

Evaluating Dog-hunting for White-tailed Deer: Dog Movements, Deer Movements, and the Potential Suitability of National Forest Lands for Dog-hunting in Mississippi

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Prepared by

**Gino J. D'Angelo
Thomas J. Prebyl
Jacalyn P. Rosenberger**

**Daniel B. Warnell School of Forestry and Natural Resources
University of Georgia
Athens, Georgia**

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Task 1: Evaluating Dog-hunting for White-tailed Deer Relative to Deer Movements and Property Characteristics: A Literature Review and Annotated Bibliography

Gino J. D'Angelo, Ph.D., Assistant Professor of Deer Ecology and Management
Daniel B. Warnell School of Forestry and Natural Resources
University of Georgia

Jacalyn P. Rosenberger, Graduate Research Assistant
Daniel B. Warnell School of Forestry and Natural Resources
University of Georgia

Background

Historical records confirm that dogs have been a part of the hunting tradition for white-tailed deer (*Odocoileus virginianus*) in the U.S. for at least 500 hundred years, if not thousands of years. Multiple Native American tribes used dogs to chase and bay deer and early European explorers and settlers relied on dogs to aid in procuring deer for sustenance and the market (McCabe and McCabe 1984). Modern use of dogs for deer hunting has become increasingly controversial due to the differing interests of dog-hunting and other hunting groups (Chitwood 2010), private property rights and concerns of trespass (Campo and Spencer 1991), and concerns of animal rights advocates (Muth and Jamison 2000). Today in the U.S., deer hunting with dogs is permitted in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Virginia. Where it is allowed, dog-hunting is highly regulated and limited in geographic extent (Bowers et al. 2007).

In this report, we highlight current knowledge of deer movements in response to hunting with dogs. It should be noted that no studies were designed specifically to assess intricate behaviors of deer chased by dogs in relation to property boundaries. Therefore, this review aims to summarize findings of previous research which are relevant to extrapolating how dog-hunting might impact deer movements outside of deer home ranges. We will define reasonable ranges of values for: (1) deer home ranges in the southeastern U.S., (2) changes in deer home ranges relative to hunting by humans, (3) changes in deer movements in response to hunting with dogs, and (4) deer movements during deer-initiated excursions without the influence of hunting.

Introduction

Movements, space use, and habitats of white-tailed deer can be quite variable throughout the species range (DeYoung and Miller 2011). Within a population, general inferences about the

size of home ranges and movements of deer can be predicted based on gender, age, season, and habitats (Lesage et al. 2000). However, perturbations to deer behavior brought on by hunting activities, natural disturbances, and changes in physiology can cause anomalous movements which may be less predictable.

It is well-established that deer alter their movements in response to hunting pressure (Root et al. 1988, Kilpatrick and Lima 1999, Karns et al. 2012, Little et al. 2016). Deer respond differently to hunting depending on hunting strategies (e.g., still hunting, dog-hunting), amount of pressure (e.g., number of hunters, duration), habitat, deer density, and other factors (Marshall and Whittington 1969, Corbett et al. 1971, VerCauteren and Hygnstrom 1998, Marantz et al. 2016). Knowledge of deer movement behavior has increased greatly in recent decades, especially with the advent of Global Positioning System (GPS) technology. However, only a few previous studies have described the effects of dog-hunting on deer movements, and no studies have utilized GPS collars on deer or dogs.

Given the limited practice of dog-hunting for deer in North America today, research has not focused on questions pertinent to management. There is no information in the primary literature about deer movements relative to dog-hunting as it is practiced on public lands today, regulation of dog-hunting within the broader framework of deer population management, and management of dog-hunting to minimize conflicts with other hunters and landowners adjacent to public dog-hunting areas. Well-designed studies using GPS could answer specific management questions to enhance our understanding of the interactions between deer, hunters, hunting dogs, and property boundaries.

Deer Home Range Basics

Home range is the area over which an animal regularly travels to meet life requisites (Burt 1943). The estimators used to quantify home ranges (e.g., minimum convex polygon, kernel density, dynamic Brownian Bridge Movement Models) are continually advancing and have differed across studies during the last 6 decades that radio-transmitters have been used to study movements of white-tailed deer. Home range estimates can vary depending on the estimator used. Although absolute estimates of home range size (e.g., annual home range = 250 acres) are important depending on the research question, home range estimates are most useful for exploring changes in space-use patterns over time and space. Through simulations using the same datasets of animal locations, Signer et al. (2015) demonstrated that the choice of home-range estimator was inconsequential for detecting biologically meaningful trends. Therefore, comparison of home ranges among studies in our analyses was valid since we gave consideration to the circumstances in which deer movements were expressed.

Home ranges can be classified as the area utilized during various time periods, such as a 24-hour period (i.e., diel), season (e.g., fall), biological period (e.g., breeding season), or relative to an external event (e.g., 3 days pre-hunt). The home ranges of adult male white-tailed deer are larger than those of females, usually on the order of two to three times larger (DeYoung and Miller 2011). Young deer ≤ 18 months old may disperse from their natal range for unknown reasons, perhaps related to resource availability of sociobiological interactions (DeYoung and Miller 2011). Bucks disperse at a much higher rate than does. For example, in Illinois Nixon et al. (2007) observed dispersal rates of 65% and 39% for males and females, respectively. Dispersing individuals make sudden and rapid movements >1.8 miles and establish a new and usually permanent home range (Long et al. 2005).

White-tailed deer exhibit strong fidelity for their home ranges, meaning that once they establish an area of regular use, they continue utilizing those areas throughout their life. The size and shape of home ranges for individual deer shift throughout the year (i.e., seasonal home ranges), but are located in the same general geographic area in non-migratory populations such as most deer in the southeastern U.S. Within their home range, deer demonstrate preferential use of key areas (i.e., core areas) which comprise only a portion of their annual or seasonal home range (Samuel et al. 1985, Campbell et al. 2004, Tomberlin 2007). Locations within the home range may change daily or seasonally in response to the deer's needs or external influences such as resource availability (DeYoung and Miller 2011). Even deer exposed to significant disturbances, such as intensive hunting pressure, maintain their home ranges, but may shift core areas or locations by time of day (e.g., Kilpatrick and Lima 1999). Deer use spatial memory from prior experiences in an area to take advantage of resource availability within their home range and beyond. Use of spatial memory by deer has been observed to search for mates (Foley et al. 2015), to find preferred foods (Gillingham and Bunnell 1989), to migrate to seasonal ranges (Nelson 1998), to avoid hunting pressure (VerCauteren and Hygnstrom 1998), and to return to home ranges following experimental translocation (Nelson 2015).

In some species, home range size decreases as population density increases (Sanderson 1966), however this relationship has not been ubiquitous for white-tailed deer (Kilpatrick et al. 2001). Home range size and arrangement on the landscape within deer populations likely depends on resource availability and social interactions among deer. Home range size influences deer movements, especially during times of changing resources (e.g., mast drop, crop harvest, availability of mates) or disturbances. Deer rarely move outside of their established home range

and rather regulate their movement rates or locations within their home range to meet their needs.

Analysis of Deer Home Ranges in the Southeastern U.S.

We reviewed the primary literature to extract home range metrics from studies of white-tailed deer in the southeastern U.S., particularly during the fall, winter and including hunting seasons (Appendix A). Nineteen studies provided information about deer home ranges, including adult male and adult female deer from 9 states including Alabama, Arkansas, Florida, Louisiana, Maryland, Mississippi, Missouri, South Carolina, and Virginia. Most studies concentrated on adult female deer. Generally, radio-collars for adult male deer were not practical due to the swelling of their necks during breeding season. Even recent advances in collar design have had limited application on adult males.

Deer exhibited extreme plasticity in their movement behaviors. The size of home ranges varied depending on the study, location, gender of animals, and monitoring period (Figure 1). Diel home ranges were reported only for adult female deer. Diel home ranges averaged 101 acres (SE = 16) ranging from 32 to 213 acres across studies. Monitoring-period home ranges for adult female deer averaged 331 acres (SE = 46), ranging widely between 62 and 741 acres. In a study of deer in bottomland hardwoods of Mississippi, Mott et al. (1985) reported an average fall home range for 4 adult female deer which was nearly twice the area of all other studies of females in our review. We excluded this outlier from our analysis of female home ranges, but it should be noted that it was similar to the average monitoring-period home range for adult males. Annual home ranges of adult females were similar to monitoring-season home ranges ($F = 0.015$, $P = 0.904$), averaging 390 acres (SE = 87) and ranging between 200 and 848 acres. The 95%

confidence interval for monitoring-period and annual home ranges of adult females was 265-427 acres.

Monitoring-period home ranges of adult males were on average nearly 3 times the area of adult females (average = 902, SE = 137), ranging from 247 to 1,863 acres. Annual home ranges of adult males did not differ from monitoring-season home ranges ($F = 0.194$, $P = 0.664$) and varied widely (average = 1,006 acres (SE = 187), range = 148-1,730 acres). The 95% confidence interval for monitoring-period and annual home ranges of adult males was 712-1,162 acres.

Deer Excursions Unrelated to Hunting

Adult male and adult female white-tailed deer make temporary, long-range movements (i.e., excursions) outside of their established home ranges which are believed to be unrelated to hunting activities, dispersal, or other unnatural influences. The nature of these infrequently displayed movements suggests that deer may have had prior knowledge of the areas traveled, such as areas encountered during dispersal from their natal range or previous excursions. Deer likely apply information about resources available within their home range to new areas encountered. For example, thick hiding cover aids in concealing detection by hunters. Alternatively, deer making excursions due to immediate necessity (e.g., hunting pressure, breeding) may move rapidly with less regard for specific habitats and instead aim to cover as much distance as necessary to meet their needs. D'Angelo et al. (2004) identified 12 excursions (360% average increase in daily home range) by 8 white-tailed does which coincided with repeated estrus. Nine of 10 adult female white-tailed deer monitored by Kolodzinski et al. (2010) in Delaware and Maryland made short- (0.4-0.7 miles) and long-distance (1.5-2.8 miles) excursions during the breeding season. Karns et al. (2011) identified 37 excursions during the fall and winter by 32 adult male white-tailed deer in Maryland. They associated the

extraordinary movements with breeding season rather than hunting or food resources, and mean minimum distance traveled was 0.5 miles (Karns et al. 2011). In Pennsylvania, 9 of 13 GPS-collared mature male white-tailed deer demonstrated excursions in spring which averaged 2.5 miles from their home range boundaries (Olson et al. 2015). In general, excursive movements are characterized by rapid, linear movements with deer returning to the home ranges within hours or days.

Deer Movements Relative to Hunting by Humans

Deer maintain strong fidelity to their home ranges under hunting pressure (Downing and McGinnes 1976, VerCauteren and Hygnstrom 1998, D'Angelo et al. 2003, Simoneaux et al. 2016). With the exception of 1 study (Root et al. 1988), the area used by deer during hunts did not differ from pre-hunt home ranges in all of the studies we reviewed where hunting by humans without dogs was the source of disturbance (Table 1).

The intensity (i.e., number of hunters) and duration (i.e., hours per day, season length) of hunting may have variable effects on deer behavior (Root et al. 1988, Kilpatrick and Lima 1999, Little et al. 2016). For example, Kilpatrick and Lima (1999) found that deer shifted core areas and reduced movements in hunted areas during the day. On public and private land in Alabama, deer responded to periods of elevated hunting activity by decreasing movements by 18% and becoming more nocturnal (Wiskirchen 2017). In some studies, deer made short-distance flight movements to avoid hunters, but stayed within their home range (Marshall and Whittington 1969, Root et al. 1988).

With sufficient disturbance or active pursuit, deer will leave their home ranges when exposed to hunting by humans, however such excursions are generally short-term (e.g., hours to days) and relatively close to the periphery of their home range (VerCauteren and Hygnstrom

1998, Karns et al. 2012). Karns et al. (2012) documented 23 interactions between hunters and mature bucks, of which only 7 deer exhibited pronounced flight behavior averaging 282 yards. In central New York, Whitman et al. (2018) found that most deer made excursions out of their home ranges, but of those that were harvested by hunters, 79% died within their home range. Familiarity with cover and resources within their home ranges likely causes deer to feel less vulnerable within their home ranges when exposed to risk.

Deer Movements Relative to Dog-hunting

There is limited information in the primary literature concerning movements of deer relative to dog-hunting. However, the movement behaviors of deer exposed to hunting with dogs appeared to be similar to their responses to hunting by humans and deer-initiated excursions. Intensive monitoring of deer during chases with dogs suggested that deer used intricate movements (e.g., backtracking, circuitous, rapid straight line) and increased their rate of travel to elude dogs and remain within their home range boundaries (Sweeney et al. 1971, D'Angelo et al. 2003). D'Angelo et al. (2003) found that in hunt units containing hundreds of hounds and hunters, deer remained in their home ranges for the majority of 3-4 hour hunts. However, in every study we reviewed of dog-hunting (Table 2), $\geq 54\%$ of deer left their home ranges. Distance deer traveled outside of their home range boundaries varied and was difficult to discern from several studies. Of data available, distance deer traveled outside of their home ranges averaged approximately <0.75 miles (SE = 0.1). Consistently, deer returned to their home ranges soon after the conclusion of a hunt, usually within hours and almost always within days. Although longer distance movements (maximum = 13.4 miles) most dog hunting was contained within a 2.5-mile radius including the area of the focal deer's home range.

Future research investigating deer movements relative to dog-hunting should focus on intricate deer movements relative to property boundaries, dog and hunter numbers, and areas of refugia (i.e., buffers along property boundaries). GPS collars for deer will allow a high frequency of locations to be collected. Additionally, dogs and hunters may be fitted with GPS trackers to evaluate their effects on deer movements and the efficacy of remote tracking and behavior correction collars for dogs.

Conclusions About Containment of Dog-hunting

Extraordinary movements by deer outside of their home ranges occur in response to hunting and during deer-initiated excursions for breeding and due to other causes. Such extraordinary movements are typically within several miles of the deer's home range. However, given their unpredictable nature (both hunting-related and non-hunting related) and short duration, it would be impractical to adjust management of hunting to account for these relatively long-distance movements.

Across studies, locations, and deer populations, deer had a strong propensity to remain within their home range, including when they were exposed to hunting by humans and dog-hunting. In response to dog-hunting, most deer left their home ranges at some point during a chase. But, most remained within 1 mile of the periphery of their home range. The sizes, configurations, and arrangements of deer home ranges on the landscape are unknown for most areas of the southeastern U.S. Even in deer populations that were the subject of intensive study, these factors did not follow clear standards.

In a subsequent Global Information Systems exercise we will use parameters from our literature review to investigate the potential movements of deer in response to dog-hunting in the study area. We believe that applying a range estimates for the size of deer home ranges (i.e.,

95% confidence intervals from our review) is reasonable to capture the variability among individual deer since no data were available for the study area. The proportion of deer within age and sex classes is unknown in the population. Also unknown is the gender and age of particular deer that dogs will chase during a hunt, so it is necessary to account for the size differential between the home ranges of adult males and adult females. Therefore, in an iterative process, we will randomly select (50:50) values from within the range of male and female home range sizes, and distribute adjacent and overlapping sample home ranges for deer within the study area. Since an average of 80% of deer leave their home range during dog-hunting, 20% of sample home ranges will be assigned a buffer of 0, and 80% of sample home ranges will be assigned a buffer averaging 0.75 miles (SE = 0.1). Sample home ranges will be distributed across the study site overlapping the property boundary. We will conduct multiple iterations of this exercise to estimate buffer areas required to contain 50%, 70%, and 90% of dog-deer hunting on the study area.

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Figure 1. Home range size (acres) of adult female and adult male white-tailed deer (*Odocoileus virginianus*) in the southeastern U.S. during fall and winter, including hunting seasons. Home ranges were delineated by diel periods (i.e., 24 hours), relative to breeding, seasons, and annually.

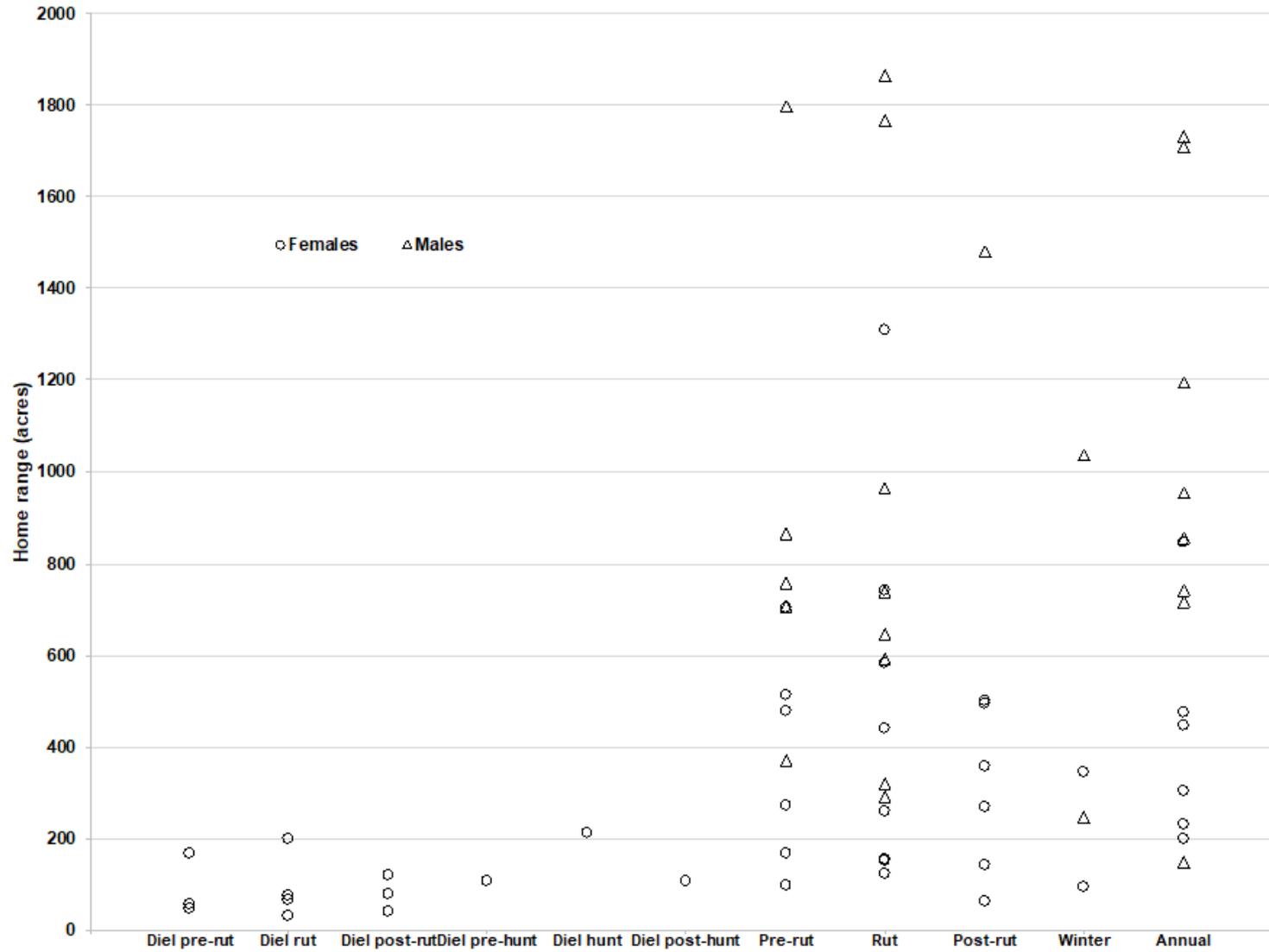


Table 1. Movements of white-tailed deer (*Odocoileus virginianus*) relative to hunting by humans without dogs.

Location	Animal (sex/age class)	No. deer	Mean pre-hunt home range (acres)	Mean hunt home range (acres)	Change in home range size from pre- to hunt	Reference
Connecticut	Females (adult)	5	99	115	None	Kilpatrick and Lima (1999)
Florida	Males (adult)	15	964	1,038	None	Sargent and Labisky (1995)
Florida	Females (adult)	14	54 (diel)	64 (diel)	None	Kilgo et al. (1998)
Maryland	Males (adult)	19	756	645	None	Karns et al. (2012)
Missouri	Males (adult, yearling)	6	1,796	1,764	None	Root et al. (1988)
Missouri	Females (adult, yearling; non-refuge)	16	477	741	Increased 1.6 times	Root et al. (1988)
Nebraska	Female (adult, juveniles)	15	329	351	None, however some home range centers shifted	VerCauteren and Hygnstrom (1998)
Oklahoma	Males (adult)	30	-	-	Space use declined	Little et a. (2016); Marantz et al. (2016)

Table 2. Movements of white-tailed deer (*Odocoileus virginianus*) relative to hunting with dogs.

Location	Animal (sex/age class)	No. deer	Percent left home range during hunt	Mean estimated distance of chase (mi)	Mean distance beyond home range (mi)	Maximum distance beyond or including home range (mi)	Reference
Alabama, Florida, South Carolina	Females and males (adults)	6	78%	2.4	<1.0	Max. = 13.4; 90% within 1.0	Sweeney et al. (1971)
Arkansas (Ozark Mountains)	Females and males (adults)	7	100%	1.9	0.7	3.1	Gipson and Sealander (1977)
Arkansas (Coastal Plain)	Females and males (adults)	6	100%	1.6	0.3	1.6	Gipson and Sealander (1977)
North Carolina	Females and males (adults)	7	70%	2.4	>1.0	6.8	Corbett et al. (1971)
South Carolina	Females (adult)	13	54%	-	0.5	1.4	D'Angelo et al. (2003)
Texas	Not specified	43	-	-	1.0 total chase distance	4.6	Campo et al. (1987)

Appendix A. Annotated bibliography of selected primary literature pertinent to evaluating the feasibility of dog-hunting with respect to property boundaries.

