

Best Management Practices and Current Status of Dog-Deer Hunting in the Southeastern United States

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Abstract: Hunting white-tailed deer (*Odocoileus virginianus*) with dogs (herein, dog-deer hunting) has been steeped in tradition and controversy. Today in the United States, dog-deer hunting for white-tailed deer only occurs in nine states of the Southeast. We reviewed hunting regulations and primary literature, interviewed state-agency biologists, and simulated deer movements on national forests to investigate the current status of dog-deer hunting and develop recommendations for best practices to manage methods associated with the tradition. We recommend: 1) developing plans for consistent communication among agencies and stakeholders, 2) allowing dog-deer hunting where the practice is accepted culturally, 3) developing and enforcing permit systems to ensure hunter accountability, and 4) encouraging or requiring tracking and correction collars on dogs to reduce trespass.

Key words: deer movements, regulations, simulations, *Odocoileus virginianus*

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Historical records confirm that dogs have been a part of the hunting tradition for white-tailed deer (*Odocoileus virginianus*) in the United States for at least 500 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). Hunting deer with dogs was a popular hunting method and form of recreation and social interaction in colonial America and the newly established states (Virginia Department of Game and Inland Fisheries 2008). However, by the mid-1700s, deer populations were declining in some areas because of unregulated hunting and habitat loss, hunting with dogs lost favor, and the practice was prohibited at least in northeastern states by the 1920s (Virginia Department of Game and Inland Fisheries 2008).

Today in the United States, dog-deer hunting for white-tailed deer is permitted only in the southeastern states of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Virginia. Where it is allowed, dog-deer hunting is highly regulated and limited in geographic extent (Bowers et al. 2007). Modern use of dogs for deer hunting has become increasingly controversial due to differing interests of dog-deer hunters and other hunting groups (Marchinton et al. 1970, Chitwood et al.

2011), private property rights and trespass (Campo and Spencer 1991), and animal rights concerns (Muth and Jamison 2000).

Our objective was to elucidate best practices for managing dog-deer hunting to minimize conflicts among stakeholders. First, we examined the evolution and current status of dog-deer hunting regulations in states where dog-deer hunting currently is allowed. Second, we reviewed primary literature to highlight current knowledge of deer movements in response to hunting with dogs. Third, we utilized published estimates of deer movements to conduct a spatial analysis that identified areas on national forest lands in Mississippi where dog-deer hunting is expected to have minimal conflicts.

Methods

Regulations

We summarized the current status, salient regulatory changes since 1980 and key management strategies related to the management of dog-deer hunting by state wildlife agencies. For each state where dog-deer hunting currently occurs ($n=9$) and Texas (the most recent state to ban dog-deer hunting—in 1990), we interviewed the state-wide deer biologist(s) by phone or email and asked them to provide answers to a 13-question survey. Survey

questions were based on our perception of information needed to better understand each state's historical account as related to dog-deer hunting: including past and current legislation, recognized conflicts among deer-hunting groups and landowners, and efficacy of regulatory efforts to minimize those conflicts. Interviewees often suggested we also contact other natural resource professionals with specific knowledge about the subject in their respective states. In addition, we asked representatives from each state's wildlife management agency to supply us with copies of their annual hunting regulation publications from 1980–2019 and other documents (e.g., wildlife law enforcement code, deer dog-deer hunting permits, etc.) that would add to our understanding of dog-deer hunting in their state.

Deer Movements

We examined peer-refereed publications located using keyword searches in Google Scholar to extract metrics of deer movements and home ranges from studies of white-tailed deer in the eastern United States. Study-defined monitoring periods (e.g., fall, pre-rut, hunt, 24-h diel, etc.) differed among studies. We included movement metrics for monitoring periods which occurred during the fall, winter, and hunting seasons. We used published values from our literature review to define ranges of metrics for: 1) deer home ranges in the eastern United States, 2) changes in deer home ranges relative to hunting by humans, and 3) changes in deer movements in response to hunting with dogs.

Spatial Analysis

To estimate where dog-deer hunting is likely to have minimal conflicts with surrounding private landowners, we sought to: 1) calculate the expected buffer distances required to contain 50%, 70%, and 90% of dog-deer hunts, and 2) map portions of national forests in Mississippi, expected to satisfy these levels of containment. We estimated the required buffer distances from a probability distribution of expected distances travelled by deer during dog hunts in a simulated population, relying on our literature review to make the following assumptions: 1) home range size will follow a normal distribution with mean and SD values for each sex (females = 152 ha, SD = 117; males = 365 ha, SD = 222) but truncated to exclude values <2 ha, 2) the probability of a deer exiting its home range will follow a Bernoulli distribution with probability = 0.80, 3) home range exit distances will follow a normal distribution (mean = 1.2 km, SD = 0.44) but truncated to values greater than zero, 4) the male/female sex ratio will be 0.5 and will follow a categorical distribution (since no estimates of sex ratios for deer populations on national forests in Mississippi were available and the likelihood of dogs encountering male or female

deer was considered equal), 5) all home ranges will be circular. Based on these assumed distributions, we then calculated the resulting joint distribution of expected hunt distances from 500,000 random samples where each sample was drawn as follows: sample sex, sample home range size for given sex, sample home range exit, sample home range exit distance (if exit exists), calculated distance traveled (radius of home range + home range exit distance). All random sampling was performed using R version 3.5.3 (R Core Team 2013). The 50th, 70th, and 90th percentiles of the resulting joint distribution were assumed to represent the buffer distances required to contain 50%, 70%, and 90% of dog-deer hunts.

