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**EVALUATION OF REPRODUCTIVE PHENOLOGY AND
ECOLOGY OF THE EASTERN WILD TURKEY (*MELEAGRIS
GALLOPAVO SILVESTRIS*) IN WEST-CENTRAL LOUISIANA**

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Science

in

The School of Renewable Natural Resources

by
Erin Elizabeth Ulrey
B.S., Northern Michigan University, 2011
May 2021

DEDICATION

I would like to dedicate this to my fiancé Nick, my parents, and all of my family and friends who have influenced my life for their loving support and encouragement to pursue my M.S. degree. Without all of your love and support, I would not have been able to do this.

ACKNOWLEDGMENTS

I would like to thank my major professor, Dr. Bret Collier and thesis committee members, Dr. Ashley Long and Dr. Michael Chamberlain for their mentoring, support, and patience during the pursuit of my M.S. Degree.

Additionally, I would like to thank the following collaborators for providing financial support for this research: Louisiana Department of Wildlife and Fisheries and Louisiana State University's School of Renewable Natural Resources. Furthermore, I would like to especially thank all of the Louisiana Department of Wildlife and Fisheries and United States Forest Service employees who assisted with the project especially L. Bennett, C. Boles, C. Cedotal, B. Parker, C. Sonnier, and J. Nolde. Also a big thank you to all the graduate students that helped me along the way including N. Bakner, A. Gerrits, D. Moscicki, N. Raginski, C. Argabright, J. Kunberger, C. Terry, and J. Bushaw. I also need to recognize and thank the various research associates and undergraduates that helped in the field, data analysis, and were just a pleasure to work with: B. Stafford, H. Poole, L. McFarland, M. Stafford, M. Saladino, O. Roy, E. White, A. Bauer, and C. McKeever.

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ABSTRACT

Nest predation is the primary source of nest failure, with vegetative conditions at the nest sites considered drivers of reproductive success. Our current understanding of how incubating Eastern wild turkeys (*Meleagris gallopavo silvestris*, hereafter, wild turkey) use vegetative characteristic relating to specific predators of wild turkey nests is limited. We quantified the occurrence, diversity, and distribution of potential wild turkey nest predator species across Kisatchie National Forest and Peason Ridge WMA in central Louisiana in relation to vegetative conditions located within incubation ranges used by nesting female wild turkeys. We used 210 camera trap sites surveying 5,144 trap nights and recording 2,925 photographs of potential nest predator species. Potential nest predator species were widely distributed and regularly occurred within nesting areas. Our results suggest that the most important factor affecting a nest's outcome may be the placement of the nest on the landscape relative to use by potential predator species.

Alternatively, the influence of reproductive timing on nest success is most likely driven by social rank, however the relationship is unknown. Monogamous species regularly demonstrate reproductive synchrony as male investment in female courtship limits extra pair reproductive activities. However, in non-monogamous species, social rank dictates access of individuals to reproductive mates, where typically one male copulates with the majority females creating a strong reproductive skew. Our objective was to evaluate reproductive synchrony within and between presumed social groups and we defined social groups as females captured together as individuals. Using GPS data collected from 225 female Eastern wild turkeys, we identified 30 reproductive groups with 6 females per group on average. Our results indicate female wild turkeys rarely disperse from their social groups prior to the beginning of

reproduction and suggest social hierarchy existed within groups. We found the number of days between first nest initiation was longer than expected based on previous literature. If the number of days between subsequent nest attempts is an important factor influencing reproductive success, then factors that cause disruption to breeding behavior could have negative effects on fitness.

CHAPTER 1. INTRODUCTION

The wild turkey (*Meleagris gallopavo*) is the largest galliform in North America and widely distributed across the continent. In the mid-1990s, the wild turkey was nearly extirpated across its range in the United States due to unregulated hunting and lack of effective habitat conservation practices. The restoration of the wild turkey is one of the greatest success stories in wildlife management due to extensive efforts by state and non-profit organizations that brought it back to sustainable population levels. In many regions of the United States there has been a decline in the Eastern wild turkey (*Meleagris gallopavo silvestris*, hereafter, wild turkey) populations due to a decrease in productivity (Byrne et al. 2015). As such, wildlife researchers and land managers are challenged with identifying potential drivers of population decline to maintain a sustainable population and thus gain the economic benefits from the resource to support further conservation efforts.

The wild turkey is a popular big game species with an estimated 10,800 hunters in Louisiana (LDWF 2019). To retain hunters, who contribute approximately \$120 million to the state's economy each year, it is important to ensure a sustainable population (LDWF 2006).

The wild turkey is a ground-nesting uniparental species inhabiting the southeastern United States. The reproductive period occurs during the months of March to July with the incubation period ranging from 28–30 days. Reproductive activities for ground-nesting birds are physiologically expensive and create periods of high risk. Female wild turkeys are generalists and locate their nest sites in diverse vegetative conditions with varying undergrowth characteristics (Holbrook et al. 1987, Porter 1992, Badyaev 1995, Streich et al. 2015, Yeldell et al. 2017). Research on wild turkeys suggest that the primary drivers of reproductive success are nest site selection and vegetative characteristics at the nest site (Badyaev et al. 1996b, Miller et

al. 1999, Byrne and Chamberlain 2013, Conley et al. 2015, Streich et al. 2015, Little et al. 2016, Yeldell et al. 2017). Within avian literature there exists a long history of evaluating the location of nest sites using measurements of vegetation and relating nest site selection to habitat preference and reproductive success. However, other studies suggest that conditions around the nest site may have greater impacts on nest success than at the nest site (Borgo and Conover 2016, Dreibelbis et al. 2016, Bakner et al. 2019, White et al. 2020, Lohr et al. 2020).

Wild turkeys have a diverse array of nest predators that exhibit substantive plasticity in habitat selection (Miller and Leopold 1992). The primary cause of nest failure (Vangilder et al. 1987, Vander Haegen et al. 1988, Vangilder and Kurzejeski 1995) and limiting factor to population sustainability is commonly identified as nest predation (Dillon and Conway 2018). Nest predation is regularly viewed as a process wherein nest sites are considered a resource to potential predator species and risk of predation is influenced by distribution and abundance of potential predators across the landscape. Historically researchers suggest using management techniques that increase visual obstruction and ground cover at the nest site to decrease predation under the assumption that vegetation mitigates predation (Badyaev 1995, Conley et al. 2015, Streich et al. 2015, Yeldell et al. 2017). Although potential nest predator species have been documented in the literature, a quantification of the distribution and occurrence of potential nest predator species relative to vegetative conditions wild turkeys nest sites is limited.

As annual reproductive output is a primary driver of population growth and sustainability, researchers are challenged with understanding how social structure influences reproductive timing and success. Wild turkeys exhibit a complex social structure within flocks consisting of a linear pecking order where the highest-ranking individual dominates all others (Watts and Stokes 1971, Eaton 1992, Healy 1992). An individual's social rank is established

through agonistic actions between siblings during the fall (Healy 1992) and rank seldom changes as long as the dominant bird remains alive (Watts and Stokes 1971). Social rank determines access to mates where higher ranking individuals may disrupt subordinate individuals from gaining access to preferred mates (Robel and Ballard 1974). Higher-ranking females that mate first may gain access to the preferred male, giving themselves advantages associated with early nesting, forcing subdominant females to either nest later, potentially causing delays in nesting or mate with an inferior male (Robel and Ballard 1974). However, there is a lack of understanding of how social dominance may influence aspects of wild turkey reproduction.

Using the advancements of GPS transmitters for wild turkeys, we evaluated how potential vegetative and landform characteristics may influence potential nest predator occurrence. Additionally we evaluated reproductive synchrony within and between identifiable reproductive groups. In this thesis, we present data from 5 study sites located in west-central Louisiana. Chapter 2 describes the occurrence, diversity, and distribution of specific wild turkey nest predators in relation to vegetative characteristics in areas used by incubating wild turkeys. In Chapter 3 I evaluate the impact of synchrony or lack thereof on nest success and identify if social rank can be inferred via reproductive timing. Chapter 4 provides overall conclusions of the thesis and provides management implications and suggestions for future research.

CHAPTER 2. SPATIAL DISTRIBUTION OF POTENTIAL WILD TURKEY NEST PREDATORS IN WEST-CENTRAL LOUISIANA

2.1. Introduction

Identifying drivers of nest success is important because annual reproductive output influences population sustainability (Ghalambor and Martin 2002, Martin 2002). Across avian species, nest predation is the primary source of reproductive failure (Ricklefs 1969, Martin 1993, Martin 1995*b*, Thompson 2007), accounting for approximately 80% of avian nest loss (Martin 1993, Webb et al. 2012). As such, reproductive activities create periods of high predation risk for many ground nesting species (Martin 1993). Nest success is an important determinant of population trajectories and intensity of predation largely drives patterns of reproductive success (Martin 1992). Life history theory suggests that in systems where nest predation rates are low, species with larger clutch sizes and extended incubation periods should be favored (Martin 1993).

Nest predation is commonly viewed as a process wherein nest sites are considered a resource to potential predatory species and predator resource use is driven by density and accessibility of nests within the landscape. There exists a long history within the avian literature evaluating the location of nests sites, often tied to measurements of vegetation and how the selection of sites relates to habitat preference and hence reproductive success. For ground nesting birds, the corollary is that vegetative selection, as measured at the nesting location, mitigates predation via a relationship between vegetation density and nest concealment that reduces predator accessibility. Predation risk for a nest is influenced by the distribution and abundance of potential predators across the landscape (Dijak and Thompson 2000, Chalfoun et al. 2002, DeGregorio et al. 2014) as well as the concealment ability (limiting attack rate) of potential prey. Concomitantly, a standard assumption is that greater abundance of predator species should

increase the probability of predation based on the likelihood of interactions occurring on the landscape (Martin 1993). Ultimately, however, predation risk has substantive influences on nest success, and understanding how specific predators interact with vegetative features thought to reduce accessibility is necessary.

The Eastern wild turkey (*Meleagris gallopavo silvestris*; hereafter wild turkey) is a ground nesting uniparental galliform widely distributed across North America. Female wild turkeys lay between 10–12 eggs and continuously incubate their eggs from 25–29 days, thus with >40 days required for each nesting attempt, life history theory would predict that predation risk for wild turkey nests should be low (Martin et al. 2006). However, nest predation is the primary cause of nest failure for wild turkeys (Vangilder et al. 1987, Vander Haegen et al. 1988, Vangilder and Kurzejeski 1995) and is commonly identified as the primary limiting factor to wild turkey sustainability (Dillon and Conway 2018). Across the United States, female wild turkeys locate nest sites in diverse vegetation conditions with varying undergrowth characteristics and vegetation densities (Holbrook et al. 1987, Porter 1992, Badyaev 1995, Streich et al. 2015, Yeldell et al. 2017). Historically, researchers have focused on vegetative characteristics at the nest site as a driver of predation risk (Badyaev et al. 1996b, Miller et al. 1999) and have frequently linked vegetative conditions at the nest site to nest success (Byrne and Chamberlain 2013, Conley et al. 2015, Streich et al. 2015, Little et al. 2016, Yeldell et al. 2017). Under the previously described assumption that vegetation mitigates predation (Martin 1993) several studies have suggested that increasing visual obstruction and ground cover at nest sites increases reproductive success and decreases predation (Badyaev 1995, Nguyen et al. 2004, Conley et al. 2015, Streich et al. 2015, Yeldell et al. 2017). However, other studies have suggested that conditions around nest locations or wild turkey behavioral ecology may have

greater impacts on nest success (Borgo and Conover 2016, Dreibelbis et al. 2016, Bakner et al. 2019, White et al. 2020, Lohr et al. 2020).

Decades of conservation efforts to mitigate nest loss in wild turkeys have primarily focused on vegetation management under the assumption that vegetation conditions exist that reduce the probability of nest-predator interactions and lead to increased nest success (Miller and Leopold 1992, Lehman et al. 2008, Fuller et al. 2013). Wild turkeys have a diverse array of nest predators that exhibit substantive plasticity in habitat selection (Miller and Leopold 1992), and female turkeys show similar plasticity in regards to nest placement relative to vegetative characteristics (Yeldell et al. 2017, Wood et al. 2019). Conversely, little work has been conducted to quantify the distribution and occurrence of potential nest predator species relative to vegetative conditions located within the incubation ranges used by wild turkeys (Conley et al. 2016, Bakner et al. 2019). Understanding how vegetative characteristics in areas used by incubating wild turkeys relate to specific predators of wild turkey nests is critical to identify and perhaps mitigate effects on wild turkey reproduction. Our objective was to quantify the occurrence, diversity, and distribution of potential wild turkey nest predator species across a broad spatial scale, to evaluate potential vegetative and landform characteristics that may influence predator occurrence, and to predict, spatially, based on local environmental metrics the likely occurrence of potential nest predators.

2.2. Study Area

We conducted research on the Kisatchie National Forest (KNF) and Peason Ridge Wildlife Management Area (WMA) in west central Louisiana. The KNF is owned and managed by the United States Forest Service (USFS), whereas Peason Ridge WMA is jointly owned by the USFS and the US Army. Both sites were pine-dominated forests composed of rolling hills,

high ridges, and sandy creek bottoms. Vegetation communities consisted of loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*), short leaf pine (*Pinus echinata*), slash pine (*Pinus elliottii*), mixed pine-hardwood forests, and hardwood riparian areas. Both sites contained forest openings, utility rights-of-way, and forest roads distributed throughout (Yeldell et al. 2017). Rural infrastructure, agricultural fields, pasture and privately-owned lands used for industrial timber bordered our study sites. Prescribed fire was applied on a 3–5 year return interval across both study sites on publicly-owned lands. Our study sites experienced subtropical climates, with mean daily temperatures ranging from a low of 9.4°C in January to 28.3°C in July, and mean annual rainfall of approximately 114 cm. Common predators of turkey nests at KNF, Peason Ridge WMA, and surrounding areas included western rat snake (*Pantherophis obsoletus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), bobcat (*Lynx rufus*), Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), Cooper’s hawk (*Accipiter cooperii*), and Barred owl (*Strix varia*).

2.3. Methods

We captured female wild turkeys using rocket nets baited with cracked corn during January – March 2018 – 2019. We classified each individual as a subadult or adult based on presence of barring on the ninth and tenth primary feathers (Pelham and Dickson 1992). All individuals were fitted with a uniquely identifiable aluminum rivet tarsal band and backpack-style GPS/VHF transmitter (Biotrack Limited, Wareham, Dorset, UK; Guthrie et al. 2011). We programmed GPS units to record one location per hour daily from 05:00 to 20:00 and one roost location at night (23:59:58) until the battery died or the unit was recovered (Cohen et al. 2018). We immediately released individuals at the capture location following processing. Capture,

handling, and marking procedures were approved by the Louisiana State University Agricultural Center Animal Care and Use Committee (Permit A2015-07 and Permit A2018-13).

We monitored live-dead status daily during the reproductive season using handheld Yagi antennas and Biotracker receivers (Biotrack Ltd., Wareham, Dorset, UK). We downloaded GPS locations once per week via a VHF/UHF handheld command unit receiver (Biotrack Ltd., Wareham, Dorset, UK). We derived dates of nest incubation from spatio-temporal GPS locational data and determined a female was incubating when an individual's locations became concentrated around a single point for several days (Guthrie et al. 2011, Conley et al. 2015, Yeldell et al. 2017, Wood et al. 2019). We defined the date of nest incubation initiation as the first day the nightly roost location was recorded at the nest site, indicating the female continued incubation during the night (Bakner et al. 2019). Nesting females were not disturbed or flushed from nest sites during monitoring, but were instead live-dead checked daily via VHF from a distance >20 m. Wild turkey nests require about 27 days of continuous incubation before hatching (Williams et al. 1971), but incubation can vary from 25 to 29 days (Healy and Nenno 1985). After nest termination, we located nest sites using GPS locations to confirm the estimated nest location and to determine nest fate. We considered a nest to have been depredated or abandoned if the female left the nest ≤ 25 days into incubation, or if only intact eggs, no eggs, or egg fragments were found at the nest bowl. We considered a nest successful if ≥ 1 live poult hatched, and was confirmed visually during subsequent brood surveys (Chamberlain et al. 2020). To quantify the distribution, occurrence, and richness of nest predator species within the landscape used by reproductively active GPS-tagged wild turkeys, we conducted camera surveys during the primary nesting period of wild turkeys on our study sites (1 April to 30 June, Yeldell et al. 2017). We conducted camera surveys using Bushnell Trophy (Bushnell Outdoor Products,

Overland Park, KS, USA) or Moultrie game cameras (PRADCO Outdoor Brands, Calera, AL, USA). We programmed all cameras to collect photographs using Passive Infra-Red (PIR) motion sensors over the daily cycle using a burst of 3 photos with a one-minute delay between bursts. We placed cameras approximately 30–40 cm above the ground which would allow the cameras to capture species such as squirrels (*Sciurus* spp.) or Virginia opossum but also capture larger species such as white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*; Kelly and Holub 2008). We cleared understory growth at each camera site when necessary to reduce the frequency of non-target images (Claridge et al. 2004, Meek and Pittet 2012).

We delineated 3 categories of camera sites, which included random, active, and passive sites. To generate random survey sites, we used GPS locations of females to create an approximate minimum convex polygon of wild turkey use that encompassed all GPS locations from all females during 2018. We then used the random point tool in ArcMap 10.6 (Environmental Systems Research Institute, Inc., Redlands, CA, USA) to randomly locate 36 sites (approximate number of nest locations each year, Yeldell et al. 2017, Bakner et al. 2019) with a minimum distance of 200 m between sites. We placed a single trail camera at each random site, and randomly selected 18 of the 36 random sites to be baited with disks impregnated with fatty acid scent (USDA Pocatello supply department, Pocatello, ID, USA). We used the bait disks as a strategy to evaluate whether the presence of scent, potentially similar to a wild turkey on a nest, had any effect on predator accessibility or attendance. Disks were roughly the size of a quarter and in dry weather, the scented disks were expected to be effective for 3 to 4 weeks but in periods of greater precipitation, the expected effectiveness range is reduced to about 5 days. Thus, we visited baited cameras every 14 days to rebait, as we assumed that time frame would not lead to potential nest predators following our trail (Dreibelbis et al. 2011). We

operated the randomly distributed cameras continuously from 1 April to 30 June. We focused herein on data collected from 1 April to 1 May, which coincides with the peak period of wild turkey nest incubation on our study sites (Yeldell et al. 2017, Bakner et al. 2019). While temporal symmetry (e.g., all camera survey being initiated on the same day) would be optimal, we were dealing with nest sites identified in 2018 and 2019 and logistical limitations restricted our ability to exactly time camera distribution to the start, or end, of nesting activities by individual birds.

We used known wild turkey nesting locations to generate active and passive sites. We classified nest site locations from the previous breeding season (2018) as passive sites. Passive sites were theoretically unoccupied during the 2019 reproductive season, but were known to be occupied by active turkey nests during the 2018 reproductive season. Following Conley et al. (2015), we defined the sampling area for our passive sites by building incubation ranges for each unique nest using the nesting female's GPS locations during the incubation period to build 99% dynamic Brownian Bridge movement models in R (v.3.2.5. R, Core Development Team 2020) and R package move (Kranstauber et al. 2013). We censored the first and last day of incubation to reduce spatial prediction bias caused by individuals that commenced incubation halfway through the day (Conley et al. 2015, Bakner et al. 2019). Within each of the estimated incubation ranges, we randomly generated 2 locations using the random point tool in ArcMap 10.6, and placed trail cameras at each sample location simultaneously during the period (adding 1 day to each end) that each nest was active during 2018. For example, the incubation range of a female that began incubating 9 April 2018 with an estimated hatch date of 6 May 2018 would have been sampled from 8 April to 7 May 2019. We baited all cameras at passive sites with attractants

impregnated with fatty acid scent due to the absence of a potential incubating female that may have attracted potential predators to the area.

During 2019, we monitored females to determine nesting activity using aforementioned methods, and then generated camera sites associated with actively nesting female wild turkeys (active sites). We established 2 camera trap sites within approximately 5 days of a female beginning incubation. We used the mean incubation range size (11.4 ha) of females monitored during 2018 to generate 99% incubation ranges around nesting females during 2019, using a circular buffer with a radius of about 190 m. To ensure that incubating females were not disturbed during deployment of cameras, we used an internal radius of 100 m and did not locate any camera sites within the 100 m buffer around the nest. We then randomly generated locations in the area between the 100 and 190 m circular buffer, and operated cameras for a 28-day incubation period. We collected cameras after day 28 or once a female successfully hatched. We did not use scent tabs or monitor cameras during the 28-day period at active sites to reduce the possibility of disturbing the incubating female or attracting predator species to the camera site (Dreibelbis et al. 2011).

We visually evaluated all images collected at each camera location to quantify daily total occurrence of each predator species. We defined images as independent when consecutive images of a species were separated ≥ 30 minutes (O'Brien et al. 2003, Kelly and Holub 2008). We treated both cameras as representative as an incubation range and we assumed that camera observations were independent and we summarized the frequency of incubations ranges that had the same predator species photographed on both cameras during the sample period and on the same day within the sample period. We tallied the detections of nest predator species at each camera site for each day, classifying each image as a dependent or independent event, and

calculated total captures for each camera site category (random, passive, active). We used the Shannon-Wiener diversity index to estimate the diversity of predator species for each camera site category (random, passive, active), failed and successful nests, and baited and unbaited random sites. We used the relative abundance indices (RAI) as an index of species abundance by calculating the number of independent events of a species, divided by the number of trap nights (TN; nights the camera was deployed), multiplied by 100 (O'Brien et al. 2003), which scaled abundance relative to camera deployment time. We calculated RAI for each camera site category (random, passive, active), failed and successful nest, and unbaited and baited site.

Next, we used the occurrence data (presence or absence) of individual potential predator species within incubation ranges in conjunction with spatial vegetative characteristics to develop a predictive model of the likely distribution of potential nest predators across our study sites. We used a 30 m resolution imagery from USGS Landsat-8 Operational Land Imager and delineated primary landcover types within the study area, excluding imagery with $\geq 10\%$ cloud cover. We used supervised classification in ERDAS Imagine Software (v16.00.0000.00199, Hexagon Geospatial, Peachtree Corners Circle Norcross 2016) with 30 classes, and recoded and combined classes to create 6 unique landcover classes (water, coniferous, deciduous, mixed coniferous-deciduous, infrastructure, and open). To quantify the density of plant growth, we calculated the Normalized Difference Vegetation Index (NDVI) with results for a given pixel ranging from -1 to 1, where no green leaves would provide values closer to zero, whereas values closer to 1 indicated high density of green vegetation. We used a 20m resolution imagery from the European Space Agency (ESA) Sentinel 2 satellite, excluding imagery with $\geq 10\%$ cloud cover. We used imagery from months of April, May, and June because these months encompass the primary period of nest incubation on our study site.

Prescribed fire can influence the occurrence and behavior of predators by altering the structural complexity of an area (Cherry et al. 2016a), so we calculated the delta Normalized Burn Ratio (ΔNBR) to estimate the burn severity in 2019. The ΔNBR formula is similar to NDVI except that it uses near-infrared (NIR) and shortwave-infrared (SWIR) wavelengths, where healthy vegetation has a high NIR reflectance and low SWIR reflectance pre-fire compared to burned areas that have relatively low NIR reflectance and high SWIR reflectance. We used a 20 m resolution imagery from ESA Sentinel 2 satellite, excluding imagery with $\geq 10\%$ cloud cover. We calculated the ΔNBR using imagery from January (Pre-fire) and June (Post fire). To examine how the density of roads influenced predator occurrence, we acquired an ArcGIS shapefile depicting roads in Louisiana from OpenStreetMap.org and made available by MapCruzin. We buffered the line shapefile by 7.62 m because a standard lane is 3.65 m wide and therefore a typical rural road would be approximately 7.62 m wide (2, 3.65-m-wide travel lanes).

We used the average incubation range size (11 ha) and created 11 ha hexagons centered on each random, passive, and active camera survey sites from which we extracted camera survey landscape metrics from each hexagonal grid cell. Hexagons reduce sampling bias from edge effects related to high perimeter area ratios. Next, we used generalized linear models with a logit link function, the presence (1) or absence (0) of each predator species within an incubation range using a species-specific set of candidate models. For all candidate models, we used second-order Akaike's Information Criterion (AIC_c) to assess the amount of support for the different candidate models (Burnham and Anderson 2002). We provide the regression estimates for the best ranked species-specific model(s), and used them to project occurrence probabilities to 11 ha hexagons distributed across our study areas using the vegetative, fire, NDVI, and road density measurements found to be best supported for predicting presence-absence of each predator

species. We did not include type of camera site and presence or absence of bait as variables in our spatial models because it was impossible to quantify the effect of the variables across the landscape where they did not exist.

2.4. Results

We monitored 43 nests in 2018 (4 successful, 39 failed) and 44 nests in 2019 (6 successful, 38 failed). We used 210 camera trap sites (86 passive, 88 active, and 36 random) and after removing days due to malfunctioning cameras, we surveyed 5,144 trap nights. We recorded 2,925 photographs of known nest predator species, including Nine-banded armadillo (*Dasypus novemcinctus*), coyote, bobcat, American crow (*Corvus brachyrhynchos*), white-tailed deer, feral pigs (*Sus scrofa*), gray fox, Virginia opossum, and raccoon. We limited our analysis to the above mammalian and corvid species, but also recorded infrequent occurrences of striped skunk (*Mephitis mephitis*), red shouldered hawk (*Buteo lineatus*), barred owl, black bear (*Ursus americanus*), pileated woodpecker (*Dryocopus pileatus*), North American river otter (*Lontra canadensis*), great blue heron (*Ardea herodias*), and greater roadrunner (*Geococcyx californianus*). We recorded 668 independent capture events of our focal species and an overall trap success for all predator species of 13/100 trap nights. We identified 42 incubation ranges where a picture of the same potential predator species was taken on both cameras, however, of those 42, only 4 incubation ranges had a picture of the same species on the same day, and none of them occurred in our sample window (1 April to 1 May).

Feral pigs were present at 58 camera sites, followed by coyote ($n = 50$), armadillo ($n = 44$), opossum ($n = 25$), raccoon ($n = 23$), crow and gray fox ($n = 18$), and bobcat ($n = 15$) (Figure 2.1.). Deer were ubiquitous across the landscape and were only absent from 5 sites. Passive sites had a greater estimated species diversity (1.83) than active (1.70) and random (1.59) sites.

Passive failed sites had a greater species diversity (1.53) compared to passive successful sites (1.19). Active sites had similar species diversity (failed = 1.70, successful = 1.75) as did baited and non-baited random sites (baited = 1.42, non-baited = 1.47).

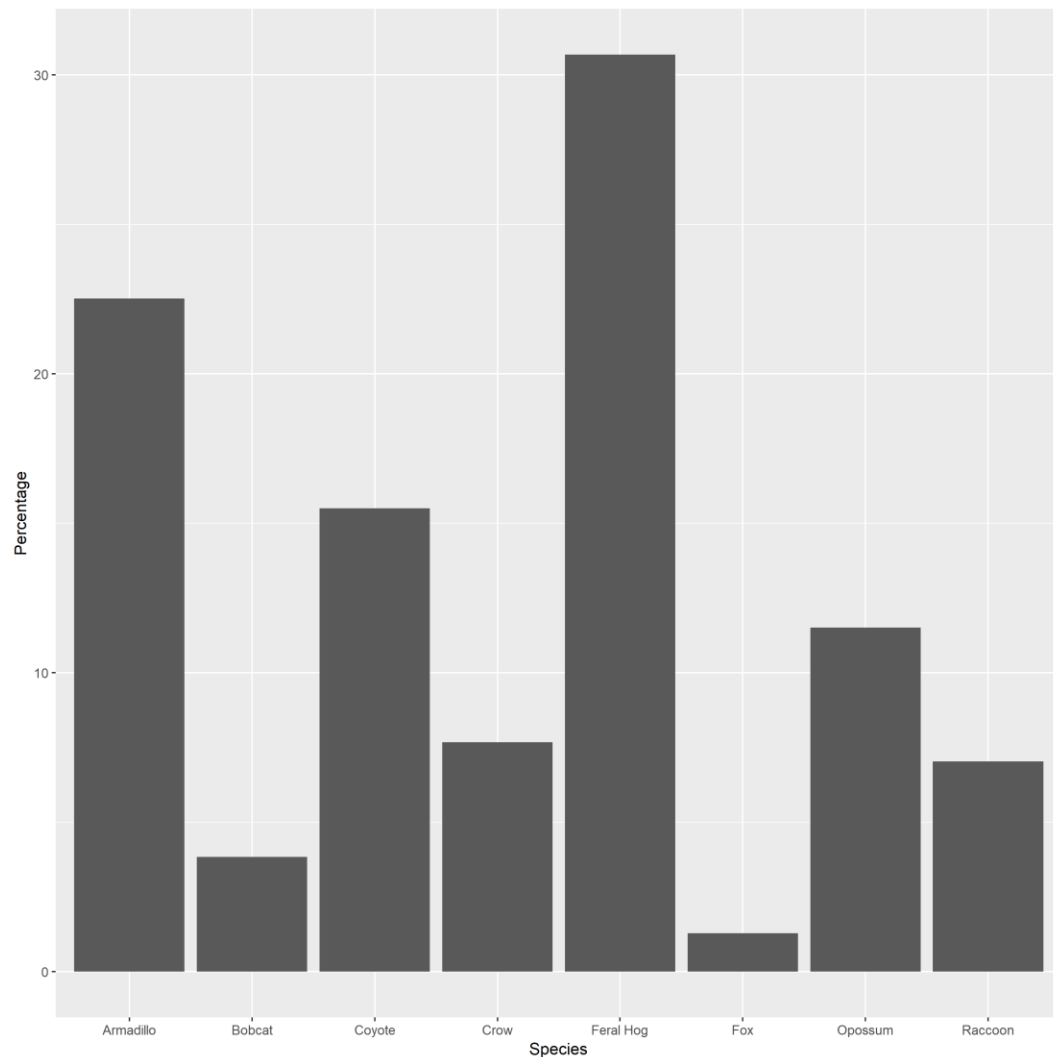


Figure 2.1. Relative percentage of all potential Eastern wild turkey (*Meleagris gallopavo silvestris*) nest predators across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019.

Feral pigs were the most abundant species photographed (3.73/100 TN), followed by armadillo (2.74/100 TN), coyote (1.88/100 TN), opossums (1.4/100 TN), crow (0.93/100 TN), raccoon (0.85/100 TN), bobcat (0.46/100 TN), and fox (0.15/100 TN) across all sites combined

(Figure 2.2). The RAI for all predator species combined varied among site categories ranging from 14.2/100 TN at passive sites, 12.7/100 TN at active sites, and 3.13/100 TN at random sites. At passive sites, the RAI at successful and unsuccessful nests was 0.66/100 TN and 13.78/100 TN, respectively. At active sites associated with successful nests and unsuccessful nests, the RAI was 1.8/100 TN and 10.4/100 TN, respectively (Figure 2.3.). At baited and unbaited random sites, the RAI was 2/100 TN and 4.3/100 TN, respectively.

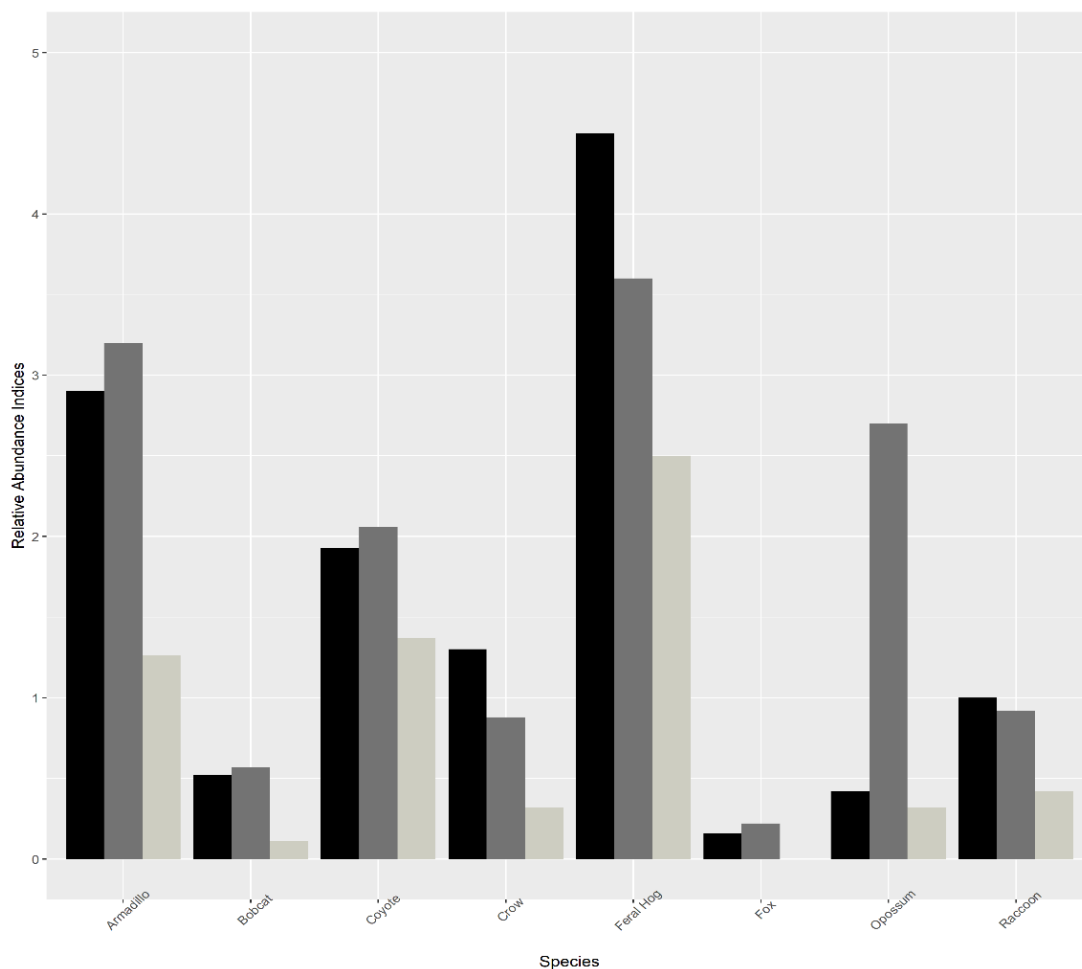


Figure 2.2. Relative abundance indices of potential Eastern wild turkey (*Meleagris gallopavo silvestris*) nest predators at active, passive, and random camera sites across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019.

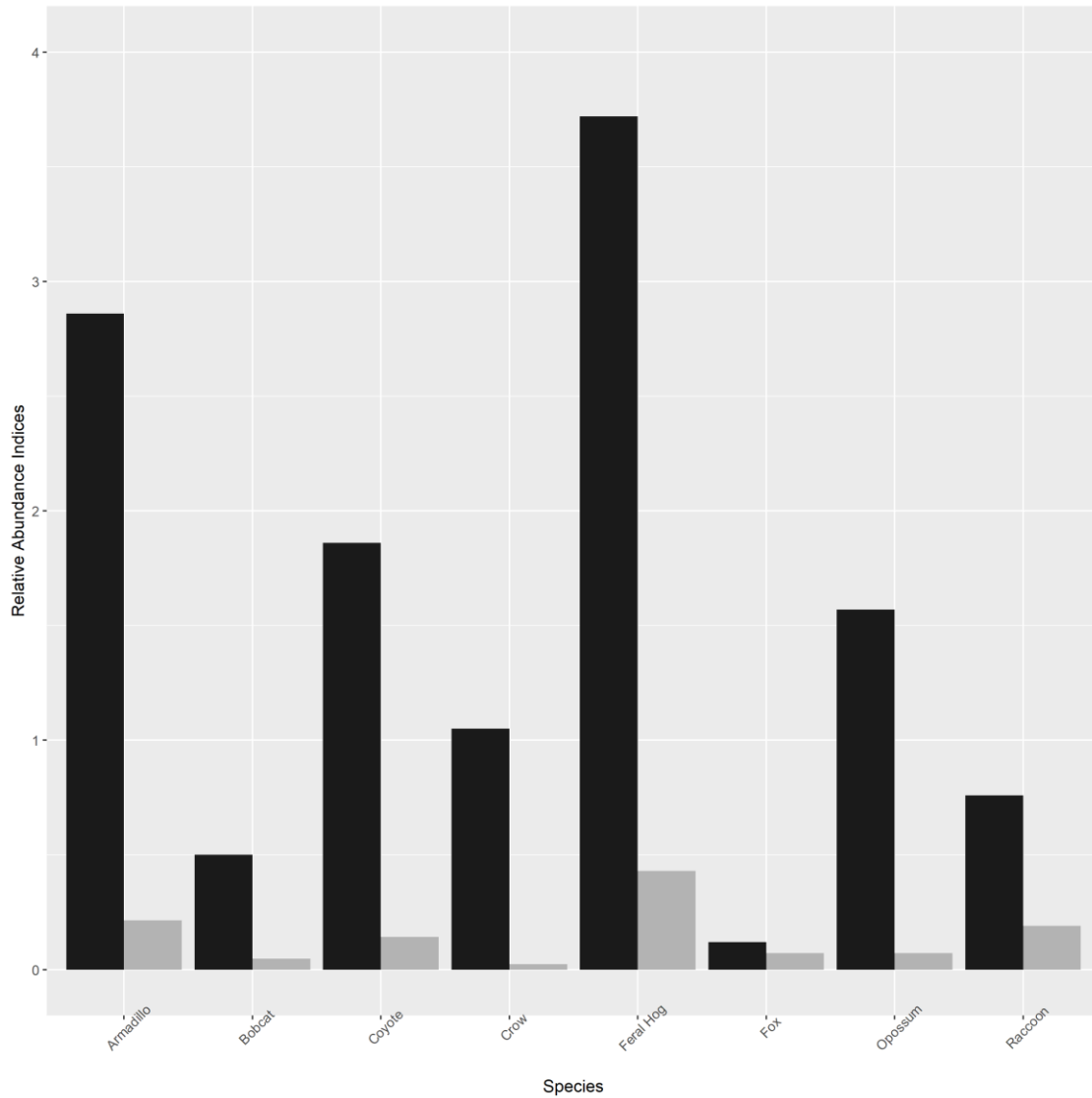


Figure 2.3. Relative abundance indices of potential Eastern wild turkey (*Meleagris gallopavo silvestris*) nest predators at unsuccessful and successful nests across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019.

The best approximating model for predicting coyote occurrence included main effects for the proportion of hardwood forest ($\beta = 31.55$, $SE = 16.71$) and NDVI ($\beta = -0.22$, $SE = 5.66$) and the interaction term ($\beta = -46.09$, $SE = 24.39$; Table 2.1.), but we observed model selection uncertainty, and noted that 2019 ΔNBR (burn severity) ($\beta = 4.31$, $SE = 2.07$) also appeared to influence coyote occurrence. Using mean estimates of hardwood forest and NDVI, our naïve

estimate of coyote occurrence was 0.376 (SE=0.054) but showed considerable spatial variation (Figure 2.4a.). Bobcat occurrence was best estimated based on road density ($\beta = -22.61$, SE = 12.30; Table 2.2.), and although there was model selection uncertainty, road density was found in the top 3 models supporting its relative importance. Using mean estimates of road density, our naïve estimate of bobcat occurrence was 0.119 (SE = 0.031) and showed little variation spatially (Figure 2.4b.).

Table 2.1. Akaike Information Criterion (AIC_c), number of parameters (K), Δ AIC, Akaike weight (w_i), and log-likelihood (LL) for candidate models used to estimate coyote (*Canis latrans*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

Occurrence model	K	AIC _c	Δ AIC _c	w_i	LL
Ψ (Hardwood Forest, May NDVI)	4	165.50	0.00	0.29	-78.58
Ψ (Burn 2019)	2	165.55	0.05	0.28	-80.73
Ψ (May NDVI)	2	165.64	0.14	0.27	-80.77
Ψ (Open)	2	169.39	3.88	0.04	-82.64
Ψ (Hardwood Forest)	2	169.83	4.32	0.03	-82.86
Ψ (Pine Forest)	2	170.00	4.49	0.03	-82.95
Ψ (Road Density)	2	170.09	4.59	0.03	-83.00
Ψ (Road Density, Open)	4	171.91	6.41	0.01	-81.79
Ψ (Road Density, Hardwood Forest)	4	173.84	8.34	0.00	-82.75

Table 2.2. Akaike Information Criterion (AIC_c), number of parameters (K), Δ AIC, Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate bobcat (*Lynx rufus*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC _c	Δ AIC _c	w_i	LL
Ψ (Road Density)	2	90.84	0.00	0.22	-43.37
Ψ (Mix Pine Hardwood Forest, Road Density)	4	90.90	0.05	0.22	-41.28
Ψ (Burn 2019, Road Density)	4	91.05	0.21	0.20	-41.36
Ψ (Burn 2019)	2	91.31	0.47	0.18	-43.61
Ψ (May NDVI)	2	93.43	2.59	0.06	-44.66
Ψ (Open)	2	94.12	3.28	0.04	-45.01
Ψ (Hardwood Forest, Road Density)	4	94.73	3.89	0.03	-43.20
Ψ (Hardwood Forest)	2	95.00	4.16	0.03	-45.45
Ψ (Hardwood Forest, May NDVI)	4	96.46	5.61	0.01	-44.06

The best approximating model for raccoon occurrence included main effects for proportion of water ($\beta = 61.93$, $SE = 29.10$) and hardwood forest ($\beta = -0.60$, $SE = 1.54$) and their interaction ($\beta = -169.1$, $SE = 83.95$; Table 2.3.). Using mean estimates of water and hardwood forest, our naïve estimate of raccoon occurrence was 0.238 ($SE = 0.058$) and showed negligible spatial variation (Figure 2.4c.). Opossum occurrence was best estimated based on 2019 prescribed burning ($\beta = 3.89$, $SE = 2.49$; Table 2.4.), but there was model selection uncertainty across the model set.

