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Waterfowl density on agricultural fields managed to retain water in winter

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Abstract Managed water on private and public land provides habitat for wintering waterfowl in the Mississippi Valley, where flood control projects have reduced the area of natural flooding. We compared waterfowl densities on rice, soybean, and moist-soil fields under cooperative agreements to retain water from 1 November through 28 February in Arkansas and Mississippi and assessed temporal changes in waterfowl density during winter in 1991–1992 and 1992–1993. Fields flooded earlier in Arkansas, but retained water later in Mississippi. Over winter, waterfowl densities decreased in Arkansas and increased in Mississippi. Densities of waterfowl, including mallard (*Anas platyrhynchos*), the most abundant species observed, were greatest on moist-soil fields. However, soybean fields had the greatest densities of northern shoveler (*Spatula clypeata*).

Key words abundance, agricultural fields, mallard, Mississippi Alluvial Valley, moist-soil, northern shoveler, private lands, rice, soybean, waterfowl, winter-flooding

Flood control within the Mississippi Alluvial Valley has contributed to the conversion of most forested wetlands to agricultural fields (Korte and Fredrickson 1977, Forsythe 1985, Reinecke et al. 1989). Consequently, much of this land is no longer subject to regular inundation, even if reforested, and wintering habitat for migratory waterfowl has been reduced (Reinecke et al. 1988). The area of flooded habitat during winter influences mallard (*Anas platyrhynchos*) body weight and condition index (Delnicki and Reinecke 1986), population distribution (Nichols et al. 1983), survival (Hepp et al. 1986, Blohm et al. 1987, Reinecke et al. 1987), and ultimately recruitment and population levels (Heitmeyer and Fredrickson 1981). Therefore, wildlife managers on public and private land have undertaken alternative measures to increase area of flooded habitat for waterfowl during winter.

Cooperative efforts of federal, state, and non-government conservation organizations and private landowners have established water management capabilities on agricultural fields by constructing levees and installing water control structures (Reinecke et al. 1989, Baxter et al. 1996). Although these same techniques are used to enhance and re-establish hydrologic regimes on forested lands, opportunities are limited because most privately owned land in the Mississippi Valley has been converted to agriculture. Private landowners participating in these cooperative management efforts agree to retain water—including rain, runoff, and water pumped from surface or groundwater sources—on fields from 1 November through 28 February.

Although cotton, soybean, and rice are the most abundant crops in the lower Mississippi River floodplain (Bellow and Graham 1992), flooded cotton fields offer few benefits to waterfowl because of their limited food resources. In contrast, flooded post-harvest rice and soybean fields, as well as sea-

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sonally flooded herbaceous fields (moist-soil fields), provide valuable foraging habitat for wintering waterfowl. Indeed, about two-thirds (0.60–0.71) of mallards observed during 5 aerial surveys of the Mississippi Alluvial Valley were on these 3 habitats (Reinecke et al. 1992). Rice fields are more frequently flooded under cooperative agreements to manage winter water than are soybean or moist-soil fields because of water control needed for rice production.

To assess the effectiveness of cooperatively managed lands at providing habitat for waterfowl, we quantified waterfowl densities on agricultural fields under cooperative agreements with the United States Fish and Wildlife Service (USFWS) in Arkansas and Mississippi. Specifically, we compared waterfowl densities among rice, soybean, and moist-soil fields and between the states of Arkansas and Mississippi. We also assessed temporal changes in flood condition and in waterfowl density through winter.

