Surveys

Effect of Weekly Hunting Frequency on Duck Abundances in Mississippi Wildlife Management Areas

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Abstract

Management of waterfowl habitat and hunting frequency is important to sustain hunting opportunities in Mississippi and elsewhere in North America. Managers have limited scientific information regarding the effect of weekly hunting frequency on waterfowl abundance for use in developing hunting plans for public hunting areas. We divided the hunted portions of three Mississippi Wildlife Management Areas into two treatments to evaluate the effect of hunting 2 versus 4 d/wk on duck abundance. Abundance of all ducks, mallard *Anas platyrhynchos*, northern shoveler *Anas clypeata*, and green-winged teal *Anas crecca* were not detectably different between weekly hunting frequencies. Sanctuary use increased approximately 30% during the first 1.25 h after sunrise regardless of hunting disturbance being present or absent. Our results indicate that duck abundance did not increase with increased rest days at Wildlife Management Areas, suggesting these areas may be hunted 4 d/wk without significantly decreasing duck abundance. Sanctuaries were used daily and may be vital to attract and retain ducks on Wildlife Management Areas.

Keywords: abundance; ducks; Mississippi; sanctuary; waterfowl hunting

Received: November 14, 2012; Accepted: January 15, 2013; Published Online Early: February 2013; Published: June 2013

Citation: St. James EA, Schummer ML, Kaminski RM, Penny EJ, Burger LW. 2013. Effect of weekly hunting frequency on duck abundances in Mississippi Wildlife Management Areas. *Journal of Fish and Wildlife Management* 4(1):144–150; e1944-687X. doi: 10.3996/042012-JFWM-034

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Introduction

State and federal wildlife agencies provide areas for public waterfowl hunting, which may assist in retaining hunters with limited access to private hunting property (Miller and Hay 1981). Researchers have observed waterfowl movements, abundance, and distribution in response to hunting and nonhunting disturbances in Europe and North America (e.g., Hockin et al. 1992; Cox and Afton 1997; Bregnballe and Madsen 2004; Dooley et al. 2010). Most studies evaluated the effect of hunting seasons or singular disturbance events that may be atypical of hunting conditions (e.g., Cox and Afton 1997; Davis et al. 2009; Dooley et al. 2010), but few studies have documented the effect of weekly hunting frequency (e.g., Bregnballe and Madsen 2004; St. James 2011). Consequently, most managers rely on expert opinions and anecdotal comparisons of past weekly hunting pressure and success to manage waterfowl hunting on public and private lands.

Managers provide sanctuaries to restrict disturbance of waterfowl completely (i.e., spatial sanctuary) or partially during selected hours or days of the week (temporal sanctuary; Fox and Madsen 1997; Madsen 1998). Sanctuaries may attract and retain waterfowl in and near hunting areas because sanctuaries provide

