Winter Abundance of Waterfowl and Waste Rice in Managed Arkansas Rice Fields

J. Houston Havens,[1] *Department of Wildlife, Fisheries and Aquaculture, Box 9690, Mississippi State University, Mississippi State, MS 39762*

Richard M. Kaminski, *Department of Wildlife, Fisheries and Aquaculture, Box 9690, Mississippi State University, Mississippi State, MS 39762*

J. Brian Davis,[2] *Ducks Unlimited, Inc., 646 Cajundome Boulevard, Suite 180, Lafayette, Louisiana 70506*

Samuel K. Riffell, *Department of Wildlife, Fisheries and Aquaculture, Box 9690, Mississippi State University, Mississippi State, MS 39762*

Abstract: Flooding harvested rice fields in winter provides important ecological services, including benefits to waterfowl, other waterbirds, agronomics, and soil and water conservation. We conducted experiments in six rice fields in Arkansas during winters 2004–2006 to evaluate effects of different post-harvest stubble-management practices and flooding on abundance of dabbling ducks, geese, and waste rice. During both winters, rolled rice paddies attracted the greatest diurnal density of mallards (*Anas platyrhynchos*; $\bar{x} = 4.18$ birds/ha/survey, SE = 0.36). Burned paddies attracted the greatest densities of other dabbling duck species ($\bar{x} = 2.29$ birds/ha/survey, SE = 0.46) and geese ($\bar{x} = 2.88$ birds/ha/survey, SE = 0.97). Paddies with standing stubble contained the most waste rice in late November 2004 ($\bar{x} = 96.83$ kg/ha, SE = 17.99), but geese may have depleted fields of waste rice by late December 2004. Nonetheless, waterfowl continued using rice fields during winter. We recommend managers set head fires after harvest when stubble is dry in rice fields to burn stubble patchily and create an interspersion of cover and open water attractive to waterfowl and other waterbirds during fall and winter flooding. Additionally, we recommend that similar studies be replicated in other rice growing regions of the United States.

Key words: agriculture, ducks, habitat management, Mississippi Alluvial Valley, rice fields, waste rice, waterfowl.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 63:41–46

The Mississippi Alluvial Valley (MAV) is a continentally important region for migrating and wintering waterfowl in North America (Reinecke et al. 1989). The North American Waterfowl Management Plan (NAWMP) and other conservation programs have emphasized the importance of the MAV in providing wintering and migration habitat for North American waterfowl and other birds. Historically, the MAV was a vast bottomland-hardwood ecosystem (>10 million ha) that extended from southern Illinois to southern Louisiana (Fredrickson et al. 2005). Overflows from the Mississippi River and its tributaries regularly flooded the MAV during winter and spring (Reinecke et al. 1988, Reinecke et al. 1989). Flood-management projects since the late 1920s have reduced the extent, frequency, and duration of seasonal flooding in the MAV. Additionally, flood management has facilitated forest clearing and conversion of the MAV from largely lowland forests to croplands (Bonney et al. 1999). Nonetheless, the MAV remains a critical ecoregion for migrating and wintering waterfowl.

Waterfowl have adapted and use agricultural and natural foods in the MAV (Delnicki and Reinecke 1986). Rice is an important cereal crop and food for waterfowl in the MAV (Reinecke et al. 1989, Stafford et al. 2006). Rice fields are used by waterfowl and other waterbirds (Delnicki and Reinecke 1986, Reinecke et. al. 1989), and field infrastructure (e.g., levees, pumps) facilitates flooding fields for these birds (Twedt and Nelms 1999, Manley et al. 2004). Rice provides 3.34 kcal/g (dry mass) in true metabolizable energy for mallards (*Anas platyrhynchos*) which is slightly less than corn (3.67 kcal/g) but greater than soybean (2.65 kcal/g; Reinecke et al. 1989, Kaminski et al. 2003). Additionally, rice resists decomposition when flooded; more than 70% of the mass of rice placed in wetlands during winter persisted after 120 days of flooding whereas ≥80% of soybean mass deteriorated after 90 days (Neely 1956, Shearer et al. 1969, Nelms and Twedt 1996). Clearly, flooding harvested rice fields during winter is a valuable management practice to provide foraging and other habitat for waterfowl and other waterbirds; it benefits farmers by decomposing straw, reducing winter weeds, and generating hunting lease fees; and it improves water quality through sediment filtration and runoff reduction (Nelms and Twedt 1996; Manley et al. 2004, 2005, 2009).