Study area

We selected 2 study areas, the Lower Yazoo River Basin in Mississippi and the Grand Prairie in Arkansas (Figure 1), based on high mallard densities during aerial surveys from 1987 to 1990 (Reinecke et al. 1992; M. W. Brown, USFWS, unpublished data) and the number of landowners enrolled with the United States Fish and Wildlife Service in cooperative "private lands" projects (S. E. Mott, USFWS, unpublished data). We obtained study fields through a random selection, with replacement, of enrolled landowners ($n \geq 96$). When selected landowners had multiple fields under cooperative agreements, we chose fields based on our ability to visit them for observations. We selected 60 study fields: 5 rice, 5 soybean, and 5 moist-soil within each of the 2 states, during each of 2 winters (1991-1992 and 1992-1993). We observed 2 of the 60 study fields in both years; in Arkansas, 1 moist-soil field was observed both years, and in Mississippi, 1 study field planted with rice the first year was planted with soybean the second year of study. Because

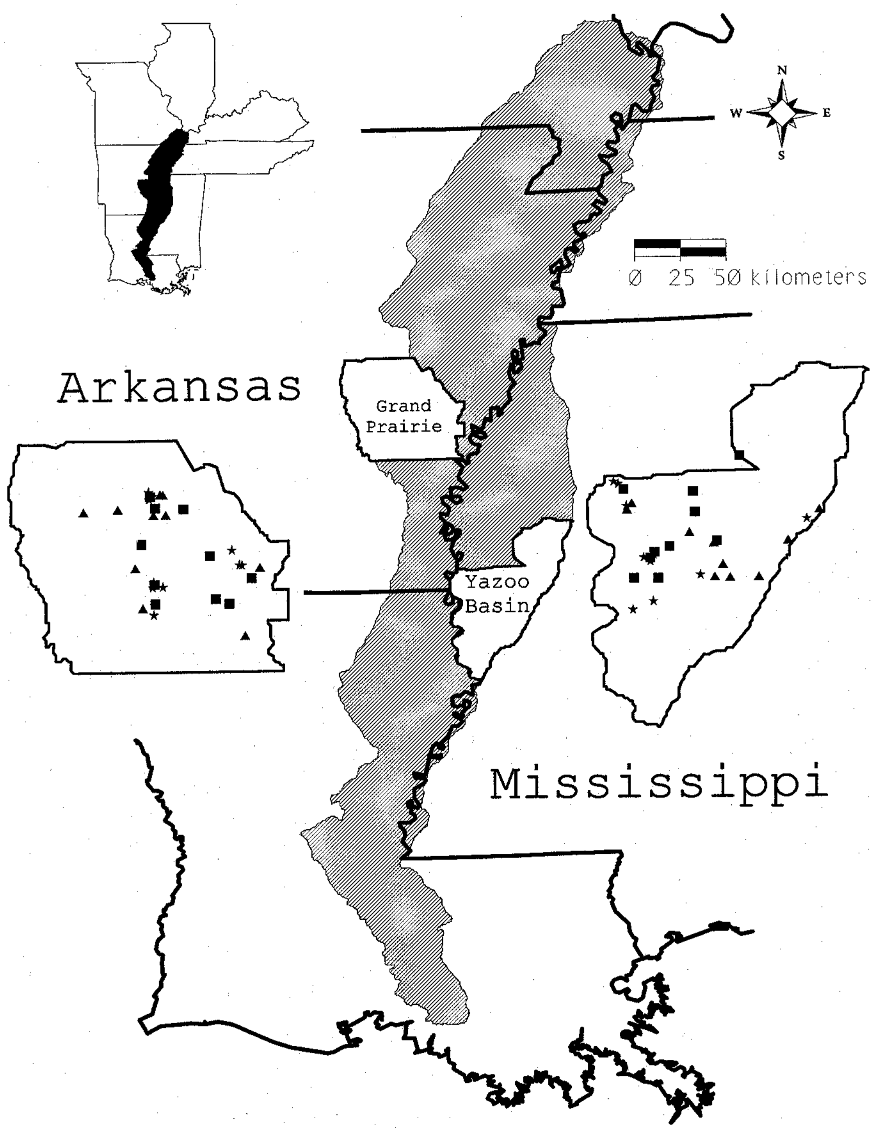

Figure 1. Locations of moist-soil (▲), rice (■), and soybean (✱) study fields in the Yazoo River Basin, Mississippi, and Grand Prairie, Arkansas, in the Mississippi Alluvial Valley (shaded) during winters of 1991–1992 and 1992–1993.

most fields under cooperative agreements were rice fields, we included soybean and moist-soil fields that were not under cooperative agreements but on which water was managed as if they were under such an agreement. Eight moist-soil and 2 soybean fields were located on state or federal wildlife areas; all remaining fields were on privately owned land. Study fields averaged 7 km (range=0 to 29 km) from public wildlife management areas; moist-soil, rice, and soybean fields were 5.6 (SE=1.6), 8.6 (SE=1.6), and 6.5 (SE=1.1) km, respectively. We determined areas of fields from GPS coordinates superimposed on satellite (TM) imagery.