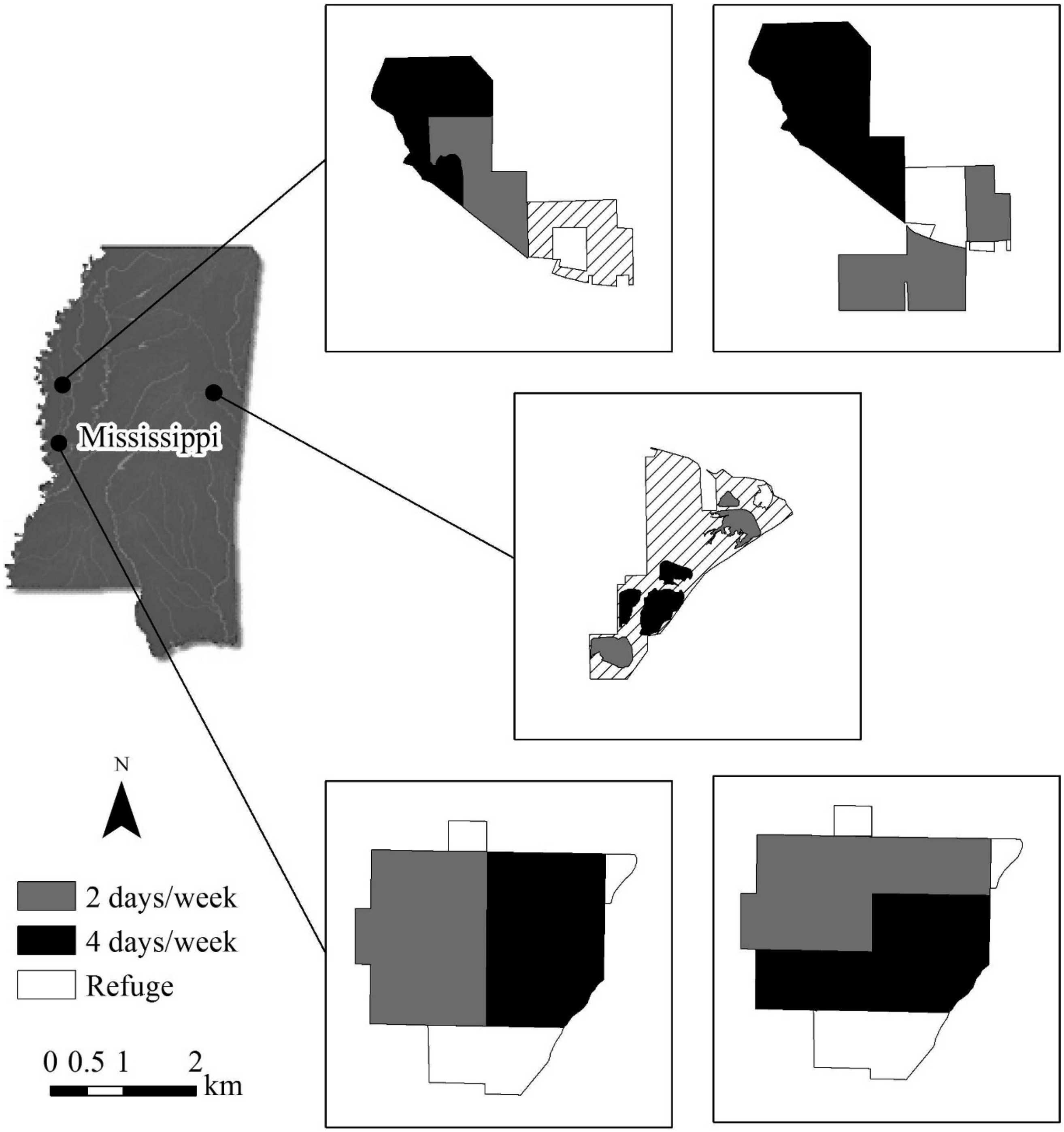

Figure 1. Location of areas hunted for waterfowl 2 or 4 d/wk and location of sanctuaries, December–January, at **(a)** Muscadine Farms 2008–2009, **(b)** Muscadine Farms 2009–2010, **(c)** Trim Cane 2008–2010, **(d)** Howard Miller 2008–2009, and **(e)** Howard Miller 2009–2010 Wildlife Management Areas in Mississippi.

undisturbed habitat where waterfowl can feed and perform other activities (e.g., pairing, resting, comfort movements, etc.) without risks associated with hunting disturbance (Hockin et al. 1992; Fox and Madsen 1997; Madsen 1998). If areas are hunted on consecutive days, then waterfowl abundance will often decrease; a 1–2-d period without hunting may be necessary to maintain or increase duck abundance on such sites (Fox and Madsen 1997; Bregnballe and Madsen 2004; Dooley et al. 2010). Areas temporarily closed to hunting can sustain and attract waterfowl, but spatial sanctuaries typically sustain greater abundances of birds than do temporal ones (Fox and Madsen 1997).

Life-history strategy influences the likelihood of duck species to use or avoid areas with hunting disturbances (Ackerman et al. 2006). Species with relatively longer

Table 1. Number (*n*) and summed area (ha) of hunt units open for waterfowl hunting by experimental morning-only hunting frequencies of 2 or 4 d/wk at three Wildlife Management Areas in Mississippi, December–January 2008–2010.

Hunting season	Hunting frequency	Howard Miller		Muscadine Farms[a]		Trim Cane	
		n	ha	*n*	ha	*n*	ha
2008	2 d/wk	12	399	5	123	3	41
	4 d/wk	12	370	6	150	3	41
2009	2 d/wk	12	397	10	186	3	41
	4 d/wk	12	372	11	273	3	41

[a] Area of hunt units increased between hunting seasons at this WMA because of acquisition of additional property.

lifespan and larger body size (e.g., mallard *Anas platyrhynchos*) have an increased capacity to store nutrients and may take fewer risks than smaller species with less longevity (e.g., green-winged teal *Anas crecca;* hereafter, teal; Nagy 2005; Ackerman et al. 2006). Prior studies suggest hunting disturbance may influence species composition and abundance of waterfowl on hunted areas, but studies empirically quantifying waterfowl responses to hunting frequency have not been conducted. Therefore, our objectives were to test whether 1) abundance of total ducks and selected dabbling duck species with different life-history strategies varied between experimental weekly hunting frequencies of 2 or 4 hunting days/wk, and 2) use of spatial sanctuaries by ducks differed among mornings when all, part, or none of the hunt units within the wildlife management area (WMA) were open to hunting.

