General Session

Antler Regulation Effects on White-tailed Deer on Mississippi Public Hunting Areas

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Abstract: Antler restrictions, intended to protect younger, male white-tailed deer (*Odocoileus virginianus*) from harvest and increase harvest of older bucks, are prevalent throughout the Southeast. Mississippi's statewide regulation, initiated in 1995, protects bucks with less than four antler points. We quantified the regulation's effects on age composition, harvest rate, and antler size by analyzing harvest data collected prior to (1991–1994) and after (1997–2001) the regulation was initiated on 22 public areas encompassing 240,000 ha. Relative composition of harvest shifted ($P<0.001$) from 59% 1.5-year males prior to the regulation to 83% 2.5- and ≥ 3.5-year males 3–8 years later, primarily due to a reduction in harvest of 1.5-year males. Harvest rate of 2.5-year males did not change and there was only a small increase ($P<0.05$) in harvest of ≥3.5-year males. Total harvest decreased ($P<0.01$) from 3.1 to 1.8 males per 405 ha. Antler size within age classes generally declined during the post-regulation period across the range of soil resource regions. Antler restrictions should be considered a short-term solution to age-structure problems because of the potential negative biological effects. Long-term solutions should focus on teaching hunters benefits of an older male age structure.

Key words: antler regulation, antler size, harvest, Mississippi, *Odocoileus virginianus*, white-tailed deer.

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Lack of older-aged males available for harvest can limit management success with cervids. Antler size increases with age (Strickland and Demarais 2000) and presence of older males can improve population reproductive characteristics (Noyes et al. 1996). Antler-based restrictions have been used to manipulate harvest age of mule deer (*Odocoileus hemionus*, Carpenter and Gill 1987) and elk (*Cervus elaphus*, Boyd and Lipscomb 1976, Carpenter and Gill 1987, Bender and Miller 1999) in the western United States. Harvest regulations designed to protect young, male white-tailed deer and increase harvest of older males are prevalent throughout the Southeast, and are found in part or all of 10 states.

Mississippi's statewide regulation initiated in 1995 prohibits harvest of males with less than four antler points. Strickland et al. (2001) reported decreased antler size of 2.5- and 3.5-year males through the 1998 harvest season in the Delta soil physiographic region, but no effect was documented in the Upper and Lower Coastal Plains. More information is needed on regional variation in antler regulation effects within Mississippi. Additionally, given widespread use of antler regulations across the Southeast, managers need information on efficacy, variability, and effects of antler regulations (Strickland et al. 2001). Thus, we quantified effects of Mississippi's statewide antler regulation (<4 points protected from harvest) on age composition of the harvest, harvest rate, and antler size by comparing harvest data collected prior to and after the regulation was implemented.

Methods

We collected deer harvest data from 21 wildlife management areas (WMAs) operated by Mississippi Department of Wildlife, Fisheries, and Parks and Noxubee National Wildlife Refuge (NNWR) operated by the U.S. Fish and Wildlife Service (USFWS), totaling about 240,000 ha (Fig. 1). The WMAs included Okatibbee, Caney Creek 1, 2, and 3, Starr Forest-Noxubee and Cypress Creek units, Malmaison, Calhoun County, O'Keefe, Copiah County, Marion County, Red Creek Demonstration, Ward Bayou, Sandy Creek, Little Biloxi, Wolf River, Old River, Pascagoula River, Chickasaw, Upper Sardis, Choctaw, Sunflower, Chickasawhay-Jones County, Tallahala, Red Creek, and Leaf River. Check stations were generally mandatory, but number of days of operation varied among management areas.

Harvest data were categorized as pre-regulation (1991–1994) and post-regulation (1996–2001 for 2.5-year males and 1997–2001 for ≥3.5-year males). There were no antler restrictions in place during 1991–1994 on the study areas. We did not use data collected in 1995 to allow 1.5-year males protected in 1995 to reach older ages. During the 2003 season on NNWR, special sub-four point tags made all bucks vulnerable to harvest. We estimated age of harvested animals based on tooth replacement and wear (Severinghaus 1949). We pooled all animals within an age class within the pre- and post-regulation time periods. We assumed deer were aged correctly and that our sample of hunter-harvested males was representative of the male population.