Methods

Beginning 15 November, we censused study fields twice during each of 9 consecutive, 2-week observation periods, or 18 visits/field. However, we made only 1 visit to all study fields in Arkansas during the observation period 9 of 1991-1992 and to 1 moist-soil field during all periods of 1992-1993. We counted waterfowl (by species) using binoculars or spotting scopes. We ocularly estimated the percentage of each field inundated by water to the nearest 10% on each visit. Within each state, we visited 15 study fields annually in a systematic sequence along survey routes. To prevent bias in the time when we visited fields, we randomly selected the date (within each observation period) and time when we began each survey route. Each field was entirely censused during a single visit. If we could not census a field before dark, the survey route was interrupted and resumed at the same location the following dawn. We converted numbers of waterfowl counted on fields during each visit to densities (number of waterfowl/flooded ha).

Because densities were not normally distributed, we performed analysis of variance (ANOVA) on the normalized ranks of these densities (Blom 1958). In the ANOVA, we examined differences between 2 states, between 2 years of study, and among 3 habitats (crop types) using 5 fields (experimental units)

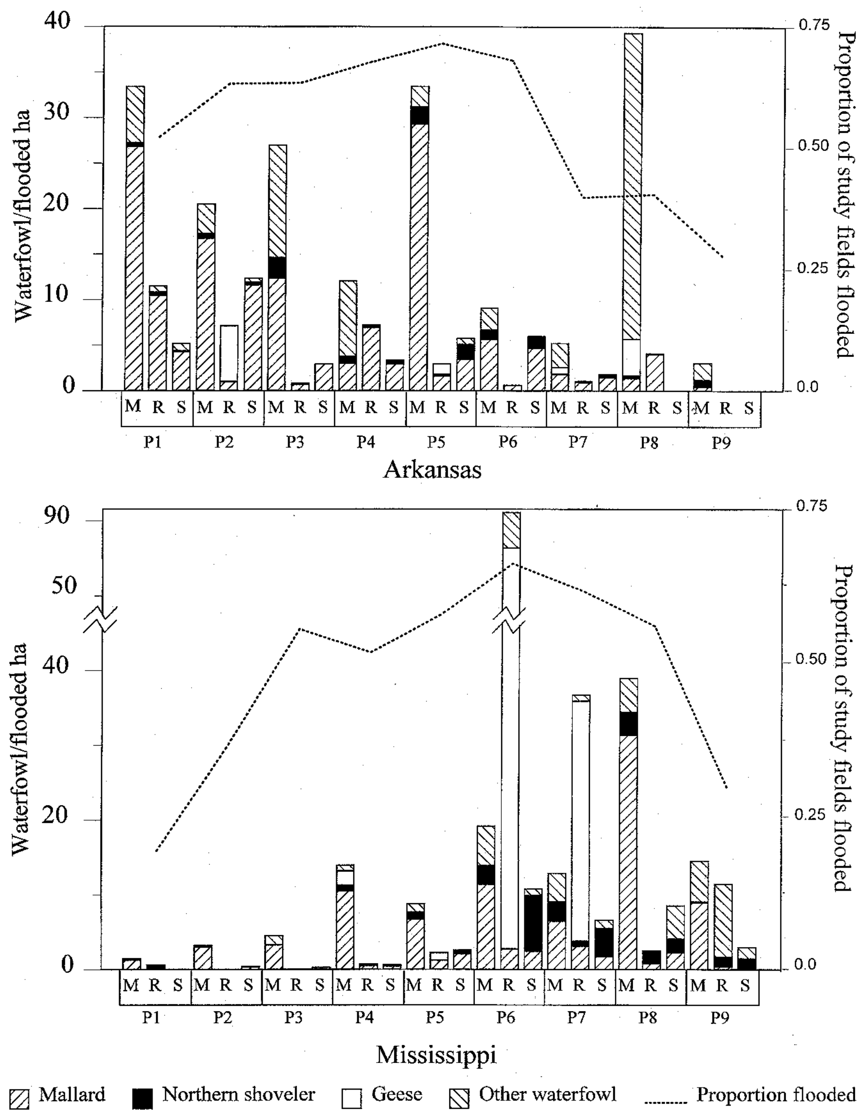

Figure 2. Densities (waterfowl/flooded ha) of mallard, northern shoveler, and other waterfowl (ducks, geese, and coots) observed on moist-soil (M), rice (R), and soybean (S) fields within the Yazoo River Basin, Mississippi, and the Grand Prairie, Arkansas, during 9 consecutive, 2-week periods (P1 through P9) beginning 15 November 1991–1992 and 1992–1993 and mean proportion of all study fields flooded (dotted line).

within each state-year-habitat combination; we examined differences among the 9 observation periods using 2 visits within each period. Observation periods and visits were treated as repeated measures (Milliken and Johnson 1984). When significant interaction terms warranted, we used specific contrast statements within the overall ANOVA to make comparisons within the interactions. Where appropriate, the comparisons made via contrast statements included comparisons between the 2 states, pairwise comparisons between the 3 crop types (soybean vs. moist-soil, moist-soil vs. rice, and rice vs. soybean), and a test for linear trend across observation periods. We conducted 3 separate ANOVAs, 1 for each of the 2 most numerous species (mallard and northern shoveler [*Spatula clypeata*]) and 1 for all other waterfowl (ducks, geese, and coots).

