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# How Does the Creation of Temporary Wetland Habitat on Agricultural Fields in the Mississippi Alluvial Valley Affect the Abundance of Migratory Shorebirds?

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# HOW DOES THE CREATION OF TEMPORARY WETLAND HABITAT ON AGRICULTURAL FIELDS IN THE MISSISSIPPI ALLUVIAL VALLEY AFFECT THE ABUNDANCE OF MIGRATORY SHOREBIRDS?

A Thesis
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in the Department of Biology
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by
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# ABSTRACT

Although the causes of broad population declines of migratory shorebirds are not well understood, it is likely that loss of migratory stopover habitat is a contributing factor. In the Lower Mississippi Alluvial Valley (LMAV), much of the historical stopover sites have been converted to agricultural land. To combat this dearth, we have incentivized farmers to create temporary wetland habitat on shallowly flooded corn and soybean cropland in the LMAV during the fall after harvest. In a two-year study, shorebird surveys were completed bi-weekly on employed farm sites to determine the abundances of shorebirds present on five different temporal flood treatments repeated on four farm sites, and a sister study quantifying chironomid abundance and biomass happened simultaneously to determine associations between bird and invertebrate abundances. Additionally, shorebirds were captured and radio-tagged to determine stopover duration and ultimately total numbers of individual shorebirds visiting during a field season. In the fall, shorebirds were significantly more abundant on actively flooded fields vs dry control, passive, or winter fields. During the winter, abundances were significantly higher on the two active flooded fields than the control, but only the field actively flooded for a longer duration had significantly higher abundances than all other treatments. Shorebirds and chironomids were positively associated across both seasons. Shorebird stopover durations were longer based on our radio data than prior estimates for certain species in the same region, but the cause of this extension is unknown. Based on these results, it is recommended that flooding fields post-harvest in the fall is important for attracting the highest abundances of shorebirds during a time of need. Further, there seems to be a positive implication of flooding early and holding water on a field into the winter. Working cooperatively with farmers can help all involved parties meet their needs most efficiently, and flooding multiple adjacent parcels of land may create the most optimal stopover conditions for shorebirds.

# ACKNOWLEDGEMENTS

Thanks to the Environmental Protection Agency for awarding the Farmer to Farmer Grant (award # 02D01321) to support the larger project of which this study was a part, as well as the State Wildlife Grant from the State of Mississippi to Delta Wind Birds, to help support the radio-tagging project. All participating farmers together provided hundreds of acres of shorebird habitat. I thank my advisor, Dr. Jason Hoeksema, for his spectacular guidance and grace, as well as my committee members, Dr. Richard Buchholz and Dr. Lainy Day for their input on the project. Additionally, thanks to my friends Dr. Jason Taylor and Victoria Simek at the USDA Sedimentation Laboratory for their mentorship and positive spirits.

My older brother, Adam, passed away far too young during the second year of this project. His unending friendship and support have allowed me to become the person I am today to execute this study. For this, I thank him.

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# INTRODUCTION

Shorebirds (Aves: Charadrii) are a group of largely migratory birds with numbers worldwide declining for several reasons, including degradation and loss of stopover habitat (Golet et al., 2018). These stopover habitats are crucial during the birds' migratory journeys in the spring and fall where individuals feed intensively (hyperphagia) to fuel for the completion of their journey, affecting their overall health and ability to reproduce in the breeding season (Helmers, 1992, Colwell, 2010). In the Mississippi Delta region, stopover habitat is particularly limited in the fall, when rainfall is sparse and many water sources have evaporated during the summer (Twedt et al., 1998). This project seeks to understand how to effectively create temporary wetland stopover habitat for migratory shorebirds by flooding corn and soybean cropland post-harvest in the Mississippi Delta during the fall and winter.

The causes for global declines of migratory shorebird populations, which are more severe for some species than others, are not fully known, but the annual cycles and migratory behaviors of these birds can pose several threats to their survival. Many shorebird species are long distance migrants, completing unparalleled, arduous flights ranging from 12,000 to 25,000 km (Morrison, 1984) twice a year. During both spring and fall migration in the western hemisphere, high quality stopover habitat is critical for the birds to forage intensively and effectively to complete the journey to their breeding grounds in the arctic or their wintering grounds (Myers et al. 1987, Helmers 1992), sometimes as far south as the tip of South America. Much of historically existing stopover habitat has been degraded or lost, making it difficult to find safe, high-quality habitat and attain enough food (Twedt et al., 1998, Howell et al., 2019). Such difficulty finding high-quality stopover habitat can result in; 1) Underweight birds attempting the next portion of the migratory journey, which can reduce the probability of surviving migration and can have adverse effects on subsequent breeding success (Farmer & Parent, 1997, Colwell, 2010), or 2) Delayed migration due to spending too much time feeding in a non-productive stopover site or having to visit multiple sites (Collwell, 2010). These threats could become exacerbated with climate change through sea level rise, increased rainfall and/or drought, expansion of urbanization, and/or shortages of food sources (Johnson et al., 2010, Strum et al., 2013, Galbraith et al. 2014).

Upwards of forty species of shorebirds occur in the interior region of North America, the majority of which pass through during both spring and fall migration (Helmers 1992), and the conversion of interior wetlands into agriculture has greatly reduced the availability of stopover habitat available to those species during migration (Farmer & Parent, 1997, Skagen 2006). Some shorebirds migrating through North American interior corridors have punctuated flights where large groups stopover periodically to forage at a few locations, while other species may take meandering, indirect routes within those corridors (Twedt et al., 1998). As such, it is crucial to have an abundance of widespread, high-quality stopover sites capable of supporting large numbers of birds with various migratory strategies across these inland migratory paths. Conversion of natural wetlands, such as oxbow lakes, streams, and bayous, into agricultural lands through channelization and drainage projects has depleted much of the historically widespread stopover habitats available to shorebirds (Myers et al., 1987, Helmers 1992, Twedt et al., 1998). For example, the Lower Mississippi Alluvial Valley (LMAV) was historically a forested wetland in the floodplain of the lower Mississippi River and has been victim to this landscape conversion predominantly in the name of industrial agricultural expansion. However, the vast expanses of farmland in the LMAV have the potential to provide ideal stopover feeding conditions for large concentrations of shorebirds through the creation of temporary wetlands on working agricultural lands.

Ideal stopover habitat for many shorebirds during migration includes both exposed, muddy substrate and some sparse, decomposing, or shallowly flooded vegetation for individuals to wade about and feed on benthic invertebrates (Colwell, 2010), and flooded post-harvest agricultural fields can provide just that. Use of flooded agricultural fields for migratory shorebird habitat is quite common in rice fields in the California Central Valley, where a staggering percentage of historic wetlands have been converted for agriculture or urbanization (Golet et al., 2018), but where conservation organizations are compensating private landowners to temporarily create shallow water habitat on rice fields seasonally during times of habitat dearth (Strum et al. 2013, Reynolds et al. 2017). These dynamic conservation strategies allow adjustment of the timing, extent, and location of temporary habitat to meet the specific needs of the target species (Reynolds et al. 2017). Some farmers and landowners in the LMAV already lease and flood fields post-harvest for waterfowl, including dabbling and diving ducks (Twedt et al., 1998). However, these flooded areas are typically deep, so that even the largest shorebirds are commonly unable to utilize them (Isola et al., 2000). Further, these flooded habitats are often made available in the late fall and winter, after the peak of fall shorebird migration has already passed in this area (Twedt et al., 1998, LMVJV, 2019, Laney, 2023). The Lower Mississippi Valley Joint Venture (LMVJV) Shorebird Plan considers the seasonally targeted creation of shallow water habitat with appropriate vegetation the single most important management goal for the shorebirds migrating through the LMAV (LMVJV, 2019). Intentionally flooding agricultural fields shallowly following harvest starting in September and October could create high-quality habitat for shorebirds and the invertebrate food sources they rely on during stopover, particularly during the early fall habitat gap that coincides with the highest abundances of migrants.

