences were relatively small and inconsistent across periods. Similarly, switching between ownership categories remained limited throughout the study period, with most females maintaining consistent landownership associations across spring. Among females that switched, however, the first switch generally occurred near the beginning of the hunting period and slightly before the opening of the regular firearms season. This timing could indicate a response to disturbance associated with pre-season scouting or activity during the earlier youth and archery seasons. However, because hunter presence and scouting activity were not directly measured, this interpretation remains speculative. Collectively, these results differ from studies documenting pronounced hunting-related shifts in male roost selection or movement (Wakefield et al. 2020; Wightman et al. 2023; Roth et al., 2024), but they are consistent with studies reporting limited or variable changes in wild turkey space use following hunting disturbance (Williams et al. 1978; Gross et al. 2015; Collier et al. 2017). The limited avoidance observed in Kansas therefore may reflect a sex-specific response in which reproductive females continue to use important habitats despite the presence of hunters.

Because landownership effects were small and inconsistent across daily and weekly scales, I found limited evidence that females using public lands moved greater distances than females using private lands during spring. Additionally, these results suggest that spring movement patterns of female wild turkeys were more closely associated with seasonal timing associated with reproductive behaviors than with dominant land-ownership use. Increased movement during the hunting period may reflect mate searching, nest prospecting, or shifts in space use associated with the transition from pre-nesting to nesting.

One explanation for these limited behavioral responses is that reproductive females are constrained by the distribution of available nesting and roosting habitat. In grassland-dominated systems such as Kansas, woody cover providing roost habitat is patchily distributed and often concentrated along riparian corridors and within shelter belts. Females establishing nests near wooded patches containing roost trees may be unable to substantially alter space use during spring because reproductive demands and habitat availability limit behavioral flexibility. Consequently, females may tolerate elevated disturbance levels rather than abandon areas containing critical reproductive resources. This interpretation aligns with the Predation Risk Allocation Hypothesis, which predicts that individuals experiencing prolonged or unavoidable risk may reduce avoidance responses when constrained by competing energetic or reproductive demands (Lima and Dill, 1990).

The absence of a broad-scale movement response also does not preclude finer-scale behavioral effects on reproduction. Quance (2025) developed a behavioral model predicting that females at hunted sites would remain away from their nests for longer consecutive periods than females at nonhunted sites. Longer incubation recesses have been associated with greater female survival but increased nest loss, suggesting a trade-off between adult survival and reproductive success (Lohr et al. 2020). Thus, females may respond to hunting disturbance by altering nest-attendance behavior rather than relocating their home ranges or switching ownership categories. Because the present study evaluated daily and weekly movement, space use, ownership associations, and survival, it could not identify changes in incubation-recess frequency, recess duration, nest attendance, or nest survival. Potential reproductive consequences of hunting disturbance may therefore occur at temporal and spatial scales that were not captured by the present analyses.

The predominance of private land use further supports the importance of habitat distribution in shaping female wild turkey ecology in Kansas. Most females remained associated with private properties throughout spring, while extensive use of WIHA properties was rare. However, WIHA represented a small and unevenly distributed portion of the landscape, and it may not have been available within the spring use areas of many monitored females. Consequently, limited WIHA use should not necessarily be interpreted as avoidance or evidence of lower habitat suitability without accounting for its availability to individual females. The harvest of male wild turkeys on WIHA properties indicates that these areas supported turkey activity and received hunting use, but male occurrence does not establish that WIHA was readily accessible or provided suitable reproductive habitat for females in this study. Where WIHA was available, differences in habitat composition could have influenced female use because some properties were dominated by agricultural or U.S Department of Agriculture Conservation Reserve Program fields and may have contained limited combinations of roosting, nesting, and brood-rearing cover. In contrast, private lands may provide a broader combination of forage availability, nesting cover, and roosting habitat. Among the 184 females that switched ownership categories, 76 females (41.3%) first moved from public or WIHA lands to private lands, with a median first-switch date of 3 April. Because this timing generally preceded the regular firearms season, these movements may have reflected selection for reproductive habitat rather than direct avoidance of peak hunting disturbance.

Although behavioral responses were limited, mortality occurred disproportionately on public lands relative to their availability across the landscape. This pattern suggests that ecological factors associated with public lands may indirectly elevate mortality risk. Public properties in Kansas are frequently associated with reservoirs, riparian corridors, and structurally complex woody habitats that may support greater predator abundance. Predators capable of depredating adult wild turkeys, including coyotes (*Canis latrans*), bobcats (*Lynx rufus*), and great horned owls (*Bubo virginianus*), may be more common in these environments due to increased prey availability and habitat heterogeneity. Consequently, differences in predator communities and habitat structure may contribute more strongly to female mortality patterns than hunting disturbance itself.

These relationships may be particularly important in Great Plains systems where availability of roost trees spatially limits potential nest sites (Chapters I, II). In grassland-dominated landscapes, female wild turkeys often rely on isolated woody draws, riparian corridors, and shelterbelts for roosting, which constrains the availability of potential nesting and brood-rearing habitat as females rarely nest >300 m from woody cover (Skidmore 2026). The limited distribution of these habitat features may constrain female movement flexibility during periods of disturbance. Bakner et al. (2024) demonstrated that roost-tree availability strongly influences female space use in fragmented prairie systems, suggesting that females may be unable to avoid areas experiencing elevated disturbance if roosting habitat is limited. Consequently, behavioral responses to hunting disturbance may be moderated by habitat availability and reproductive constraints rather than disturbance alone.

Overall, results suggest that current spring hunting regulations may exert limited direct influence on female wild turkey behavior and survival in Kansas. Instead, female ecology during spring appears to be shaped primarily by habitat availability, reproductive constraints, and landscape composition. These findings highlight the importance of considering habitat structure and resource distribution when evaluating the indirect effects of hunting disturbance on nontarget wildlife populations. Future research comparing hunted and nonhunted landscapes with similar habitat composition would improve understanding of how disturbance, predator communities, and reproductive constraints interact to influence female wild turkey ecology.

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Figures

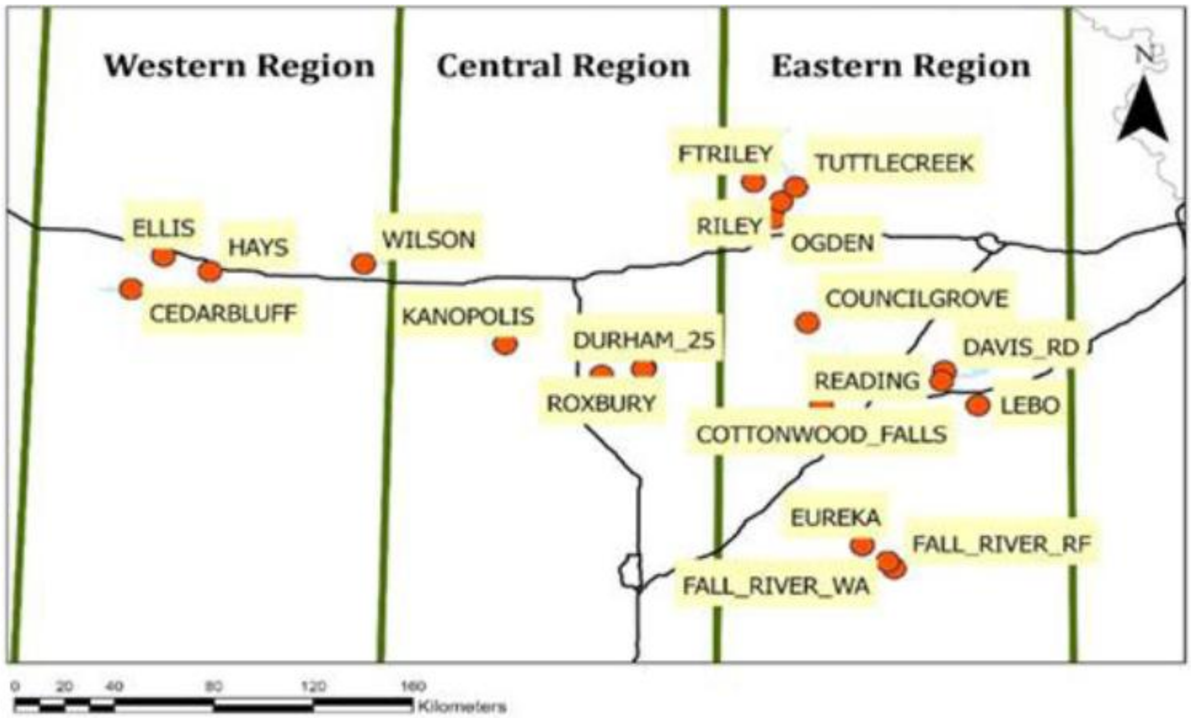

Figure 3.1 The study area split into three study regions (West, Central, and East) where wild turkeys were captured and marked with 160-gram G5-T2A Iridium backpack units with global positioning systems (GPS) and very-high-frequency (VHF) radio transmitter components. Captures occurred across 19 different sites in Kansas, USA, 2024–2025.

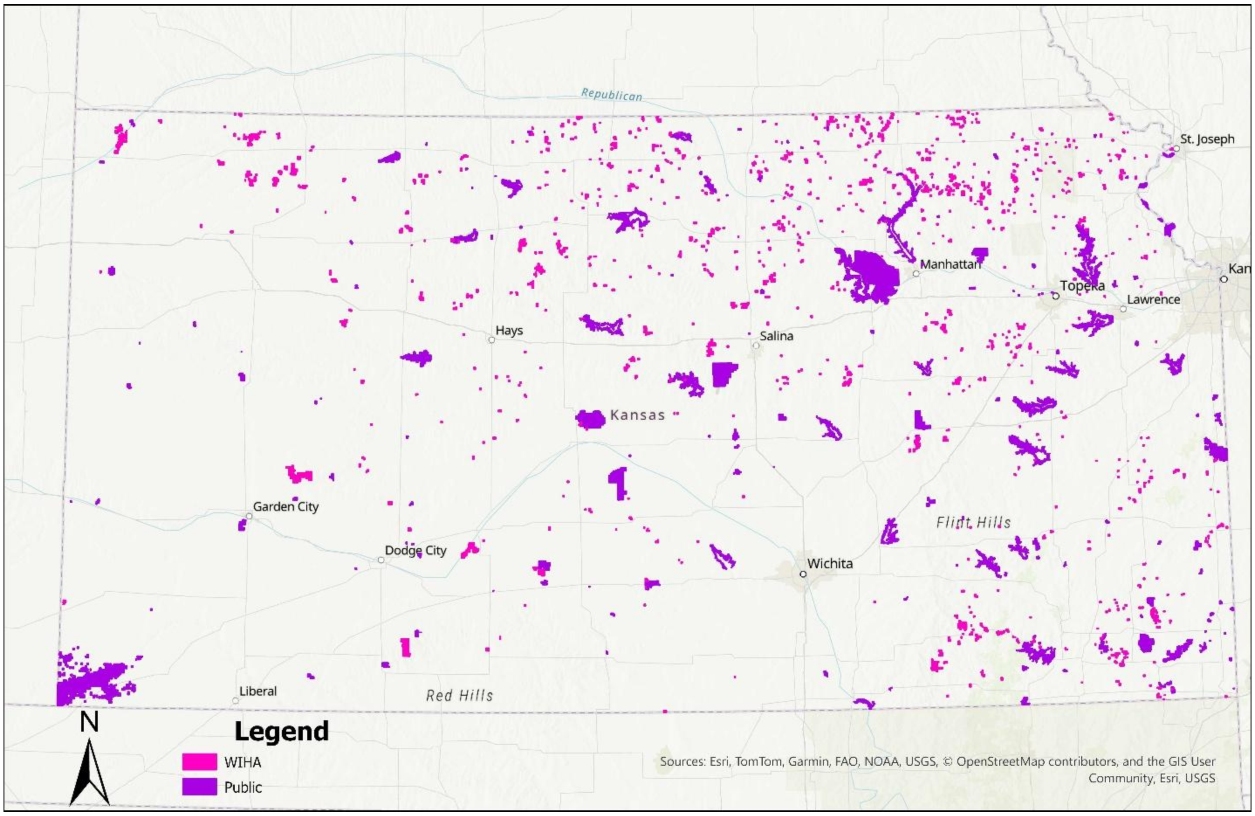

Figure 3.2 Location of public land and Walk-In-Hunting-Access (WIHA) land available to harvest wild turkeys in Kansas, USA.

