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## Abstract

Approximately 500,000 shorebirds travel through the Mississippi Alluvial Valley (MAV) each spring and fall. During migration, the average 45 g shorebird needs to eat approximately 8 g of invertebrates per day. While shorebird stopover habitat guidelines for the MAV are based on an expert estimate of 2 g of invertebrates/$m^2$, this estimate has not been quantified in Arkansas. Invertebrate biomass available for shorebird foraging was examined on five properties in southeastern Arkansas during spring and fall migration (fall 2010, spring and fall 2011, and spring 2012).

Macroinvertebrate biomass was less than the estimated 2 g/$m^2$ in three of the four sampled seasons. Further validation of the expert invertebrate biomass estimate should be undertaken in the other regions of the MAV. These results suggest that current land management of shorebird stopover habitat in southeastern Arkansas is not providing adequate invertebrate forage to reach the current habitat management goals.

## Introduction

Land managers in the Mississippi Alluvial Valley (MAV) face the challenge of providing stopover sites to approximately half a million shorebirds each fall and spring (Loesch et al. 2000). Migrating shorebirds forage on aquatic and benthic macroinvertebrates along with small amounts of terrestrial macroinvertebrates, small fish, and some plants (Lehnen and Krementz 2007, Mitchell and Grubaugh 2005, Skagen and Oman 1996). Invertebrate abundance is considered to be more important to shorebirds than species composition because migrating shorebirds are highly flexible in their prey selection (Lehnen and Krementz 2007, Mitchell and Grubaugh 2005, Skagen and Oman 1996). This flexibility in prey selection is due to the high variability of available habitat from year to year, requiring shorebirds to be adaptive in their response to changing prey availability (Davis et al. 2005, Davis and Smith 1998, Mitchell and Grubaugh 2005).

Foraging habitat in the MAV is generally more abundant during spring migration than fall migration because of natural hydrology, flooding of rice fields, and spring rains (Loesch et al. 2000). Fall migration, however, occurs when seasonal precipitation is at its lowest, and when rice fields are drained to facilitate harvest. This dichotomy has led to the identification of the fall migration period as the time of most concern for shorebird stopover habitat management by Partners in Flight (PIF). PIF suggests that shorebird management objectives are most easily met on public lands that are currently managed for waterfowl (Loesch et al. 2000). Ensuring management compatibility among shorebirds, early migrant waterfowl, and late migrant waterfowl is of great concern (Loesch et al. 2000).

An average shorebird needs approximately 6 g of invertebrate forage daily in order to maintain its body mass (Loesch et al. 2000). An additional 2 g must be consumed daily to balance the increased energy requirements of migration. PIF used an expert estimate of 2 g of invertebrates/$m^2$ to calculate that the average migrating shorebird required 4 $m^2$ of foraging habitat per day (Loesch et al. 2000). Following these habitat need estimates, PIF recommended a total of 2000 ha of foraging habitat are required to support the estimated 500,000 shorebirds migrating through the MAV (Loesch et al. 2000).

Further research and validation is needed throughout the MAV. Little quantitative work has been done to validate the PIF estimate with regards to benthic communities and available biomass in the MAV (Augustin et al. 1999). The objective of this study is to determine whether public and private lands in SE Arkansas are meeting the PIF estimate of available invertebrate forage.

## Materials and Methods

Each site was visited weekly during the sampling period. In fall 2010, sampling took place from 25 August to 13 October though the actual migration period began approximately 2 weeks earlier. In spring 2011, sampling took place from 24 March to 19 April. In fall 2011, sampling took place from 11 August to 29 September. Finally, in spring 2012, sampling took place from 13 March to 12 April (Table 1).