Table 2.3. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate raccoon (*Procyon lotor*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Water, Hardwood Forest)	4	116.07	0.00	0.79	-53.87
Ψ (Hardwood Forest)	2	121.43	5.36	0.05	-58.67
Ψ (Road Density)	2	121.51	5.44	0.05	-58.71
Ψ (Infrastructure)	2	122.16	6.08	0.04	-59.03
Ψ (Water)	2	122.21	6.14	0.04	-59.06
Ψ (Road Density, Infrastructure)	4	123.48	7.41	0.02	-57.57
Ψ (Water, Road Density)	4	125.14	9.07	0.01	-58.40

Table 2.4. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate opossum (*Didelphis virginiana*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Burn 2019)	2	125.70	0.00	0.41	-60.80
Ψ (Infrastructure)	2	126.58	0.88	0.26	-61.24
Ψ (Hardwood Forest, Infrastructure)	4	127.71	2.01	0.15	-59.68
Ψ (Road Density)	2	127.85	2.15	0.14	-61.88
Ψ (Road Density, Infrastructure)	4	130.06	4.36	0.05	-60.86

Using mean burn severity, our naïve estimate of opossum occurrence was 0.150 ($SE = 0.044$) and showed only slight spatial variation (Figure 2.4d.). Armadillos were ubiquitous on the landscape and occurrence was best predicted by infrastructure ($\beta = -6.07$, $SE = 3.84$; Table 2.5),

and we estimated a naïve estimate of armadillo occurrence of 0.361 (SE = 0.044) and also found limited spatial variation across the landscape (Figure 2.5a.). Gray fox occurrence was best described using the proportion of hardwood forest ($\beta = -12.98$, SE = 8.66; Table 2.6) and our naïve estimate of gray fox occurrence was 0.005 (SE = 0.009) which varied little spatially (Figure 2.5b.).

Table 2.5. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC_c , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate armadillo (*Dasypus novemcinctus*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Infrastructure)	2	161.24	0.00	0.58	-78.57
Ψ (Road Density)	2	163.81	2.57	0.16	-79.85
Ψ (Road Density, Infrastructure)	4	163.81	2.58	0.16	-77.74
Ψ (Hardwood Forest, Infrastructure)	4	164.93	3.70	0.09	-78.30

Table 2.6. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC_c , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate gray fox (*Urocyon cinereoargenteus*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Hardwood Forest)	2	40.28	0.00	0.59	-18.09
Ψ (Open, Road Density)	4	42.66	2.38	0.18	-17.16
Ψ (Open, Hardwood Forest)	4	43.99	3.71	0.09	-17.83
Ψ (Mix Pine Hardwood Forest)	2	45.48	5.19	0.04	-20.69
Ψ (Open)	2	45.76	5.48	0.04	-20.83
Ψ (Burn 2019)	2	45.91	5.62	0.04	-20.90
Ψ (Infrastructure, Road Density)	8	46.84	6.56	0.02	-14.79

Feral pig occurrence was best estimated by the proportion of hardwood forest ($\beta = 1.49$, SE = 0.97), open landcover ($\beta = 0.81$ (SE = 2.60), and their interaction ($\beta = 55.37$, SE = 30.12; Table 2.7.). Feral pigs were ubiquitous on the landscape, and our naïve estimate of occurrence was 0.661 (SE = 0.092) although feral pigs were predicted to occur primarily in riparian corridors (Figure 2.5c). Crow occurrence was best estimated based on road density ($\beta = -36.49$, SE =

23.34), proportion of pine forest ($\beta = -3.24$, $SE = 1.39$) and their interaction ($\beta = 78.12$, $SE = 35.18$; Table 2.8.).

Table 2.7. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC_c , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate feral pig (*Sus scrofa*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Hardwood Forest, Open)	4	166.34	0.00	0.66	-79.00
Ψ (Pine Forest)	2	169.39	3.05	0.14	-82.64
Ψ (Pine Forest, Open)	4	170.90	4.56	0.07	-81.28
Ψ (Hardwood Forest)	2	171.61	5.27	0.05	-83.75
Ψ (Mix Pine Hardwood Forest)	2	172.73	6.39	0.03	-84.32
Ψ (Hardwood Forest, Water)	4	173.61	7.27	0.02	-82.63
Ψ (Road Density, Hardwood Forest)	4	173.88	7.54	0.02	-82.77
Ψ (Burn 2019)	2	174.15	7.81	0.01	-85.02
Ψ (Mix Pine Hardwood Forest, Road Density)	4	174.24	7.90	0.01	-82.95

Table 2.8. Akaike Information Criterion (AIC_c), number of parameters (K), ΔAIC_c , Akaike weight (w_i), log-likelihood (LL) for candidate models used to estimate crow (*Corvus brachyrhynchos*) occurrence at Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

Occurrence model	K	AIC_c	ΔAIC_c	w_i	LL
Ψ (Road Density, Pine Forest)	4	101.86	0.00	0.40	-46.76
Ψ (May NDVI)	2	102.57	0.71	0.28	-49.24
Ψ (Open)	2	104.45	2.59	0.11	-50.18
Ψ (Mix Pine Hardwood Forest, Open)	4	105.15	3.29	0.08	-48.41
Ψ (Road Density, Mix Pine Hardwood Forest)	4	105.29	3.43	0.07	-48.47
Ψ (Mix Pine Hardwood Forest)	2	105.87	4.01	0.05	-50.89

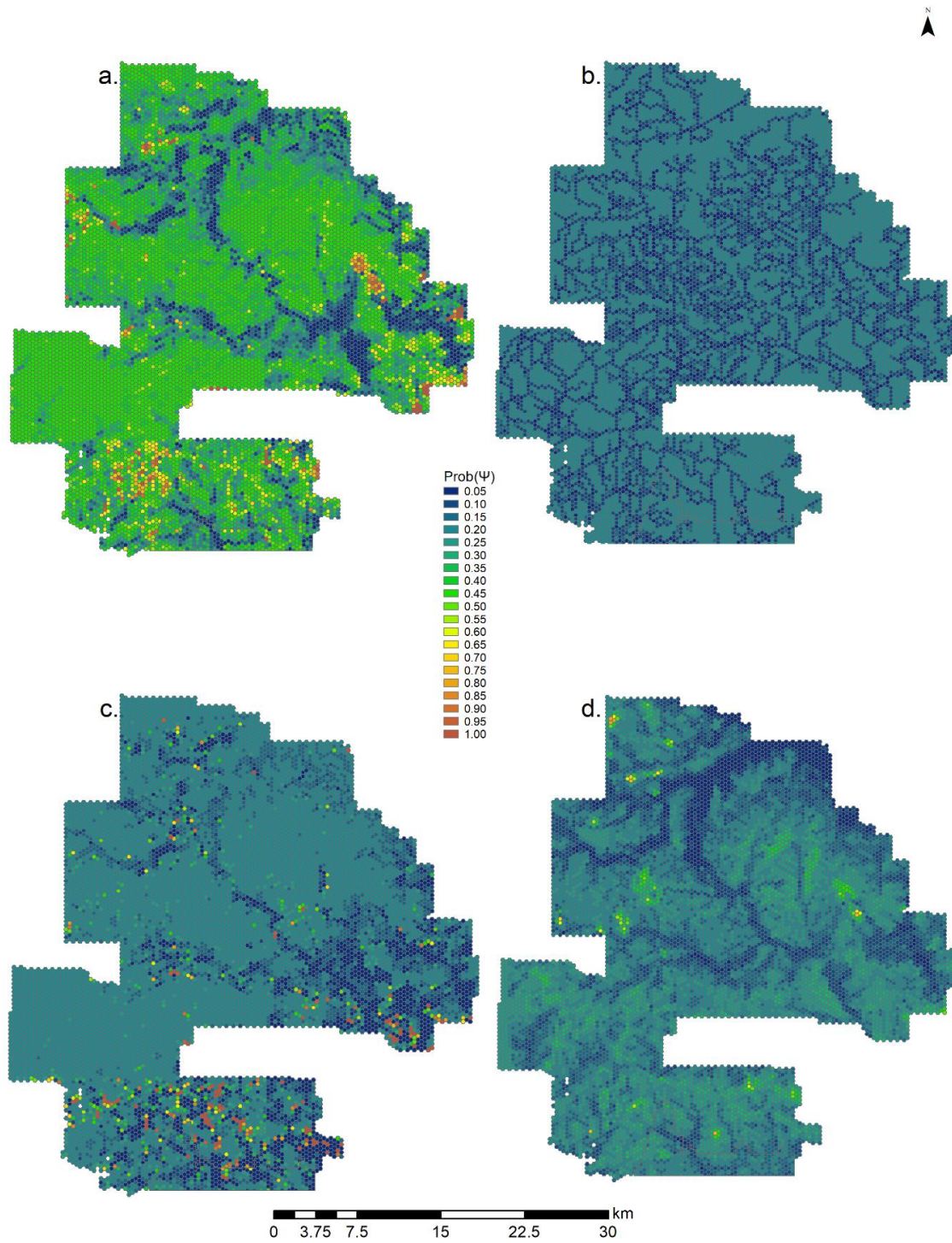


Figure 2.4. Predicted mean occurrence of nest predators across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019. (a) Coyote (*Canis latrans*), (b) Bobcat (*Lynx rufus*), (c) Raccoon (*Procyon lotor*), and (d) Opossum (*Didelphis virginiana*) based on the best fitting candidate models.

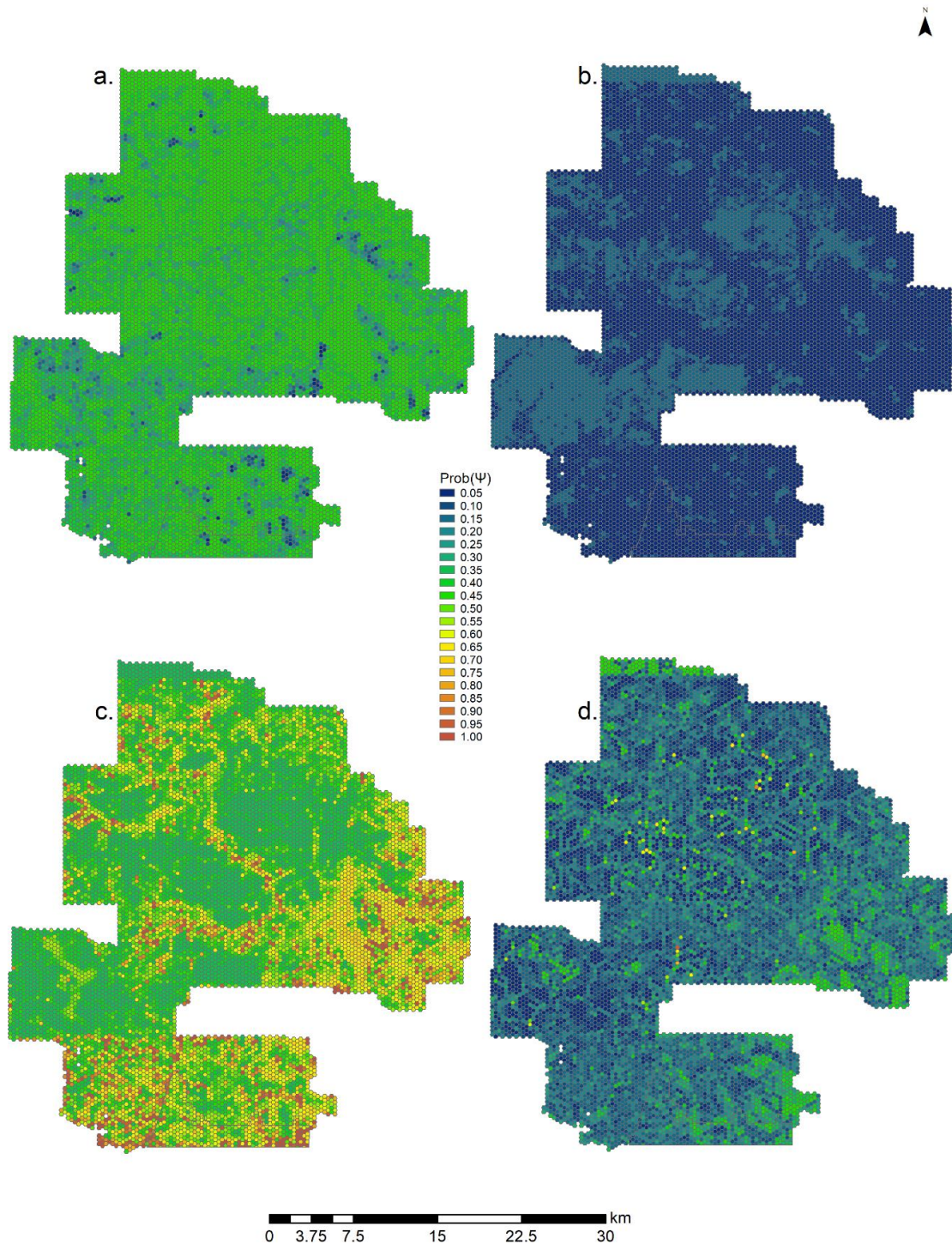


Figure 2.5. Predicted mean occurrence of nest predators across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019. (a) Armadillo (*Dasypus novemcinctus*), (b) Fox (*Urocyon cinereoargenteus*), (c) Feral pig (*Sus scrofa*), and (d) Crow (*Corvus brachyrhynchos*) based on the best fitting candidate models.

Our naïve estimate of crow occurrence was 0.126 (SE = 0.033) which varied considerably spatially (Figure 2.5*d*.). For the 4 species that were present within the most incubation ranges (feral pigs, coyote, armadillo, opossum), successful nests were typically found in areas wherein each species were predicted to have a <0.50 probability of occurrence (Figure 2.6.).

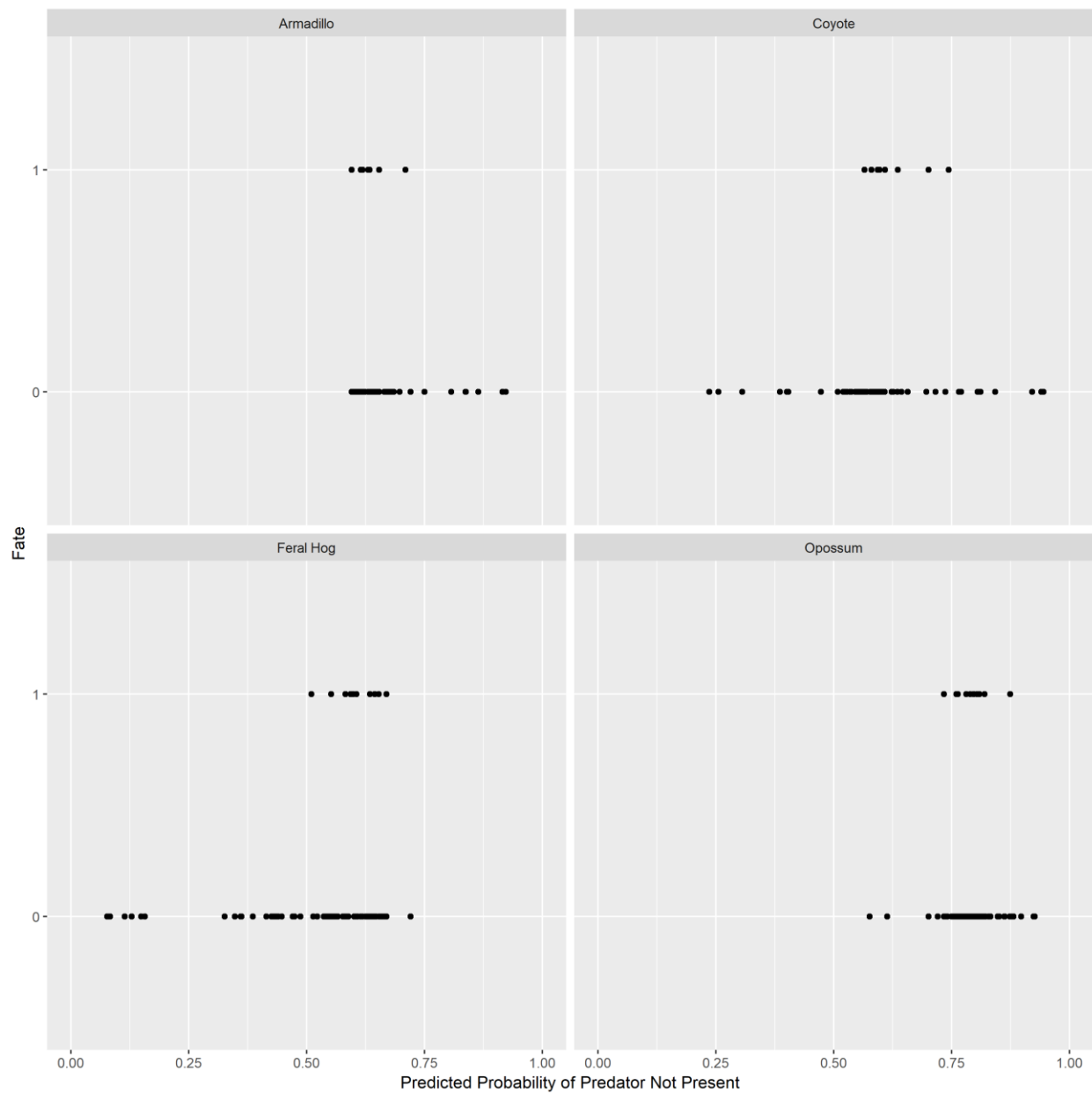


Figure 2.6. Nest success by predicted occurrence probability for the 4 most common potential nest predators across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during 2019.

2.5. Discussion

We observed that potential nest predator species were widely distributed and regularly occurred within the nesting areas (Conley et al. 2015, Bakner et al. 2019) used by reproductive active wild turkeys. Nest success in our study (9% and 13% for 2018 and 2019, respectively) was slightly lower than recent estimates across the southeastern United States (21%, Chamberlain et al. 2020). We found that successful nesting areas (both passive and active) had lower indices of predator abundance than unsuccessful nesting areas. Interestingly, relative abundance estimate for potential predator species at random sites was higher for unbaited than baited sites. Across species, the RAI was generally low with all species having a $RAI > 5/100$ TN. We note, however, that no part of our study was a convenience sample wherein cameras were located within known predator use areas, within specific habitats such as along roads or trails (O'Brien 2011, O'Connell and Bailey 2011, Burton et al. 2015). Rather, our work evaluated the landscape where wild turkeys selected to nest, or at random locations across our study sites. Thus, our use of random locations provided an unbiased estimate of potential predator occurrence, and we note that our findings were lower than values published in contemporary studies across North America (Gompper et al. 2006, Kelly and Holub 2008).

We observed that passive sites (nesting areas from 2018 monitored in 2019) had greater diversity of nest predators than active sites (nesting areas from 2019 surveyed in 2019). It is plausible that the use of predator attractant at passive sites increased visitation to passive sites (Linhart and Knowlton 1975, Linscombe et al. 1983). We assumed the predator attractant was no more noticeable to potential predators than the availability of a nesting wild turkey, however we admit our assumption is tenuous as information on wild turkey accessibility due to scent is unknown. However, baited and unbaited random sites had similar estimates of predator diversity,

which may indicate that presence of a predator attractant did not bias our estimates of predator diversity. We note, however, that one limitation to our study was our inability to quantify RAI for snakes, as we were focused on predator occurrence within a broader scale (Conley et al. 2015) beyond simply the nest site. Snakes represent an important predator of ground nesting birds (Patten and Bolger 2003), and snakes are known to depredate wild turkey nests (Dreibelbis et al. 2008, Dreibelbis et al. 2011).

Based on our results for RAI, our work suggests that the most important factor impacting a nest's outcome may be the spatial placement of the nest on the landscape relative to use by potential predator species. For several species, the modeled habitat-relationships indicated that there were areas of our study site that were predicted to have high occurrence of certain potential predator species. For example, both coyotes and feral pigs had strong positive relationships with hardwoods availability, and weaker effects of and vegetation density and open habitats, respectively. Hardwoods on our study sites were primarily found in riparian areas, and provide access to potential food sources and flooded areas used by feral pigs (Hayes et al. 2009). Coyotes, alternatively, tended to avoid areas of dense vegetation and were positively associated with burned stands consistent with previous work (Hinton et al. 2015, Cherry et al. 2016b, Stevenson et al. 2018). Wild turkeys on our study sites are known to select upland areas and burned stands during nesting, that are often interspersed with riparian corridors (Yeldell et al. 2017, Bakner et al. 2019, Cohen et al. 2019). Both coyotes and feral pigs are ubiquitous and widely distributed within the landscape we studied, and while there is significant evidence of coyote predation on wild turkey nests, feral pig depredation of active wild turkey nests is rare and is typically tied to secondary predation events (Dreibelbis et al. 2008, 2011, Melville et al. 2014). We note 2 specific caveats regarding coyotes and feral pigs, in that 1) our estimates of

occurrence could be biased low as coyotes are known to avoid cameras (Séquin et al. 2003, Gompper et al. 2006, O'Connell et al. 2006) and 2) the high RAI for feral pig observations is likely related to group size and sociality present in feral pigs that are not present in the other potential predator species. Feral pigs are gregarious within matrilineal groups (sounders) but exhibit territoriality amongst groups (Sparklin et al. 2009). By default, numerous unique individuals could be detected simultaneously at our camera sites, which would not occur for solitary species such as bobcats (Benson et al. 2006) or even for cooperative breeding species such as coyotes (Ward et al. 2018).

Our spatial prediction models indicate that a wide suite of potential nest predators are regularly occurring with the incubation range across our study sites. We note that our analysis provides some support that successful nests are found in regions with a lower probability of occurrence for the ubiquitous potential predator species on the landscape. Contemporary research has indicated that vegetation at nest sites has limited use in predicting nest success (Borgo and Conover 2016, Dreibelbis et al. 2016, Bakner et al. 2019). Our results suggest that vegetative characteristics within incubation ranges may influence predator behaviors and thus influence nest success. We also note, however, that our spatial metrics were derived via 30 m resolution satellite imagery, and therefore are coarse relative to vegetation conditions that could be identified via LIDAR or 1-m resolution imagery.

Raccoons, foxes, and bobcats have regularly been identified as wild turkey nest predators (Schwertner et al. 2004, Dreibelbis et al. 2008, 2011, Fyffe et al. 2018). Raccoons prefer heterogeneous landscapes (Byrne and Chamberlain 2015) and typically select hardwood stands and areas adjacent to water because of foraging opportunities and available den sites (Chamberlain et al. 2002; 2003, Byrne and Chamberlain 2011) which was generally supported

by our results. Gray fox and bobcat occurrence was low and was negatively associated with proportion of hardwood forests and density of roads within incubation ranges, respectively. Previous works have shown that foxes are known to avoid coyotes (Chamberlain and Leopold 2005), due both to competition for foraging resources and direct interference competition between the species (Fedriani et al. 2000, Chamberlain and Leopold 2002). The negative relationship between gray fox occurrence and proportion of hardwood forest may be related to spatial avoidance of coyotes. Bobcat avoidance of roads is consistent with previous studies that found bobcat occurrence increased in areas with fewer roads (Lovallo and Anderson 1996, Lesmeister et al. 2015), although roads can be important for bobcats (Little et al. 2018), presumably for use as travel corridors (Conner and Leopold 1998). We note that our work only included secondary USFS roads, and did not include maintained but primitive roads used for private lands access, which can provide travel corridors and edge habitats bobcats are known to select (Chamberlain et al. 2003).

As such, based on our work, we suggest that spatial placement of the nest on the landscape may be fairly informative to the likely probability of nest success, perhaps in conjunction with female behavioral activities (Bakner et al. 2019, Lohr et al. 2020). Additionally, as behavioral and movement ecology of most potential predatory species is unknown relative to actively nesting wild turkeys, there remains the need to better categorize space use by potential predator species during the reproductive season to quantify interactions between potential nest predators and nesting females. We found that known nest predator species occur frequently within the incubation ranges used by wild turkeys. However, although the relative abundance of nest predators was similar for active and passive sites, relative abundance was much lower at random sites. Potential predator species were widespread within incubation

ranges, however, the number of predators occurring, or abundance, within incubation ranges, did not adequately define nest success. One of the primary limitations managers face when addressing nest success is the lack of understanding of how wild turkeys and potential wild turkey nest predators use space during the reproductive period. We suggest that future work on wild turkey nest success incorporate behavioral ecology of both wild turkeys and potential nest predators such that further details on the mechanisms underlying drivers of interactions on the landscape be identified.

CHAPTER 3. REPRODUCTIVE ASYNCHRONY AND SOCIAL RANK IN FEMALE WILD TURKEY BREEDING

3.1. Introduction

Social information plays an important role in the distribution of wildlife across the landscape. Wildlife derive information on resource availability from the occurrence of individuals (Danchin et al. 2004), and the performance of conspecifics and heterospecifics, wherein habitat patches conferring improved fitness attract more individuals (Doligez et al. 2002, Campomizzi et al. 2008). Congregation of individuals within resource patches is often driven by conspecific attraction (Stamps 1988). As such, clustering of species during the reproductive period has shown positive fitness benefits via information transfer on resource availability, predation risk, and mate availability (Alexander 1974, Forbes and Kaiser 1994, Danchin et al. 1998). Thus, social information is a known determinant of reproductive decisions and underlies the coordination of the timing of reproduction (Brandl et al. 2019).

Coordination in timing of reproduction is driven by resource availability for a wide array of species (Lack 1968, Perrins 1970) as optimization of reproductive success hinges on matching the reproductive activities with ecological conditions (Ims 1990a). As such, temporal clustering of reproductively active individuals is typically driven by climatic seasonality (Ims 1990a), especially when breeding seasons are restricted to shorter temporal periods (Emlen and Demong 1975, Findlay and Cooke 1982). The availability of social information, which underlies spatial clustering, can influence temporal clustering (Helm et al. 2006) and certain life history events (migration, reproduction) are inherently temporally clustered (Lack 1968, Gochfeld 1980). Monogamous species regularly demonstrate a high degree of reproductive synchrony (Emlen and Oring 1977, Gochfeld 1980) as male investment in courtship limits extra-pair reproductive

activities (Grant and Kramer 1992) with the consequence being synchronized reproductive activities (Knowlton 1979). Colonial birds consistently demonstrate high degrees of clustered parturition, (Darling 1938, Lack 1968, Gochfeld 1980), as individuals synchronize reproduction to simultaneously reproduce (Gochfeld 1980), resulting in higher rates of nest success (Di Maggio et al. 2013) by reducing offspring mortality (Darling 1938). However, in non-monogamous systems, social rank may dictate breeding access of individuals within a local population (Robel and Ballard 1974, Foster 1981). Typically, higher ranked males copulate with more females (Robel 1970), creating a strong reproductive skew (Mackenzie et al. 1995). When high-ranking males can more effectively monopolize access to females, asynchronous breeding is predicted to occur (Webster 1994). Thus, asynchronous breeding may disproportionately affect fitness amongst individuals, potentially increasing fitness of higher ranking individuals and decreasing fitness of lower ranking individuals.

The eastern wild turkey (*Meleagris gallopavo silvestris*; hereafter, wild turkey) has a complex social structure, wherein flocks exhibit social hierarchies where the highest ranking individual dominates others and the lowest ranking individual dominates none (Watts and Stokes 1971, Eaton 1992, Healy 1992). The establishment of dominance hierarchies occurs through agonistic interactions within cohorts (Healy 1992) and rank seldom changes as long as the dominant bird survives (Watts and Stokes 1971). Male and female wild turkeys maintain separate social hierarchies within and between flocks (Healy 1992) and ranking is typically defined by the age of the individual (Watts and Stokes 1971). Wild turkeys use a male dominance polygynous mating system wherein males communicate with females via elaborate courtship display and vocalizations (Healy 1992). The establishment of dominance hierarchies determines access to mates for both sexes (Emlen and Oring 1977, Williams and Austin 1988).

In species that maintain social hierarchies, higher-ranking females may prevent subordinate females from gaining access to the preferred male, giving themselves advantages associated with early nesting (Robel and Ballard 1974). Additionally, if initial nest attempts of higher-ranking females initial nest attempts fail quickly, renesting attempts should be synchronized with that of lower ranked females laying initial nests. This would potentially increase renest success due to greater numbers of nests on the landscape simultaneously, thereby contributing to swamping predator populations (Imms 1990b, O'Donoghue and Boutin 1995, Sweeney and Vannote 1982).

We evaluated reproductive synchrony within and between presumed social groups of GPS tagged female Eastern wild turkeys by inferring an individual's social rank based on reproductive timing (Watts and Stokes 1971, Healy 1992). We hypothesized that the social rank of dominant females, inferred from the onset of nest initiation, would influence the timing of reproduction in subordinate females. We predicted that dominant females would nest first, and when their initial nest failed, would rejoin her previous social group and reinsert herself in the reproductive hierarchy over remaining subordinate females attempting to mate. Therefore, dominant females who nested first would be more likely to have subsequent renest attempts before likely subordinate females attempted their first nest.

3.2. Study area

We conducted research on the Kisatchie National Forest (KNF) and Peason Ridge WMA in west central Louisiana. Kisatchie National Forest is owned and managed by the United States Forest Service (USFS) and is divided into 5 Ranger Districts. We conducted research on the Catahoula Ranger District, Kisatchie Ranger District, Winn Ranger District, and the Vernon unit of the Calcasieu Ranger District located in Grant, Natchitoches, Winn, and Vernon parishes, respectively. Peason Ridge WMA is jointly owned by the USFS and the US Army. The spatial

area of Catahoula Ranger District, Kisatchie Ranger District, Winn Ranger District, Vernon unit, and Peason Ridge WMA area were approximately 49,169 ha, 41,453 ha, 67,408 ha, 61,202 ha, and 74,309 ha, respectively. Our study sites were composed of pine-dominated forests encompassing rolling hills, high ridges, and sandy creek bottoms. Vegetative communities consist of loblolly pine (*Pinus taeda*), longleaf pine (*P. palustris*), short leaf pine (*Pinus echinata*), slash pine (*Pinus elliotti*), mixed pine hardwood forests, and hardwood riparian areas. Our sites contained forest openings, utility rights-of-way, and forest roads distributed throughout (Yeldell et al. 2017). Rural infrastructure, agricultural fields, pasture, and privately-owned lands used for industrial timber bordered our study sites. Prescribed fire was applied on a 3–5 year return interval (Cohen et al. 2019). The study sites experienced subtropical climates with mean daily temperatures ranging from a low of 9.4°C in January to 28.3° C in July, and a mean rainfall of approximately 114 cm.

3.3. Methods

We captured male and female wild turkeys using rocket nets baited with cracked corn from January – March 2014–2019. We classified each individual as a sub adult or adult based on presence of barring on the ninth and tenth primary feathers (Pelham and Dickson 1992). All females were fitted with a uniquely identifiable aluminum rivet tarsal band and backpack style GPS/VHF transmitter (Biotrack Limited, Wareham, Dorset, UK; Guthrie et al. 2011). Backpack GPS units were programmed to collect data at 1-hour intervals (Cohen et al. 2018) between 05:00 to 20:00 daily with one location at night (23:59:58) to identify roosts until the battery died or the unit was recovered. We immediately released individuals at the capture location following processing. Capture, handling, and marking procedures were approved by the Louisiana State University Agricultural Center Animal Care and Use Committee (Permit A2015-07 and permit

A2018-13). We monitored live-dead status daily during the reproductive season using handheld Yagi antennas and Biotracker receivers (Biotrack Ltd., Wareham, Dorset, UK). We downloaded GPS locations once per week via a VHF/UHF handheld command unit receiver (Biotrack Ltd., Wareham, Dorset, UK).

When winter flocks disband, social groups of wild turkeys alter space use and focus efforts on reproduction (Badyaev et al. 1996b, Thogmartin 2001). We assumed that all females within a social group had access to the same mates, and presumably the same dominant males. Therefore, we defined a breeding group as a group of females captured together during January to March as GPS data indicated that turkeys did not disperse from wintering flocks before reproduction started, contrary to work by Badyaev et al. (1996a). While we defined females captured together as a breeding group, and we acknowledge that we may not have captured all of the females in the same breeding group. We assumed, based on estimates of daily movements by females (Conley et al. 2016, Bakner et al. 2019), that individuals captured within 2 km of each other were members of the same breeding group as these individuals have been shown to regularly interact. To further ensure we accurately defining breeding groups, we used a dynamic Brownian Bridge movement model (dBBMM) to create 99% utilization distributions (UDs) for each individual for the 21 before the first female in each breeding group laid her first egg (Byrne et al. 2014). We chose to use the 21 day window before the first female of each breeding group laying her first egg because we were interested in overlap in space use during the time immediately preceding initiation of the first nest by the presumed dominant female. We calculated all UD in program R version 3.2.5 (R Core Development Team 2020) using package move (Kranstauber and Smolla 2013). We used a window and margin size equal to 21 and 9 respectively, and a location error of 10 m (Byrne et al. 2014). Individuals that share space constitute a single social unit (Brown

1975), therefore we calculated the percentage of utilization distributions that overlapped at least one other UD within a defined breeding group during the 21 day period to quantify shared space use (Kernohan et al. 2001). We assumed that any individuals with a range that did not overlap at least one other range within her breeding group or individuals within subgroups were of lower rank and as such should subsequently nest later. We defined subgroups as smaller groups within breeding groups containing 2–3 individuals with ranges that did not overlap with the main breeding group and only overlapped ranges within the subgroup (Figure 3.2.).

We determined locations of each nesting attempt for each female when an individual's locations became concentrated around a single point for several days (Guthrie et al. 2011, Conley et al. 2015, Yeldell et al. 2017, Wood et al. 2019). We defined the first date of nest incubation as the first day we recorded the nightly roost location at the nest site, indicating the female continued incubation during the night (Bakner et al. 2019). To determine the first date of egg laying which we defined as nest initiation, we evaluated GPS locations to establish when a female initially visited her nest site as female wild turkeys do not visit their nest site until they lay their first egg (Conley et al. 2016). We monitored each nesting attempt following Bakner et al. (2019) and after nest termination, located nest sites using VHF telemetry and GPS data to confirm the nest location and determine nest fate. We considered a nest to have been depredated or abandoned if the female left the nest ≤ 25 days into incubation, or if only intact eggs, no eggs, or egg fragments were found at the nest bowl. We considered a nest successful if ≥ 1 live poult hatched, and was confirmed visually during subsequent brood surveys (Chamberlain et al. (2020)).

We scaled the initiation date of the first nest attempt to each breeding group, where the date of the first nest initiation was noted as day 1. We delineated subsequent nest attempts based on

the number of days after the 1st nest was initiated. We subtracted the initiation day of the second nest from the initiation day of the first nest, and then subtracted the initiation day of the third nest from the initiation day of the second nest, and so on for each first nest attempt within each breeding group. We calculated the mean number of days between each nest initiation attempt within each breeding group. We predicted that breeding groups with more individuals would have more days between subsequent nest attempts compared to smaller breeding groups. Presumably, larger groups would contain more females competing to copulate with the dominant male, whereas smaller groups would have less competition and thus be able to copulate in a shorter temporal window, and subsequently initiate nests in a similar window.

Females that attempt reproduction earlier within a season are expected to have greater annual reproductive success compared to later breeding individuals (Lack 1968, Perrins 1970) and previous research has noted that in lekking birds the dominant females breed first (Foster 1983, Robel and Ballard 1974). Dominant females presumably would have the opportunity to select nest sites that can confer improved fitness through nest success (Sæther 1990, Martin 1995a, Martin 1995b), compared to subordinate females that nest later and may be forced to travel further distances to find available areas to nest. Therefore, we predicted that females that mated first, based on nest initiation dates, would travel shorter distances from the centroid of their 21 day range prior to nest initiation to their nest location. To test our prediction, we used the distance between a female's nest location and the centroid of the UD range of the 21-day period before the first nest of each breeding group was initiated as our metric. We measured the distance between the centroid of each female's 99% UD range to each of her nest attempts in ArcGIS 10.6 (Environmental Systems Research Institute, Inc., Redlands, California, USA; Figure 3.1.). To locate the centroids of each females 99% UD, we calculated the x and y centroid

of each UD in the attribute table. We then created a line between each nest attempt and the centroid and calculated the distance between each nest attempt and 99% UD.

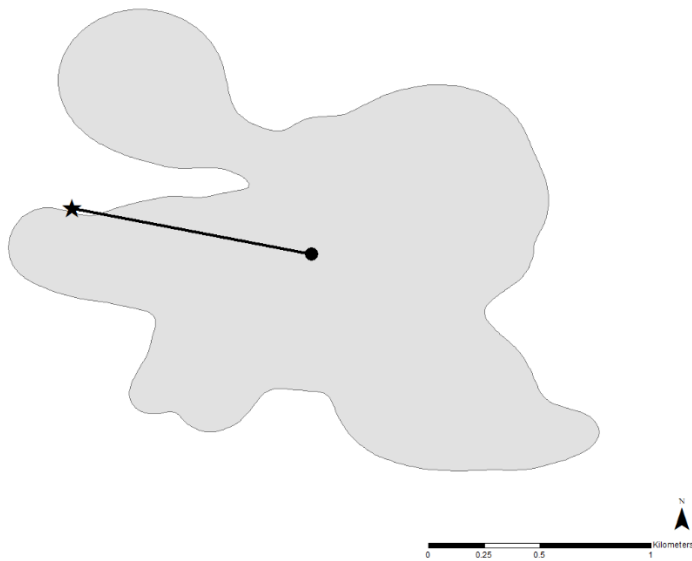


Figure 3.1. Straight-line distance between the centroid (black dot) of female 46478's 99% utilization distribution and her nest attempt (star) on the Kurthwood section of Peason Ridge WMA, Louisiana during 2019.

We used a binomial generalized linear model (GLM) in R (R Core Team 2020) to estimate nest success as a function of first nest initiation date, and used a Poisson GLM to estimate the rate (in days) at which female wild turkeys left their individual breeding groups and initiated their first and second nesting attempts as a function of group size, year, and site.

3.4. Results

We captured and radio-marked 225 female turkeys (201 adults, 24 juveniles) during 2014-2019. We monitored 245 nesting attempts (158 first nest attempts, 69 second nest attempts, 17 third nest attempts, and 1 fourth nest attempt) from 158 females during the 2014-2019 reproductive season. There were 30 breeding groups with an average of 7 females per group (Table 3.1.). Across all breeding groups and years, mean proportion of individual ranges during

the 21 day period prior to first nest initiation that did not overlap was 7.18%. We identified subgroups of 2–3 females separating from 6 defined breeding groups (Figure 3.2.). Within breeding groups $\geq 80\%$ of female ranges overlapped during the 21 day period prior to nest initiation (Figure 3.3.). Mean distance from 21 day range centroid to the subsequent nest location ranged from 974 to 6403 m (Table 3.1.) and averaged 2107 m (SD=2131) over all females. Mean distance from 21 day range centroid to the subsequent nest location for successful nests was 1743 m (SD = 1175) and 2154 m (SD = 2236) for failed nest attempts and was not statistically different ($t = -1.28$, $df = 46$, $P = 0.205$). We identified 15 instances of females who's initial nest failed, followed by their rejoining the initial breeding group, and ultimately appearing to reinsert themselves into the reproductive hierarchy over remaining subordinate females that had not initiated a nest.

Table 3.1. Number of female wild turkeys within each breeding group (s), number of nesting attempts (n), number of first (A.1), second (A.2), third (A.3), and fourth (A.4) nesting attempts, mean date of first nest initiation, median date of first nest initiation, range of dates of first nest initiation, mean number of days between first nest attempts, mean distance between each nest location and the centroid of 99% utilization distributions 21 days prior to the first nest attempt range of each female wild turkey (*Meleagris gallopavo silvestris*) by breeding group across Kisatchie National Forest and Peason Ridge WMA in west-central Louisiana, USA during 2014–2019.