Antler measurements collected at harvest included basal circumference (cm), main beam length (cm), number of points, and inside spread (cm). We summed these values to generate an antler index, which we used to estimate gross, non-typical Boone and Crockett score (Boone and Crockett Club 1997) according to predictive equations developed by Strickland and Demarais (2000).

Because the goal of antler regulations is to increase survival of 1.5-year males, we determined if proportions of harvested 1.5-, 2.5-, and ≥3.5-year males changed

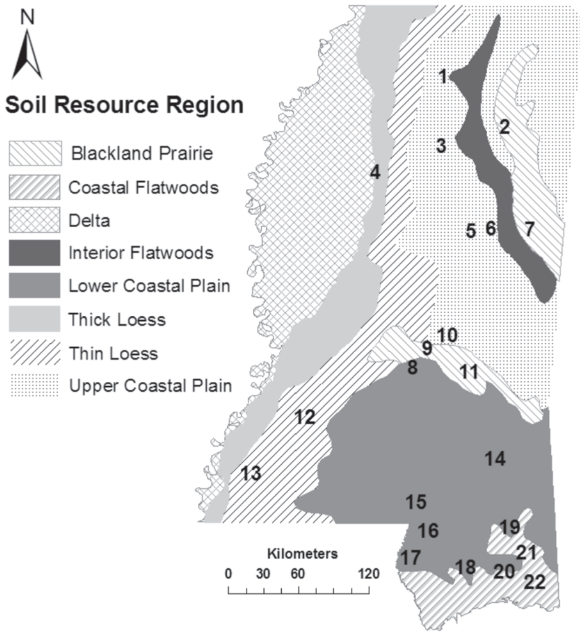

Figure 1. Study areas sampled prior to and following implementation in 1995 of a statewide antler regulation in Mississippi: 1 = Upper Sardis WMA, 2 = Chickasaw WMA, 3 = Calhoun County WMA, 4 = Malmaison WMA, 5 = Choctaw WMA, 6 = Starr Forest WMA, 7 = Noxubee NWR, 8 = Caney Creek 1 WMA, 9 = Caney Creek 2 WMA, 10 = Caney Creek 3 WMA, 11 = Tallahala WMA, 12 = Copiah County WMA, 13 = Sandy Creek WMA, 14 = Chickasawhay-Jones County, 15 = Marion County WMA, 16 = Wolf River WMA, 17 = Old River, 18 = Little Biloxi WMA, 19 = Leaf River, 20 = Red Creek WMA, 21 = Pascagoula River WMA, 22 = Ward Bayou WMA.

after 1995 implementation of the statewide four-point regulation. We compared age composition of males harvested pre- and post-regulation from the 21 WMAs using chi-square analysis (SAS 1990). We compared harvest rate pre- and post-regulation as measured by number of males harvested per 405 ha from the 21 WMAs using a paired t-test, assuming a normal distribution of harvest rates (SAS 1990).

To evaluate cohort antler size before and after implementation of the antler restriction, we examined harvest records from NNWR and 5 of the above mentioned 21 WMAs. We restricted this analysis to age-specific cohorts (1.5, 2.5, and 3.5 years) because age affects antler size (Strickland and Demarais 2000). We restricted this analysis to fewer WMAs with the requirement of a minimum of 10 samples of 3.5-year males, in contrast to the "3.5 and older" age class used for harvest rate analyses. We compared antler size pre-and post-regulation using a *t*-test (SAS 1990). Because soil resource region (Pettry 1977) affects age-specific antler development in Mississippi (Strickland and Demarais 2000), we included management areas across a variety of soil resource regions. Noxubee National Wildlife Refuge was located within the Interior Flatwoods region. Chickasaw and Choctaw WMAs were located in the Upper Coastal Plain region. Talahalla WMA was located in the Blackland Prairie region. Caney Creek – Unit 3 and Chickasawhay Jones County WMAs were located in the Lower Coastal Plain region.

