Predator Removal and White-tailed Deer Recruitment in Southwestern Georgia

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Abstract: We assessed the efficacy of predator removal as a tool for increasing white-tailed deer (*Odocoileus virginianus*) recruitment at the Joseph W. Jones Ecological Research Center in southwestern Georgia, an area with a low-density (2–6 deer/km^2) deer herd. We partitioned our 11,736-ha study area into predator removal (approximately 4,200 ha) and non-removal (approximately 2,800 ha) zones with a 4,500-ha buffer between them. We removed 23 coyotes (*Canis latrans*) and 3 bobcats (*Lynx rufus*) from the removal zone between January and August 2008. Most of these (14 coyotes and 1 bobcat) were removed during the fawning period (June–August 2008). Pre-hunting season camera surveys conducted during September 2008 indicated a difference in fawn:doe ratios between the two zones (0.68 in the removal zone; 0.07 in the non-removal zone). Post-hunting season surveys conducted during February suggested a fawn:doe ratio of 0.97 in the removal zone and 0.45 in the non-removal zone. Our study provides further evidence that predator management may be an effective tool for increasing fawn recruitment in low-density deer herds.

Key words: Canis latrans, coyote, fawn recruitment, *Lynx rufus* predation, *Odocoileus virginianus*, white-tailed deer

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White-tailed deer (*Odocoileus virginianus*) are one of the most economically important game species in Georgia and throughout the Southeast. Many wildlife managers in Georgia are now managing their herds under Quality Deer Management guidelines, which advocate socially and biologically balanced deer herds (Bowers et al. 2005). This management strategy typically protects younger bucks (≤2.5 yrs.) from harvest while encouraging doe harvests to promote a healthy herd.

Natural resource managers often want to minimize the impact of deer on the landscape, while simultaneously promoting a healthy deer herd. This is accomplished by keeping the population below habitat carrying capacity (K). Without some sort of predation (including sport hunting), white-tailed deer populations can increase to levels which can lead to destruction of vegetation by overbrowsing, ultimately reducing carrying capacity, and lowering reproductive rates (Kie et al. 1979, Kie and White 1985, Ballard et al. 2001). Potential impacts of predation on deer populations are influenced by the deer population relative to the carrying capacity of the habitat. When deer density approaches K, predation is often compensatory because it does not cause an increase in overall mortality; rather, it replaces another mortality factor such as starvation or disease (Ballard et al. 2001). Alternatively, in low-density herds, predation can limit population growth by reducing recruitment. In these herds, predation may be additive, resulting in an increase in overall mortality (Ballard et al. 2001). Individual mortalities have a greater impact on populations when a deer herd is managed well below K (Ballard et al. 2001).

Herd monitoring efforts on the Joseph W. Jones Ecological Research Center (since 1993) suggest that although deer abundance has remained relatively stable, the number of harvested deer, lactation rates of harvested deer, and observed fawn:doe ratios have declined since 2001. Although deer density on our study area has remained constant since 2001, hunter effort has increased while hunter success has decreased, creating a desire to provide more deer harvest opportunities (Joseph W. Jones Ecological Research Center 2008). Coyote (*Canis latrans*) densities have greatly increased in the Southeast since 1972 (Hill et al 1987); however, a dramatic increase in coyote density has been documented since 2001 on our study area (J. Stober, Joseph W. Jones Ecological Research Center, personal communication). Because the long-term data indicated a decline in recruitment, we initiated a predator removal experiment to determine if predation was limiting recruitment on our study area. Specifically, we investigated the impacts of an intensive predator removal during fawning season on fall and winter fawn:doe ratios. Based on research conducted in Alabama (VanGilder 2008), Oklahoma (Stout 1982) and Texas (Beasom 1974), we predicted significantly greater recruitment rates on the predator removal area relative to the non-removal site.

Study Area

The Joseph W. Jones Ecological Research Center (Ichauway) in Baker County, Georgia, is an 11,736-ha, privately-owned research center in the Upper Gulf Coastal Plain. The landscape is dominated by a longleaf pine (*Pinus palustris*) overstory with a wiregrass (*Aristida stricta*) understory. Limesink and cypress-gum (*Taxodium ascendens-Nyssa biflora*) wetlands are interspersed within the riparian hardwood hammocks along Ichawaynochaway Creek that bisects the property longitudinally and the Flint River that forms the eastern property boundary.