Year	Breeding Group	s	n	A.1	A.2	A.3	A.4	Mean Initiation Date (SD)	Median Initiation Date	Range of Initiation Dates	Mean Days Between First Nest Attempts	Mean Distance Between Nests and Centroid (m)
2014	Anthill	9	9	5	4	0	0	23 April (5.12)	21 April	4/17 – 4/29	3 (3.16)	2883.79
	Beasley	7	7	4	2	1	0	13 April (17.51)	10 April	3/28 - 5/5	12.67 (7.57)	3493.68
	FS 329	7	6	4	2	0	0	23 April (5.85)	23 April	4/17 – 5/1	4.67 (1.53)	983.12
	South Gum Springs	3	5	2	1	1	1	13 April (6.36)	13 April	4/9 – 4/18	9	2895.87
	MM 26	2	2	2	0	0	0	6 May (5.66)	6 May	5/2 – 5/10	8	1234.13
	W70D	4	5	3	2	0	0	12 April (3.51)	12 April	4/9 – 4/16	3.5 (0.71)	1767.23
2015	Blue Hole	7	5	4	1	0	0	14 April (17.23)	15 April	3/25 – 5/3	13 (3)	3754.62
	Corral Camp	4	5	3	2	0	0	3 April (6.43)	1 April	3/30 – 4/11	6 (5.67)	2709.09
	Packton	3	3	2	1	0	0	3 April (8.49)	3 April	3/28 – 4/9	12	2093.83
	Posted Plot	8	14	7	4	3	0	5 April (8.70)	7 April	3/20 – 4/15	4.3 (3.33)	1912.91

(table cont'd)

Year	Breeding Group	s	n	A.1	A.2	A.3	A.4	Mean Initiation Date (SD)	Median Initiation Date	Range of Initiation Dates	Mean Days Between First Nest Attempts	Mean Distance Between Nests and Centroids (m)
2016	K10Massey	9	12	9	3	0	0	23 April (16.20)	1 May	4/9 – 5/1	5.25 (5.97)	2227.73
	Pipeline	3	3	2	1	0	0	9 April (20.51)	9 April	3/26 – 4/24	29	2680.97
	Sammy Edwards	9	6	5	1	0	0	24 April (10.40)	28 April	4/9 – 5/1	7.3 (8.08)	1696.89
	VanWest	6	4	3	1	0	0	30 April (14.47)	8 May	4/24 – 5/10	13 (15.56)	1293.28
2017	309	13	15	11	3	1	0	1 April (7.86)	1 April	3/19 – 4/15	2.7 (2)	1179.05
	AR Dowden	12	16	10	6	0	0	4 April (15.05)	29 March	3/20 – 5/5	5.11 (5.95)	2741.72
	Corral Camp	5	8	5	3	0	0	25 March (9.07)	29 March	3/12 – 4/5	6 (4.24)	1939.59
	Donna Reed Field	9	8	6	1	1	0	15 April (8.52)	15 April	4/2 – 4/27	5 (3.94)	6402.55
	Food Trough	3	5	3	2	0	0	19 April (10.26)	22 April	4/8 – 4/28	10 (5.66)	1420.76
	Sonny Martin	9	7	6	1	0	0	11 April (8.45)	8 April	4/2 – 4/23	4.2 (3.63)	973.98
2018	130	6	8	5	3	0	0	10 April (10.11)	8 April	3/29 – 4/26	7 (6.78)	1436.55
	304	13	12	7	4	1	0	19 April (15.99)	26 April	3/27 – 5/8	7 (6.16)	1554.60
	330	11	10	8	1	1	0	22 April (13.36)	22 April	4/8 – 5/15	5.29 (4.07)	1329.59
	CO39D	3	3	3	0	0	0	24 March (14.85)	24 March	3/14 – 4/4	21	1637.19

(table cont'd)

Year	Breeding Group	s	n	A.1	A.2	A.3	A.4	Mean Initiation Date (SD)	Median Initiation Date	Range of Initiation Dates	Mean Days Between First Nest Attempts	Mean Distance Between Nests and Centroids (m)
2018	Kurthwood	15	19	12	5	2	0	14 April (13.95)	12 April	3/29 – 5/10	3.82 (2.6)	1651.96
	Saddle Bayou Camp	3	3	2	1	0	0	22 April (17.68)	22 April	4/10-5/5	25	3394.54
2019	East	10	14	7	4	3	0	6 April (11.41)	6 April	3/21 – 4/24	5.67 (3.27)	2029.72
	Kurthwood	7	10	7	2	1	0	5 April (23.15)	26 March	3/19 – 5/23	10.83 (13.91)	2485.82
	Pete Temple	7	14	6	6	2	0	30 March (14.05)	27 March	3/16 – 4/24	7.8 (5.36)	2045.85
	West	9	7	5	2	0	0	10 April (15.33)	3 April	3/28 – 5/5	9.5 (8.58)	1915.99

Across all years, mean date of first nest initiation was 12 April (SD = 14.84, range = 12 March – 23 May, median= 10 April). Earliest mean date of the first nest initiation occurred on 24 March (SD =14.85, range = 14 March – 4 April, Median = 15 April) whereas latest mean date of first nest initiation occurred on 6 May (SD = 5.66, range =2 May – 10 May, Median = 6 May; Table 3.1, Figure 3.4). Mean number of days between the initiation of subsequent first nesting attempts varied across years from 4.66 (SD = 4.29) to 8.5 (SD = 9.49) and ranged between 1 and 34 days (Table 3.1). Our data suggested that number of days between all subsequent nest attempts may be influenced by group size (Figure 3.5). For all years, there were 21 successful first nest attempts, of which 6 were the first nests initiated within the respective breeding group, and mean day of initiation for successful first nest attempts occurred on 7 April. We found no statistical relationship between success of first nest attempts and date of nest initiation ($\beta = -0.011$, SE = 0.021, $P = 0.58$).

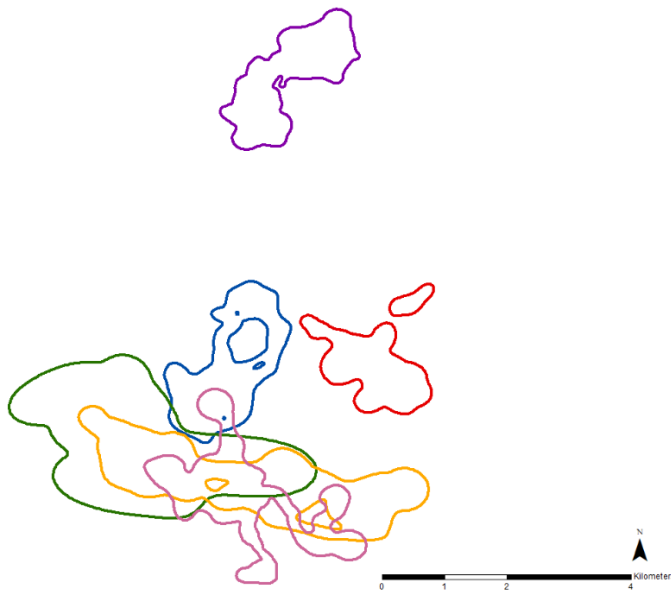


Figure 3.2. Utilization distributions (99%) for the Sonny Martin breeding group during the 21 day period prior to the first nest initiation by the presumed dominant female on the Cold Springs section of Peason Ridge WMA, Louisiana during 2017.

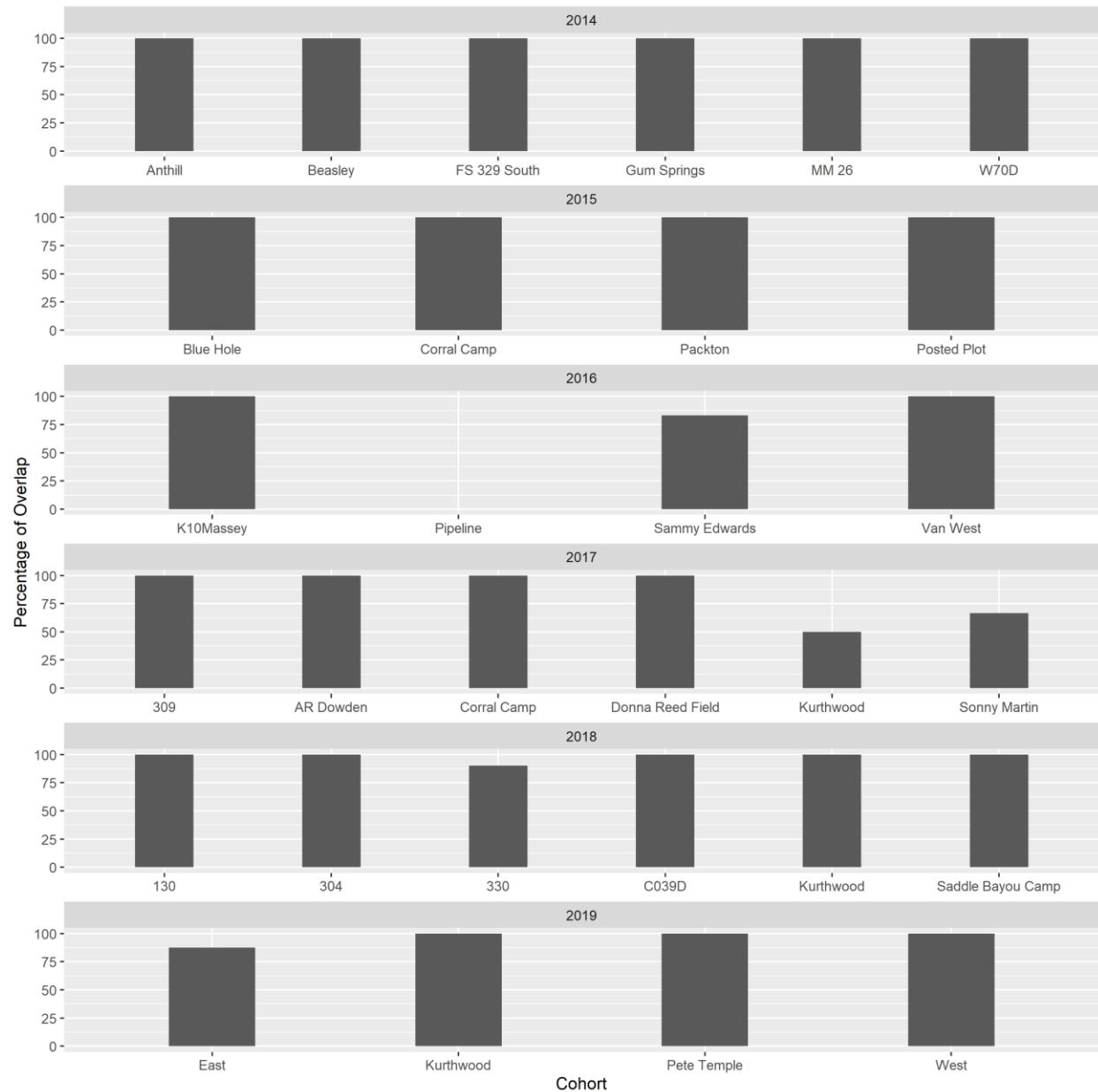


Figure 3.3. The proportion of incubation ranges within each breeding group during the 21 day period prior to the initiation of the first nest attempt that overlapped at least one other range on Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA during the years of 2014–2019. We note that the 2016 Pipeline breeding group has a zero value because it was a group of 2 and the ranges did not overlap.

Estimated number of days between first nest initiation varied between 3 and 7 days across years (2014: 3.85 (SE = 0.52); 2015: 3 (SE = 0.54); 2016: 7.35 (SE = 0.65); 2017: 4.21 (SE = 0.32); 2018: 4.62 (SE = 0.41); 2019: 7.2 (SE = 0.53), and between sites (KNF: 4.45 (SE = 0.24); Cold Springs: 5.22 (0.54); Kurthwood: 6.41 (SE = 0.41), respectively (Figure 3.6.). Estimated number

of days between first nest attempts was lower for successful (2.76, SE = 0.40) than failed (5.47, SE = 0.21) attempts ($z = -4.51$, $P < 0.05$).

Table 3.2. Number of female wild turkeys within each breeding group (s), mean day of first nest initiation, and range of first nest initiation days where day 1 is the first nest initiation of the breeding group by female Eastern wild turkeys (*Meleagris gallopavo silvestris*) on Kisatchie National Forest and Peason Ridge WMA in west-central for the years of 2014 – 2019.

Year	Breeding Group	s	Mean Day (SD)	Range of Days
2014	Anthill	9	7.2 (5.12)	1-13
	Beasley	7	17 (17.51)	1-39
	FS 329 South	7	7.75 (5.85)	1-15
	Gum Springs	3	5.5(6.36)	1-10
	MM 26	2	5 (5.66)	1-9
	W70D	4	4.33(3.51)	1-8
2015	Blue Hole	7	21.25 (17.23)	1-40
	Corral Camp	4	5.67 (6.43)	1-13
	Packton	3	7 (8.49)	1-13
	Posted Plot	8	17 (8.70)	1-27
2016	K10 Massey	9	23.4 (16.20)	1-43
	Pipeline	3	15.5 (20.51)	1-30
	Sammy Edwards	9	16 (10.40)	1-23
	Van West	6	17.67 (14.47)	1-27
2017	309	13	14.82 (7.86)	1-28
	AR Dowden	12	16.1 (15.05)	1-47
	Corral Camp	5	14.6 (9.07)	1-25
	Donna Reed Field	9	14.83 (8.52)	1-26
	Food Trough	3	12.33 (10.26)	1-21
	Sonny Martin	9	10.17 (8.45)	1-22
2018	130	6	13.2 (10.11)	1-29
	304	13	24.43 (15.99)	1-43
	330	11	15.88 (13.36)	1-38
	CO39D	3	11.5 (14.85)	1-22
	Kurthwood	15	17.17 (13.95)	1-43
	Saddle Bayou Camp	3	13.5 (17.68)	1-26
2019	East	10	17.28 (11.41)	1-35
	Kurthwood	7	18.57 (23.15)	1-66
	Pete Temple	7	15.83 (14.05)	1-40
	West	9	14 (15.33)	1-39

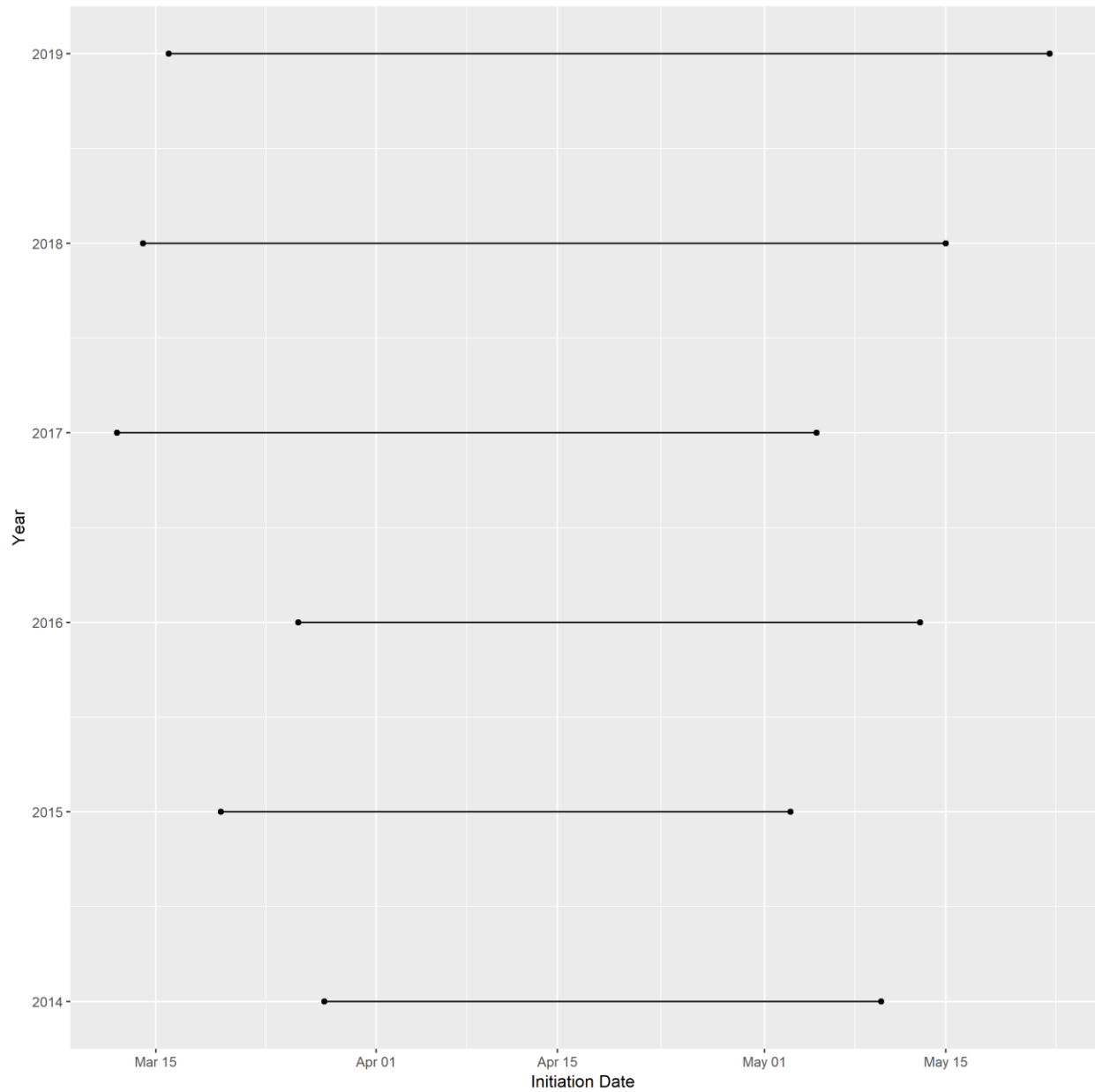
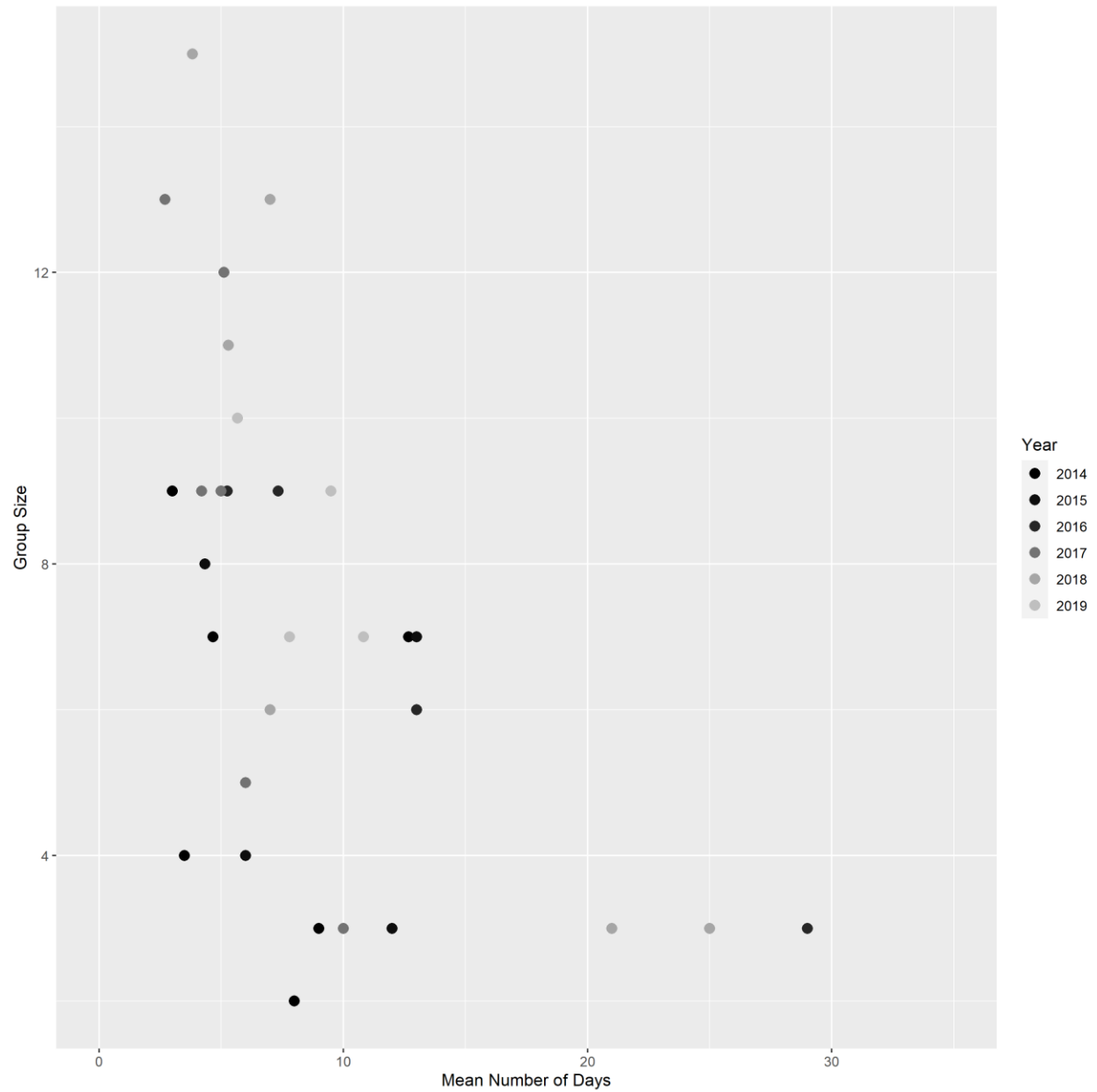


Figure 3.4. Range of first nest initiation dates of from 2014-2019 on Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA.



3.5. Discussion

Our collective understanding of social behavior in wild turkeys is limited to observations of interactions between individuals occurring during the breeding season (Watts and Stokes 1971, Healy 1992). Our approach to assessing social behavior used high resolution movement data provides an alternative approach using behaviors to evaluate reproductive synchrony in wild turkeys (Bakner et al. 2019, Lohr et al. 2020). We found that female wild turkeys have social organization within breeding groups, likely maintained by social hierarchies (Watts and Stokes 1971, Healy 1992), that suggests social dominance dictates an individual's access to mates, and impacts reproductive success.

We found that female wild turkeys rarely dispersed from breeding groups prior to initiation of their first nest attempts. Likewise, female wild turkeys in Arkansas dispersed from their winter flocks at the same time regardless of physiological factors or age (Badyaev et al. 1996a). We found 95% of female ranges prior to the onset of breeding overlapped, implying females within breeding groups occupied shared space and constituted a single social unit (Brown 1975). Similarly, stable breeding groups have been observed in multiple avian species, including female black grouse (*Lyrurus tetrix tetrix*) who frequently occupied the same territory while foraging (Kruijt and Hogan 1967). Female sage grouse (*Centrocercus urophasianus*) demonstrated peck dominance during reproduction (Scott 1942) and social interactions were observed within groups of female greater prairie chickens (*Tympanuchus cupido pinnatus*) during visits to the lek (Robel and Ballard 1974).

Within breeding groups, we found there were multiple days on average between subsequent initial nest attempts, suggesting that social hierarchies existed within breeding groups and influenced reproductive timing. Social rank within wild turkey groups is established among

siblings as poults, and although rank is frequently challenged among individuals, it rarely changes as long as the dominant bird lives (Watts and Stokes 1971). Thus, the fact that asynchronous nesting occurs when social rank dictates access to mates (Robel and Ballard 1974, Foster 1981, Webster 1994) is not surprising. Healy (1992) observed sibling poults establishing dominance hierarchies at 8 weeks of age and by autumn, social hierarchies were fully established well before the breeding season period we evaluated. Likewise, larger sibling groups were usually dominant over smaller groups, as groups often compete as units (Watts and Stokes 1971). Presumably, larger social groups would function differently than smaller groups, both for breeding opportunities with dominant males and subsequent timing of nest initiation.

We found variation in the range of dates at which females initiated their nest attempts within breeding groups, but the overall chronology of nest initiation at the population level was synchronous across years. Stated differently, onset of nest initiation at the population level (e.g., across our study sites) was similar across years, but within breeding groups we found notable temporal variation within years. Researchers have noted similar behaviors previously, and attributed synchronous nesting behaviors to the fact that photoperiod most influences timing of reproduction (Healy 1992). Thus, across years, nest initiation should naturally demonstrate more synchronized patterns, but within breeding groups individuals could vary due to social constraints. On our study area, first nest initiation dates of female wild turkeys were similar to dates reported elsewhere in the southeastern United States (Thogmartin and Johnson 1999, Palmer et al. 2013). Individuals reproducing early typically have greater expected annual reproductive success (Lack 1968). However, we did not find a relationship between the initiation date of first nest attempts and nest success. Although 29% of all successful nests laid by the presumed dominant female occurred during the earliest part of the hunting season. Willow

ptarmigan (*Lagopus lagopus*) demonstrated a relationship between nest success and date of nest initiation, experiencing an increase in nest success at the beginning of the breeding season followed by a decrease and then slight increase as the season progressed (Wilson et al. 2007). Early nest initiation is generally considered advantageous but has mainly been discussed in terms of seasonal productivity (Shustack and Rodewald 2011) although we found no advantage or disadvantage between initiating a nest early within the breeding season.

Within breeding groups, we expected 1–2 days to occur between each female initiating their first nest attempt, based on observations of nesting behaviors in captive wild turkeys detailed in Healy (1992). However, we found that on average, 3–7 days elapsed between subsequent nest attempts by individual females within a social group. Robel and Ballard (1974) noted that disruption of subordinate female greater prairie chickens by dominant females on the lek caused delays of 2 to 3 days in copulation (Robel and Ballard 1974). Although we have no way of confirming that we captured the dominant female within each breeding group, and also recognize that we didn't capture all individuals in a breeding group, we offer that it's reasonable to assume that dominance influenced the number of days between nest initiations. Disruption of subordinate females could cause more time between nest attempts, which may ultimately benefit dominant females if she delayed copulation by a subordinate or forced subordinates to mate with an inferior male (Foster 1981). However, we also recognize that disruption is unlikely to solely explain the 3–7 days we found between initial nest attempts by females within a breeding group. We found the number of days between subsequent nest attempts within breeding groups were less for successful first nest attempts than failed nest attempts. If the number of days between subsequent nesting attempts is an important factor influencing reproductive success, then other factors that could cause disruptions to breeding behaviors could have negative effects on fitness.

Wild turkeys are unique in that they are hunted primarily during the peak of their reproductive period (Chamberlain et al. 2018, Isabelle et al. 2018). There is evidence that hunting disproportionately removes vocal males (Chamberlain et al. 2018, Wakefield et al. 2020) which are theoretically dominant males as signaling in other wildlife species is often driven by dominance and securing breeding opportunities (Neuman et al. 2010, Bolt 2013). Previous work on prairie chickens found that the removal of dominant males from the lek reduced the overall mating success of the local population, because females copulated less with subdominant males, which disrupted the social organization (Robel 1970, Ballard and Robel 1974, Robel and Ballard 1974). We postulate that removal of dominant male wild turkeys during the breeding season may contribute to delays between nest attempts within breeding groups of females. Theoretically, removal of dominant males could plausibly force individual females to either reassess the remaining subdominant males available within her home range, travel to another area to find other dominant males, or allow the social hierarchies of remaining males within her range to become settled where a new dominant male was present (Ginsberg and Milner-Gulland 1994). Regardless, all of these scenarios would delay nesting efforts within breeding groups where either dominant males or substantive percentages of total males were removed, which could have a potentially negative effect on population-level fitness.

Previous works noted that females typically nest within a distance of 2 to 3.8 km from their winter range (Vander Haegan 1988, Badyaev and Faust 1996). As females presumably shift their habitat use prior to incubation, our ranges immediately prior to the onset of breeding may not represent winter ranges. We found that female wild turkeys located their first nest attempts an average of 2107 m from the centroid of their 21 day range prior to nest initiation. In central Montana, 68% of female sage grouse nested within 2.5 km of the lek on which they were

captured (Wallestad and Pyrah 1974) and 55% of sage grouse in southeastern Idaho nested ≤ 3 km from their lek of capture (Wakkinen et al. 1992). We predicted that females that mated first would move shorter distances between the center of their 21 day range prior to nesting, but our findings did not support this prediction. Likewise, we did not find that distance between nest sites and the centroid of an individual's 21 day range before nest initiation influenced nest fate. However, in Arkansas females that traveled farther, nested earlier, allowing for greater nesting success, although the size of their pre-nesting ranges were most likely overestimated (Badyaev et al. 1996b).

Our findings suggest that social hierarchies within female wild turkey breeding groups may influence reproductive success. We speculate that social constraints within breeding groups could cause variation in nest initiation. We found a longer amount of time between initiation of subsequent first nest attempts within breeding groups than expected based on previous research, and less time between first nest initiation attempts for successful than failed nest attempts. This suggests disruption during copulation within breeding groups is occurring with evidence that delays in nesting effort could have a negative effect on fitness. We suggest further work on wild turkey nest success incorporate genetic research on wild turkeys captured together and eggshells of clutches. Understanding how social hierarchies within wild turkey breeding groups influence reproductive success as well as the consequences that can occur when social hierarchy is disrupted.

CHAPTER 4. CONCLUSIONS

Our results suggest that vegetative characteristics within incubation ranges may influence predator behaviors and thus influence nest success. We found that successful nesting areas for both active and passive sites had lower indices of predator abundance than unsuccessful areas. Our work suggests that the spatial placement of the nest on the landscape relative to use by potential predator species may be the most important factor impacting a nest's outcome. Spatial prediction models indicate that a wide suite of potential nest predators are regularly occurring within incubation ranges across our study sites. Our analysis provides some support that successful nests are found in regions with a lower probability of occurrence for the ubiquitous potential predator species on the landscape. We suggest that future work on wild turkey nest success incorporate behavioral ecology of both wild turkeys and potential nest predators such that future details on the mechanisms underlying drivers of the landscape can be identified.

Our results indicate female wild turkeys rarely disperse from their wintering flocks prior to the state of reproduction. We found the majority of female wild turkey ranges on our study site prior to the onset of breeding overlapped. Within female wild turkey breeding groups we found multiple days on average between subsequent initial nest attempts suggesting that social hierarchy exists within breeding groups. Our results suggested that the number of days between successful first nest attempts were less than failed nest attempts. We found female wild turkeys on our study area traveled a mean distance 2090 m for first nest attempts, 2258 m for second nest attempts, and 2018 m for third nest attempts. Any event that potentially disrupts the social organization of male or female flocks could be detrimental to fitness. Further research examining the genetics of females of each breeding group would be another step in understanding how social organization influences reproductive success of the breeding groups.

APPENDIX A. SUPPLEMENTARY MATERIAL FOR CHAPTER 2

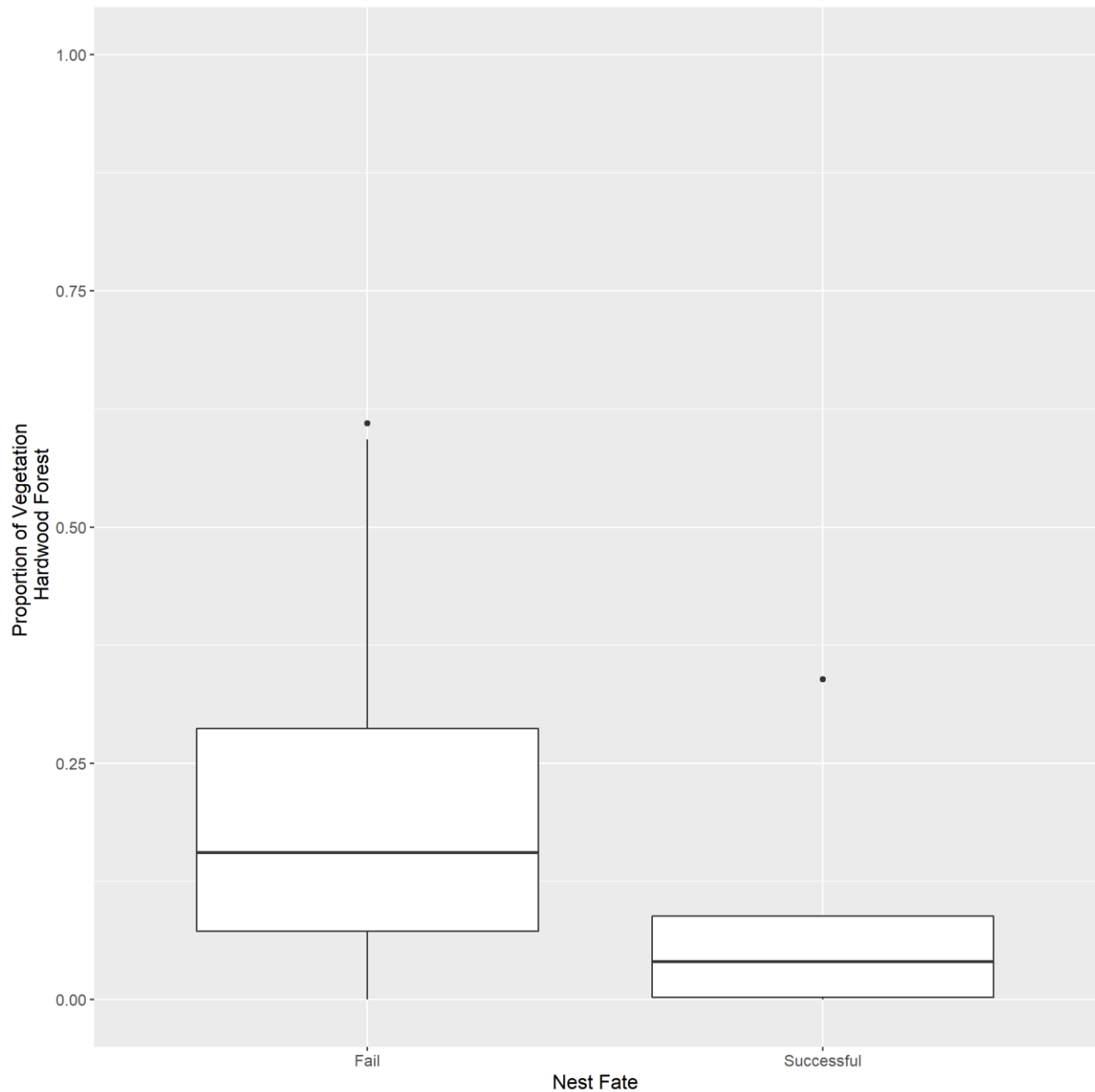


Figure A.1. Proportion of hardwood forest at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

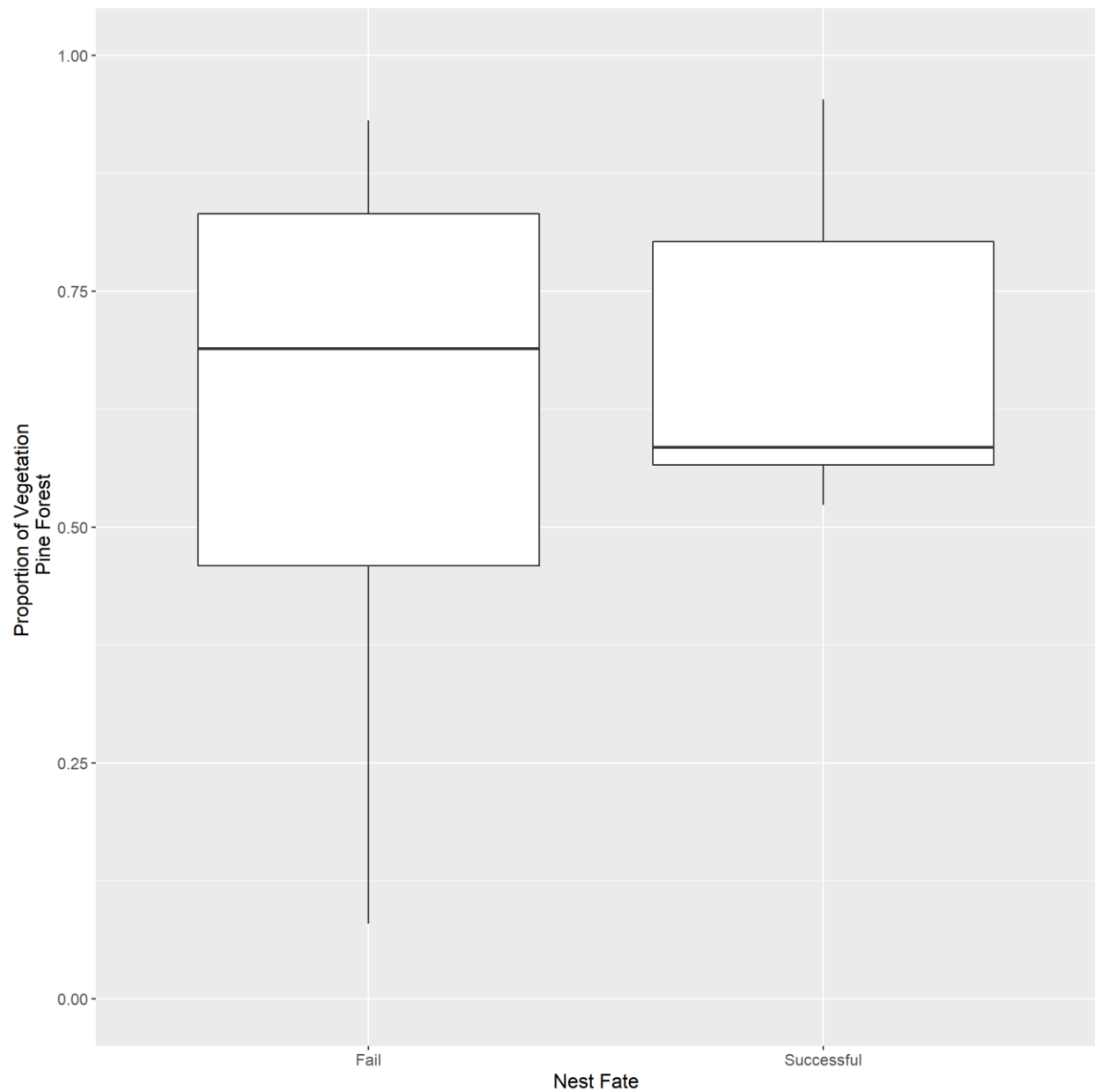


Figure A.2. Proportion of pine forest at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

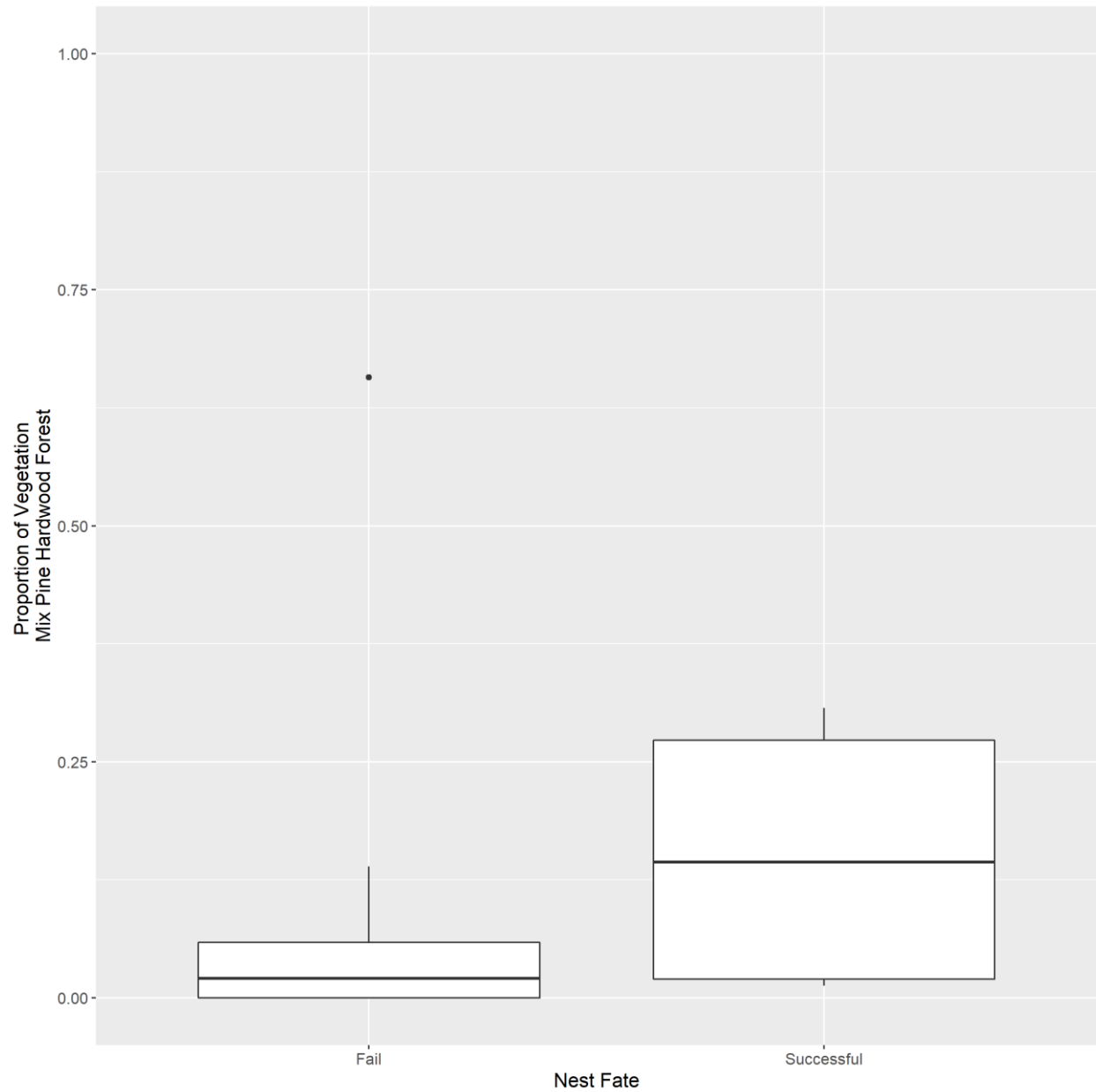


Figure A.3. Proportion of mix pine hardwood forest at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

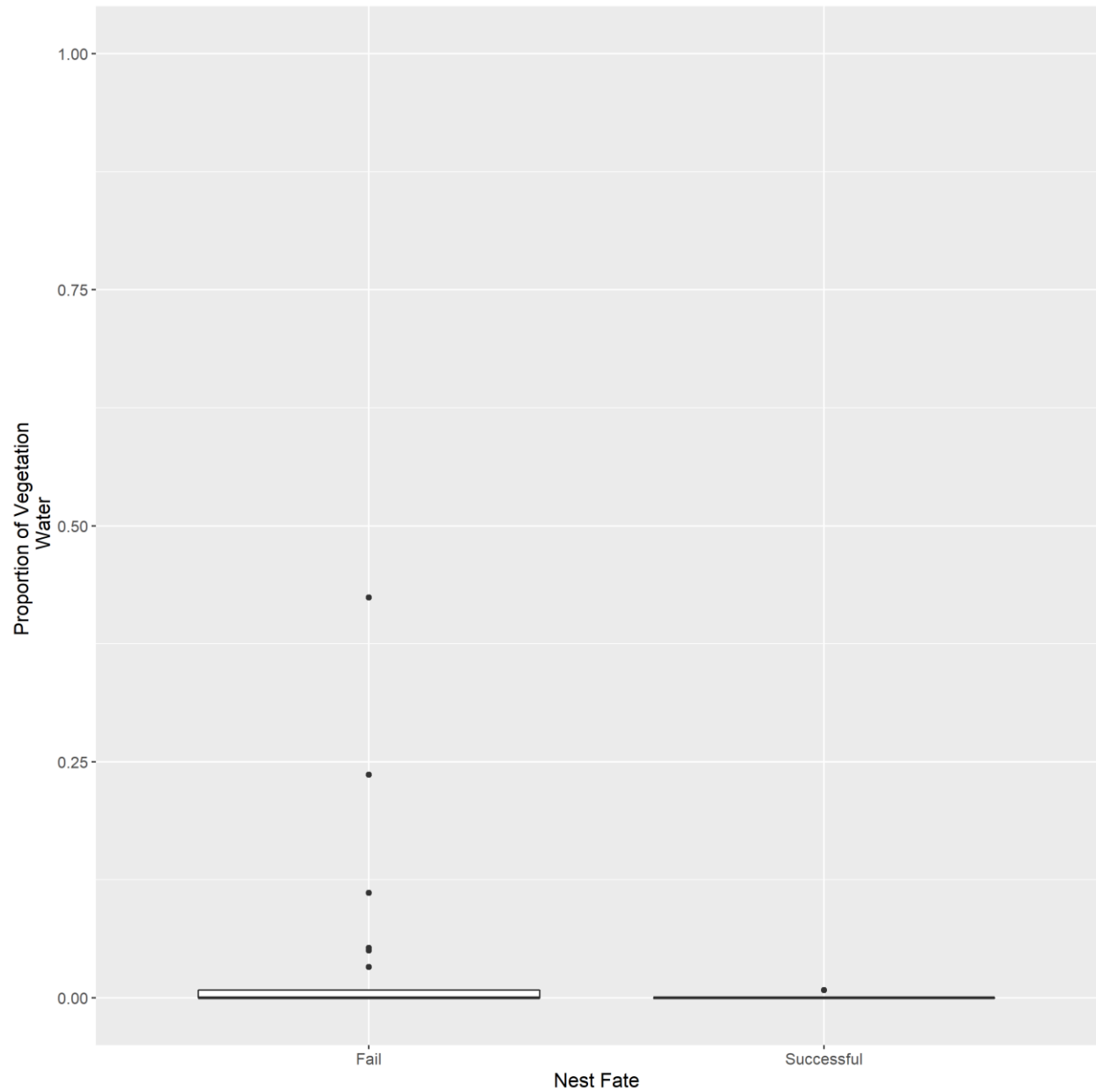


Figure A.4. Proportion of water at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National and Peason Ridge WMA, west-central Louisiana, USA, 2019.