To illustrate areas where dog-deer hunts would likely be contained on properties with varying areas, boundary configurations, and in-holdings, we mapped (ArcMap Version 10.6.1, Environmental Systems Research Institute 2018) the 50%, 70%, and 90% containment thresholds on nine national forest properties managed by U.S. Forest Service (USFS) in Mississippi. For each national forest we generated 30-m resolution Euclidian distance raster based on the distance to the nearest non-USFS parcel. Thus, for every location (30-m pixel) on national forest 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 was centered on the location. We conducted two additional analyses for demonstration purposes using the same mapping procedures with two changes simulated separately: 1) ignoring in-holdings and only considering USFS proclamation boundaries to contain dog-deer hunts, and 2) removal of deer excursions outside of their home ranges.

Results

Regulations

Our interviews and review of available documents revealed many differences regarding how states regulate deer hunting with dogs (Table 1). Only Mississippi allowed the use of deer dogs on all private lands without accountability for hunter location. Florida allowed deer dogs on all private lands following a hunter-registration process. Most states (7 of 10) restricted deer dogs to private lands within specific deer management zones, areas, or counties designated based on several criteria including tradition and public acceptance, typical parcel size, deer population density, and habitat characteristics. In addition, Alabama and Georgia required a special permit to hunt with deer dogs on private lands and required hunters or groups of hunters to own or lease a minimum acreage before qualifying for a permit. Six states used season structure and timing as methods of minimizing conflicts between dog-deer hunters and still hunters (i.e., defined as stalking or sitting in a deer stand without use of a dog) on private lands. For ex-

Table 1. State-specific regulations regarding deer hunting with dogs in the southeastern United States in effect during the 2018–2019 white-tailed deer (*Odocoileus virginianus*) hunting season.

Regulations	AL	AR	FL	GA	LA	MS	NC	SC	VA
Deer dogs on all private lands						X			
Deer dogs on private lands by permit or registration only	X		X	X					
Deer dogs on private lands in specific parts of state	X	X		X	X		X	X	X
Deer dogs prohibited on some or all public lands	X	X	X	X	X	X	X	X	X
Deer dogs on at least some national forests	X	X	X			X	X	X	
Deer dogs on some public lands by permit only			X			X			
Special still-hunting only areas within dog-deer hunting areas					X				
Minimum acreage required on private or public lands	X		X	X					
Deer dogs during all of gun deer season in some areas			X	X	X		X	X	X
Deer dogs during part of gun deer season in some areas	X	X		X		X			
Deer dog-training allowed only during deer seasons	X			X	X			X	
Deer dogs prohibited on Sunday							X		X
Prohibit hunting from public roads	X	X	X	X	X	X	X	X	X
Require registration of hunters or clubs using deer dogs	X		X	X					
Require permit and/or hunter information on dog or collar	X	X	X	X					
Require visible marking of vehicles used in hunting				X					
Require electronic collars on deer dogs in some areas			X			X			

Table 2. State-specific regulations regarding dog-deer hunting opportunities for white-tailed deer (*Odocoileus virginianus*) during the 2018–2019 hunting season in the southeastern United States.

State ^a	Dogs allowed	Dogs not allowed	Percent of management units where allowed	Season length (days, statewide range)
Alabama	24 counties (without permit) 17 counties (with permit)	26 counties	61	60
Arkansas	14 zones	10 zones	58	23–46
Florida	67 counties (with registration)	0 counties	100	14–81
Georgia	41 counties (with permit)	118 counties	26	37–86
Louisiana	9 deer areas	1 deer area	90	30–44
Mississippi	82 counties	0 counties	100	39
North Carolina	50 counties	55 counties	48	52–80
South Carolina	28 counties	18 counties	61	123–140
Virginia	56 counties	39 counties	59	50–61

a. Information was gleaned from the following respective state agency sources: Alabama Department of Conservation and Natural Resources (2018), Arkansas Game and Fish Commission (2018), Florida Fish and Wildlife Conservation Commission (2018), Georgia Department of Natural Resources (2018), Louisiana Department of Wildlife and Fisheries (2018), Mississippi Department of Wildlife, Fisheries and Parks (2018), North Carolina Wildlife Resources Commission (2018), South Carolina Department of Natural Resources (2018), Virginia Department of Game and Inland Fisheries (2018).

ample, Alabama, Arkansas, Georgia, and Mississippi allowed deer hunters to use dogs only during a portion of the gun deer season whereas North Carolina and Virginia prohibited the use of deer dogs on Sundays, allowing only still hunting on those days. Four states passed regulations to prohibit training of deer dogs on private lands outside of approved deer seasons.

All nine states where dog hunting for deer is legal prohibited use of dogs on at least some public lands (Louisiana prohibited dog hunting for deer on all public lands). Where allowed on public lands, parcel size, amount of road access, characteristics of adjacent land ownership, and public acceptance were primary considerations when setting regulations. Florida and Mississippi each had at least one public hunting area where deer hunters using dogs are required to first acquire a special permit. Six states allowed deer hunting with dogs on at least one of their national forests.