The implementation of such targeted, dynamic habitats on working agriculture lands can be challenging for a few reasons. The predominant reason being the conflicting timelines between peak shorebird migration and corn and soybean harvest in the LMAV. In the Mississippi Delta, southbound shorebirds start to ramp up in abundance beginning in August, with high numbers persisting through mid-October (Sullivan et al., 2009). Typical harvest times, dependent on weather, occur from late-August to mid--September for corn and from mid-September to mid-October for soybeans. It is also standard for farmers to prepare their fields (e.g., tilling, amending, rowing) in the fall after harvest, which can increase delays between harvest and flooding. Cost effectiveness can be difficult to achieve, especially if surface water resources are unavailable or unreliable, and this situation can be common with hot, dry falls. Some farmers also express concerns regarding the potential for delayed spring planting if fields are too soggy from flooding (Laney, 2023) and/or for adverse changes in soil nutrients that could decrease yields (Sah et al., 1989, Koger et al., 2013). Together these issues can create hesitancy among farmers regarding flooding.

Invertebrates are the primary food source for most shorebirds during migration, and thus high abundances of these organisms are critical at stopover habitat sites during migration (Safran et al., 1997, Davis & Bidwell, 2008). As such, variability in invertebrate population densities among flooded agricultural stopover habitats could be an indicator of habitat quality and a predictor of shorebird distributions and abundances on a finer scale. Shorebirds rely on their stopover sites to provide enough foraging resources in the form of aquatic macroinvertebrates to refuel and rapidly increase their body mass, sometimes by as much as 100% (Mitchell &

Grubaugh, 2005). The seasonal availability of macroinvertebrate prey heavily constrains the timing of fall migration for shorebirds. Invertebrate populations bloom in the spring and summer, then decrease heading into winter, giving shorebirds a tight timeline in the fall to access high numbers of those prey to support their journey (Myers et al. 1987). According to Lourenço, the abundance of these prey was strongly correlated with the birds' distributions in coastal environments (Lourenço et al., 2018). Although invertebrate biomass is an indicator of high-quality stopover habitat desirable to migrating shorebirds (Collwell, 2010), few studies have correlated invertebrate densities with shorebird densities at inland stopover habitats.

Limited data on the length of time that individuals remain at a stopover site poses challenges for estimating total birds visiting an area, and at a broader level, total population trends (Smith et al., 2023). For example, McDuffie et al. (2022) found that GPS-tagged Lesser Yellowlegs breeding in Alaska and Western Canada migrate south directly through the Mississippi Delta. Lesser Yellowlegs populations have been steeply declining in recent years, raising tremendous concern among conservationists (Martin et al., 2022). Currently, there are no stopover duration estimates for Lesser Yellowlegs in the region to provide any context for how long these birds linger in the area, or how many total birds are passing through. Filling this knowledge gap could help gauge the proportion of North American Lesser Yellowlegs using the region as stopover and how to best fortify the habitat patches for their success. Preliminary data suggest that stopover durations may be longer for some species in the LMAV than suggested by previous estimates at inland sites in North America (J. Hoeksema et al., *unpublished data*).

Since fall 2018, scientists from a regional bird conservation non-profit, Delta Wind Birds, and from the USDA National Sedimentation Laboratory in Oxford, MS have been collaborating to study temporary wetlands created by post-harvest flooding on one farm in Sunflower County, MS, in the LMAV. Preliminary data from those studies showed that this practice attracted many water bird species, including shorebirds, waterfowl, and wading birds. Data from shorebird surveys in fall of 2020 tallied a total of 4013 shorebirds consisting of 15 species, all of which were disproportionately found in flooded vs unflooded fields, except for Killdeer (*Charadrius vociferus*), which also utilize unflooded fields (Anderson 2020, *unpublished data*). However, significant variation in bird usage was noted among fields and over the two-month study period, raising the question of whether such variation could be predicted by abundances of invertebrates or other factors. Moreover, flooding of these fields had so far always followed a corn harvest and preceded a soybean crop and has lasted from fall through winter. Results from these trial floods in Sunflower County raised the question of how abundance and composition of shorebirds would respond to habitat that was flooded only in the fall, or only in the winter, compared to continuous flooding throughout the fall and winter, and whether such responses might be correlated with densities of invertebrate food resources. Beginning in the fall of 2021, additional farm sites were enrolled in a study to address these questions.

The major goals of this collaborative project are to understand and quantify the consequences of fall and winter flooding for migrating shorebirds, invertebrate abundances, soil characteristics, nutrient cycling, and crop yield. Here, I focus on the responses of shorebirds to various temporal flooding treatments, on whether these responses can be predicted by invertebrate abundances in soil, and on providing more localized stopover duration estimates for the species present. The study addressed the following questions and hypotheses:

*Question 1.* How does the temporal availability of managed habitat affect the abundance of shorebirds visiting agricultural fields?

*Hypothesis 1.* Shorebirds are non-randomly distributed across available habitat patches, responding dynamically to optimal wetland habitat conditions.

*Prediction 1.* The highest numbers of shorebirds in fall season will be in fall and fall/winter actively flooded fields, and highest numbers in winter season will be in fall/winter and winter actively flooded fields.

*Question 2.* How do migratory shorebirds decide where to feed?

*Hypothesis 2.* Shorebirds use the absolute abundance of food to decide in which patch (field) to forage.

*Prediction 2.* Shorebird abundance will be positively associated with invertebrate abundance across fields.

*Question 3.* What is the stopover duration for individuals of different species on agricultural habitats in the LMAV in the fall?

*Hypothesis 3.* Stopover duration is variable among species and longer in winter than in fall across species.

*Prediction 3.* Stopover duration will be longer than available literature estimates for Least Sandpiper and Pectoral Sandpipers on these sites.

# METHODS

## Study Sites

The study was conducted over two fall/winter seasons: 2021/2022 ("Year 1") and 2022/2023 ("Year 2") across farm sites in the Sunflower River Basin of the Mississippi Alluvial Valley (MAV). In Year 1, we established four study sites (named based on the initials of respective landowners: FFA, FFB, FP, and WP) operating on a corn/soybean rotation, each with five fields located closely together of comparable size (between 20 and 40 acres each) and shape (rectangular) and having surface water retention systems or other sources of surface water, so that flood treatments would not require pumping of groundwater. Each field was shallowly graded, with one or more drainage pipes and associated water control structures at the low end.

In Year 2, we employed a study design in which FFA and FFB were the focus of intensive sampling, and six additional "satellite" sites were also employed with lower-intensity sampling, including FP. WP was dropped from the study in the second year, as the coarse soil texture at that site prevented water being held on flooded fields. In Year 1, sites were spatially clustered in pairs (FP near WP, FFA near FFB; Figure 1). FP and WP are located slightly west of the town of Sunflower, MS directly across Sunflower Road from one another. FFA and FFB are located east of Indianola, MS, with FFB directly adjacent to the Sunflower River. The satellite sites in Year 2 were scattered north and south through Sunflower and Humphreys counties (Figure 2). Each site was bordered predominantly by other agricultural fields, although some tree lines were present near parts of FP, WP, and FFB.