Four randomly selected substrate samples were collected at each site each week with a 10 cm diameter core sampler (Miller and Bingham 1987). Substrate samples 5 cm deep were collected to sample the depth of substrate available to most shorebirds (Piersma 1987, Sherfy et al. 2000). Two substrate samples were taken in the water < 10 cm in depth and two substrate samples were taken above the waterline on the mudflat. Since different species of shorebirds forage in different areas (for example, some forage only in the water, some forage only on mudflats, some forage on the waterline) this allowed for better coverage of the range of shorebird foraging habitat. Samples were preserved in the field with a 70% ethanol solution. Invertebrates were hand sorted then dried at 60 degrees Celsius for 24 hrs (Augustin et al. 1999, Sherfy et al. 2000). Samples were weighed to the nearest 0.001 g to establish available biomass (Augustin et al. 1999, Sherfy et al. 2000).

Fall 2011 invertebrate biomass was log-transformed in order to meet assumptions of homogeneity and normality (Augustin et al. 1999). Data from all other seasons met assumptions of homogeneity and normality. The one-sample, one sided Student's *t*-test was used to compare each site's mean invertebrate biomass to the PIF's 2 $g/m^2$ estimate (Loesch et al. 2000). Single factor ANOVAs were used to detect differences in mean invertebrate biomass both among sites in each season and weekly mean invertebrate biomass at each site in each season (Andrei et al. 2008). If weekly means were found to be different ($P < 0.05$), a Tukey's multiple comparison test was used (Augustin et al. 1999).

Sampling of all sites except Five Oaks took place during the spring and fall migration periods over two years. Five Oaks was sampled during spring 2011, fall 2011, and spring 2012. Each season's sampling began when migratory species began to be reported by observers on the eBird.org database, and ceased when no migratory species were observed at any study site (Sullivan et al. 2009).

Five management areas in southeastern Arkansas were sampled. The Bob White Memorial Wetlands Research and Teaching Station (BWMW) is located in Chicot County, Arkansas. The property originally was used for agriculture, but was enrolled by the Natural Resources Conservation Services in 2002-2003 as a permanent Wetland Reserve Program easement (Whittsit and Tappe 2009). Current vegetation includes cattails (Typha spp.), Eastern Baccharis (Baccharis halimifolia), and hardwood saplings. The study site at BWMW consisted of a 1.8 ha pond and was not actively managed.

Five Oaks is a private hunting club managed by Five Oaks Wildlife Services in Arkansas County, Arkansas. The study site consisted of a 5.2 ha impoundment, managed to mimic the natural hydrology of the area; flooding in winter and spring and slow drying through summer and fall. No vegetation was planted, and the site had minimal moist soil plants.

Overflow National Wildlife Refuge (Overflow NWR) is located in Ashley County, Arkansas. Overflow NWR covers approximately 5260 ha of wetlands consisting of bottomland hardwoods, seasonally flooded impoundments, and greentree reservoirs. The impoundments at Overflow NWR were alternately leased for agriculture and managed for shorebirds and waterfowl. Three impoundments were sampled over the course of this study due to changes in which impoundments were under waterfowl and shorebird management

Table 1. Timeline and sampling area size (ha) on each site during each migration season.

| Site | Fall 2010 | Spring 2011 | Fall 2011 | Spring 2012 |
|---|---|---|---|---|
| BWMW | 1.8 | 1.8 | 1.8 | 1.8 |
| Five Oaks | X | 5.2 | 5.2 | 5.2 |
| Halowell | 0.6 | 8.5 | 8.5 | 8.5 |
| Overflow NWR | 53.3 | 6.0 | 6.0 | 11.6 |
| Wrape | 15.6 | 15.6 | 15.6 | 15.6 |

## Results

Only BWMW and Halowell Reservoir in fall 2010, and Overflow NWR and the Wrape Plantation in spring 2012 had invertebrate biomasses that were not less than the PIF estimate of 2 $g/m^2$. Of the overall season mean invertebrate biomass, only fall 2010 was

not less than the 2 g/m$^2$ estimate (Table 2). During fall 2010 and fall 2011, no invertebrates were collected at Overflow NWR because the impoundment was completely dry.

No difference in invertebrate biomass was detected among sites in fall 2010 (P = 0.7383), spring 2011 (P= 0.4289), or spring 2012 (P = 0.0792). Invertebrate biomass at BWMW was over three times greater than any of the other sites in fall 2011 (P = 0.0042).