Our interviews revealed that dog trespass onto unauthorized properties was a common complaint that each state’s wildlife agency received from disgruntled landowners and hunters. Furthermore, hunter permitting and registration requirements, as implemented in Alabama, Florida, and Georgia, have made hunters more accountable for trespass and therefore have been beneficial, based on each interviewee’s perception of fewer public complaints. Alabama and Arkansas required each deer dog to wear a collar with its owner’s/hunter’s information. In Florida and Georgia, dogs must be marked with the hunter’s registration or permit numbers. According to the interviewees, being able to link deer dogs (and, in the case of Georgia, marked hunting vehicles) back to hunters has made it easier for law enforcement agents and landowners to recognize when deer dogs and hunters have trespassed onto unauthorized properties. On select public lands in Florida and Mississippi, the use of electronic tracking (i.e., location monitoring) and correction (i.e., behavior adjustment by sound, vibration and/or electric pulse stimulation) collars on deer dogs was required. Interviewees with knowledge of dog-deer hunting on those properties believed the electronic collars reduced dog trespass onto adjacent unauthorized properties by increasing hunter cognizance of the location of their dogs. Based on our discussions with interviewees, hunting from roadways has been a common public complaint regarding dog-deer hunting, and all states have passed legislation to reduce or prevent road-related conflicts.

Regulations related to areas open to deer hunting with dogs and season length affected hunting opportunity and also varied among states (Table 2). When considering percentage of the state’s management units (i.e., area, county, or zone) where deer dogs were allowed on private lands, Florida and Mississippi ranked highest with 100% and Georgia ranked lowest with 26%. The number of days during which hunters could pursue deer with dogs ranged

from 14 for parts of Florida to 140 for parts of South Carolina. Additional state-specific information gathered during our interviews and review of documents is also summarized.

Alabama.—We interviewed Michael Weathers, chief of enforcement, and Christopher Cook, deer program coordinator, both with the Alabama Division of Wildlife and Freshwater Fisheries. In addition, we extracted information from the 2017–18 and 2018–19 hunting regulations (Code of Alabama 220-2-.112) and Alabama dog-deer hunting permit plans. A dog-deer permit system was initiated in 1985 in two Alabama counties. Additional counties were added in subsequent years by county-wide referendum. Dog-deer hunting groups must lease or own ≥ 202.4 contiguous ha unless they were grandfathered into the permit system under earlier acreage requirements (i.e., ≥ 81 contiguous ha). It currently is unlawful to hunt with deer dogs on three of four national forests and all but three of >30 Wildlife Management Areas (WMAs). WMAs have a structured-season framework of hunting dates. According to interviewees, the permit system prevented the possibility that deer hunting with dogs would have been outlawed altogether because participating hunters were forced to become more accountable for their actions, resulting in greater compliance with property boundaries and fewer dog trespass-related complaints.

Arkansas.—We interviewed Ralph Meeker, deer program coordinator for Arkansas Game and Fish Commission, and extracted information from the 1980 through 2018–19 hunting regulations. From 1980 to 2018, the number of deer management zones, which allowed the use of deer dogs, decreased from 21 to 14. However, major zone restructuring also occurred during that period, which at least partially could have been reflected in this change. The number of days for dog-deer hunting increased over time to mirror changes in lengths of the general modern gun deer seasons. Deer dogs are prohibited on WMAs, a regulation which probably dates to the period of deer population reestablishment (1930s–1950s). Prohibition of dog-deer hunting on WMAs likely was borne of concern for deer abundance, small size of many WMAs, and potential dog-related conflicts with adjacent landowners and other user groups. The Ozark-St. Francis National Forests were closed to dog-deer hunting in 2002 when the properties were fully included in the state-managed WMA system, which precluded dog-deer hunting. The Ouachita National Forest currently is not under the WMA system and no special regulations govern use of deer dogs. Until 1985, there was a height restriction (≤ 38 -cm shoulder height) on deer dogs in zones with mountainous terrain; however, interviewees were uncertain about the reasons for such dog-height restrictions.

Florida.—We interviewed Becky Shuman, assistant deer management program coordinator, Florida Fish and Wildlife Conservation Commission, and reviewed documents including le-

gal statutes since 2005 as well as 2018–2019 hunting regulations. Since 2005, it has been lawful to hunt deer with dogs throughout Florida after completing a registration process. The registration system was a way to monitor dog-deer hunting participants and their locations. To date, no applicants have been denied permission to hunt with dogs on their listed properties. Any landowner, lessee, or person designated by the landowner were authorized to allow dog-deer hunting within property boundaries under their control. Consideration of dog-deer hunting on WMAs is based on the following criteria: 1) level of local and regional interest in dog-deer hunting versus other wildlife-oriented recreation, 2) local and regional availability of dog-deer hunting opportunities, 3) size of tract being evaluated (e.g., no tract $< 13,355$ ha will be considered for unrestricted dog-deer hunting), 4) shape of area being evaluated (e.g., no area averaging < 3.2 km wide), 5) adequacy of road system, 6) desired deer and turkey population levels, and 7) surrounding land uses. Blackwater WMA in the Florida Panhandle has a long history of dog-deer hunting and has experienced many regulatory changes since the mid-1960s. Two of the most innovative regulations were enacted on Blackwater WMA in 2014 (i.e., remote tracking collars required) and in 2016 (i.e., remote behavior correction collars required).