We assumed pre-regulation populations represented 2.5- and 3.5-year males that were harvested randomly. We also assumed post-regulation populations represented 2.5- and 3.5-year males that were "passed" in previous years as 1.5-year-olds due to the four-point regulation, or they simply never presented themselves for harvest in previous years.

Availability of sub-four point tags to all hunters during the 2003 season on NNWR allowed the first sampling of all antler sizes since initiation of the antler regulation in 1995. We compared relative percentage of antler point categories within the 1.5-, 2.5-, and 3.5-year age classes prior to initiation of the antler regulation and during the 2003 season using chi-square analysis (SAS 1990).

Results

Relative composition of harvest shifted (χ^2_2 = 14.48, P < 0.001) from predominantly 1.5-year males prior to the regulation (59%) to predominantly older males (42% 2.5- and 41% ≥3.5-year males) after the regulation had been in place 3–8 years (Table 1). However, this change in percentages was due primarily to a reduction in harvest of 1.5-year males (1.9 to 0.3 per 405 ha; Table 1). The harvest of 2.5-year males remained unchanged (0.7 per 405 ha), and there was only a small increase (P < 0.05) in harvest of ≥3.5-year males (0.5 to 0.7 per 405 ha; Table 1). Total harvest decreased (P<0.01) from 3.1 to 1.8 males per 405 ha (Table 1). Although harvest of 1.5-year males decreased by 1.6 males per 405 ha, harvest of 2.5- and 3.5-year males combined increased by only 0.2 males per 405 ha. Thus, the total number of bucks harvested was reduced by 40%. Yearling males protected from harvest were not incorporated as older males in subsequent harvests.

Antler size within age classes generally declined during the post-regulation period (Table 2). This decline was evident in at least one of the two age classes evaluated across the range of soil physiographic regions, including the Delta, Upper Coastal Plain, Interior Flatwoods, and Lower Coastal Plain. For these cases, gross Boone and Crockett scores decreased 5–9 inches for 2.5-year males and 10–17 inches for 3.5-year males.

Distribution of antler points within harvested age classes on NNWR changed (P < 0.01) for 3.5-year males between the pre-regulation period and the 2003 hunt-

Table 1. Comparison of age-specific harvest on 21 state wildlife management areas prior to (1991–1994; Pre) and following (1997–2001; Post) implementation in 1995 of a statewide antler regulation (<4 antler points protected from harvest) in Mississippi.

	Percent of total harvest				Buck harvest per 405 hectares			
Age	Pre	Post	χ^2_2	P	Pre	Post	t_{20}	P
1.5	58	16	13.333	≤0.01	1.9	0.4	4.38	≤0.01
2.5	25	42			0.7	0.8	–0.31	0.76
≥3.5	17	42			0.5	0.7	–2.39	0.03
Total	100	100			3.1	1.8	3.11	0.01

Table 2. Age-specific mean Boone and Crockett scores of male white-tailed deer harvested on 6 public hunting areas prior to (1991–94; Pre) and following (1996–2001; Post) implementation in 1995 of a statewide antler regulation (<4 points protected from harvest) in Mississippi.

		Pre		Post			
Site	Age	*N*	$\bar{x}$	*N*	$\bar{x}$	*t*-	*P*
Caney Creek 3 WMA	2.5	33	83	80	74	–2.27	0.03
	3.5	12	108	51	91	–2.42	0.02
Chickasawhay WMA[a]	2.5	49	63	88	56	–2.04	0.04
	3.5	45	82	60	74	–1.52	0.13
Chickasaw WMA	2.5	56	82	75	77	–1.99	0.05
	3.5	19	110	37	101	–1.85	0.07
Choctaw WMA	2.5	40	65	55	61	–0.90	0.37
	3.5	19	92	46	82	–1.73	0.09
Noxubee NWR	2.5	260	81	251	81	–0.18	0.86
	3.5	46	105	135	93	–3.52	0.01
Tallahala WMA	2.5	51	77	207	70	–2.39	0.02
	3.5	32	87	115	88	0.37	0.71

a. Jones County portion of Chickasawhay WMA.

ing season (Table 3). All three antler point categories that would be considered indicative of "inferior" antler production at 3.5 years (i.e., 2–3, 4–5, and 6–7 points) increased in prevalence (Table 3). Males with 2–3 points had not been recorded during the pre-regulation period, but made up 6% of the 3.5-year harvest in 2003. Males with 4–5 and 6–7 points increased in prevalence from 4% to 17% and 15% to 31%, respectively. Males with ≥8 points decreased from 81% to 47% (Table 3).