SELECTED DEER HOME RANGE STUDIES IN THE SOUTHEASTERN U.S.

Holzenbein, S., and G. Schwede. 1989. Activity and movements of female white-tailed deer during the rut. *Journal of Wildlife Management* 53:219-223.

Holzenbein and Schwede studied the movements and home ranges of eight adult female white-tailed deer during the breeding season at the National Zoo's Conservation and Research Center in Virginia. The study area consisted of gentle rolling hills, ridges, hollows, and steep slopes and was mostly dominated by tulip poplar, red oaks, and black locust. For each period (pre-rut, rut, and post-rut), locations were obtained at 1-hour intervals during 6 4-hour phases on 6 different days. Differences in activity, mobility, and home range sizes among day and night, pre-rut, rut, and post-rut and among the 8-day periods were tested. From pre-rut to post-rut, total and diurnal activity continually decreased but there was no change in nocturnal activity. Total and diurnal movements also decreased from pre-rut to rut and nocturnal mobility did not change. Mean home range size decreased between pre-rut and post-rut. Home ranges tended to be larger at the beginning and end of the rut period, but tighter in-between. One female made an excursion of 1.7 km before she was tended by an adult male at the end of the rut. The remaining seven concentrated movements to their core areas before establishing tending bonds. This suggests that if females reach the onset of estrous without a mate, they are capable of switching to a search strategy. Therefore, excessive movements by many adult females must indicate lack of availability of males or reduced breeding performance by males.

Ivey, T. I., and M. K. Causey. 1981. Movements and activity patterns of female white-tailed deer during rut. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 35:149-166.

Ivey and Causey studied breeding season changes in movement and activity patterns of 13 female white-tailed deer in an un-hunted population to help determine behaviors caused by the rut. The study area was the 2,226-ha Fred T. Stimpson Sanctuary in southwestern Alabama, which is closed to the public and predominantly composed of mature timber stands and about 6% food plots. Locations for 10 does were triangulated and activity was monitored hourly during 74 diel periods, occurring before, during, and after peak rut. The following metrics were compared among pre-rut, rut, and post-rut: minimum home range, minimum total distance moved in diel period (MTD), distance between extreme diel locations (DBE), minimum bedding area, minimum portion of home range utilized (MPU), minimum diel area, average distance between consecutive diel radio locations (DBC), diel activity index, and group circadian activity index. Full descriptions of each metric are on page 151. Minimum home range during the rut was 63 ha with no significant difference among the time periods. Does restricted bedding activities to smaller portions of their home ranges during the rut compared to pre- and post-rut. Mean MTD (3.5 km) was significantly shorter and mean MPU (21%) was significantly lower during the rut than pre- and post-rut. Does moved less and stayed within smaller portions of their home ranges during the rut. Minimum diel area (13 ha) decreased, DBE (0.71 km) was shorter, and DBC decreased (0.16 km) during the rut when compared to pre- and post-rut. General movement patterns during pre- and post-rut were long and linear whereas during the rut, deer exhibited shorter, repeated crossing movements within smaller areas. Mean diel activity index was significantly greater during the rut with a sharp decline in activity during post-rut. The period of

highest activity coincides with the time of peak buck-doe interactions (determined via observation). Heightened activity, in conjunction with repeated crossing movements within smaller areas, could increase the likelihood of males finding females' scent trails.

Kammermeyer, K. E., and R. L. Marchinton. 1976. The dynamic aspects of deer utilizing a refuge. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 29:466-475.

Kammermeyer and Marchinton studied the impact of refuges on deer movements at Berry College properties in northwestern Georgia, which was composed of 21,000 acres of forest (mostly pine) and 4,000 acres of agriculture. Half of the property was a refuge and the other half was a managed hunting area. Forty deer (21 does and 19 bucks) were captured and marked at three locations on the refuge area for census purposes. Three to four counts were conducted per week from August 1973 - September 1974. Mean home range size for six resident deer captured on the refuge was 127 ha. Bucks expanded their home ranges during the rut. Six bucks dispersed off the refuge into wooded areas open to hunting that had lower deer densities and five were harvested. Daily population estimates at one refuge location abruptly increased at the onset of hunting season. Estimates increased from 267 in October to 461 in November. Similarly, the summer estimate was 70, fall was 240, and winter was 246. Spring was not measured but observationally seemed to decrease. Percentages of bucks seen on the refuge were significantly lower than on the hunted area, even though bucks were selectively removed by hunting in the latter. Managed hunts started in 1971. The first two seasons of a 6-day buck-only hunt in early December saw low hunter success rates. The next season was a 3-day hunt in late October, which saw larger success rates. In 1974, there was an early 4-day hunt that included a 1,215 ha portion of the refuge. Hunter success rates were 10% higher than the previous season. Deer

seemed to initially move to the refuge due to hunting pressure and remained there for the abundant food supply during winter. Refuges may be advantageous in areas with issues of overharvest. Limited removal of deer from the refuge may reduce the flow of deer from the refuge rather than decreasing the population within it. Because deer move freely between refuge and hunted areas, inadequate harvests and overabundance can occur. Kammermeyer and Marchinton suggest that hunting on the refuge and earlier harvests are the best ways to control overabundant deer populations and decrease seasonal migration to exhausted refuge areas.

Labisky, R. F., and D. E. Fritzen. 1998. Spatial mobility of breeding female white-tailed deer in a low-density population. *Journal of Wildlife Management* 62:1329-1334.

The purpose of this study was to test the hypothesis that female white-tailed deer in low-density populations with intensive harvest of adult males play more active roles, therefore increase mobility, in finding mates. It was conducted in the Osceola National Forest in northern Florida, which is characterized as flat with low-quality sand-based soils. It is composed of pine-palmetto flatwoods, cypress swamps, bay swamps, and creek swamps and has a deer density of one per 20 ha. Fourteen adult females were located via triangulation every two hours during 5 or 6 24-hr diel periods during the 3 periods: pre-rut, peak-rut, and post-rut. Four measures were used to quantify spatial mobility: 1) Home range size increased from pre- to post-rut, 2) Rate of travel increased from pre- to post-rut, 3) Distance between extreme diel locations increased from pre- to peak-rut but decreased from peak- to post-rut, and 4) Core area use decreased from pre- to peak-rut and from pre- to post-rut. Rates of travel and core area use did not differ between diurnal and nocturnal hours for any of the three periods. Results support the search-strategy hypothesis for low density populations. Low availability of breeding males has the following negative effects on the population: offspring born outside of optimal birth season, higher energy

costs and risk for mortality for females traveling outside familiar home ranges, and reduced fecundity of females due to sperm limitation of available males.

Marchinton, R. L., and L. K. Jeter. 1967. Telemetric study of deer movement-ecology in the southeast. Proceedings of the Conference of the Southeastern Association of Fish and Wildlife Agencies 20:189-206.

Marchinton and Jeter studied the movement ecology of white-tailed deer in the southeastern United States from 1962-1966. Their four study areas were 1) Citrus Tract in west central Florida, composed of longleaf pine-turkey oak sandhill vegetation with low quality soils, n=2; 2) Eglin Reservation in the northwestern Florida panhandle, composed of large open areas of herbaceous annuals with older sections of turkey-oak regeneration, n = 4; 3) Choccolocco area in northeastern Alabama, a mountain habitat province with mostly mixed pine-hardwood hillsides, n=4; and 4) North Auburn area in east central Alabama, which is in the Piedmont habitat province and dominantly composed of pine-oak-hickory forest, but the primary land use is agricultural. It had a low deer density compared to other study locations, n=2 pen raised deer that were released. Deer were monitored via radio telemetry every 1-3 hours for a 24-hour period once or twice weekly. The following metrics were obtained (refer to p. 192-193 for full descriptions): minimum home range, home range major and minor axis, distance between extreme diel locations (DBE), average distance between extreme diel locations (average DBE), minimum total distance moved in diel period (MTD), and average minimum total distance moved in diel period (average MTD). Results are presented in tabular format for each individual deer on p. 193-194. They are not averaged or summarized in the text. Marchinton and Jeter emphasize the need for movement ecology studies specific to the areas being targeted for management, as results from other parts of the country are much less applicable.

Marshall, A. D., and R. W. Whittington. 1969. A telemetric study of deer home ranges and behavior of deer during managed hunts. Proceedings of the Conference of the Southeastern Association of Fish and Wildlife Agencies 22:30-46.

Marshall and Whittington studied white-tailed deer seasonal home ranges, food plot utilization, and behavioral responses to hunting in an 800-acre section of Clark Hill Wildlife Management Area in the Piedmont section of Georgia. This section was composed 98% of pine-hardwood forest and 2% food plots and supported a deer density of approximately 53 per square mile. Five deer were tracked via radio telemetry. During the spring tracking period, movement activity for does was greatest during mid-morning and late afternoon. They spent nights in or near food plots and usually travelled about one mile over a 24-hour period. The same general pattern was observed during the fall tracking period but the only buck in the study moved 1 to 1.5 miles in 24-hour periods and was hardly located in a food plot. Location data were obtained from three deer during hunting season. Daytime movement patterns were different during the hunt compared to before or after the hunts. Deer number 1 remained in the northern part of its home range during hunting season, which was believed to have the least level of hunting pressure, until it was harvested. Hunting pressure was evenly distributed on deer number 2's home range. It kept to the northern and southern boundaries and constantly stayed on the move, probably due to constant hunter pressure and lack of understory vegetation for cover. It also was harvested. Deer number 3 traveled in a more linear pattern during the hunt, as opposed to its normal circular pattern and it was killed on the fourth day of the hunt. No deer left its home range, despite the large amount of hunting pressure. Deer movement increased with hunting pressure (hunter density was estimated for each day of the hunt). Marshall and Whittington concluded that a hunter density of 5 hunters per 100 acres is enough to "move" deer in areas of

low levels of understory vegetation. Maximum home ranges of two does in the fall were 78 and 87 acres. Maximum home range of the yearling buck was 360 acres. One doe's home range decreased from spring (121 acres) to fall (87 acres), while another one increased from 40 to 78 acres.

Mott, S. E., R. L. Tucker, D. C. Guynn, and H. A. Jacobson. 1985. Use of Mississippi bottomland hardwoods by white-tailed deer. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 39:403-411.

Mott et al. tracked 5 male and 4 female white-tailed deer for ≥ 9 months. Home ranges in this study were much larger than most other studies in the southeastern U.S., ranging from 176-1245 ha seasonally and 455-2216 ha annually. Deer in this study used bottomland hardwoods more than expected based on the availability of those habitats. In summer, 3 deer shifted their home ranges toward soybean fields.

Rhoads, C. L., J. L. Bowman, and B. Eyler. 2010. Home range and movement rates of female exurban white-tailed deer. Journal of Wildlife Management 74:987-994.

Rhoads et al. studied characteristics of white-tailed deer home ranges on the Fair Hill Natural Resource Management Area in northeastern Maryland to provide information for a potential future hunting season in this exurban landscape. It was highly developed on the eastern edge but faded into a rural landscape consisting of mixed hardwood forest, hayfields, and pastureland. Sixty females were captured from January 2004 to March 2005. They were located via biangulations and 6-hour visual observations during four time periods beginning in June 2004. Dates and times were randomly selected for each focal observation. Rhoads et al. established five seasons, including three potential hunting seasons (1 Aug – 30 Sept; 1 Oct – 30 Nov; 1 Dec – 31 Jan), post hunting season, and fawning season. Annual core area and home

range sizes were 21.2 ha and 192.4 ha, respectively (n=25). Rhoads et al. only report that seasonal 95% home ranges generally increase in size from the early season to post-hunting period, roughly averaging 110 to 140 ha, respectively. The 50% home ranges follow the same trend with early season roughly averaging 14 ha and post-hunting period roughly averaging 22 ha. Harmonic mean activity centers shifted 233-574 m between consecutive seasons. Percent overlap of 50% and 95% home ranges was similar among seasons except post-hunting to fawning which had significantly less overlap than the others. Dusk movement rate was greater than other circadian periods for every season. The greatest difference occurred during the late season, in which dusk movement rate was about 45 m/h greater than dawn, day, or night. Annual and seasonal home range size estimates were similar to those reported for agricultural and forested areas. Large post-hunting home ranges may have been due to availability of food and suitable cover, severe weather events, or annual long distance home range shifts.

Tomberlin, J. W. 2007. Movement, activity, and habitat use of adult male white-tailed deer at Chesapeake Farms, Maryland. Thesis. North Carolina State University, Raleigh.

Tomberlin fitted 18 adult male whit-tailed deer with GPS collars and tracked their movements, activity, and habitat use in relation to season and climate variables. The study was conducted on Chesapeake Farms, Maryland. Mean home range was 300 ha with pre-breeding and breeding season home ranges being significantly larger than summer. Period of day and temperature were the best predictors of deer activity and movements across all seasons.

Vanderhoof, R. E., and H. A. Jacobson. 1993. Food plots and deer home range movements in the southern coastal plain. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 47:33-42.

Vanderhoof and Jacobson radio-collared 7 male and 13 female white-tailed deer in southern Mississippi. They tracked production in food plots planted in the study area and evaluated deer home ranges relative to the plantings. Annual home ranges were large relative to other studies, averaging 691 ha for adult bucks and 343 ha for adult does. Deer moved toward and away from food plots, and there was no consistent trend noted in deer use of food plots.

DEER EXCURSIONS UNRELATED TO HUNTING

D'Angelo, G. J., C. E. Comer, J. C. Kilgo, C. E. Comer, C. D. Drennan, D. A. Osborn, and K. V. Miller. 2004. Daily movements of female white-tailed deer relative to parturition and breeding. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 58:292-301.

To study how deer herd demographic features affect reproductive behaviors, D'Angelo et al. assessed female white-tailed deer movements relative to parturition and breeding. The following summary will focus only on the movements relative to breeding. The study was conducted on the Savannah River Site in South Carolina, which consists of pine-dominated forests and smaller areas of swamps, riparian bottomlands, and upland hardwoods. Deer population density was low and the sex ratio was near even. Deer were located every hour via radio telemetry during 6-13 24-hour diel monitoring sessions during the following periods: pre-rut, rut, and post-rut. Diel home range (area used during a 24-h period), diel rate of travel (m/h),

and distance between extreme diel locations (m) were determined (n = 13 female deer; 12 adults, 1 yearling). No difference was detected in the three measures listed above between the pre-rut and rut periods, but all three decreased between pre-rut and post-rut. All three were greater during the rut than during post-rut. Data indicated the occurrence of 12 estrous-related excursions from 8 does from 26 Sept to 6 Dec. This suggested that females must actively seek potential mates in low density populations. Besides excursions, movements did not differ throughout pre-rut and rut. Movements were reduced during post-rut possibly due to seasonal variations in food availability or weather.

Karns, G. R., R. A. Lancia, C. S. DePerno, and M. C. Conner. 2011. Investigation of adult male white-tailed deer excursions outside their home range. *Southeastern Naturalist* 10:39-52.

Karns et al. studied excursive behaviors in 32 adult male white-tailed deer and overall movements of 14 adult females from June – August 2003-2007 at Chesapeake Farms in Maryland. The study area is a wildlife management and agricultural research center that consists of 50% non-alluvial swamps and roughly equal parts cash crops, fallow fields, wildlife food plots, non-forested wildlife cover and waterfowl impoundments. Deer density was high with about 33 deer/km². Excursions were defined as movements >0.5 km for 6 or more continuous hours that occurred between 24 Sept and collar release date. Females were collared so that adult male excursions could be related to adult female movements. Thirty-seven excursions were documented with 14 occurring during the breeding period and 22 (59%) occurring during combined pre-breed and breeding periods. Five excursions occurred during the two-week firearms season. Karns et al. concluded that hunting did not explain these five excursions, due to low levels of hunting pressure, abundant cover, and flight distance data from a previous Karns et

al. study that never exceeded 0.6 km. Mean duration and mean minimum distance of excursions were 10.5 hours and 0.778 km, respectively. None of the excursion movement paths aligned simultaneously with movements of the collared adult females. Sixty-three percent of collared males made excursions and because the majority of these occurred during pre-breed and breeding periods, breeding season activities most likely drove these movements. Excursions in the post-breed period (hunting season) are more likely related to younger females coming into late estrous.

Kolodzinski, J. K., L. V. Tannenbaum, L. I. Muller, D. A. Osborn, K. A. Adams, M.

C. Conner, W. M. Ford, and K. V. Miller. 2010. Excursive behaviors by female white-tailed deer during estrus at two mid-Atlantic sites. *American Midland Naturalist* 163:366-373.

Kolodzinski et al. studied movements of ten adult female white-tailed deer during the rut at Chesapeake Farms in Maryland and Great Cypress Swamp in Delaware. Populations in both study areas are intensively managed to promote equal sex ratios and a mature male age structure. They have densities of 30-40 deer/km². GPS collars recorded locations every 45 minutes from 1 Oct 2006 to 27 Jan 2007. Excursions were defined as an isolated string of points extending more than 0.75 km outside of the seasonal home range (SHR) or an isolated string of points with more than 50% of the daily points occurring outside of the SHR. Seven of the ten does made a single excursion, two made repeat excursions over the course of two days, and the remaining one did not exhibit any excursive behaviors. Four deer made long distance excursions over short periods of time (a few hours) and then returned to their SHR. Five made short distance excursions for several hours and then returned to their SHR. Previous studies involving high deer densities with balanced sex ratios found that does adopted more sedentary breeding strategies. Kolodzinski et

al. noted that their results more closely match those of low deer densities with unbalanced sex ratios. They argue that mate selection by females is the most likely explanation for the observed excursive behaviors, especially considering does made their excursions around the time of conception. And they argue previous studies involving radio telemetry may not have been able to capture these relatively brief movements with their infrequent sampling schedules.

Olson, A. K., W. D. Gulsby, B. S. Cohen, M. E. Byrne, D. A. Osborn, and K. V.

Miller. 2015. Spring excursions of mature male white-tailed deer (*Odocoileus virginianus*) in northcentral Pennsylvania. *American Midland Naturalist* 174:96-104.

Olson et al. studied excursive behaviors in 13 adult male white-tailed deer during the spring season in northcentral Pennsylvania. The study area was on private land and consisted of contiguous forest, mostly mature and regenerating northern hardwood species. GPS collars recorded hourly locations. 95% UD isopleth home ranges were calculated and excursions were defined as any occasion when bucks travelled 1.6 km or more outside of their home range boundaries for 12 hours or more. Nine of 13 males made an excursion from 6 April through 6 June. Six of these made more than one excursion. Mean maximum distance from the home range boundary was 4.0 km, mean duration was 22 hours, and mean total distance traveled was 11.0 km. Olson et al. do not provide an explanation for excursive behaviors rather they discount a few, including female aggression associated with pre-parturition, trips to natal ranges, and visits to mineral sites.

DEER MOVEMENTS RELATIVE TO HUNTING BY HUMANS

Downing, R. L., B. S. McGinnes, R. L. Petcher, and J. L. Sandt. 1969. Seasonal change in movements of white-tailed deer. Pages 19-24 in Proceedings of the Symposium: White-tailed Deer in Southern Forest Habitat. Southern Forest Experiment Station, Nacogdoches, Texas, USA.

Downing et al. investigated long, irregular deer movements at Radford Army Ammunition Plant in western Virginia from 1965-1968. Radford is a 2,322-acre enclosure that contained 200-450 deer during this period. The area is rolling, open grassland with clumps of hardwoods, cedar, and young pine plantations scattered throughout. 177 fawns were captured and marked to allow for long-distance identification, however their results focus on the 1966 cohort of fawns (n=60) of which 36 made irregular movements. Deer were observed for 32 months with the least number of sightings of any of the deer being 19 and the average being 43. The following describe hunting season movements: Harassment of deer was intense with archery hunters occupying every available clump of trees on the study area. Deer learned to stay in the large open areas. Most deer were observed close to their centers of activity and no detectable changes in home range occurred. The following describe food and cover related movements: Two food sources were particularly attractive to deer during fall and winter: a 22 acre clear-cut from summer 1968 and a 20 acre planting of new grasses. None of the marked deer traveled long distances to reach these food sources, however. No migrations occurred, such as those observed in northern United States during winter. Significant winter movements were not expected, though, as food and cover are of equal abundance and quality throughout the enclosure. The following describes breeding season movements: More than 2/3 of deer moved

outside their normal home range boundaries but no long-term changes in home range occurred. The following describes summer movements: One of 13 does moved more than 0.5 mile from her center of activity during the first year. This increased as does aged with 39% moving between 0.5 and 1 mile and 23% moving more than 1 mile when they were 1 year-old and the trend continued when does were 2 years of age. Males also increased movement with age and three changed their home ranges. One moved more than one mile away from his original home range and the other two shifted their ranges while keeping portions of their original ones.

Downing et al. documented irregular movements during hunting season for all age classes (move longer distances), the rut for mature bucks (move greater distances), and summer, mostly during fawning season, for yearling and 2 year-old does.