Georgia.—We interviewed Charlie Killmaster, state deer biologist for the Georgia Department of Natural Resources Wildlife Resources Division. In addition, we extracted information from the 2009 through 2018–19 hunting regulations. Counties allowing dog-deer hunting has declined over time (e.g., 1960 = 74, 1970 = 66, 1980 = 46, 1990 = 45, 2000 to 2019 = 41). Dog-deer hunting is allowed only in the southern half of the state because of large parcel size, historical dog-deer hunting, and current interest in dog-deer hunting by local hunters. During the 2002–2003 hunting season, conflicts escalated among landowners, still hunters, and dog hunters resulting in regulatory proposals to eliminate dog-deer hunting in four counties (Bowers et al. 2007). Similar proposals were anticipated from six additional counties. To prevent likely loss of 25% of acreage available statewide for dog-deer hunting, the Georgia Dog Hunters Association led an effort resulting in regulatory changes. In 2003, legislation passed which compelled owners of properties meeting minimum acreage requirements (i.e., 405 ha of leased land or 101 ha of private land) to apply for permits for dog-deer hunting and to post permit numbers on dogs and vehicles used during hunting. The ruling made revocation of permits possible for properties or individuals in violation. Since enacting the permit system, public complaints have declined. Dog-deer hunting is allowed on select WMAs where considered reasonable based on acreage and public support. No dog-deer hunting was allowed on federal lands in Georgia.

Louisiana.—We interviewed Jonathan Bordelon, deer program manager for Louisiana Department of Wildlife and Fisheries (LDWF). In addition, we extracted information from the 2018–19 hunting regulations. Dog-deer hunting is permitted statewide except in one deer management area with habitat not appropriate for allowing dog-deer hunting due to fair chase concerns (i.e., too much water) and low deer abundance. According to a 2017 survey conducted by LDWF, dog-deer hunting is not considered to be popular among deer hunters (4%–5% participation), with 58% of deer hunters having an unfavorable opinion about dog-deer hunting, and it is common for private landowners to prohibit dog-deer hunting on their properties. In each deer management area that allows deer dogs, only still-hunting is allowed during segments of the firearms season or in certain locations because of public requests and political pressures to prohibit deer dogs. Dog-deer hunting is illegal on all >50 WMAs. Until 2013, dog-deer hunting was legal on Kisatchie National Forest (244,430 ha). The prohibition of deer dogs on Kisatchie was proposed by USFS in 2009 based on public safety concerns, hunter-landowner conflicts, and trespass. Louisiana Sportsmen Alliance unsuccessfully sued the USFS in 2012 and 2016 in attempts to prevent and overturn deer dog bans.

Mississippi.—We interviewed William McKinley, deer program coordinator, Mississippi Department of Wildlife, Fisheries, and Parks and a recommended interviewee Mr. Bill Meriwether, District wildlife and fisheries specialist, Homochitto National Forest, USFS. In addition, we extracted information from the 2018–2019 hunting regulations and from the guidelines for hunting with dogs on Homochitto National Forest. Currently, it is legal to dog-deer hunt throughout Mississippi including all federal lands and some WMAs depending on annual regulations. Only hunters on the Homochitto National Forest are required to possess a dog-deer hunting permit. On open public lands, it is only legal to kill bucks when dog-deer hunting. However, deer of either sex may be killed on privately owned lands when dog-deer hunting.

North Carolina.—We interviewed Jonathan Shaw, deer biologist for North Carolina Wildlife Resources Commission (NCWRC). In addition, we extracted information from the 2009–10 through 2018–19 hunting regulations and legislative rules and code during 1975–2018. In 1979, the legislature defined where dog-deer hunting could occur. NCWRC could not restrict or prohibit use of dogs, in season or out, except during 15 April–15 June, in the area of the state east of the newly designated dog-deer hunting line. West of the dog-deer hunting line and on Game Lands (public and private lands managed by NCWRC), wildlife refuges, and public-hunting grounds, NCWRC was given authority to regulate use of dogs for taking wildlife with respect to seasons, times, and places of use. Currently, it is legal to dog-deer hunt east of the dog-deer hunting

line during gun deer seasons. There are no acreage requirements for dog-deer hunting on private lands east of the dog-deer hunting line. However, it is illegal to dog-deer hunt on Sundays in any case. In general, counties east of the dog-deer hunting line have larger parcel sizes and higher deer abundance than counties to the east. On Game Lands, the decision to allow or prohibit dog-deer hunting is made case-by-case based on parcel size, landowner requests, and surrounding land uses. Of four national forests in North Carolina, only Croatan National Forest has a dog-deer hunting season.

Shaw believed the number of deer hunters using dogs, where it is allowed, has declined over time; in any case, hunter surveys conducted by NCWRC in 2006 and 2019 reported a decline in hunters in those counties that strongly agreed with the practice (33% to 22%) and an increase in those that strongly disagreed with dog-deer hunting (24% to 37%; Palmer 2009, Shaw et al. 2017). Results of a North Carolina hunter survey reported by Cook et al. (2015) indicated 46% of interviewees believed dog-deer hunting should be illegal and 36% were supportive of dog-deer hunting.