In addition to observing study fields, while traveling between fields we recorded the location of all flooded non-study fields and numbers of waterfowl on them.

Results

Mean area of moist-soil fields (12 ha, range=2 to 39) was less than half the area of rice fields (26 ha, range=4 to 64) or soybean fields (26 ha, range=3 to 91). All study fields retained rainfall or runoff for floodwater, whereas groundwater was pumped onto 1 rice field in Arkansas to provide water early in November. Because of within-field elevation differences, presence or absence of levees in field interiors, and differential rainfall, proportion of flooding among and within fields varied over winter. Fields in Arkansas and Mississippi, however, were at 50–70% of their maximum flood potential from mid-December through mid-February. Flooding was greater in Arkansas early in the winter, but Mississippi fields held as much or more water during late winter (Figure 2).

Differences in waterfowl densities between states over winter

Significant interactions among state, year, and observation period ($F_{8,384}>2.21$, $P<0.02$) indicated that mallard, northern shoveler, and other waterfowl used flooded fields differently in each state in winter. Mallard densities were significantly greater ($F_{1,32}=14.23$, $P<0.01$) in Arkansas (9.8 mallard/flooded ha, SE=2.5) than in Mississippi (0.9 mallard/flooded ha, SE=0.4) during early winter. Through winter, however, mallard densities increased significantly ($F_{1,384}>7.29$, $P<0.01$) in Mississippi and decreased in Arkansas (Figure 2), such that mallard densities did not differ between states during mid- or late winter ($P>0.11$).

Northern shoveler densities (Figure 2) increased through winter in Mississippi ($F_{1,384}=28.10$, $P<0.01$), but not in Arkansas ($P=0.69$). By late winter, shoveler densities were greater ($F_{1,32}>3.70$, $P<0.06$) in Mississippi (1.8 shoveler/flooded ha, SE=0.4) than in Arkansas (0.2 shoveler/flooded ha, SE=0.1).