Discussion and Management Implications

Reduction in harvest pressure applied to younger-aged males is a prerequisite for improving the male age structure. Mississippi's statewide antler regulation (<4 points protected from harvest) should have protected from harvest 77% of 1.5- and 18% of 2.5-year males, based on antler harvest data collected on the study areas prior to implementation (B. K. Strickland, Mississippi State University, unpublished data). Increased male age structure can increase prevalence of larger-antlered males due to the positive relationship between age and antler size (Demarais et al. 2000). A higher prevalence of older males may also improve breeding dates (Jacobson 1992), perhaps by stimulating an earlier female estrus (McComb 1987). Increasing age of principal sires from 1 year to 5 years in a population of elk shortened the rut from 71 days to 41 days and shifted it 3 weeks earlier (Noyes et al. 1996).

Relative prevalence of age classes within a harvest sample can indicate population age structure only if there is no harvest bias. Biologists often have used the high

Table 3. Age-specific distribution of number of antler points from male white-tailed deer harvested on Noxubee National Wildlife Refuge prior to (1989–94) and following (2003) implementation in 1995 of a statewide antler regulation (<4 points protected from harvest) in Mississippi.

Age	Antler points	% of 1989–94 buck harvest	% of 2003 buck harvest	χ^2_2	*P*
1.5	2–3	72	80	2.68	0.44
	4–5	18	12		
	6–7	9	8		
	≥8	1	0		
2.5	2–3	9	15	5.27	0.15
	4–5	19	26		
	6–7	34	34		
	≥8	38	25		
3.5	2–3	0	6	28.64	<0.001
	4–5	4	17		
	6–7	15	31		
	≥8	81	47		

prevalence of 1.5-year males in the harvest as an indicator of excessive harvest pressure on the yearling age class and as justification of antler regulations. It naturally follows that a decrease in prevalence of 1.5-year males in the harvest would be used as an indicator of success of antler regulations. As such, the significant shift in age class composition from a preponderance of 1.5-year males to 2.5- and older males on the 22 WMAs could be considered a positive metric. However, this change in percentages can be almost totally explained mathematically by removal of 1.5 males from the harvest. Therefore, judging success of an antler restriction based on a shift in percentages of age classes in the harvest can lead to incorrect conclusions and should be avoided.

Lack of increase in absolute harvest of 2.5-year males and only minor increases in harvest of ≥3.5-year males indicates that antler regulations have failed to increase harvest of older aged males in a biologically and socially significant fashion. The inability to incorporate yearling males protected from harvest into subsequent harvests was similar to results reported for mule deer and elk in the western United States (Boyd and Lipscomb 1976, Carpenter and Gill 1987, Weigand and Mackie 1987, Bender and Miller 1999). Western authors concluded that significant increases in harvest rates of mature males required more than antler restrictions and should include reducing hunter access and/or opportunity for harvest (Carpenter and Gill 1987, Weigand and Mackie 1987).

A significant reduction in hunter effort or a shift in hunter selection could be alternative explanations for lack of increased harvest of older males during the post-regulation period. However, hunter effort on the 22 WMAs was relatively stable at about 7,000 man-days of effort during the study. Additionally, harvest rate of females was stable at about 2.3 does per 405 ha during the study (L. E. Castle, Mississippi Department of Wildlife, Fisheries, and Parks, unpublished data).