Rice that falls to the ground before or during harvest operations (i.e., waste rice) is an important source of food for waterfowl, and its abundance and that of other agricultural and natural foods are used by the Lower Mississippi Valley Joint Venture to estimate carrying capacity of wintering waterfowl habitat in the MAV (Reinecke et al. 1989, Loesch et al. 1994). However, Manley

1. Present Address: Mississippi Department of Wildlife, Fisheries, and Parks, 1505 Eastover Drive, Jackson, MS 39211.
2. Present Address: Department of Wildife, Fisheries and Aquaculture, Box 9690, Mississippi State University, Mississippi State, MS 39762.

et al. (2004) reported substantial loss of waste rice in Mississippi fields from 492 kg/ha after harvest to <60 kg/ha in early December. Further, in a landscape sample survey of waste rice in the MAV, Stafford et al. (2006) documented a 71% decline in waste rice from time of harvest (271 kg/ha; mid-late September) through late fall (78.4 kg/ha; late November-early December). Increased harvester effectiveness and early planting and harvest contribute importantly to the decline in waste rice during fall. Early planting and harvest increase the number of days in autumn when waste rice is exposed to losses resulting from germination, decomposition, and granivory (Stafford et al. 2006).

Manley et al. (2004) and Stafford et al. (2006) recommended evaluation of post-harvest treatments of rice fields to determine if certain practices would differentially conserve waste rice between harvest and early winter. Kross et al. (2008a) compared abundance of waste rice among five post-harvest management practices used in the MAV (i.e., burning, disking, mowing, rolling, and no manipulation [control]) and found that leaving rice stubble standing or burning it conserved greatest amounts of waste rice. We extended their study and conducted an experiment to examine winter abundance of waste rice and diurnal densities of waterfowl in relation to these post-harvest management practices on a rice production farm in Arkansas (Havens 2007).

Methods

We conducted our study at the Monsanto Farm and Wildlife Management Area, a 1,214-ha area in the Arkansas Grand Prairie, approximately 8 km south of Stuttgart, Arkansas (Arkansas County; 34°30′00″ N, 91°33′04″ W). We selected this site because of regional importance for rice production, wintering waterfowl abundance, and the Monsanto staff's interest and willingness to cooperate. We conducted our experiment in six different harvested rice fields during winters 2004–05 and 2005–06. In falls 2004 and 2005, the staff provided three rice fields for our study in which they could logistically apply our experimental treatments as prescribed without risk of damage from treatments (e.g., fire) described below. We used a randomized complete block design and designated individual rice fields as blocks. We used levees between adjacent paddies within fields to separate randomly assigned post-harvest treatments (Kross et al. 2008a). Farm staff harvested rice fields with a conventional combine and applied treatments to experimental paddies (0.4–4.2 ha) ≤2 weeks after harvest in September 2004 and 2005. Farm staff applied five post-harvest treatments in 2004 (i.e., burning, disking, mowing, rolling [crushing], and no treatment of rice stubble [control]) each to a separate paddy within each of the three different fields. In 2005, staff applied three treatments (i.e., burning, rolling, and no treatment) following the same protocol as in 2004. We did not apply disking and mowing in 2005 because waterfowl responses to these treatments were lowest or intermediate in winter 2004–05, and rice farmers do not routinely mow rice stubble (Havens 2007). Using a combination of rainfall and pumped groundwater, farm staff flooded fields to depths of 10–40 cm in mid-November each year to provide habitat for wintering waterfowl and other waterbirds.

Waterfowl Densities

Using a modified scan sampling technique (Altmann 1974) and a spotting scope from a stationary elevated blind at each of the three rice fields, we conducted diurnal observations of waterfowl to quantify their densities each winter. We made observations of each experimental paddy at intervals of approximately one week, including four survey dates across December 2004 and 2005; three and four dates across January 2005 and 2006, respectively; and one date in February 2005 and 2006 (Havens 2007).

To generate estimates of diurnal use, we observed waterfowl using treated and control paddies in each of three fields each year for one hour in the morning (0700 – 1200 CST) and one hour in the afternoon (1200 – 1700) of each sampling day (i.e., 3 fields x 2 h/day = 6 h/day). We scanned each paddy three times in an alternating sequence during each morning and afternoon sampling period. We calculated the mean density of waterfowl by species as *n* birds/ha (rice paddy)/survey date (hereafter, survey). To ensure observations were distributed equally across diurnal periods and rice fields, we randomly ordered fields for observation from the first sampling day of each winter and rotated the starting field in the sequence for each subsequent sampling day during the remainder of winter. We allowed a "settling time" of 15 minutes from our arrival time at the blind to our first scan, so we could assume we did not disturb any birds present.