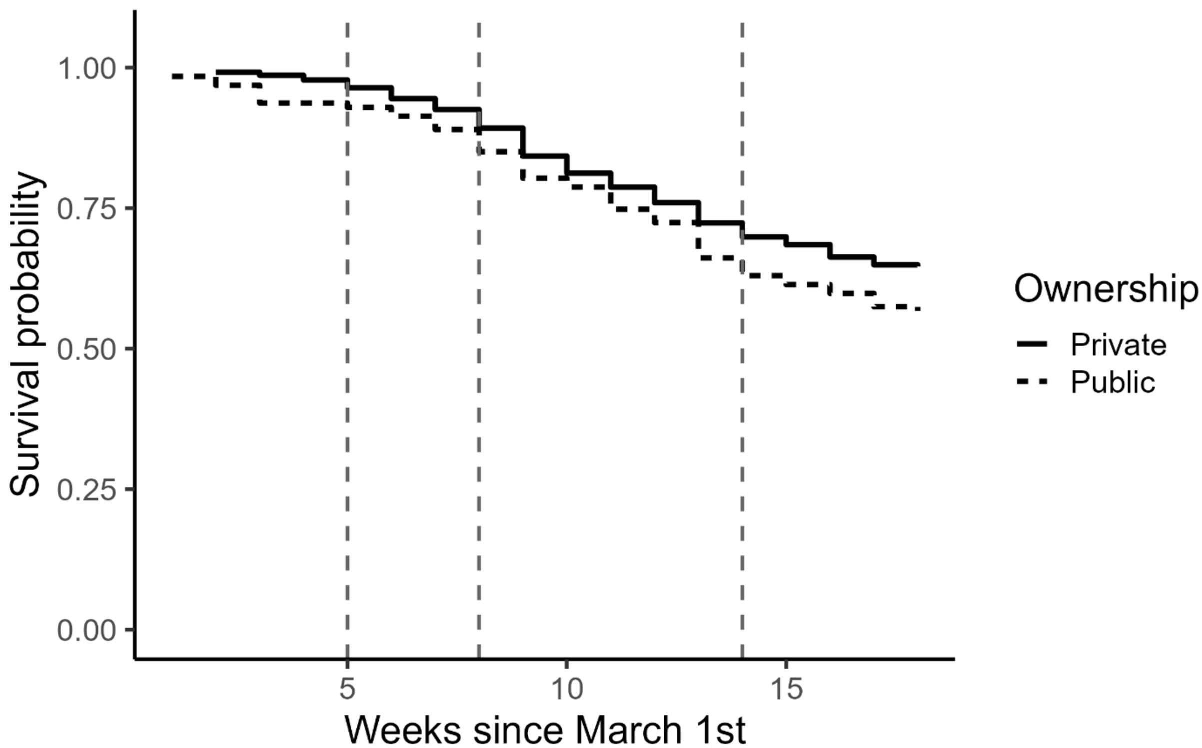

Figure 3.3 Cumulative survival of female wild turkeys during 1 March–30 June of 2024 and 2025 with weeks categorized as 1 month prior to the hunting season (weeks 1-4), hunting season (1 April – 31 May, weeks 5-13), and 1 month post hunting season (weeks 14-18) in Kansas, USA. First vertical dashed line is the beginning of the hunting season, second is the beginning of regular hunting season, and the last in the end of the hunting season.

Tables

Table 3.1 Mean daily path length and standard deviation (km/day) of female wild turkeys classified as private- or public-dominant during the pre-hunting, hunting, and post-hunting periods in Kansas, USA, 2024 and 2025.

	Private			Public				
Period	*n*	km/day	SD	*n*	km/day	SD	*z*	*P*
Pre	9884	1.34	0.94	3611	1.34	0.88	-0.30	0.76
Hunt	17727	1.61	1.21	7278	1.49	1.14	-1.73	0.08
Post	7683	1.14	0.90	1963	1.10	0.83	-5.24	<0.001

Table 3.2 Mean weekly movement distance of female wild turkeys classified as private- or public-dominant during the pre-hunting, hunting, and post-hunting periods in Kansas, USA, 2024 and 2025. Sample size represents the number of complete individual-week observations.

	Private			Public				
Period	*n*	km/week	SD	*n*	km/week	SD	*z*	*P*
Pre	1248	9.09	3.98	411	8.97	3.20	0.45	0.65
Hunt	2335	11.50	6.72	937	10.56	6.08	0.60	0.55
Post	1025	8.08	5.06	251	8.00	4.92	-1.56	0.12

Table 3.3 Mean roost-roost displacement distance of female wild turkeys classified as private- or public-dominant during the pre-hunting, hunting, and post-hunting periods in Kansas, USA, 2024 and 2025.

	Private			Public				
Period	*n*	km	SD	*n*	km	SD	*z*	*P*
Pre	9480	0.466	0.915	3433	0.437	0.750	-4.42	<0.001
Hunt	13006	0.563	0.887	5430	0.548	0.817	-6.88	<0.001
Post	4744	0.397	0.579	1394	0.421	0.538	-3.40	<0.001

Table 3.4 Mean 95% minimum convex polygon (MCP) area (ha) of female wild turkeys classified as private- or public-dominant during the pre-hunting, hunting, and post-hunting periods in Kansas, USA, during 2024 and 2025.

	Private			Public					
	n	MCP	SD	*n*	MCP	SD	df	*t*	*P*
Pre	370	8.07	14.2	117	4.03	5.59	1244	1.83	0.07
Hunt	335	9.35	18.6	134	5.49	6.30	1197	1.08	0.28
Post	234	2.03	2.72	63	2.19	2.25	1240	-0.88	0.38

Table 3.5 Mean 95% kernel density estimate (KDE) area (ha) of female wild turkeys classified as private- or public-dominant during the pre-hunting, hunting, and post-hunting periods in Kansas, USA, during 2024 and 2025.

	Private		Public				
	KDE	SD	KDE	SD	df	*t*	*P*
Pre	20.2	35.4	10.4	18.5	1244	1.47	0.14
Hunt	18.0	47.0	9.94	14.5	1195	1.29	0.20
Post	4.09	6.27	4.09	5.44	1238	-0.03	0.98

Table 3.6 Model ranking for estimation of survival of female wild turkeys during March-June of 2024 and 2025 in Kansas, USA. Models evaluated effects of age class, dominant landownership category, and spring period on survival. Dominant landownership was classified as private or public, and spring period was classified as pre-hunting, hunting, or post-hunting.

MODEL[A]	AIC_C[B]	ΔAIC_C[C]	W_I[D]	K[E]
S(age + owner + period)	1670.58	0.000	0.26	5
S(age + period)	1671.02	0.44	0.21	4
S(owner + period)	1671.37	0.79	0.17	4
S(period)	1671.69	1.11	0.15	3
S(age + owner x period)	1671.97	1.39	0.13	7
S(owner x period)	1672.73	2.15	0.09	6
S(owner)	1700.03	29.45	0.00	2
S(.)	1700.24	29.66	0.00	1

[A] *S* denotes apparent survival; age denotes age class; owner denotes dominant landownership category; period denotes spring period; × denotes an interaction between variables; and (.) denotes constant survival. Additive effects are indicated by +.

[B] Akaike's Information Criterion corrected for small sample size.

[C] Difference in AICc between each candidate model and the highest-ranked model.

[D] Akaike model weight, representing the relative support for each model within the candidate model set.

[E] Number of estimable parameters in the model.

Chapter 4 - Landowner intentions and audience segments for wild turkey management in Kansas

Introduction

Wild turkey (*Meleagris gallopavo*) conservation in the United States depends on landscape-scale habitat management that incorporates public and private land. In the United States, >60% of land, or 1.4 billion acres, is privately owned, and much of that private land consists of non-urban working landscapes such as cropland, forest, and grassland (Winters-Michaud et al., 2024). However, wildlife research and management are often publicly funded and frequently conducted on public lands, creating a disconnect between where research is commonly implemented and where the majority of wildlife lives (Baier and Segal, 2020; Benson et al., 1999; Benson, 2001). This imbalance is especially important in the Great Plains, where nearly 90% of the landscape is privately owned, and in Kansas, where approximately 98% of land is under private ownership (NRCS, 2021; USGS-GAP, 2024).

These ownership patterns mean wildlife managers cannot rely solely on public lands to achieve management objectives, particularly in landscapes where public parcels are limited, fragmented, and often disconnected from one another. For wide-ranging species and species dependent on large-scale landscape composition, small pockets of public land are unlikely to provide sufficient landscape connectivity or management capacity (Burger et al., 2019; Knight, 1999; Rudnick et al., 2012; With, 1999). For wild turkeys, this limitation is especially relevant because they require a mix of habitat resources across seasons. In Kansas, many of these habitat resources occur on privately owned working lands (Marchese, 2026; Skidmore, 2026). Because wild turkeys are a culturally and economically important game species experiencing regional declines (Chamberlain et al., 2022; Collier et al., 2025), effective management in Kansas must include private landowners and the landscapes they manage.

Private lands in Kansas are integral to wildlife management because farms and ranches can provide multiple life-cycle requirements. Many wildlife species can coexist with agricultural operations when land-management practices support these life-cycle needs (Benson et al. 1999; Lindell & Dayer 2022; Poudyal & Hodges 2009). As a result, landowners are important conservation decision-makers because their management decisions influence whether practices are implemented at scales meaningful for wildlife populations. Wild turkey management provides a useful case study of this relationship because wild turkeys are socially, culturally, and economically important game birds that contribute to hunting traditions, outdoor recreation, and local economies (Arnett and Southwick 2015; Chapagain et al. 2020; Cooper et al. 2015; Heffelfinger et al. 2013; Steele and Lashley, 2025). At the same time, growing concerns about wild turkey populations in parts of their range highlight the need to understand both ecological drivers and landowner perspectives (Daley et al., 2004; Jahn, 1973; Lindzey and Wanless, 1973). In Kansas, where most wild turkey habitat occurs on private land, management recommendations are unlikely to succeed unless they align with landowner goals, property conditions, available resources, and perceived constraints (Chipault et al., 2010; Ciuzio et al., 2013; Gore, 1973).

Wildlife management efforts increasingly emphasize voluntary private lands management because many wildlife populations rely on resources found on private land (Benson et al., 1999). Approaches to private lands management can range from regulatory mechanisms to voluntary programs that provide technical assistance, financial support, or educational resources to landowners. Voluntary approaches are often preferred because they can support landowner autonomy, encourage intrinsic motivation, and increase the likelihood that conservation behaviors continue beyond formal program commitments (Dayer et al. 2018; DeCaro & Stokes 2008; Kamal et al. 2015; Lindell & Dayer 2022). However, voluntary conservation is also challenging because landowners must recognize a need for action, believe they can contribute to the solution, and have the resources necessary to implement management practices.