The site is characterized by relatively flat, karst topography with hot, humid summers and short, mild winters. The average daily temperature ranges from 11.1C in winter to 27.2C in summer with an average precipitation of 132 cm per year (Boring 2001). Ichauway is managed on a two-year prescribed fire rotation. Private lands surrounding Ichauway are comprised mainly of agricultural fields and plantation-style timber tracts. Just over 10% of the property consists of agricultural fields and food plots planted with winter wheat (*Triticum aestivum*), Egyptian wheat (*Sorghum* spp.), grain sorghum (*Sorghum vulgare*), brown top millet (*Brachiaria ramose*), and cowpeas (*Vigna* spp.).

Ichauway lies in Georgia's Deer Management Unit 6, which consists of 31 counties in the Upper Gulf Coastal Plain where deer densities average 8.1 deer/km^2 (Bowers et al. 2005). The deer management goal for Ichauway is to maintain a herd density that maximizes herd health while minimizing negative ecological impacts of the herd on its forest ecosystem. Past data indicate that Ichauway's white-tailed deer herd has remained at a constant density of 3.8–5.8 deer/km^2 (10–15 deer/$mile^2$) and a relatively even sex ratio since the early 1990s. The site-wide fawn:doe ratio averaged 0.53 from 2001–2008 (Joseph W. Jones Ecological Research Center 2008).

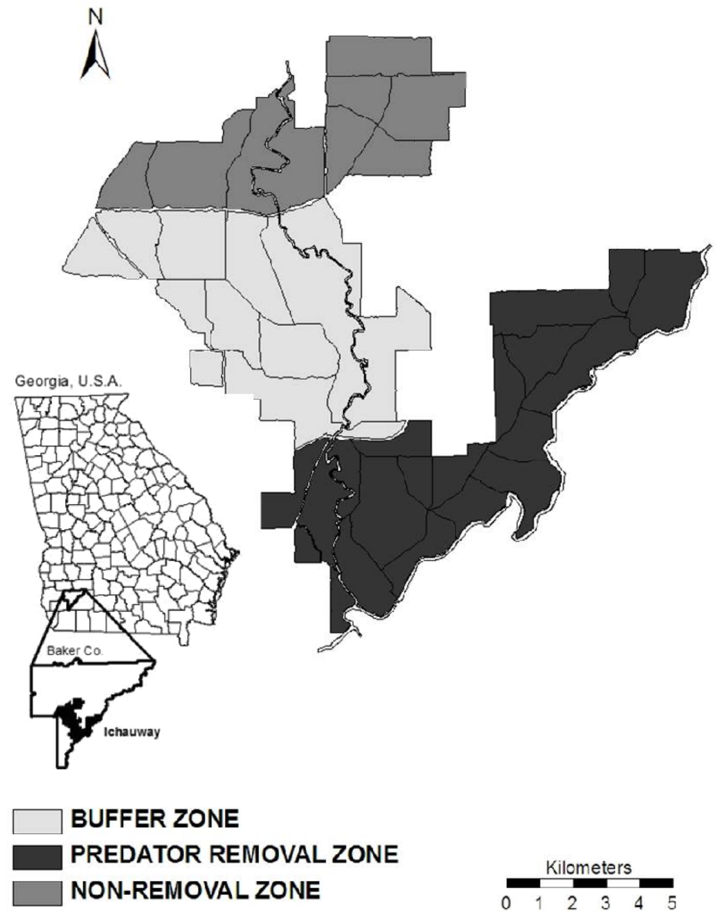

Figure 1. Predator management zones on the Joseph W. Jones Ecological Research Center (Ichauway), Baker County, Georgia, 2008.

Methods

For this study, we divided the property into three zones. The southern portion of Ichauway (4,200 ha) was designated as the predator removal zone (Figure 1). A 2,800-ha area on the northern portion of the property served as a control area with no predator removal. Between the two experimental units there were two major highways and a 4,500-ha buffer area to minimize impacts of the predator removal on the control area. Limited predator removal occurred within this buffer zone but focused on predators that do not prey on deer fawns (e.g., raccoons, *Procyon lotor* and opossums, *Didelphis virginiana*).