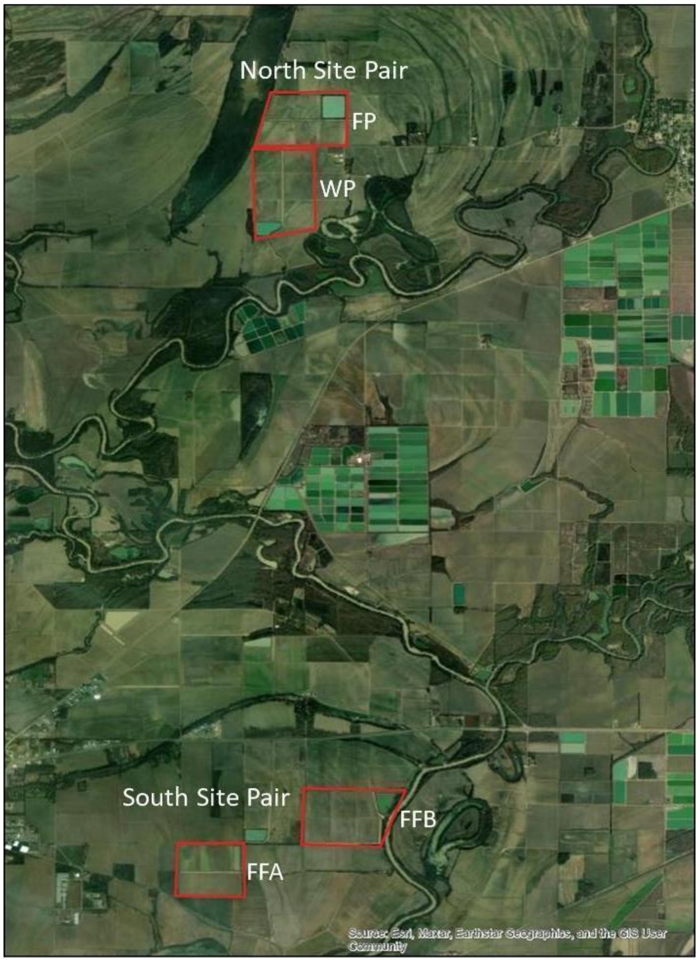

**Figure 1.** Overview of the 4 intensive survey sites from Year 1 showing the spatial clustering.

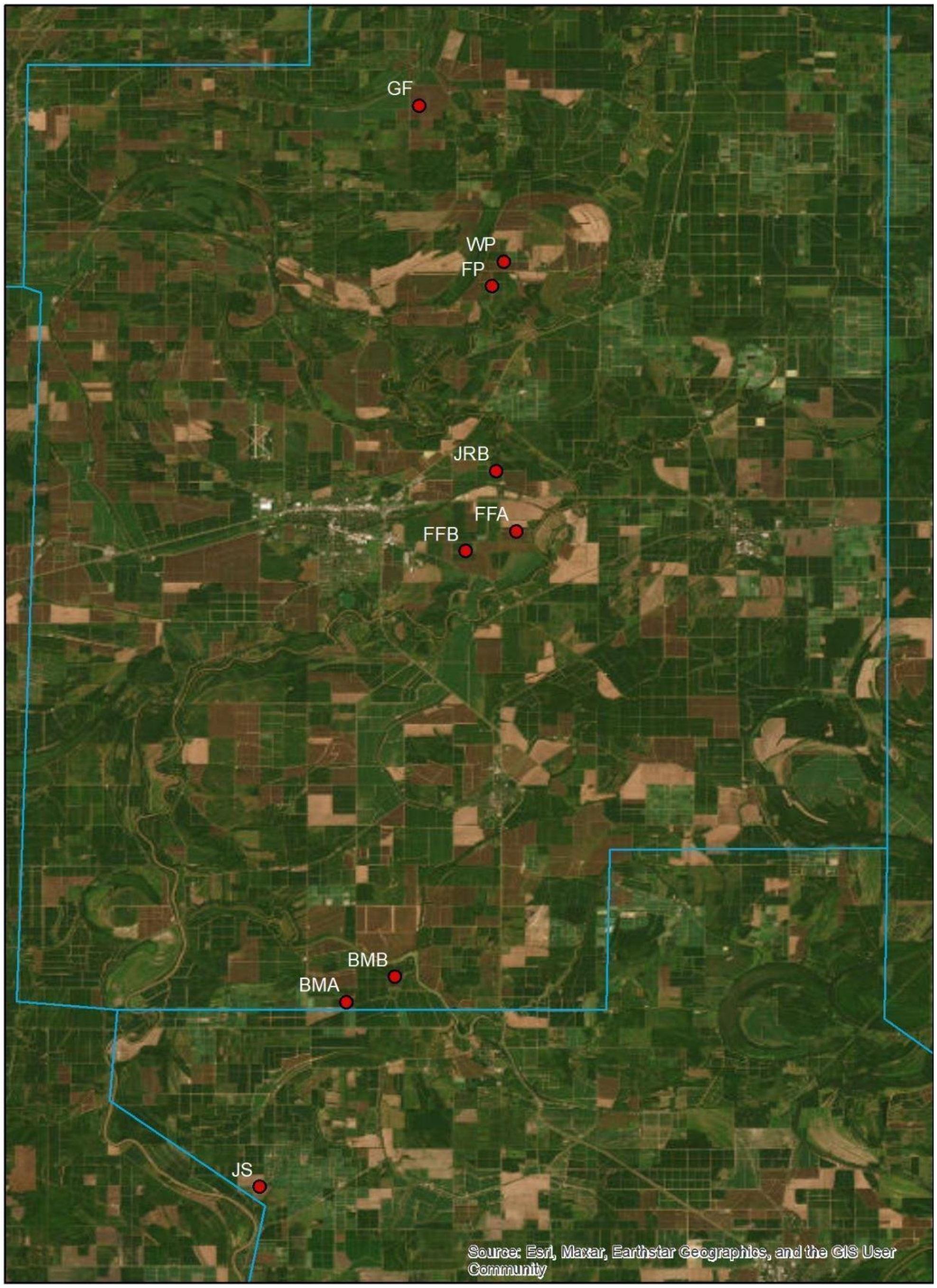

**Figure 2.** All sites (intensive and satellite) between both years. Mississippi counties are outlined in blue.

## Flooding Treatments

In Year 1, each of the four sites had five flood treatments, with one field per treatment (Figure 3): 1) passive flood (riser boards installed after harvest to prevent draining of naturally collected rainwater), 2) active fall flood (water actively pumped starting as soon as possible after harvest in late September - early October and held through mid to late November), 3) active winter flood (water is actively pumped on the same date the fall field is drained and held through January 31), 4) active fall and winter flood (water is actively pumped onto the field following fall harvest and maintained through January 31), and 5) control (no passive or active flooding). In Year 2, the two intensive sites (FFA and FFB) had four treatments with one field each during the fall flood period: 1) active fall flood, 2) active winter flood, 3) active fall and winter flood, and 4) control. At FFB during the winter of Year 2, the control field was passively flooded by the farmer, meaning there was no control field at that site in the winter. For the seven satellite sites in Year 2, only control and active fall/winter flood treatments were implemented. Start dates for treatments varied with each site due to varying harvesting and flooding schedules (Table 1). Surface water sources were used for flood treatments at all sites except one (JS in Year 2).

**Figure 3.** Flooding treatment layout of one site (FFB) in Year 1 of the study.

### Waterbird Surveys

Surveys of waterbird abundance and composition were conducted at each intensive site (all four sites in Year 1, and FFA and FFB in Year 2) every two weeks, for both years. Because of the clustering of sites into two groups of two in Year 1, WP and FP were typically surveyed on the same date or week, as were FFA and FFB. Earlier in the fall season when densities and activity levels of the birds were higher, some sites were surveyed more frequently. For the satellite sites in Year 2, surveying was less frequent, about once every 6 to 8 weeks. Start time was no earlier than 30 minutes after sunrise, and typically ended before 12:00 p.m. Surveys involved walking the entire perimeter of each treated field, stopping whenever groups of shorebirds were encountered to scan with a spotting scope (Kowa TSN-884 Prominar), to count all shorebirds, waterfowl, and wading bird species encountered. Because farmers managing the sites typically shaped their planting beds before flooding treatments, and often left some amount of crop stubble, field topography was complex and precluded counting all birds in any one field from any one point. For a subset of surveys, all birds were also counted from a single stationary point, for estimation of detection efficiency differences between the two methods. Numbers of birds were tallied for each field separately. If a bird or group of birds was spotted in one field but later seen to move to another, they were counted only for the field from which they flew. Surveys were not conducted under conditions of heavy rain, lightning, very heavy wind, or other conditions that were unsafe or prevented accurate estimation of bird numbers. I also recorded any shorebirds, waterfowl, and/or wading birds present in adjacent runoff ditches and surface water reservoirs, as well as start and end time, temperature, and sky (0 = clear, 1 = partly cloudy, 2 = cloudy or overcast, 4 = fog or smoke, 5 = drizzle, 7 = snow, 8 = showers) and wind codes (0 = <1 mph, 1 = 1-3 mph, 2 =4-7 mph, 3= 8-12 mph, 4 = 13-18 mph, 5 = 19-24 mph). Data on invertebrate abundances and biomass focused on chironomids (*Chironomidae*) and were collected approximately every 2 weeks by Mason Thomas (Mississippi State University) on the flooded fields at the intensive sites for both Year 1 and 2. These data were made available for combined analyses with the bird data (Thomas, 2023).