Voluntary wildlife management depends on landowner willingness, capacity, and perceived relevance. Therefore, understanding how landowners evaluate specific management practices is critical. Previous human dimensions research has examined landowner attitudes toward wildlife management, conservation program participation, and private lands stewardship (O'Brien et al. 2021; Poudyal & Hodges 2009; Willcox et al. 2012; Vandervort 2023). Less is known about how Kansas landowners perceive wild turkeys or evaluate specific wild turkey management practices. Landowners may differ in whether they view wild turkeys as beneficial, neutral, or problematic (Gregonis et al., 2010; Isabelle and Reitz, 2015; Kaetzel et al., 2012; Perry-Hill and Prokopy, 2014; Sorice et al., 2014). They may also differ in the types of practices they are willing to implement. Some landowners may be willing to adjust agricultural practices, while others may be more receptive to targeted wild turkey management. These differences matter because outreach that treats landowners as a single uniform audience may fail to address the motivations and barriers that shape individual management decisions.

Personal contact with landowners is often considered one of the most effective ways to encourage wildlife management behavior, but direct outreach can be limited by time, staffing, and financial constraints (DeCaro & Stokes, 2008; Ryan, 2009; Shindler et al., 2009; Toman et al., 2006). As a result, conservation professionals need efficient ways to identify landowners most receptive to different types of outreach, technical assistance, and management recommendations. Research on private lands provides one important point of contact between conservation professionals and landowners (O’Brien et. al, 2025; O’Brien et al., 2021; Vandervort, 2023). These interactions may influence how landowners understand wildlife issues, evaluate management practices, and perceive agencies or professionals involved in wildlife management. However, research access alone does not ensure future management action. To translate ecological research into applied management, biologists must also understand the human dimensions of private land decision-making.

For wild turkey management in Kansas, combining behavioral theory with audience segmentation can improve both understanding and application. The Theory of Planned Behavior (TPB) can identify psychological factors associated with intention, while segmentation can identify distinct landowner groups that may require different outreach strategies (Gibson et al. 2021; Hill-Sullins et al. 2025; Orton et al. 2024; Warner et al. 2016). This approach is particularly useful in a state dominated by private working lands, where conservation outcomes depend on voluntary decisions made by individual landowners. This study focuses specifically on Kansas landowners who had previously voluntarily allowed the Kansas State University to access their property for field research on wild turkeys. These landowners represent an important subset of private landowners because they have already engaged with wildlife researchers and may differ from landowners who have not allowed research access (O’Brien et al., 2025). By understanding who within this group is most willing to implement wild turkey management practices, what predicts that willingness, and how landowner groups differ, conservation professionals can tailor outreach to each landowner group.

My objective was to identify the determinants that inform Kansas landowners’ intention to implement wild turkey management practices on their privately owned land and examine if differences in those determinants, and demographics, exist between landowner segments.

Specifically, this study addressed three research questions: (RQ1) Do TPB constructs and landowner characteristics predict landowners' intention to implement wild turkey management practices on their property? (RQ2) What distinct clusters of landowners can be identified based on their intention to implement wild turkey management practices? and (RQ3) How do landowners within each cluster differ on TPB constructs, demographic characteristics and property attributes?

Theoretical Framework

The Theory of Planned Behavior provides a useful framework for understanding landowner intentions for implementing wild turkey management practices. The theory proposes behavioral intention is predicted by attitudes toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 1985). Applied to wild turkey management, attitudes reflect whether landowners view wild turkeys on their property favorably. Subjective norms reflect whether landowners perceive that important people or groups, such as family members, neighbors, or conservation professionals, support those practices. Perceived behavioral control reflects whether landowners believe they have the knowledge, resources, opportunity, and ability to implement management practices on their property. Together, these constructs can help explain why some landowners intend to adopt wild turkey management practices while others do not.

Within TPB, background factors such as experience, demographics, and past behavior are not typically treated as direct theoretical constructs. Instead, they are understood as factors that may shape the beliefs underlying attitudes, subjective norms, and perceived behavioral control, which then influence behavioral intention (Ajzen, 1985; Dayer et al., 2018; Poudyal & Hodges, 2009; Willcox et al., 2012). In this study, prior management experience and age were included as background factors because they may be especially relevant to private land management decisions. Landowners who have already implemented habitat or land-management practices may be more familiar with the labor, equipment, costs, timing, and outcomes associated with management (Lambert et al., 2014; Medwid, 2016; Ranjan et al., 2019). This experience may increase their perceived ability to implement future wild turkey management practices and make those practices seem more feasible or compatible with existing land-use goals (Golden et al., 2012; Prokopy et al., 2019). Age may also provide important context because landowners at different life stages may differ in available time, physical capacity, financial flexibility, management priorities, or long-term planning horizons (Ajzen, 1985; Medwid, 2016; Prokopy et al., 2019; Soule et al., 2000; Willcox et al., 2012). Examining these factors alongside core TPB constructs allowed this study to evaluate whether landowner background characteristics helped explain intention beyond attitudes, subjective norms, and perceived behavioral control alone.

Together, TPB constructs and relevant background factors also provide a useful basis for audience segmentation because they help identify landowners who may differ in their intentions, constraints, and outreach needs. Rather than assuming all landowners respond to the same message, segmentation identifies groups of people who share similar intentions, beliefs, behaviors, or characteristics (Gibson et al. 2021; Hill-Sullins et al. 2025; Orton et al. 2024; Warner et al. 2016). In wildlife management contexts, audience segmentation can help agencies and practitioners use limited resources efficiently by tailoring outreach to the needs of different landowner groups. Understanding landowner heterogeneity is especially important for management communication. Landowners vary by age, property size, land use, agricultural dependence, hunting participation, management experience, and conservation values. They also differ in their trust of wildlife agencies, conservation professionals, and technical recommendations. Even when landowners share general support for wildlife, they may face barriers such as cost, lack of equipment, expertise, or concerns about property rights. These constraints can limit adoption of science-based practices, even among landowners with positive attitudes toward wildlife management. Knowing characteristics of defined clusters can be utilized to create targeted outreach. Targeted outreach may help to ease the strain on natural resource organizations to reach targeted audiences.

There is a need to better understand which private landowners are willing to implement wild turkey management practices, what factors shape that willingness, and how outreach can be tailored to different landowner groups. Previous research has shown voluntary wildlife management depends on landowner attitudes, perceived ability, trust, past experience, and compatibility with land-use goals, but these factors have not been well examined for wild turkey management among Kansas landowners (Ajzen, 1985; Dayer et al., 2018; Lindell & Dayer, 2022; Willcox et al., 2012). Fulfilling this need matters because wild turkey conservation in Kansas depends heavily on voluntary management decisions made by private landowners, and agencies have limited time and resources to reach landowners through one-size-fits-all outreach strategies (Gibson et al., 2021; Hill-Sullins et al., 2025; Warner et al., 2016). To address this need, this study used an analytical approach that combines core TPB constructs, relevant background factors, communication preferences, and audience segmentation. This approach recognizes landowner decision-making is shaped by attitudes, social influence, and perceived ability, as well as relationships with conservation professionals and preferences for how management communication is received. Including audience segmentation also allows this study to move beyond treating private landowners as a single group and instead identify subgroups with different levels of intention, barriers, and outreach needs. By integrating TPB, landowner background characteristics, communication preferences, and audience segmentation, this study provides a foundation for developing targeted communication and management strategies that align wild turkey conservation needs with the realities of private land stewardship in Kansas.

Methods

An anonymous quantitative survey was conducted with private landowners and land managers in Kansas who had previously allowed Kansas State University to access their properties to conduct wild turkey research. The survey was designed to evaluate the potential of private-land wild turkey management in Kansas by identifying factors associated with landowner intentions to implement management practices and assessing related landowner characteristics, property characteristics, past management experiences, and communication preferences. A quantitative survey approach was appropriate because the research questions required standardized responses from a relatively large group of landowners, allowing statistical analysis of patterns, relationships, and differences among groups. Unlike qualitative approaches, which are useful for exploring detailed experiences and perspectives, quantitative surveys allow researchers to measure the strength of associations among variables and test whether groups differ in measurable ways (Black, 1999; Carr, 1994; Denscombe, 2010; Punch, 1998). The survey instrument was built in Qualtrics and reviewed by wildlife agency personnel, wildlife biologists, and a human dimensions expert prior to distribution. The study was approved by the Kansas State University Institutional Review Board under protocol #13455 (Appendix A).

The instrument was pilot tested with Nebraska landowners who had allowed wild turkey research on their property by the University of Nebraska-Lincoln. Invitations to participate were mailed to 66 landowners in February 2026. The pilot survey closed in April 2026. Of the 66 mailed invitations to participate, 40 landowners responded to some portion of the survey, resulting in an initial response rate of 61%. After removing incomplete surveys or respondents who did not meet screening criteria, 25 usable surveys remained for analysis. Cronbach's alpha values were calculated to evaluate internal consistency of survey scales, and all scales were considered reliable, with alpha values >0.734 (DeVellis, 2003, 2012; Kline, 2005). No major changes were made to the instrument following the pilot test.

Questionnaire Design and Administration

The survey instrument consisted of 25 numbered questions evaluating landowner demographics, property characteristics, past management practices, attitudes toward wild turkeys, subjective norms, perceived behavioral control, trust, communication preferences, and intention to implement wild turkey management practices (Appendix B). Together, these questions were designed to measure both the psychological factors associated with management intention and the respondent characteristics that could distinguish intention-based landowner groups.

Sociodemographic variables included respondent's age, gender, household income, percentage of income from farming or ranching, national or ethnic background, level of education, state of residence, property characteristics, and hunter status. Hunter status was measured by asking participants to indicate which of the past five years they hunted in general and which of the past five years they specifically hunted wild turkeys. These responses were transformed into dichotomous variables for analysis. Respondents who reported hunting in at least one of the past five years were coded as hunters, and respondents who reported no hunting during the past five years were coded as nonhunters. The same approach was used to create a dichotomous wild turkey-hunter variable. Property-related variables included acres owned or managed in Kansas and property-use diversity. Property-use diversity was calculated as a count of reported uses from 12 possible property categories, including: crop fields, grazed native pasture, grazed planted or improved pasture, ungrazed or unhayed pasture, hayfields, native forest, planted timber, wetlands, riparian areas, ponds or water tanks, buildings or other structures, and residences.

Past wild turkey management was measured as a count of practices respondents had implemented within the past five years. Respondents selected all that applied from 13 management practices, including: prescribed fire, haying or mowing, livestock grazing, thinning thick timber undergrowth, timber stand improvement, predator control, conservation strips, planting or maintaining food plots, tree, grass, or forb planting for habitat, improving water sources, conservation tillage, unharvested grain patches, and control of invasive vegetation.

Theory of Planned Behavior factors were examined using scales adapted from previous literature (Wilcox, 2012). Attitudes towards wild turkeys were measured with 8-item, 5-point Likert-type scale ranging from strongly disagree = 1 to strongly agree = 5. Subjective norms regarding managing for wild turkeys were collected using 8-item, 5-point Likert-type scale ranging from strongly disagree = 1 to strongly agree = 5. Perceived behavioral control over the resources needed to manage wild turkeys was collected using 10-item 5-point Likert-type scale ranging from strongly disagree = 1 to strongly agree = 5. Intention to implement wild turkey management practices was collected using a 13-item, 5-point Likert ranging from extremely unlikely = 1 to extremely likely = 5. Trust in Kansas Department of Wildlife and Parks was collected using a 6-item, 5-point Likert-type scale ranging from strongly disagree = 1 to strongly agree = 5.