Given available data, we analyzed densities (i.e., birds/ha/survey) of three taxa of waterfowl: (1) mallards, (2) other dabbling ducks combined (i.e., American wigeon [*Anas americana*], gadwall [*A. strepera*], American green-winged teal [*A. crecca carolinensis*], northern pintail [*A. acuta*], and northern shoveler [*A. clypeata*]), and (3) snow geese (*Chen caerulescens*) and white-fronted geese (*Anser albifrons*) combined using a factorial repeated-measures analysis. We tested the null hypotheses that variation in duck and goose densities was not influenced by post-harvest treatment, sequential survey number within winters, or the interaction of treatment and survey (PROC MIXED; SAS Institute 1999). We used the small-sample version of Akaike's Information Criterion (AIC_c: Burnham and Anderson 2002) to select the compound symmetry temporal covariance structure (Littell et al. 2006).

Because only three replicate fields were available each year, we expected statistical power for detecting differences among treatments would be low. Therefore, we selected an a priori Type I error rate of $\alpha = 0.10$ which is acceptable for management-related experiments with small sample size (Tacha et al. 1982). To test homogeneity of variances, we performed Levene's test on each response variable (PROC GLM; SAS Institute 1999). When we detected a treatment effect ($P \leq 0.10$), we performed all pair-wise comparisons of means using Tukey's test (Freund and Wilson 2003:256).

Waste Rice Densities

We collected 10 soil core samples (10-cm diameter and depth; 785.4 cm^3) from random points in each treated or control paddy of each field (Stafford et al. 2006, Kross et al. 2008a). We sampled fields in late November 2004 to estimate a baseline abundance of waste rice in experimental paddies and again in late December 2004, late January 2005, and mid-February 2005. We selected sampling periods to encompass the time-frame when rice fields were flooded and could potentially be used by wintering waterfowl. We collected soil cores only in winter 2004–05, because financial resources prevented collection and processing samples in the second year of the study and because harvested rice fields had been previously sampled and waste rice estimated throughout the MAV (Stafford et al. 2006, Kross et al. 2008*a*).

We processed samples following protocols of related studies from our laboratory (Manley et al. 2004; Stafford et al. 2005, 2006; Kross et al. 2008a). We stored samples in a freezer at −10 C until processed. We thawed and soaked samples in a mixture of ≤250 cm^3 of baking soda and ~1 liter of water to oxidize clays. We rinsed samples with water through a series of three graduated sieves (sizes 4 [4.75-mm aperture], 18 [1.0-mm aperture], and 50 [300-µm aperture]) to separate seeds from rice straw and sediments and used a 3% solution of hydrogen peroxide (H_2O_2) to further oxidize and wash clay particles from seeds (Bohm 1979:117). We assumed these solutions did not bias mass of rice seeds in samples because Reinecke and Hartke (2005) and Kross et al. (2008b) found that mass of millet (*Echinochloa* spp.) seeds were not affected by similar techniques. We removed seeds from each sample, dried seeds to constant mass at 87 C for 24 hours, and measured mass to the nearest 0.0001 g.

We calculated mean dry mass (kg/ha) of waste rice based on 10 core samples from each of five experimental paddies in three fields and for each of four sampling periods during winter 2004–05. We used a factorial repeated measures analysis to test the null hypotheses that mean abundance of waste rice at the paddy level was not influenced by field treatment, monthly sampling period, or their interactions (PROC MIXED; SAS Institute 1999). For December 2004 and January and February 2005 waste rice data, we designated the previous month's abundance of waste rice and the current month's combined diurnal duck and goose densities as covariates of paddy-specific rice data. We also included interaction of treatment and each covariate to test if the effect of the covariate varied among treatments (Gotelli and Ellison 2004). When model effects and their interactions were not significant ($P > 0.10$), we deleted them from subsequent analyses.