**Table 1**. Listing of the sites and other information for each. Dates in the fall flood columns show the variability in fall flooding times between different farms for both years.

| Site | Flood Regime | Years Employed | Latitude | Longitude | Water Source | 2021 Crop | 2022 Crop | Year 1 Fall Flood | Year 2 Fall Flood |
|---|---|---|---|---|---|---|---|---|---|
| FFA | Intensive | Both | 33.44976 | -90.5848379 | Reservoir | Beans | Corn | 9/21/2021 | 9/17/2022 |
| FFB | Intensive | Both | 33.44266 | -90.6032348 | Reservoir | Beans | Beans | 9/29/2021 | 9/27/2022 |
| FP | Intensive/Satellite | Both | 33.53817 | -90.5935598 | Reservoir | Corn | Beans | 10/11/2021 | 10/19/2022 |
| WP | Intensive | Year 1 | 33.54714 | -90.589341 | Reservoir | Beans | Beans | 10/19/2021 | N/A |
| JRB | Satellite | Year 2 | 33.47157 | -90.5922318 | River | N/A | Beans | N/A | 10/16/2022 |
| BMA | Satellite | Year 2 | 33.27988 | -90.646069 | River | N/A | Beans | N/A | 10/10/2022 |
| BMB | Satellite | Year 2 | 33.28898 | -90.6285636 | River | N/A | Beans | N/A | 10/14/2022 |
| JS | Satellite | Year 2 | 33.21319 | -90.6773413 | Well | N/A | Corn | N/A | 10/31/2022 |
| GF | Satellite | Year 2 | 33.60336 | -90.6197764 | River | N/A | Beans | N/A | 10/26/2022 |

### Radio Tagging

Beginning in Year 2, we initiated efforts to capture, band, and radio tag birds of certain species (Dunlin, Killdeer, Lesser and Greater Yellowlegs, Least Sandpiper, Long-billed Dowitcher, Pectoral Sandpiper, Stilt Sandpiper, and Wilson's Snipe) at the FFA and FFB research sites, with the goal of gaining more localized estimates on the length of time these individuals are staying on site. Birds were captured with mist nets placed within the flooded research fields. Nets were opened pre-dawn and closed mid-morning, 5:00 am until around 10:00 am, depending on the volume of birds caught in a session. Captured and extracted birds of all species received a USGS identification band (Gratto-Trevor, 2018). Only shorebird species listed above received activated radio tags.

Radio tags used included Lotek Nanotag (0.9 g) and CTT Powertag (either 1.0 g or 0.5 g). Tags were not to exceed 3% of a bird's bodyweight. Activated tags were attached to the rump of each individual after clipping feathers in the area then applied using a combination of super glue and eyelash glue. After allowing glue to dry for 5 minutes, birds were released.

Nineteen birds across 7 species were successfully captured and tagged during three sessions in fall of 2022, and transmitted radio signals were captured on a custom radio tower installed on site and connected remotely to the Motus Wildlife Tracking System.

### Analysis

All analyses were conducted using R Statistical Software (v4.3.0; R Core Team, 2023). For one type of analysis, I conducted repeated-measures analyses for fall and winter subsets (for analysis purposes, a binary "season" variable (fall vs winter) was used to represent the time of the study when the active fall vs the active winter fields were flooded) for Year 1 and Year 2. This analysis ignored the degree of turnover in individuals of each species from one survey to another. To account for the nested design of the study in Year 1 (two pairs of sites, each pair with two sites), data collected across two years, and repeated measures on each field, I used linear mixed modeling with the lmerTest package in R (v3.1.3; Kuznestova et al., 2017). Random effects included year, site pair, site nested within site pair, and field nested within site. Flooding treatment, with 5 levels in Year 1 and 4 levels in Year 2, was treated as the fixed effect. Abundance variables were transformed as necessary, square root for the fall model and log for the winter, to meet the normality assumptions of these models. I followed significant fixed effects of treatment on summed shorebird counts by performing Tukey's HSD tests to determine which treatment marginal means differed from which using the emmeans package in R (v1.8.6; Lenth, 2023). This was also conducted for individual species subsets for which there were enough non-zero observations to meet the assumption of normality. For individual species analyses, Greater Yellowlegs, Killdeer, Least Sandpiper, Lesser Yellowlegs, and Wilson's Snipe abundances were log transformed, and Long-billed Dowitcher abundances were square root transformed.

Another repeated-measures linear mixed model analysis was conducted for the fall and winter seasons separately using the lmerTest package in R to describe the association between chironomid abundances and shorebirds abundances for all species ignoring turnover between surveys on the intensive sites across both years. This model used a subset of data that excluded control and passive flood treatments due to absence of invertebrate sampling in those fields. Invertebrate surveys were paired temporally with shorebird surveys on a field-by-field basis, and composite values (3 samples per survey day per field) were used to represent invertebrate abundances. Random effects were year, site pair, site, and field. Numerical invertebrate abundance was treated as the fixed effect. To meet the assumption of normality, the shorebird abundance variable was square root transformed for the fall subset. Normality of residuals was determined by a visual assessment of histograms.

For Year 2, a data subset including satellite site data along with only the control and active fall+winter flood treatments from FFA and FFB was analyzed in a third repeated-measures linear mixed model using the lmerTest package in R. Random effects included site and field. Flood treatment with two levels was used as the fixed effect. The shorebird abundance response variable was log transformed to meet the normality assumption.

I also conducted an analysis attempting to account for turnover of individuals within a species across surveys, estimating the total number of individuals of each species visiting each field in the fall and winter. For this analysis, I summed bird abundances by species, survey date, and field using the cast function in the reshape package in R (v0.8.9; Wickham, 2007). Then I used a custom trapezoidal area-under-the-curve function (Hilborn et al., 1999), which assumes linear changes in abundances between surveys, to create a summed "bird days" variable for each species and field. This variable was then divided by an estimated stopover duration, or average number of days an individual spends at a stopover site, to calculate an estimate of total birds visiting each field during each season.  For this analysis, three separate models were conducted with differing turnover rate estimates, Fall A, Fall B, and Winter. In the Fall A model, we assumed residence times averaged from literature estimates from studies previously conducted at sites within the region: 5.44 days for Least Sandpipers (Lehnen & Krementz, 2007, Farmer and Durbian, 2006) and applied to other detected small sandpiper species, and 7.45 days for Pectoral Sandpipers (Lehnen & Krementz, 2005, Farmer and Durbian, 2006) and applied to all other medium to large shorebird species.

While previous estimates of stopover duration for Least Sandpiper and Pectoral Sandpiper are informative, they represent a small number of species and were collected on NWR managed moist-soil habitats rather than temporarily flooded agricultural fields. Because of this, data from our on-site radio tagging efforts were used to supplement estimated stopover durations for certain species in the Fall B and Winter analyses. For Fall B, minimum stopover duration was estimated as 27.75 days for Pectoral Sandpipers (n=4) and as 7.75 days for all other species (n=4) based on our radio tag data from September and October 2022. In the Winter model, the estimated minimum stopover duration for all species was 19.33 days. This value was averaged from Least Sandpipers (n=6) caught in November 2022, which may be a good species to help infer broader shorebird migration patterns for interior North America (Lehnen & Krementz, 2007). Estimated stopover durations are considered minimums, since individuals may have been on site for an unknown number of days before capture and tagging.

Bird Days were divided by these stopover estimates to obtain an estimate of total birds (the “Birds” variable), summed across species by field by year. These totaled values were then used in a linear mixed model with Treatment as the fixed effect and year, site pair, and site as the random effects. The Birds variable was transformed as necessary, square root for Fall A and Fall B, to meet normality assumptions. This was not a repeated-measures analysis, since the Birds variable integrates the repeated measures over time within each field. This latter process was also repeated for Fall B and Winter models on subsets for focal species which met statistical assumptions of the model. Normality of residuals was determined by a visual assessment of histograms. Within these focal species models, for Long-billed Dowitcher, Birds were square root transformed in Fall B. Also in Fall B, for Greater Yellowlegs, Killdeer, Pectoral Sandpiper, and Stilt Sandpiper, Birds was log transformed. In Winter for Dunlin, Long-billed Dowitcher, and Wilson’s Snipe, Birds were square root transformed.

All graphs were generated using the ggplot2 package in R (v3.4.2; Wickham, 2016).

# RESULTS

The first repeated-measures models showed that flood treatment had a significant effect on square-root-transformed shorebird abundances in the fall ($F_{4,17.3} = 16.51$, $P < 0.0001$) and log-transformed shorebird abundances in the winter ($F_{4, 171.5} = 18.189$, $P < 0.0001$) in Year 1 and Year 2. In the fall season, the active fall and fall+winter treatments had significantly higher shorebird abundances than any of the non-active flood treatments (control, passive, and inactive winter) (Figure 4). During the winter season, although there were significantly higher shorebird abundances on active winter treatments than the control, there were no significant differences between active winter and the other inactive flood treatments. However, the active fall+winter treatment had significantly higher shorebird abundances than control, passive, inactive fall, or active winter treatments (Figure 5).