Study Site

We conducted our experiment at Howard Miller WMA (971 ha; 32°49′48.93″N, 90°58′51.61″W), Muscadine Farms WMA (316 ha; 33°13′29.32″N, 90°59′01.51″W), and Trim Cane WMA in Mississippi (324 ha; 33°31′30.27″N, 88°50′47.19″W; Figure 1). Our study areas were managed primarily for waterfowl hunting by the Mississippi Department of Wildlife, Fisheries, and Parks. Howard Miller WMA was open to morning-only hunting 3 d/wk for 1 season prior to our study. Muscadine Farms and Trim Cane WMAs were open to morning-only hunting 2 d/wk for 6 seasons prior to our study. In 2008, the Mississippi Department of Wildlife, Fisheries, and Parks increased Muscadine Farms WMA by 48% with acquisition of an additional 291 ha (33°12′48.62″N, 90°57′55.49″W; Table 1); this area was available for hunting during the 2009–2010 waterfowl hunting season. Spatial sanctuaries at Howard Miller (182 ha) and Trim Cane (4 ha) WMAs were established when the WMAs opened for hunting and encompassed the same portion of the WMA as during our study period (St. James 2011; Figure 1). Prior to our study, no spatial sanctuary existed at Muscadine Farms. The acquisition of adjacent land at Muscadine Farms allowed for spatial sanctuaries beginning in the 2008–2009 hunting season (26 ha in 2008–2009 hunting season, 74 ha in 2009–2010 hunting season; Figure 1).

Vegetation within hunt units and sanctuaries of WMAs primarily consisted of 1) moist-soil vegetation (e.g., naturally occurring or planted grasses; Fredrickson and Taylor 1982; Kross et al. 2008; Schummer et al. 2012) with supplemental plantings of browntop millet, corn, Egyptian wheat, grain sorghum, Japanese millet, rice, soybean, or Sudan-grass; 2) harvested rice or soybean crops; or 3) non–mast producing trees (e.g., willow *Salix* spp.; St. James 2011).

Methods

Experimental hunting frequencies

We divided hunted areas within WMAs into two experimental treatment areas and randomly assigned a morning-only (0.5 h before sunrise to 1200 hours) hunting frequency of 2 or 4 d/wk (Figure 1). Treatment areas were of approximately equal summed area of hunt units and similar vegetation (Table 1). We chose these treatments because morning-only hunting 4 d/wk doubled the previous hunting frequency at Muscadine Farms and Trim Cane WMAs. Hunters were selected by the Mississippi Department of Wildlife, Fisheries, and Parks using an online prehunting season random lottery system or they could arrive on the morning of the hunt as stand-by hunters and select hunting sites not claimed by reservation holders. On the day of each hunt, hunters selected hunting sites from available hunt units based on a random draw system. Hunters were allowed to have 1–4 people within a hunt unit. Hunters spent similar amounts of time hunting at WMAs ($\bar{x}$ = 192.4 ± 2.1 min [SE; *n* = 929] for areas hunted 2 d/wk; $\bar{x}$ = 192.2 ± 1.7 min [SE; *n* = 1670] for areas hunted 4 d/wk; St. James 2011).

Duck density surveys

We conducted flush-count surveys twice weekly, December through January 2008–2010, to index duck abundance within the hunt units. We conducted surveys on nonhunt days, so that hunters would not be disturbed by researchers. Surveys were conducted while walking, or from an all-terrain vehicle, along levees adjacent to hunt units (Kaminski and Prince 1981; Dubovsky 1987). We selected this method because it was consistent with regulations for visitors using WMAs on nonhunt days and allowed us to survey a greater portion of each WMA than if we conducted stationary counts. Surveys occurred 1 and 3 d after hunt units were open to hunting in the 2 d/wk treatment and 1 d after the hunt units were open to hunting in the 4 d/wk treatment. Hunt units were surveyed between 1000 and 1130 hours, after morning movements of ducks, when ducks are primarily resting (Paulus 1984). Additionally, we selected a mid-morning survey time because it was within hunting hours on hunt days and we did not want

Table 2. Least-squared mean (±SE) densities (ducks/ha) and associated statistics[a] for all ducks and selected species observed in areas hunted 2 ($n = 94$) or 4 ($n = 94$) d/wk across three Wildlife Management Areas in Mississippi, December–January 2008–2010.