South Carolina.—We interviewed Charles Ruth, big game program coordinator, South Carolina Department of Natural Resources (SCDNR). In addition, we extracted information from the 2018–2019 hunting regulations. Few regulatory changes related to dog-deer hunting have occurred during recent years with several exceptions regarding activities on public roads. Although the topic of dog-deer hunting arises in the state legislature about every 8–10 years, primarily because of trespass issues, no action has been taken. SCDNR was directed by the legislature to participate in two dog-deer hunting stakeholder working groups in the past 10 years to resolve conflicts among dog hunters, still hunters, and landowners. However, the process concluded with a lack of consensus and no subsequent regulatory changes were proposed. Currently, dog-deer hunting is legal on private lands in coastal counties and illegal in Piedmont/mountain counties and on WMAs except for the Francis Marion National Forest and Manchester State Forest.

Virginia.—We interviewed Matt Knox, deer project co-leader, Virginia Department of Game and Inland Fisheries (VDGIF). In addition, we extracted information from the 2018–2019 Virginia hunting regulations. During 2017, in the 56 counties and three city jurisdictions where dog-deer hunting was lawful, 54% of the 70,746 deer harvested by hunters were killed with the aid of dogs. Since the late 1700s, dog-deer hunting has been illegal west of the Blue Ridge Mountains (i.e., dog-deer hunting line) and Virginia Code continues to prohibit dog-deer hunting in all counties west of the Blue Ridge (about 1/3 of the state). East of the dog-deer hunting line, deer can be hunted with dogs during firearms seasons. Trespass onto private lands has been and continues to be controversial in eastern Virginia. Virginia Code provides hunters of all

Table 3. Movements of white-tailed deer (*Odocoileus virginianus*) relative to hunting by humans without dogs in the United States.

State	Sex (age class)	Deer (n)	Mean pre-hunt home range (ha)	Mean hunt home range (ha)	Change in home range size from pre- to hunt	Study
Connecticut	Females (adult)	5	40	47	None	Kilpatrick and Lima (1999)
Florida	Males (adult)	15	390	420	None	Sargent and Labisky (1995)
Florida	Females (adult)	14	22 ^a	26 ^a	None	Kilgo et al. (1998)
Maryland	Males (adult)	19	306	261	None	Karns et al. (2012)
Missouri	Males(adult, yearling)	6	727	714	None	Root et al. (1988)
Missouri	Females(adult, yearling)	16	193	300	Increased 1.6 times	Root et al. (1988)
Nebraska	Female (adult, juveniles)	15	133	142	None, home range centers shifted	VerCauteren and Hygnstrom (1998)
Oklahoma	Males (adult)	30	–	–	Space use declined	Little et al. (2016); Marantz et al. (2016)

a. Diel (24-h) home range.

game the right to retrieve their dogs on unauthorized lands if the hunter willfully identifies themselves to the landowner. Virginia Code prohibits dog-deer hunting on Sundays. Dog-deer hunting is restricted during certain dates east of the dog-deer hunting line, including the first 14 days of firearms deer season in two counties. Dog-deer hunting is prohibited on all or parts of 12 WMAs east of the dog-deer hunting line. Dog-deer hunting is not permitted on federal lands, although the state has many federal properties. The goal of VDGIF is “to preserve the heritage and tradition of hunting deer with dogs, for both management and recreational benefits, while ensuring that hunting methods are consistent with and respect the rights of private property owners and other citizens” (Virginia Department of Game and Inland Fisheries 2015). Strategies proposed to address this goal include: 1) identify conflicts; 2) develop and implement education, regulations, guidelines, and recognition to reduce conflicts; 3) discourage illegal activities; and 4) establish dialogue between deer hunters and landowners.

Deer Movements

We extracted information about home ranges of adult male and adult female deer for our simulations from 20 studies in nine eastern states including Alabama (Marchinton and Jeter 1967, Ivey and Causey 1981), Arkansas (Humphreys and Nelson 2000), Florida (Marchinton and Jeter 1967, Sargent and Labisky 1995, Kilgo et al. 1998, Labisky and Fritzen 1998), Louisiana (Thayer et al. 2009, Harrelson 2011, Hasapes and Comer 2016), Maryland (Tomberlin 2007, Rhoads et al. 2010, Karns et al. 2012), Mississippi (Mott et al. 1985, Vanderhoof and Jacobson 1993), Missouri (Root et al. 1988), South Carolina (Henderson et al. 2000, D'Angelo et al. 2003, D'Angelo et al. 2004), and Virginia (Holzenbein and Schwede 1989). Most studies concentrated on adult female deer. Deer exhibited

plasticity in their movement behaviors. The size of home ranges varied depending on the study, location, and sex. Annual home ranges of adult females were similar to home ranges for study-defined monitoring periods (e.g., pre-hunt, rut) during fall and winter ($F=0.015$, $P=0.904$). Therefore, to include home ranges representing a greater number of studies across the region in our simulations, we pooled estimates of annual and monitoring-period home ranges. The 95% confidence interval for home ranges of adult females was 107–173 ha. Mott et al. (1985) reported a mean fall home range for four 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.

Monitoring-period home ranges of adult males were on average nearly three times the area of adult females (mean = 365 ha, SE = 55). Annual home ranges of adult males did not differ from monitoring-period home ranges ($F=0.194$, $P=0.664$); therefore, we pooled estimates of annual and monitoring-period home ranges. The 95% confidence interval for home ranges of adult males was 288–470 ha.