During the fall season for both years, treatments had a significant effect on Greater Yellowlegs ($F_{4, 17.3} = 6$, $P = 0.0032$), Killdeer ($F_{4, 11.1} = 31$, $P < 0.0001$), Long-billed Dowitcher ($F_{4, 16.3} = 7.03$, $P = 0.0018$), Least Sandpiper ($F_{4, 18.1} = 9.3$, $P = 0.0003$), Lesser Yellowlegs ($F_{4, 9.7} = 9.66$, $P = 0.002$), and Wilson’s Snipe ($F_{4, 11.4} = 9.59$, $P = 0.0012$). For all those species, abundances were significantly higher on the active fall and fall+winter treatments than any of the inactive fields, except for Greater Yellowlegs, for which abundances were only significantly higher in the fall+winter treatment. In the winter, none of the individual species could meet normality assumptions for this model.

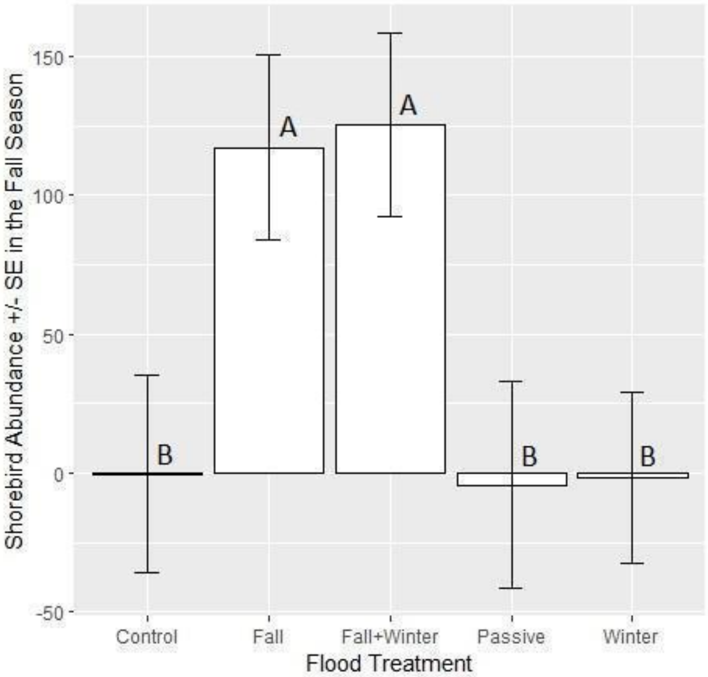

**Figure 4.** Effect of flood treatment on mean shorebird abundance across intensive sites in the fall for Year 1 and Year 2. Treatments with common letters are not significantly different from one another.

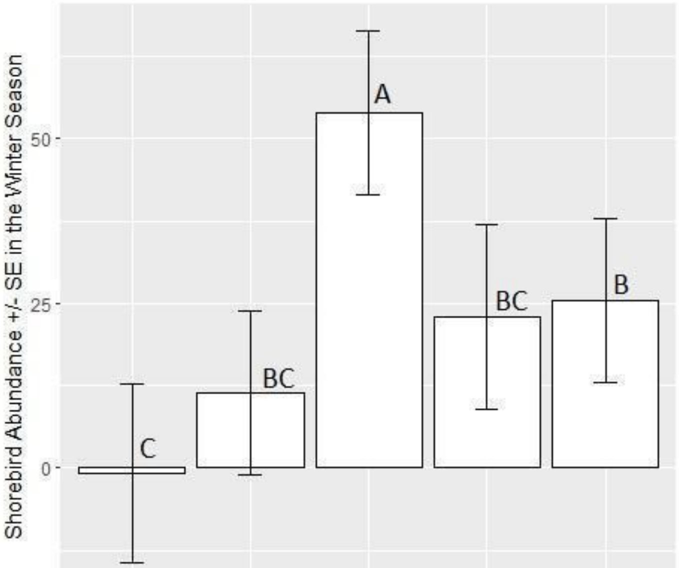

**Figure 5.** Effect of flood treatment on mean shorebird abundance across intensive sites in the winter for Year 1 and Year 2. Treatments with common letters are not significantly different from one another.

For both fall and winter seasons, there was a significant, positive association between chironomid abundances and shorebird abundances in the repeated-measures models assessing only actively flooded fields on intensive sites for Year 1 and Year 2 (Fall: Slope = 4.867, $F_{1, 70.7} = 5.93$, P = 0.017; Winter: Slope = 3.76, $F_{1, 105.7} = 4.91$, P = 0.029).

For the repeated-measures model assessing all sites, intensive and satellite, in Year 2 with two treatment categories (control and fall+winter flood), the effect of treatment was significant on log transformed shorebird abundances ($F_{1,6} = 27.91$, P = 0.002), with higher abundances on the fall+winter flood treatment (Figure 6).

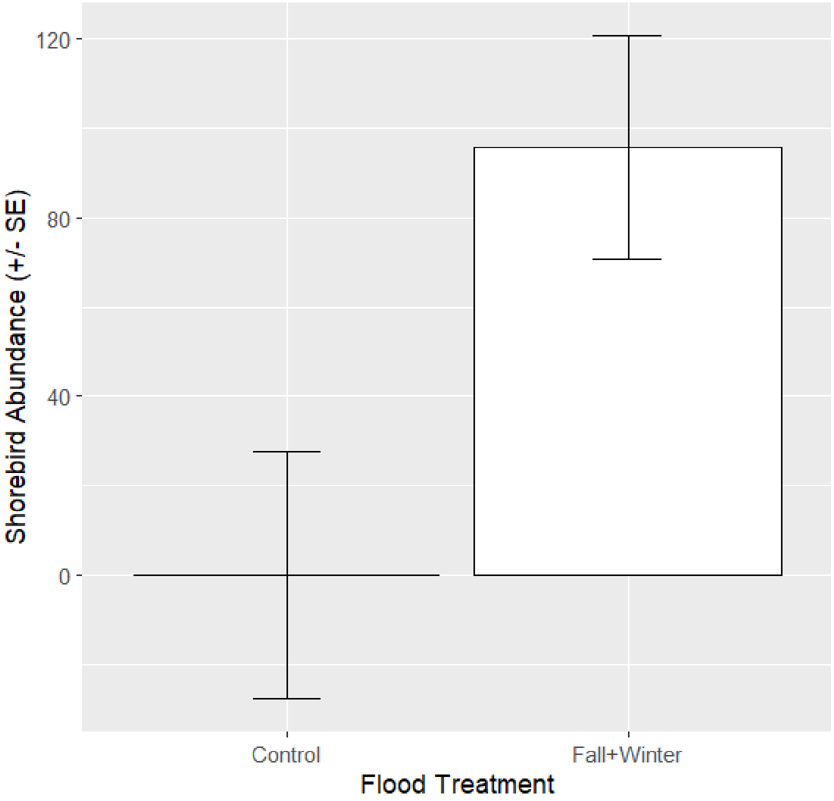

**Figure 6.** Mean shorebird abundance across all intensive and satellite sites in Year 2 between the two flood treatments.

When accounting for the estimated turnover of individuals on the intensive sites over time during Year 1 and Year 2, the effect of treatment was still significant for each model: for Fall A ($F_{4,\ 20.4}$ = 15.01, P < 0.0001), which used turnover rates from the literature; and for Fall B ($F_{4,\ 20.4}$ = 14.87, P < 0.0001)(Figure 7) and Winter ($F_{4,\ 20.2}$ = 5.2749, P = 0.0045) (Figure 8), which both used turnover rates from our radio data. For both Fall A and Fall B, the trends were the same with both actively flooded treatments (fall and fall+winter) having significantly higher total individual shorebird abundances than the inactive treatments (winter, passive, and control). In the winter, the fall+winter treatment had significantly higher total individual shorebird abundance than the inactive fall or control fields, but none of the other treatments had significant differences in abundances from each other.