In all seasons, only BWMW and Halowell Reservoir in fall 2010, and Overflow NWR and the Wrape Plantation in spring 2012 were not less than the PIF estimate of 2 g/m$^2$. Of the overall season mean invertebrate biomass, only fall 2010 was not less than the 2 g/m$^2$ estimate (Table 2).

Table 2. Mean invertebrate biomass of each site during each season, and overall mean season invertebrate biomass in g/m$^2$ ± SE. T-test p-value results testing for biomass ≥ 2.0 g.

| Site | Mean Invertebrate Biomass | P-Value |
|---|---|---|
| | Fall 2010 | |
| *Overall* | 1.45 ± 0.37 | (P = 0.0685) |
| BWMW | 1.50 ± 0.61 | (P = 0.2105) |
| Five Oaks | X | X |
| Halowell | 1.84 ± 0.79 | (P = 0.4216) |
| Overflow NWR | X | X |
| Wrape | 1.05 ± 0.50 | (P = 0.0342) |
| | Spring 2011 | |
| *Overall* | 0.98 ± 0.14 | (P < 0.0001) |
| BWMW | 0.39 ± 0.09 | (P < 0.0001) |
| Five Oaks | 1.17 ± 0.46 | (P = 0.0093) |
| Halowell | 0.41 ± 0.12 | (P < 0.0001) |
| Overflow NWR | 0.85 ± 0.37 | (P = 0.0020) |
| Wrape | 1.13 ± 0.57 | (P = 0.0317) |
| | Fall 2011 | |
| *Overall* | 0.79 ± 0.27 | (P < 0.0001) |
| BWMW | 2.78 ± 0.91 | (P = 0.0520) |
| Five Oaks | 0.78 ± 0.39 | (P < 0.0001) |
| Halowell | 0.18 ± 0.09 | (P < 0.0001) |
| Overflow NWR | X | X |
| Wrape | 0.16 ± 0.11 | (P < 0.0001) |
| | Spring 2012 | |
| *Overall* | 0.99 ± 0.22 | (P < 0.0001) |
| BWMW | 0.16 ± 0.11 | (P < 0.0001) |
| Five Oaks | 0.18 ± 0.02 | (P < 0.0001) |
| Halowell | 1.13 ± 0.35 | (P = 0.0224) |
| Overflow NWR | 1.59 ± 0.27 | (P = 0.1438) |
| Wrape | 1.87 ± 0.99 | (P = 0.8981) |

## Discussion

In three of the four sampling seasons, the average available invertebrate biomass was less than the 2 g/m$^2$ Partners in Flight (PIF) recommendation. Using the average invertebrate biomass of both fall seasons (1.18 g/m$^2$), the estimate of needed shorebird foraging habitat in Arkansas increases from 520 ha to 881 ha, a 69.5% increase. However, Augustin et al. (1999) concluded that the invertebrate biomass of their study sites (2.15 to 5.74 g/m$^2$) in western Tennessee were comparable to the PIF model requirements. Mitchell and Grubaugh (2005) found an average invertebrate biomass of 3.43 g/m$^2$ on their sites throughout the Lower MAV (Arkansas, Mississippi, and Louisiana), although the biomass ranged from less than 0.1 g/m$^2$ to 24.4 g/m$^2$.

In three of the four sampling seasons, the average available invertebrate biomass was less than the 2 g/m$^2$ PIF estimate (Augustin et al. 1999). The MAV covers approximately 10 million ha in seven states; using one estimate of highly variable factor such as invertebrate biomass to make habitat recommendations for the entire MAV may lead to overestimation of habitat needs in one area while underestimating needs in another (Smith et al. 1989).

Further validation of the PIF invertebrate biomass estimate should be undertaken in the other regions of the MAV. Whether the shortfalls found in this study were due to natural drought conditions, lack of funding for management activities, or the failure of waterfowl focused management to provide adequate fall stopover habitat for shorebirds, it is clear that habitat goals for southeastern Arkansas should be reassessed by Partners in Flight.

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