Because only three replicate fields were available and estimates of waste rice often are variable (Stafford et al. 2006), we expected statistical power to detect differences among treatments would be low. Therefore, we again chose an *a priori* Type I error rate of $\alpha = 0.10$ (Tacha et al. 1982). We used Levene's test to assess homogeneity of variances for each response variable (PROC GLM; SAS Institute 1999). We used the small-sample version of Akaike's Information Criterion (AIC_c: Burnham and Anderson 2002) to select the autoregressive temporal covariance structure (Littell et al. 2006). When we detected a treatment effect ($P \leq 0.10$), we performed all pair-wise comparisons of means using Tukey's test (Freund and Wilson 2003:256).

Results

Waterfowl Densities

Mallards.—Density of mallards varied among surveys in winter 2004–05 ($F_{7, 70} = 3.60$, $P = 0.002$), but we did not detect an effect of post-harvest field treatments ($F_{4, 70} = 1.68$, $P = 0.165$) or an interaction between survey and treatment effects ($F_{28, 70} = 0.60$, $P = 0.932$). In winter 2005–06, density of mallards varied among surveys ($F_{8, 46} = 1.96$, $P = 0.074$) and post-harvest treatment ($F_{2, 46} = 4.35$, $P = 0.019$), but there was no interaction of survey and treatment effects ($F_{16, 46} = 0.62$, $P = 0.851$). Mallard use of rolled paddies ($\bar{x} = 6.07$ birds/ha/survey, SE = 1.27) was nearly five times greater ($t_{46} = 2.83$, $P = 0.019$) than that of paddies with standing stubble ($\bar{x} = 1.32$ birds/ha/survey, SE = 1.27) and nearly three times greater than that of burned paddies ($\bar{x} = 2.46$ birds/ha/survey, SE = 1.27; $t_{46} = -2.14$, $P = 0.092$). We did not detect a difference in mallard density between burned and standing stubble paddies ($t_{46} = 0.68$, $P = 0.775$).

When we combined data for the three treatments applied in both winters (i.e., burned, rolled, or no treatment), we detected an interaction of treatment and year effects ($F_{2, 131} = 3.52$, $P = 0.033$). In both winters, use by mallards of burned or rolled paddies was four times greater than that of paddies with standing stubble (Figure 1).

Other Dabbling Ducks.—For winter 2004–05, we did not detect effects of surveys ($F_{7, 70} = 1.37$, $P = 0.230$), post-harvest treatments ($F_{4, 70} = 1.18$, $P = 0.325$), or their interaction ($F_{28, 70} = 0.92$, $P = 0.585$) on variation in density of dabbling ducks other than

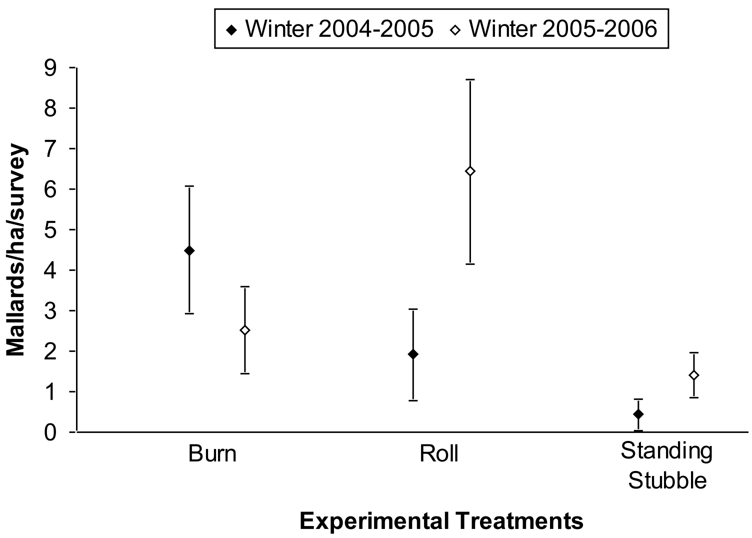

Figure 1. Mean indices (± SE) of diurnal use by mallards (*Anas platyrhynchos*) of rice fields managed with different post-harvest treatments at the Monsanto Farm and Wildlife Management Center, Stuttgart, Arkansas, winters 2004–05 and 2005–06.