It is well-established that deer alter their movements in response to hunting (Root et al. 1988, Kilpatrick and Lima 1999, Karns et al. 2012, Little et al. 2016). Deer maintain strong fidelity to their home ranges under hunting pressure (VerCauteren and Hygnstrom 1998, D'Angelo et al. 2003, Simoneaux et al. 2016). Except for one study (Root et al. 1988), the area used by deer during hunts did not differ from pre-hunt home ranges in all the studies we reviewed where hunting by humans without dogs was the source of disturbance (Table 3). Among studies we reviewed of dog-deer hunting, $\geq 54\%$ of deer left their home ranges (Table 4). Distance deer traveled outside of their home range boundaries varied and was difficult to discern from several studies. Of data available, distance

Table 4. Movements of white-tailed deer (*Odocoileus virginianus*) relative to hunting with dogs in the southeastern United States.

State	Sex (age class)	Deer (n)	Deer left home range (%)	Mean chase distance (km)	Mean distance beyond home range (km)	Maximum distance beyond home range (km)	Study
Alabama, Florida, South Carolina	Females and males (adults)	6	78	3.9	<1.6	21.6 ^b	Sweeney et al. (1971)
Arkansas (Ozark Mountains)	Females and males (adults)	7	100	3.1	1.1	5.0	Gipson and Sealander (1977)
Arkansas (Coastal Plain)	Females and males (adults)	6	100	2.6	0.5	2.6	Gipson and Sealander (1977)
North Carolina	Females and males (adults)	7	70	3.9	>1.6	10.9	Corbett et al. (1971)
South Carolina	Females (adult)	13	54	–	0.8	2.3	D'Angelo et al. (2003)
Texas	Not specified	43	–	–	1.6 ^a	7.4	Campo et al. (1987)

a. Total chase distance
 b. 90% of chases within 1.6 km

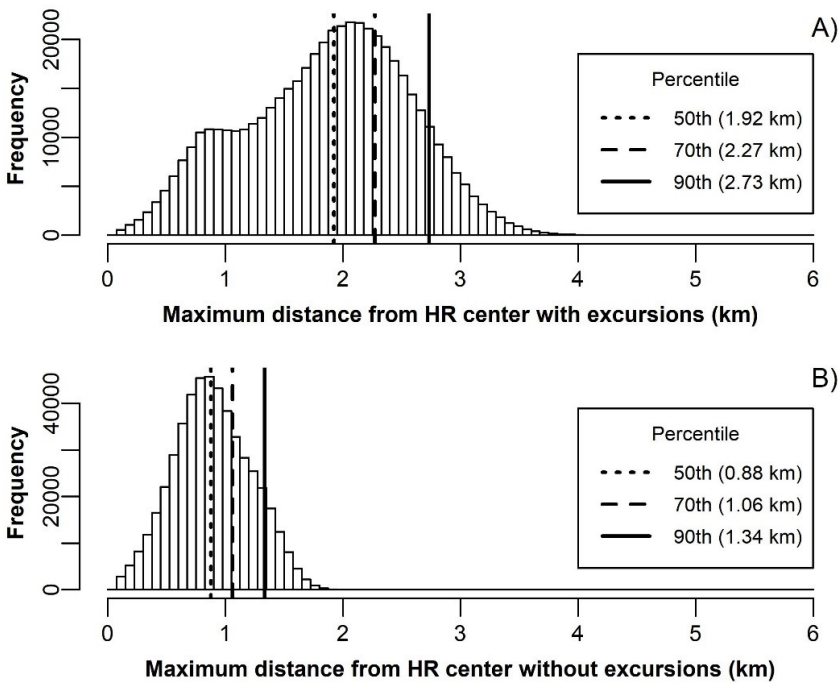


Figure 1. Expected distribution of maximum distances travelled by white-tailed deer (*Odocoileus virginianus*) from home range (HR) center during dog-deer hunts on national forests in Mississippi with: A) excursions by deer and B) assuming no excursions by deer. Distributions resulted from 500,000 random 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.

deer traveled outside of their home ranges averaged approximately 1.2 km (SE = 0.1). Although deer made longer distance movements when exposed to dog-deer hunting (maximum = 21.6 km) most dog-deer hunts were contained within a 4-km radius including the area of a focal deer’s home range.

Spatial Analysis

The results of our simulations indicated that the 50th, 70th, and 90th percentiles of the expected maximum distances travelled by deer during dog-deer hunts to be 1.92 km, 2.27 km, and 2.73 km, respectively (Figure 1). We therefore assumed hunts would need to be limited to areas ≥1.9 km from USFS property boundaries to ensure 50% of hunts are completely contained on USFS prop-

erty, ≥2.3 km to ensure 70% containment, or ≥2.7 km to ensure 90% containment. When excursions by deer were eliminated from simulations, the expected distances required to contain 50%, 70%, and 90% of hunts were reduced ≥52% to 0.88 km, 1.06 km, 1.34 km respectively. When considering the most conservative containment threshold of ≥2.7 km, only four of the nine national forests in Mississippi had areas where at least 90% of dog-deer hunts were expected to be contained and these areas ranged from 11–2593 ha in size (Table 5). When considering the lower 70% and 50% containment thresholds, two additional national forest units had huntable areas ranging from 55–1119 ha. In contrast, when we removed beyond-home-range excursions from the simulations, all nine national forests had areas where >90% of hunts were expected

Table 5. Tabulated areas (hectares) of space where dog-deer hunt locations could begin to contain 0–49%, 50%–69%, 70%–89%, and 90%–100% of white-tailed deer (*Odocoileus virginianus*) movements on National Forest Lands in Mississippi, United States resulting from simulations of deer movements with and without deer excursions outside of their home range boundaries.