To create participant-level measures for later analyses, item responses within each TPB scale were averaged to produce overall mean scores for attitudes, subjective norms, and perceived behavioral control. Overall intention was calculated as the mean of all 13 wild turkey management intention items. After principal components analysis indicated intention was multidimensional, item responses were also averaged within each retained intention dimension to create mean scores for Food and Habitat Plantings, Land and Vegetation Management, and Intensive Habitat Management. Trust was calculated as the mean of the six trust items. Higher mean scores represented more positive attitudes toward wild turkeys, stronger perceived social support for managing for wild turkeys, greater perceived behavioral control, stronger intention to implement management practices, or greater trust, respectively.

Respondents also rated their preferences for receiving wild turkey management communication from eight possible organizations: Kansas Department of Wildlife and Parks, Kansas State University Extension, U.S. Department of Agriculture Natural Resource Conservation Service, National Wild Turkey Federation, Turkeys for Tomorrow, Pheasants Forever, U.S. Fish and Wildlife Service, and Kansas Forest Service (5-point Likert scale ranging from not at all preferred = 1 to extremely preferred = 5). Communication channel preferences were measured across 13 formats: email newsletter, mailed newsletter, face-to-face communication, phone call, text message, short video, long video, Extension publication, property visit, workshop, field day, podcast, and social media.

Participants were recruited from a contact list developed during the Kansas State University wild turkey research project during 2023–2026. This list included all landowners who had been contacted for permission to access private property for wild turkey research. For this study, I limited the sample to landowners who had previously given permission to access their property (N = 471). I chose to use this subsection of Kansas landowners because other studies have shown these landowners are more open to wildlife management strategies and more likely to respond due to personal connection (Hargriss and Dekeyser, 2014; Hilty and Merenlender, 2003; O'Brien et al., 2021). Respondents were eligible to participate if they were at least 18 years old and had previously allowed wild turkey research on their property.

Following a modified Tailored Design Method, multiple mail and text-message contacts were used to encourage participation, increase response rates, and provide repeated opportunities to complete the survey (Dillman, 2009; Wardropper et al. 2021). This approach was beneficial because repeated contacts increased the likelihood landowners would notice the survey, while multiple formats allowed respondents to choose a convenient participation method. Mail contacts provided a formal introduction to the study and reached all participants in the sampling frame, whereas text-message reminders provided direct access to the online survey and reduced the effort required to participate. Landowners first received a letter of introduction beginning April 8, 2026 (Appendix C). The first packet included a letter that explained the purpose of this study with a unique ID, a handout with an overview of data collected by the Kansas State University wild turkey research project, and a wild turkey sticker. Nonrespondents then received a postcard reminder, which arrived between April 13 and April 15. Two follow-up text messages were sent, with the first on April 17 and the final text reminder on April 29 (Appendix D). Data collection ended May 15, 2026.

Of the 471 mailed invitations to participate, 221 landowners responded to some portion of the survey, resulting in an initial response rate of 47%. After removing incomplete surveys or respondents who did not meet screening criteria, 176 usable surveys remained for analysis. Responses were received across all stages of the multi-contact recruitment approach. Approximately 21% of usable responses were completed following the first mailed letter, 19% followed the postcard reminder, 42% followed the first text message, and 14% followed the final text reminder. An additional 5% of respondents requested a physical survey and returned it by mail. Although text messages prompted more than half of all responses, 27% of those respondents still completed the survey by scanning the QR code rather than using the direct survey link.

Respondent Characteristics

Respondents were primarily Kansas residents (94%), male (84%), white (97%), and sixty years of age or older (65%; Table 4.1). Average respondents age was 63.39 years. Respondents owned or managed an average of 1,839.17 acres in Kansas, although property size varied widely from 1 acre to 40,000 acres. On average, respondents reported 4.51 property-use types and had implemented 3.41 wild turkey management practices within the past five years.

Scale Reliabilities

Principal components analysis and reliability analysis were used to evaluate whether survey items represented the expected TPB constructs, intention dimensions, and trust scale. Principal components analysis was conducted using varimax rotation; Cronbach's alpha was used to evaluate internal consistency of each scale.

The TPB scales each loaded onto a single component. The attitude scale explained 54.34% of the variance and had acceptable reliability ($\alpha = 0.71$). The subjective norm scale explained 64.08% of the variance and showed good reliability ($\alpha = 0.81$). The perceived behavioral control scale explained 61.77% of the variance and also showed good reliability ($\alpha = 0.84$). Trust in Kansas Department of Wildlife and Parks demonstrated excellent reliability ($\alpha = 0.94$).

The 13 intention items had good overall reliability ($\alpha = 0.83$), but principal components analysis indicated intention was multidimensional. Three components with eigenvalues greater than one were extracted and together explained 58.10% of the variance after rotation. The first component, Food and Habitat Plantings, explained 25.33% of the variance after rotation and included conservation strips, food plots, habitat plantings, and unharvested grain patches. The second component, Land and Vegetation Management, explained 17.25% of the variance after rotation and included livestock grazing, improving water sources, conservation tillage, and invasive vegetation control. The third component, Intensive Habitat Management, explained 15.53% of the variance after rotation and included prescribed fire, haying or mowing, thinning thick timber undergrowth, and timber stand improvement. Predator control did not clearly align with the three interpreted intention dimensions and was not included in the three intention-dimension mean scores used for cluster analysis; however, it was retained as an individual intention item and in the overall 13-item intention scale. Mean scores were 2.59 ± 1.10 SD for Food and Habitat Plantings, 3.50 ± 0.87 SD for Land and Vegetation Management, and 3.38 ± 0.94 SD for Intensive Habitat Management.

Data Analysis

Only fully completed and eligible surveys were included in final analysis. All data analysis was conducted using SPSS v.30. No items were reverse coded. Alpha level of significance was set a priori at $p = 0.05$. Descriptive statistics were used to summarize respondent demographics, property characteristics, previous management experience, and communication preferences.

RQ1

I used hierarchical multiple regression to evaluate whether TPB constructs predicted landowner intention to implement wild turkey management practices. The overall mean intention score was used as the dependent variable. In Model 1, attitudes, subjective norms, and perceived behavioral control were entered as predictors. In Model 2, the number of wild turkey management practices implemented within the past five years was added. In Model 3, age was added to determine whether it improved model fit beyond TPB constructs and past management experience.

RQ2

To identify distinct groups of landowners based on intention to implement wild turkey management practices, I used a two-step cluster analysis. Respondents were clustered using the three intention dimensions identified through principal components analysis: Food and Habitat Plantings, Land and Vegetation Management, and Intensive Habitat Management. First, hierarchical cluster analysis was conducted using Ward's method and squared Euclidean distance to evaluate the appropriate number of clusters. Ward's method was used because it groups cases by minimizing within-cluster variation while increasing separation among clusters (Everitt et al., 2011; Gibson et al., 2021; Hill-Sullins et al., 2025; Ward, 1963; Yim & Ramdeen, 2015). The agglomeration schedule and dendrogram were visually inspected to determine the number of clusters that best represented maximum dissimilarity within the data. After the number of clusters was identified, k-means cluster analysis was used to assign each respondent to a final cluster.

RQ3

After cluster assignment, I compared intention scores, including intention to implement each individual wild turkey management practice, TPB constructs, demographic variables, property characteristics, land-use variables, previous management practices, and communication preferences among intention-based landowner clusters. Continuous variables were compared among clusters using one-way analysis of variance (ANOVA). Welch's ANOVA was used when

Levene's test indicated unequal variances. When significant differences were detected, Tukey HSD post hoc tests were used for variables meeting the assumption of homogeneity of variance, and Games-Howell post hoc tests were used for variables with unequal variances. Omega-squared was used to evaluate effect size for ANOVA results.

Associations between cluster membership and categorical landowner characteristics were evaluated using chi-square tests of independence. These variables included household income, education, hunter status, turkey hunter status, and recent implementation of individual wild turkey management practices. Household income and education were collapsed into three-category variables because some original categories had expected cell counts less than five. Gender was not evaluated because the sample was overwhelmingly male. Cramer's V was used to evaluate effect size for significant chi-square tests. For categorical variables where expected cell-count assumptions were not met and categories could not be meaningfully collapsed, statistical significance was not interpreted; however, counts and proportions were still summarized descriptively.

Results

RQ1

A hierarchical multiple regression was used to determine if the addition of past management practices and then age improved the prediction of TPB alone. The regression models indicated that landowner intention to implement wild turkey management practices was explained by the TPB constructs, past management practices, and age (Table 4.2). The full model, which included TPB constructs, past management practices, and age, was statistically significant and explained 40.9% of the variance in intention ($R^2 = 0.409$, $F_{(5, 170)} = 23.49$, $P <$ 0.001). This represents a large overall effect for the model. The TPB-only model explained

16.3% of the variance in intention, and adding past management practices increased the explained variance by 22.8 percentage points. Adding age produced a smaller increase of 1.7 percentage points. Among the predictors, past management practices had the strongest standardized relationship with intention (β = 0.488), indicating that landowners who had recently implemented more management practices also reported stronger intention to implement wild turkey management practices in the future.

RQ2

Hierarchical cluster analysis using Ward's method indicated that three-clusters best represented the data. K-means cluster analysis then assigned respondents to three intention-based groups: low-intention, moderate-intention, and high-intention landowners (Table 4.3). The low-intention cluster included 31 respondents. This group had the lowest average intention across all three practice categories, with particularly low intention to implement food and habitat plantings The moderate-intention cluster included 56 respondents. This group reported low intention for food and habitat plantings but moderate intention for land and vegetation management and intensive habitat management The high-intention cluster included 89 respondents. This group reported the greatest intention for food and habitat plantings although still moderate on the scale and similarly moderate intention for land and vegetation management and intensive habitat management.

RQ3

TPB constructs

Attitudes toward wild turkeys differed significantly among intention-based clusters ($F_{(2, 173)} = 6.85$, $P = 0.001$). Mean attitude scores were smallest for the low-intention cluster (M = 56.19, SE = 3.85) and moderate-intention cluster (M = 56.89, SE = 2.45), and largest for the high-intention cluster (M = 66.60, SE = 1.71). Tukey post-hoc comparisons showed that high-intention landowners had significantly more positive attitudes toward wild turkeys than both low-intention landowners ($P = 0.02$) and moderate-intention landowners ($P = 0.005$). Low- and moderate-intention landowners did not differ from one another ($P = 0.98$). Subjective norms did not differ among clusters ($F_{(2, 173)} = 2.31$, $P = 0.10$). Mean subjective norm scores increased from the low-intention cluster (M = 50.42, SE = 4.19), to the moderate-intention cluster (M = 53.54, SE = 2.55), to the high-intention cluster (M = 58.47, SE = 1.99), but these differences were not statistically significant. Perceived behavioral control approached significance ($F_{(2, 173)} = 2.91$, $P = 0.06$). Mean perceived behavioral control was smallest among low-intention landowners (M = 34.71, SE = 2.40), intermediate among moderate-intention landowners (M = 37.71, SE = 1.91), and largest among high-intention landowners (M = 41.36, SE = 1.51). The strongest pairwise contrast was between the low- and high-intention clusters, although this comparison was marginally nonsignificant ($P = 0.06$). Overall, attitudes were the clearest TPB construct distinguishing high-intention landowners from the other groups, whereas perceived social norms were least useful for distinguishing clusters. Effect sizes supported this pattern. Attitudes had a moderate effect size, $\omega^2 = 0.062$, whereas subjective norms, $\omega^2 = 0.015$ and perceived behavioral control, $\omega^2 = 0.021$ had small effect sizes.

Demographic, property, and land-use characteristics

Several respondent and property characteristics differed among intention clusters (Table 4.4). Age differed among clusters ($F_{(2, 173)} = 3.74$, $P = 0.03$). Low-intention respondents were older on average than both moderate-intention respondents and high-intention respondents. Post hoc comparisons indicated that the low- and high-intention clusters differed ($P = 0.021$). Welch's test was also significant ($P = 0.007$), supporting differences in age among clusters. However, the effect size was small, $\omega^2 = 0.030$, suggesting that age helped distinguish clusters but was not one of the strongest cluster differences.