Ducks taxon	2 d/wk	4 d/wk	*df*	*F*	*P*
All ducks	2.49 ± 0.69	3.11 ± 0.69	1, 5.44	1.17	0.326
Mallard *Anas platyrhynchos*	0.86 ± 0.09	0.81 ± 0.09	1, 6.26	0.18	0.687
Northern shoveler *A. clypeata*	0.64 ± 0.11	0.51 ± 0.11	1, 2.01	2.32	0.266
Green-winged teal *A. crecca*	0.37 ± 0.26	0.55 ± 0.26	1, 5.36	1.32	0.299

[a] Test statistics from an ANOVA ($\alpha = 0.10$) comparing duck densities between morning-only hunt frequency treatments.

bird abundance to be confounded with time of day. We reversed the starting point of surveys between sequential weeks, so each unit was not surveyed at the same time of day.

We identified and counted ducks within hunt units before they flushed. We also counted ducks that flushed from hunt units if they had not been counted previously. When ducks flushed, we noted the number that landed in hunt units not yet surveyed and subtracted these from subsequent counts (Kaminski and Prince 1981). We surveyed hunt units open to hunting 2 d/wk and 4 d/wk during each survey to control for potential bias that may have been associated with surveying hunt frequencies on different days.

We calculated weekly mean density of all ducks (ducks/ha/wk) for all areas. Dabbling ducks (tribe Anatini) comprised 93% of all ducks detected and diving ducks (tribe Aythyini) comprised the remaining ducks observed (see Data S1, Tab 1, Tab 4, *Supplemental Material*). Mallard, northern shoveler *Anas clypeata* (hereafter, shoveler), and teal were the most abundant dabbling ducks observed, comprising 30%, 20%, and 16% of all ducks detected, respectively (see Data S1, Tab 1, Tab 4, *Supplemental Material*). We used ANOVA with repeated measures (i.e., week of hunting season) in a randomized complete block design (WMAs) to test whether all ducks, mallard, shoveler, and teal densities differed between areas open for hunting 2 or 4 d/wk (PROC MIXED; SAS 2002; Gutzwiller and Riffell 2007).

In addition to surveying duck abundance with the hunt units, we also surveyed sanctuary abundance. Sanctuary units were surveyed six times per wk using scan sampling from a concealed aerial or ground blind to generate two indices of duck use during morning when all, part (only areas with a hunting frequency of 4 d/wk), or none of the hunt units within the WMA were open to hunting (Altmann 1974; Havens et al. 2009). Regulations restricted visitors from entering sanctuaries; therefore, we selected a stationary sampling technique to minimize observer effects. Data for both indexes were collected concurrently beginning 15 min before sunrise over a 1.5-h observation period.

We identified and counted ducks within one impoundment every 15 min for seven scan samples to develop our first sanctuary index. The sizes of the impoundments surveyed at Howard Miller and Muscadine Farms during the 2008–2009 season, Muscadine Farms during the 2009–2010 season, and Trim Cane WMAs were 26 ha, 11 ha, 5 ha, and 4 ha, respectively. Vegetation within the impoundments was representative of the vegetation within the sanctuary. We calculated mean number of all ducks/ha, mallard/ha, shoveler/ha, and teal/ha observed during each scan to generate mean use of ducks/ha for each sampling day. Dabbling ducks and diving ducks comprised 40% and <1% of all ducks identified, respectively (see Data S1, Tab 2, *Supplemental Material*). Mallard/ha, shoveler/ha, and teal/ha represented 12%, 15%, and 8%, respectively, of all ducks observed and were the most abundant dabbling duck species (see Data S1, Tab 2, Tab 4, *Supplemental Material*). We used ANOVA with a repeated measures (i.e., week of hunting season) in a randomized complete block design (WMAs) to test whether weekly mean density of all ducks, mallard, shoveler, and teal in sanctuaries differed among mornings when all, part, or none of the hunt units within the WMA were open to hunting (PROC MIXED; SAS 2002; Gutzwiller and Riffell 2007).