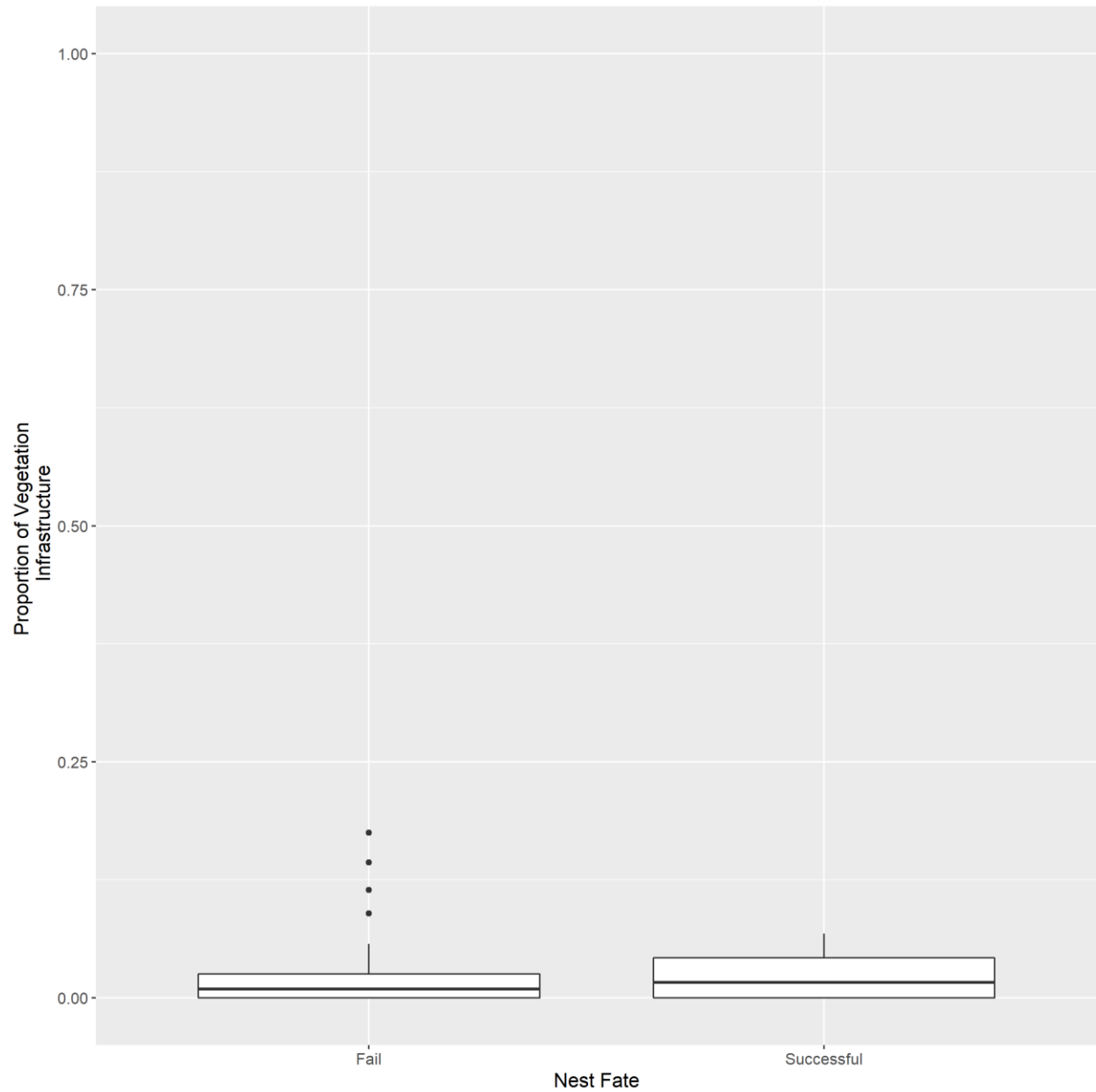


Figure A.5. Proportion of infrastructure at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

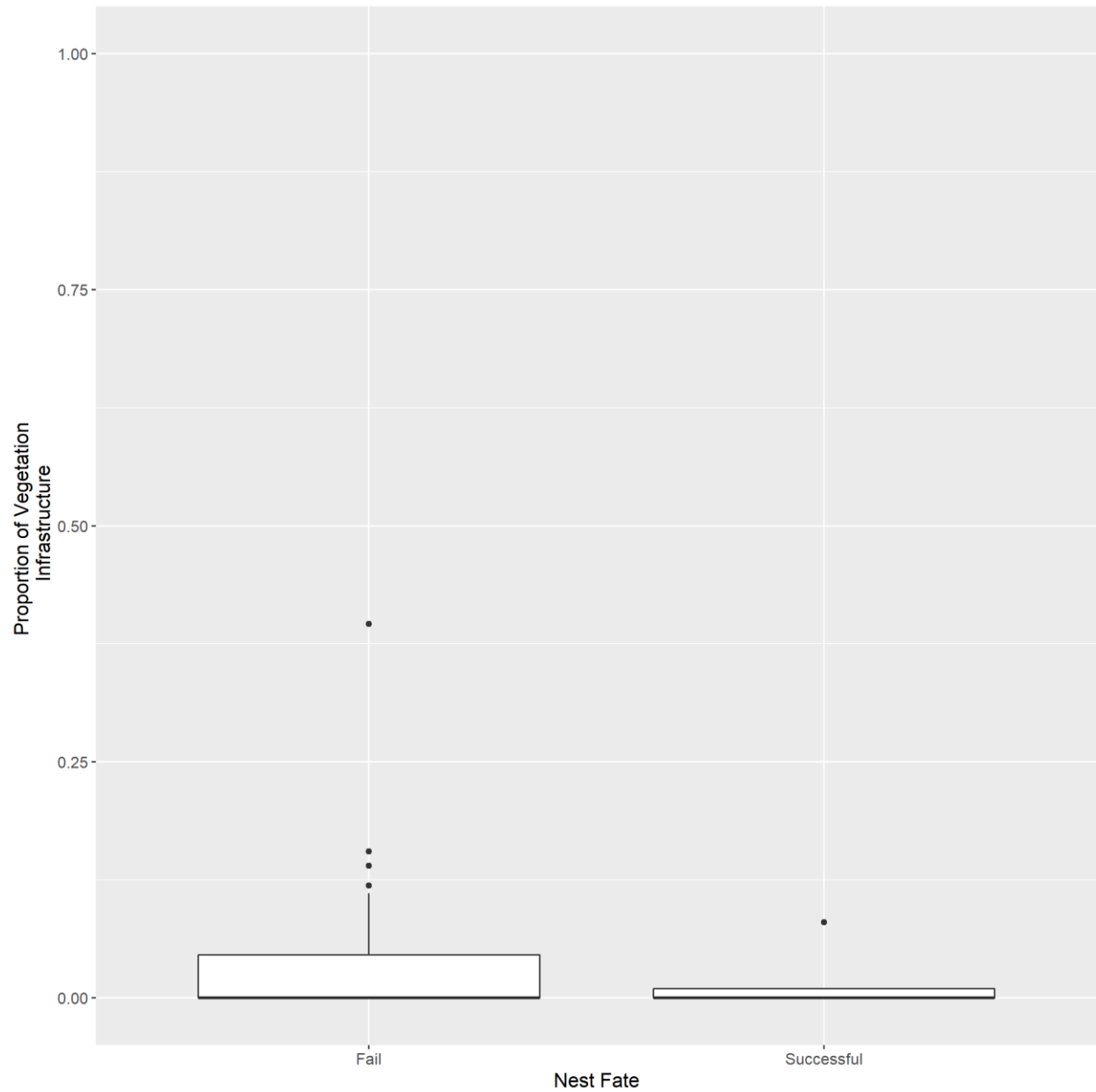


Figure A.6. Proportion of open habitat at nest sites where armadillos (*Dasypus novemcinctus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

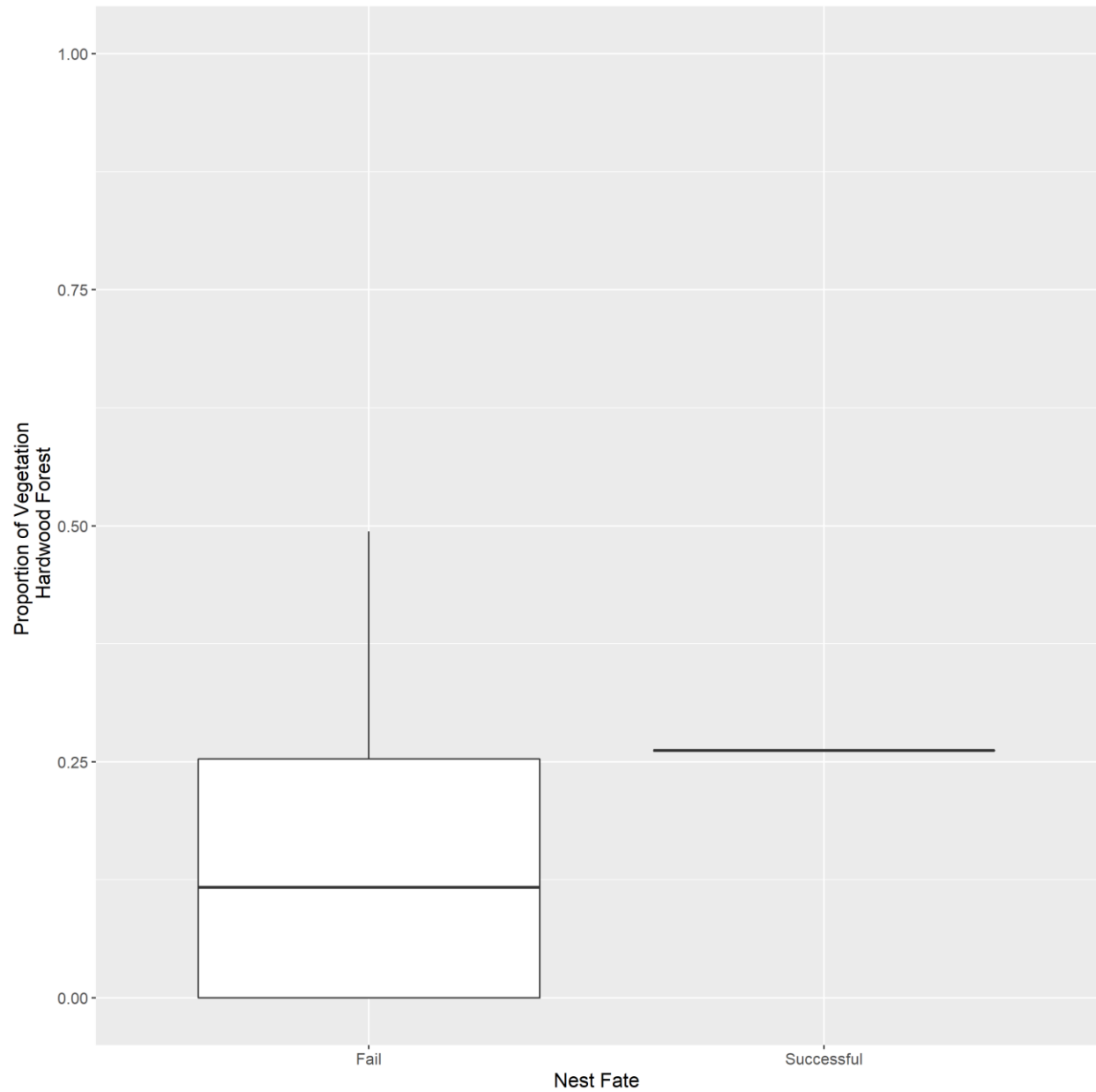


Figure A.7. Proportion of hardwood forest at nest sites where bobcat (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across of Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

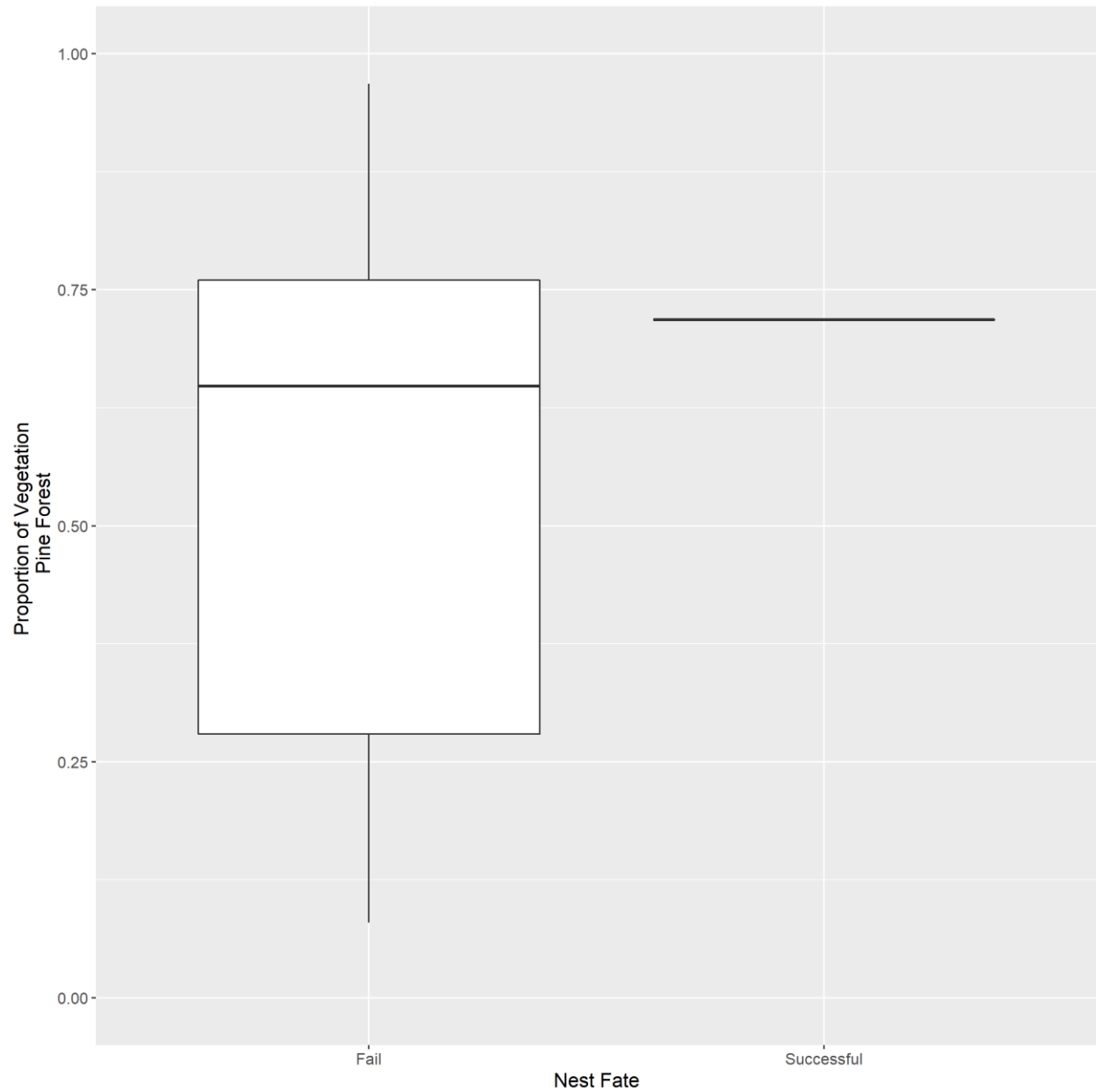


Figure A.8. Proportion of pine hardwood forest at nest sites where bobcats (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

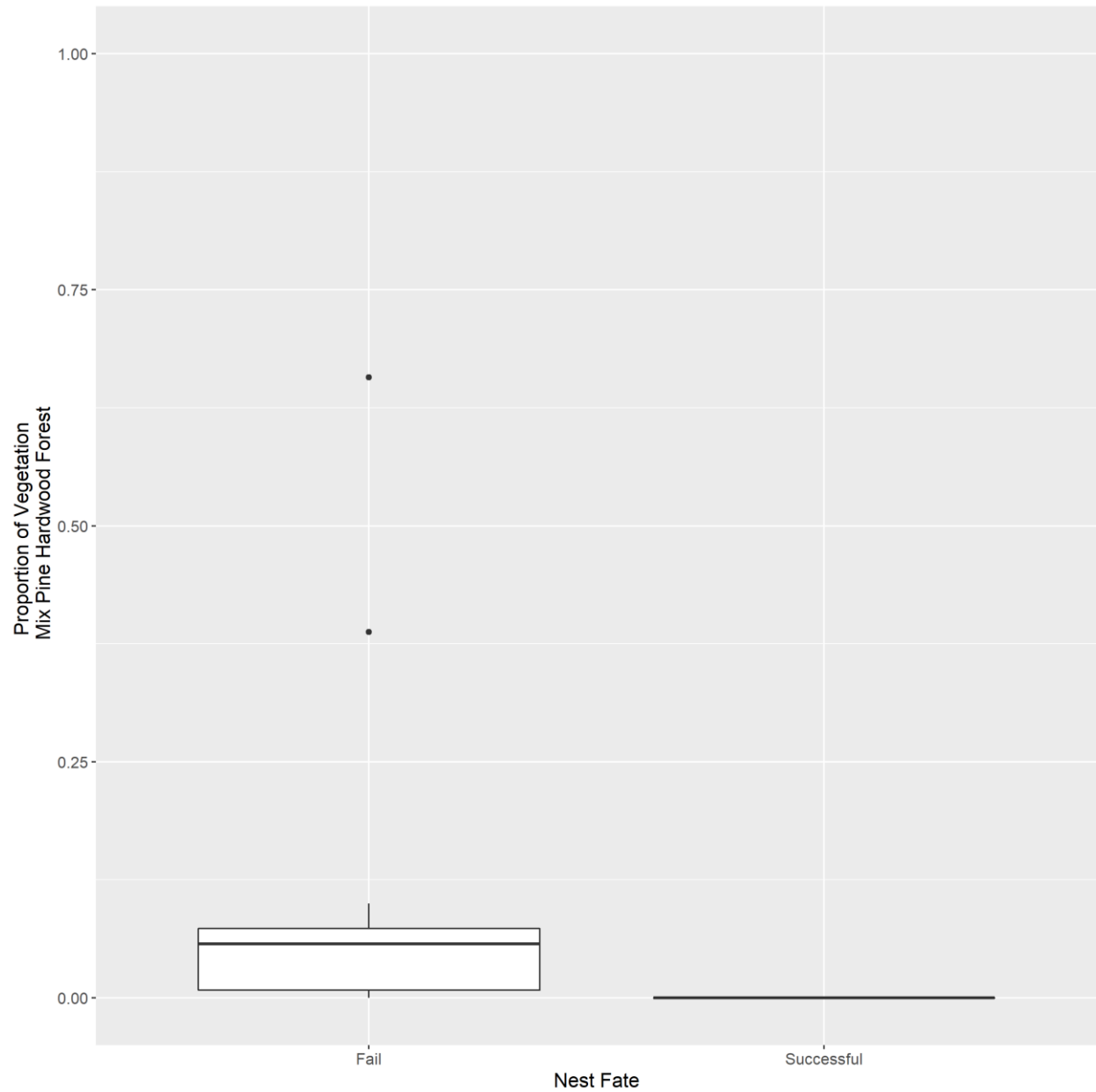


Figure A.9. Proportion of mix pine hardwood forest at nest sites where bobcats (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

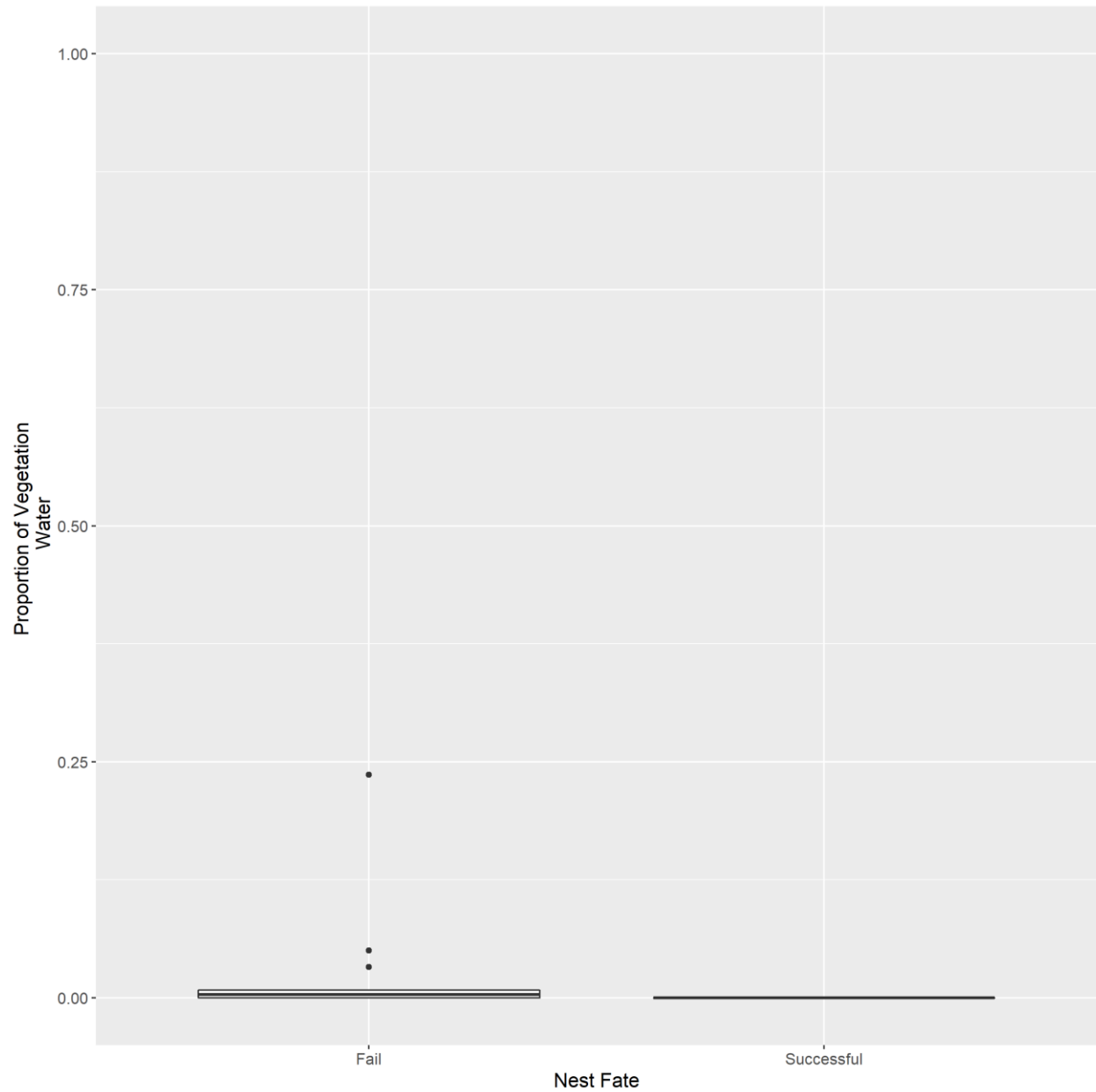


Figure A.10. Proportion of water at nest sites where bobcats (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

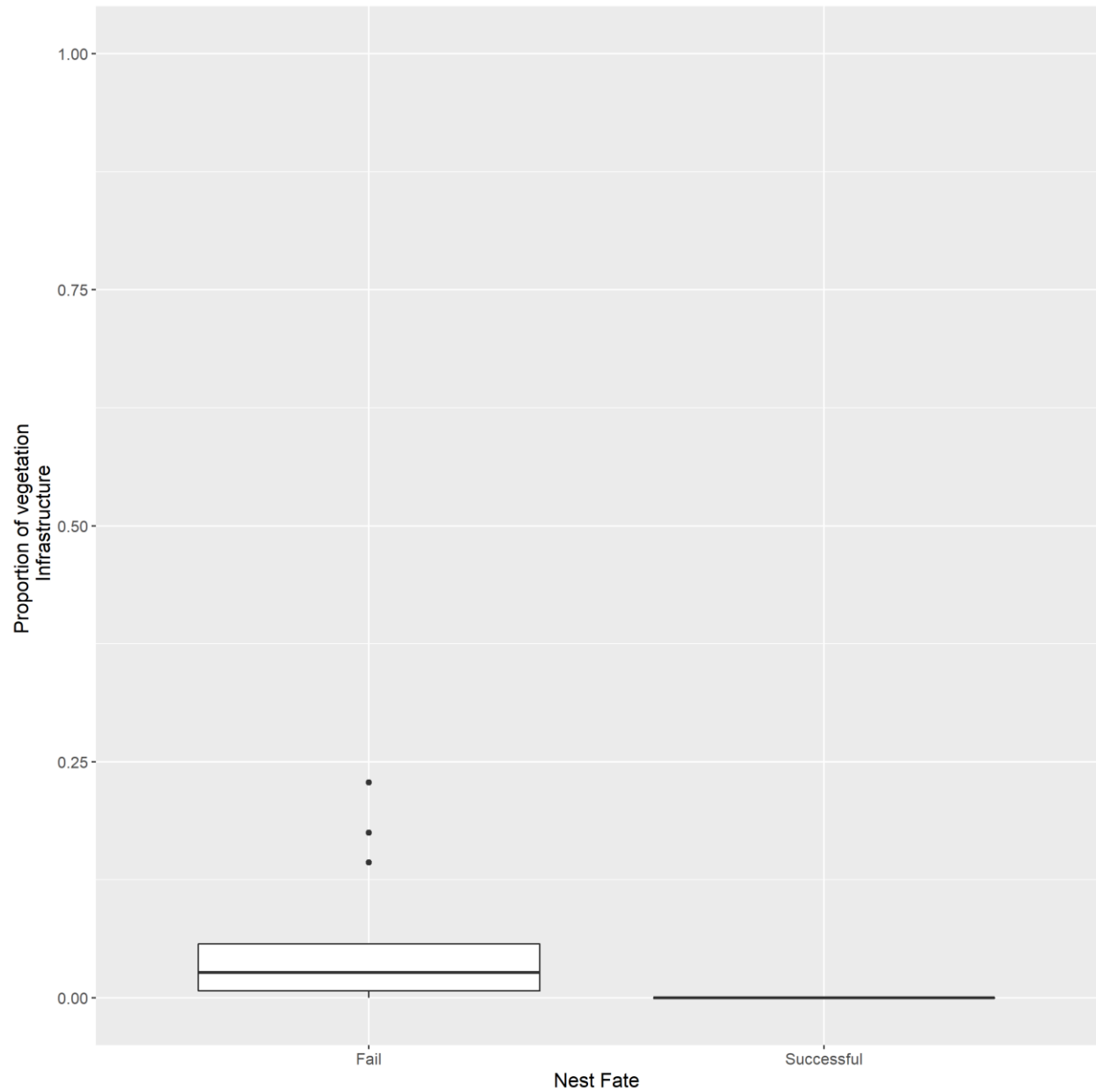
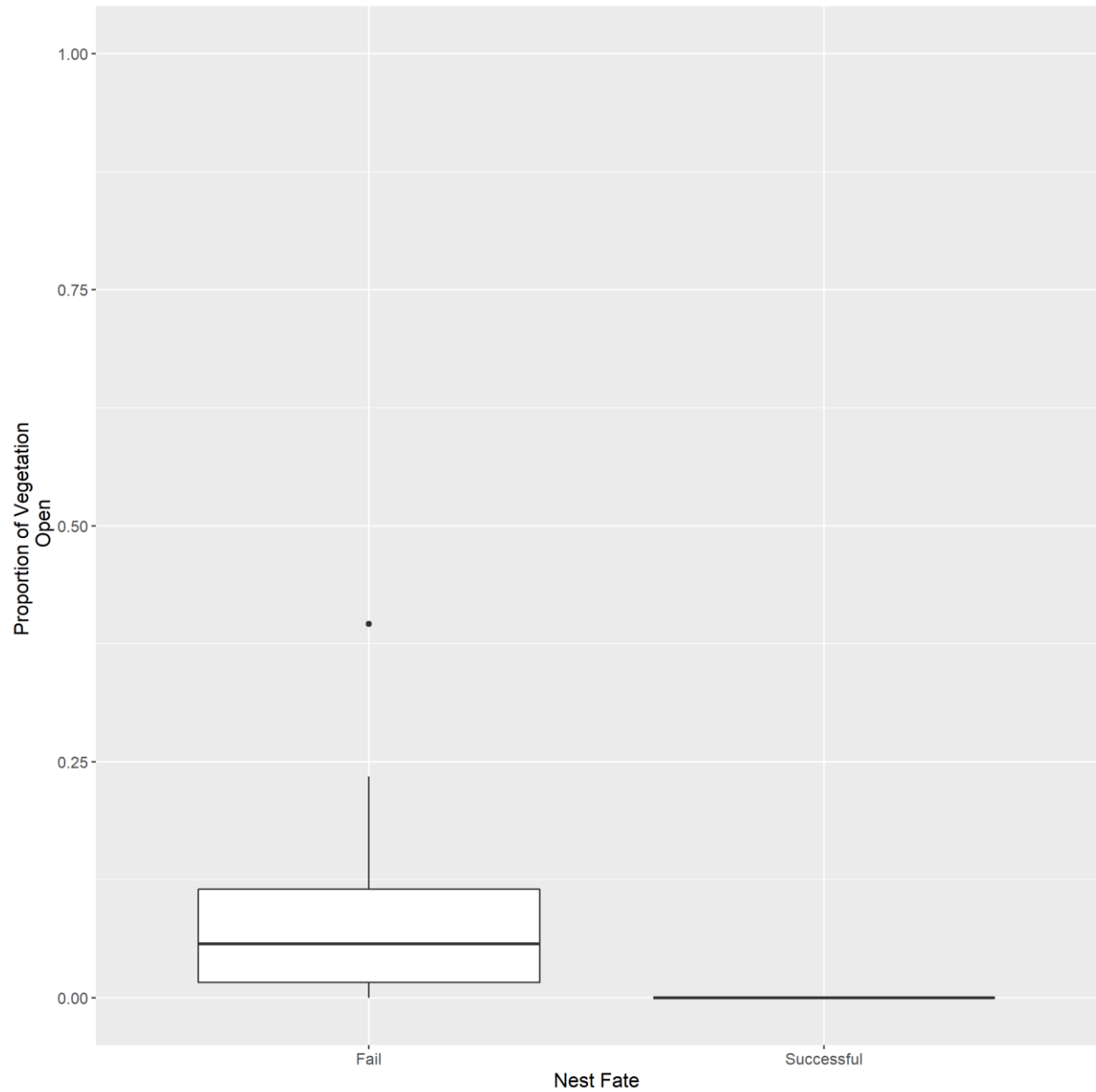


Figure A.11. Proportion of infrastructure at nest sites where bobcats (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.



A.12. Proportion of open habitat at nest sites where bobcat (*Lynx rufus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

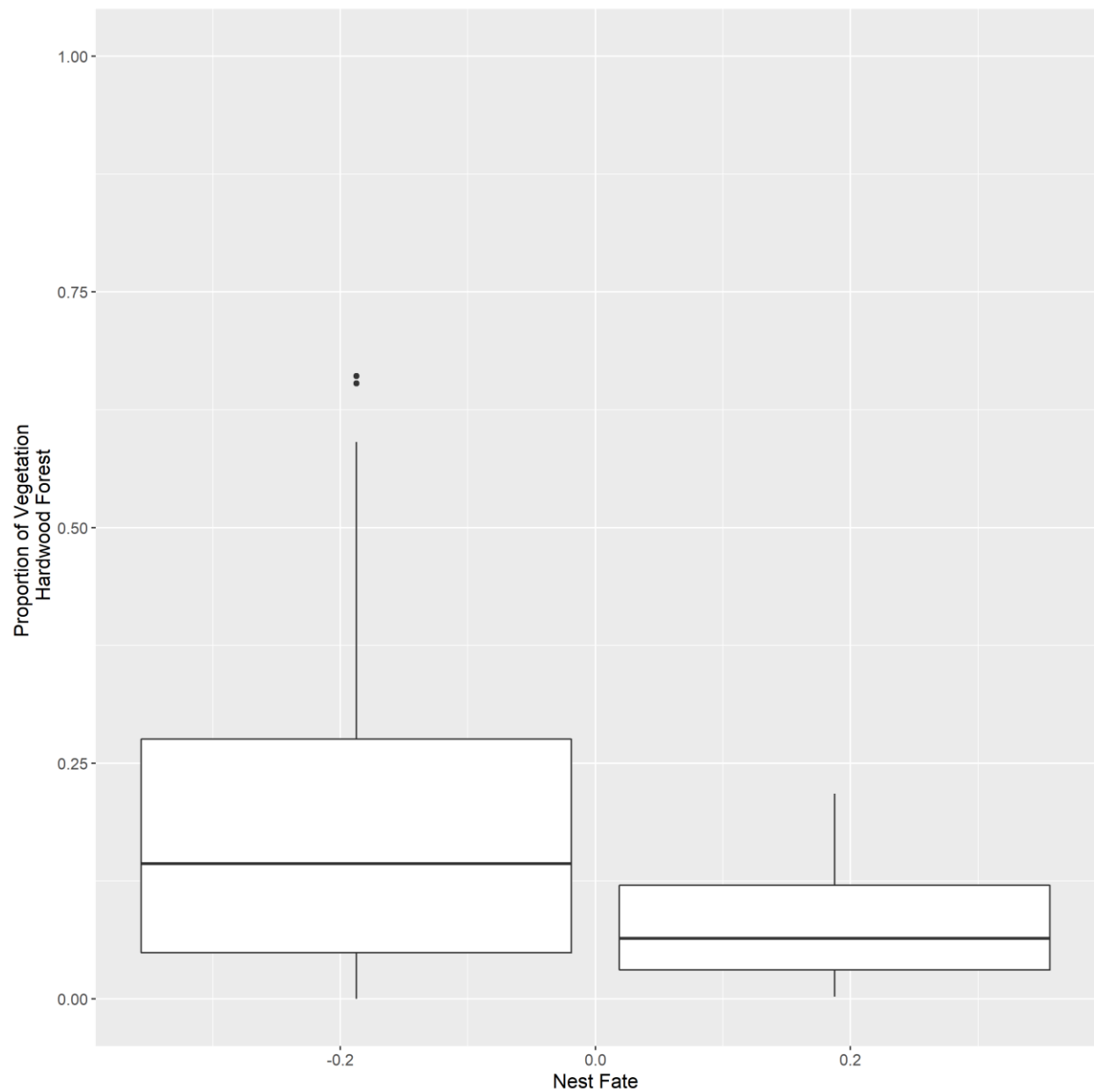


Figure A.13. Proportion of hardwood forest at nest sites where coyote (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

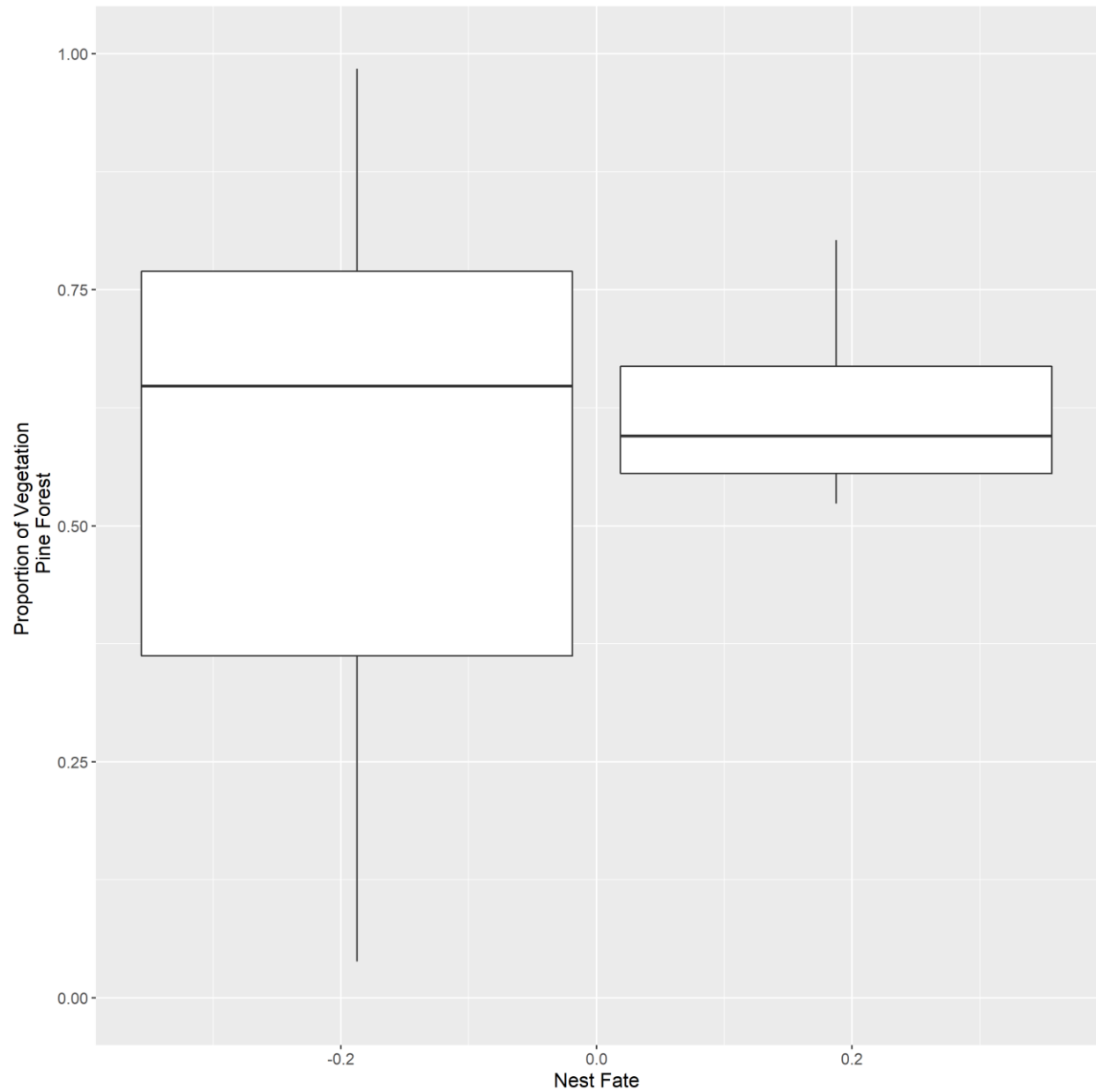


Figure A.14. Proportion of pine forest at nest sites where coyotes (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