The amount of acreage over which respondents reported decision-making authority in Kansas increased across intention clusters, but this result should be interpreted cautiously because property size was highly variable. Low-intention respondents reported decision-making authority over an average of 801.10 acres (SE = 218.50), moderate-intention respondents reported an average of 1,554.46 acres (SE = 336.25), and high-intention respondents reported an average of 2,379.88 acres (SE = 598.63). The standard ANOVA was not significant ($F_{(2, 173)} = 1.73$, $P = 0.18$), but Welch's test was significant ($P = 0.02$). This pattern suggests that acreage may be related to intention, but the unequal variation in acreage among clusters makes this relationship less consistent than other cluster differences. The effect size for acreage was very small, $\omega^2 = 0.008$, further suggesting that acreage was not a strong distinguishing characteristic among clusters.

Property-use diversity differed among intention clusters ($F_{(2, 173)} = 10.27$, $P < 0.001$). Low-intention respondents reported the fewest property uses, moderate-intention respondents were intermediate, and high-intention respondents reported the greatest property-use diversity. Post-hoc comparisons showed that the low-intention cluster differed from both the moderate-intention cluster ($P = 0.03$) and high-intention cluster ($P < 0.001$). These results indicate that landowners with more diverse property uses tended to have stronger intentions to implement wild turkey management practices.

Percentage of household income from farming or ranching differed among clusters. Because the assumption of homogeneity of variance was violated, Welch's ANOVA was used to interpret this result. Mean percentage of household income from farming or ranching was lowest for the low-intention cluster, compared to the moderate-intention cluster and high-intention cluster. The standard ANOVA ($F_{(2, 173)} = 3.17$, $P = 0.04$), and Welch's test ($P = 0.008$) were significant. Post-hoc comparisons indicated that the low- and moderate-intention groups differed ($P = 0.04$). The effect size was small, $\omega^2 = 0.024$, indicating that farm/ranch income contributed to cluster differences but was not a primary distinguishing variable.

Trust in Kansas Department of Wildlife and Parks did not differ among clusters ($F_{(2, 173)} = 0.73$, $P = 0.48$). The effect size was approximately zero, $\omega^2 = -0.003$, indicating that trust did not meaningfully distinguish intention clusters. Mean trust scores were relatively high across all groups and largest among low-intention respondents, followed by high-intention respondents and moderate-intention respondents.

Categorical landowner characteristics

Chi-square tests were used to evaluate whether categorical respondent characteristics were associated with cluster membership (Table 4.5). Hunter status was strongly associated with intention cluster membership, ($\chi^2_{(2)} = 31.13$, $P < 0.001$, N = 176; Table 4.5). Overall, 52.3% of respondents identified as hunters, but hunters were more common in the high-intention cluster than in the low- or moderate-intention clusters. Among low-intention respondents, 32.3% were hunters; among moderate-intention respondents, 30.4% were hunters. In contrast, 73.0% of high-intention respondents were hunters. Of all respondents who identified as hunters, 70.7% were classified in the high-intention cluster. Wild turkey hunter status showed a similar pattern, ($\chi^2_{(2)} = 19.19$, $P < 0.001$, N = 176). Overall, 26.1% of respondents reported hunting wild turkeys, making up 9.7% of the low-intention cluster and 12.5% of the moderate-intention cluster, compared to 40.4% of the high-intention cluster. Of all respondents who hunted wild turkeys, 78.3% were classified in the high-intention cluster. These findings indicate that hunting participation, especially wild turkey hunting, was strongly associated with greater intention to implement wild turkey management practices.

Household income was also associated with cluster membership after income categories were collapsed to address low expected cell counts indicating that household income helped describe cluster membership but was not a primary distinguishing characteristic ($\chi^2_{(4)} = 10.04$, $P = 0.04$, N = 176). Education was not significantly associated with cluster membership after categories were collapsed ($\chi^2_{(4)} = 7.02$, $P = 0.14$, N = 176). Together, these results suggest that hunting participation was more useful than broad socioeconomic categories for distinguishing intention-based landowner groups.

Recently implemented management practices

Recent implementation of management practices varied among intention clusters and generally followed the same pattern as future management intention. Landowners in the moderate- and high-intention clusters were more likely than low-intention landowners to have recently implemented several habitat or land-management practices, including prescribed fire. Prescribed fire was significantly associated with cluster membership, ($\chi^2_{(2)} = 14.16$, $P < 0.001$, N = 176; Cramer's V = 0.28). Only 12.9% of low-intention respondents had recently implemented prescribed fire, compared to 53.6% of moderate-intention respondents and 44.9% of high-intention respondents. Because several individual practices had low expected cell counts, results for those practices were summarized descriptively rather than interpreted using chi-square significance tests.

Communication source preferences

Communication source preferences showed fewer differences among clusters than demographic or hunting-related characteristics (Table 4.6). Across all respondents, Kansas

Department of Wildlife and Parks had the largest mean preference score as a source for wild turkey management communication (M = 3.18, SE = 0.09), followed by Kansas Extension (M = 3.09, SE = 0.09). Preference for Kansas Extension differed significantly among clusters ($F_{(2, 173)}$ = 3.66, P = 0.03). The effect size was small, $\omega^2 = 0.029$, indicating that Kansas Extension preference differed among clusters but was not a major distinguishing feature. Mean preference for Kansas Extension was smallest among low-intention respondents (M = 2.61, SE = 0.24), intermediate among moderate-intention respondents (M = 3.09, SE = 0.13), and largest among high-intention respondents (M = 3.25, SE = 0.12). Preferences for most other sources generally increased from low- to high-intention groups, but differences were not statistically significant. For example, Kansas Department of Wildlife and Parks was rated highly by all clusters, with mean preference scores of 2.94 for low-intention respondents, 3.21 for moderate-intention respondents, and 3.25 for high-intention respondents.

Communication channel preferences

Communication channel preferences differed among intention clusters for several forms of wild turkey management communication delivery (Table 4.7). Across all three clusters, mailed newsletters were among the highest-rated communication channels, with mean scores of 2.55, 3.09, and 2.98 for low-, moderate-, and high-intention respondents, respectively. For the high-intention cluster, mailed newsletters tied with property visits as the highest-rated channel. Email newsletters were the next highest-rated channel among low-intention respondents, whereas Extension publications were the next highest-rated channel among moderate-intention respondents.

Preferences differed significantly among clusters for face-to-face communication, phone calls, text messages, short videos, long videos, extension publications, property visits, workshops, field days, podcasts, and social media posts. Effect sizes for communication channels were generally small to moderate. Property visits had the largest effect size, $\omega^2 = 0.071$, followed by face-to-face communication, $\omega^2 = 0.057$, text messages, $\omega^2 = 0.056$, workshops, $\omega^2 = 0.051$, and social media posts, $\omega^2 = 0.050$. Overall, high-intention respondents generally rated communication channels higher than low-intention respondents, particularly for more direct, interactive, or technology-based formats. The strongest differences were observed for property visits, face-to-face communication, text messages, workshops, and social media posts. Although several channel preferences differed statistically, most mean scores remained between slightly preferred and moderately preferred, suggesting that no single communication channel was strongly preferred by all respondents. In contrast, emailed and mailed newsletters did not differ significantly among clusters, indicating that these formats may be useful for broad outreach across intention groups.

Discussion

Overall, this study demonstrates Kansas landowners' intentions to implement wild turkey management practices are shaped by a combination of behavioral beliefs, previous management experience, and property context. Use of TPB provided a useful foundation for explaining intention, as attitudes, subjective norms, and perceived behavioral control were positive predictors of intention to implement wild turkey management practices. This finding is consistent with previous applications of TPB in private lands and natural resource contexts, where attitudes, perceived social expectations, and perceived ability have been used to explain landowner or stakeholder willingness to engage in conservation-related behaviors (Chaudhary et al., 2017; Willcox et al., 2012;). However, the results also show intention was not explained by TPB constructs alone. Past management experience and age added explanatory value, suggesting landowner decision-making reflects both beliefs about wild turkey management and practical realities of managing private working lands (Ajzen, 1985).

Results using TPB provided a useful framework for understanding Kansas landowners intention to implement wild turkey management practices. Attitudes, subjective norms, and perceived behavioral control were all positive predictors of intention, suggesting that landowners were more willing to implement practices when they viewed management favorably, perceived social support for management, and felt capable of completing the practices (Ajzen, 1985). Attitudes were the strongest TPB predictor, a finding partly consistent with Willcox et al. (2012), who found that attitudes and subjective norms predicted cattle ranchers' intentions to integrate wildlife management into ranch operations. Unlike Willcox et al. (2012), perceived behavioral control also predicted intention in this study, suggesting that landowner perceptions of whether they had the knowledge, time, resources, and ability to complete management practices were also important. Therefore, outreach efforts may be most effective when they clearly communicate the ecological and land-management benefits of wild turkey habitat practices. However, TPB constructs explained only part of the variation in intention, suggesting that other factors, including prior management experience, land-use objectives, property size, available labor, equipment, financial resources, and life stage may also influence landowner decision-making.

The importance of previous management experience is especially relevant for voluntary private lands conservation. Landowners who had recently implemented more habitat or land-management practices may have already had the equipment, knowledge, labor, or confidence needed to consider future wild turkey management. This pattern supports the idea that conservation behavior is often easier to maintain or expand when it aligns with existing land-use practices and landowner routines. Dayer et al. (2018) emphasized wildlife management persistence after voluntary programs depends on more than initial participation; it also depends on whether practices remain feasible, valuable, and compatible with landowner goals. In this study, prior implementation may represent a similar form of readiness. Landowners who had already used practices such as prescribed fire, grazing management, invasive plant control, conservation tillage, or timber management may have perceived wild turkey management as an extension of existing stewardship rather than as an entirely new responsibility.

Although TPB helped explain intention, these results also show why landowners should not be treated as a single, uniform audience. The three intention-based clusters differed in their willingness to implement wild turkey management practices and in the property, demographic, hunting, and management characteristics associated with those intentions. This supports previous audience segmentation research showing meaningful subgroups can be identified based on behavioral intentions, beliefs, values, and communication preferences (Gibson et al., 2021; Hill-Sullins et al., 2025; Orton et al., 2024; Warner et al. 2016). Similar to Hill-Sullins et al. (2025), who combined TPB and cluster analysis to identify groups with different levels of intention and barriers, this study demonstrates that segmentation can help move research from explanation to application. Rather than simply identifying whether landowners intend to manage for wild turkeys, segmentation helps identify which landowners may be most receptive, which practices may be most acceptable, and what types of outreach may be most appropriate for each group (Slater, 1996, Wedel & Kamakura, 1999).

The low-intention cluster represented landowners with limited willingness to implement nearly all of the practices evaluated. Control of invasive vegetation, haying or mowing, and conservation tillage were among this group's highest-rated practices, but their mean ratings remained below the level of somewhat likely. These respondents were older, managed fewer acres, reported fewer property uses, relied less on farming or ranching income, and had lower levels of previous management implementation. Together, these characteristics suggest that low intention may reflect fewer opportunities, less perceived need, or limited compatibility between wild turkey management and existing property goals. Outreach to this group should therefore emphasize low-barrier practices that complement existing land uses and provide benefits beyond wild turkeys. Examples could include targeted removal of eastern red cedar (*Juniperus virginiana*), conservation tillage to retain crop residue and reduce soil loss, or delayed haying near forest edges to reduce disturbance and maintain reproductive cover.