Densities of other waterfowl (Figure 2) were significantly greater in Arkansas (3.2 waterfowl/flooded ha, SE=1.4) than in Mississippi (0.2 waterfowl/flooded ha, SE=0.1) during early winter ($F_{1,32}=4.63$, $P=0.04$), but densities increased linearly ($F_{1,384}=37.66$, $P<0.01$) in Mississippi through winter such that densities did not differ between states during mid- or late winter ($F_{1,32}<1.07$, $P>0.31$).

Waterfowl densities vary among crop types

Mallard densities (Figure 2) differed among crop types ($F_{2,48}=6.09$, $P<0.01$). Density of mallards (10.3/flooded ha, SE=1.9) on moist-soil fields was greater than on either soybean or rice fields ($P<0.01$). Mean mallard density on soybean fields (2.3/flooded ha, SE=0.4) also was greater ($P<0.01$) than on rice fields (2.0/flooded ha, SE=0.7).

Mean densities of northern shoveler were 1.0 (SE=0.7), 0.3 (SE=0.1), and 1.1 (SE=0.3) shoveler/flooded ha for moist-soil, rice, and soybean fields, respectively, but we found significant variation ($F_{16,384}=2.03$, $P=0.01$) among crop types through winter (Figure 2). During midwinter, northern shoveler densities on soybean fields (1.9/flooded ha, SE=0.7) were greater ($F_{1,32}=14.72$, $P<0.01$) than on rice fields (0.1/flooded ha, SE=0.5). Northern shoveler densities increased significantly ($F_{1,32}=5.84$, $P<0.02$) through winter on moist-soil and soybean fields, but not on rice fields ($P=0.09$).

During 1992–1993, densities of other waterfowl varied among crop types ($F_{2,48}=3.88$, $P=0.03$); densities of other waterfowl on moist-soil fields (6.7/flooded ha, SE=4.0) were greater ($F_{1,48}>4.83$, $P<0.03$) than on soybean fields (0.9/flooded ha, SE=0.4) or on rice fields (0.3/flooded ha, SE=0.2). During 1991–1992, densities of other waterfowl differed similarly among crop types, but only in Arkansas ($F_{2,48}=10.55$, $P<0.01$).

Discussion

Greater flooding in Arkansas during early winter probably accounted for greater numbers of mallards and other waterfowl in that state. Differences in the area of flooding on study fields were corroborated by seasonal changes in number of flooded non-study fields observed (Figure 3). Over winter, the decline in the proportion of fields flooded in Arkansas and the increasing proportion of fields flooded in Mississippi are reflected in declining waterfowl densities on Arkansas fields and increasing densities on Mississippi fields. These temporal shifts culminated in greater densities of mallard, northern shoveler, and other waterfowl on Mississippi fields during late winter. The numbers of waterfowl we observed on non-study fields reflected waterfowl densities we observed on study fields (Figure 3). Similar temporal shifts in the distribution of mallards within a winter were noted by Reinecke et al. (1992), probably in response to changing flood conditions.

In 5 aerial surveys of managed and unmanaged lands in the Mississippi Alluvial Valley, Reinecke et al. (1992) found the greatest proportion of mallards on rice fields (0.30), followed by soybean fields (0.25) and moist-soil (0.11). These data on mallard abundance are related inversely to the mallard densities we found on cooperatively managed lands; flooded moist-soil had 10.3 mallard/flooded ha, followed by soybean (2.3 mallard/flooded ha), and rice (2.0 mallard/flooded ha).

Several factors probably account for this relationship between abundance and density. On moist-soil fields, foraging opportunities, in terms of abundance and diversity of seeds and invertebrates, may be greater than on flooded, harvested crop fields (Fredrickson and Taylor 1982, McAbee 1994). Additionally, moist-soil fields are often managed specifically to attract waterfowl and thus hold more water for a longer time period. The limited availability of moist-soil fields, however, is probably responsible for the lower proportion of the mallard population on these areas, while concurrently contributing to greater densities of waterfowl.