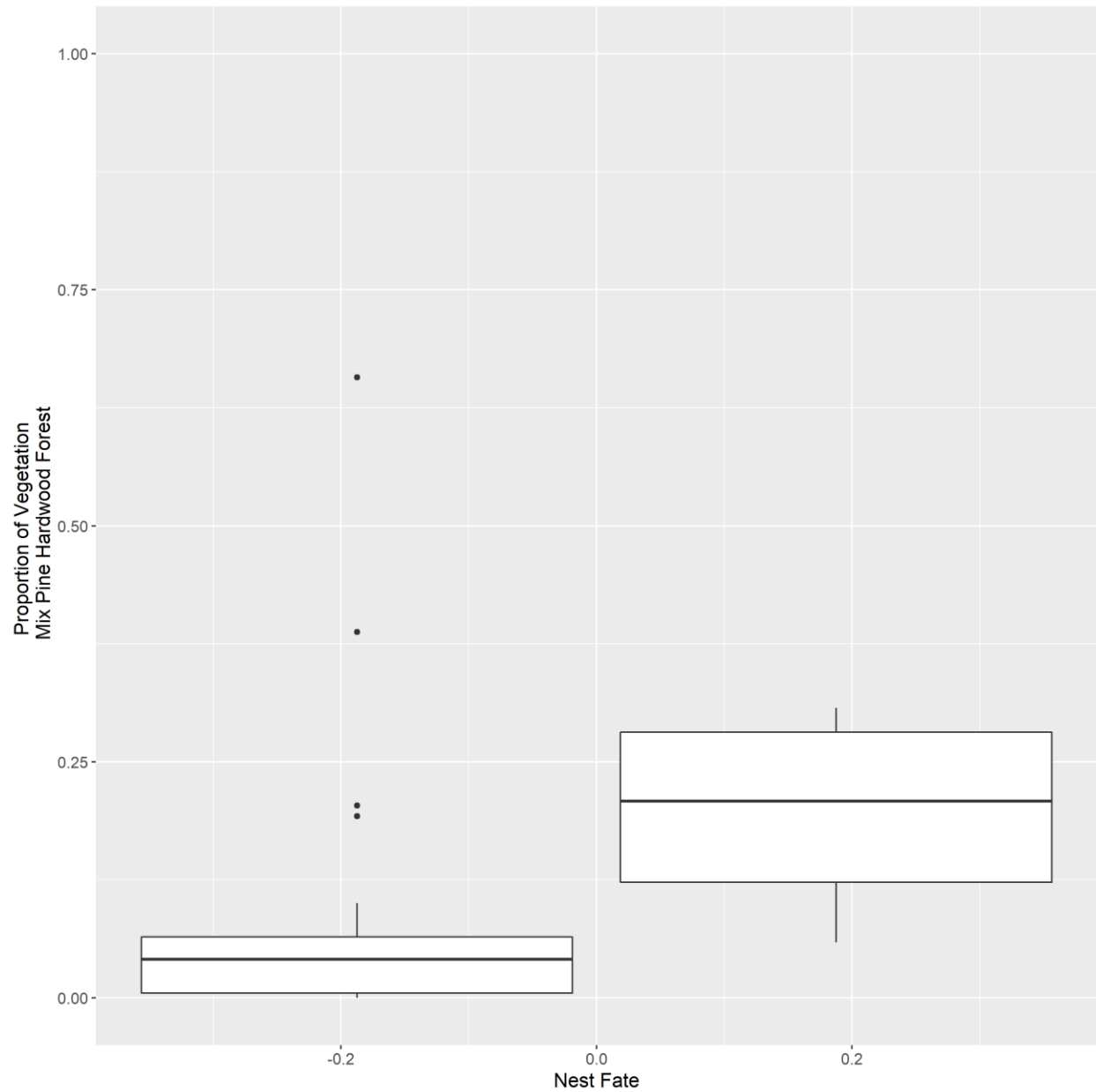


Figure A.15. Proportion of mix pine hardwood forest at nest sites where coyotes (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

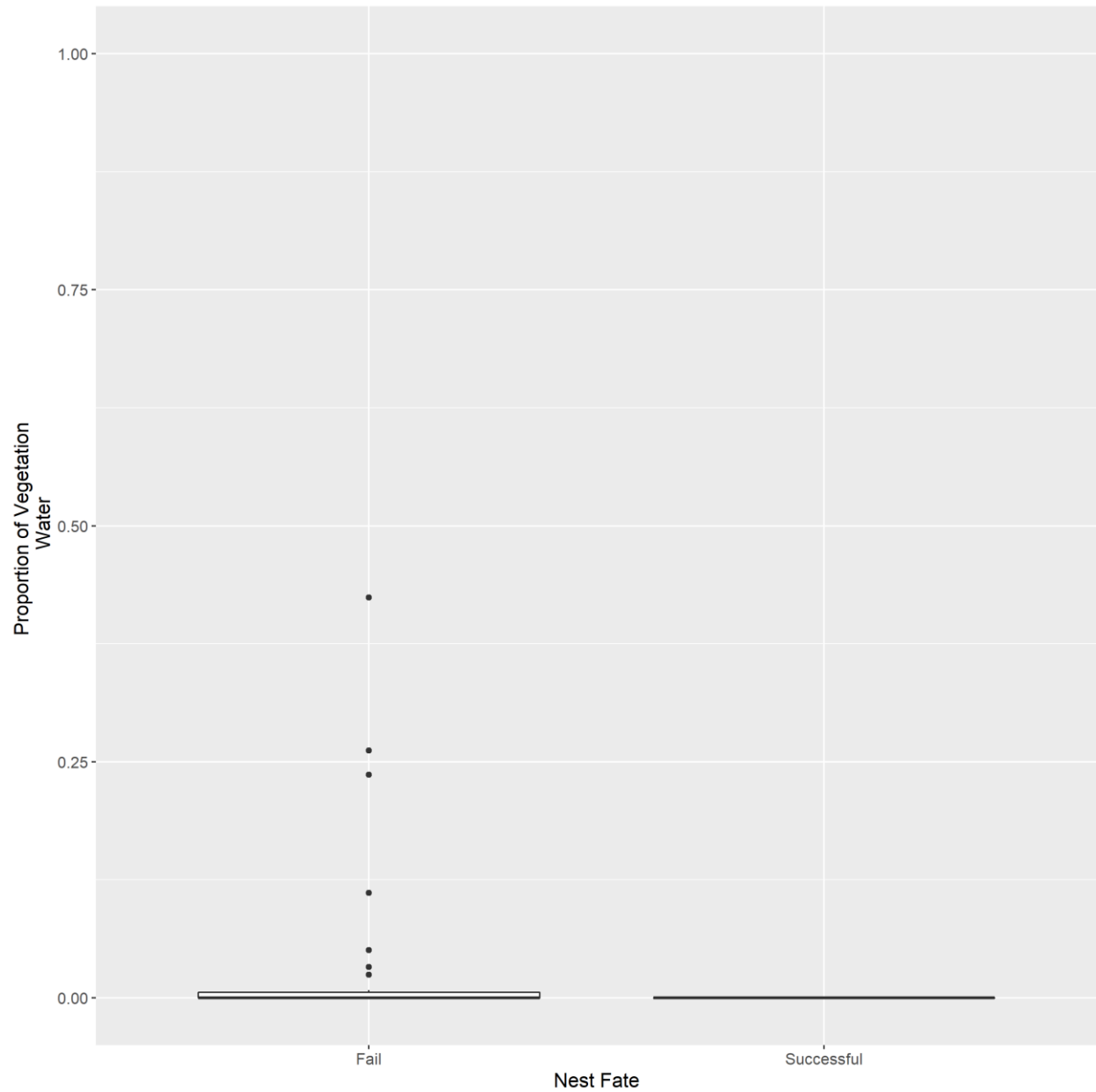


Figure A.16. Proportion of water at nest sites where coyotes (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

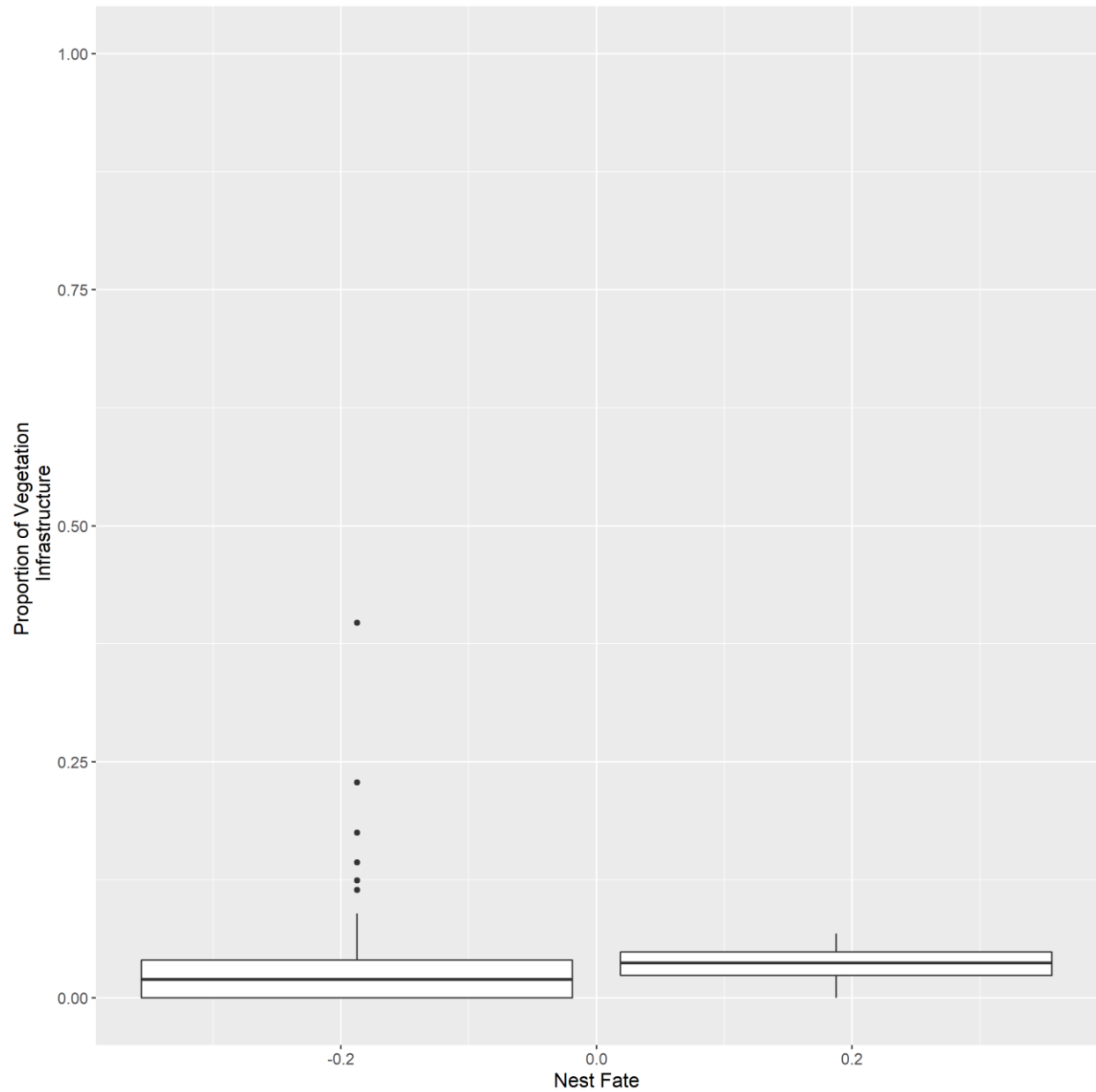


Figure A.17. Proportion of infrastructure at nest sites where coyotes (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

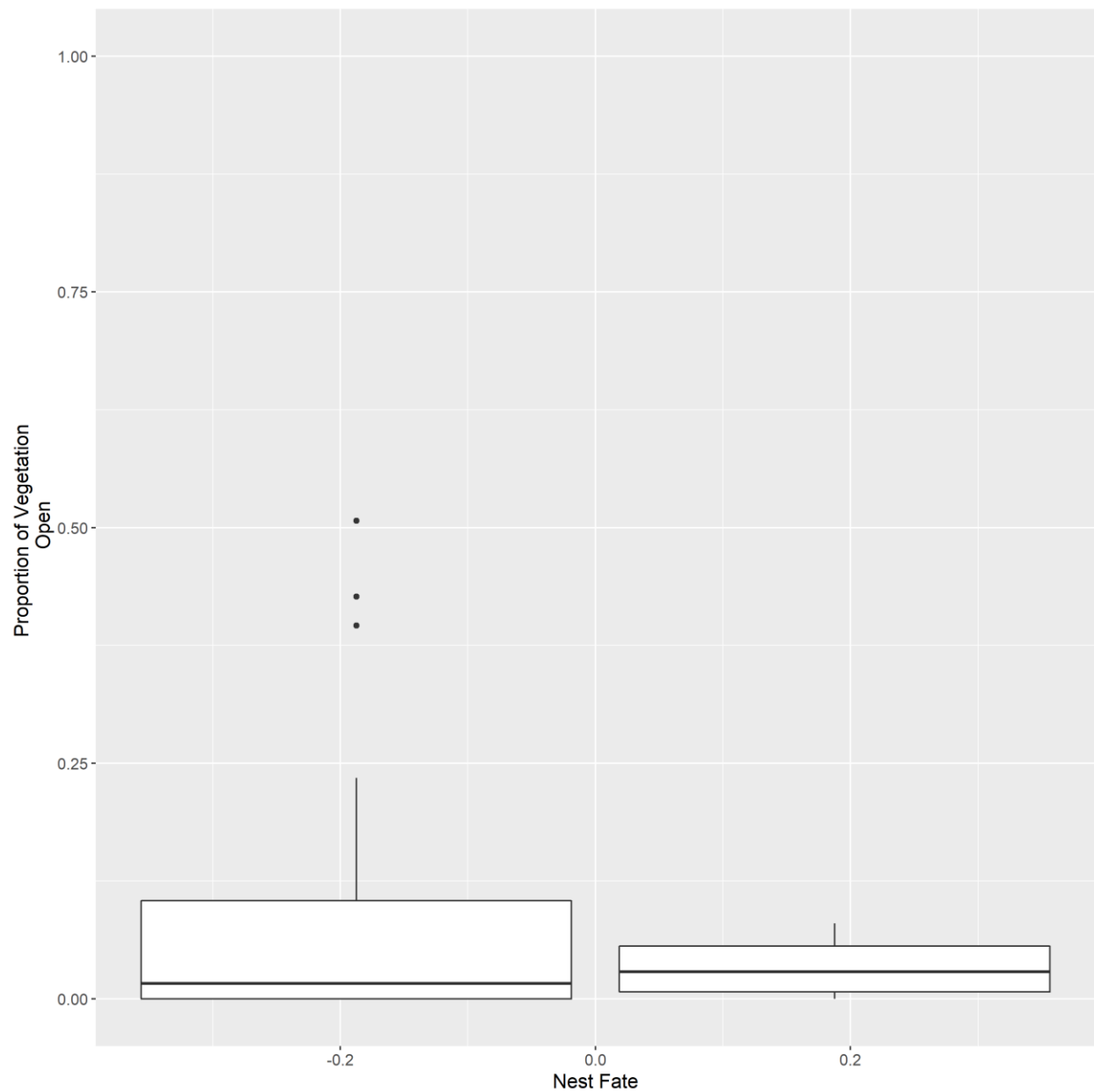


Figure A.18. Proportion of open habitat at nest sites where coyotes (*Canis latrans*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

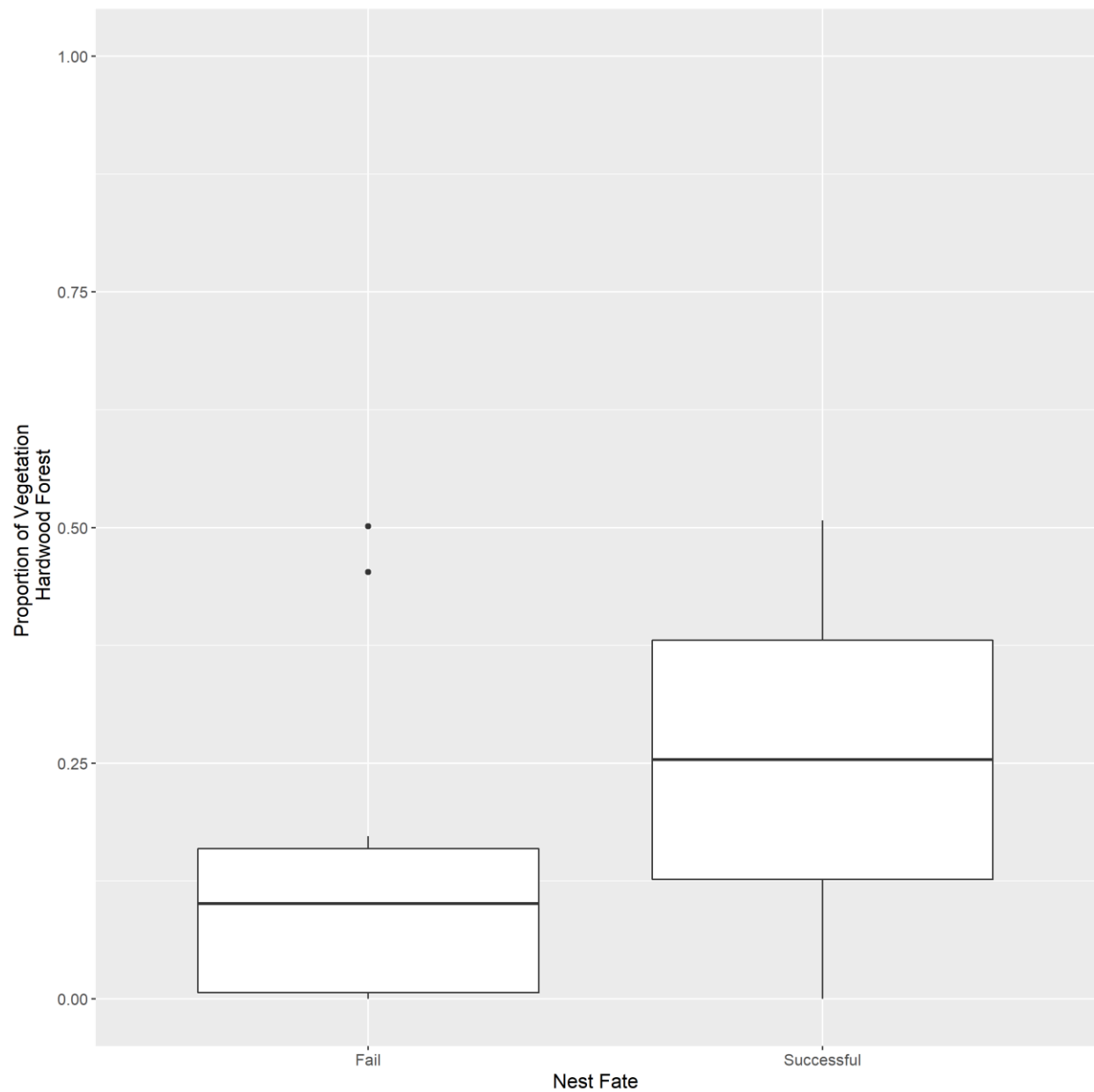


Figure A.19. Proportion of hardwood forest at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

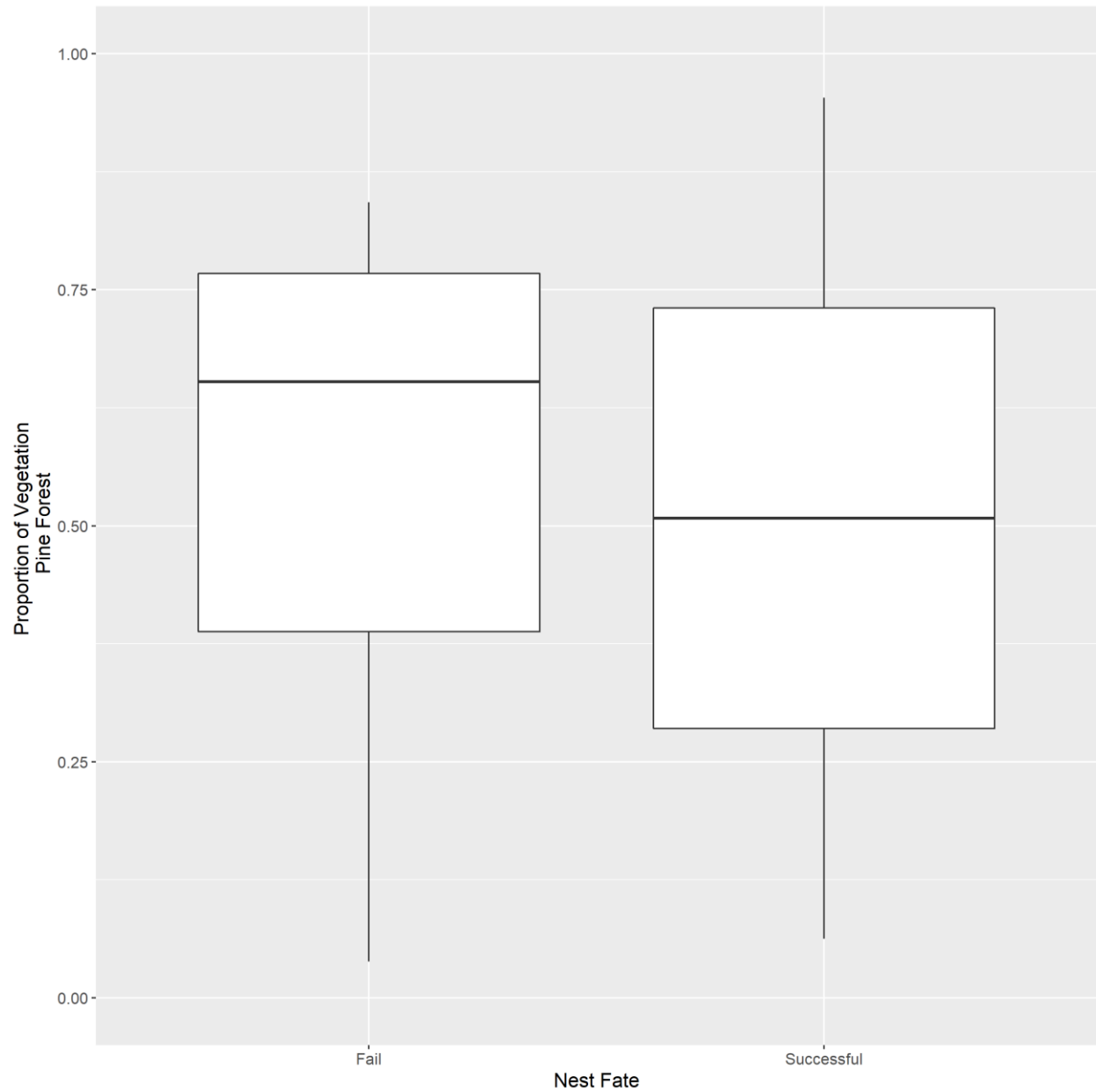


Figure A.20. Proportion of pine forest at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

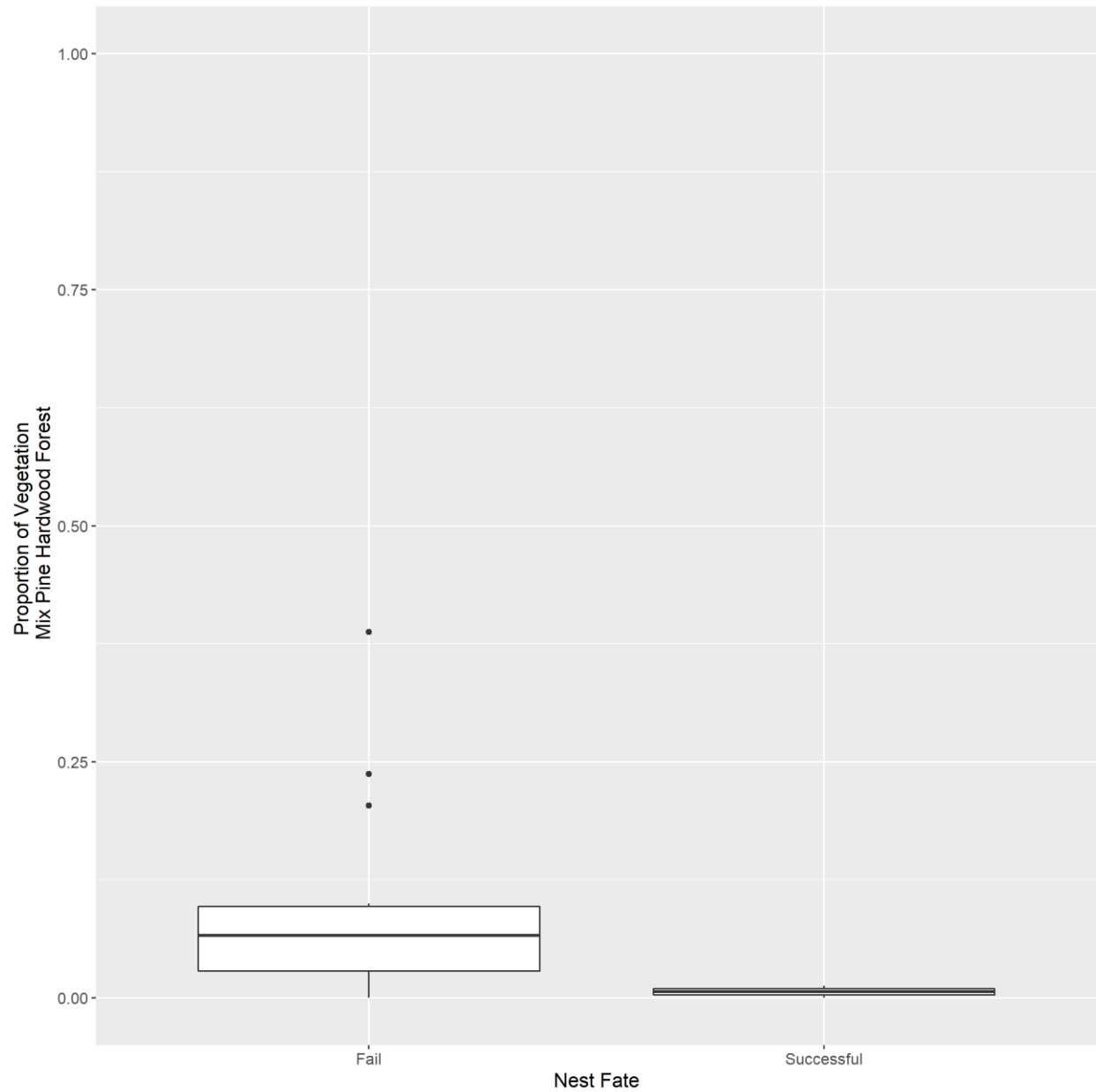


Figure A.21. Proportion of mix pine hardwood forest at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

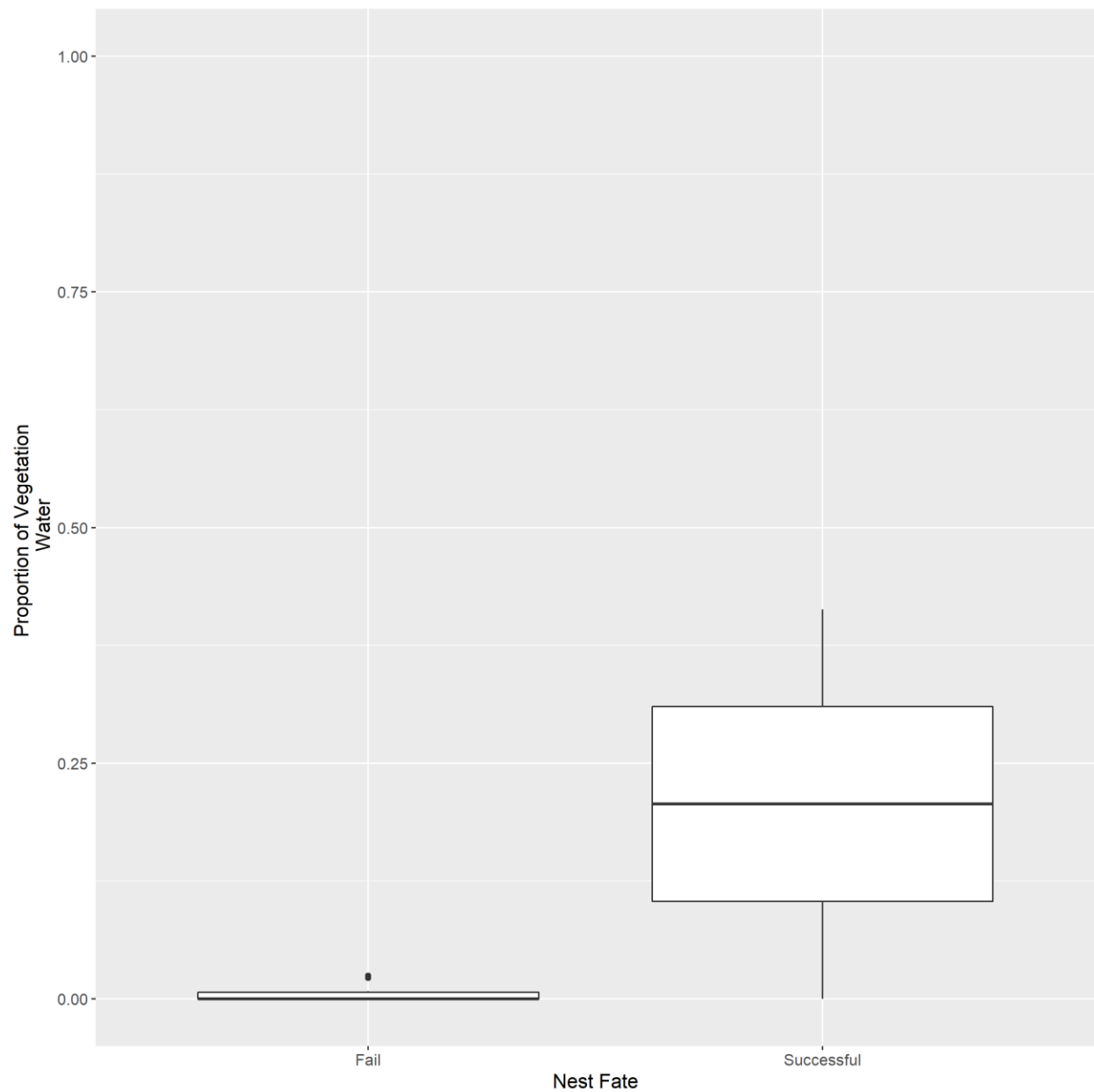


Figure A.22. Proportion of water at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

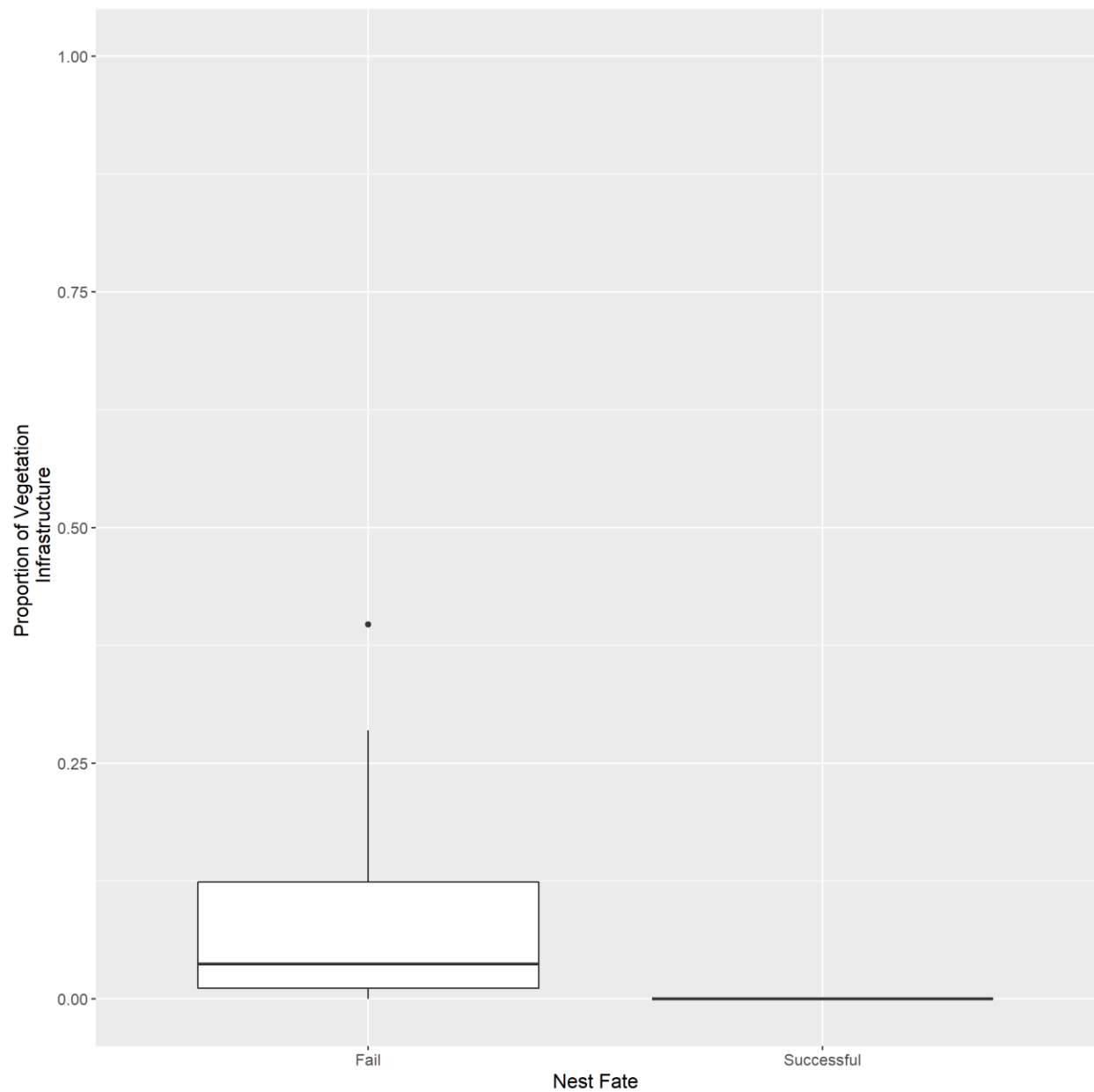


Figure. A.23. Proportion of infrastructure at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

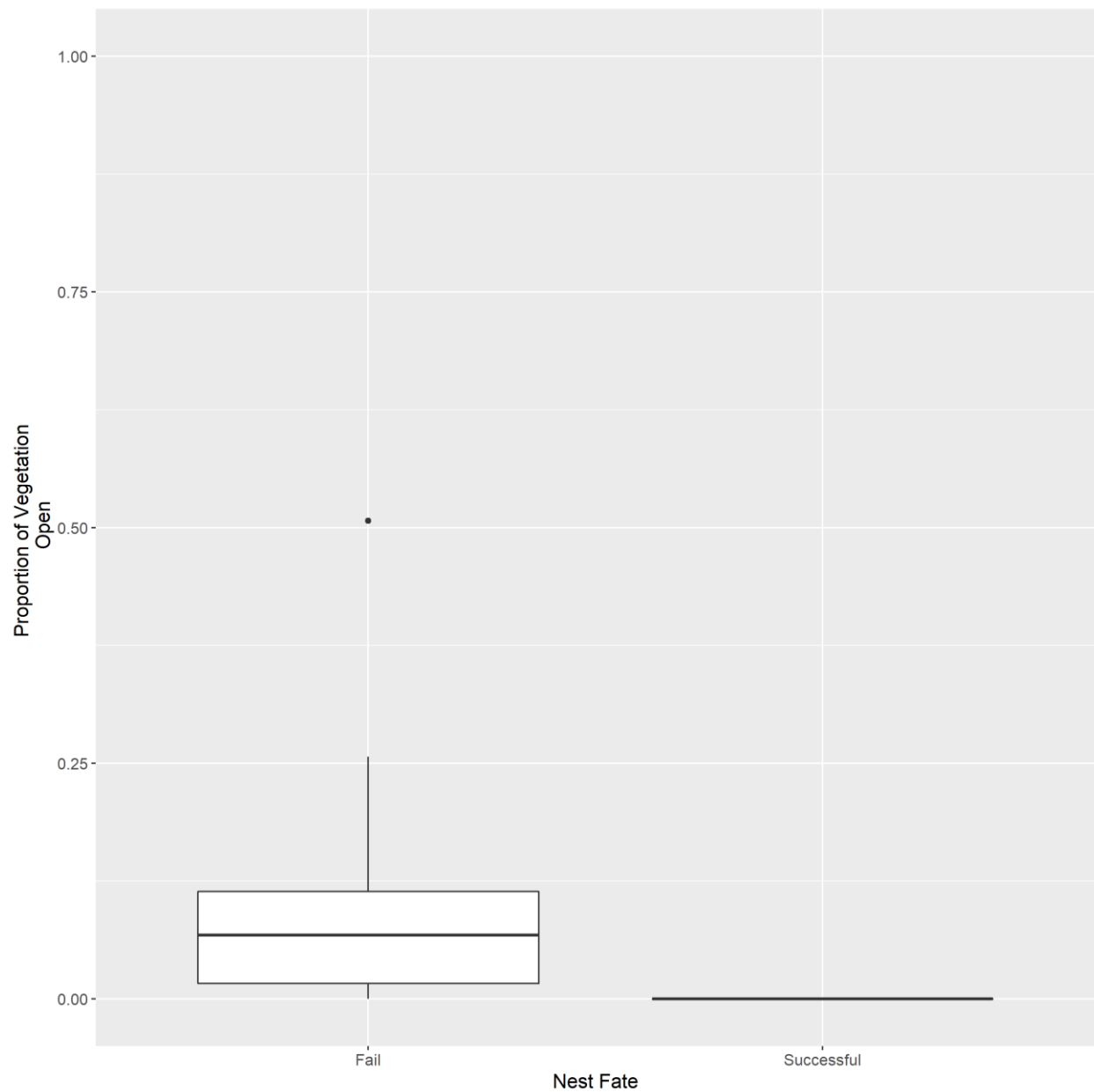


Figure A.24. Proportion of open habitat at nest sites where crows (*Corvus brachyrhynchos*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

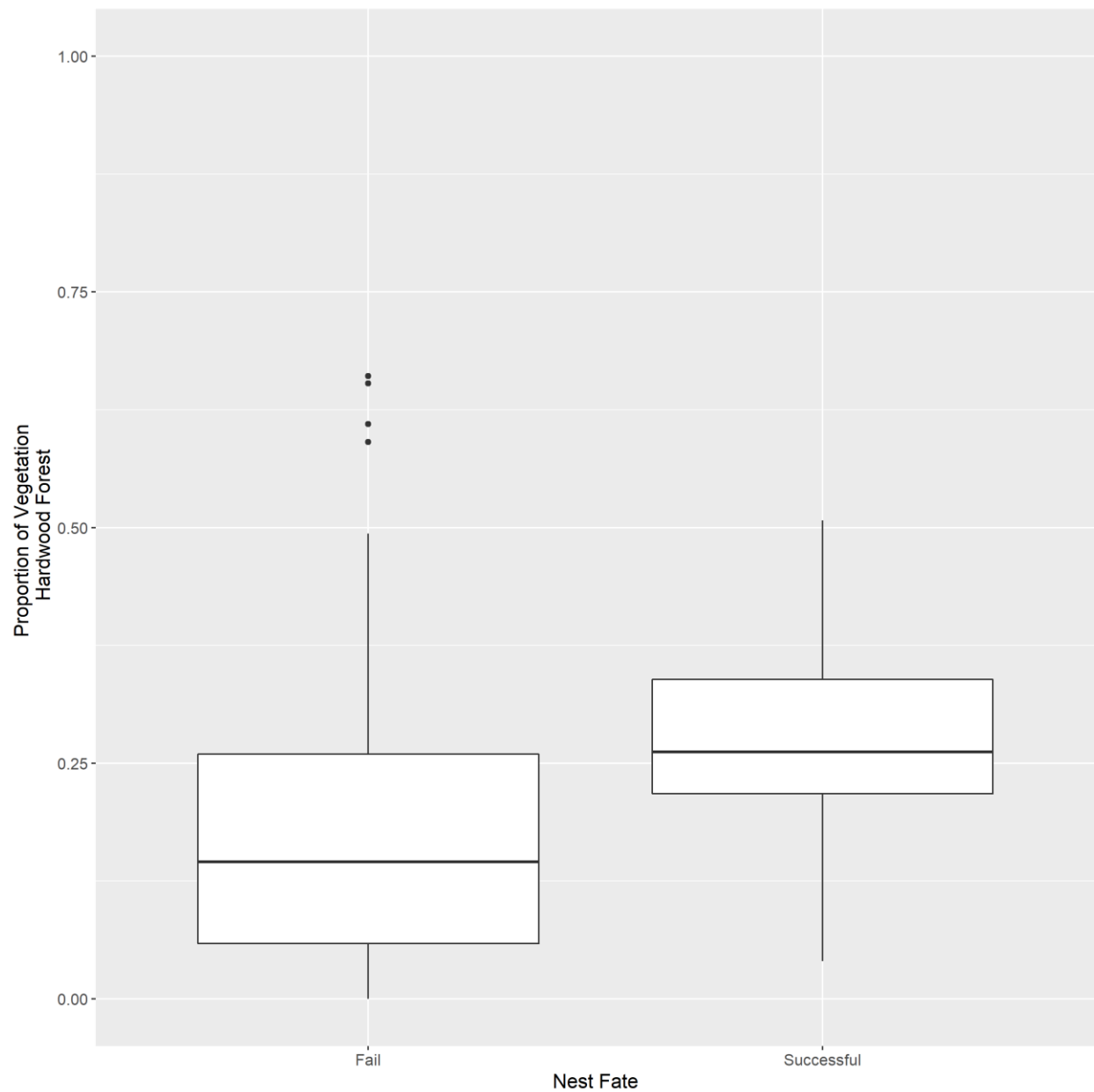


Figure A.25. Proportion of hardwood forest at nest sites where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