The moderate-intention cluster appears to represent landowners who may already be engaged in land management but are selective about which practices they are willing to implement. This group reported relatively high willingness to implement land and vegetation management and intensive habitat management practices, but lower willingness to implement food and habitat plantings. This pattern suggests that moderate-intention landowners may be more receptive when wild turkey management is framed through practices they already recognize as part of working-land management, such as grazing management, prescribed fire, invasive vegetation control, water-source improvements, and timber management. This finding aligns with Willcox et al. (2012), who examined rancher willingness to consider wildlife management as part of routine cattle management activities. Outreach to this group may be most effective when it connects wild turkey habitat goals to existing working-land practices rather than presenting management as a separate wildlife-only action. For example, rotational, mosaic, or patch-burn grazing can improve forage conditions for cattle while creating a heterogeneous landscape that supports different life-cycle requirements for wild turkeys. Additionally, thinning thick timber undergrowth could improve livestock and equipment access, reduce competition for water and nutrients, increase herbaceous forage, and lower accumulated woody fuels and wildfire risk while improving wild turkey movement and access to roost trees.

The high-intention cluster appears to represent the most receptive audience for wild turkey management outreach. This cluster was particularly receptive to food and habitat plantings, including food plots. When established with diverse native grasses and forbs, these plantings can provide food and cover for wild turkeys while also benefiting pollinators and other wildlife. Respondents in this cluster were also younger on average, managed larger and more diverse properties, and more likely to identify as hunters or wild turkey hunters. These characteristics may provide both greater opportunities to incorporate habitat practices into existing land management and stronger personal motivation to support wild turkey populations. High-intention landowners rated a wide range of communication formats favorably, including email, mailed materials, face-to-face communication, text messages, short videos, Extension publications, and property visits. This broad receptiveness suggests that outreach to this group could combine general informational materials with more individualized and interactive support. These landowners may be particularly strong candidates for property visits, technical assistance, demonstration projects, peer-to-peer outreach, and more intensive habitat-management programs. They may also serve as early adopters or demonstration partners who can show how management practices are implemented under local conditions.

Hunter status was one of the clearest characteristics distinguishing intention clusters. Hunters and wild turkey hunters were more common in the high-intention cluster, suggesting that personal use of wildlife may be an important motivator for private lands management. Landowners who hunt may be more likely to recognize the value of habitat management, observe changes in wild turkey populations, or feel a personal stake in improving conditions for game species. This finding can be connected to Metcalf et al. (2017), who discussed public wildlife management on private lands as a relationship shaped by reciprocity, population status, and stakeholder normative beliefs. Wild turkeys are a public wildlife resource, but in Kansas, much of the habitat needed to support that resource occurs on private land. Landowners who hunt may therefore connect private land stewardship with both personal and public wildlife benefits. However, outreach should not focus only on hunting benefits because many respondents were not turkey hunters. Instead, wild turkey management can be framed as part of broader land stewardship. Practices that benefit wild turkeys can also improve vegetation structure, increase plant diversity, maintain early successional cover, support pollinators, and provide resources for other grassland, shrubland, riparian, and woodland-associated wildlife. This broader framing may help reach landowners who value wildlife or land health but are not primarily motivated by hunting.

Across clusters, intention appeared closely tied to how landowners already use and manage their property. Landowners with more diverse land uses may have more ways to incorporate wild turkey management into existing activities, whereas landowners with fewer land uses may see fewer opportunities or less relevance. For example, landowners already managing grazing systems may be receptive to rotational grazing, patch-burn grazing, invasive plant control, or water-source improvements. Landowners managing cropland may be more receptive to field-edge cover, unharvested grain patches, reduced disturbance, or conservation tillage. Landowners with recreational or hunting interests may be more receptive to food plots, native plantings, prescribed fire, or timber stand improvement. Framing wild turkey management as compatible with existing property objectives may therefore increase the likelihood that landowners view practices as realistic and useful.

The relationship between trust and intention was more complex than expected. Although trust is often considered important for wildlife management participation, trust in Kansas Department of Wildlife and Parks did not differ significantly among clusters and was relatively large even among low-intention respondents. This suggests that trust alone may not be sufficient to motivate management action. A landowner may trust an agency but still lack interest, resources, time, equipment, perceived need, or compatible property goals. This finding is useful when considered alongside other studies that found that engagement in private lands research can influence landowners' management knowledge, attitudes, awareness, and behavioral intentions (O'Brien et al. 2021, 2025; Vandervort 2023). Because this study sampled landowners who had already allowed wild turkey research on their properties, respondents may have already had relatively positive relationships with researchers or agencies. That prior engagement may help explain why trust was high overall, but it also reinforces that research access alone does not make landowners uniform in their future management intentions. Therefore, trust may be necessary for successful outreach, but it may not translate into behavioral intention unless landowners also view practices as relevant, feasible, and compatible with their land-use objectives.

Communication preferences further support the need for segmented outreach. Across clusters, respondents generally appeared to prefer familiar and locally connected sources of advice. Kansas Department of Wildlife and Parks and Kansas Extension were among the most preferred sources of wild turkey management communication; Kansas Extension showed some evidence of greater preference among higher-intention landowners. This suggests that agency-led wild turkey management may benefit from partnerships with Extension, local conservation districts, producer groups, and peer landowners. Kansas Department of Wildlife and Parks may provide technical wildlife expertise, while Extension and local partners may provide practical agricultural knowledge, local relationships, and trusted delivery networks. This fits with broader recommendations for private lands management that emphasize tailoring strategies to local ecological and social conditions, building relationships, reducing barriers, offering a menu of options, and supporting long-term persistence of management behavior (Lindell et al., 2022; Ryan 2009; Shindler et al. 2009; Toman et al. 2006; Wardropper et al. 2021). Wild turkey outreach may be strongest when management recommendations are delivered through partnerships that combine wildlife expertise with local familiarity and practical land-management guidance.

Although tailoring wild turkey management outreach to distinct landowner segments would be ideal, limited agency staffing, funding, and time may constrain the ability to develop separate programs for each group. Similarities among clusters therefore provide practical opportunities for broader outreach. Mailed and emailed newsletters were generally preferred across all three clusters, suggesting these formats could efficiently distribute management information to a wide audience. Invasive vegetation control and haying or mowing also received relatively favorable ratings across clusters, making them useful entry points for broadly applicable management recommendations. However, because willingness differed in magnitude among clusters, these practices should be described as areas of shared receptivity rather than actions all landowners are equally likely to implement. Respondents across clusters also preferred information from familiar, locally connected sources, particularly Kansas Department of Wildlife and Parks and Kansas Extension. Partnerships between these organizations could therefore provide a practical foundation for broad outreach, while more targeted technical assistance could be reserved for landowners interested in adopting additional or more intensive management practices.

These findings should be interpreted within the context of the study sample. Respondents were not randomly selected from all Kansas landowners, but were drawn from landowners who had previously allowed access to their property for wild turkey research by Kansas State University. As a result, this sample may represent landowners who are already more willing to interact with wildlife researchers, conservation professionals, or management agencies than the broader population of Kansas landowners. This sampling approach may have contributed to the uneven cluster sizes, with fewer respondents in the low-intention cluster (N = 31) than in the moderate- (N = 56) or high-intention clusters (N = 89). Therefore, results should not be generalized to all private landowners in Kansas. Instead, these findings provide insight into a specific and important group of landowners who have already participated in wildlife research and may be more reachable through future outreach. As a result, this sample likely represents a more reachable or research-engaged subset of Kansas landowners. This limitation is also one of the study's contributions. The results show that even among landowners who have already interacted with wildlife researchers, intention to implement wild turkey management varies substantially. Future research should expand beyond research-access landowners to compare whether similar clusters exist among broader Kansas landowner populations, landowners who have declined research access, absentee landowners, and landowners in regions with different wild turkey population trends. Future work should also evaluate whether targeted outreach based on these segments leads to actual implementation and long-term persistence of wild turkey management practices.

Future research should build on this study by testing whether segmented outreach can increase actual implementation of wild turkey management practices. This study identified three intention-based groups, but it did not evaluate whether tailored outreach would lead to behavior change. Future work could develop outreach materials or pilot programs specific to each cluster, then evaluate whether those approaches increase landowner participation, practice adoption, and long-term management persistence. This would connect the audience segmentation approach used in this study to broader private lands wildlife management research emphasizing that voluntary management depends not only on willingness to participate, but also on feasibility, continued relevance, and persistence over time (Dayer et al., 2018; Hill-Sullins et al. 2025; Lindell & Dayer, 2022; O'Brien et al. 2021). Future research should also expand beyond landowners who previously allowed wild turkey research on their property. Because this sample may represent a more research-engaged and conservation-receptive group, broader surveys should include landowners who have not interacted with wildlife researchers, landowners who declined research access, absentee landowners, and landowners in areas with different wild turkey population trends. Comparing these groups would help determine whether the clusters identified here are unique to research-engaged landowners or reflect broader patterns in Kansas private lands conservation.

Conclusion

Kansas landowners who had previously allowed wild turkey research on their property vary in their intention to implement wild turkey management practices. These differences were best represented by three intention-based clusters. The low-intention cluster reported low willingness across management options, particularly food and habitat plantings. The moderate-intention cluster showed limited interest in food and habitat plantings but greater willingness to implement land and vegetation management and intensive habitat practices. The high-intention cluster reported the greatest willingness across all management categories.

These results suggest wild turkey management should not be presented as a single, uniform conservation action. Instead, landowners appear to evaluate management options based on how well those practices fit their property, land-use objectives, resources, and management experience. Practices such as grazing management, invasive plant control, conservation tillage, prescribed fire, mowing, and timber stand improvement may be more acceptable to some landowners than plantings or food plots, while highly motivated landowners may be receptive to a broader suite of habitat practices.

The three-cluster structure provides a useful framework for audience segmentation. High-intention landowners may be strong candidates for technical assistance, demonstration projects, and early adoption of habitat practices. The strong association between hunter status and high management intention further suggests that hunters may provide a practical starting point for initial outreach, pilot programs, and demonstration projects aimed at increasing implementation of wild turkey management practices. Moderate-intention landowners may benefit from outreach that connects wild turkey habitat goals to practices they are already willing to conduct, especially land and vegetation management. Low-intention landowners may require outreach focused on relevance, feasibility, and low-barrier entry points rather than broad promotion of wild turkey management.

Overall, this study demonstrates that landowner intention to manage for wild turkeys is shaped not only by general support for conservation, but also by the specific type of management practice being considered. Recognizing these differences can help agencies, Extension, and conservation partners develop more effective, locally relevant outreach strategies that support voluntary wild turkey management and broader private lands conservation in Kansas.

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Tables

Table 4.1 Demographic characteristics of respondents to a 2026 survey of landowners who permitted wild turkey research on their properties in Kansas, USA, during 2023–2026.

Demographic Characteristics		*n*	%
Generation	Silent generation	11	6.3
	Baby boomers	94	53.4
	Generation X	52	29.5
	Generation Y	18	10.2
	Generation Z	1	0.6
Gender	Female	27	15.3
	Male	148	84.1
	Prefer not to say	1	0.6
Ethnicity	White or Caucasian	170	96.6
	Prefer not to answer	6	3.4
Hispanic	Hispanic or Latino	1	0.6
	Not Hispanic or Latino	153	86.9
	Prefer not to answer	22	12.5
Household Income	<25,0000	10	5.7
	25,000-49,999	19	10.8
	50,000-74,999	25	14.2
	75,000 -99,000	31	17.6
	100,000-149,000	38	21.6
	150,000-199,999	20	11.4
	>200,000	33	18.8
Education	Some education	2	1.1
	High school diploma	48	27.3
	Trade school	15	8.5
	Associate's degree	16	9.1
	Bachelor's degree	64	36.4
	Master's degree	20	11.4
	Professional or advanced degree	11	6.3

State of Residence	Kansas[A]	166	94.3
	Florida	1	0.6
	Idaho	1	0.6
	Missouri	1	0.6
	Oklahoma	1	0.6
	Oregon	2	1.1
	Tennessee	1	0.6
	Texas	2	1.1
	Wisconsin	1	0.6

Note. N = 176. n = number of respondents. Percentages may not total 100 because of rounding. [A] Respondents were classified as Kansas residents when no other state of residence was selected.