We trapped predators from January 2008 through August 2008, but most trapping efforts were concentrated during May–August 2008. All predators were trapped using No. 1.75 offset, laminated leg-hold traps (Woodstream Corp., Lititz, Pennsylvania). Captured predators were dispatched using a .22 caliber rifle. All predators were handled under Georgia Department of Natural Resources' Scientific Collecting Permit No. 29-WTN-07-103 and University of Georgia's Institutional Animal Care and Use Committee Proposal No. A2006-10093.

We used Cuddeback 2.0 megapixel digital trail cameras (Non Typical Iinc., Park Falls, Wisconsin) to survey two 608-ha blocks in the predator removal and two blocks of the same size in the non-removal zones. Camera surveys occurred during September 2008 and February 2009 following protocol from Jacobson et al. (1997), McKinley (2002), and McDonald (2003). Camera surveys in the removal and non-removal zones were conducted simultaneously. Survey sites used a camera density of 1 camera per 67.5 ha. Cameras were placed on trees 50–90 cm above the ground, set on a 5-min delay, and positioned such that they faced either northward or southward to avoid glare from the sun which could reduce ability to identify animals. We placed bait piles consisting of whole corn ~4.5 m from the camera and replenished corn as needed. Prebaiting occurred for 7 days prior to beginning camera surveys and survey periods lasted for 14 days. Since the 2001–2002 deer hunting season, 15–18 hunters have systematically recorded the number, sex, and age (fawn or adult) of all deer observed while hunting. Therefore, we obtained annual fawn:doe ratios using these observations. To reduce observational bias, hunters were unaware of the zone in which they were hunting.

We used a χ^2 test of independence (Dowdy and Wearden 1991) in SAS (SAS Institute 2003) to determine if camera observations of fawns and does were independent of predator removal and non-removal zones. We then used a similar approach to determine if there were differences between the 2001–2008 hunter observed fawn:doe ratios and the 2008–2009 hunting observed fawn:doe ratios within both predator removal and non-removal zones (i.e., we performed a before and after test for each zone). Finally, we applied the same statistical test to determine if hunter observed fawn:doe ratios were independent of the two zones during the 2008–2009 hunting season. Animals that could not be positively identified were excluded from analysis. For all hypotheses tests, we set $\alpha = 0.05$.

Results

We removed 23 coyotes and 3 bobcats (*Lynx rufus*) from the removal zone between January and August 2008. Most (14 coyotes, 1 bobcat) were removed during the fawning season (June-August).

Pre-hunting season camera surveys conducted during September 2008 revealed a fawn:doe ratio of 0.68 in the removal zone compared to 0.07 in the non-removal zone ($\chi^2_1 = 99.8$, $P < 0.0001$; Table 1). Post-hunting season camera surveys in February 2009 indicated a fawn:doe ratio of 0.97 in the removal zone and 0.45 in the non-removal zone ($\chi^2_1 = 104.8$, $P < 0.0001$; Table 1). The pre-hunting season fawn:doe ratios were 9.71 times higher in the removal zone than the non-removal zone; whereas post-hunting season ratios were 2.15 times higher in the removal zone.

The hunter-observed fawn:doe ratio in the removal zone during the 2008–2009 hunting season (0.96) was greater ($\chi^2_1 = 4.6$, $P = 0.032$) than the hunter-observed fawn:doe ratio during the 2001–2008 hunting seasons (0.61). However, the hunter-observed fawn:doe ratio in non-removal zone during the 2008–2009 hunting season (0.44) was similar ($\chi^2_1 = 0.02$, $P = 0.893$) to the 2001–2008 hunting season fawn:doe ratio (0.47) observed in this area. Finally, the hunter-observed fawn:doe ratio in the removal zone (0.96) during the 2008–2009 hunting season was greater ($\chi^2_1 = 3.9$, $P = 0.048$) than the fawn:doe ratio observed in the non-removal zone (0.44) during the same period.

Discussion

We removed fewer animals per unit area than previous studies reported in the literature (Table 2). However, monitoring efforts suggest that our removal efforts were equivalent to removing 1 coyote for every 8.5 deer based on the 2008–2009 white-tailed deer thermal camera survey data (deer density estimate = 4.6 deer/km^2; Joseph W. Jones Ecological Research Center 2008). Although coyote populations can withstand annual harvests of 70% in some areas (Connolly and Longhurst 1975), we removed 34%–43% of the estimated coyote population in our predator removal zone based on track count estimates of 1.44 + 0.16 coyotes/km^2 (J. Stober, Joseph. W. Jones Ecological Research Center, personal communication). This reduction was apparently sufficient to result in an increase in fawn recruitment.