mallards. In winter 2005–06, density of other dabbling ducks varied among post-harvest treatments ($F_{2, 46}=11.06$, $P \leq 0.001$), but not among surveys ($F_{8, 46}=1.59$, $P=0.153$) or with the interaction of treatments and surveys ($F_{16, 46}=1.12$, $P=0.365$). Use of rolled paddies in winter 2005–06 by other dabbling ducks ($\bar{x}=0.89$ birds/ha/survey, SE = 0.20) was nearly seven times greater ($t_{46}=4.27$, $P \leq 0.001$) than paddies with standing stubble ($\bar{x}=0.13$ birds/ha/survey, SE = 0.20) and four times greater than that of burned paddies ($\bar{x}=0.21$, SE = 0.20; $t_{46}=-3.84$, $P=0.001$), but we did not detect a difference between burned and standing stubble paddies ($t_{46}=0.44$, $P=0.901$). When we combined data for both winters on density of other dabbling ducks, we detected an interaction of treatment and year effects ($F_{2, 131}=5.86$, $P=0.004$). In both winters, use by other dabbling ducks in rolled or burned paddies was three to seven times greater than that of paddies with standing stubble.

Geese.—We found the combined density of snow and white-fronted geese varied among surveys in winter 2004–05 ($F_{7, 70}=2.78$, $P=0.013$), but we did not detect an effect of post-harvest treatments ($F_{4,70}=1.06$, $P=0.384$) or an interaction of treatment and survey effects ($F_{28, 70}=0.53$, $P=0.970$). We did not observe geese using experimental rice paddies in winter 2004–05 until late December ($\bar{x}=16.94$ birds/ha/survey). Subsequently, goose density was relatively low from early to mid-January 2005 (i.e., <0.03 birds/ha/survey) but increased in late January 2005 ($\bar{x}=4.44$ birds/ha/survey). Density of geese in winter 2005–06 also varied among surveys ($F_{8, 46}=2.38$, $P=0.031$), but we did not detect an effect of post-harvest treatments ($F_{2, 46}=0.16$, $P=0.854$) or an interaction of survey and treatment effects ($F_{16, 46}=0.20$, $P=1.000$). We observed geese using experimental paddies from early December 2005 to early January 2006. Maximum density of geese occurred in early December 2005 ($\bar{x}=12.58$ birds/ha/survey) but then decreased to <1 bird/ha/survey by mid-December 2005 and did not increase subsequently.

When we combined data for both winters, we found that density of geese varied among post-harvest treatments ($F_{2, 131}=2.56$, $P=0.081$), but we did not detect an interaction of treatment and year effects ($F_{2, 131}=1.35$, $P=0.264$). Goose use of burned paddies ($\bar{x}=2.88$ birds/ha/survey, SE = 0.97) in winters 2004–06 was three times greater ($t_{131}=2.05$, $P=0.105$) than that of rolled paddies ($\bar{x}=0.98$ birds/ha/survey, SE = 0.88), but we did not detect a difference in goose use between burned and standing stubble paddies ($\bar{x}=1.03$ birds/ha/survey, SE = 0.88; $t_{131}=1.99$, $P=0.119$) or between rolled and standing stubble paddies ($t_{131}=-0.06$, $P=0.998$).

Waste Rice Densities

We detected neither an effect of the previous month's abundance of waste rice ($F_{1, 14}=1.39$, $P=0.258$) nor an interaction of treatments with this covariate ($F_{4, 14}=2.14$, $P=0.130$). Additionally, we did not detect an effect of the current month's diurnal waterfowl density ($F_{1, 14}=0.00$, $P=0.969$), interactions of treatments with this covariate ($F_{4, 14}=0.88$, $P=0.499$), or an interaction between the two covariates ($F_{1, 14}=0.00$, $P=0.960$). Therefore, we deleted the covariates from subsequent analyses testing effects of treatments, sampling periods, and their interaction.

For winter 2004–05, we detected an interaction of post-harvest treatment and sampling period on variation in waste-rice abundance ($F_{8, 25}=2.05$, $P=0.081$). Averaged across sampling periods, waste-rice abundance in paddies with standing stubble was >1–2 times greater than that in other treatments. Averaged across treatments, abundance of waste rice in late November 2004 was five to seven times greater than in December 2004, January 2005, and February 2005.