Karns, G. R., R. A. Lancia, C. S. DePerno, and M. C. Conner. 2012. Impact of hunting pressure on adult male white-tailed deer behavior. Proceedings of the Conference of the Southeastern Association of Fish and Wildlife Agencies 66:120-125.

Karns et al. studied the effects of hunting pressure on the movements and home range sizes of nine adult male white-tailed deer at Chesapeake Farms in Maryland. This wildlife management and agricultural research center consists of 50% non-alluvial swamps and roughly equal parts cash crops, fallow fields, wildlife food plots, non-forested wildlife cover and waterfowl impoundments. GPS collars recorded hourly fixes from September – March and 20min fixes from 5 November to 9 December in 2006 and 2007. 95% fixed kernel home ranges and 50% core areas were calculated. Mean overall home range size was 386 ha with no significant difference between pre-hunt (306 ha) and hunting season (261 ha) home range size. Mean overall core area size was 81 ha with no significant difference between pre-hunt (71 ha)

and hunting season (59 ha). There was a decrease in movement and overall activity from pre-hunt to hunt periods but they noted this was likely due to the hunting period corresponding to the post-breeding period. Additionally, deer had greater movements during dusk and night hours during the hunting period. Karns et al. concluded that hunting pressure levels on Chesapeake Farms were not significant enough to impact adult male white-tailed deer behavior because documented disturbances did not cause deer to move out of their home range and changes in movement were most likely due to breeding season activities.

Kilgo, J. C., R. F. Labisky, and D. E. Fritzen. 1998. Influences of hunting on the behavior of white-tailed deer: implications for conservation of the Florida panther. Conservation Biology 12:1359-1364.

Kilgo et al. studied the impact of hunting on white-tailed deer movements in the Osceola National Forest in Florida, which is characterized by flat terrain with pine vegetation. Locations of 14 female deer were triangulated based on weekly and diel monitoring schedules from June 1990 - July 1991. The following were determined for hunting and non-hunting seasons based on weekly monitored locations: distance of deer to nearest road, habitat selection, and habitat diversity in areas surrounding deer locations. Distance from roads did not differ between diurnal and nocturnal time periods within the hunting season. During hunting season, swamps and pine stands over 30 years old were preferred, whereas pine stands under 30 years were avoided. During non-hunting season, pine stands 11-30 years were preferred. Habitat diversity of areas surrounding deer locations was greater during non-hunting season. The following were determined for hunting and non-hunting seasons based on diel monitored locations: distance between home range activity center and nearest road, home range activity center to radio-location distance, and diel, diurnal, and nocturnal deer activity. Females were located further

from roads during hunting season than during non-hunting season. Mean diel home range size did not differ between hunting and non-hunting seasons but activity centers were further from roads during hunting season. Mean nocturnal rate of activity during hunting season was greater than the mean diurnal rate of activity during hunting season and also greater than the mean nocturnal rate of activity during non-hunting season. Overall mean diel rate of activity was not different between hunting and non-hunting season. Deer responded to hunter disturbance by shifting further from roads, around which most hunters were concentrated. Disturbance by hunters was strong enough to influence diel and weekly movements. Because deer are prey for the Florida panther, Kilgo et al. discusses the potential impact of deer hunting on Florida panther population dynamics and behavior.

Kilpatrick, H. J., and K. J. Lima. 1999. Effects of archery hunting on movement and activity of female white-tailed deer in an urban landscape. *Wildlife Society Bulletin* 27:433-440.

Kilpatrick and Lima investigated movements of white-tailed deer in hunted and unhunted populations before and during a 9-week archery hunt. Their study occurred in a coastal community in Connecticut consisting of housing lots and conservation lands, 50% of which was hardwood forest and 50% was salt marsh. Locations of 28 female white-tailed deer were triangulated weekly for a 24-hour period (6 times per 24-hour period) from April 1995 to Dec 1996. Day and night periods were considered sunrise to sunset and sunset to sunrise, respectively. Deer were classified as hunted or unhunted, based on whether they had >60% or <10% of pre-hunt locations on conservation land open to archery hunting, respectively. Fourteen of 28 deer used the land open to hunting; 10 of which were considered hunted and four were considered unhunted. Five of the 10 hunted deer were harvested. Four of the 5 remaining

hunted deer and 4 of 4 unhunted deer stayed within their annual home range during the hunt. One hunted deer moved outside its annual home range and didn't return until 2 weeks after the close of hunting season. Hunted deer had similar pre-hunt and hunt home range sizes. Mean core area size increased between pre-hunt and hunt periods for hunted deer but decreased for unhunted deer. Hunted and unhunted deer used the hunt zone less during the day between the pre-hunt and hunt periods but nightly use was not different. Two of the 4 hunted deer increased movement, whereas two decreased movement from pre-hunt to hunt periods. Unhunted deer had no change in movement. No excursions were documented. Although deer stayed within their home ranges when exposed to hunting, they shifted core area use to areas with less hunter activity during the day. Unhunted deer avoided the hunt zone during the day when hunting was occurring. Kilpatrick and Lima suggest that deer responses to hunting pressure may decrease and vulnerability may increase if a series of short, intense hunt periods are separated by periods of no hunting.

Little, A. R., S. L. Webb, S. Demarais, K. L. Gee, S. K. Riffell, and J. A. Gaskamp.

2016. Hunting intensity alters movement behaviour of white-tailed deer. *Basic and Applied Ecology* 17:360-369.

Little et al. studied the effects of risk of hunters on the movement rates and displacement of 37 adult male White-tailed Deer. The Samuel Roberts Noble Foundation's Oswalt Ranch in southcentral Oklahoma was used as the study area, which includes wooded areas, bottomlands, uplands, and rangeland. GPS collars collected locations every eight minutes during the 36-day study period, which was divided into the following: pre-season, scouting, pre-hunt, hunt, and post-hunt. Three risk treatments areas were used: Control (no hunters), low risk (1 hunter/101 ha), and high risk (1 hunter/30ha). Temporal periods of risk, diurnal and nocturnal, were also

considered. The impacts of the risk treatment levels, temporal period of risk, and time on two metrics, movement rate and relative displacement, were analyzed. They found that movement rate declined across all risk treatment levels and temporal periods of risk over the 36-day period. Movement rate was greatest in the low risk treatment during the nocturnal hours. Deer in both low and high risk treatments had greater movement rates than those in the control. Movement rate declined faster during the day in the high risk compared to low risk treatment but the opposite was observed during the night. Movement rate also declined faster during the day in the high risk compared to the control but the opposite was true during the night. Relative displacement was only influenced by time and it declined over the 36 days. The main points are that deer utilized less space over time; reducing distance traveled and increasing site fidelity. Even though this trend applies to all risk treatments, it does so at different magnitudes and generally there were greater movements during nocturnal hours for the two risk treatments, suggesting that hunting altered deer behavior. Movements decreased despite expected increase due to breeding season, indicating that hunting could have a stronger influence on movements than the breeding season.

Marantz, S. A., J. A. Long, S. I. Webb, K. L. Gee, A. R. Little, and S. Demarais.

2016. Impacts of human hunting on spatial behavior of white-tailed deer

(*Odocoileus virginianus*). Canadian Journal of Zoology 94:853-861.

Marantz et al. studied the effects of hunting on adult male white-tailed deer movement and space use patterns at Noble Foundation Oswalt Road Ranch in southcentral Oklahoma, which consists of prairie, savannah, and woodland habitats. GPS collars were programmed to collect locations every 8 minutes for 36 days (n=30 individual deer; 37 deer-year combinations). Both path-based and polygon-based analysis were conducted to assess overall movements and

home ranges, respectively. They found that total distance travelled decreased as hunters became present on the landscape, with declines starting during the scouting period and continuing until 3 days post-hunting season. Deer used microranges more intensively during hunting season. Microrange areas started to decrease during the scouting period with the greatest declines during hunting season. Marantz et al. also found an increased range disappearance and decreased range expansion as time progressed into hunting season, indicating that deer concentrated their activities within smaller areas during times of perceived risk. Hunters changed behavior of deer in that movement and space use patterns declined with hunter presence. Marantz et al. noted that hunting season corresponded with the rut, a time when adult male deer are expected to increase movement and expand range size. Therefore, the perceived risk of hunters must significantly influence deer space-use behavior.

Root, B. G., E. K. Fritzell, and N. F. Glessman. 1988. Effects of intensive hunting on white-tailed deer movement. Wildlife Society Bulletin 16:145-151.

Root et al. studied the movement responses of white-tailed deer to intensive hunting pressure and assessed the use of a seasonal refuge during firearms season in northeastern Missouri. The study area, 1500 ha of which was open to hunting and 81 ha closed to hunting, was 83% forested, mostly oak-hickory. Fields, food plots, and pastures comprised the remainder. 24 deer of both sexes and various age classes were located via triangulation every two hours during the 27-day study period. Preseason, hunting, and postseason were each 9 days. Deer were divided into either a refuge (n=8) or non-refuge group (n=16) based on the percentage of time spent on a refuge during preseason (>75% were considered refuge). Refuge (R) females spent an average of 91.6% of their time on the refuge and Non-Refuge (NR) females spent 48.3% of their time on the refuge throughout the study period. Percentage of time spent on the

refuge did not change among pre-, hunting, and post season for R or NR females. Mean movement indices were greater during firearms season for NR females but did not change among seasons for R females. NR females occupied larger home ranges during firearms season compared to pre- and postseason and compared to that of R females during firearms. Home range size did not differ for R females among time periods. Mean movement indices and home range sizes were much larger for males (not divided into R and NR). Root et al. observed one male with 50% of its preseason home range located within the refuge, shift activity centers to the refuge portion of the home range when firearms season started. R deer were protected from intense hunting pressure but none of the NR deer moved to the refuge in response to hunting activity. Females moved greater distances over larger areas when exposed to intense hunting pressure than at other times, while males did not follow this pattern. Root et al. note that habitat conditions, especially cover, may influence deer movement responses to intensive hunting disturbance.

Sargent, R. A., and R. F. Labisky. 1995. Home range of male white-tailed deer in hunted and non-hunted populations. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 49:389-398.

Home range sizes for 30 adult male white-tailed deer in Big Cypress National Preserve (BCNP; hunted) and 24 adult males in Everglades National Park (ENP; non-hunted) were compared from April 1989 to March 1992. These southern Florida study areas were mostly composed of wet prairie (seasonally flooded) and also included mixed hardwood hammocks. Deer densities were between 3-5 deer per km². Deer were located once every five days via radio telemetry from fixed-wing aircraft. Mean annual home ranges and core areas were greater in size for adult males in BCNP than ENP. Home range size during the rut was larger than during

pre-rut and did not differ between hunt and post-hunt periods in ENP. Mean hunt home range in BCNP was larger than mean rut home range in ENP. Home ranges during all 4 periods: pre-rut, rut, hunt, and post-hunt, were greater for BCNP deer. Males in BCNP did not utilize ENP as a refuge during hunting season, nor did they travel there regularly during the rut. Sargent and Labisky suggest that these males' large home ranges could be explained by the sparse distribution of cover in the study area. Mean home range size decreased 58% from rut to hunting season in ENP and increased 7% in BCNP. The larger home ranges of males in BCNP during hunting season may increase their harvest susceptibility, thus contributing to the already low deer density and decreased female fecundity in the study area.

Simoneaux, T. N., B. S. Cohen, E. A. Cooney, R. M. Shuman, M. J. Chamberlain, and K. V. Miller. 2016. Fine-scale movements of adult male white-tailed deer in northeastern Louisiana during the hunting season. Journal of the Southeastern Association of Fish and Wildlife Agencies 3:210-219.

Simoneaux et al. tested the explanatory power of five variables on the movement activities of adult male white-tailed deer during hunting season. They captured individuals on Tensas River National Wildlife Refuge in northeastern Louisiana, which consisted of mature bottomland hardwood and swamps with agriculture bordered on all sides. Adult male deer (n=24) were fitted with GPS collars that recorded 30-minute locations during the state-wide hunting season. Movement was defined as the linear distance between consecutive 30 min locations. Explanatory variables include: Time of day (crepuscular, day, and night periods), macrohabitat (agriculture, regenerating hardwood, and mature hardwood), reproductive phase (non-breeding, pre-rut, rut, and post-rut), age (young mature: 3.5-4.5 or old mature: 5.5+), and hunting pressure. Eight generalized linear mixed models were used to test the effects of various

combinations of these variables on deer movements. The following results take each variable individually: Greater movements during crepuscular and night hours than during the day, similar movements in agriculture and mature hardwoods but less in regenerating hardwoods, movements greatest during the rut, young mature males moved more than old mature males, greater movements in areas open to hunting rather than in refuge areas. The model that best predicted movement involved reproductive phase and period. Deer in areas open to hunting tended to move more during crepuscular periods suggesting that hunting made deer more nocturnal.

VerCauteren, K. C., and S. E. Hygnstrom. 1998. Effects of agricultural activities and hunting on home ranges of female white-tailed deer. *Journal of Wildlife Management* 62:280-285.

VerCauteren and Hygnstrom studied the effects of corn development, corn harvest, and hunting on home ranges and movements of female white-tailed deer. This summary will solely focus on the effects of hunting. Desoto National Wildlife Refuge (DNWR) in Nebraska was the study area and it was composed of 35% forest, specifically mature cottonwood bottomlands, 32% cropland, and the remainder a mix of warm-season native grasses. Locations of 30 female deer (20 adult, 10 juvenile) were biangulated 1-4 times per day from February 1991 to February 1993. 95% isopleth home ranges and 25% isopleth core areas were calculated. Annual and seasonal home ranges were not different in size for adults and juveniles and the centers of all annual home ranges were composed of wooded habitat. Mean home range size did not differ before and after the hunt period. Home range centers shifted but remained in areas of permanent cover. Of 19 does that had home ranges located in hunted portions of DNWR, 10 moved out of their home range to un-hunted portions of DNWR during hunting season and two shifted activity to un-hunted areas of their home range. All but one, which established a new home range,

returned to their pre-hunt range within 6 days. Vercauteren and Hygnstrom note that changes in deer movements and home ranges due to hunting are highly dependent on habitat conditions.

DEER MOVEMENTS RELATIVE TO DOG-HUNTING

Barkalow, F. S., and W. E. Keller. 1950. Escape behavior of white-tailed deer. *Journal of Wildlife Management* 14:246-247.

In this observational study, Barkalow and Keller noted the importance of swimming to white-tailed deer being pursued by hunting dogs. Deer readily use water to throw hounds off their scent trail. Bucks have been documented to remain bedded and hidden as hunters pass by them, even at distances of a few feet, but this behavior is rare for bucks being pursued by dogs. The authors provide personal testimony to the escape capabilities of deer being pursued by dogs. “These observations also indicate that the white-tail deer will exhibit its skulking behavior in the water. It preferred to skulk in the icy water under the bank rather than to continue attempting to escape by flight.”

Campo, J. J., G. E. Spencer, and B. Ortego. 1987. White-tailed deer hunting with dogs in east Texas. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 41:404-409.

Campo et al. conducted 53 experimental chases of white-tailed deer with dogs. Chases averaged 18 minutes in length. Dog dispersal averaged 1.1 km and 70% of chases were within 1.6 km of the dog release point. The authors related dog dispersal data to the area required to hunt deer with dogs to avoid trespass. They concluded that 2,514 ha were needed to hunt deer

with dogs in a 405-ha core area to prevent trespass in 70% of chases, assuming a square-shaped tract of land.

Corbett, R. L., R. L. Marchinton, and C. E. Hill. 1971. Preliminary study of the effects of dogs on radio-equipped deer in a mountainous habitat. Proceedings of the Southeastern Association of Game and Fish Commissioners 25:67-71.

Corbett et al. studied the effects of dogs on movement patterns, behavior, and mortality of white-tailed deer on the Mt. Mitchell Wildlife Management Area in western North Carolina. It is a mountainous habitat consisting of the following forest communities: oak and oak-pine, mixed mesophytic, northern hardwood, and spruce-fir. Deer of both sexes and various age classes were tracked via radio telemetry every 1-3 hours for 24 hour periods once or twice weekly. Six deer were radio-monitored during four raccoon and bear hunts but no chases were recorded. Twenty experimental chases were conducted on 8 radio-equipped deer from mid-February to July 1971. Deer escaped in 18 of these chases but were caught in two. Deer left home ranges in 70% of chases. These chases averaged 3.14 miles, whereas, those in which deer remained in their home ranges averaged 0.73 mi. Short durations were due to hounds losing the scent trail. Deer returned to their home ranges in 2.5 hours to 7 days with half requiring longer than one day. The most observed escape behavior involved distance running and running through streams. (These escape patterns are described in the summary of Sweeney et al. 1971.) Corbett et al. observed deer continuing to travel out of their home ranges even after hounds had lost their scent. The average distance travelled outside of the home range in these instances was 0.71 mi for 15 chases. They also observed individual deer repeatedly using the same escape routes. Dogs killed two study animals but both deer were old and in poor physical condition. They had a strong presence of internal parasites; one deer had damage in its lungs due to these

parasites. Corbett et al. compared their results to dog studies in Coastal Plain habitats (such as Sweeney et al. 1971) and concluded that in mountainous habitats chase patterns were more predictable, deer seemed to suffer more physical injury during chases, and deer took more time to return to their home ranges.

D'Angelo, G. J., J. C. Kilgo, C. E. Comer, C. D. Drennan, D. A. Osborn, and K. V.

Miller. 2003. Effects of controlled dog-hunting on the movements of female white-tailed deer. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 57:317-325.

D'Angelo et al. assessed the effects of controlled dog-hunting on movements of 13 adult female white-tailed deer on the Savannah River Site in South Carolina, which was mostly composed (97%) of pine-dominated forest. Hourly locations were obtained via radio telemetry during pre- and post-hunt periods and 20 minute locations on the hunt days. Four hunts occurred on 28 Sept, 30 Oct, 2 Nov, and 4 Dec. Mean measures of diel home range size were greater during the hunt days than during the pre- and post-hunt periods. Mean measures of distance between extreme diel locations was also greater during the hunt days than the pre- and post-hunt periods. There was no significant difference among the periods in mean diel rate of travel. Based on estimated movement paths, D'Angelo et al. concluded deer avoided dogs by backtracking, running long distances, and remaining inactive for long periods. Deer utilized thick escape habitats such as young pine plantations and stream corridors. They traveled outside their fall home ranges in 8 of 15 monitoring periods during hunts at a mean distance of 0.8 km. All, except one, returned to their home range in less than 13 hours. D'Angelo et al. detected only short-term effects of controlled dog-hunting on adult female white-tailed deer movements. All deer remained within the hunt boundaries on hunt days and displayed high fidelity to their annual

and seasonal home ranges. Therefore, increasing hunt duration may allow for a more effective harvest.

Gavitt, J. D., R. L. Downing, and B. S. McGinnes. 1974. Effects of dogs on deer reproduction in Virginia. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 28:532-539.

This study occurred on a 2,040-acre enclosure at Radford Army Ammunition Plant in western Virginia. It consisted of abandoned pastureland with clumps of mature hardwoods and young pine plantations and supported a dense deer population. To determine the effects of dog chasing on white-tailed deer reproduction, Gavitt et al. released hounds on groups of pregnant does in two separate phases. During Phase 1, 30 total chases were conducted during weekends from 22 April to 3 June 1972 on about 40% of the 106 tagged adult females. The remaining 60% served as a control. Fawn production was compared between chase and control groups. Rearing success was determined on 15 September. Chases averaged 11 min and 0.8 miles. The majority of deer were driven from their home ranges but returned within two days or less. No permanent changes in home range were detected and no significant difference in fawn production per doe was detected between the two groups. During Phase II, all deer in the study area were potentially subjected to chases every weekend from 21 October through late May 1973, except during the 6-week hunting season in late November and December. Chase duration was longer compared to Phase I because hounds did not have to be stopped at chase area boundaries. An average day's chase moved more than 100 deer. Six tagged does left their home ranges temporarily but returned within a few days. No permanent changes in home range were detected and there was no significant difference in fawn production per doe when compared to previous

years' data. Gavitt et al. note that the dogs tired quickly in this study but in hunting situations where several packs of fresh dogs may be used in succession, these results may differ. One piebald fawn was killed but they conclude that dogs are only able to catch deer in poor physical condition. Dogs have the physical ability to catch young fawns, but the protective nature of the does and the low chance of dogs locating bedded fawns does not allow them to be a significant threat to fawn survival.

Florida Game and Fresh Water Fish Commission. 1991. The use of free-running dogs in sport hunting of white-tailed deer in Florida: a review of pertinent information and discussion of the issues. Tallahassee, Florida, USA.

Florida Game and Fresh Water Fish Commission staff initiated this review to examine four primary areas of concern about dog-hunting: 1) the effects of dog-hunting on deer populations, 2) the effects of dog-hunting on turkey populations, 3) the effects of dog-hunting on turkey hunting success and hunter satisfaction, and 4) implications of dog-hunting in trespass problems. They reviewed data from their agency and other agencies in the southeastern U.S., and published literature. They concluded that dog-hunting does not depress deer populations, nor do deer permanently move out of areas with dog-hunting. While the review concluded that dog-hunting did not negatively impact turkey populations, dog-hunting was likely to impact satisfaction of turkey hunters by displacing turkeys to areas with less disturbance. Based on common intensities of dog-hunting observed on state wildlife management areas relative to the area's size, they concluded that 33,000 acres would be required to accommodate 10 dog-hunting parties with a 20% likelihood of trespass or overlap among dog packs. They proposed that only areas >2 miles in width with adequate road systems would be considered for dog-hunting on public lands.