Although overall densities on rice and soybean fields were less than on

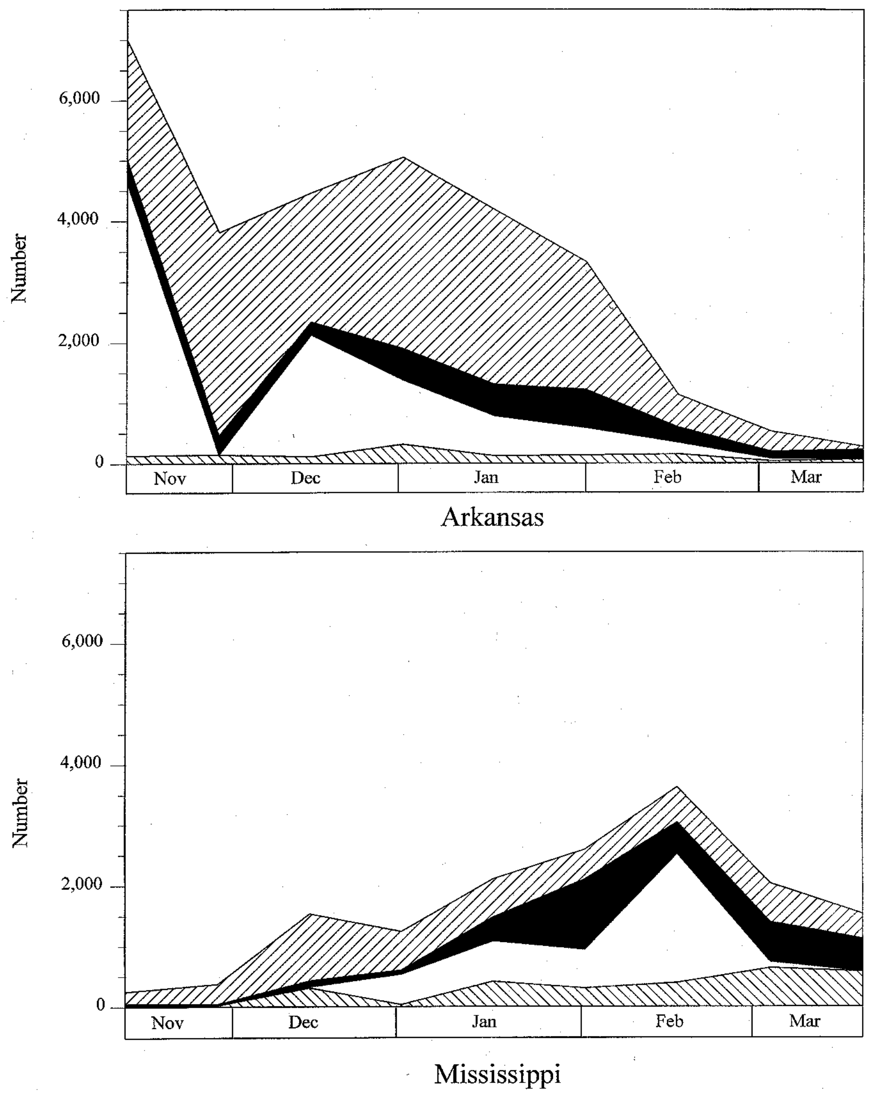

Figure 3. Numbers of waterfowl and number of flooded fields observed on non-study fields within the Yazoo River Basin, Mississippi, and the Grand Prairie, Arkansas, during winters of 1991–1992 and 1992–1993.

moist-soil fields, these flooded, harvested crops were used more than moist-soil by specific species or during specific winter periods. For example, northern shoveler densities were greater on soybean fields than on other crop types during midwinter. Although densities were less on rice, flooded rice was the most abundant habitat available to waterfowl. The regional importance of flooded harvested rice is illustrated by the fact that 55% of all non-study fields observed harboring waterfowl were rice fields and 64% of all waterfowl observed on non-study fields were on rice fields. Further, Reinecke et al. (1992) suggest that the proportion of mallards (0.29–0.39) they observed on rice fields in the Mississippi Alluvial Valley was predominantly on lands managed for waterfowl. Thus, the lower densities we found on rice fields may in part reflect the greater abundance of this crop type within the study area.