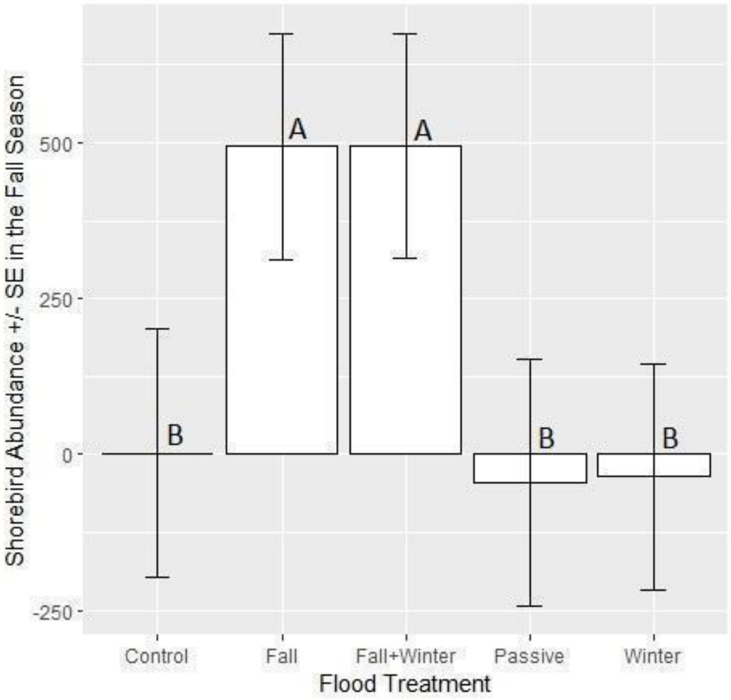

**Figure 7**. Mean total shorebird individuals per treatment across both years in the fall season. Treatments with common letters are not significantly different from one another.

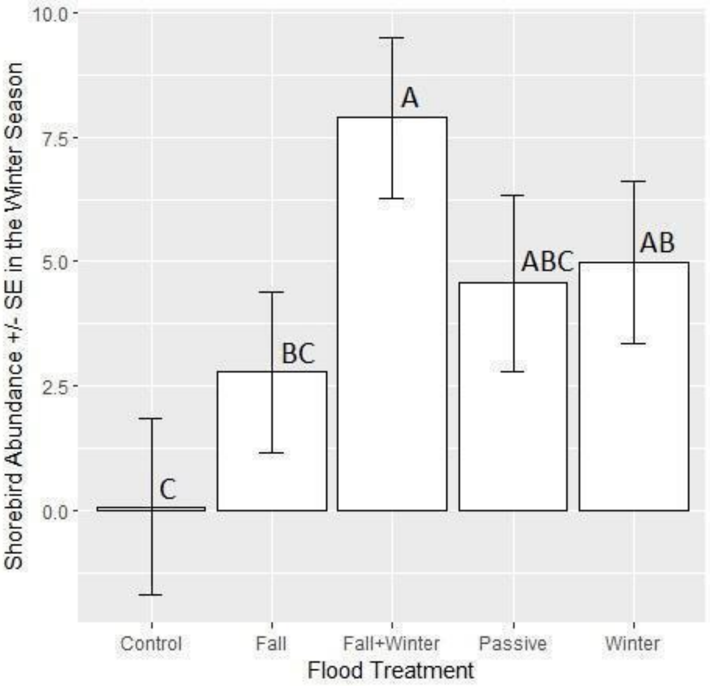

**Figure 8.** Mean total shorebird individuals per treatment across both years in the winter season. Treatments with common letters are not significantly different from one another.

The following focal species also showed significant impacts on abundance due to treatment in the Fall B model: Dunlin ($F_{4, 21}$ = 8.69, P = 0.0003), Greater Yellowlegs ($F_{4, 20.5}$ = 7.509, P = 0.0007), Killdeer ($F_{4, 20.2}$ = 14.874, P < 0.0001), Long-billed Dowitcher ($F_{4, 18.4}$ = 4.553, P = 0.01), Least Sandpiper ($F_{4, 20.5}$ = 6.043, P = 0.0022), Lesser Yellowlegs ($F_{4, 22}$ = 6.419, P = 0.001), Stilt Sandpiper ($F_{4, 18.9}$ = 5.953, P = 0.0028), and Wilson's Snipe ($F_{4, 20.1}$ = 7.413, P = 0.0008)(Table 2). Dunlin had higher abundances in the fall+winter fields than all other treatments, including active fall. Greater Yellowlegs and Killdeer were more plentiful in fall and fall+winter than all inactive fields. Long-billed Dowitcher had higher abundances in fall+winter than passive and winter. For Least Sandpiper, Stilt Sandpiper, and Wilson's Snipe, fall was significantly higher than control, passive, or winter, but none of the other treatments were significantly different.

**Table 2.** Marginal means and standard errors for each species and treatment for the Fall B Model. Used here are 4-letter species codes for Dunlin, Greater Yellowlegs, Killdeer, Long-billed Dowitcher, Least Sandpiper, Lesser Yellowlegs, Stilt Sandpiper, and Wilson's Snipe.

| | | **Fall** | **Fall+Winter** | **Winter** | **Passive** | **Control** |
|---|---|---|---|---|---|---|
| **DUNL** | Mean | 9.02 | 25.5 | 0 | -0.11 | 0.11 |
| | SE | 4.22 | 4.22 | 4.22 | 4.92 | 4.92 |
| **GRYE** | Mean | 2 | 1.87 | -0.01 | -0.01 | -0.02 |
| | SE | 0.56 | 0.56 | 0.56 | 0.63 | 0.63 |
| **KILL** | Mean | 2.73 | 3.39 | 0.51 | 0.44 | 0.32 |
| | SE | 0.51 | 0.51 | 0.51 | 0.57 | 0.57 |
| **LBDO** | Mean | 5.68 | 6.79 | -0.74 | -1.08 | -0.54 |
| | SE | 2.74 | 2.74 | 2.74 | 2.95 | 2.95 |
| **LESA** | Mean | 234.3 | 173.79 | -18 | -17.47 | -4.12 |
| | SE | 80.4 | 80.4 | 80.4 | 87.8 | 87.8 |
| **LEYE** | Mean | 3.16 | 2.76 | -0.22 | -0.13 | -0.13 |
| | SE | 1.06 | 1.06 | 1.06 | 1.17 | 1.17 |
| **STSA** | Mean | 1.86 | 0.93 | -0.16 | -0.11 | -0.1 |
| | SE | 0.63 | 0.63 | 0.63 | 0.68 | 0.68 |
| **WISN** | Mean | 4.68 | 4.72 | 0.29 | 0.5 | 0.67 |
| | SE | 1.48 | 1.48 | 1.48 | 1.55 | 1.55 |

For the winter model, the impacted species included: Dunlin ($F_{4,\ 19.4} = 4.01$, $P = 0.015$), Greater Yellowlegs ($F_{4,\ 22} = 7.11$, $P = 0.0008$), Killdeer ($F_{4,20.2} = 4.1$, $P = 0.0136$), Long-billed Dowitcher ($F_{4,\ 20.4} = 3.26$, $P = 0.03$), Least Sandpiper ($F_{4,\ 20.4} = 3.14$, $P = 0.04$), and Wilson's Snipe ($F_{4,\ 20.1} = 5.92$, $P = 0.0026$)(Table 3). For Dunlin and Greater Yellowlegs, the fall+winter treatments had higher shorebird abundances than all other treatment fields, including active winter. Least Sandpipers were higher in fall+winter than control. Long-billed Dowitcher was more abundant in fall+winter than fall. Wilson's Snipe had higher numbers in fall+winter than control, passive, or winter.

**Table 3.** Marginal means and standard errors for each species and each treatment in the winter model. Used here are 4-letter species codes for Dunlin, Greater Yellowlegs, Killdeer, Long-billed Dowitcher, Least Sandpiper, and Wilson's Snipe.

| | | **Fall** | **Fall+Winter** | **Winter** | **Passive** | **Control** |
|---|---|---|---|---|---|---|
| **DUNL** | Mean | 0.06 | 1.83 | 0.98 | -0.13 | -0.13 |
| | SE | 0.6 | 0.6 | 0.6 | 0.66 | 0.66 |
| **GRYE** | Mean | 0.18 | 8.85 | 0.36 | 0.61 | 0.05 |
| | SE | 1.66 | 1.66 | 1.66 | 1.94 | 1.94 |
| **KILL** | Mean | 1.52 | 2.64 | 2.19 | 2.35 | 0.03 |
| | SE | 0.66 | 0.66 | 0.66 | 0.75 | 0.75 |
| **LBDO** | Mean | 0.05 | 2.61 | 0.97 | 0.13 | 0.1 |
| | SE | 0.8 | 0.8 | 0.8 | 0.9 | 0.9 |
| **LESA** | Mean | 4.09 | 14.77 | 5.62 | 1.74 | -0.1 |
| | SE | 4 | 4 | 4 | 4.6 | 4.6 |
| **WISN** | Mean | 0.76 | 2.71 | 2.14 | 0.76 | 0.02 |
| | SE | 0.53 | 0.53 | 0.53 | 0.61 | 0.61 |

# DISCUSSION

*How does the temporal availability of managed habitat affect the abundance of shorebirds visiting agricultural fields?*

My results suggest that providing actively flooded habitat on agricultural fields in the fall during peak migration in the LMAV supports the highest abundances of shorebirds (Figure 4), whether or not stopover duration is considered (Figure 7). This is perhaps because options for stopover habitat in the region, and in inland North America generally, are so limited and unpredictable during that time. Although birds were present on all water holding treatments to a higher degree than the corresponding dry or drained treatments across both seasons, the mean shorebird abundances on the active flooded fields during the fall season were much higher than even the most effective treatments during the winter season (Figures 5 and 8).