Gipson, P. S., and J. A. Sealander. 1977. Ecological relationships of white-tailed deer and dogs in Arkansas. Pages 3-16 in Proceedings of the 1975 Predator Symposium. Montana Forest and Conservation Experiment Station, Missoula, Montana, USA.

Gipson and Sealander studied the direct and indirect effects of repeated harassment by dogs on white-tailed deer in both high- and low-density populations. The high density population was in the gently rolling Gulf Coastal Plain in southeastern Arkansas and the low density population was in the rugged Ozark Mountains in northwestern Arkansas. Locations were obtained from 6 does and 3 bucks on the Ozark study area and 6 does and 2 bucks on the Coastal Plain study area via triangulation during 24 or more hours each month. Sixty-one experimental chases were conducted involving 7 deer in the Ozark area and 6 deer in the Coastal Plain area from June 1972 – May 1974. Deer escaped in all instances. Mean chase duration for the Ozark and Coastal Plain populations were 40 min and 52 min, respectively, and average distance was 1.9 and 1.6 miles, respectively. Typically, chases involved deer running short, rapid bursts followed by rest stops with dogs following at a slower pace. Deer left their home ranges in 69% of chases in the Ozarks and 61% in the Coastal Plain. In most cases, deer returned within one day but in all cases, within 72 hours. Average distance travelled outside the home range for the Ozark and Coastal Plain deer were 0.7 and 0.3 miles, respectively. Observed escape patterns were similar to those described by Sweeney et al. 1971. The most common include, running through a group of deer, zigzag running, and distance running. Deer in the Ozark area also escaped by entering the Kings River. Gipson and Sealander describe another escape technique as “road running,” in which deer would dart out of the woods, run along a gravel road and then turn 90 degrees into the woods again. Escape routes were more predictable in the mountainous Ozark study area, which can lead to much higher hunter efficiency. Chases

were faster-paced and covered greater distances in the rugged terrain of the Ozark area, indicating that deer worked harder to escape hounds there. Gipson and Sealander did not find that dogs catch or indirectly kill a significant number of deer. No long-term home range or activity pattern disruptions occurred. They conclude that dogs are relatively inefficient predators of deer as compared to natural ones.

Marchinton, R. L., A. S. Johnson, J. R. Sweeney, and J. M. Sweeney. 1970. Legal hunting of white-tailed deer with dogs: biology, sociology and management. Proceedings of the Conference of the Southeastern Association of Game and Fish Commissioners 24:74-89.

Marchinton et al. studied the movements of 57 deer (including 5 pen-reared deer released in the wild) in experimental chases with dogs in Alabama, Florida, Georgia, and South Carolina. Deer were radio-located and packs of dogs were released near their location. Additionally, tame deer were chased in a 2-acre enclosure. They noted that deer could be chased out of their home ranges, but usually returned within 1 day or less. They also investigated the administrative nature of managing dog-hunting. The authors recommended that managers consider only encouraging dog-hunting where legal dog-hunting was traditionally practiced, and where it was biologically and sociologically suitable.

Olson, J. C. 1974. Movements of deer as influenced by dogs. Indiana Department of Natural Resources, Job Progress Report, Project W-26-12-5:8-12.

This job progress report briefly describes an ongoing study by the Indiana Department of Natural Resources in 1974 to determine the effects of dog harassment on the daily movement patterns of female white-tailed deer. Twenty-three females were radio-collared and modified minimum home ranges were calculated; 198 acres for 17 native deer and 78 acres for 6

transplanted deer. One hound was used in seven experimental chases. Average duration was 26 minutes and all deer (including a few fawns) escaped.

Progulske, D. R., and T. S. Baskett. 1958. Mobility of Missouri deer and their harassment by dogs. Journal of Wildlife Management 22:184-192.

To determine the effects of year-long harassment by dogs on the mobility of white-tailed deer, Progulske and Baskett conducted their study on the University of Missouri's Ashland Wildlife Refuge, most of which is forested with oak and hickory and is adjacent to private farmland. Deer were uniquely marked with ear tags and collars so that individuals could be identified through observation. Mobility characteristics of 31 marked deer (17 adult males, 11 adult does, and 3 fawns) were made by observation by foot, from a tower, blind, car, small airplanes, and by trailing in the snow. The mean maximum distance moved by females (includes 2 male fawns) and adult males on an annual basis was 1.4 mi and 1.9 mi, respectively. Mean areal measure of movement, which was obtained by connecting the outermost points of observation and measuring the encompassing polygon, for females and the two male fawns was 400 acres and for adult males was 940 acres. Mean maximum distance moved by the females and male fawns during the fall and winter was 1.0 mi. Mean maximum distance moved by adult males was 1.6 mi and mean areal movement was 630 acres. A total of 310 chases by hounds were documented from Oct 1954 to May 1956 with the most occurring in November, December, and May. Progulske and Baskett observed some deer moving long distances and leaving their home ranges due to these chases but these results were not quantified. They could not evaluate the ultimate effects of harassment by dogs.

Sweeney, J. R., R. L. Marchinton, and J. M. Sweeney. 1971. Responses of radio-

monitored white-tailed deer chased by hunting dogs. Journal of Wildlife Management 35:707-716.

Sweeney et al. studied the behavioral responses and movements of white-tailed deer (both sexes and various age classes) chased by hunting dogs on three study areas: Auburn, Alabama; Eglin Air Force Base in Florida; and Savannah River Plant in South Carolina. The researchers recorded 65 chases involving 6 different deer from August 1966-September 1969. The deer escaped the hounds in every chase. Average duration and distance of chases were 33 minutes and 2.4 miles, respectively. Seventy-eight percent of chases resulted in deer leaving their home ranges, in which 86% remained within 1 mile of their home range. In all instances except one, deer returned to their home ranges in one day or less. Deer preferred running through water, such as swamps and streams, when escaping the hounds, as they were utilized in 58% of chases. Dogs lost the trail in 38 of 40 chases involving water. Other escape patterns include holding (deer remain bedded even when hounds are close), distance running (deer run in a straight line, using speed and endurance to evade dogs), running zigzag patterns (deer stay within their home range and frequently cross their own trail), separating from a group (often resulted in hounds pursuing other members of the group). Sweeney et al. concluded that chase duration is related to deer density and habitat. Greater densities increase the likelihood of dogs switching to the trail of a different deer, thus decreasing chase duration. Swamp was the most significant habitat type, as it appeared to mask the deer's scent and act as a physical barrier to hounds.

Task 2: Spatial Analysis of National Forest Lands in Mississippi Suitable for Dog-hunting

Gino J. D'Angelo, Ph.D., Assistant Professor of Deer Ecology and Management

Daniel B. Warnell School of Forestry and Natural Resources

University of Georgia

Thomas J. Prebyl, Graduate Research Assistant

Daniel B. Warnell School of Forestry and Natural Resources

University of Georgia

Introduction and Methods

The objectives of our mapping effort were to: 1) calculate the expected buffer distances required to contain 50, 70, and 90% of deer-dog hunts, and 2) map the portions of US Forest Service (USFS) property that are expected satisfy these levels of containment. In order to calculate the required buffer distances, we first needed to calculate a probability distribution of expected distances that white-tailed deer (*Odocoileus virginianus*) would travel during dog-deer hunts based on parameters from our literature review (Table 1). We calculated this hunt distance distribution as the joint distribution that resulted from randomly sampling our assumed distributions of deer home range sizes, the probability of a deer exiting its home range during a hunt, distances travelled upon exiting a home range, and the sex ratio of the population. We simulated 500,000 samples from the joint distribution, where each sample was calculated as follows: 1) sample sex (male or female) from a categorical distribution with equal probabilities; 2) sample home range size from normal distribution with mean (sd) values for each sex, and truncated to exclude values less than 5 acres; 3) sample home range exit from Bernoulli distribution with probability = 0.80; 4) sample home range exit distance from normal distribution (mean = 0.75 miles, sd = 0.275 miles) truncated to values greater than 0; 5) assumed home range and buffer were circular and that the maximum distance travelled was equal to radius of the buffered/un-buffered home range. See Figure 1 for an example of random samples from these distributions randomly placed on a portion of Homochitto National Forest property.

Results and Discussion

From the full joint distribution resulting from the 500,000 samples (Figure 2), we calculated the 50th, 70th, and 90th percentiles of expected maximum distances travelled by deer during hunts to be equal to 1.19, 1.41, and 1.70 miles, respectively. In turn, we expect hunts

would need to be limited to areas at least 1.19 miles from USFS property edges to ensure 50% of hunts are completely contained on USFS property, or 1.41 miles to ensure 70% containment, or 1.70 miles to ensure 90% containment. We mapped these containment thresholds for each national forest using a 30-m resolution Euclidian distance raster based on the distance to the nearest non-Forest Service property (Figures 3-11). Thus, for every location (30-m pixel) on USFS property we calculated the expected probability that a dog-deer hunt would be contained if initiated at the location, given a deer's home range is centered on the location. The shaded areas should be considered areas where a hunt could begin to meet the percentages of containment rather than the area where the hunt would be contained in its entirety.

The areas available to conduct dog-hunts on most national forest properties in Mississippi were relatively minimal (Table 2) given the parameters used in our exercise. We conducted two additional analyses for demonstration purposes using the same mapping procedures with two changes simulated separately: 1) ignoring in-holdings and only giving consideration to USFS proclamation boundaries to contain dog-hunts, and 2) removal of deer excursions outside of their home range.

While ignoring in-holdings in our simulations, the area available to conduct dog-hunting increased substantially (Table 2). See Figure 12 as an example for DeSoto National Forest. However, this simulation serves to indicate how important consideration of in-holdings is when selecting dog-hunting areas rather than a real-world scenario. Without cooperative agreements (e.g., leases paid to allow access by hunters to retrieve dogs), extensive trespass issues would be highly likely.

Our simulations with the removal of deer excursions outside of their home range boundaries may represent containment of hunts when correction collars are utilized properly.

Expected hunt distances were reduced $\geq 52\%$ when excursions by deer were excluded (Figure 13). This change increased areas likely to contain 50%, 70%, and 90% of dog-hunting activities on all national forests we examined (Figures 14-22). Our literature review revealed that across studies, locations, and deer populations, deer had a strong propensity to remain within their home range, including when they were exposed to dog-hunting. This tendency suggests that correction collars would allow hunters to monitor dog movements relative to hunt boundaries and prevent long-distance movements associated with excursions when they occur.

Conclusions

We recommend that managers consider our primary simulations (Figures 3-11) as liberal estimates—the areas needed to contain dog-hunting using the full suite of parameters in our simulations, including deer excursions. Our simulations removing deer excursions (Figures 14-22) may be more realistic. However, without use of correction collars, deer excursions would cause dogs to travel outside of these hunt areas. We recommend that future field-based studies examine the movements of deer and dogs relative to designated hunt areas with and without use of correction collars.

Table 1. Parameters used to simulate movements of white-tailed deer (*Odocoileus virginianus*) on National Forest Lands in Mississippi.

Parameter	Value	Units	Distribution
Male:female sex ratio	0.50	proportion	categorical
Home range size (mean (sd))			
Female	376 (290)	acres	truncated normal
Male	902 (548)	acres	truncated normal
Home range exit probability	0.80	probability	Bernoulli
Home range exit distance (mean (sd))	0.75 (0.275)	miles	truncated normal

Table 2. Tabulated acreages of dog-hunting areas where hunts could begin to contain 0-49%, 50-69%, 70-89%, and 90-100% of deer movements on National Forest Lands in Mississippi resulting from simulations of white-tailed deer (*Odocoileus virginianus*) movements with and without deer excursions outside of their home range boundaries.

National Forest	Total acres	Expected hunts contained							
		With deer excursions				Without deer excursions			
		0-49%	50-69%	70-89%	90-100%	0-49%	50-69%	70-89%	90-100%
Bienville	180,184	178,579	953	592	60	154,468	9,160	8,639	7,916
Delta	61,445	54,762	3,236	2,065	1,384	34,834	4,588	6,147	15,878
Delta (Chickasawhay Unit)	151,424	147,948	2,766	710	0	112,346	10,955	12,291	15,832
DeSoto	382,027	360,047	8,702	6,870	6,406	275,761	25,267	27,884	53,115
Holly Springs	135,217	133,888	774	529	27	122,474	4,360	3,654	4,730
Holly Springs (Yalobusha Unit)	20,889	20,889	0	0	0	18,933	912	715	329
Homochitto	191,561	190,122	1,303	137	0	156,749	11,290	11,444	12,079
Tombigbee (Ackerman Unit)	40,495	40,495	0	0	0	36,659	1,974	1,176	687
Tombigbee (Trace Unit)	26,787	26,787	0	0	0	22,880	1,879	1,437	592

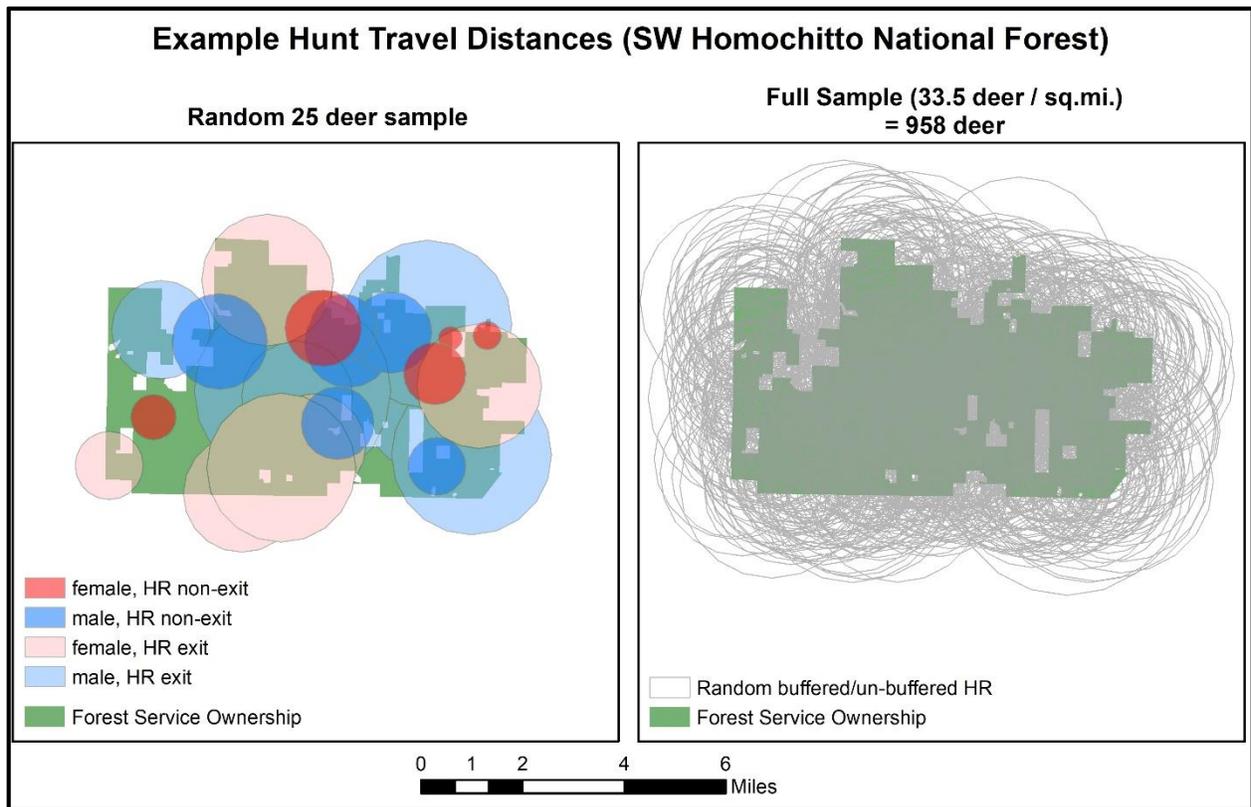


Figure 1. Examples of expected dog-deer hunt areas generated for a southwestern portion of Homochitto National Forest, Mississippi. The figure on the left represents a random sample of 25 white-tailed deer (*Odocoileus virginianus*), showing the sampled sex, home range size, and home range buffer (when deer exited home range). The figure on the right demonstrates a random sample for the total number of deer (958) that are expected to be present in this example area, given an estimated density of 33.5 deer per square mile for Homochitto National Forest (William McKinley, Deer Program Coordinator, Mississippi Department of Wildlife, Fisheries, and Parks, unpublished data).

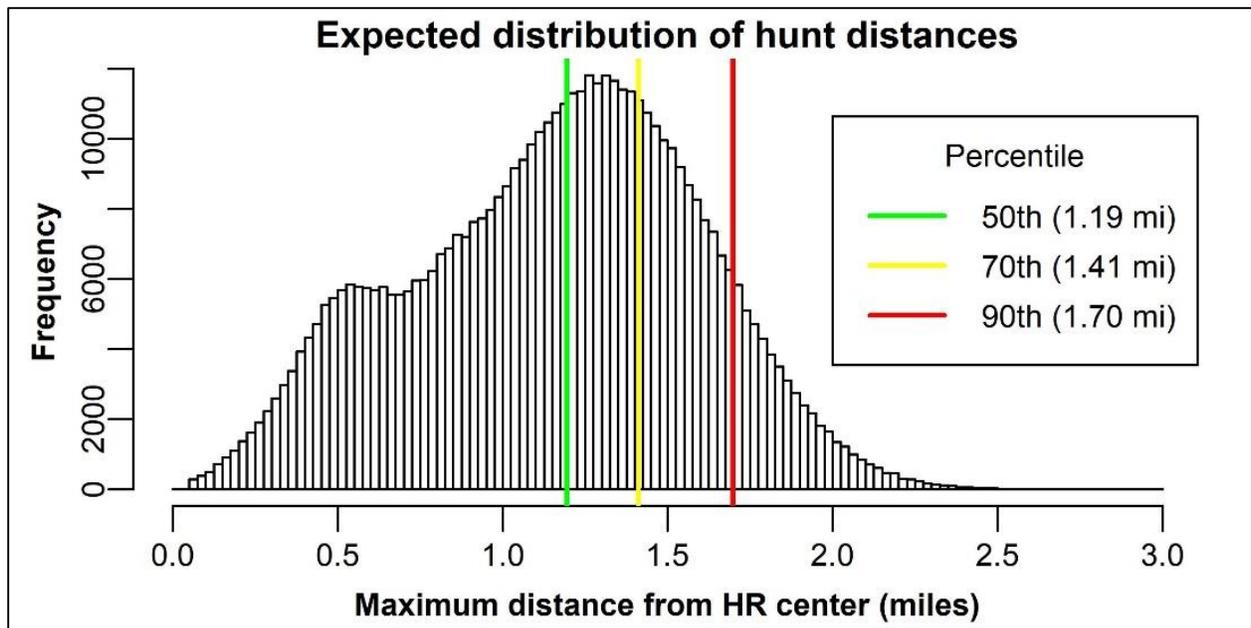


Figure 2. Expected distribution of the maximum distances travelled from a white-tailed deer (*Odocoileus virginianus*) home range center during a dog-deer hunt. This distribution is the result of 500,000 random samples from the assumed distributions for deer-sex ratios, male and female home range sizes, expected probability of deer exiting their home range during a hunt, and home range exit distances.