For the second sanctuary index, we counted numbers of ducks entering and leaving sanctuaries six times, every 10 min with 5-min intervals before each count, to calculate percent relative change in all duck use during observation periods (see Data S1, Tabs 3 and 4, *Supplemental Material*). We used ANOVA with repeated measures (i.e., week of hunting season) in a randomized complete block design (WMAs) to test whether percent change (increase or decrease) in duck use differed among mornings when all, part, or none of the hunt units within the WMA were open to hunting (PROC MIXED; SAS 2002; Gutzwiller and Riffell 2007).

Residuals of all data exhibited equal variances and were distributed normally. We selected compound symmetry from a suite of covariance structures for all analyses, because variances were generally homogenous (Littell et al. 2006). We designated $\alpha = 0.10$ for all models a priori (Tacha et al. 1982).

Results

Abundance of all ducks, mallard, shoveler, and teal using hunt units did not differ between areas hunted 2 or 4 d/wk (Table 2). Abundance of all ducks, mallard, shoveler, and teal using sanctuaries were similar among mornings when all, part, or none of the hunt units within the WMA were open to hunting (Table 3). Similarly, percent change in abundance of all ducks within sanctuaries was similar among mornings when all ($\bar{x}$ = 28% ± 7% [SE]), part ($\bar{x}$ = 32% ± 7%), or none ($\bar{x}$ = 33% ± 6%; $F_{2,7.16} = 0.19$, $P = 0.834$) of the hunt units within the WMA were open to hunting.

Discussion

Our results contradict most studies that report a direct relationship between hunting disturbance and duck use

Table 3. Least-squared mean (±SE) density (ducks/ha) and associated statistics[a] for all ducks and selected species observed in sanctuaries during mornings when all ($n = 93$), part ($n = 92$), or none ($n = 89$) of the hunt units within three Wildlife Management Areas in Mississippi were open for waterfowl hunting, December–January 2008–2010.

Ducks taxon	All	Part	None	*df*	*F*	*P*
All ducks	15.46 ± 4.42	4.57 ± 4.49	5.38 ± 4.69	2, 9.45	1.84	0.211
Mallard *Anas platyrhynchos*	0.65 ± 0.37	1.11 ± 0.37	1.37 ± 0.37	2, 7.82	2.59	0.137
Northern shoveler *A. clypeata*	1.19 ± 0.78	1.07 ± 0.78	1.78 ± 0.78	2, 3.97	1.61	0.308
Green-winged teal *A. crecca*	0.89 ± 0.35	0.65 ± 0.36	0.46 ± 0.35	2, 3.88	1.69	0.297

[a] Test statistics from an ANOVA ($\alpha = 0.10$) comparing duck densities between mornings when all, part, or none of Wildlife Management Area was open to hunting.

of temporal and spatial sanctuaries (e.g., Tamisier 1976; Cox and Afton 1997; Madsen 1998; Evans and Day 2002). At the scale of our studied WMAs, we did not detect an effect of weekly hunting frequency on relative abundance of ducks, and use of WMA sanctuaries by ducks was similar on hunting and nonhunting days. Additionally, mean duck densities from our study conducted on public land were less than half the densities recorded during concurrent studies in moist-soil habitats on federal, state, and private sanctuaries (minima $\bar{x} = 32.7 \pm 8.0$ [SE] ducks/ha; Hagy and Kaminksi 2012) and Wetlands Reserve Program lands (minima $\bar{x} = 4.51 \pm 2.05$ [SE] ducks/ha; Fleming 2010) generally hunted ≤2 d/wk in the Mississippi portion of the Mississippi Alluvial Valley. Differences in duck densities among sanctuaries, hunted Wetlands Reserve Program lands, and hunted WMAs are consistent with ducks responding to varying levels of disturbance at a scale larger than that in our study (Hockin et al. 1992; Madsen 1998).