Discussion

Although harvested rice fields left in standing stubble during fall in the MAV conserved the greatest abundance of waste rice (Kross et al. 2008a), we observed the greatest densities of waterfowl in paddies that were burned or rolled after harvest and flooded in late fall. Waterfowl may have been attracted to these paddies by the interspersion of rice stubble and open water following flooding. Interspersion of rice stubble and open water may be a proximate cue attracting waterfowl to burned or rolled and flooded rice fields similar to waterfowl and other waterbirds being attracted to natural wetlands with interspersion of live or dead emergent veg-

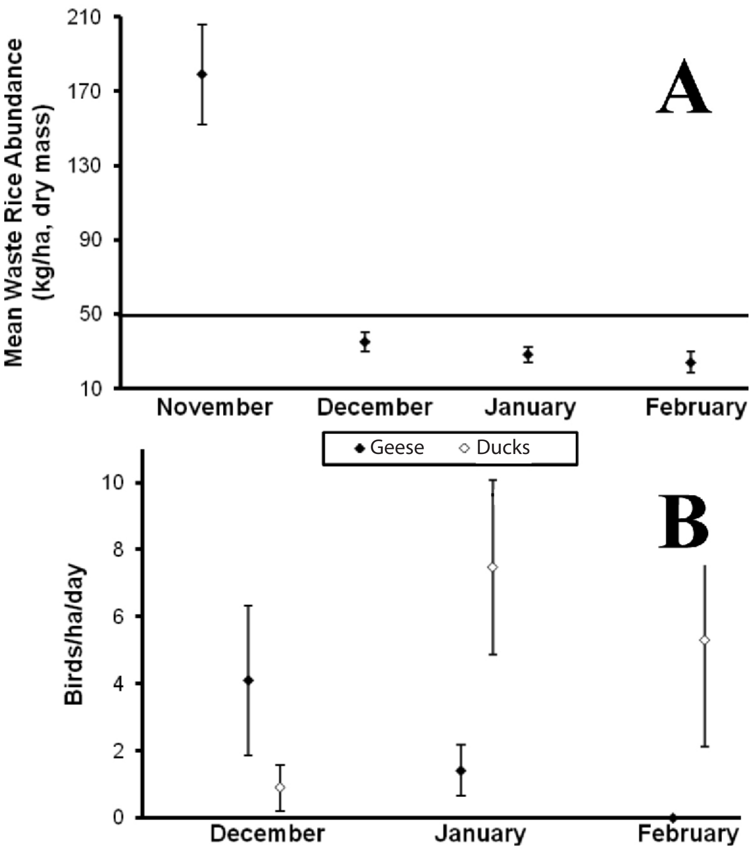

Figure 2. Mean abundance (± SE) of waste rice (A) and indices of diurnal use by waterfowl (B) in rice fields treated with post-harvest management practices at the Monsanto Farm and Wildlife Management Center, Stuttgart, Arkansas, winter 2004–05. Horizontal line at 50 kg/ha (A) represents the hypothesized "giving-up" density at which waterfowl cease foraging in rice fields (Reinecke et al. 1989, Greer et al. 2009).

etation and open water (Kaminski and Weller 1992). Experiments in natural wetlands on waterfowl breeding (Kaminski and Prince 1981) and wintering grounds (Smith et al. 2004) demonstrated that waterfowl were most attracted to manipulated sites that had relatively equal coverage of emergent vegetation and open water (i.e., "hemi-marshes"; Weller and Fredrickson 1973). We did not estimate percent cover of rice stubble and open water in experimental paddies. Nonetheless, our results suggest that patchy distributions of standing stubble and open water in rice fields may have attracted waterfowl. Additionally, open water may facilitate birds landing and swimming through paddies, whereas dense stubble may impede access and movement.

In both winters, we observed little or no diurnal use by mallards and other dabbling ducks of experimental paddies until geese used paddies. Ducks are known to forage in and otherwise use rice fields at night, but our study did not account for nocturnal use by ducks. Because we did not observe any duck feathers or muddy water within paddies before geese arrived, we believe experimental paddies received little or no duck use before the geese. Additionally, live green stems and leaves of rice and stubble protruded through the water densely and reduced the area of open water in paddies. When geese used paddies, they grubbed and trampled vegetation and created open water. Thus, use of rice fields by geese may provide open water and facilitate use by mallards and other dabbling ducks. Furthermore, presence of geese and resulting interspersion of stubble and water may be co-acting proximate cues of potential foraging, refuge, or other habitat.