Although bird abundances in the fall were higher on actively flooded fields as predicted, this pattern becomes more nuanced in the winter. While the control and fall have no structures to hold water, the passive does and in the right rain and soil conditions, it can hold a good deal of water, as much as the actively flooded fields in some cases. However, even with the passive, winter, and fall+winter all holding similar water levels during this season, the trends in the repeated-measures model winter subset suggest that shorebirds prefer the habitat that has been flooded for longer, the fall+winter fields (Figure 5). While this result is not quite significant in the winter turnover rate model, the trend is the same. Having both models utilizing raw shorebird counts and estimates of total individuals across a season offers various insights and shortcomings, in which the raw counts may not consider the length of stay of individuals, or the numbers individuals present in between surveys, but the turnover rate models are operating on some heavy assumptions of turnover rate estimates with small sample sizes.

One explanation for some flooded fields being preferred over others in winter could be that birds that are there during the switchover between fall flood and winter flood are gravitating to the fall+winter, which remains stable across the seasons. Additionally, there is some variation in habitat quality even among fields at certain sites, with some fields holding water better due to soil properties. At some sites, like FP, those better fields included the fall+winter floods. However, the random effect of Site should have accounted for that variation in the model. More likely, there is some sort of benefit to having water on during the warmer time periods due to beneficial microbial activity as well as invertebrate populations (Mitchell & Grubaugh, 2005), given there is a positive association between the abundances of birds and invertebrates. Invertebrates were also positively associated with temperature in a sister study on the field sites (Thomas, 2023).

On California rice farms in the winter, Strum et al. (2013) found that actively flooded fields benefited shorebirds and other water bird species, while passive and unflooded fields had limited value for wintering habitat. This trend was similar for our study in the fall season, although in the winter, birds did seem to have some presence on passive flooded fields. Passive flooding success in the winter can be notable due to ease of setting up as well as a lower cost for the farmers. In the LMAV, Twedt et al. (1998) found shorebirds preferred flooded soybean fields over rice and other moist-soil managed habitats in the region during the winter. However, neither of these studies tested for the effect of timing or duration of flooding, and therefore did not identify the abundance patterns that vary across a season with various temporal flood treatments.

### *How do migratory shorebirds decide where to feed?*

The positive association found between chironomid abundances and shorebird abundances in the fall and winter seasons suggests that shorebirds may be using presence and abundance of invertebrate prey in the form of chironomids as a metric for choosing which field or habitat patch in which to feed on a field-by-field scale. This association would be expected in the fall due to the intense, efficient foraging required to maintain and rapidly increase body mass during migration. Similarly, in the winter, birds have high energy requirements for maintaining body mass during challenging environmental conditions. Invertebrate abundance sampled at isolated times may not be the best variable for capturing the dynamic nature of invertebrate populations in these habitats (Grubaugh et al., 1996). To improve this, invertebrate productivity, the total amount of invertebrate biomass being produced in a particular area within a set period of time, could be used to gain a better estimate of the overall invertebrate levels on a field taking into consideration births, deaths, length of larval life, and bird predation (Hauer and Benke, 1991).

Thomas's findings that the winter flood fields had the highest average abundances and biomass of chironomids between the three active flood treatments is intriguing because this trend is inconsistent with typical population trends for aquatic invertebrates where abundances and growth rates are usually higher in the spring and summer, followed by a decrease flowing into winter (Colwell, 2010, Hauer and Benke, 1991). In fact, a study in California found significantly higher densities of chironomids in areas flooded earlier in the fall than later (Batzer et al., 1997), and a study in the LMAV found the highest biomass of invertebrates in impoundments with longer inundation periods either starting or running through the summer months (Mitchell & Grubaugh, 2005). Perhaps the less severe winters of the southeastern US are allowing for one final chironomid population peak on these winter flood fields during November when they are freshly flooded, and predation from shorebirds may be lower due to lower overall shorebird abundances in the winter season.

*What is the stopover duration for individuals of different species on agricultural habitats in the MAV in the fall?*

Compared to prior studies in the region, we estimated Pectoral Sandpipers to be staying 20.3 days longer (Lehnen & Krementz, 2005, Farmer and Durbian, 2006) and Least Sandpipers to be staying 13.89 days longer (Lehnen & Krementz, 2007, Farmer and Durbian, 2006) on average, compared to prior studies in this region. With the low tagging rate (n=19 for fall 2022 sessions) and the variable species capture distribution across months, it is difficult to discern if stopover duration is increasing as the season progresses, but there is reason to believe that as we approach the end of the calendar year at these LMAV locations, the birds still present are increasingly likely to be wintering residents rather than fall stopover migrants. Several species, including Dunlin, Least Sandpipers, Long-billed Dowitchers, and Wilson's Snipe, not only pass-through during fall, but also have wintering ranges in the region. Thus, individuals arriving on site later in fall may be more likely to continue their stay into winter.

Longer time spent on these stopover sites could be viewed through the lens of the Marginal Value Theorem (Charnov, 1976). If shorter travel time between available habitat patches along an inland migratory route is desirable for birds, they may be staying in the LMAV for longer if other stopover sites were unavailable or unable to support larger numbers of birds. For example, mid-continent habitats along the Texas high plains have been degraded by agricultural prominence and could result in those shorebirds using routes through the Mississippi

Delta and surrounding areas (Mitchell & Grubaugh, 2005). It is also possible that food availability on these sites is low, lowering invertebrate intake rates and requiring longer stopovers to reach dietary goals of continuing migration. Loesch et al. (2000) estimated similar shallow water habitats in the LMAV as having 2 g/m$^2$ of invertebrate biomass. However, these sites were moist soil habitats with much longer flood durations than our own working land sites. A study in Southeastern Arkansas (Aycock & Sims, 2015) found this projection to be higher than the biomass found on their managed sites (overall mean in g/m$^2$ for Fall 2010 = 1.45 ± 0.37, and Fall of 2011 = 0.79 ± 0.27), but even this is much higher than the average biomass per meter squared found in the samples on our farm sites (overall mean in mg/m$^2$ for Fall 2021 = 4.23) (Thomas, 2023). Predator abundance or perceived risk could also contribute to longer stopovers if birds are less likely to be predated at agricultural sites. Ultimately, these longer stopover durations could create management implications based on use that differ from birds who stopover for shorter periods.

Using stopover estimates from our radio tag data does provide estimates for a higher number of species in the LMAV during the fall than previously available and might allow a more accurate estimate for stopover duration on agricultural field habitats, but it does have some flaws. Our sample size for many of our representative species was small, the highest being Least Sandpipers with an n = 6, and thus uncertainty associated with our estimates was high. Additionally, my calculation of estimated stopover duration used mean minimum stopover for a species, despite variation in stopover durations among individuals within a species. Not including such variation in calculations could create inaccurate estimates of total numbers of birds, as illustrated by the example of Pectoral Sandpipers. The mean stopover duration derived was 27.75 days (n=4). When using this average, the highest number of estimated individuals was

8.5 per field, which is inaccurate, because there were surveys where I saw over 30 Pectoral Sandpipers on a single field. Going forward, this analysis could be improved upon by randomly sampling from a distribution of minimum stopover durations from radio data for a particular species, when using bird days and stopover duration to estimate numbers of individuals.

### *Implications for Habitat Management and Conservation*

Perhaps the most important result from this study is the confirmation that flooding agricultural fields during the fall in the LMAV attracts high numbers of migratory shorebirds using these patches as stopover habitat. This is highly valuable because of the sheer abundance of acreage in the region, and providing habitat on these working lands can benefit wildlife in a way that doesn't conflict with important economic drivers such as agriculture. In fact, in some cases, farmers who participated in our study had increases in yields in the flooded fields (Hoeksema & Taylor, unpublished data).