During the pre-hunting season camera survey we observed fawn:doe ratios to differ by an order of magnitude. This is the greatest response to predator reduction reported in the literature to date. However, we are unsure of what caused this large difference, and suggest that our pre-season camera survey estimates may not provide a reliable representation of the true impact of predator reduction on fawn recruitment. Peak fawning on our study area occurred from June–August and fawns were likely less mobile during the September surveys and therefore less likely to be photographed. Nevertheless, the fawn:doe ratio differed substantially between the removal and non-removal zones. We suggest that the increased vigilance of does in the non-removal zone may have reduced the number of fawns observed in our pre-season surveys.

The post-season removal zone fawn:doe ratio was 2.15 times greater than the non-removal zone, and we suggest that these esti-

Table 1. Number of white-tailed deer does and fawns detected during pre-hunting season and post-hunting season camera surveys within predator removal and non-removal zones at the Joseph W. Jones Ecological Research Center, Baker County, Georgia, 2008–2009.

	Predator removal zone			Non-removal zone		
Month	Adult does	Fawns	Fawn:doe	Adult does	Fawns	Fawn:doe
September	288	197	0.68	260	19	0.07
February	514	497	0.97	1705	759	0.45

Table 2. Duration of removal effort, number of predators removed, and study area size of predator-removal studies that address effects of predator removal on white-tailed deer fawn:doe ratios.

Study	Removal length	Coyotes removed	Bobcats removed	removal area size (ha)
Beasom 1974	2 years (Feb-Jun)	188	120	2,186
Stout 1982	4 years (Jan-Apr)	398	0	38,099
VanGilder 2008	6 months	22	10	810
This study	8 months	23	3	4,500

mates are more representative of the true effect of predator reduction on fawn:doe ratios. Does were harvested during the 2008–2009 hunting season, but the harvest was approximately equal in the two zones (1 doe /311 ha in the non-removal zone and 1 doe /381 ha in the removal zone), so hunting season harvests should have had little impact on post-season camera survey ratios. Hunter observed fawn:doe ratios from 2008–2009 for both the removal (0.96) and non-removal zone (0.44) were remarkably similar to our post–season camera survey results for the removal (0.97) and non-removal zone (0.45). The congruence of these different survey methods provides evidence that our post-hunting season camera surveys are more representative of the population than our pre-hunting season survey. Although we only have one year of predator removal data and no replication, the hunter observations and our post-hunting season survey suggest a positive impact of predator reduction on fawn:doe ratios.

Our increase in fawn:doe ratios in the predator removal zone is in agreement with increases reported by other studies examining the effects of predator management in relation to recruitment rates of white-tailed deer. Coyote removal efforts on Fort Sill, Oklahoma, resulted in an overall 154% increase in the doe:fawn ratio during a four-year study (Stout 1982). Predator removal in northern Alabama resulted in an increase in fawn recruitment of 189% (VanGilder 2008). Beasom (1974) also found a 74% greater net productivity of deer in predator removal areas than in control areas in Texas.

A study of both predator and deer densities on a small temporal scale (i.e., every few days) relative to predator harvest would be beneficial to gain additional insight into the predator-deer dynamics. This would permit quantification of predator recolonization rates and ultimately allow managers to better focus predator removal efforts to provide greater impacts on fawn recruitment.

Management Implications

Increasing coyote populations coupled with management strategies that manage for lower density white-tailed deer herds are creating new challenges for natural resource managers. Predation can have detrimental impacts on these deer herds if not accounted for when setting harvest goals. Removing coyotes and bobcats can have a positive impact on fawn recruitment in low-density deer herds when removal efforts are conducted properly. However, it is important to emphasize that the timing of removal efforts can be as important as the intensity of removal efforts (Hamlin 1997, Ballard et al. 2001). Previous research has suggested that trapping efforts should be concentrated before and during the fawning season (Hamlin 1997, Ballard et al. 2001) so that the area where predators are removed does not become immediately repopulated while fawns are still in their critical first 30–60 days of life. Because of the reproductive capacity of white-tailed deer, it is also recommended predator control programs stop before populations increase to a level that hunter harvest would not be able to stabilize.

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