Management implications

As of 1995, about 15,000 ha in Arkansas and 25,000 ha in Mississippi were managed to retain water under cooperative agreements. Using conservative estimates of the proportion of this area flooded during winter (0.50) and the least density among crop types (4.0 total waterfowl/flooded ha), these cooperatively managed lands provide wintering habitat for more than 80,000 waterfowl.

Although waterfowl used all flooded crop types over winter, we found that the area of flooding on managed lands influenced waterfowl densities similar to reported increases in mallard abundance with increases in the area of naturally flooded cropland (Reinecke et al. 1992). Thus, increasing the area of shallowly flooded land is paramount in providing wintering habitat for waterfowl. Analyses of classified thematic-mapper satellite data (Twedt 1996) indicate that in the Yazoo Basin, the proportion of land in potential moist-soil, soybean, and rice is 0.08, 0.16, and 0.05, respectively; in the Grand Prairie, these proportions are 0.06, 0.31, and 0.19, respectively. With the possible exception of rice in the Grand Prairie, only a small fraction of each of these habitats is managed to provided waterfowl habitat during winter. Winter flooding of only 10% of each of these habitats would result in nearly 60,000 ha of waterfowl habitat.

We recognize the practical limitations of land uses, such as moist-soil, that do not produce income. However, conservation efforts, such as the Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP), provide incentives for landowners to increase the area of moist-soil habitat. Also, lands that are of marginal value for crop production could be converted to moist-soil management. Once converted, marginal farmlands may be of equal or greater value to landowners through commercial hunting opportunities (e.g., Yarrow and Guynn 1990).

In the short-term, however, the potential to increase winter-flooded habitat is greatest on rice and soybean fields. The aforementioned requisite water-holding capabilities associated with rice cultivation give this crop the most potential. Zero-grade and near-zero-grade land forming practices for improved water conservation and reduced cost of crop production are becoming more common in the Mississippi Alluvial Valley. These land-formed fields minimize the annual cost of managing water for waterfowl, thereby increasing flooding opportunity. Finally, because of the relatively great proportion of cultivated land in soybean production and the agronomic benefit of rotating soybean with rice, we encourage winter flooding of soybean fields.

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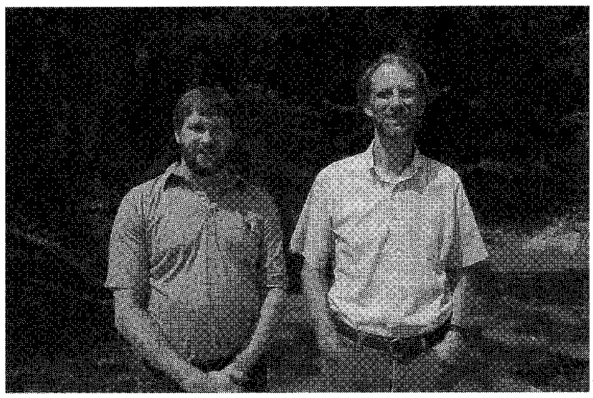

Daniel J. Twedt (right) is a wildlife biologist with United States Geological Survey's Patuxent Wildlife Research Center at Vicksburg, Mississippi. He received an M.S. degree in biology from Western Kentucky University for his work on starling ecology and a Ph.D. from North Dakota State University for his studies on yellow-headed blackbirds. His areas of interest include avian ecology, forest and wetland breeding birds (distributions-habitat use-productivity), and statistical methodologies. His current research projects focus on the impact of bottomland hardwood restoration on forest breeding birds within the Mississippi Alluvial Valley. ***Curtis O. Nelms*** (left) was a biologist with the National Wetlands Research Center at Vicksburg, Mississippi, at the time this study was conducted. He completed undergraduate studies in wildlife management at the University of Florida and received an M.S. degree in zoology from North Dakota State University. Later, while working as a biologist for the United States Fish and Wildlife Service in Mississippi and Utah, Curtis died from a heart attack while pursuing his favorite activity, duck hunting.

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