It is clear from our results that the 4-point antler regulation protected yearling males from harvest on public hunting areas in Mississippi. However, there was not an equivalent increase in harvest of older males. Based on pre-regulation harvest data (B. K. Strickland, Mississippi State University, unpublished data), a significant proportion of 2.5-year (18%) and ≥3.5-year (4%) males had less than 4 antler points and thus would not have been eligible for harvest. Additionally, non-hunting annual mortality rates of 2% for 1.5-year males and 7% for 2.5- and 3.5-year males (Coggin 1998) accounts for loss of some protected males and can partially explain lack of harvest at older age classes. Behavioral changes may occur in older males, leading to decreased susceptibility to harvest, contributing to lack of increased harvest.

Previous research incorporating harvest results through 1998 documented a negative effect of the four-point regulation on antler size, but only in the Delta soil resource region of Mississippi (Strickland et al. 2001). Significant reductions in antler size we documented in the Upper and Lower Coastal Plains and the Interior Flatwoods indicates that negative effects took longer to become noticeable in these soils regions. Rate of impact may have varied because age-specific antler expression can be influenced by inherent, regional soil fertility (Strickland and Demarais 2000). In the relatively more fertile Delta soils, yearling male antler development probably was not limited by forage quality and males expressed their genetic potential for antler size (Demarais et al. 2000). Therefore, hunters may have selectively removed yearling males that were genotypically predisposed to produce larger antlers at 1.5 years of age and subsequent years (Ott et al. 1998). In the less fertile Upper and Lower Coastal Plain and Interior Flatwood regions, yearling male antler size may have been limited by nutrition and later fawning dates. Later fawning dates in the Lower Coastal Plain compared to the Delta (Jacobson et al. 1979) may have limited antler size due to the inverse relationship between birth date and yearling antler size (Jacobson 1995). Thus, some yearling males that were protected from harvest (i.e., had <4 antler points) were not necessarily genetically programmed for smaller antlers, because antler size was constrained by environmental factors.

The differing impacts of the 4-point regulation among regions also may have been due to differences in harvest rates of vulnerable males. Strickland et al. (2001) used a cohort simulation model to show that antler regulations had less effect at lower harvest rates of vulnerable males. The Delta region may have experienced higher harvest rates of vulnerable males than the other regions, which caused quicker development of differences in antler size of pre- and post-regulation cohorts.

Diet quality can significantly influence antler development of whitetails. Varying dietary protein from 16% to 8% decreased average Boone and Crockett scores of 3.5-year males by 20 inches (Harmel et al. 1989). Therefore, our observed decline in antler size of 2.5- and 3.5-year males could potentially have been caused by a general decrease in relative nutritional carrying capacity across the range of soil physiographic regions. However, kidney fat indices and fetal rates of adult females on the study areas did not differ between pre- and post-regulation periods (B. K.

Strickland, Mississippi State University, unpublished data). Therefore, we conclude that a general decline in nutritional intake did not confound effects of antler restrictions on antler size.

The significant shift in prevalence of antler points within the 3.5-year age class at NNWR provides evidence of the mechanism by which the antler regulation decreases average antler size. Protection of 2–3 point yearling males would lead to an increase in the prevalence of 2–3 point 3.5 year males only if there was a link between antler size at 1.5 years and 3.5 years. The accuracy with which yearling antler size can be used to estimate subsequent antler size has been debated. Antler development within research pens in Texas showed that yearling antler size explained 55% of the variation in Boone and Crockett score of bucks at 4.5 years (Ott et al. 1998). In contrast, research from pens in Mississippi showed that number of antler points at 1.5 years was not related to Boone and Crockett score at 5.5 years (Jacobson 1998). We do not have the data to determine if antler development at 5.5 years was impacted by the 4-point regulation.

We conclude that Mississippi's 4-point antler regulation has caused significant negative biological effects on antler development of older males on numerous public hunting areas in Mississippi. Additionally, protection of yearling males did not result in equivalent increases in harvest of older males. These combined circumstances indicate that alternative solutions should be pursued to improve the male age structure on public hunting areas in Mississippi. Antler restrictions should be considered a short-term solution to age-structure problems because of the potential negative biological effects. The long-term solution should focus on teaching hunters the benefits of an older male age structure.

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