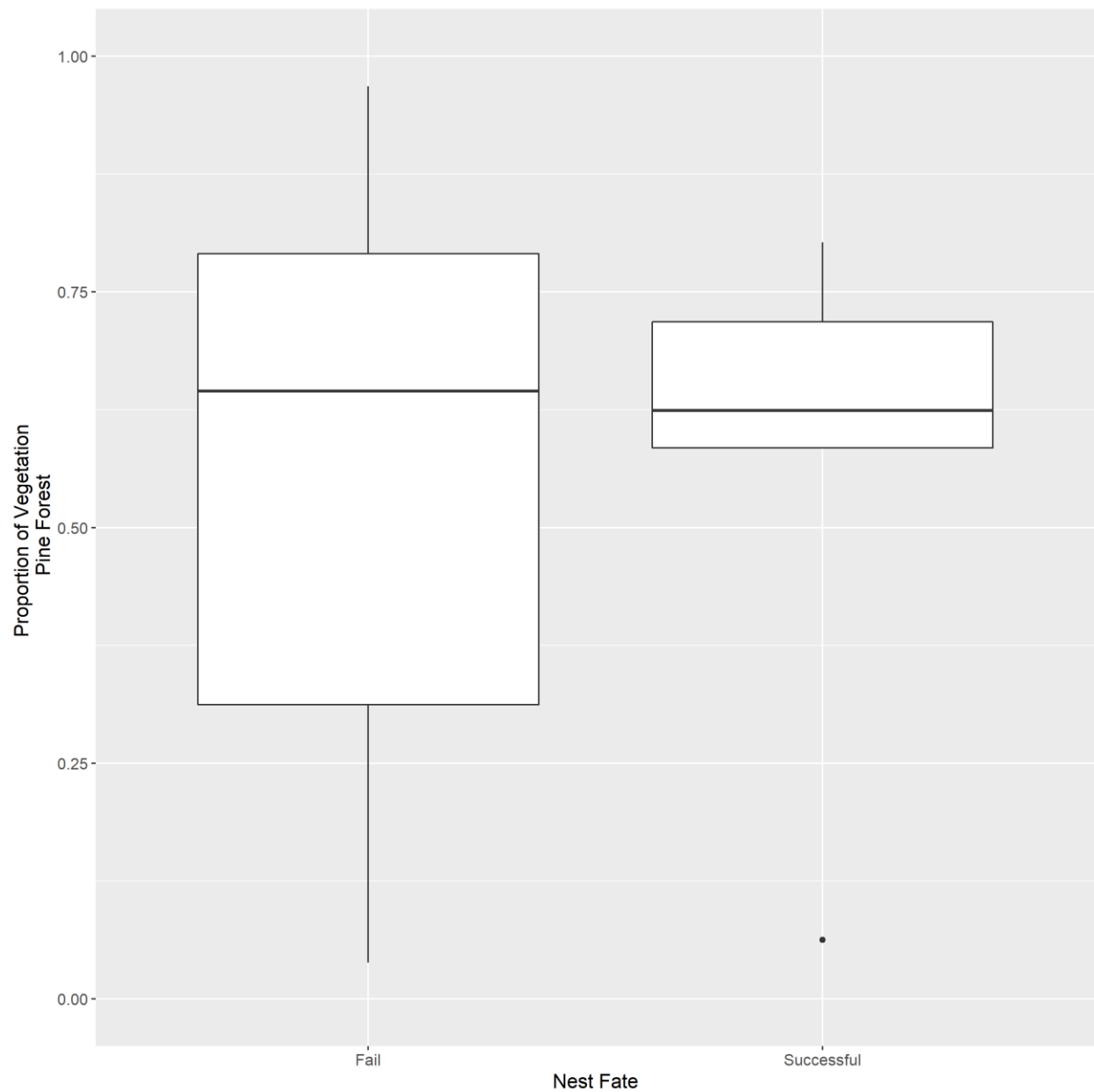


Figure A.26. Proportion of pine forest at nest site where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

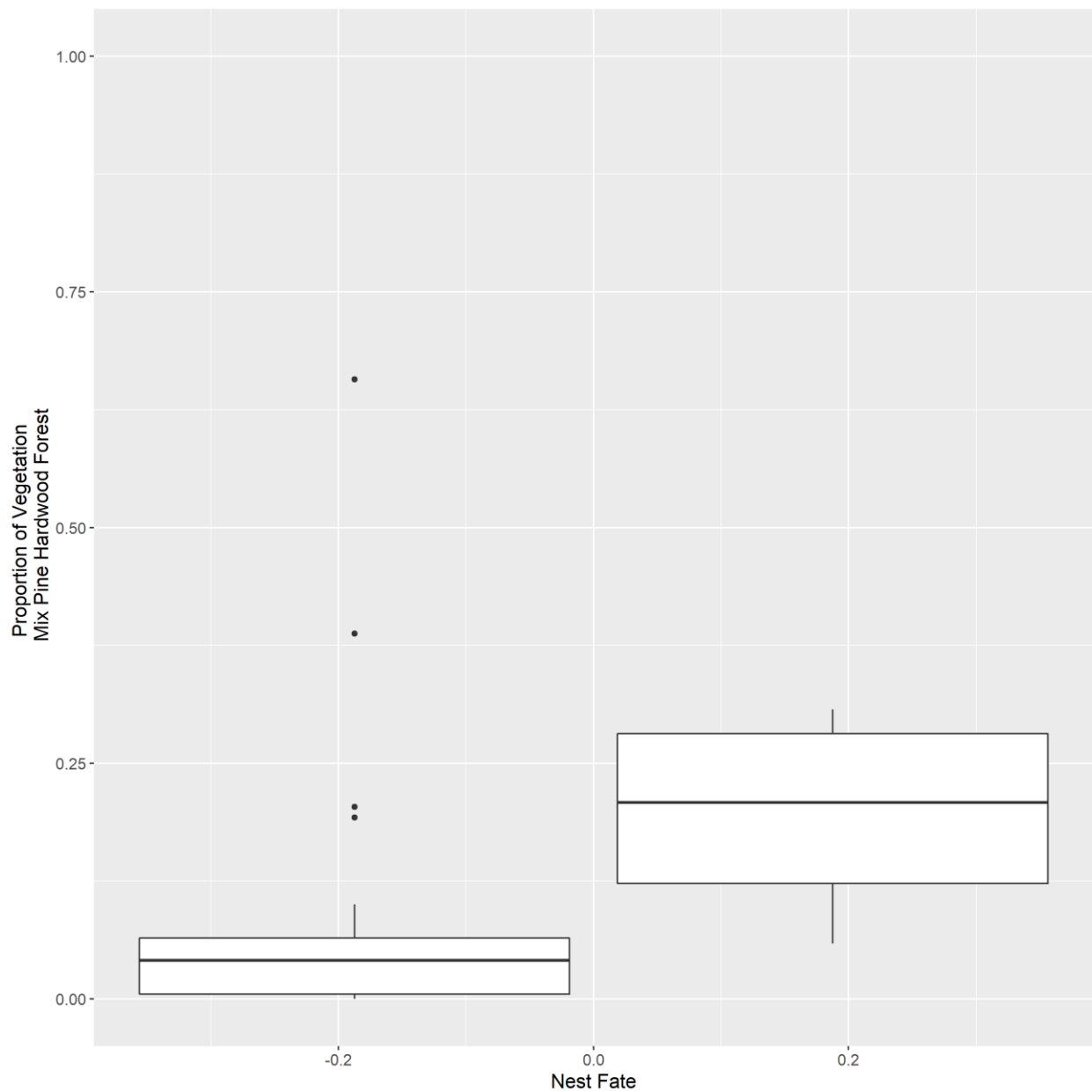


Figure A.27. Proportion of mix pine hardwood forest at nest sites where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

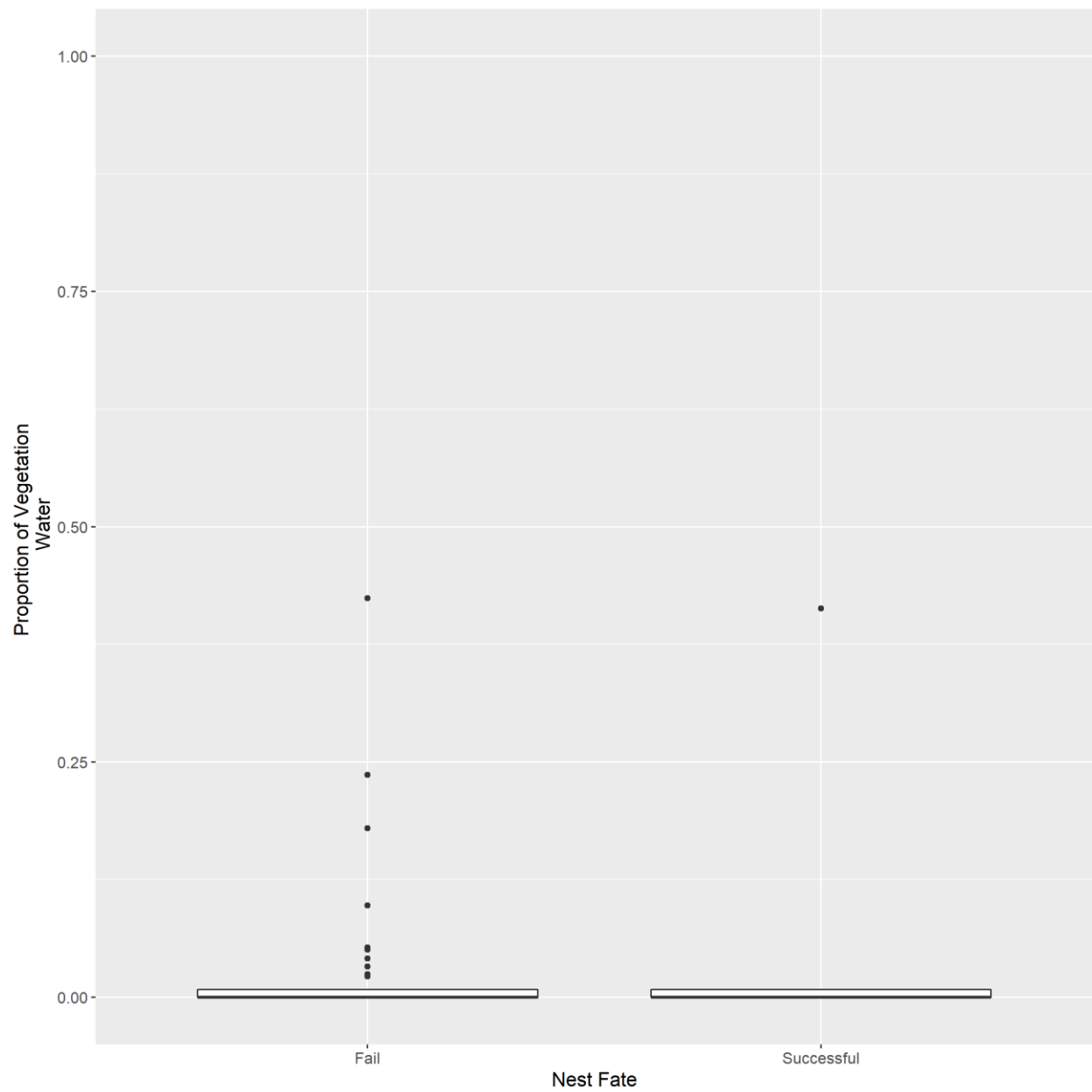


Figure A.28. Proportion of water at nest sites where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

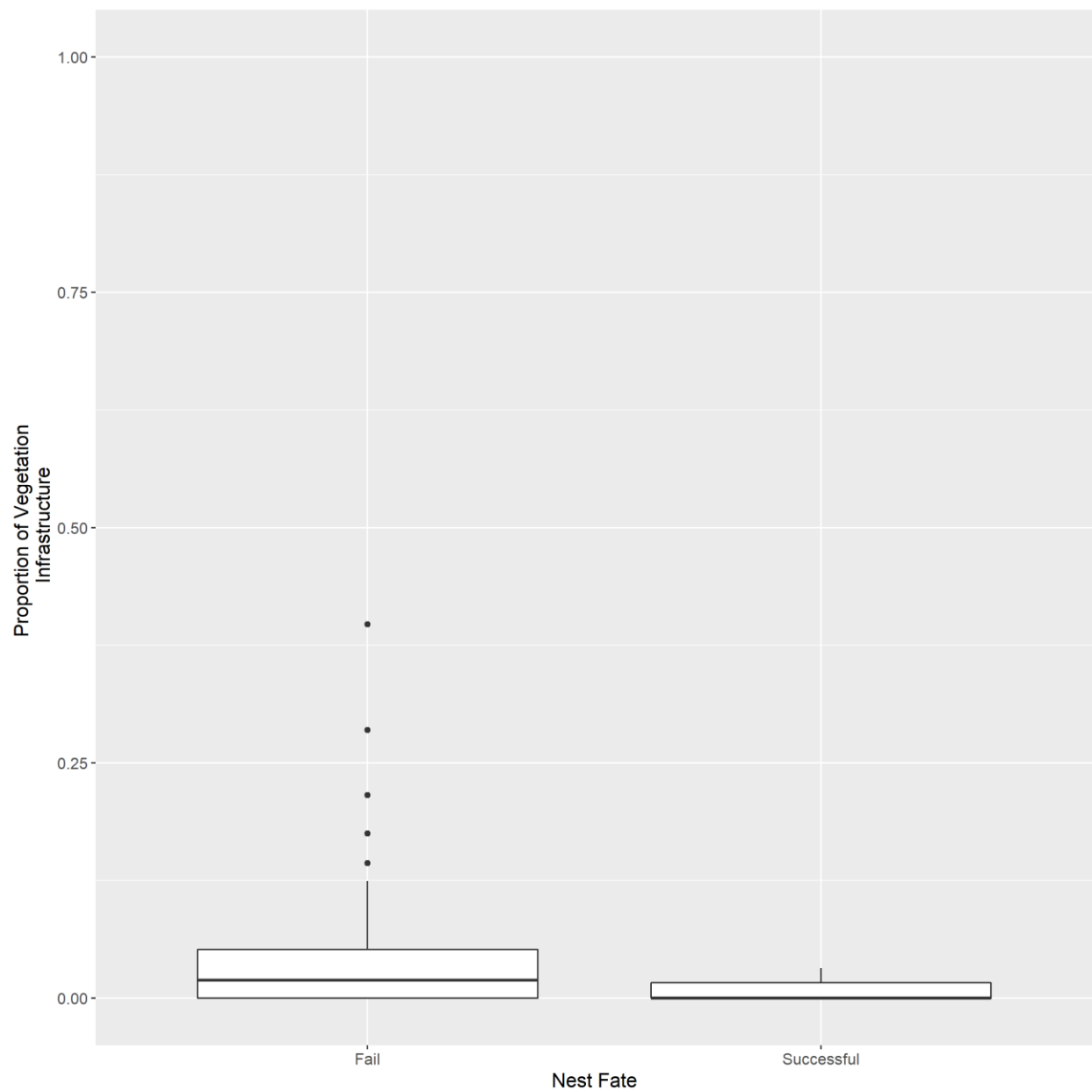


Figure A.29. Proportion of infrastructure at nest sites where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

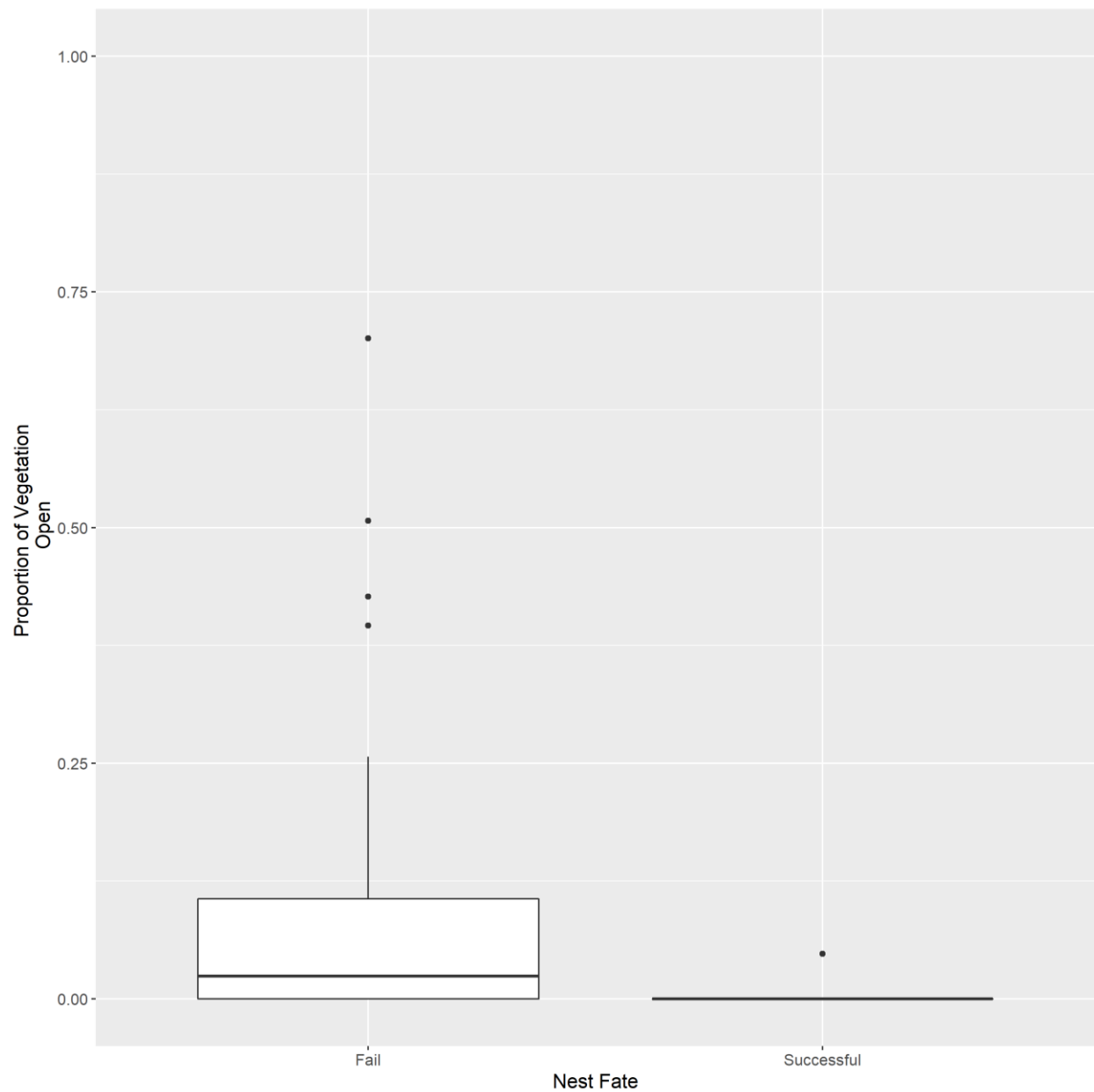


Figure A.30. Proportion of open habitat at nests sites where feral pigs (*Sus scrofa*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

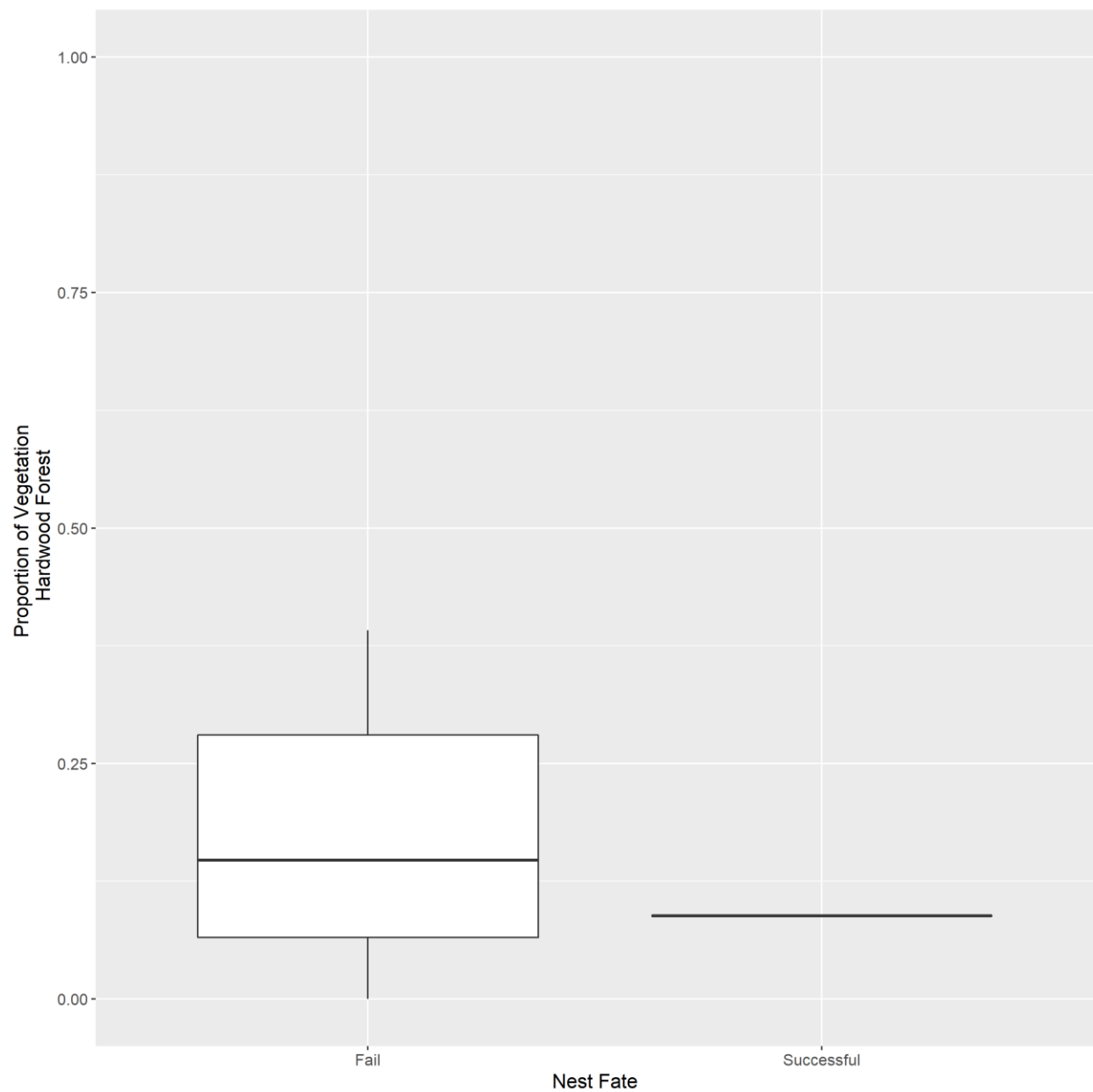


Figure A.31. Proportion of hardwood forest at nest sites where fox (*Urocyon cinereoargenteus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

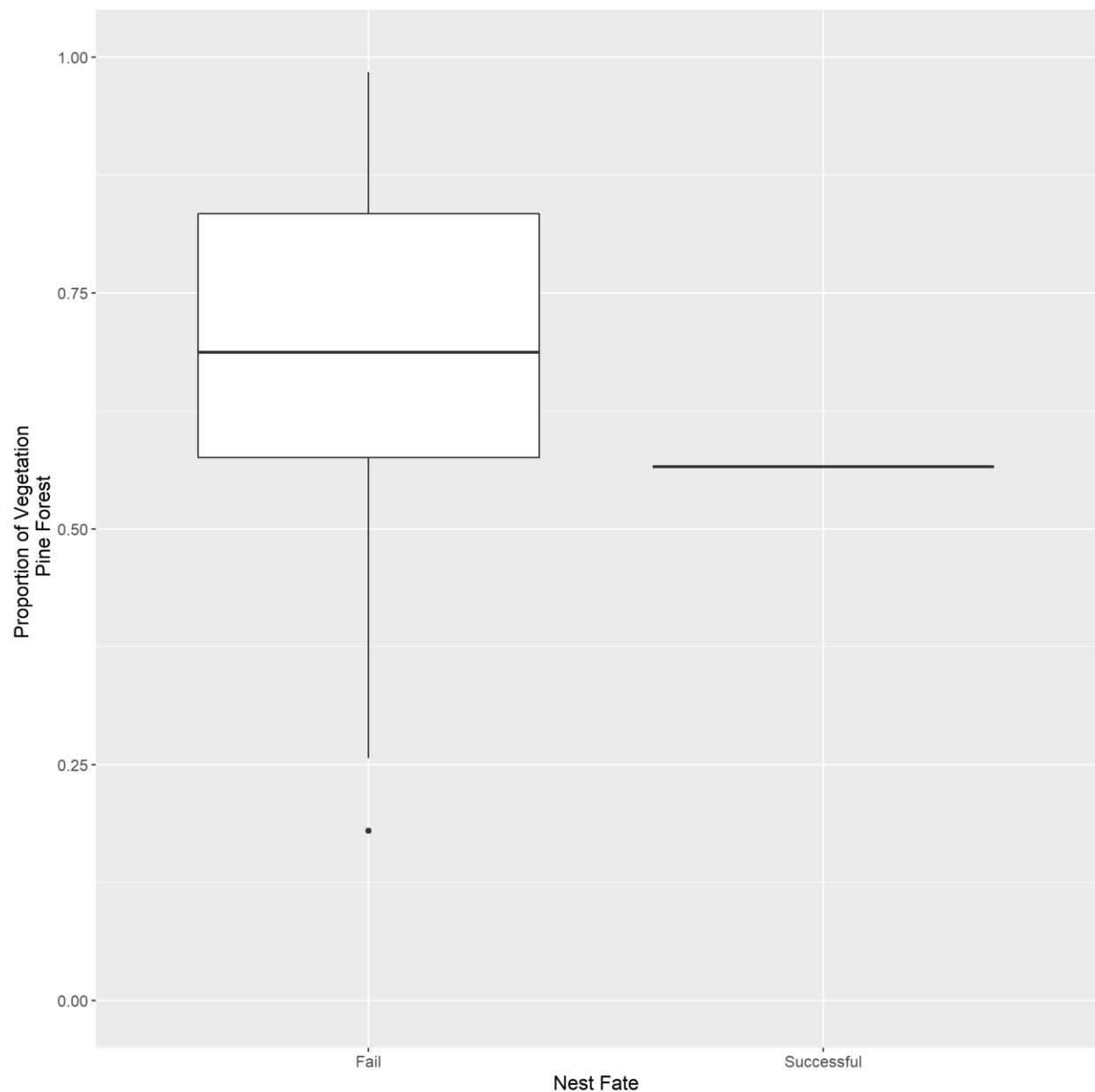


Figure A.32. Proportion of pine forest at nest sites where fox (*Urocyon cinereoargenteus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

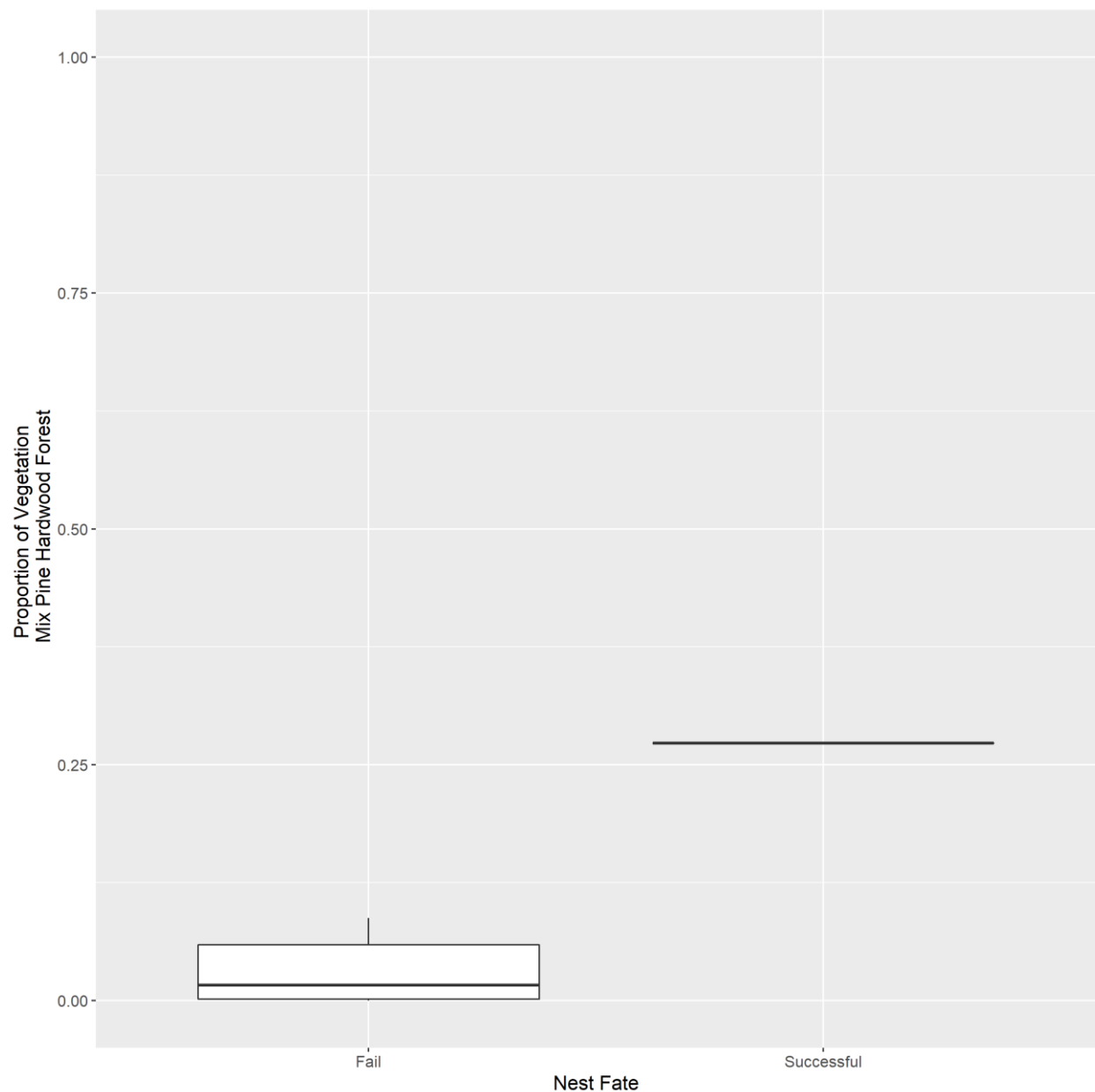


Figure A.33. Proportion of mix pine hardwood forest at nest sites where fox (*Urocyon cinereoargenteus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

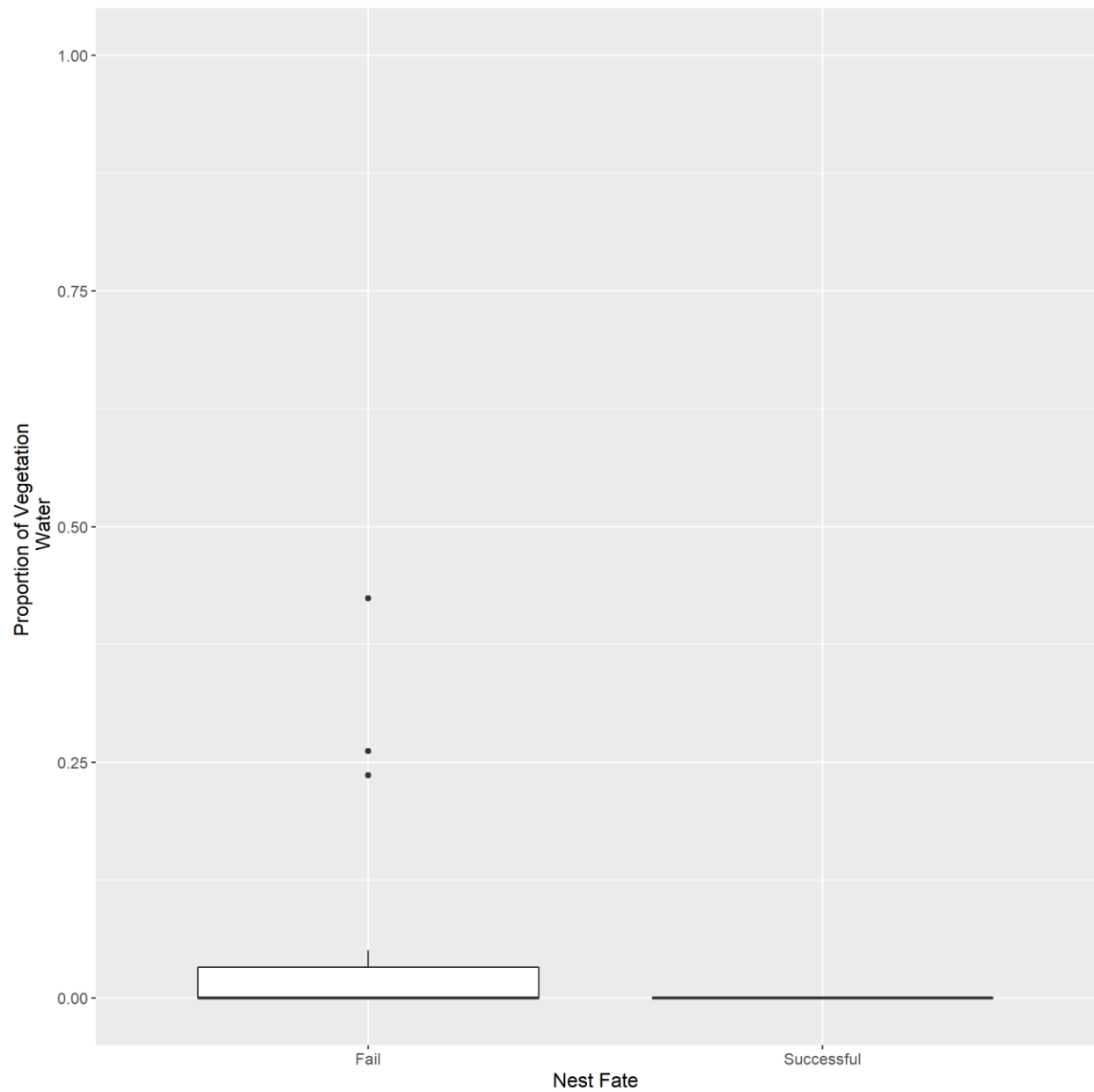


Figure A.34. Proportion of water at nest sites where fox (*Urocyon cinereoargenteus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

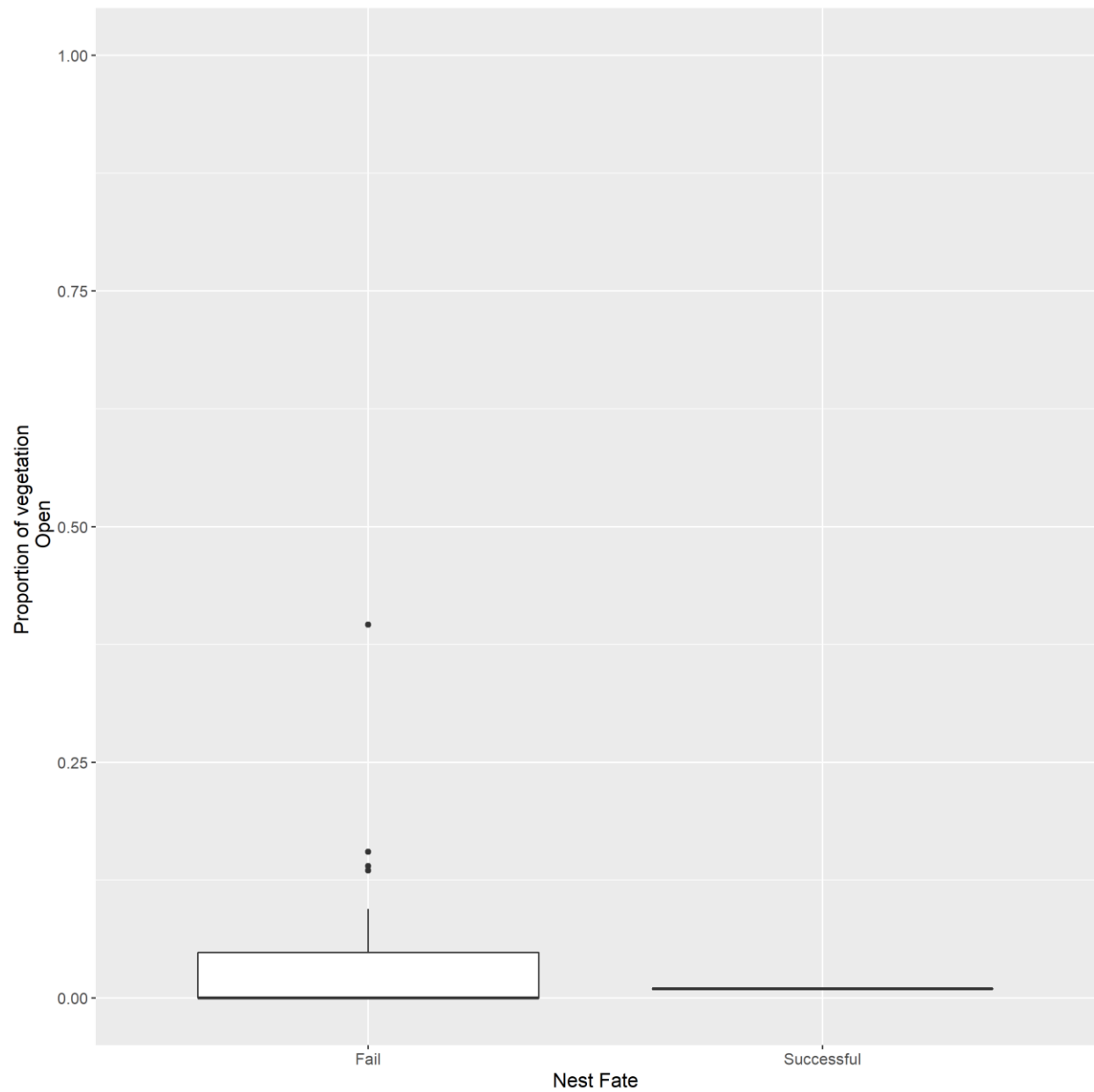


Figure A.35. Proportion of open habitat at nest sites where fox (*Urocyon cinereoargenteus*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

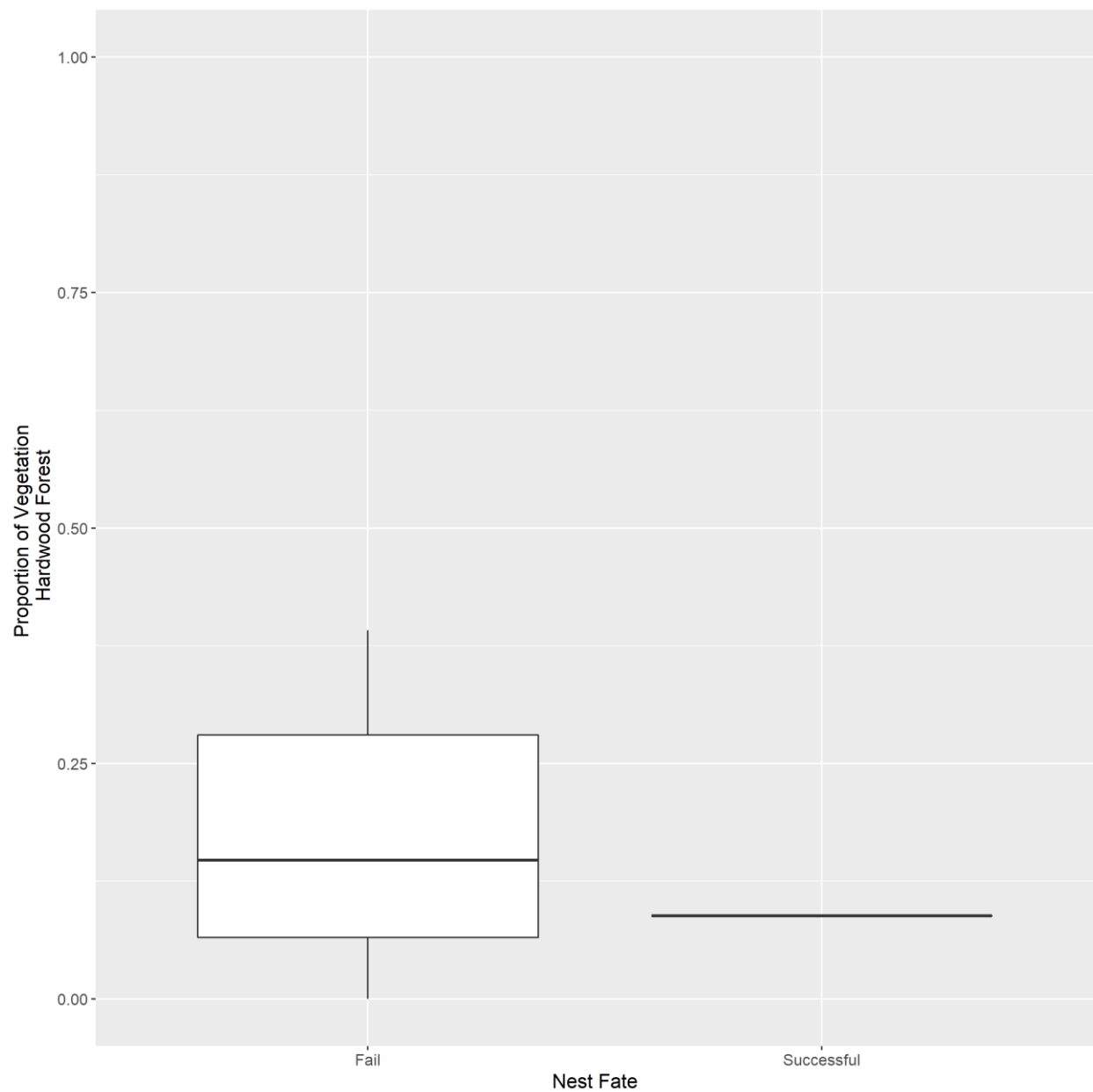


Figure A.36. Proportion of hardwood forest where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA 2019.