We cannot ascertain that hunting frequency treatments in our study were completely independent, because we imposed both experimental hunting frequencies at each WMA. Dabbling ducks within 200 m of nonhunting disturbances become more alert to, or move away from, the disturbance (Pease et al. 2005; Bregnballe et al. 2009). Shooting disturbances cause ducks to move <5 km, with 15–20% ducks returning to the disturbed areas (Bregnballe and Madsen 2004; Dooley et al. 2010). Therefore, hunting disturbance from areas open 4 d/wk may have decreased duck use of hunt units in the 2 d/wk treatment regardless of being open or closed. Despite potential for interrelationships between treatments, we chose this study design instead of our alternative (i.e., each WMA as a single treatment), which had greater potential to confound results via differences in local conditions (i.e., hunt-unit water levels, hunt-unit size, landscape juxtaposition, food availability, and weather). Thus, we interpret and compare our results with available literature recognizing this potential confounding; and we hope to stimulate additional research on responses of ducks to hunting, which will refine waterfowl hunting management on public areas.

Lifespan and body size of waterfowl have been shown to be inversely related to risk-taking behavior in response to hunting disturbance (Ackerman et al. 2006). We did not detect a difference in species-specific abundance between areas hunted 2 or 4 d/wk, which suggests that number of rest days between hunts may not influence species composition at Mississippi WMAs. Studies of mallards marked with radios have been conducted to determine the time period needed for an individual to return to a disturbed site (e.g., Dooley et al. 2010). Conducting similar studies at Mississippi WMAs, with multiple species of ducks, may enable managers to design hunting regimes that yield greatest hunting and harvest opportunities.

Ducks use spatial sanctuaries more often than temporal sanctuaries (Fox and Madsen 1997). Although we cannot ascertain whether ducks using sanctuaries moved into or within the WMAs, duck use of sanctuaries during both hunting seasons increased 30% during morning surveys regardless if all, part, or none of the WMA was hunted. Our results suggest that ducks may have become conditioned to use spatial sanctuaries during morning hunting hours, regardless of hunting being present or absent within a WMA. Preliminary findings of radiomarked female mallard movements at Muscadine Farms WMA suggest that ducks begin leaving at 0600 hours and return between 1700 and 1900 hours regardless of daily hunting regime (J.D. Lancaster and J.B. Davis, Mississippi State University, unpublished data). Continued monitoring of daily movements and habitat use during hunting and nonhunting periods will provide valuable information to biologists and managers for designing and implementing spatial and temporal sanctuaries on hunted areas (St. James 2011).

Management and Research Implications

Our data indicated that duck abundance did not increase with increased rest days at WMAs in Mississippi, which suggests that these areas may be hunted 4 d/wk with no detectable impact on duck abundance. However, information on how duck abundance and distribution influences harvest and hunter satisfaction is necessary for managers to make informed decisions regarding regulating levels of hunting activity on these WMAs and elsewhere (St. James 2011). Spatial sanctuaries were used regularly by ducks during our study and may be vital to attract and retain ducks on WMAs. To further aid in attracting and retaining waterfowl near public recreation areas, managers also may consider creating partnerships with nearby public and private landowners to increase available temporal and spatial sanctuaries for waterfowl near WMAs. Future research that evaluates individual duck movements by using telemetry within WMAs and other habitats will be essential to determine duck use in relation to various disturbance regimes.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Data S1. Data used for each ANOVA is presented in three spreadsheets: 1) S1—Hunt Unit Abundance, 2) S2—Sanctuary Abundance, and 3) S3—% Change in Sanctuary Use. We also included a spreadsheet entitled "S4-Column Title Descriptions," which provides a detailed description of the column titles for the three spreadsheets containing our data.

Found at DOI: http://dx.doi.org/10.3996/042012-JFWM-034.S1 (239 KB XLS).

Acknowledgments

We thank the Mississippi Department of Wildlife, Fisheries, and Parks for funding our study through the Federal Aid in Wildlife Restoration (Project WR-48-56).

In addition to funding, we thank Kevin Brunke, Shannon Chunn, Scott Edwards, Jackie Fleeman, Wayne Gordon, Lee Harvey, Houston Havens, Bryan Williamson, and Jerry Woods of the Mississippi Department of Wildlife, Fisheries, and Parks for providing field housing, their assistance at hunter check stations, and providing project input. We also thank James Callicutt, Ryan Hardman, Joe Lancaster, Cody Wilson, and Ed Zlonis for their assistance in data collection. We thank Dr. Kevin Hunt for serving as a thesis committee member from which these data originated. Lastly, we thank anonymous reviewers and Subject Editor of the *Journal of Fish and Wildlife Management* for reviewing our manuscript, which has been approved for publication as Mississippi State University, Forest and Wildlife Research Center Publication WFA - 336.

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