Of the individual species that were more abundant in flooded fields positive abundance trends in the turnover rate models, two species, Dunlin and Lesser Yellowlegs, stand out due to their conservation concerns (Tables 2 and 3). Dunlin are listed as a Species of Greatest Conservation Need in the 2015 State of Mississippi's Wildlife Action Plan (Mississippi Museum of Natural Science, 2015) and are notable for their extremely late-fall migration as well as some individuals being winter residents in the region. Lesser Yellowlegs have experienced significant population declines in recent decades and these declines are projected to accelerate without intervention (McDuffie et al., 2022, Smith et al., 2023). Our results suggest that flooded agricultural fields in the LMAV can provide fall stopover, and wintering habitat in the case of

Dunlin, for these species which are of particular concern in the hopes of improving their chances of surviving fall migration.

A potential concern on such manmade wetlands is exposure of attracted wildlife to agricultural chemicals (Eng et al., 2019). The bodies of chironomids collected on the site were tested for three of the most broadly used agrochemicals to determine if bioaccumulation of chemicals was of concern to shorebirds. Dimethenamid-P was detected as the highest risk, and even then at very low levels of estimated theoretical exposure (.0081 to .0151 mg/kg of body weight/day) (Thomas, 2023). However, it is possible that other chemicals were present on the field that were not tested for in this analysis, or that birds were exposed to chemicals in ways beyond food intake, such as through soil and water. In future studies in this region, it is recommended that blood samples of shorebirds be tested for agrochemicals, and compared with local pools in water, soil, and invertebrates, to understand whether shorebirds may be accumulating significant quantities of agrochemicals during stopover.

Overall, one of the leading challenges in implementing fall flooding practices on crop fields in the LMAV is the conflicting timeline in which corn and soybean harvest and subsequent field prep take place during the height of fall shorebird migration in the region. It can be challenging to find a strategy for flooding as early as possible that works both for the farmers and the birds, since farmers are engaged with harvest and it may be difficult for them to dedicate time and resources to preparing and implementing a flood. However, in 2022, we began having one on one meetings with each of the participants to more explicitly lay out the urgency for these fall migrants to have habitat available as soon after their harvests as possible. Overall, these meetings were very fruitful and engaging on both ends. Many of the participants seemed to better recognize the importance of the timeline and were able to work with us on creating a more effective early flooding schedule. Contracts in the fall following those meetings offered farmers a lower, flat rate just for implementing water control structures (i.e., boarding up runoff pipes, passive flooding) to promote natural rainfall collection in the winter. Additionally, there was the potential to receive extra payment which increased per acre with each week of earlier active flooding. This structure incentivizes and rewards farmers who put in the time and effort to pump water earlier, but still offers some motivation in the case of a dry fall in which there is not available surface water for flooding.

The potential benefits of implementing fall+winter flooding practices might include providing valuable habitat for different waves of birds: higher-volume, early-season migrants stopping more briefly as well as wintering birds. While bird abundances may be lower during the winter, they still require high quality feeding conditions in order to maintain body mass through taxing winter conditions (increased rains, lower temps) (Colwell, 2010). Additionally, it is possible that exposure to agricultural chemicals could lessen in these longer-term flood treatments over time. For example, organophosphorus and carbamate, commonly used insecticides, can have adverse effects in the short term, but may degrade rapidly in the environment (Strum et al., 2010).

While the highest numbers of shorebirds were detected on fall+winter treatments, the highest abundances and biomass of inverts were detected in winter flood treatments, suggesting that having dynamic flood management could be of the greatest benefit. In practice this might look like having one parcel of land flooded at length through a season, with a couple parcels flooded and drained at variable points in time. To conserve water, this could even mean draining one field and using that water to flood another field. Because habitat density has been found to be a predictor for shorebird occurrence and settling decisions during migration (Albanese et al., 2012), having multiple, adjacent parcels of habitat would likely encourage stopover on sites.

Flooding agricultural fields in the fall is an excellent and abundant opportunity for offering stopover habitat to migratory shorebirds visiting the LMAV. Even in the winter when bird abundances are lower, they still are present on flooded fields, especially those that were flooded earlier and remained flooded for longer. There is a positive association between shorebird and chironomid abundances during both seasons, which suggests an importance of using chironomid availability and abundance to decide where to feed. Birds on our agricultural sites have longer stopover duration than prior studies in the region and can be used to help determine the total numbers of individuals visiting our region, and thus the relative importance of our sites and the region as a whole as stopover habitat. There is value in helping farmers understand the importance of early flooding, and restrategizing payments to support earlier flooding in addition to creating dynamic flood durations on adjacent land parcels could be the most optimal management strategy.

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# VITA

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## EDUCATION

M.S. The University of Mississippi, Oxford, MS
Biological Science, August 2021 - December 2023

B.A. The University of Mississippi, Oxford, MS
Biological Science with a minor in Environmental Studies, August 2016 - May 2020
GPA: 3.92

## PROFESSIONAL AND RESEARCH EXPERIENCE

August 2021 - Present

Graduate Research Assistant, The University of Mississippi - Dr. Jason Hoeksema, Mississippi Delta Region

Working remotely conducting shorebird surveys on flooded agricultural sites in Sunflower County and surrounding areas. Participating in mist net set up, bird extraction, and radio tag activation for banding and radio tagging of approved shorebird species on research sites
Communication with and recruitment of farm owners/managers to participate in study and maintain habitat. Statistical analysis of collected data using R.

August 2020 - October 2020

Blackbird Research Technician, North Dakota State University and USDA - Morgan Donaldson, Bismarck, ND

Worked remotely with a small team traveling to rural farms statewide. Conducted point count surveys for blackbird species present. Traversed large fields to obtain data on sunflowers, blackbird damage, and other vegetation present while carrying equipment. Data entry and organization. Completed Defensive Driving and ISA training.

May 2017- July 2021 (Seasonal)

Certified Naturally Grown (CNG) Farm Manager, Native Son Farm - Will Reed, Tupelo, MS

Seeded, transplanted, maintained, and harvested CNG produce. Processed and distributed produce locally. Lead sales at local farmers markets and the Native Son Farmstand. Managed other farm hands for all the above.

January 2020 - May 2020

Undergraduate Researcher, The University of Mississippi - Dr. Jason Hoeksema, University, MS

Designed data collection protocols and lead volunteers in monitoring of windows for avian window collisions on the university campus. Collected and analyzed strike data to determine the most prominent threats. Wrote grant and supporting documentation for the procurement of collision preventing window decals. Published a manuscript and gave presentations detailing the findings of this study at the University of Mississippi

August 2019 - December 2019

Volunteer Researcher, The University of Mississippi and Strawberry Plains Audubon Center - Dr. Steve Brewer, Holly Springs, MS

Identified, tagged, and recorded data on tree saplings in fire treated vs control plots. Prepared a report and presentation on the findings of comparative effects of prescribed burn treatments on oak regeneration.

October 2019

Volunteer Researcher, The University of Mississippi - Dr. Steve Brewer, Moss Point, MS

Monitored fall flowering on plant species in pine savannas in response to disturbance vs control treatments. Simulated disturbance on plots using a weed-eater and rake. Transferred soil segments into disturbed plots from untreated areas to examine seed regeneration with and without disturbance.

## PUBLICATIONS

Counce, E. 2021. Avian window collisions at the University of Mississippi campus in Spring 2020. The Mississippi Kite.

## PRESENTATIONS

Creating Shorebird Stopover Habitat on Agricultural Landscapes in the Mississippi Delta. Guest presenter for the Mississippi Coast Audubon Society Spring Meeting (2023), Coastal Research and Extension Center, Biloxi, MS.

How does the creation of temporary wetland habitat on agricultural fields affect the abundance of migratory shorebirds? Guest lecture BISC 413 Conservation Biology (2022), The University of Mississippi, University, MS.

## GRANTS

2022 University of Mississippi Green Fund, “Avian Window Collision Deterrents” (PI: Emma Counce, $6,000)

2022 State Wildlife Grant, “Non-breeding Habitat Use of Flooded Agricultural Fields by Dunlin and Other Migrant Shorebirds within the Mississippi Delta” (PI: Jason Hoeksema & Theodore Zenzal, $38, 804), Helped draft Need, Purpose, and Results/Benefits sections.