National Forest	Total hectares	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	72,918	72,268	385	240	24	62,511	3707	3496	3204
Delta	24,866	22,161	1309	836	560	14,097	1857	2487	6425
DeSoto (Chickasawhay Unit)	61,279	59,872	1119	287	0	45,465	4433	4974	6407
DeSoto (Primary)	154,601	145,706	3522	2780	2593	111,597	10,225	11,284	21,495
Holly Springs (Primary)	54,721	54,183	313	214	11	49,564	1765	1479	1914
Holly Springs (Yalobusha Unit)	8453	8453	0	0	0	7662	369	289	133
Homochitto	77,522	76,940	527	55	0	63,434	4569	4631	4888
Tombigbee (Ackerman Unit)	16,388	16,388	0	0	0	14,835	799	476	278
Tombigbee (Trace Unit)	10,840	10,840	0	0	0	9259	760	581	240

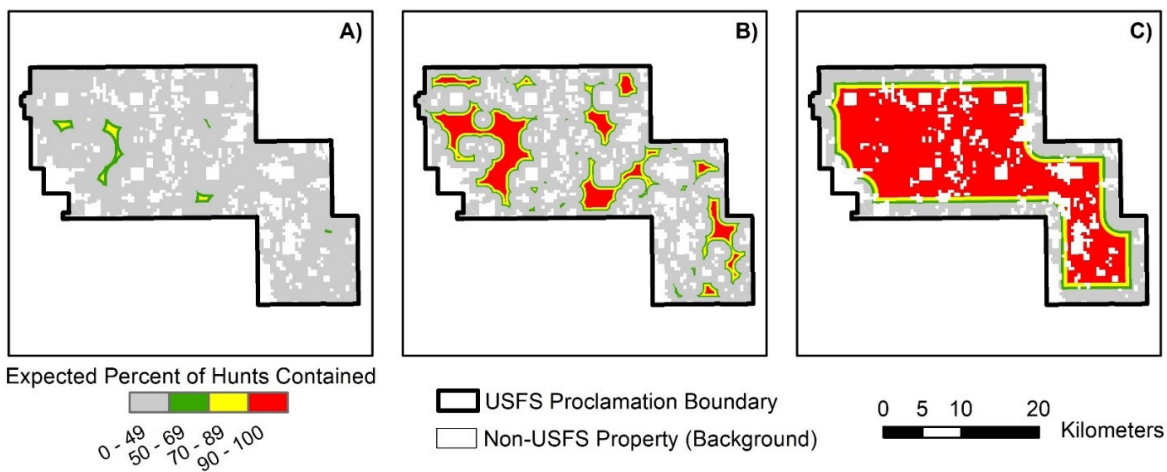


Figure 2. Expected levels of containment of dog-deer hunting for white-tailed deer (*Odocoileus virginianus*) for all portions of U.S. Forest Service (USFS) property on DeSoto National Forest (Chickasawhay Unit), Mississippi, for: A) dog-deer hunts with excursions, B) dog-deer hunts without excursions, and C) dog-deer hunts with excursions but ignoring private land inholdings within the USFS proclamation boundary. Containment levels 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-deer hunts. Percentages indicate the expected percent of dog-deer hunts at the mapped location that would be completely contained on USFS property.

to be contained between 133–21,495 ha. Additionally, we noted that private inholdings were common and when we ignored their presence, areas available for dog hunting increased (Figure 2).

Discussion

Dog-deer hunting defines identity for many hunters and even some rural communities, serving to connect hunters with nature, people, and their dogs (Chitwood et al. 2011). The flexibility of dog-deer hunting regulations often varies based on local acceptance and land-ownership patterns. Therefore, regular communication among natural resource agencies, dog hunters, still hunt-

ers, private property owners, and other stakeholders is essential to developing reasonable compromises to resolve conflicts. Based on our interviews, review of state-specific documents and simulations of deer movements, we concluded that trespass of hunters and/or their dogs onto unauthorized properties is the primary concern where dog-deer hunting currently is practiced. Secondary concerns included competition for space and resources (deer) between still hunters and dog-deer hunters and dog-deer hunting in proximity to roadways. However, most states have enacted regulations to reduce conflicts among stakeholders by restricting dog-deer hunting to specific deer management units or portions of

those units, segregating still hunters and dog-deer hunters across time with season frameworks, prohibiting hunting across or immediately adjacent to major roadways, and increasing accountability of dog-deer hunters to remain on authorized properties.

Declining participation, reduced area open to using dogs, and public opposition to dog-deer hunting were cited as reasons for the prohibition of deer hunting with dogs in Texas (Campo and Spencer 1991). Likely these factors worked in synergy, resulting in little impediment to banning dog-deer hunting. We believe a total cessation of the long-standing tradition of dog-deer hunting where it currently occurs is avoidable when considering the above regulatory tools. However, careful planning is necessary to integrate dog-deer hunting into the framework of deer population management and likely will require strategic regulations, enforcement, and stakeholder engagement.