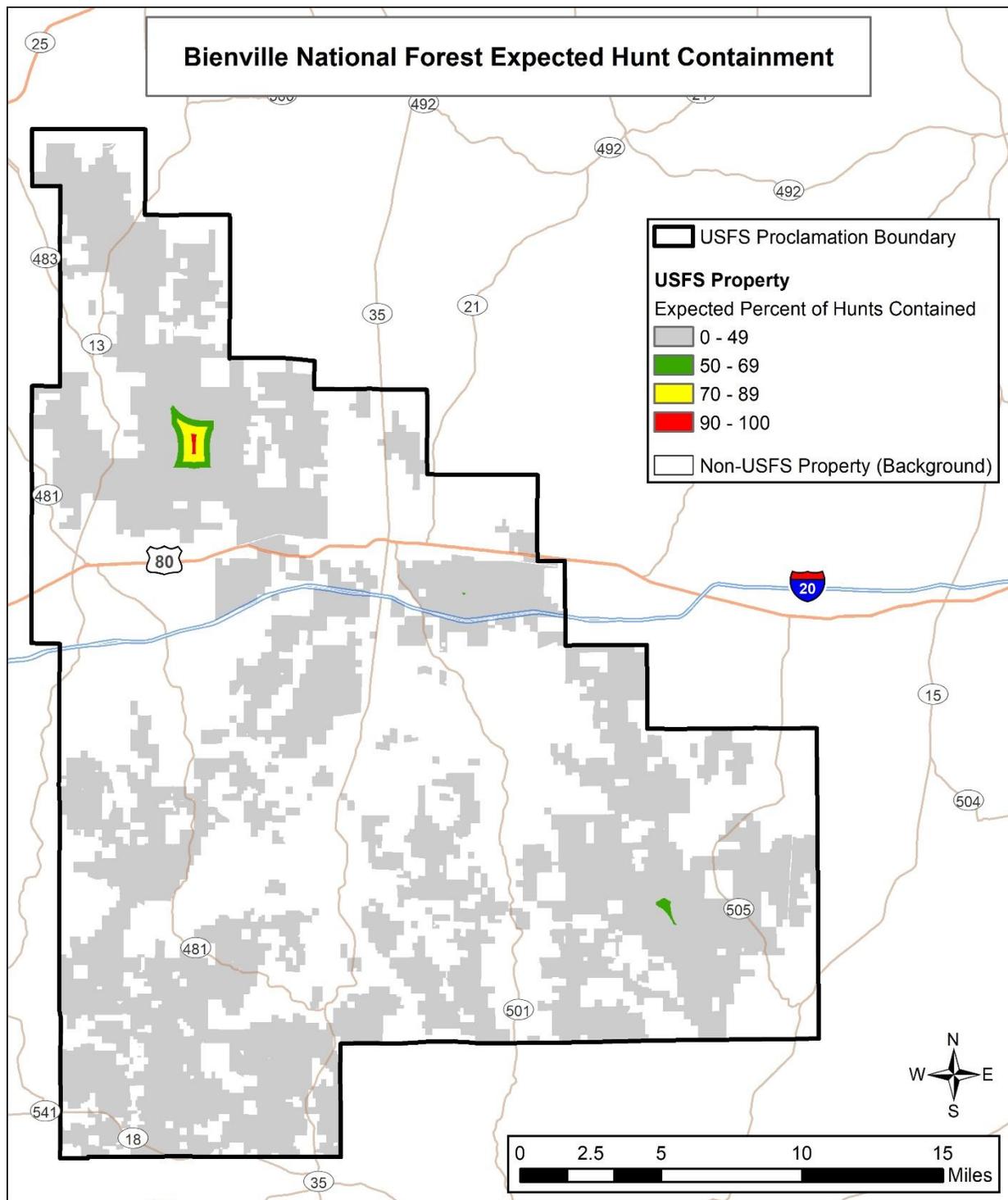


Figure 3. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Bienville National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

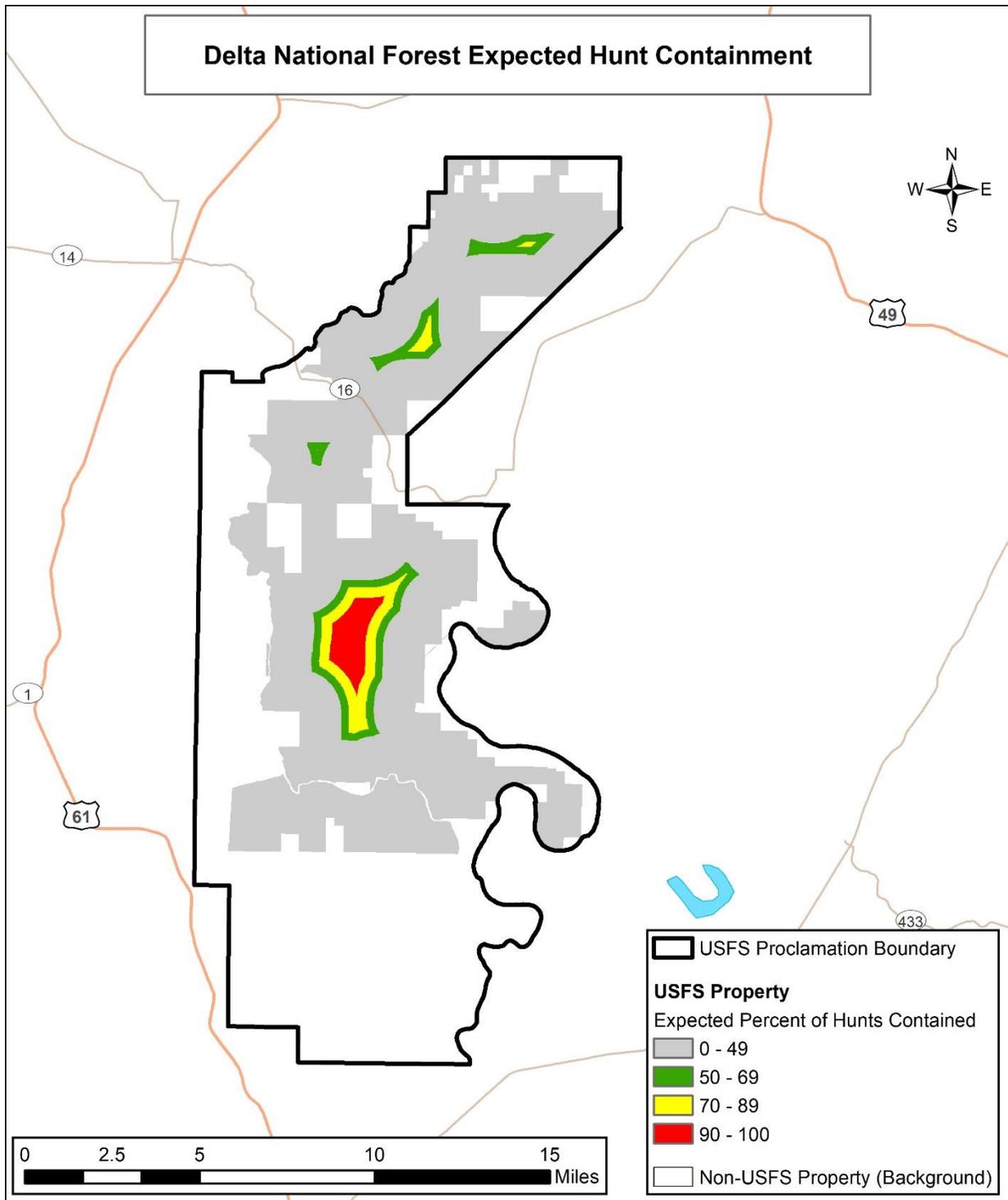


Figure 4. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Delta National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

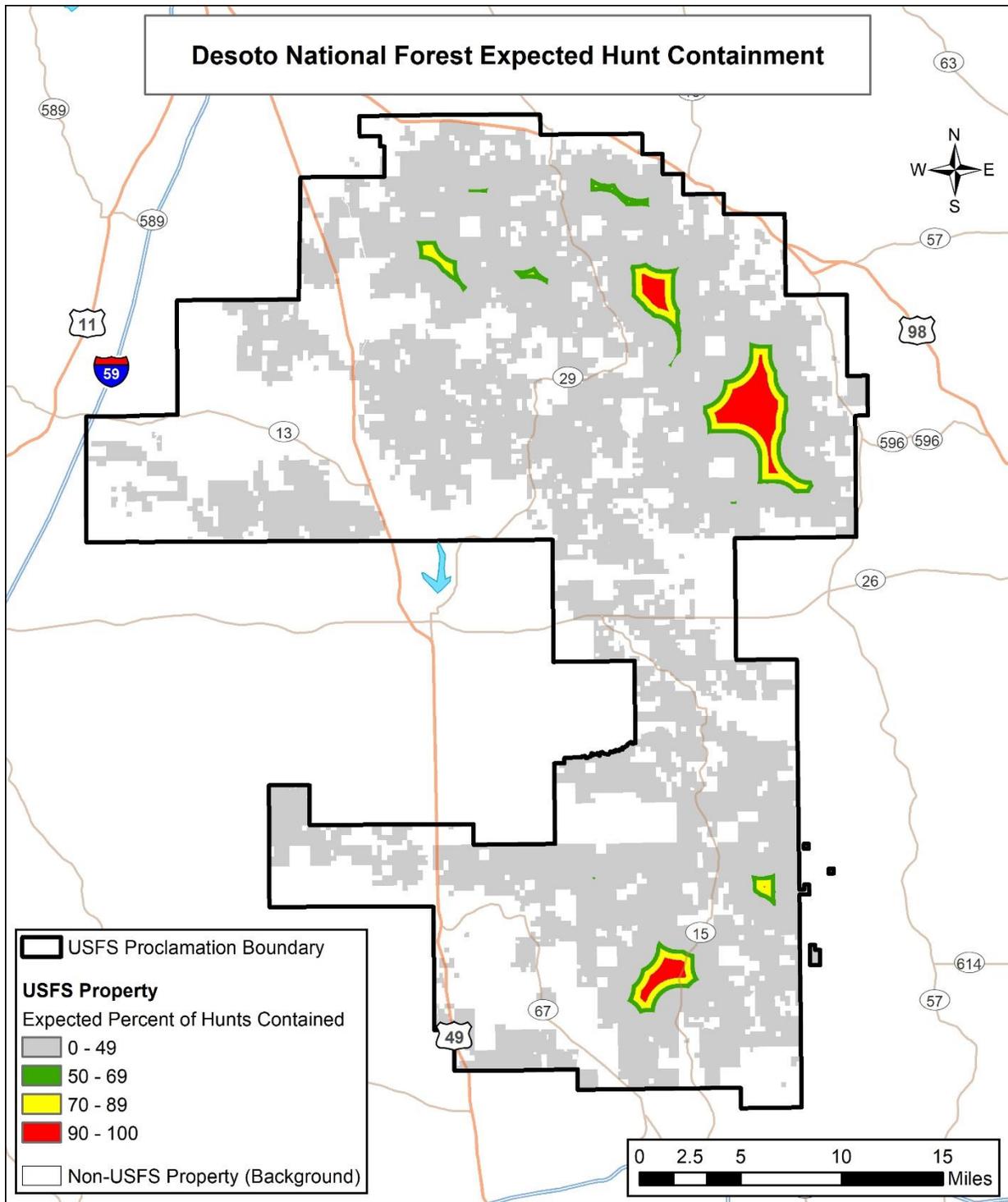


Figure 5. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on DeSoto National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

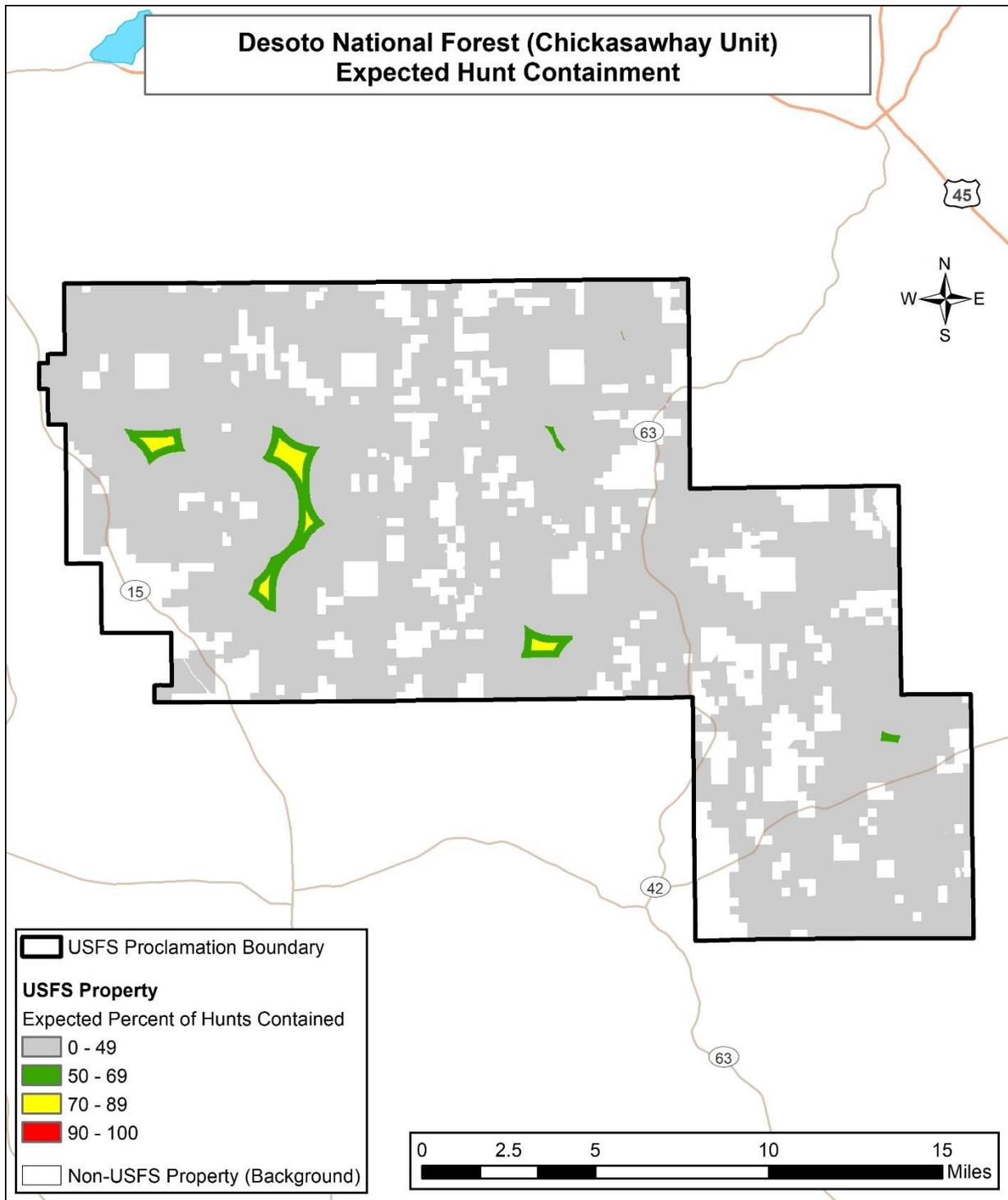


Figure 6. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on DeSoto National Forest (Chickasawhay Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

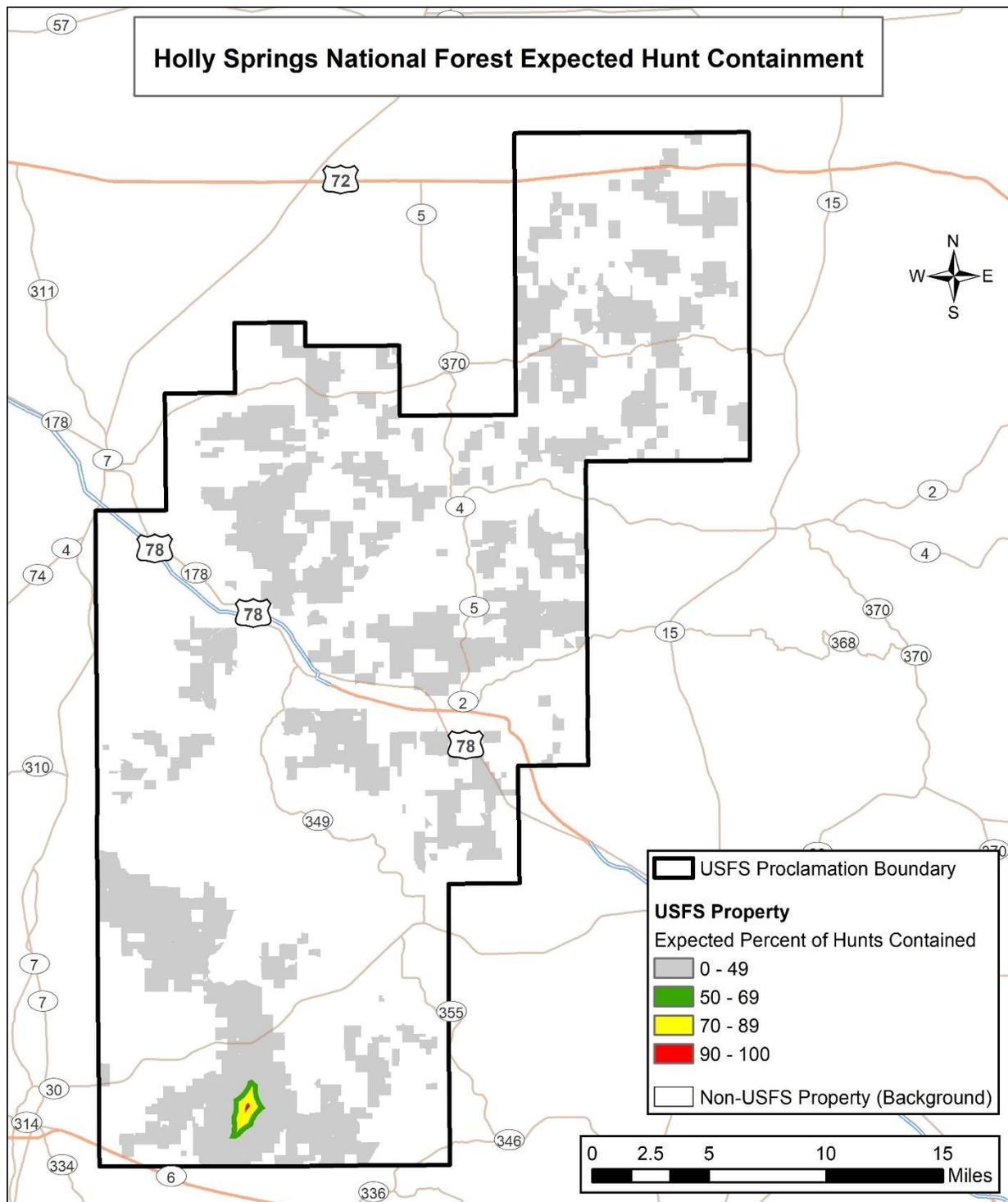


Figure 7. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Holly Springs National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

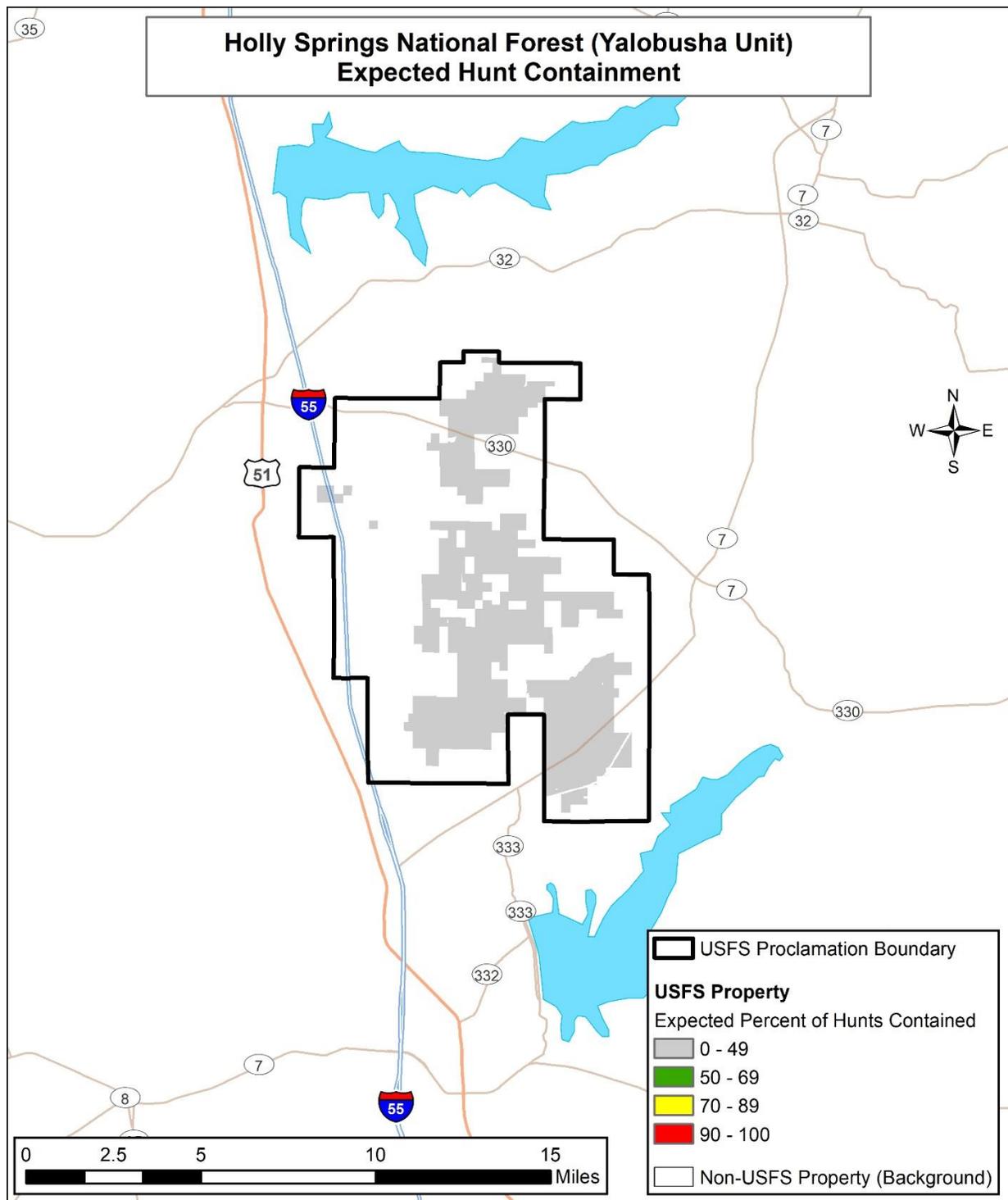


Figure 8. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Holly Springs National Forest (Yalobusha Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