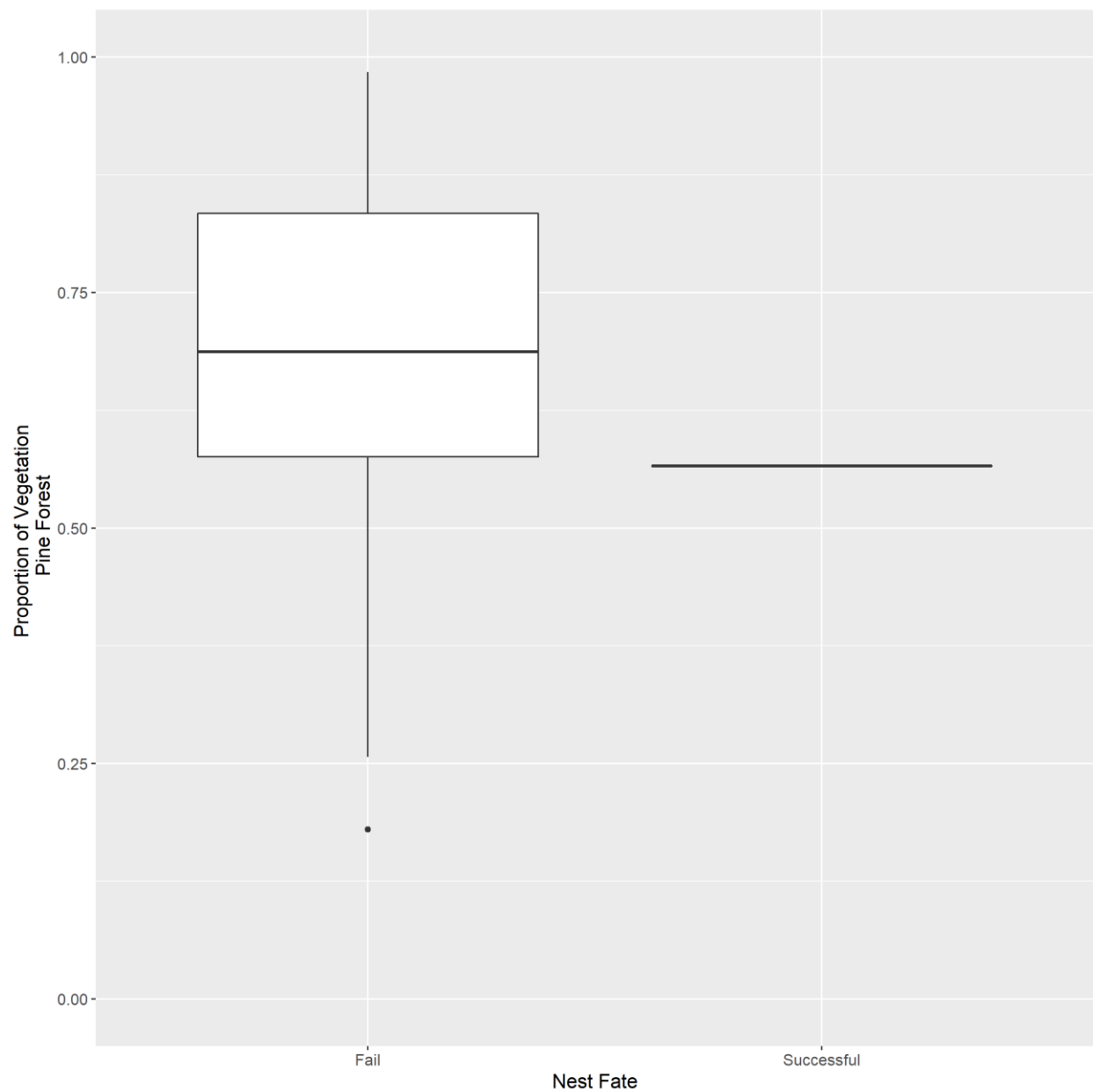


Figure A.37. Proportion of pine forest at nest sites where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

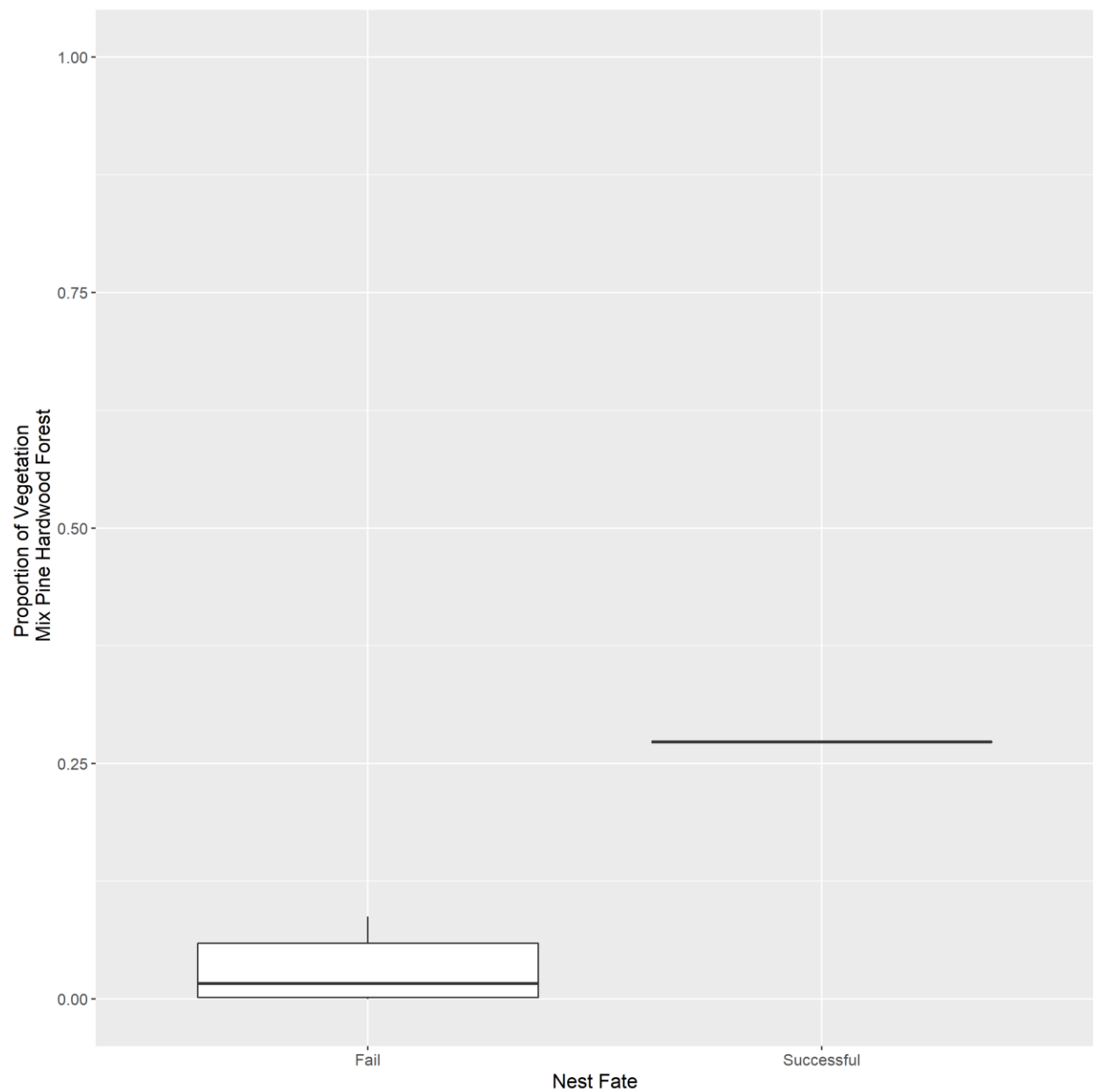


Figure A.38. Proportion of mix pine hardwood forest at nest sites where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

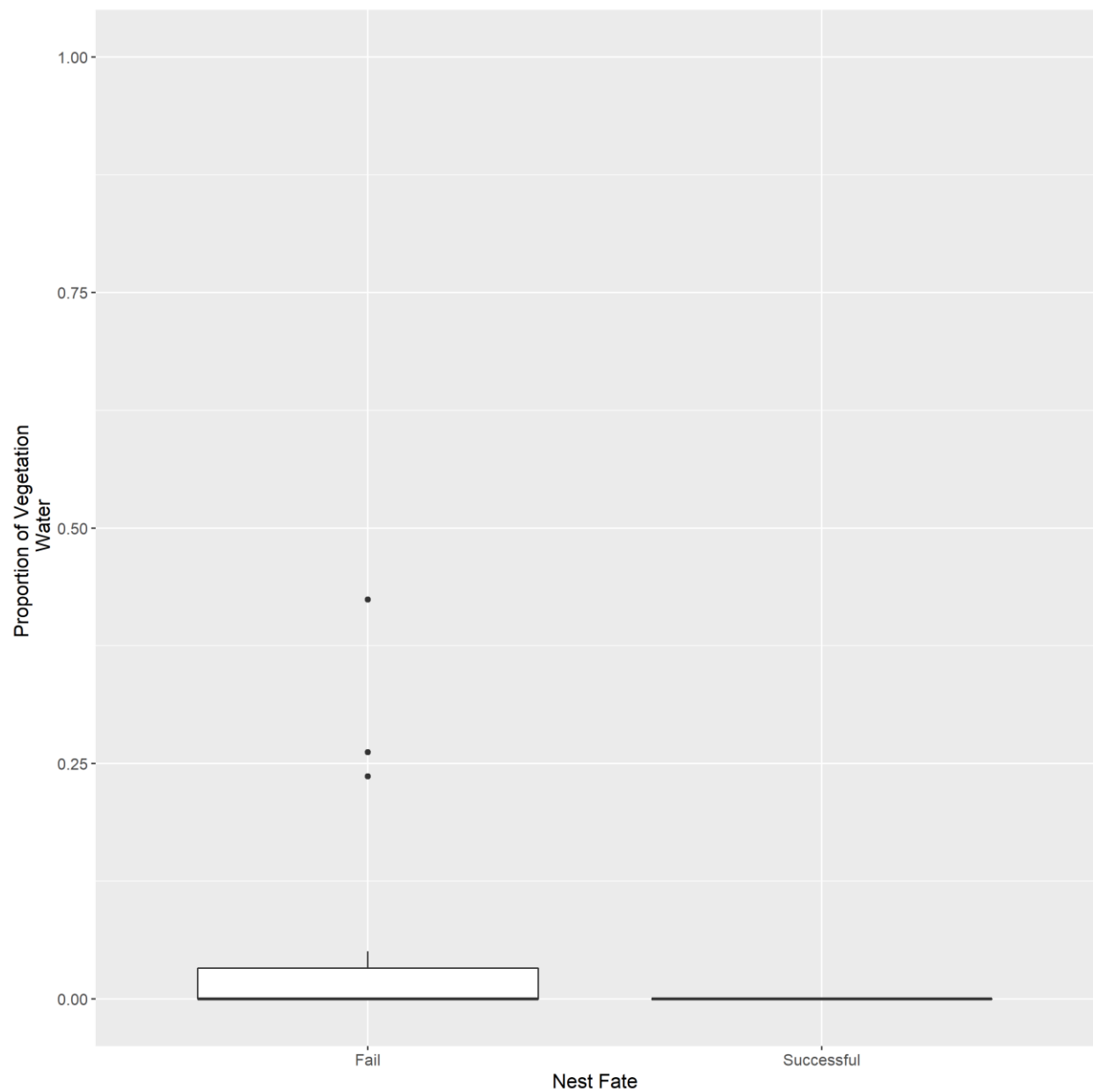


Figure A.39. Proportion of water at nest sites where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

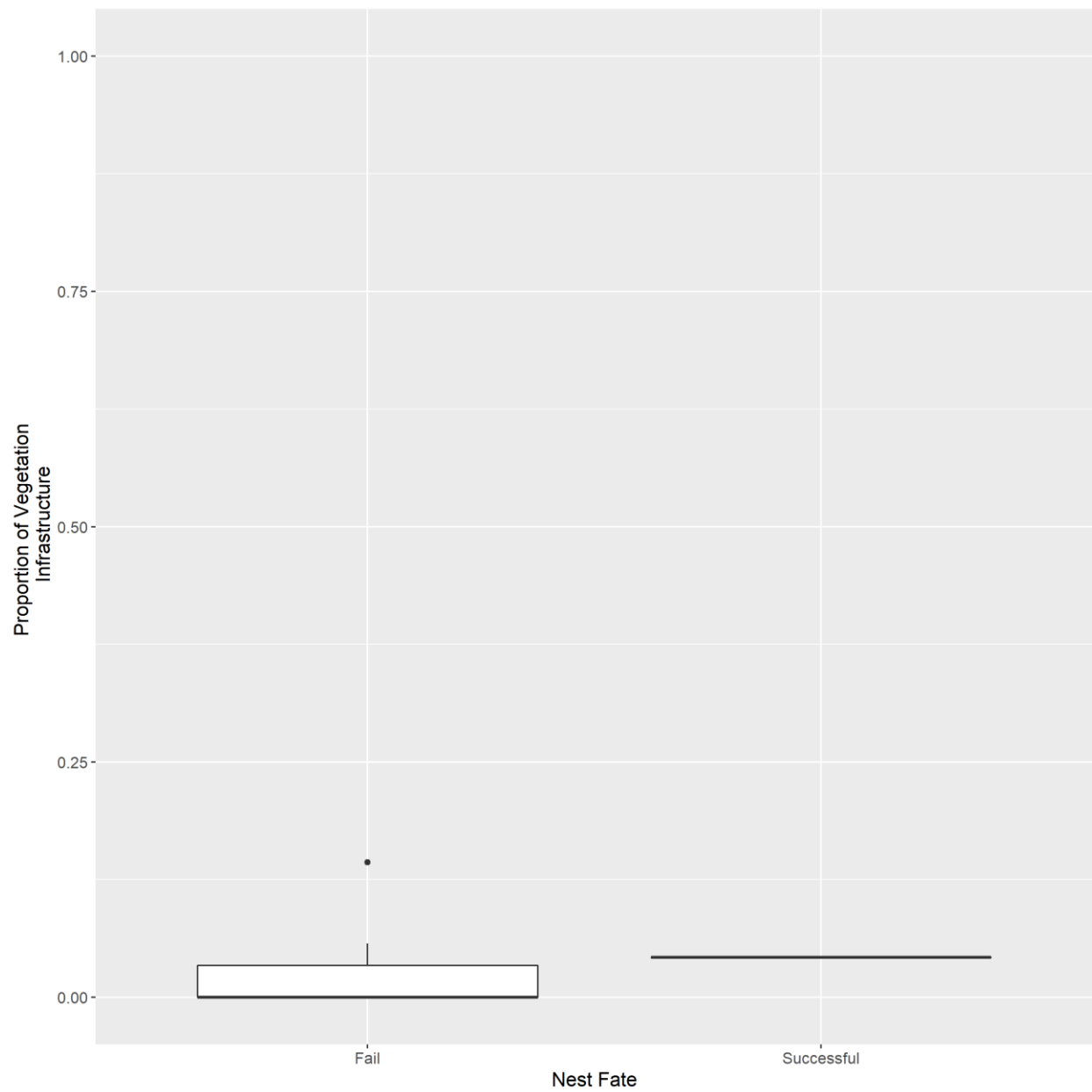


Figure A.40. Proportion of infrastructure at nest sites where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

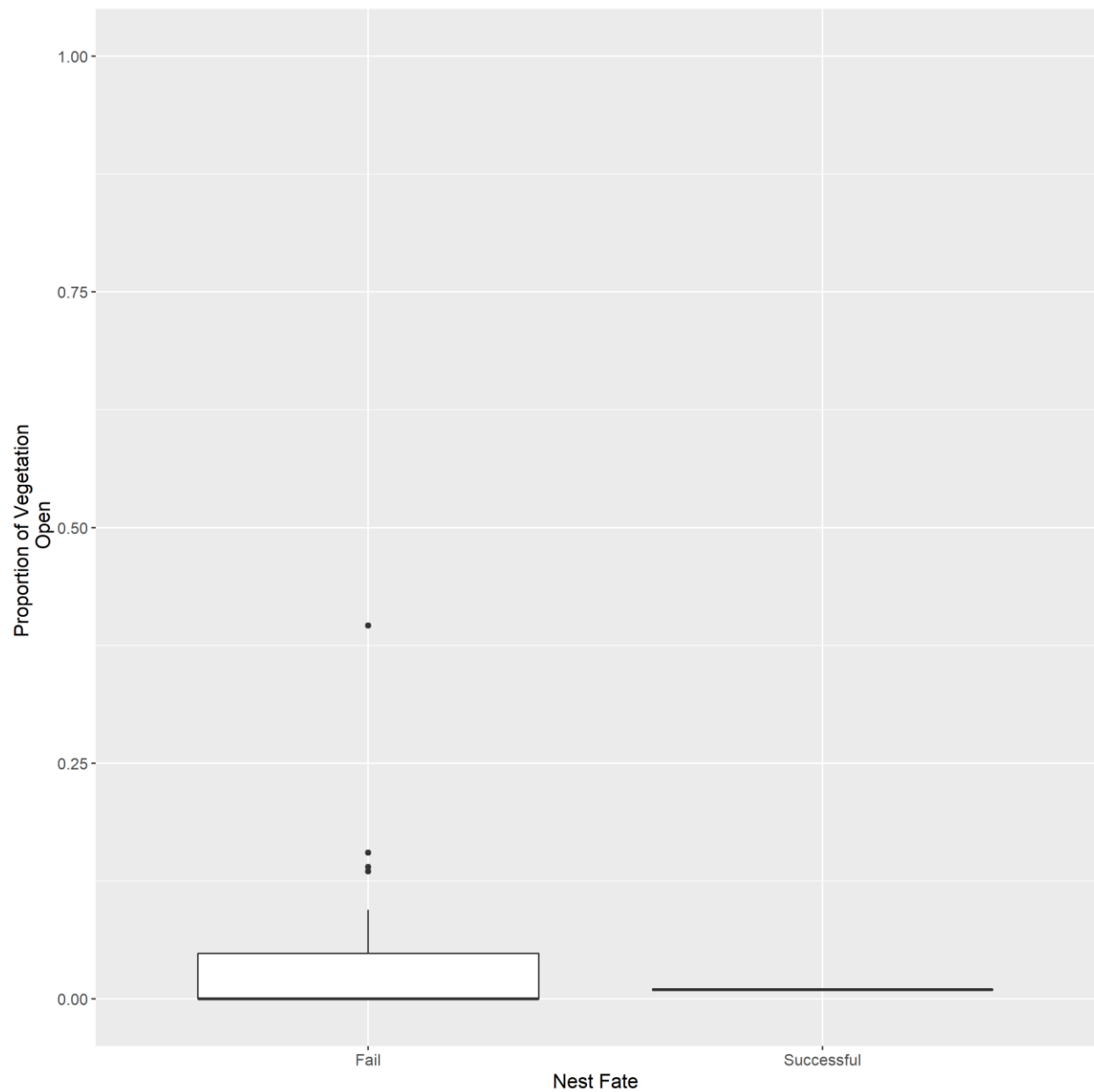


Figure A.41. Proportion of open habitat at nest sites where opossum (*Didelphis virginiana*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

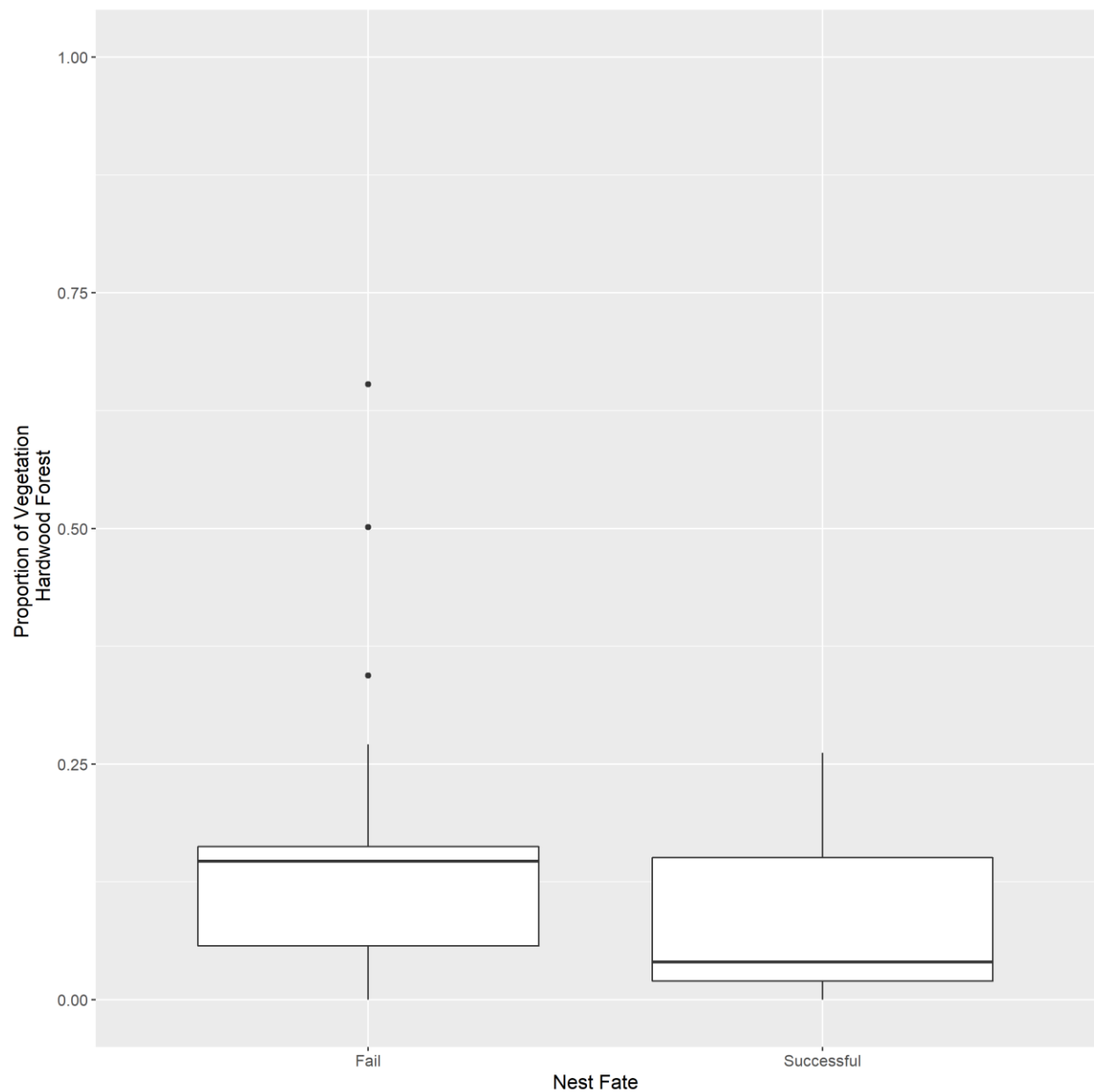


Figure A.42. Proportion of hardwood forest at nest sites where raccoons (*Procyon lotor*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

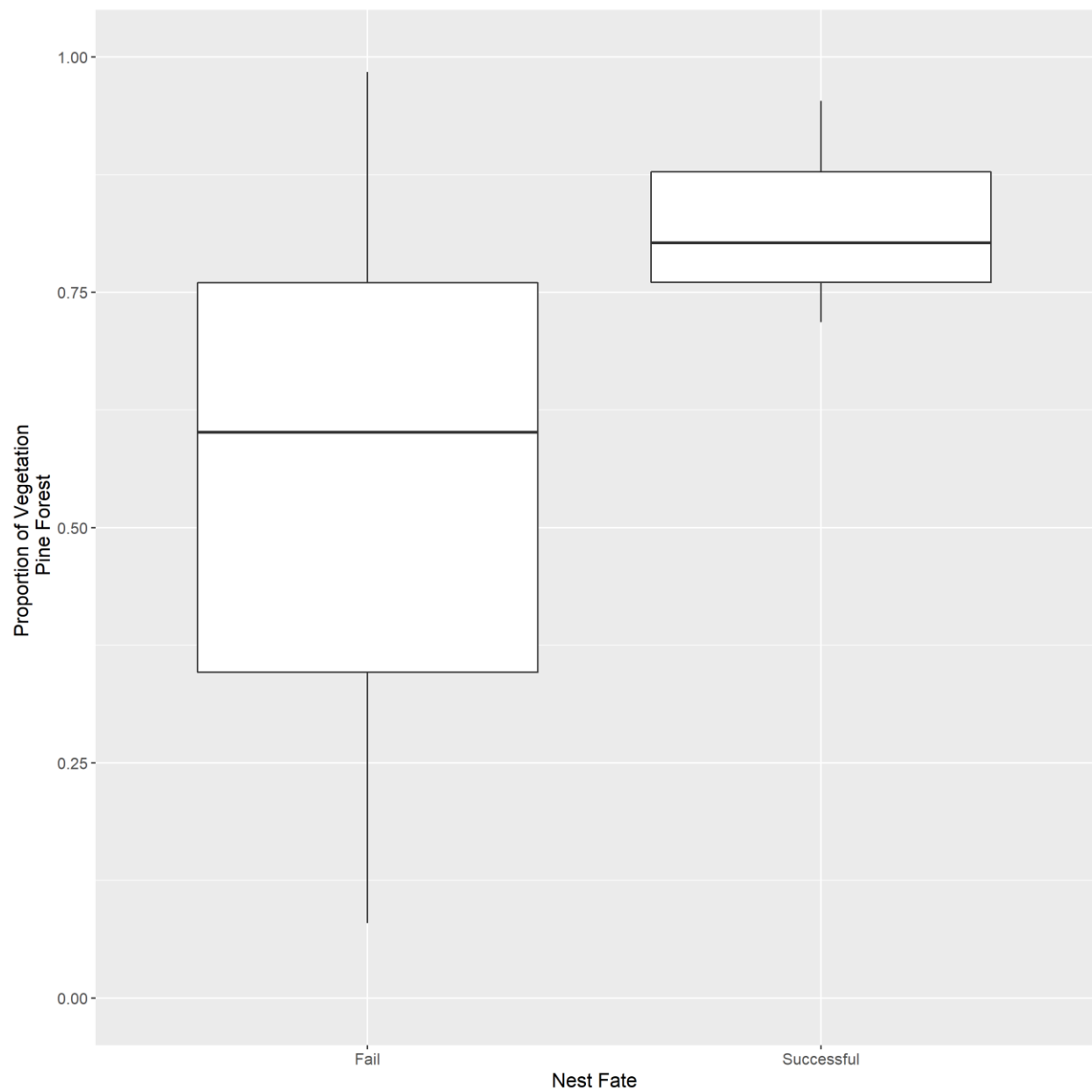


Figure A.43. Proportion of pine forest at nest sites where raccoons (*Procyon lotor*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

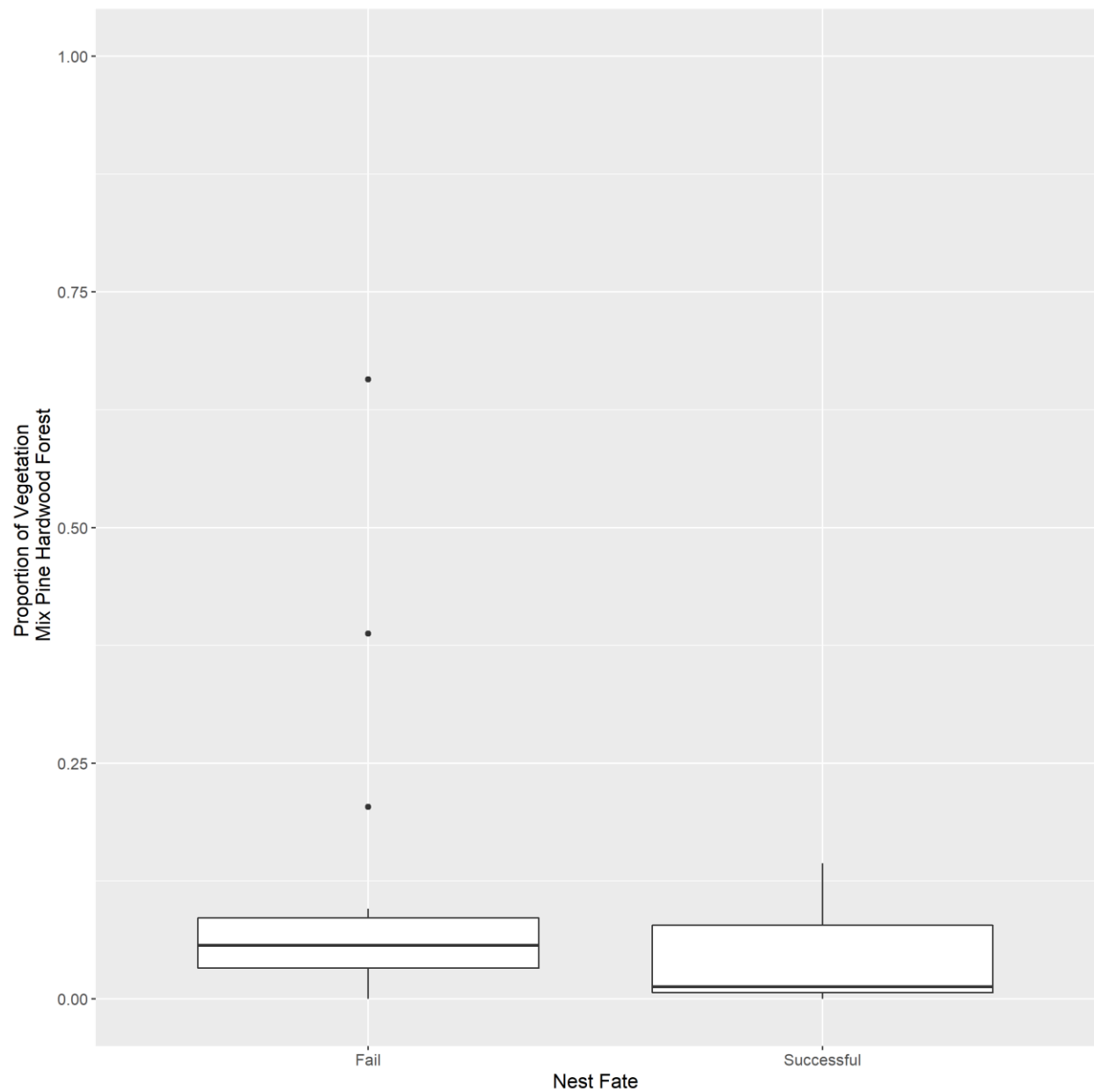


Figure A.44. Proportion of mix pine hardwood forest at nest sites where raccoons (*Procyon lotor*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

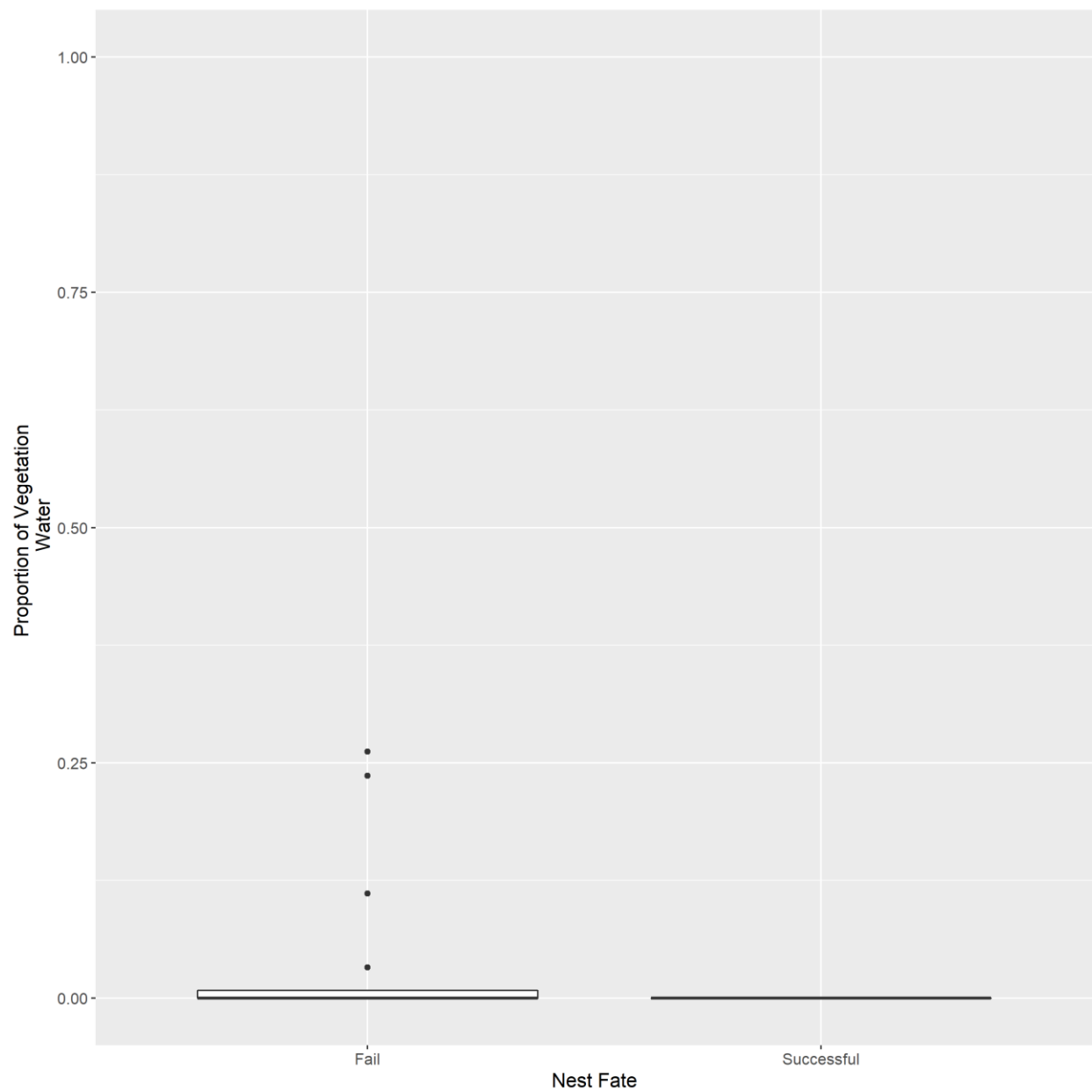


Figure A.45. Proportion of water at nest sites where raccoons (*Procyon lotor*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

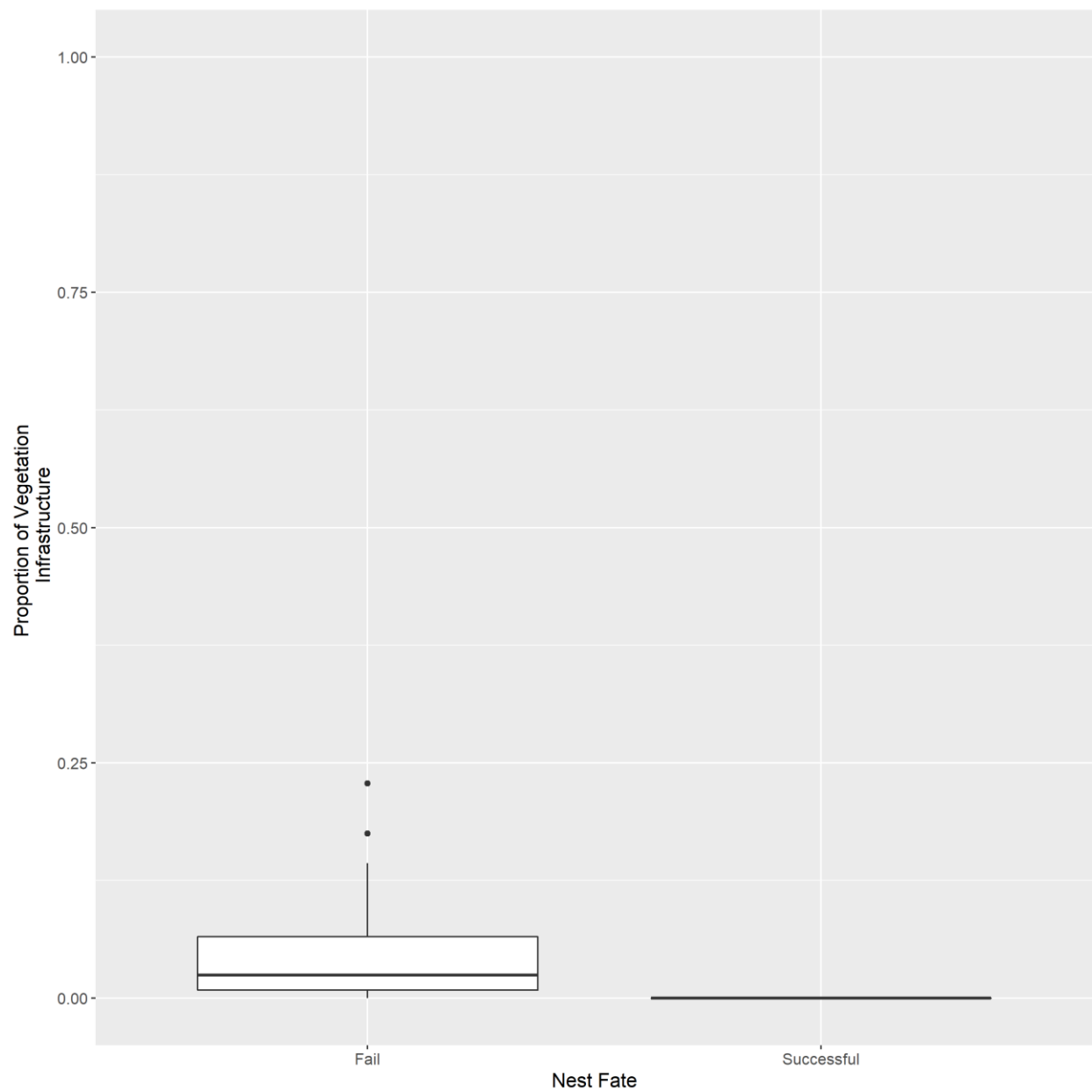
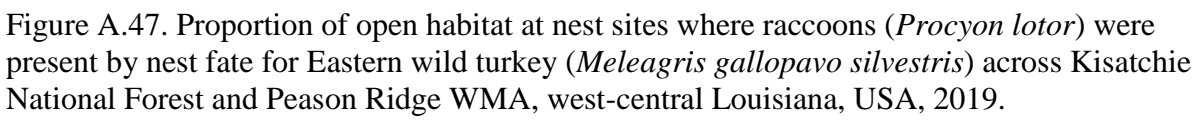


Figure A.46. Proportion of infrastructure at nest sites where raccoons (*Procyon lotor*) were present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.