Although geese may have contributed to attracting ducks to rice fields, we suspect that geese may have reduced availability of waste rice in experimental paddies in winter 2004–05, perhaps even depleting available rice in late December 2004 before most ducks began using the paddies in early January 2005. For example, following heavy use of paddies by geese, but before most ducks began using paddies ($\bar{x}$ <1 duck/ha/day), waste-rice abundance declined in late December 2004 nearly 80% from the late November 2004 level. December 2004 waste-rice abundance was 27% below the "giving-up" density of 50 kg/ha for ducks foraging in rice fields (Figure 2). Reinecke et al. (1989) and Greer et al. (2009) reported ducks cease foraging in rice fields when the density of grain falls below this potential threshold value.

Management Recommendations

When rice stubble dries after harvest, we recommend managers set head fires that burn stubble incompletely, compared to head fires which can consume all stubble fuel. Additionally, fire is a "natural" strategy (*sensu* Weller 1981) that creates interspersion of rice stubble and open water attractive to waterfowl and other waterbirds (Havens 2007); conserves more waste rice than mowing, rolling, or disking stubble (Kross et al. 2008a); costs less than mechanical treatments (Kross et al. 2008a); and remains an accepted agricultural practice in the MAV. Nevertheless, caution should be used when burning rice stubble, and "burn bans" must be observed. Although fields left in standing stubble conserved the greatest abundance of waste rice (Kross et al. 2008a) and provided environmental and agronomic benefits (Manley et al. 2005, Manley et al. 2009), mallards used burned and rolled paddies more than paddies left in standing stubble. When burning rice fields is not feasible or desired, we recommend rolling rice stubble because waterfowl in this study were most attracted to rolled paddies in winter 2005–06. Managers may roll entire fields or strips of stubble and then compare waterfowl use between these approaches. We do not recommend disking or mowing rice stubble because of increased cost and decreased abundance of waste rice and waterfowl use (Kross et al. 2008a, this study). Finally, we recommend studies similar to ours be replicated in other rice growing regions of the United States.

Acknowledgments

We sincerely appreciate financial support from the following sponsors: the Mississippi Department of Wildlife, Fisheries, and Parks (MDWFP); the Monsanto Farm and Wildlife Management Center; the U.S. Department of Interior, Natural Resources Economic Enterprises Research Grant Program; and the Mississippi State University (MSU), Forest and Wildlife Research Center (FWRC). We would like to thank the following Monsanto Company employees for implementing experimental rice field manipulations and for their assistance during our study: Dr. John Anderson, Ray Bohanan, Monty Bohanan, Derek Bohanan, and Shane Roethle. We would also like to thank Ed Penny of the MDWFP for reviewing this manuscript. Our manuscript has been approved as MSU-FWRC publication WF-282.

Literature Cited

Altmann, J. 1974. Observational study of behavior: sampling methods. Behaviour 49:227–267.

Bohm, W. 1979. Methods of studying root systems. Springer-Verlag, Berlin, Germany.

Bonney, R., D. N. Pashley, R. J. Cooper, and L. Niles, editors. 1999. Strategies for Bird Conservation: The Partners in Flight Planning Process. Cornell Lab of Ornithology.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second edition. Springer, New York, New York.

Delnicki, D. and K. J. Reinecke. 1986. Mid-winter food use and body weights of mallards and wood ducks in Mississippi. Journal of Wildlife Management 50:43–51.

Fredrickson, L. H., S. L. King, and R. M. Kaminski, editors. 2005. Ecology and management of bottomland hardwood systems: the state of our understanding. University of Missouri-Columbia, Gaylord Memorial Laboratory Special Publication Number 10, Puxico, Missouri.

Freund, R. J. and W. J. Wilson. 2003. Statistical methods. Second edition. Academic Press, San Diego, California.

Gotelli, N. J. and A. M. Ellison. 2004. A primer of ecological statistics. Sinauer Associates, Inc., Sunderland, Massachusetts.

Greer, D. M., B. D. Dugger, K. J. Reinecke, and M. J. Petrie. 2009. Depletion of rice as food of waterfowl wintering in the Mississippi Alluvial Valley. Journal of Wildlife Management. 73:1125–1133.

Havens, J. H. 2007. Winter abundance of waterfowl, waterbirds, and waste rice in managed Arkansas rice fields. Thesis Mississippi State University, Mississippi State, Mississippi.

Kaminski, R. M., J. B. Davis, H. Essig, P. D. Gerard, and K. J. Reinecke. 2003. True metabolizable energy for wood ducks from acorns compared to other waterfowl foods. Journal of Wildlife Management 67:542–550.