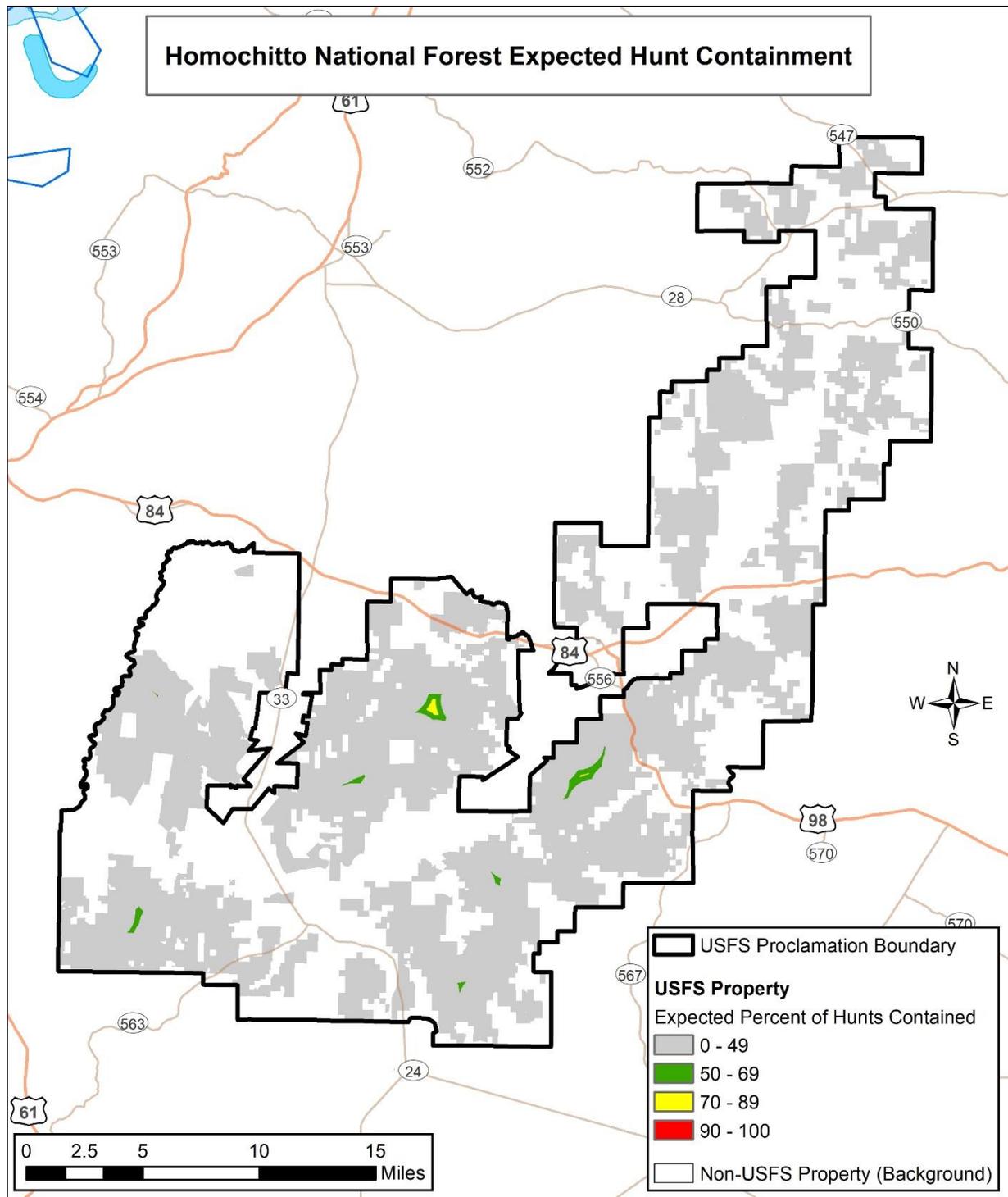


Figure 9. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Homochitto National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

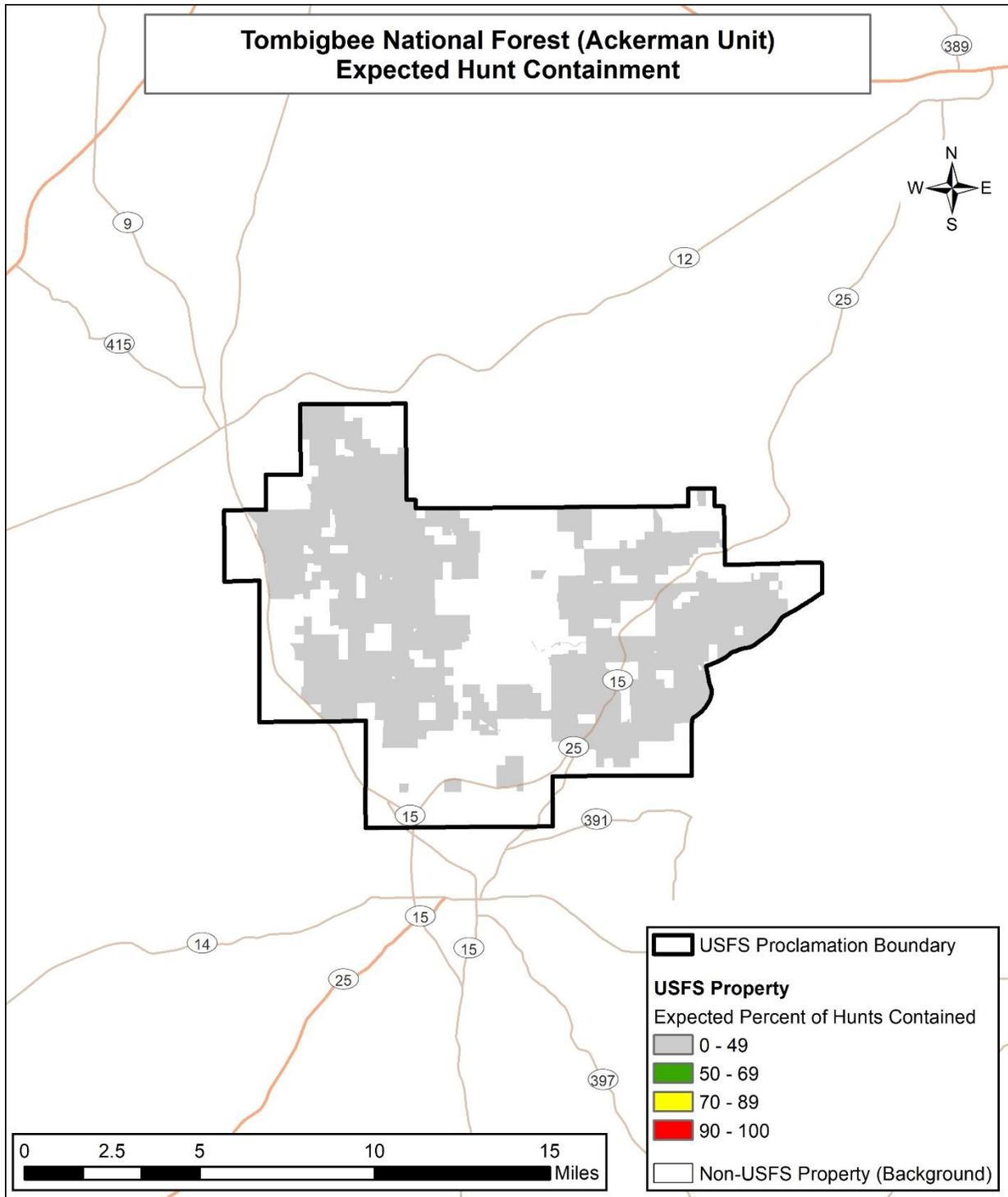


Figure 10. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Tombigbee National Forest (Ackerman Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

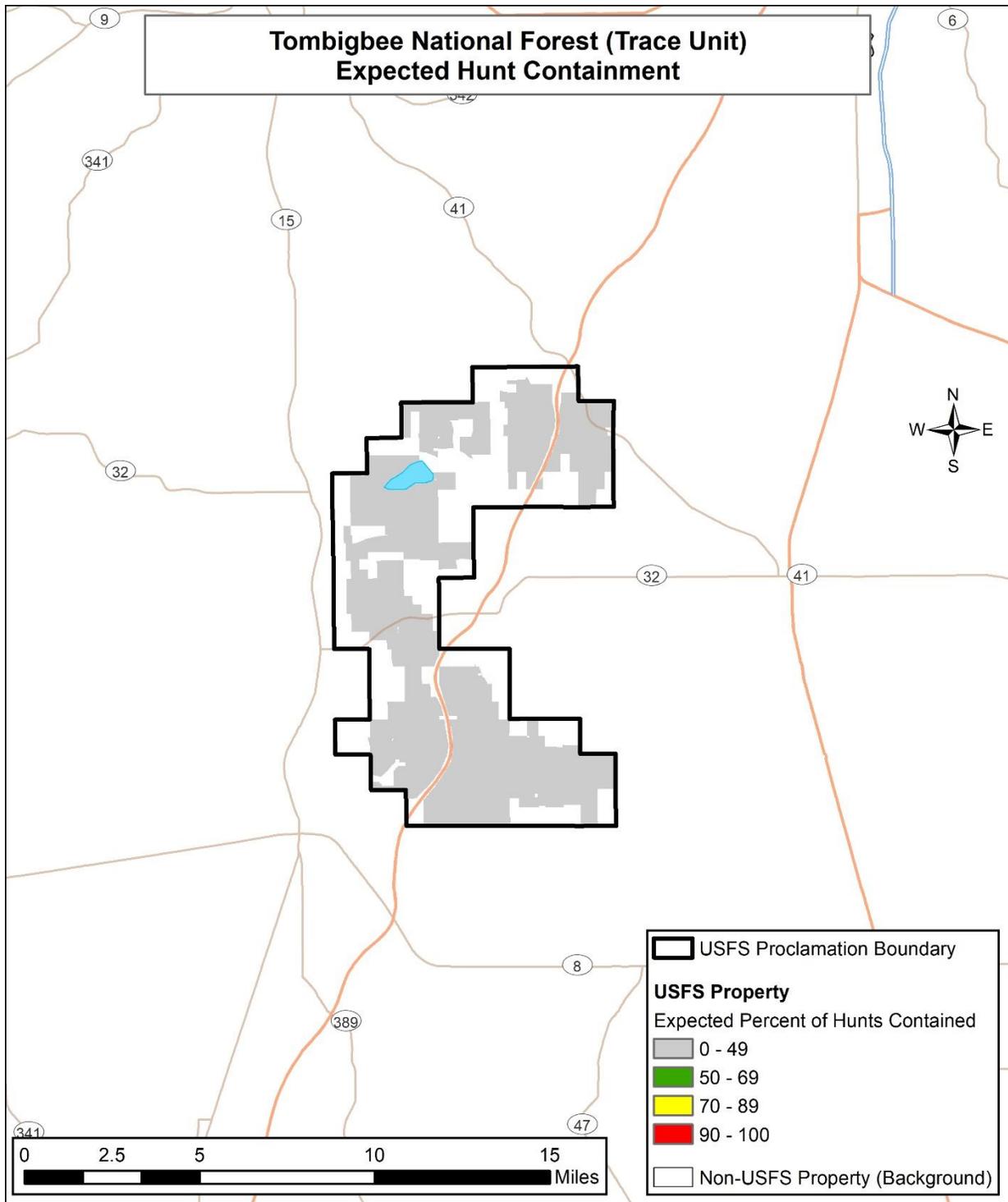


Figure 11. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Tombigbee National Forest (Trace Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

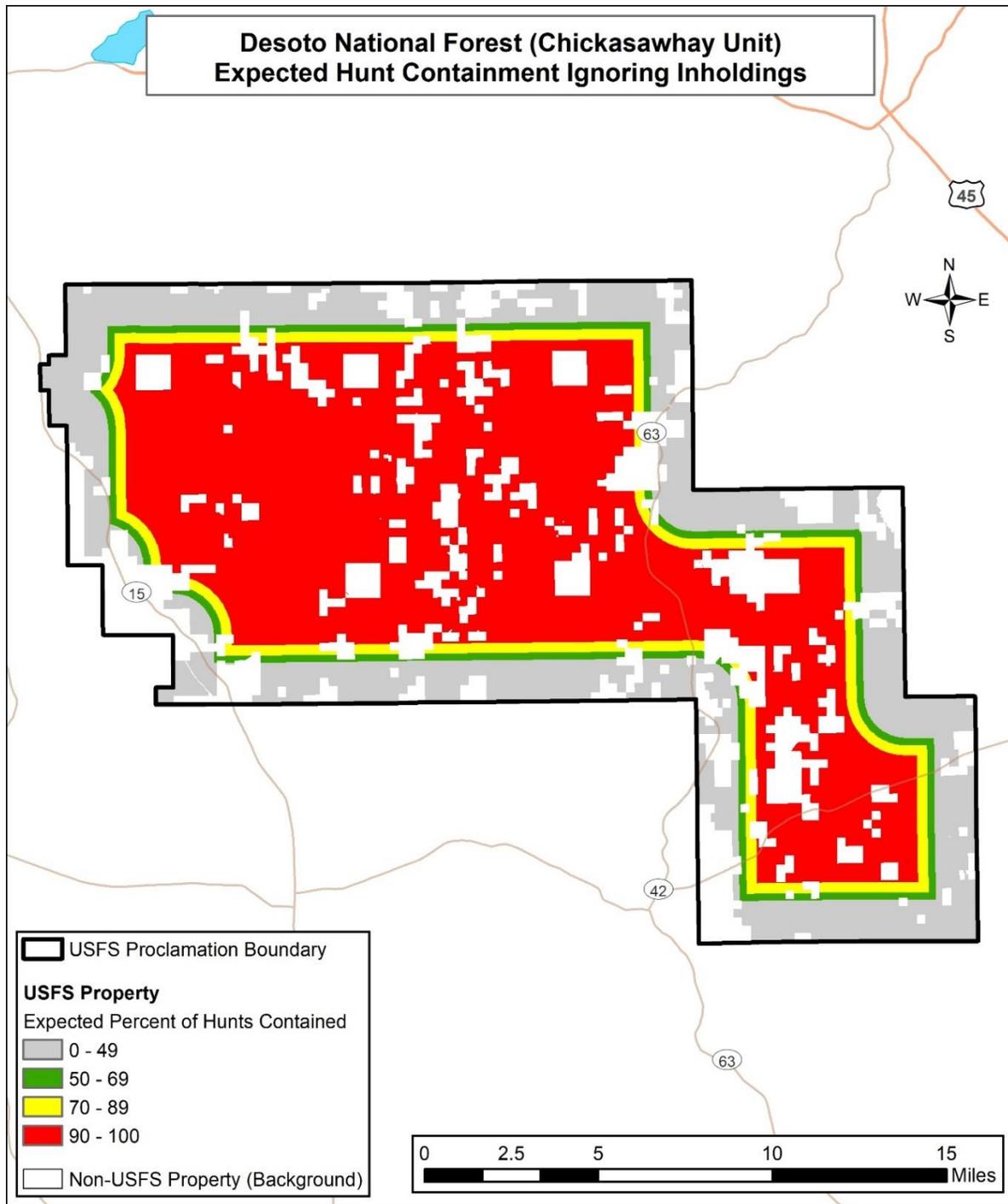


Figure 12. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on DeSoto National Forest (Chickasawhay Unit), Mississippi were calculated based on distance to nearest non-USFS property boundaries while ignoring private property in-holdings and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

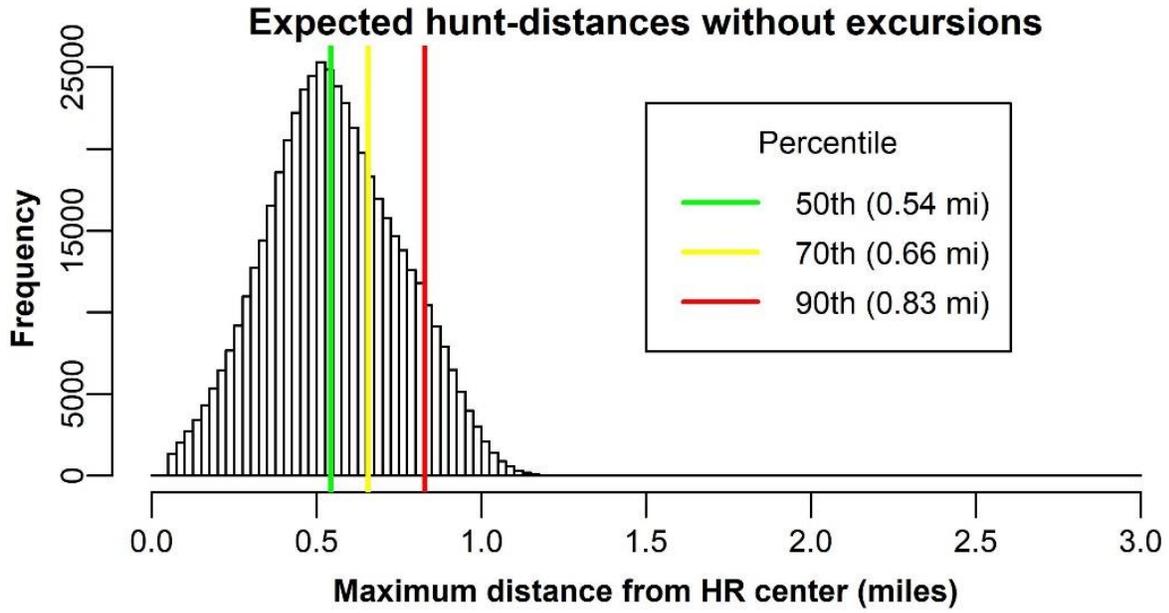


Figure 13. Expected distribution of the maximum distances travelled from a white-tailed deer (*Odocoileus virginianus*) home range center during a dog-deer hunt assuming deer do not exit home ranges. This distribution is the result of 500,000 random samples from the assumed distributions for deer sex ratios and male and female home range sizes.

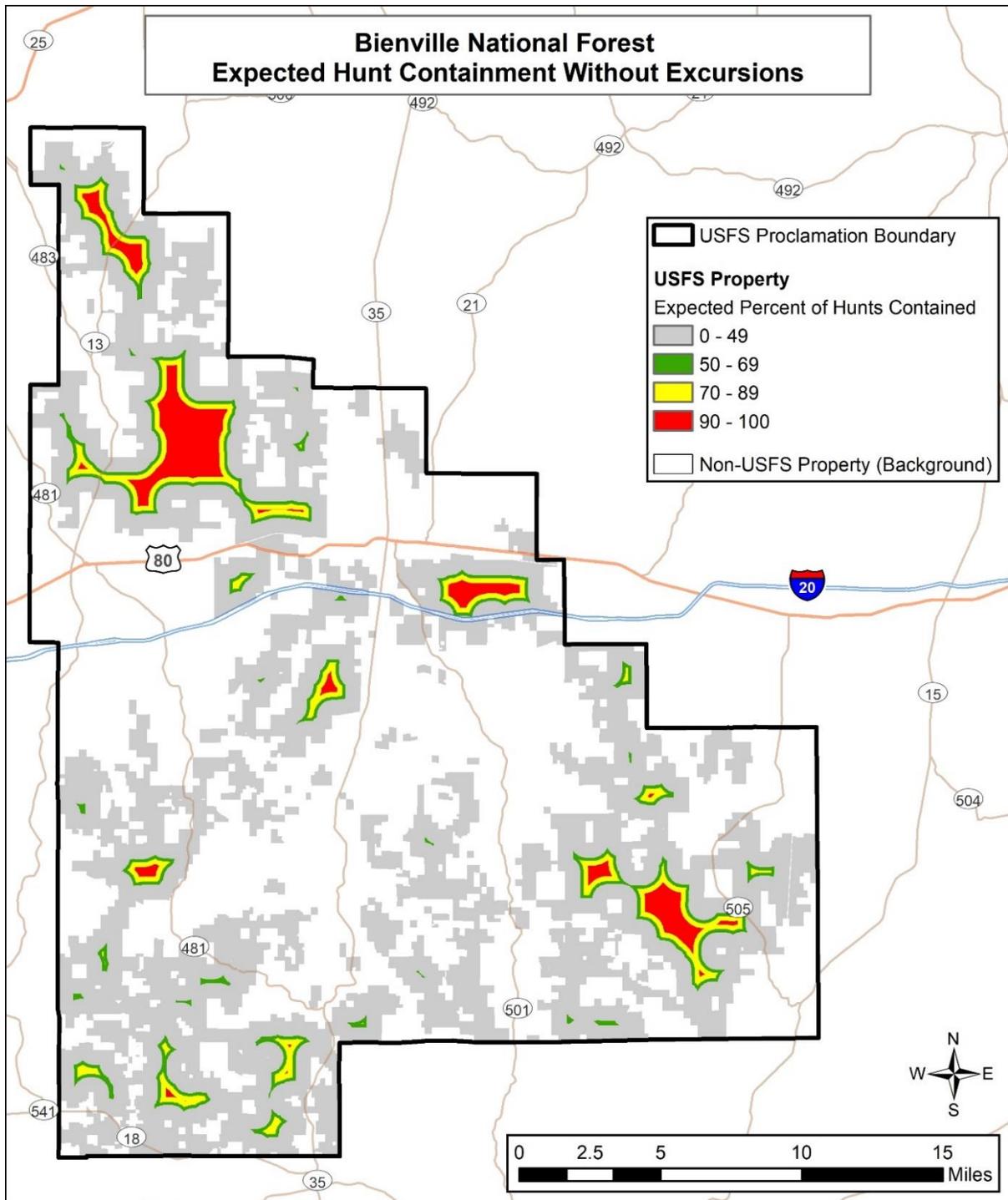


Figure 14. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Bienville National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