Table 4.2 Hierarchical multiple regression predicting intention to practice wild turkey management from Theory of Planned Behavior, past management, and age among Kansas landowners in 2026.

Model	Predictor	*B*	SE	β	*P*
Model 1: Theory of Planned Behavior constructs	Constant	1.87	0.24		<0.001
	Attitude	0.01	0.003	0.26	0.001
	Subjective Norm	0.01	0.003	0.15	0.05
	Perceived Behavioral Control	0.01	0.004	0.16	0.02
Model 2: Theory of Planned Behavior constructs and previous management	Constant	1.62	0.204		<0.001
	Attitude	0.01	0.003	0.20	0.003
	Subjective Norm	0.004	0.003	0.11	0.11
	Perceived Behavioral Control	0.009	0.003	0.17	0.006
	Previous Management Practices	0.143	0.02	0.486	<0.001
Model 3: Theory of Planned Behavior constructs, previous management, and age	Constant	2.12	0.30		<0.001
	Attitude	0.01	0.003	0.189	0.004
	Subjective Norm	0.01	0.003	0.13	0.05
	Perceived Behavioral Control	0.008	0.003	0.15	0.01
	Previous Management Practices	0.14	0.02	0.49	<0.001
	Age	-0.01	0.004	-0.13	0.03

Note. $N = 176$. Model 1: $R^2 = .163$, adjusted $R^2 = .149$, $F_{3,\,172} = 11.19$, $P < .001$. Model 2: $R^2 = .392$, adjusted $R^2 = .377$, $\Delta R^2 = .228$, $\Delta F_{1,\,171} = 64.16$, $P < .001$. Model 3: $R^2 = .409$, adjusted $R^2 = .391$, $\Delta R^2 = .017$, $\Delta F_{1,\,170} = 4.89$, $P = .028$. *B* = unstandardized regression coefficient; *SE* = standard error; β = standardized regression coefficient.

Table 4.3 Mean wild turkey management intention scores for low-, moderate-, and high-intention landowner clusters in Kansas, USA, 2026.

	Low (N=31)		Medium (N=56)		High (N=89)	
	Mean	SD	Mean	SD	Mean	SD
Food and Habitat Plantings	1.44	0.43	1.76	0.52	3.50	0.67
Land and Vegetation Management	2.26	0.76	3.67	0.61	3.83	0.65
Intensive Habitat Management	2.13	0.69	3.63	0.68	3.65	0.79

Note. $N = 176$. Intention was measured on a 5-point scale ranging from 1 = extremely unlikely to 5 = extremely likely; higher scores indicate greater intention to implement the practices. Food and Habitat Plantings included conservation strips, food plots, habitat plantings, and unharvested grain patches. Land and Vegetation Management included livestock grazing, water-source improvement, conservation tillage, and invasive-vegetation control. Intensive Habitat Management included prescribed fire, haying or mowing, thinning timber undergrowth, and timber stand improvement. Final cluster membership was assigned using *k*-means cluster analysis after Ward's hierarchical cluster analysis supported a three-cluster solution.

Table 4.4 Kansas landowners and property characteristics by wild turkey management intention cluster in Kansas, USA, 2026.

	Low (N=31)		Medium (N=56)		High (N=89)			
	Mean	SD	Mean	SD	Mean	SD	*F*	*P*
Age (years)	69.03[B]	10.18	62.75[AB]	13.50	61.82[A]	13.19	3.74	0.03
Trust[a]	3.90	0.89	3.67	0.98	3.72	0.80	0.73	0.48
% income from property[b]	22.03[A]	23.73	40.09[B]	36.15	37.29[AB]	34.48	3.17	0.04
Property size[c]	801.10	1216.54	1554.46	2516.25	2379.88	5647.46	1.73	0.18
Property diversity	3.23[B]	1.61	4.36[A]	1.81	5.04[A]	2.12	10.27	<0.001

[A, B, C] Differences among clusters designated with different uppercase letters

[a]Trust was measured on a 5-point scale ranging from 1 = strongly disagree to 5 = strongly agree; higher scores indicate greater trust in the Kansas Department of Wildlife and Parks. [b]Farm or ranch income is the percentage of annual household income obtained from farming or ranching. [c]Property size is the number of acres in Kansas over which the respondent reported management decision-making authority. [d]Property-use diversity is the number of land uses reported from 12 possible categories.

Table 4.5 Chi-squared analysis of demographic characteristics and intention to practice wild turkey management among landowners in Kansas, USA, 2026.

Demographic Characteristic	Low Intention % (N = 31)	Medium Intention % (N = 56)	High Intention % (N = 89)	χ^2	*P*	U
Income				10.04	0.040	0.17
<$75k	45.2	23.2	30.3			
$75k-$149k	16.1	50.0	40.4			
$150k+	38.7	26.8	29.2			
Education				7.02	0.135	0.14
High school or less	35.5	30.4	24.7			
Some college/trade	6.5	12.5	24.7			
College degree+	58.9	57.1	50.6			
Hunter				31.13	<0.001	0.42
No	67.7	69.6	27.0			
Yes	32.3	30.4	73.0			
Turkey Hunter				19.19	<0.001	0.33
No	90.3	87.5	59.6			
Yes	9.7	12.5	40.4			

Table 4.6 Mean preferences for sources of wild turkey management information by landowner intention cluster in Kansas, USA, 2026.

	Low (N=31)		Medium (N=56)		High (N=89)		
Communication source	Mean	SD	Mean	SD	Mean	SD	*P*
Natural Resources Conservation Service	2.58	1.21	2.88	1.01	3.06	1.16	0.12
Kansas Extension	2.61[B]	1.31	3.09[AB]	0.98	3.25[A]	1.14	0.03
National Wild Turkey Federation	2.55	1.31	2.82	1.11	3.01	1.22	0.18
Turkeys for Tomorrow	2.26	1.21	2.57	1.22	2.66	1.17	0.27
Pheasants Forever	2.39	1.33	2.70	1.28	2.98	1.31	0.08
Kansas Department of Wildlife and Parks	2.94	1.34	3.21	1.04	3.25	1.16	0.42
US Fish and Wildlife Service	2.55	1.31	2.89	1.19	2.90	1.19	0.35
Kansas Forest Service	2.55	1.34	2.79	1.17	2.94	1.17	0.28

[AB]Capital letter denotes a significant difference between intent groups

Ordered response: 1 = Not at all preferred, 2 = Slightly preferred, 3 = Moderately preferred, 4 = Very preferred, 5 = Extremely preferred; higher scores indicate greater preference for receiving wild turkey management information from the source.

Table 4.7 Mean preferences for communication channels used to provide wild turkey management information by landowner intention cluster in Kansas, USA, 2026.

	Low (N=31)		Moderate (N=56)		High (N=89)		
Communication Channel	Mean	SD	Mean	Sd	Mean	SD	Sig
Emailed newsletter	2.45	1.29	2.59	1.39	2.72	1.26	0.60
Mailed newsletter	2.55	1.46	3.09	1.34	2.98	1.28	0.18
Face-to-face conversation	1.87^{B}	1.02	2.48^{AB}	1.29	2.79^{A}	1.28	0.002
Phone call	1.65^{C}	0.92	2.20^{B}	1.18	2.40^{A}	1.18	0.007
Text message	1.97^{B}	1.05	2.27^{B}	1.29	2.78^{A}	1.23	0.003
Short video	1.97^{B}	1.08	2.20^{AB}	1.28	2.61^{A}	1.24	0.020
Long video	1.52^{A}	0.72	1.63^{AB}	0.98	1.94^{A}	1.07	0.053
Extension publication	2.23^{A}	1.15	2.89^{B}	1.12	2.64^{AB}	1.17	0.037
Property visit	2.03^{B}	1.08	2.50^{AB}	1.22	2.98^{A}	1.25	<0.001
Workshop	1.39^{B}	0.72	1.64^{AB}	0.92	2.03^{A}	1.12	0.004
Field day	1.77	0.96	2.00	1.13	2.31	1.17	0.047
Podcast	1.35^{B}	0.71	1.80^{AB}	1.12	1.98^{A}	1.11	0.020
Social media post	1.39^{B}	0.84	1.61^{B}	0.99	2.02^{A}	1.10	0.004

^{AB}Capital letters denote significant differences between groups

Ordered response: 1 = Not at all preferred, 2 = Slightly preferred, 3 = Moderately preferred, 4 = Very preferred, 5 = Extremely preferred; higher scores indicate greater preference for the communication channel.

Appendix

Appendix A - IRB Approval Letter

KANSAS STATE UNIVERSITY Office of Research Integrity, Compliance and Security

TO: Nellie Hill Proposal Number: IRB-13455

Communications & Ag Education

FROM: Lisa Rubin, Chair

Committee on Research Involving Human Subjects

DATE: 01/05/2026

RE: Proposal Entitled, "Human Dimensions of Wild Turkey Management."

The Committee on Research Involving Human Subjects / Institutional Review Board (IRB) for Kansas State University has reviewed the proposal identified above and has determined that it is EXEMPT from further IRB review. This exemption applies only to the proposal - as written – and currently on file with the IRB. Any change potentially affecting human subjects must be approved by the IRB prior to implementation and may disqualify the proposal from exemption. Based upon information provided to the IRB, this activity is exempt under the criteria set forth in the Federal Policy for the Protection of Human Subjects, **45 CFR §104(d), category:Exempt Category 2 Subsection ii.**

Certain research is exempt from the requirements of HHS/OHRP regulations. A determination that research is exempt does not imply that investigators have no ethical responsibilities to subjects in such research; it means only that the regulatory requirements related to IRB review, informed consent, and assurance of compliance do not apply to the research.

Any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Committee on Research Involving Human Subjects, the University Research Compliance Office, and if the subjects are KSU students, to the Director of the Student Health Center.

203 Fairchild Hall, 1601 Vattier St., Manhattan, KS 66506 | 785-532-3224 | fax: 785-532-3278 | comply@k-state.edu

Electronically signed by Lisa Rubin on 01/05/2026 12:59 PM ET

Appendix B - Survey Instrument

KANSAS STATE UNIVERSITY | Kansas Cooperative Fish and Wildlife Research Unit

Landowner perspectives on wild turkey management

Information About This Study

What is this research studying? This research is focused on Kansas landowner views on wild turkeys and their management practices.

What would I do if I participate? In this study, you will be asked to answer questions regarding your feelings, attitudes, behaviors, and preferences related to wild turkeys and their management in Kansas.

Can I quit if I become uncomfortable? Yes, absolutely. Your participation is completely voluntary. Participating is your choice.

How long will participation take? This questionnaire will take approximately 10 minutes to complete.

How are you protecting privacy? Your name will not be linked to any materials in reports, publications, or presentations. No one other than the researchers associated with this project will have access to the raw data. All related documentation will be secure in the researcher's locked office on a password protected computer. Your information collected as part of the research, even if identifiers are removed, will not be used or distributed for future research studies.

How will I benefit from participating? Your participation will provide valuable information that will help guide wild turkey management in Kansas. There are no foreseeable risks to your participation.