The most common complaint received by the states we reviewed was dog trespass onto unauthorized lands. Our simulations of deer movements in response to dog-deer hunting on public lands demonstrated the inherent difficulties of containing dog-deer hunts on authorized lands, especially where in-holdings exist. One of the limitations of our simulations is that we assumed movements during hunts were contained within a circular home range plus a buffered excursion distance. In reality, deer movements during hunts vary widely and are unpredictable. We expect that if we were able to realistically incorporate individual variability in movement tortuosity in our simulations, the resulting distribution of expected hunt distances would have a greater proportion of hunts falling into the upper and lower extremes of hunt distances. Additionally, we conjecture that deer movements during hunts could be influenced by deer population densities; for example, low densities may result in dogs travelling greater distances to locate deer, and, high densities may impede a dog's ability follow a single deer. However, we did not incorporate this variability into our simulations. 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). Differing arrangements and sizes of deer home ranges on the landscape would influence dog-deer movements.

The primary challenge to contain dog-deer hunting activities is that scent hounds trail deer throughout intricate and extensive movements without regard to property boundaries. Most, if not all, states in our review carefully select properties for dog-deer hunting with characteristics suitable for containing the dogs (i.e., minimum area, defined boundaries), and we believe this is paramount. However, we also believe states should encourage or require hunters to use electronic tracking of and correction collars on dogs to reduce trespass. Use of electronic collars can be

beneficial to hunters because they can monitor locations of their dogs with less effort, improve efficacy of hunting by reducing undesirable or unproductive behaviors of dogs, and reduce trespass of dogs and conflicts with other hunters. To our knowledge the only required use of correction collars was on select public lands in Florida and Mississippi.

On public lands, establishing clearly defined dog-deer hunting areas with "hard" boundaries such as roads, waterways, and fences helps to minimize confusion and thus also minimize trespass and conflicts. Sensitive areas and private in-holdings should be closed to vehicles and buffered sufficiently (e.g., at least several hundred meters) to facilitate correction of dogs and to minimize casting (i.e., turning dogs out into areas closed to dog-deer hunting). Long, linear areas with minimal width are not conducive to containing dog-deer hunting, as our simulations indicated. Buffers should be sufficient to reduce associated noises (e.g., barking, shooting, vehicle traffic) near private properties.

Although all states restricted hunting on and near roads in some manner, roads are an integral part of modern dog-deer hunting: they provide a means of access for monitoring and catching dogs to prevent trespass and, under certain conditions, offer opportunities for hunters to harvest deer. We agree with our interviewees that shooting from or across primary roads is unsafe and should be tightly regulated; in addition, shooting from boundary roads on public lands should be prohibited to avoid conflicts among hunters and adjacent landowners. Shooting from less-traveled roads within the interior of dog-deer hunting areas, however, may be acceptable where safe and legal. Given the connection between dog-deer hunting and roads, managers must design regulations regarding use of roads that are explicit and enforceable to maximize safety and to reduce conflicts.

Interviewees from Alabama and Georgia believed regulations for private lands, requiring a minimum land area, hunter registration, and information on dogs linked to a specific hunter or permit are the primary reason for relatively few dog-related conflicts when compared to years before these regulations. Although Florida does not require a minimum acreage to hunt deer with dogs, their registration system allows them to monitor participation in dog-deer hunting, locations where it occurs, and a means of communication with dog-deer hunters.

In review of our findings regarding the current status of dog-deer hunting, deer movements relative to dog-deer hunting, and lessons learned from state managers, best management practices include: 1) maintain consistent communication among management agencies, dog-deer hunters, and other stakeholders; 2) allow dog-deer hunting where accepted culturally; 3) implement a permit or registration system in which responsibility for preventing

trespass is placed solely on dog owners/handlers and violations result in revocation of privileges; and 4) encourage or require hunters to use correction collars to reduce dog trespass because deer movements are unlikely to be contained on authorized properties.

Given the limited practice of dog-deer hunting in North America today, few studies have focused on questions pertinent to management in modern context. There was no information in the primary literature about deer movements relative to dog-deer hunting as it is currently practiced on public lands, regulation of dog-deer hunting within the broader framework of deer population management, and management of dog-deer hunting to minimize conflicts with other hunters and landowners adjacent to public dog-deer hunting areas. Cook et al. (2015) highlighted the importance of creating accountability among dog hunters and educating non-dog hunters to relieve their anxiety related to a perceived competition for resources if states want to preserve the culture and heritage of dog-deer hunting. To improve management, future research of deer movements relative to dog-deer hunting should focus on intricate deer movements relative to property characteristics, dog and hunter numbers, and areas off-limits to dog-deer hunting. Our results show that deer, dogs, and hunters could be fitted with GPS trackers to evaluate the efficacy of remote tracking and behavior correction collars for dogs. In our review, managers emphasized that dog-deer hunters were well organized, willing to engage agencies, and took ownership of preserving the practice to actively police their own ranks to reduce negative hunter behaviors. States would benefit from development of structured decision making to engage dog-deer hunters and other stakeholder groups to better anticipate and resolve conflicts.

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