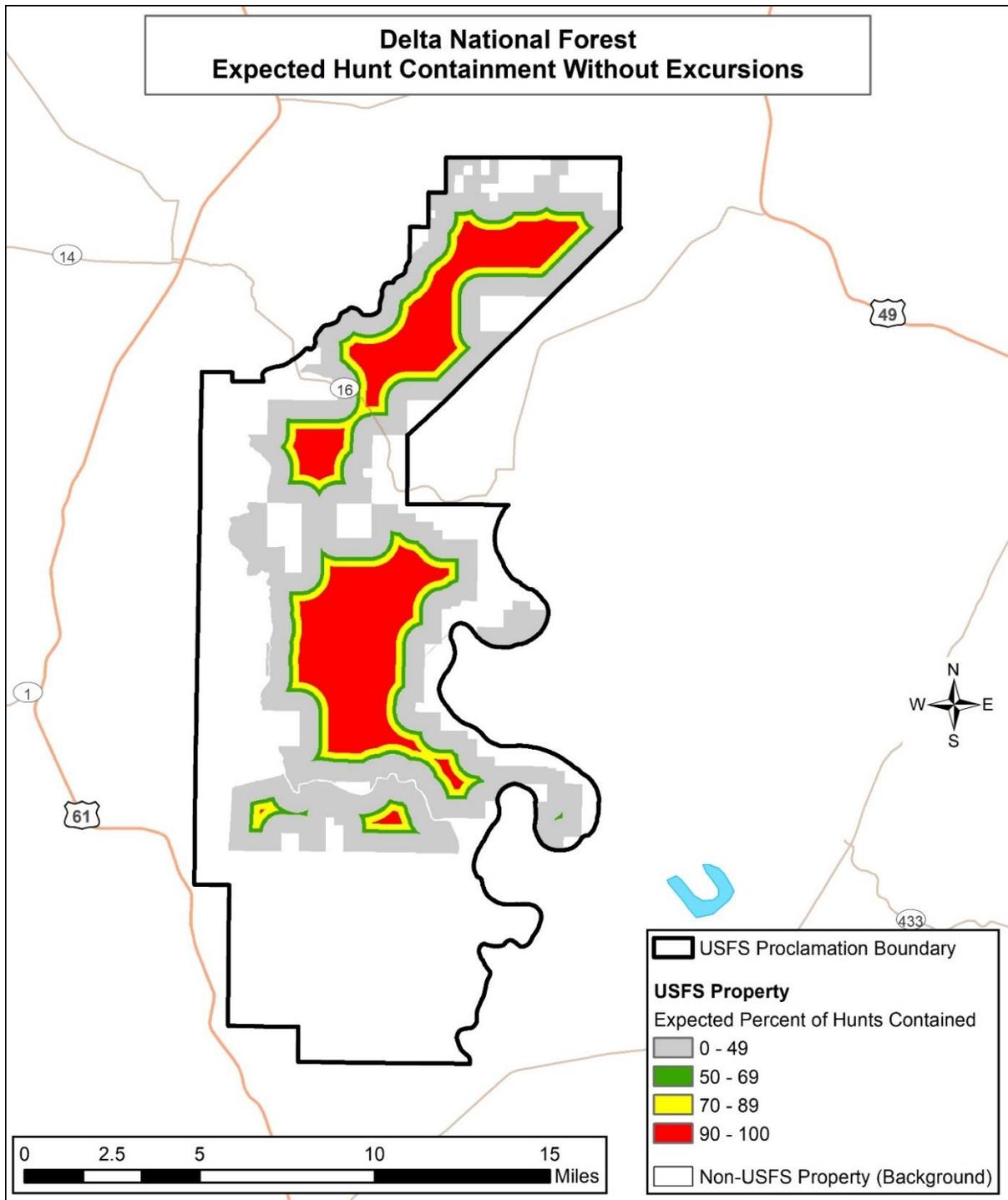


Figure 15. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Delta National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

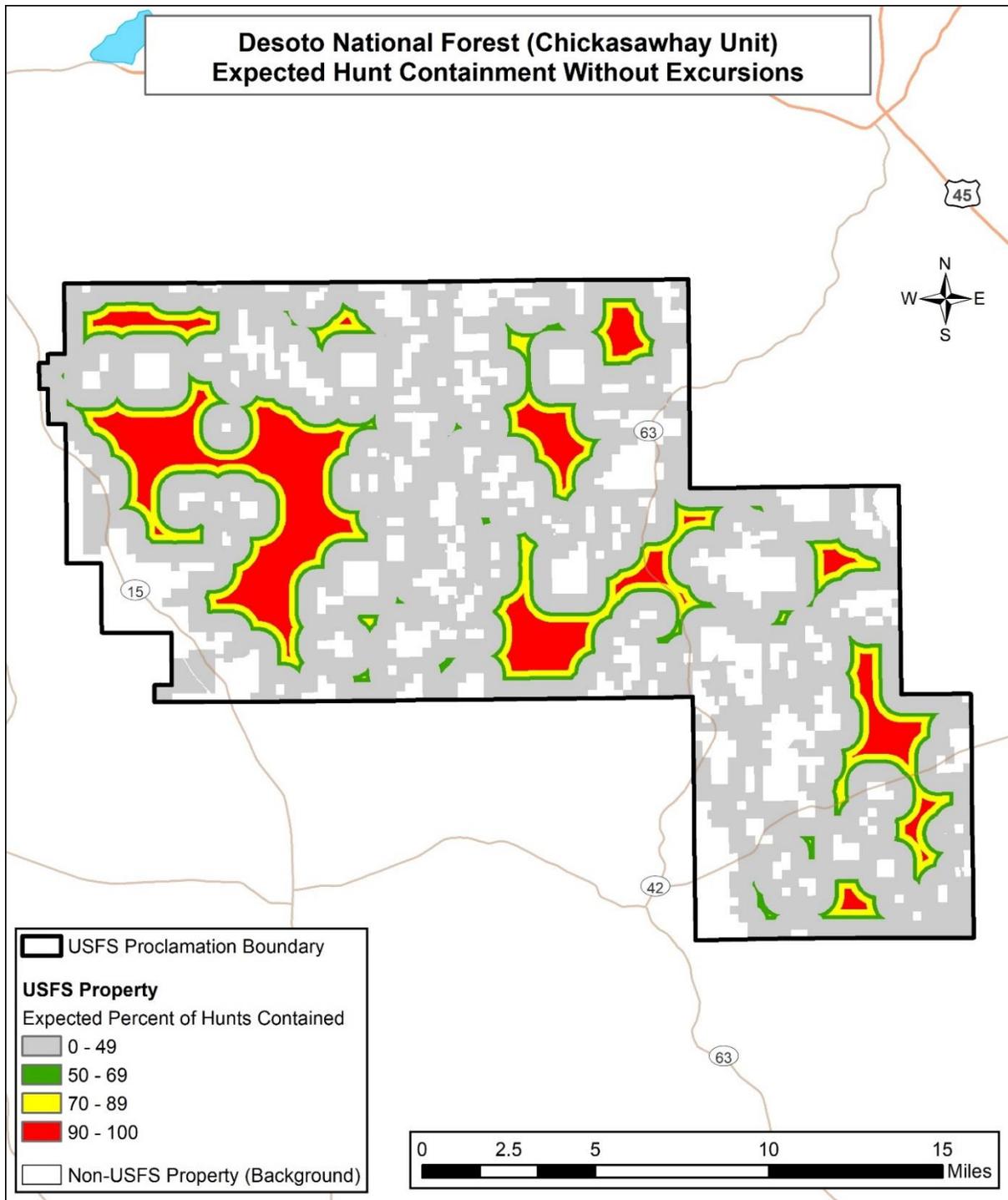


Figure 16. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on DeSoto National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

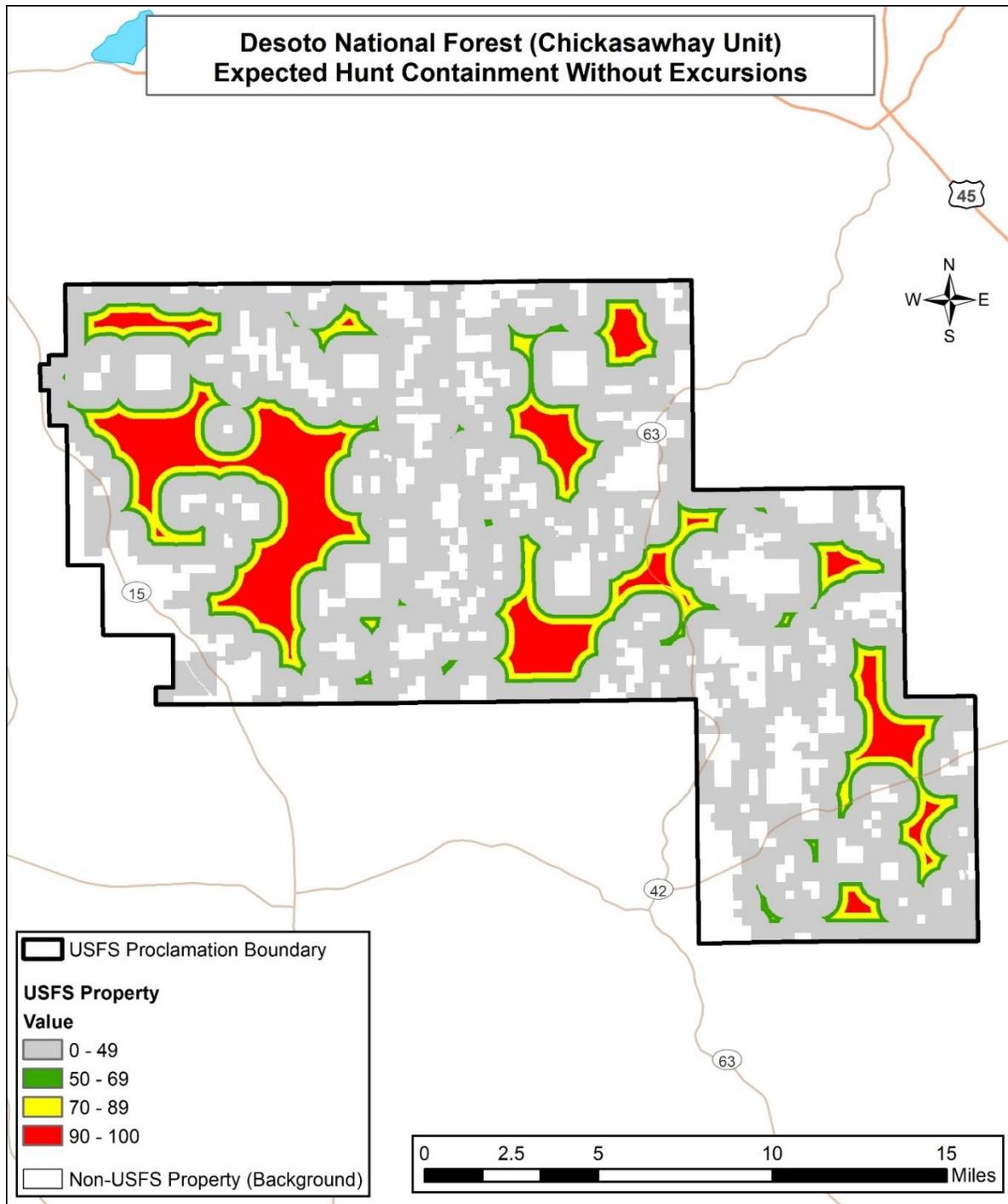


Figure 17. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on DeSoto National Forest (Chickasawhay Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

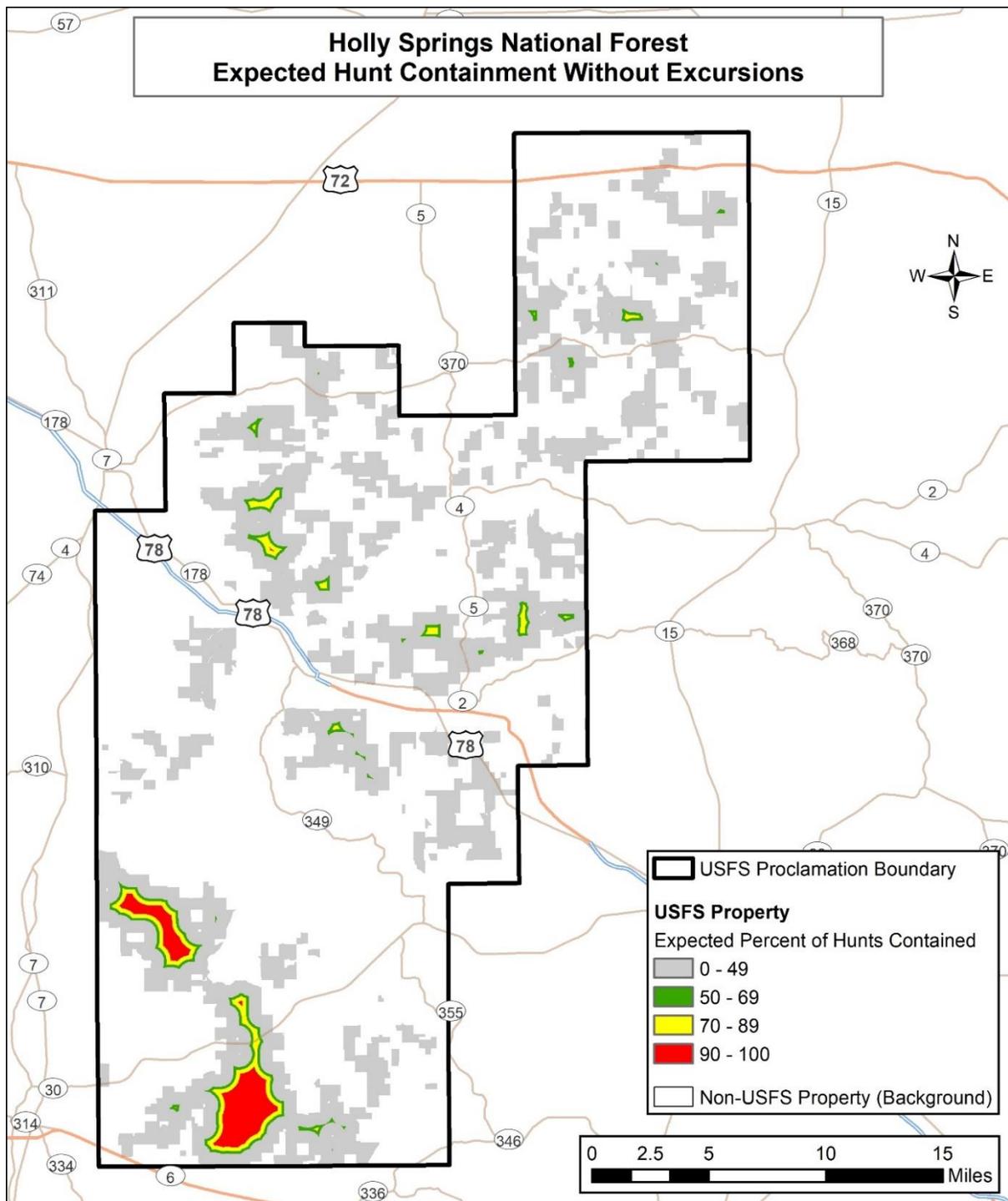


Figure 18. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Holly Springs National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

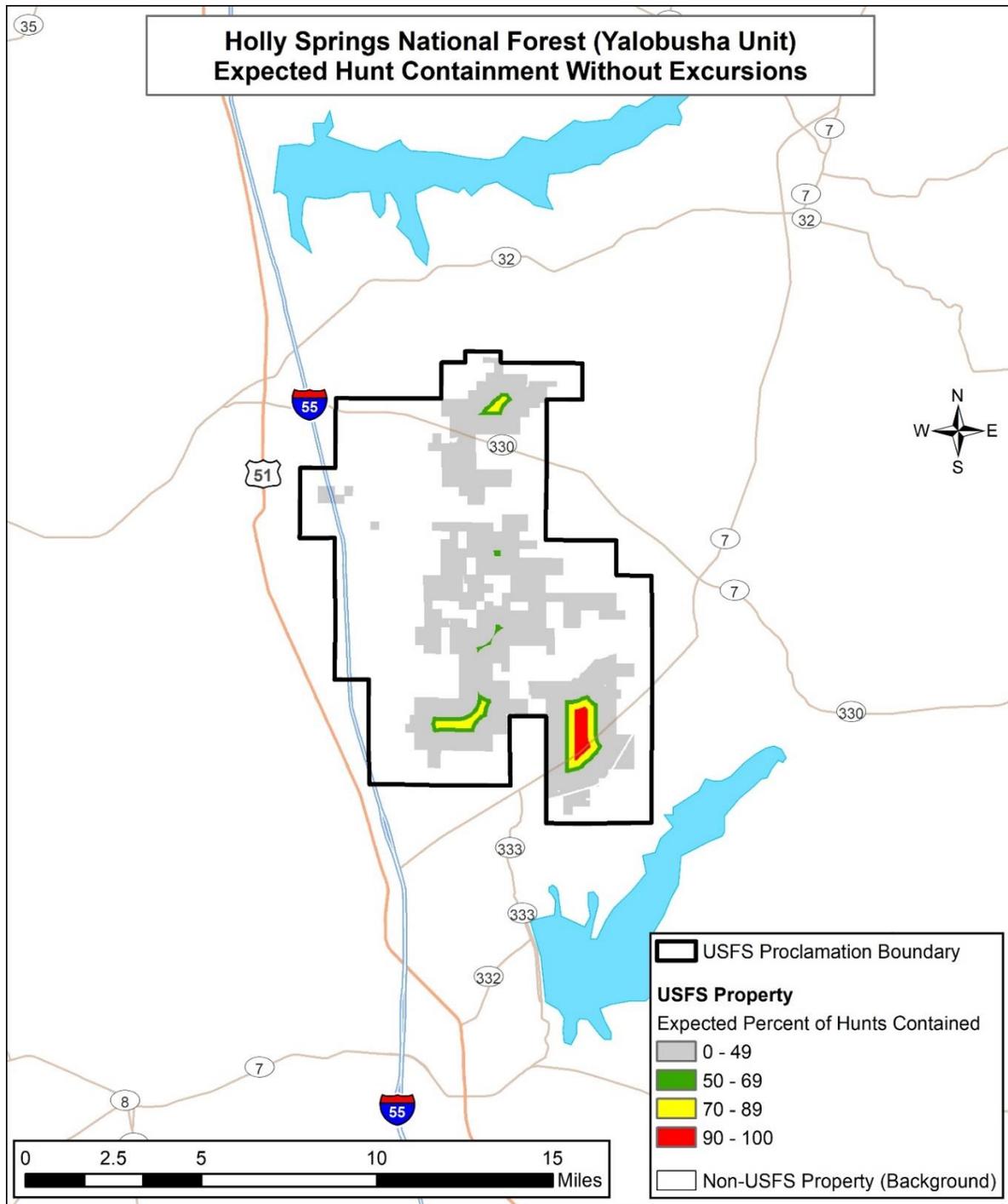


Figure 19. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Holly Springs National Forest (Yalobusha Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

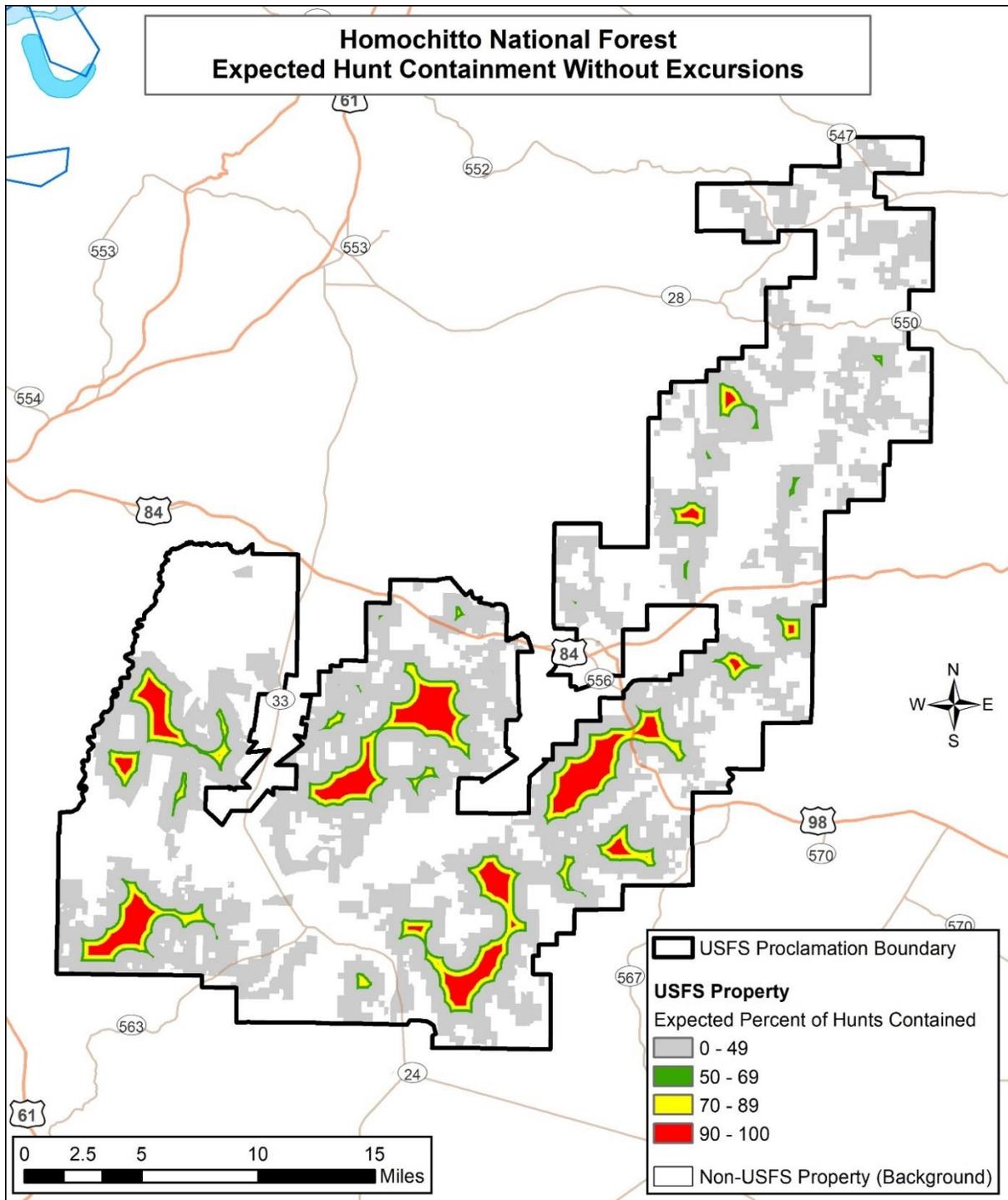


Figure 20. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Homochitto National Forest, Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