——— and H. H. Prince. 1981. Dabbling duck and aquatic macroinvertebrate responses to manipulated wetland habitat. Journal of Wildlife Management 45:1–15.

——— and M. W. Weller 1992. Breeding habitats of Nearctic waterfowl. Pages 568–589 *In* B. D. J. Batt et al., editors. Ecology and management of breeding waterfowl. University of Minnesota Press, Minneapolis.

Kross, J. K., R. M. Kaminski, K. J. Reinecke, A. T. Pearse. 2008a. Conserving waste rice for wintering waterfowl in the Mississippi Alluvial Valley. Journal of Wildlife Management 72:1383–1387.

———, E. J. Penny, and A. T. Pearse. 2008b. Moist-soil seed abundance in managed wetlands in the Mississippi Alluvial Valley. Journal of Wildlife Management 72:983–994.

Littell, R. C., G. A. Milliken, W. W. Stroup, R. D. Wolfinger, and O. Schabenberger. 2006. SAS for Mixed Models. Second Edition. SAS Institute, Cary, North Carolina.

Loesch, C. R., K. J. Reinecke, and C. K. Baxter. 1994. Lower Mississippi Valley Joint Venture Evaluation Plan. U.S. Fish and Wildlife Service, Lower Mississippi Valley Joint Venture, Vicksburg, Mississippi.

Manley, S. W., R. M. Kaminski, K. J. Reinecke, and P. D. Gerard. 2004. Waterbird foods in winter-managed ricefields in Mississippi. Journal of Wildlife Management 68:74–83.

———, ———, ———, and ———. 2005. Agronomic implications of waterfowl management in Mississippi ricefields. Wildlife Society Bulletin 33:981–992.

———, ———, P. B. Rodrigue, J. C. Dewey, S. H. Schoenholtz, P. D. Gerard, and K. J. Reinecke. 2009. Soil and nutrient retention in winter-flooded ricefields with implications for watershed management. Journal of Soil and Water Conservation 64:173–182.

Neely, W. W. 1956. How long do duck foods last underwater? Transactions of the North American Wildlife and Natural Resources Conference 21:191–198.

Nelms, C. O. and D. J. Twedt. 1996. Seed deterioration in flooded agriculture fields during winter. Wildlife Society Bulletin 24:85–88.

Reinecke, K. J., R. C. Barkley, and C. K. Baxter. 1988. Potential effects of changing water conditions on mallards wintering in the Mississippi Alluvial Valley. Pages 325–337 *in* M. W. Weller, editor. Waterfowl in winter. University of Minnesota Press, Minneapolis.

——— and K. M. Hartke. 2005. Estimating moist-soil seeds available to waterfowl with double sampling for stratification. Journal of Wildlife Management 69:794–799.

———, R. M. Kaminski, D. J. Moorehead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203–247 in L. M. Smith, R. L. Pederson, and R. M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock.

SAS Institute. 1999. SAS/STAT User's Guide. SAS Institute, Cary, North Carolina.

Shearer, L. A., B. J. Jahn, and L. Lenz. 1969. Deterioration of duck foods when flooded. Journal of Wildlife Management 33:1012–1015.

Smith, L. M., D. A. Haukos, and R. M. Prather. 2004. Avian response to vegetative pattern in playa wetlands during winter. Wildlife Society Bulletin 31:474–480.

Stafford, J. D., R. M. Kaminski, K. J. Reinecke, M. E. Kurtz, and S. W. Manley. 2005. Post-harvest field manipulations to conserve waste rice for waterfowl. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 59:155–163.

———, ———, ———, and S. W. Manley. 2006. Waste rice for waterfowl in the Mississippi Alluvial Valley. Journal of Wildlife Management 70:61–69.

Tacha, T. C., W. D. Warde, and E. P. Burnham. 1982. Use and interpretation of statistics in wildlife journals. Wildlife Society Bulletin 10:355–362.

Twedt, D. J. and C. O. Nelms. 1999. Waterfowl density on agricultural fields managed to retain water in winter. Wildlife Society Bulletin 27:924–930.

Weller, M. W. 1981. Estimating wildlife and wetland losses due to drainage and other perturbations. Pages 337–346 *in* B. Richardson, editor. Select Proceedings of the Midwest Conference on Wetland Values and Management. Minnesota Water Planning Board, St. Paul.

——— and L. H. Fredrickson. 1973. Avian ecology of a managed glacial marsh. Living Bird 12:269–291.