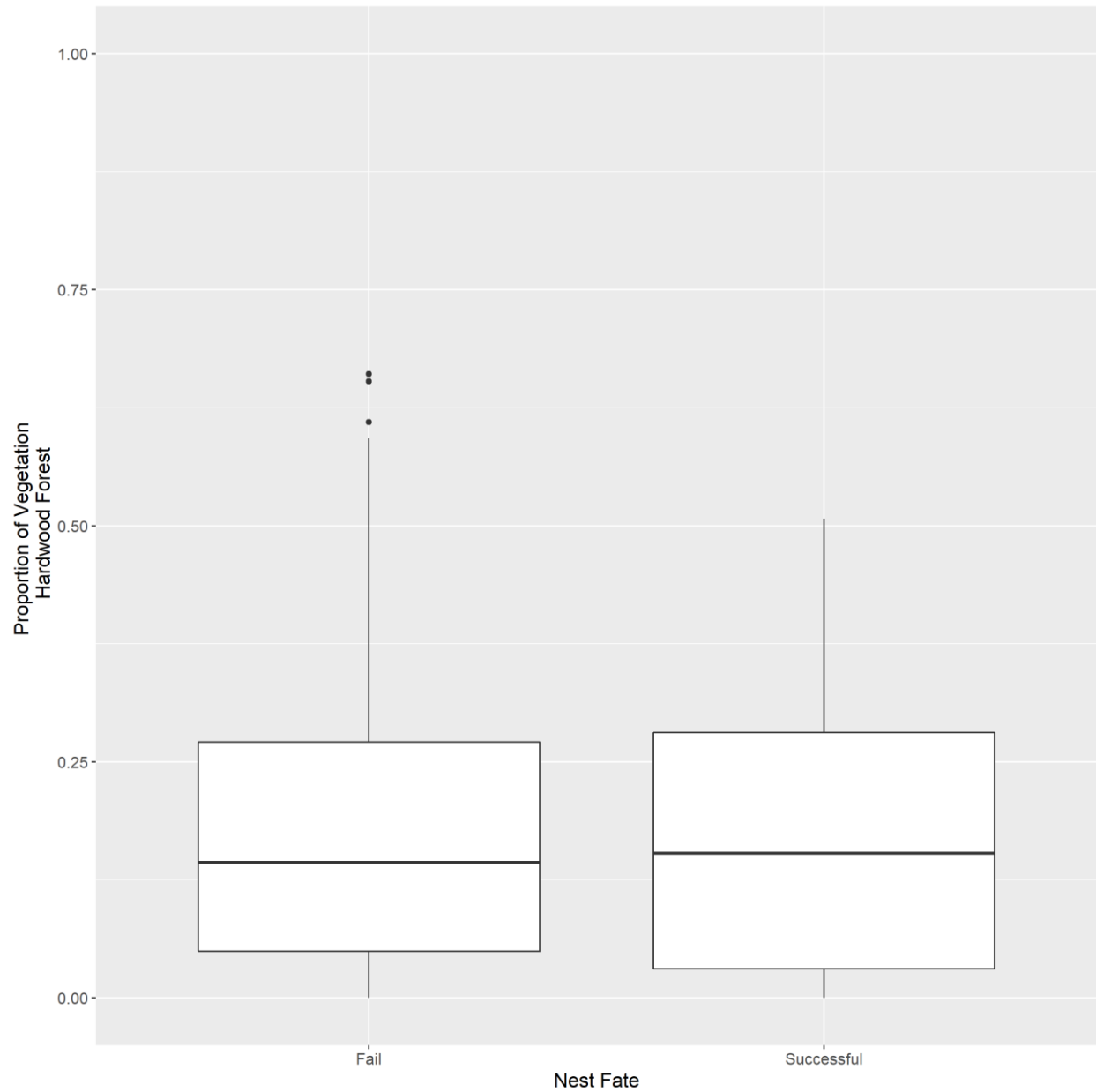


Figure A.48. Proportion of hardwood forest at nest sites with at least one predator species present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

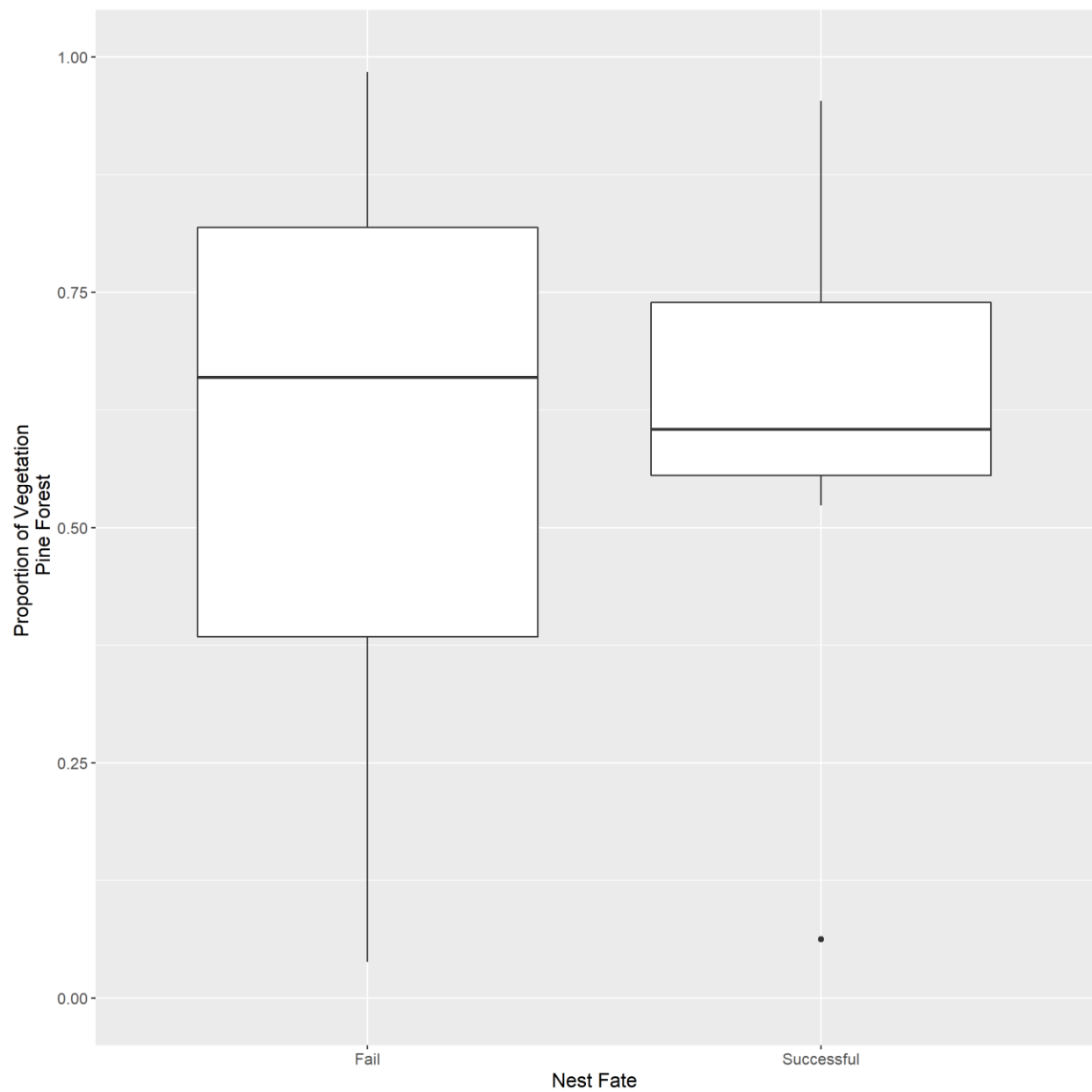


Figure A.49. Proportion of pine forest at nest sites with at least one predator species present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

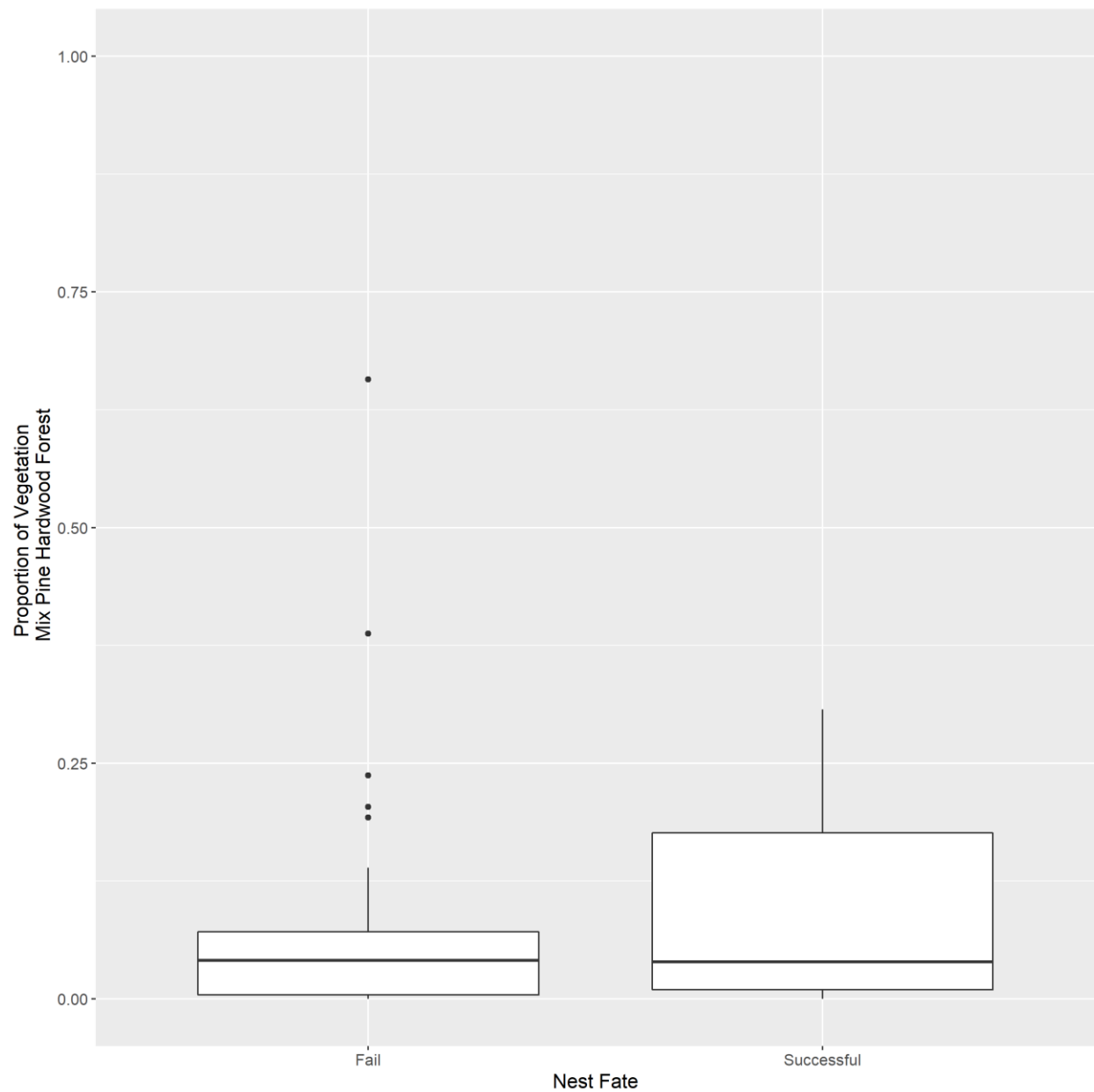


Figure A.50. Proportion of mix pine hardwood forest at nest sites with at least one predator species present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

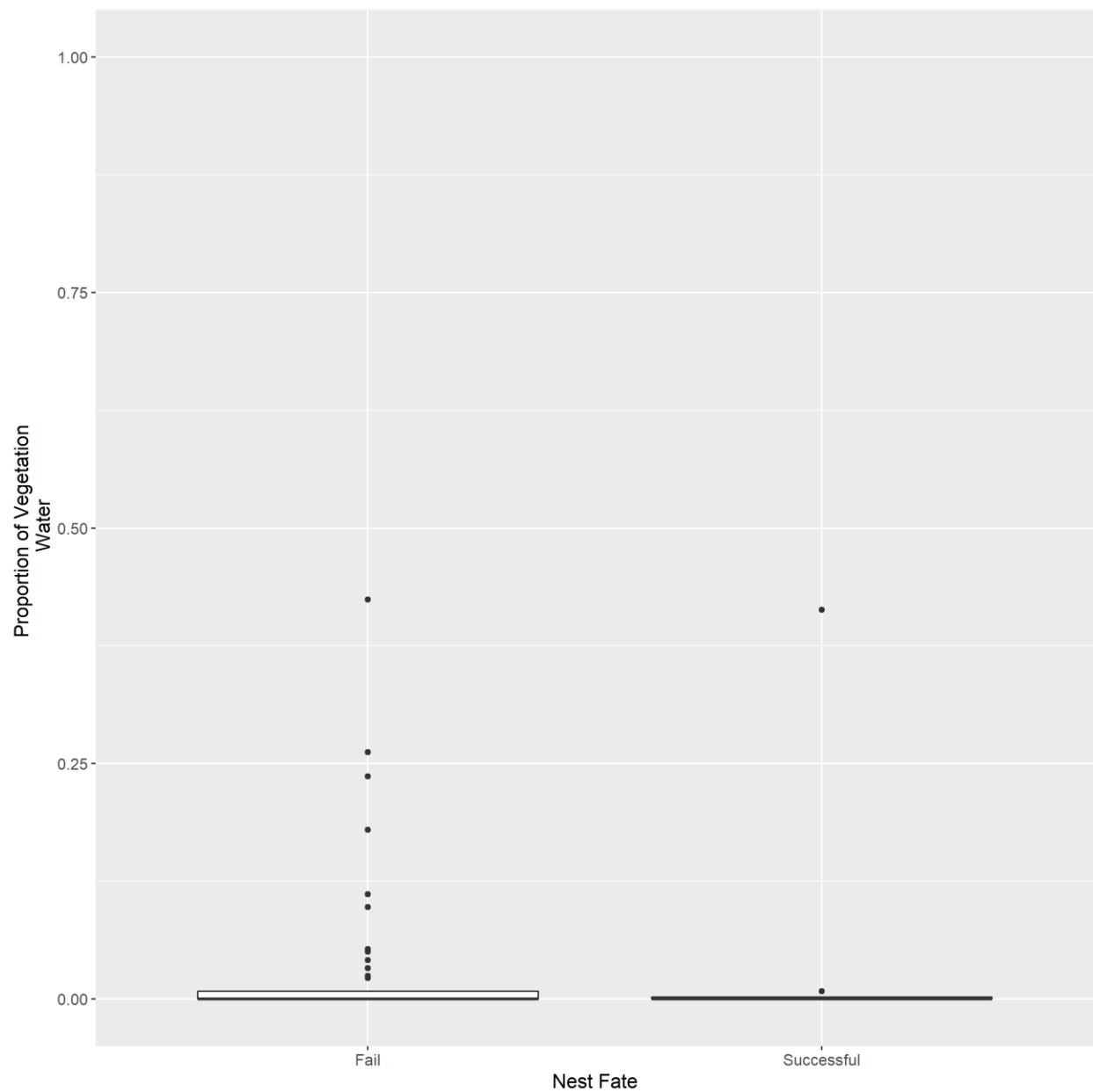


Figure A.51. Proportion of water at nest sites with at least one predator species present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

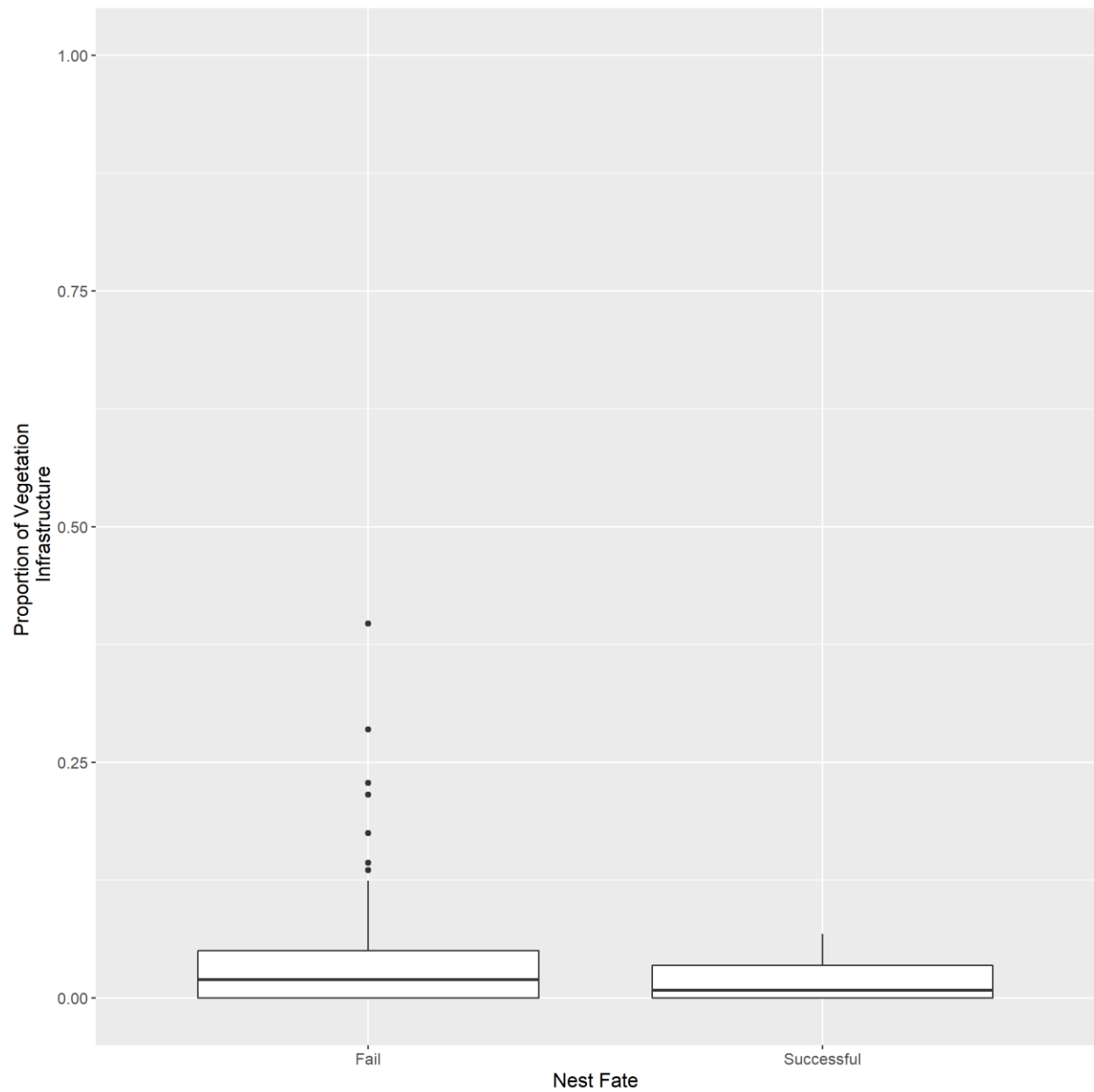


Figure A.52. Proportion of infrastructure at nest sites with at least one predator species present by nest fate for Eastern wild turkey (*Meleagris gallopavo silvestris*) across Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

APPENDIX B. SUPPLEMENTARY MATERIAL FOR CHAPTER 3

Table B.1. Mean, median, and range of initiation dates for the first nest of each breeding group by year on Kisatchie National Forest (KNF) and Peason Ridge Wildlife Management Area (PRWMA).

Year	Mean Date	Median Date	Range
2014	20 April	21 April	3/28 – 5/10
2015	6 April	7 April	3/20 – 5/3
2016	23 April	28 April	3/26 – 5/13
2017	6 April	5 April	3/12 – 5/5
2018	15 April	12 April	3/14 – 5/15
2019	5 April	1 April	3/16 – 5/23

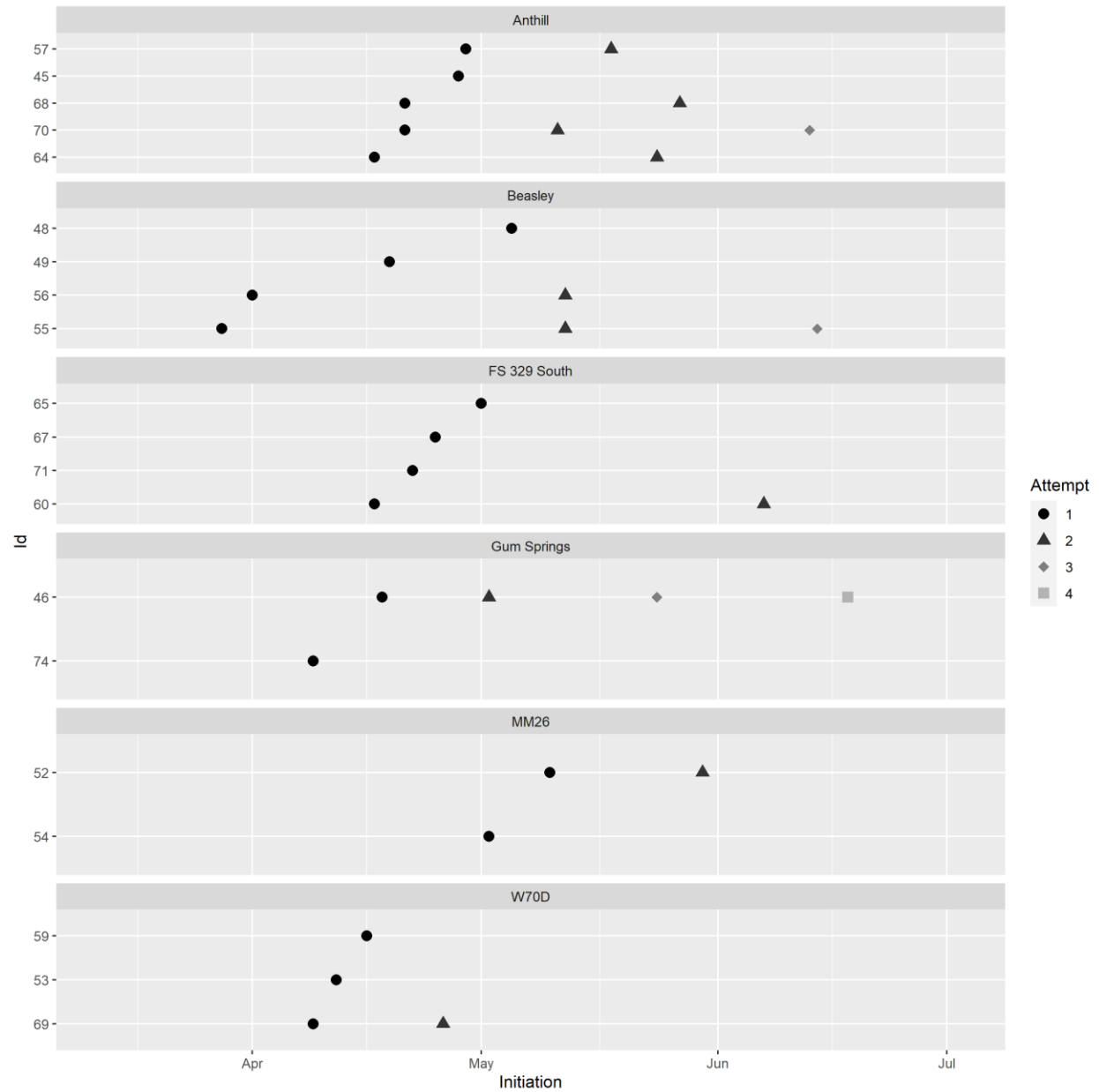


Figure B.1. Initiation date by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Kisatchie and Winn districts of Kisatchie National Forest, west-central Louisiana, USA, 2014.

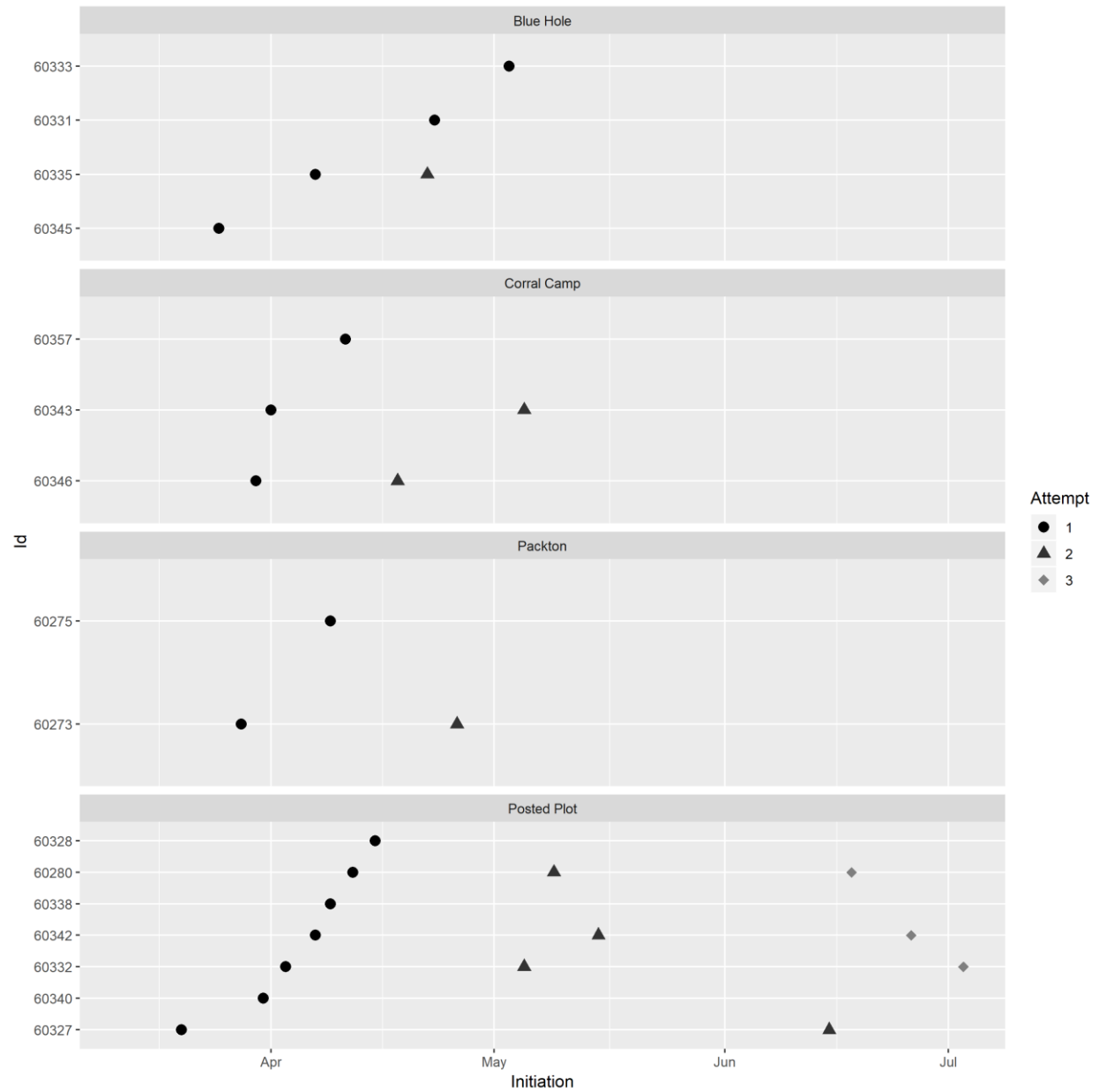


Figure B.2. Initiation date by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Kisatchie, Winn, and Vernon district of Kisatchie National Forest, west-central Louisiana, USA, 2015.

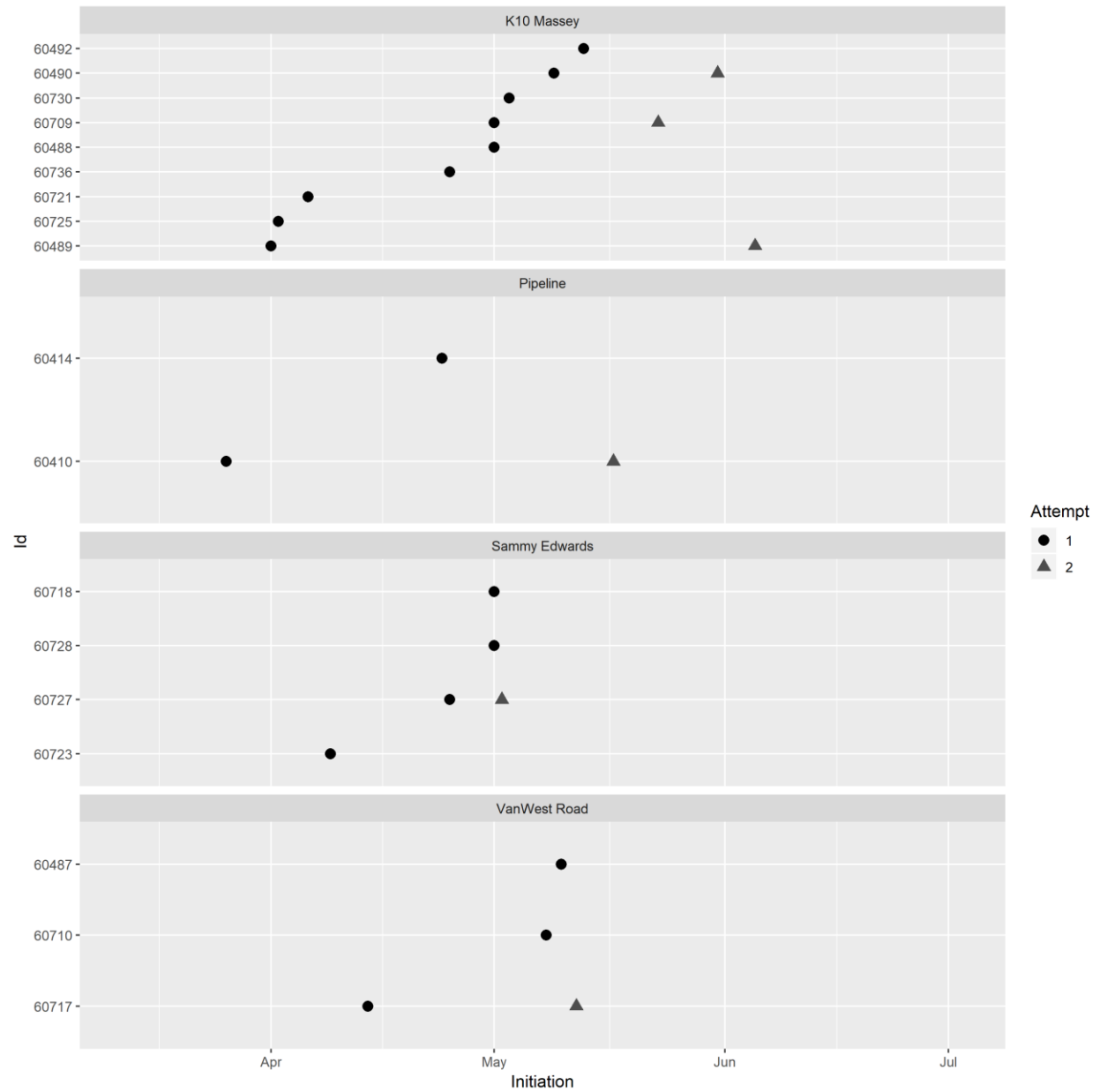


Figure B.3. Initiation dates by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Peason Ridge WMA, west-central Louisiana, USA, 2016.

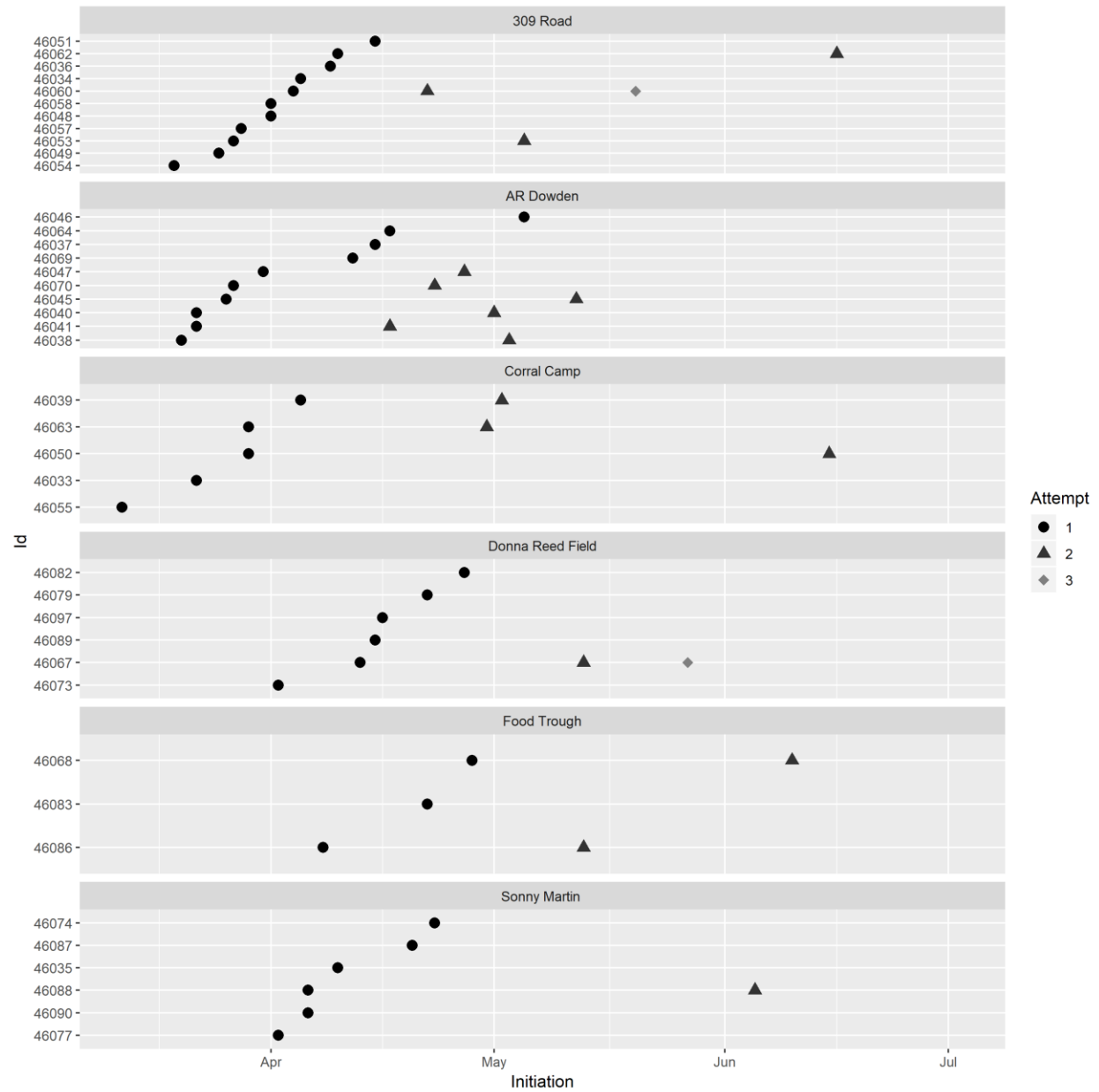


Figure B.4. Initiation date by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2017.

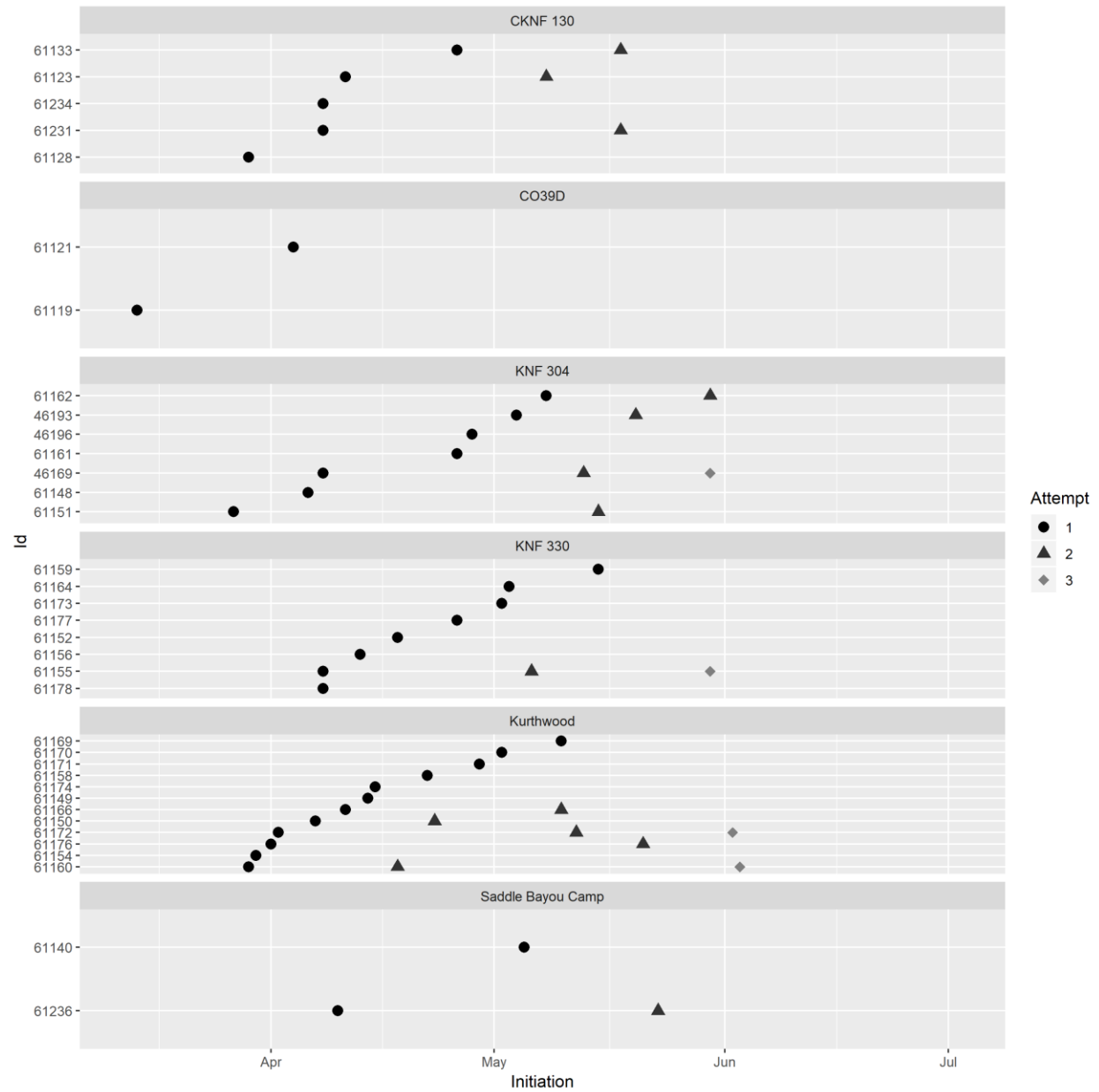


Figure B.5. Initiation date by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Catahoula and Kisatchie districts of the Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2018.

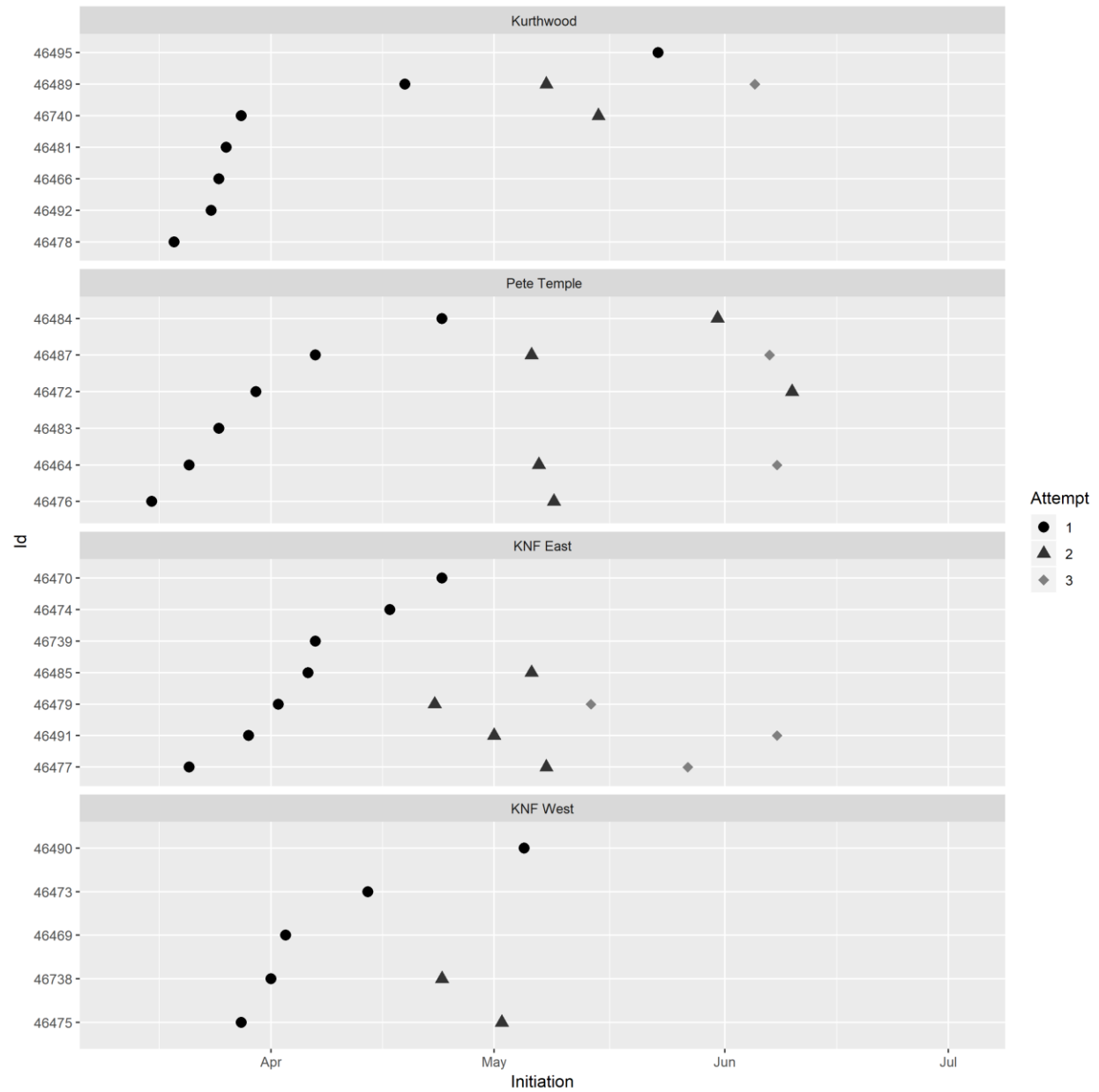


Figure B.6. Initiation date by id for female Eastern wild turkey (*Meleagris gallopavo silvestris*) across breeding groups on Kisatchie National Forest and Peason Ridge WMA, west-central Louisiana, USA, 2019.

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