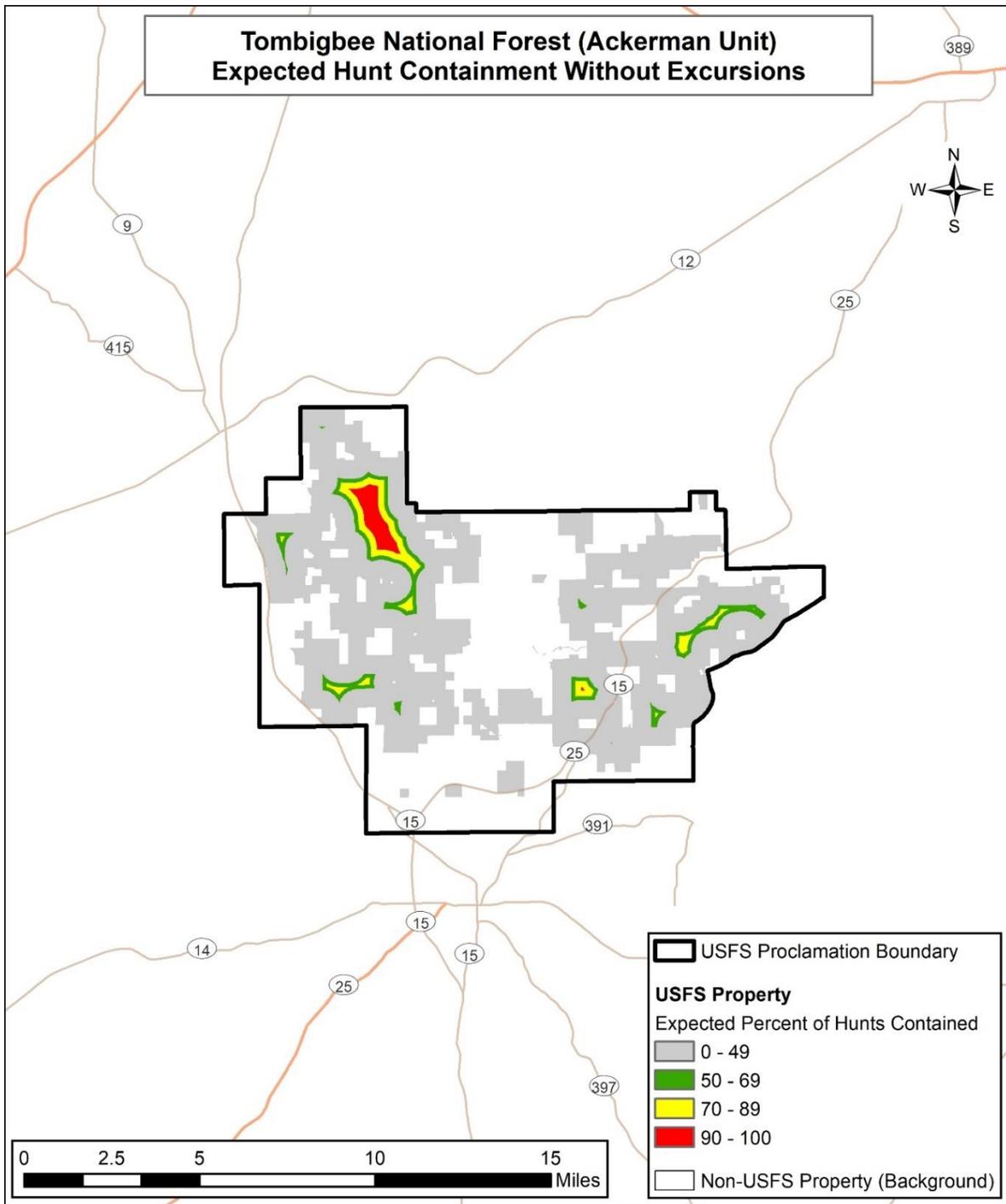


Figure 21. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Tombigbee National Forest (Ackerman Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

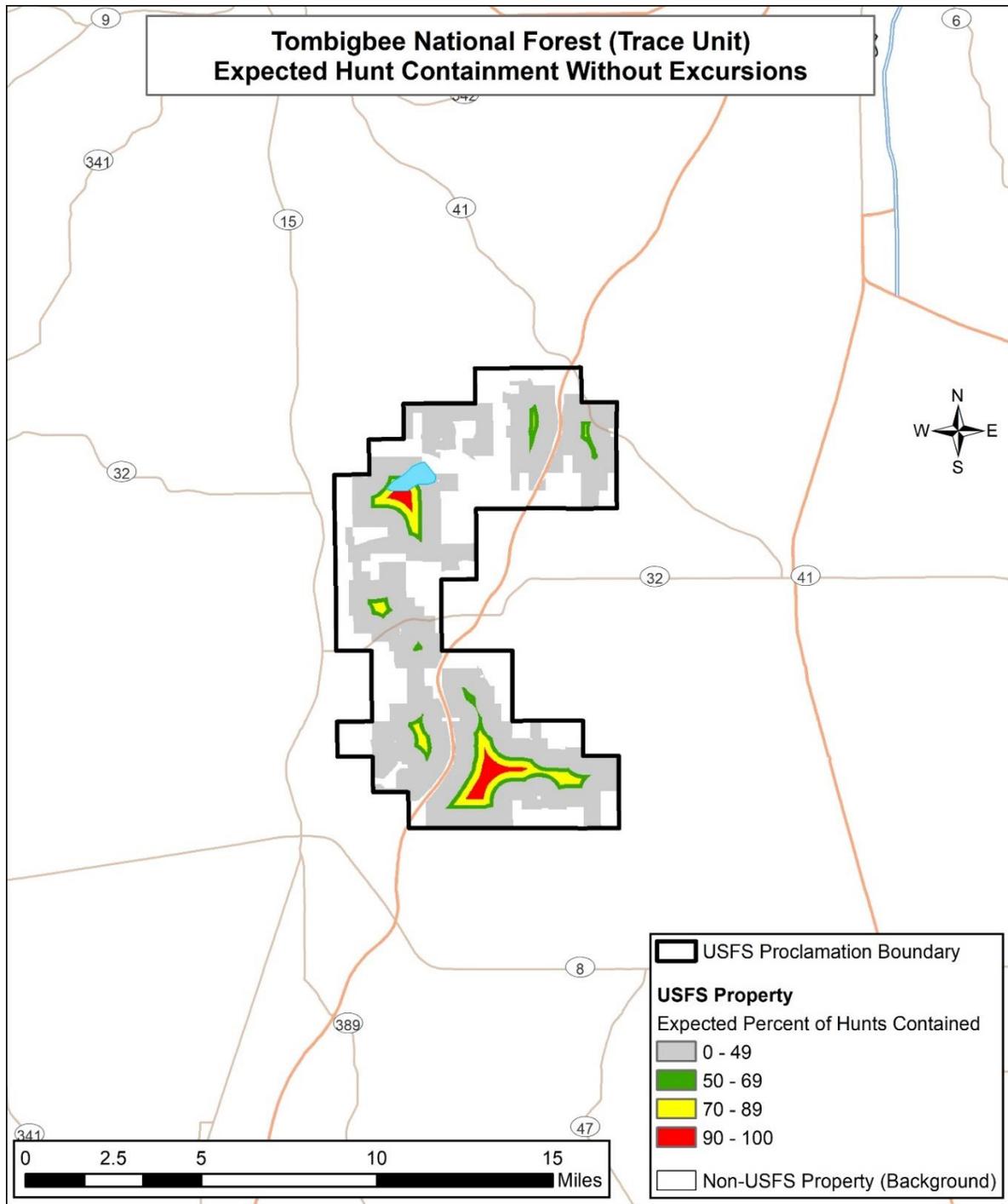


Figure 22. The expected levels of containment of dog-hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of US Forest Service property on Tombigbee National Forest (Trace Unit), Mississippi were calculated based on distance to nearest non-USFS property and the estimated 50th, 70th, and 90th percentiles of distances travelled by deer during dog-hunts excluding excursions by deer outside of their home ranges. Percentages indicate the expected percent of deer-dog hunts at the mapped location that would be completely contained on USFS property.

Task 3: Assessment of the Efficacy of Devices to Allow Remote Tracking and Behavior Correction of Dogs used for Deer Hunting

Gino J. D'Angelo, Ph.D., Assistant Professor of Deer Ecology and Management
Daniel B. Warnell School of Forestry and Natural Resources
University of Georgia

Introduction

Our review of the primary literature indicated that the home ranges of deer can vary widely in size and shape. Deer that are pressured by hunting activities can be motivated to make sudden long-distance movements. The primary challenge to contain deer-dog hunting activities is that scent hounds trail deer throughout intricate and extensive deer movements without regard to property boundaries. Devices that allow hunters to remotely track their dogs and provide behavior correction to dogs (herein, correction collars) are widely available commercially and are already utilized by many deer-dog hunters. Correction collars have two primary functions which may be used in tandem: 1) provide stimuli (e.g., electric shock, vibration, audible tone) to dogs to act as positive punishment to reinforce training and stop undesirable behavior, and 2) to track the location of dogs via Global Positioning System (GPS) satellites. Correction collars are designed to train and reinforce dogs to avoid tracking non-target animals, remotely deliver commands; and track the location of dogs relative to the hunters' desired hunting area, areas open and closed to hunting, and property boundaries. Use of correction collars should be beneficial to hunters because they can monitor their dogs with less effort, improve efficacy of hunting by minimizing undesirable or unproductive behaviors of dogs, and avoid trespass of dogs or conflicts with other hunters.

Methods

To assess the efficacy of correction collars for dog-hunting for deer, we conducted telephone interviews of conservation agency personnel where dog-hunting for deer occurs. As previously mentioned in our literature review, deer hunting with dogs is permitted currently in Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Virginia. We reviewed hunting regulations published for the 2018-2019 hunting season for

each state where dog-hunting for deer occurred to identify where use of correction collars was required. Florida was the only state with regulations specifically mentioning correction collars. Therefore, our interviews concentrated on personnel from Florida including: 1) Mr. Billy Sermons, Regional Wildlife Biologist, Florida Fish and Wildlife Conservation Commission, 2) Mr. Steve Shea, Shea Wildlife & Environmental Services, Inc. and former employee of Florida Fish and Wildlife Conservation Commission, 3) Mr. Justin Davis, Public Hunting Areas Biologist, Florida Fish and Wildlife Conservation Commission, 4) Mr. Justin Johnson, Chief of Eglin Air Force Base Wildlife Division, and 5) Mr. Christopher Johansen, Outdoor Recreation Program Manager for Eglin Air Force Base Natural Resources Section. We refer to these individuals as “managers” throughout our summary. We also interviewed a representative of a natural resources non-governmental organization in Florida who wished to remain anonymous. We provide the perspectives of this individual separately at the end of our results section.

We inquired with managers about development and implementation of regulations for requiring use of correction collars including: 1) communication with hunters, 2) effectiveness, 3) adoption and utilization by hunters, 4) enforcement, 5) other recommendations to minimize conflicts. We provide a summary of our findings and an assessment of the expected efficacy of requiring the use of corrective collars for dog-hunting for deer. Generally, we do not attribute specific information to individuals we interviewed, but rather concentrate on the broader themes elucidated among interviewees.

Findings

Communication.—Implementation of any new regulations requires advance notice, copious information, and regular communication leading up to implementation. Education must be continued for multiple hunting seasons through informational notices and positive interactions

among officials, hunters, and non-hunters in the field. Managers stressed that hunters should be afforded notice that correction collars would be required at least two hunting seasons prior to implementation. Beginning communication with organized dog-hunting groups and soliciting their input early and consistently in the process is important. Managers should provide hunters with information about the benefits of correction collars such as continuance of dog-hunting on more areas by minimizing conflicts with adjacent landowners (e.g., in-holdings on Blackwater Wildlife Management Area) or sensitive areas (e.g., proximity to live-fire ranges on Elgin Air Force Base). If applicable, hunters should be made aware that allowance of dog-hunting may occur on test areas first. With successful implementation (i.e., few violations or conflicts), the practice may be expanded to other areas where feasible. Engaging other recreational user groups (e.g., still hunters, bird dog hunters, bird watchers, ATV users) can improve communication with managers and among users to provide facts, develop mechanisms for airing complaints, and to build trust.

Enforcement.—Communication is paramount for successful regulation of dog-hunting and use of correction collars. However, enforcement of regulations is necessary to minimize illegal activities by hunters and to ensure that hunters understand and follow regulations appropriately. In our interviews, several managers used the terms “saturate”, “flood”, and “increased contact” to describe the level of law enforcement presence required to ensure that dog-hunters are educated in the early stages of requiring use of correction collars. The regular presence of law enforcement officers during dog-hunts appeared to decrease the number of complaints from non-hunters. One manager noted that the knowledge by non-hunting complainants that dog-hunters had GPS track logs to document the movements of dogs reduced exaggeration of trespass issues.

Managers recommended that enforcement officers take an especially “soft approach” during the first year of implementation to reinforce communication, reserving citations for blatant disregard for regulations. One common violation noted by managers was intentional casting-turning dogs out into areas closed to dog-hunting while hunters wait in adjacent areas open to dog-hunting. GPS technology puts the onus on the hunter who has less standing to plead ignorance of closed areas.

Establishing clearly defined dog-hunting areas with “hard” boundaries such as roads, waterways, and fences helps to minimize confusion and thus trespass and conflicts. Sensitive areas and private in-holdings should be closed to vehicle access and buffered sufficiently (e.g., at least several hundred yards) to facilitate correction of dogs and to minimize casting. Long, linear areas with minimal width are not conducive to containing dog-hunting. Although correction collars reduce trespass issues, buffers should also be sufficient to reduce associated noises (e.g., barking, shooting, vehicle traffic) near private properties. In response to growing complaints of deer-dog trespass, in 1997 the Florida Fish and Wildlife Conservation Commission passed the Hunter Responsibility Rule. The rule requires hunters to possess written permission from a private landowner or lessee in order for the hunter’s dog to be on that person’s property and dogs must bear collars with the owner’s name. Violation of the Hunter Responsibility Rule is a misdemeanor and punishable by up to a \$500 fine and 60 days in jail. Managers felt that the rule reduced trespass.

Dog-hunting boundaries that are common features (e.g., roads, rivers) may appear on GPS mapping software provided with the devices. However, managers may also make GPS layers available to hunters for upload onto their GPS units. Regulations could specify that hunters must possess equipment with boundaries uploaded to their GPS units.

Roads allow hunters to effectively maneuver in their vehicles and maintain contact with their dogs' correction collars. It is recommended that hunters not be permitted to shoot from vehicles, but shooting from roads within interior dog-hunting areas was considered acceptable by managers where safe. Shooting from boundary roads should be prohibited. Through evaluation of records about hunting accidents in other areas, Elgin Air Force Base determined that use of rifles in addition to shotguns for dog-hunting would be safe and phased-in their use. No accidents involving rifles have occurred on Elgin.

Other means of improving compliance and minimizing conflicts included limiting numbers of hunters on dog-hunting areas, implementing season quotas for deer harvest by hunters and/or parties in dog-hunting areas, requiring special dog-hunting permits with fees, increasing penalties for non-compliance including forfeiture of equipment and privileges, and increasing buffers around closed areas. Managers believed that dog-hunters, and organized groups in particular, took ownership of preserving the sport and have actively policed their own ranks to reduce negative hunter behaviors.

Effectiveness and adoption by hunters.—All managers we interviewed believed that correction collars substantially improved the ability of hunters to control their dogs. Implementation of correction collars made hunting possible on more and smaller tracts of land. When provided with a correction, properly trained dogs ceased chases and returned to their handlers. Many dog-hunters have adopted correction collars voluntarily in the last decade to improve their hunting experiences. They “spend less time hunting dogs and more time hunting.” Hunters relayed to managers that they believed most dog-hunters want to follow regulations, avoid conflicts, and respect boundaries. Hunters felt that correction collars improved their ability to do so. Managers cited anecdotal evidence suggesting that some private timber

companies allowed dog-hunters to lease smaller acreages (e.g., 2,500 acres) for hunting because of the effectiveness of correction collars. Managers added that correction collars have enhanced the image of dog-hunters to the public because of greater compliance and fewer dogs left in the field following hunts.

Effectiveness of using correction collars improves over time as hunters become more experienced with the technology. Phasing in requirement of correction collars across years lessens the financial burden on hunters since most collar systems cost several hundred dollars per dog. Also, managers stressed that training of puppies with correction collars rather than older dogs is imperative (i.e., you can't teach an old dog new tricks). Delaying requirement of correction collars for two hunting seasons affords hunters with time to obtain the equipment and puppies, and time to train their dogs. Managers noted that correction collars work equally well on small breeds (e.g., beagles) and large breeds (e.g., walker coonhounds).

Interview with anonymous non-governmental organization representative.—The representative we interviewed had worked on legal and policy issues related to dog-hunting in Florida. They also described personal experiences with dog hunters which were negative, including trespass on their personal property and threats from dog hunters. They also described negative actions by dog-hunters experienced by their friends, neighbors, and possibly people they represented professionally. They identified as a deer hunter themselves but not as a dog-hunter.

In their opinion, no technology or regulations could prevent trespass by dog-hunters. We did attempt to clarify the differences between GPS-enabled correction collars and non-GPS telemetry collars. However, they did not acknowledge the distinction between the two. They advocated strongly for spatial separation of dog-hunting activities and private in-holdings on

public lands, adjacent properties, sensitive areas, and especially residences. Given these constraints, they believed that few public properties would be suitable for dog-hunting. In their opinion, government agencies which institute dog-hunting without sufficiently regulating and enforcing trespass issues are guilty of negligence and violate the Constitutional Rights of private landowners.

They relayed knowledge of dog-hunting occurring on large private parcels (e.g., leases of several thousand acres) where ample spatial separation was provided by buffers around the aforementioned features. They described hunters on such private leases as having stringent policing by members to avoid conflicts with adjacent landowners in order to reduce the risk of losing leasing privileges.

A primary contention of theirs was that maleficence by dog-hunters reflects poorly on all hunters. Mobility of dog-hunters in vehicles, the large size of dog-hunting parties, and use of radios and cell phones by hunters all precluded successful enforcement in their opinion. They cited challenges of declining hunter numbers in many states, dog-hunters as a minority, and the inability of non-hunters to discriminate among types of hunters.

Primary Conclusions

Managers believed that hunters readily adopted correction collars because the technology improves their hunting experiences and because hunters hoped it would expand opportunities to hunt public lands and help to preserve the sport. Dog-hunters were well organized and willing to engage agencies. A major hurdle to expansion of dog-hunting opportunities was social acceptance of dog-hunting by the non-hunting public and other hunters. Correction collars helped to ease common concerns associated with dog-hunting. However, no person interviewed believed that correction collars would eliminate trespass or conflicts.

We identified five primary conclusions from our evaluation of correction collars:

- 1) Hunters must be given advance notice that correction collars will be required—at least two hunting seasons prior is recommended. Advance notice eases the financial and logistical burdens on hunters and allows time for dog training.
- 2) Diverse stakeholders must be engaged early in the process of implementing dog-hunting or changes in regulations including requirement of correction collars. Key groups include dog-hunters, dog-hunting organizations, other hunters, other recreational user groups, adjacent landowners, and the public.
- 3) Communication and enforcement should be conducted in conjunction, be on-going, and must be implemented at a high level early in the process. Increased presence of law enforcement in the field improves communication with hunters and the public and thus minimizes illegal activities and conflicts.
- 4) Sufficient spatial separation of dog-hunting activities, including dogs, vehicles, and hunters, from in-holdings, adjacent properties, sensitive areas, and still-hunt areas is key to successfully implementing dog-hunting even when correction collars are required. Clear boundaries are necessary. Roads, watercourses, and fenced areas are ideal boundaries.
- 5) Managers believed that correction collars were effective in reducing trespass issues and conflicts with adjacent landowners.