Who can I ask questions to? The study is being conducted by Mary Ware of the Division of Biology and Dr. Nellie Hill-Sullins from the College of Agriculture at Kansas State University. If you have any questions, contact Mary at mfware@ksu.edu or Dr. Hill-Sullins at nlhill@ksu.edu. Kansas State University also has a Research Compliance Office which can be contacted at (785) 532-3224 or comply@k-state.edu.

By continuing with this survey, you signify that you consent to participation.

Has your land or the land you manage been involved with the wild turkey research by Kansas State University from 2024-2026?

○ Yes

○ No

What is your age? _______________

Please write your UNIQUE ID _____________

For the remainder of this survey, any reference to management of land, my land, my property, etc. is in reference to land you may manage or own in Kansas.

In the last 5 years, which of the following management activities for wild turkeys have you implemented on any of your land in Kansas? [check all that apply]

- ☐ Prescribed fire
- ☐ Haying or mowing
- ☐ Livestock grazing - rotation, mosaic, and/or patch-burn grazing
- ☐ Thinning of thick timber undergrowth
- ☐ Timber stand improvement
- ☐ Predator control
- ☐ Conservation strips
- ☐ Planting or maintaining food plots
- ☐ Tree, grass, and/or forb planting for habitat
- ☐ Improving water sources
- ☐ Conservation tillage (leaving crop residue after harvest)
- ☐ Unharvested grain patch
- ☐ Control of invasive vegetation
- ☐ None of these

Please indicate how much you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
My family would approve of people like me managing for wild turkeys.	○	○	○	○	○
The opinions of my family matter to me.	○	○	○	○	○
My friends and neighbors encourage people like me to manage for wild turkeys.	○	○	○	○	○
My friends' and neighbors' views matter to me.	○	○	○	○	○
Landowner colleagues would approve of people like me managing for wild turkeys.	○	○	○	○	○
The approval of fellow landowners/managers matters to me.	○	○	○	○	○
State and federal agency staff (e.g. extension agents, USDA, FSA, NRCS, wildlife and natural resource departments, state foresters, etc.) encourage landowners to manage for wild turkeys.	○	○	○	○	○

Agency staff opinions matter to me.	○	○	○	○	○

Please indicate how much you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Managing for wild turkeys requires a lot of land	○	○	○	○	○
Because I have enough land, I am able to manage for wild turkeys	○	○	○	○	○
Managing for wild turkeys is expensive.	○	○	○	○	○
Because I have enough funds, I am able to manage for wild turkeys.	○	○	○	○	○
Managing for wild turkeys requires a lot of technical knowledge.	○	○	○	○	○
Because I have knowledge of wild turkey management, I am able to do it.	○	○	○	○	○
Managing for wild turkeys requires a lot of time.	○	○	○	○	○
Because I have enough time, I am able to manage for wild turkeys.	○	○	○	○	○

Managing for wild turkeys requires a lot of labor.	○	○	○	○	○
Because I have enough labor, I am able to manage for wild turkeys.	○	○	○	○	○

Please indicate how much you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
By seeing wild turkeys in their fields, pastures, and property, landowners/managers can know the land is healthy and productive.	○	○	○	○	○
Seeing wild turkeys in my fields, pastures, and property is important to me.	○	○	○	○	○
If landowners/managers have wild turkey enterprises like hunting leases, guided hunts, and ecotourism, it can contribute to their property	○	○	○	○	○
Establishing wild turkey enterprises is important to my property.	○	○	○	○	○
If landowners/managers have wildlife on their property, they can participate in activities like bird watching and/or hunting.	○	○	○	○	○

Wild turkey activities like bird watching and/or hunting on my property are important to me.	○	○	○	○	○
Wild turkeys and cattle and/or crops can exist together on a farm or ranch.	○	○	○	○	○
Having wild turkeys and cattle and/or crops on my property is important to me.	○	○	○	○	○

In the next 5 years, how likely are you to implement each of the following wild turkey management activities on any of your land in Kansas?

	Extremely unlikely	Somewhat unlikely	Neither likely nor unlikely	Somewhat likely	Extremely likely
Prescribed fire	○	○	○	○	○
Haying or mowing	○	○	○	○	○
Livestock grazing – rotation, mosaic and/or patch-burn grazing	○	○	○	○	○
Thinning of thick timber undergrowth	○	○	○	○	○
Timber stand improvement	○	○	○	○	○
Predator control	○	○	○	○	○
Conservation/prairie strips	○	○	○	○	○
Planting or maintaining food plots	○	○	○	○	○
Tree, grass and/or forb planting for habitat	○	○	○	○	○

Improving water sources	○	○	○	○	○
Conservation tillage (leaving crop residue after harvest)	○	○	○	○	○
Unharvested grain patch	○	○	○	○	○
Control of invasive vegetation	○	○	○	○	○

Please indicate how much you agree or disagree with the following statements.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Kansas Department of Wildlife and Parks has wildlife managers and biologists who are well-trained for their jobs	○	○	○	○	○
Kansas Department of Wildlife and Parks does a good job of managing wild turkeys in Kansas	○	○	○	○	○
Kansas Department of Wildlife and Parks can be trusted to make decisions about wild turkeys that are good for the resource	○	○	○	○	○
When deciding about wild turkey management in Kansas, Kansas Department of Wildlife and Parks will be open and honest in the things they do and say	○	○	○	○	○

Kansas Department of Wildlife and Parks will make decisions about wildlife management in a way that is fair	○	○	○	○	○
Kansas Department of Wildlife and Parks listens to the concerns of landowners	○	○	○	○	○

Please indicate your preference for receiving information from each of the following organizations about wild turkey management on your property.

	Not at all preferred	Slightly preferred	Moderately preferred	Very preferred	Extremely preferred
Natural Resources Conservation Service	○	○	○	○	○
Kansas Extension	○	○	○	○	○
National Wild Turkey Federation	○	○	○	○	○
Turkeys for Tomorrow	○	○	○	○	○
Pheasants Forever	○	○	○	○	○
Kansas Department of Wildlife and Parks	○	○	○	○	○
U.S Fish and Wildlife Service	○	○	○	○	○
Kansas Forest Service	○	○	○	○	○

Please indicate your preference for each method of communication that might be used to share wild turkey management information.

	Not at all preferred	Slightly preferred	Moderately preferred	Very preferred	Extremely preferred
Emailed newsletter	○	○	○	○	○
Mailed newsletter	○	○	○	○	○
Face to face conversation	○	○	○	○	○
Phone call	○	○	○	○	○
Text message	○	○	○	○	○
Video less than 10 minutes	○	○	○	○	○
Video more than 10 minutes	○	○	○	○	○
Extension publication	○	○	○	○	○
Property visit, 1-on-1	○	○	○	○	○
One day conference-style workshop	○	○	○	○	○
Field day in my area	○	○	○	○	○
Podcast episode	○	○	○	○	○
Social media post	○	○	○	○	○

The following questions are about you and your land. We are asking these questions so we can design more useful wild turkey management resources to meet the needs of landowners like you.

How do you describe yourself?

- ○ Male
- ○ Female
- ○ Non-binary / third gender
- ○ Prefer not to say

What was your total annual household income in 2025?

- ○ Less than $25,000
- ○ $25,000-$49,999
- ○ $50,000-$74,999
- ○ $75,000-$99,999
- ○ $100,000-$149,999
- ○ $150,000-$199,999
- ○ More than $200,000

What percentage of your annual household income comes from farming or ranching?

____

What is your nationality/ethnic background?

- ◯ White or Caucasian
- ◯ Black or African America
- ◯ American Indian or Alaska Native
- ◯ Asian
- ◯ Native Hawaiian or other Pacific Islander
- ◯ Prefer to self-describe : ___________________________
- ◯ Prefer not to answer

What is your ethnicity?

- ◯ Hispanic or Latino
- ◯ Not Hispanic or Latino
- ◯ Prefer not to answer

What is your highest level of education?

- ◯ Some education
- ◯ High school diploma
- ◯ Trade school
- ◯ Associate's degree
- ◯ Bachelor's degree
- ◯ Master's degree
- ◯ Professional or advanced degree

In which state do you currently reside? ____

How many acres of land in Kansas do you have decision-making power over?

____

Please indicate which of the following exists on the land you manage (owned or leased) [check all that apply]

- ☐ Crop fields
- ☐ Grazed native pasture
- ☐ Grazed planted or improved pasture
- ☐ Ungrazed, unhayed pasture
- ☐ Hayfields
- ☐ Native forest
- ☐ Planted timber
- ☐ Wetlands
- ☐ Riparian areas [trees along creeks, rivers, or streams]
- ☐ Ponds and/or water tanks
- ☐ Buildings and other structures
- ☐ House(s)

Do you own land in a state other than Kansas?

- ○ No
- ○ Yes

During which of the following years did you participate in hunting any species? Harvesting is not required to participate. [check all that apply]

- ☐ 2021
- ☐ 2022
- ☐ 2023
- ☐ 2024
- ☐ 2025
- ☐ Not applicable

During which of the following years did you participate in the spring or fall wild turkey hunting season? Harvesting a bird is not required to participate. [check all that apply]

- ☐ 2021
- ☐ 2022
- ☐ 2023
- ☐ 2024
- ☐ 2025
- ☐ Not applicable

Please let us know how and where you are currently getting wild turkey management information.

____

____

Please use the space below for any additional comments you may have.

____

____

Thank you for completing this survey.

Please place the survey in the self-addressed, pre-paid envelope to return the survey to Kansas State University and the Kansas Cooperative Fish and Wildlife Unit.

KANSAS STATE UNIVERSITY | Kansas Cooperative Fish and Wildlife Research Unit

Appendix C - Letter Invitation

[First Name] [Last Name]
[Mailing Address]
[City], [State] [Zip]

March 30, 2026

Dear [First Name] [Last Name],

Thank you for allowing the Kansas State University Wild Turkey Research team access to your property to conduct research. We greatly appreciate your support.

We are writing to invite you to participate in a brief survey about your views on wild turkeys and their management in Kansas. Your input is important and will help inform how wildlife agencies and researchers can better align wild turkey management with landowner perspectives and priorities.

To participate, **please scan the QR code below and enter your UNIQUE ID:** [Unique ID]. The survey takes approximately 10 minutes to complete. If you would like to participate but prefer an alternative method (phone or mail), please contact Mary Ware at mfware@ksu.edu or (231) 912-0003.

Your participation is voluntary, and all responses will be kept confidential.

Thank you for considering this request and for your continued support of wildlife research.

Sincerely,

Mary Ware

Mary Ware, Graduate Teaching Assistant
Kansas Cooperative Fish and Wildlife Research Unit
Division of Biology | Kansas State University

Who is conducting this survey?
This survey is being conducted by Mary Ware, graduate student in the Kansas Cooperative Fish and Wildlife Research Unit. Find out more at:
k-state.edu/kscfwru/personnel/current.html

Advising Mary is Dr. Hill-Sullins, an assistant professor of agricultural and natural resources communications at Kansas State University. Read more at:
communications.k-state.edu/about-us/people/faculty/Hill-Nellie.html

I have a question that is not answered here. How can I contact you?
Email us: Mary at mfware@ksu.edu or Dr. Hill-Sullins at nlhill@ksu.edu

Kansas State University also has a Research Compliance Office which can be contacted at (785) 532-3224 or comply@k-state.edu.

Appendix D - Sample text message

Hello {Name}, it's Mary Ware with Kansas State University. I recently sent a letter asking you to take a 10-minute survey about wild turkey management. Please click the link below and enter your unique ID {unique id} by May 4th, 2026.

https://kstate.qualtrics.com/jfe/form/SV_9G0zliDKYTk7Wey

Reply STOP to opt out of text communications