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# If You Build It, What Will Come? Assessing the Avian Response to Wetland Restoration in the Mississippi River Bird's Foot Delta Through Multiple Measures of Density and Biodiversity

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# IF YOU BUILD IT, WHAT WILL COME?
# ASSESSING THE AVIAN RESPONSE TO WETLAND RESTORATION IN THE MISSISSIPPI RIVER BIRD'S FOOT DELTA THROUGH MULTIPLE MEASURES OF DENSITY AND BIODIVERSITY

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## ABSTRACT

Multiple wetland restoration and enhancement techniques are used in Louisiana to combat land loss and provide habitat for waterbirds. We investigated the avian response to three wetland restoration techniques in the Lower Mississippi Bird's Foot Delta to determine if the different habitat types resulted in differences in the value of edge habitat. Species richness, guild richness, total bird density, bird density by foraging guild, and bird abundance relative to distance from the marsh edge was compared among (i) crevasse splays, a type of sediment diversion which allow the river to build new wetlands, (ii), beneficial use of dredged material marshes, where heavy equipment to create new wetlands from sediments dredged from navigation channels, (iii) marsh terraces, where lighter equipment is used to create strips of edge habitat from sediments dredged from the restoration site, (iv) old edge marshes, representing pre-restoration conditions at degrading marshes, and (v) open water sites. Seasonal bird counts and vegetation surveys were conducted from March 2013 to October 2014 at plots within the Pass a Loutre State Wildlife Management Area and Delta National Wildlife Refuge in Plaquemines Parish, Louisiana, USA.

We found bird abundance and diversity differs among the five habitat types during some times of the year, with habitat type and season often having a significant affect on the composition of the avian community. There was a significant relationship between habitat types and environmental factors ($p=0.002$), and a significant relationship between foraging guilds and environmental factors ($p=0.002$). Habitat type functions as a useful predictor of guild richness, but alone is not a perfect substitute for environmental variables when identifying the source of all variation in avian community composition. All habitat types studied provided habitat for birds, but were not utilized by all species or foraging guilds equally. We found that old edge marshes supported similar species richness as restored marshes during summer and winter ($p<0.05$) and open water supported the highest bird density in winter and spring ($p<0.05$). Any marsh habitat type, however, can be expected to support greater guild and species richness than open water areas during all seasons, but not greater bird density.

# CHAPTER 1: INTRODUCTION

## 1.1 Wetland Loss and Restoration in Louisiana

Louisiana has lost over 4,877 $km^2$ of coastal land since 1932, primarily due to anthropogenic modifications of the Mississippi River and its drainage basin (Couvillion et al. 2011b). This has led to the loss of important wetland habitats for resident and migratory waterbirds and other wildlife in southern Louisiana. Southeastern Louisiana consists of several delta lobes built by the Mississippi River, and thus there is strong economic (navigation, industry) and social (flood protection) reasons for maintaining the current delta lobes. Coastal deltaic wetlands across the state are also threatened by high rates of relative sea-level rise (Blum and Roberts 2009). In response to the land loss crisis, the State of Louisiana has developed a Coastal Master Plan in 2007 (most recently updated in 2012, with planned revisions for 2017) to guide the restoration of coast (CPRA 2012b). Using a combination of marsh creation and sediment diversions (CPRA 2012b), and the possible rerouting of the river to create a new delta lobe upriver (Changing Course 2015), the State of Louisiana hopes to reverse the rate of land loss in the Lower Mississippi Delta.

While the needs of wildlife were considered during the Coastal Master Plan process, projects have been selected primarily for their potential benefits to humans for flood control and storm surge protection. Our study aims to provide data to improve models for wildlife response to restoration to improve future coastal restoration efforts in Louisiana. We investigated freshwater wetland restoration projects, varying in construction technique, located in the Lower Mississippi Bird's Foot Delta, to determine if the different habitat types result in differences in the value of habitat created for waterbirds. The three types of restored marshes compared are: (i) crevasse splays (similar to river sediment diversions), which allow the river to build new wetlands, (ii), beneficial use of dredged material (referred to as "pump-in" marshes in graphs and tables), which uses heavy equipment to create new wetlands from sediments dredged from navigation channels, and (iii) marsh terraces, which uses light equipment to create strips of edge habitat from sediments dredged from the restoration site. We compared the edge habitat created by these

different restoration techniques because edge is preferred over open water by many species of waterbirds in coastal Louisiana (O'Connell and Nyman 2011). We defined edge as the open water area adjacent to emergent vegetation. Restoration sites were also be compared to natural edge sites and open water control sites to investigate the ecological equivalence of habitat created by the commonly used wetland restoration techniques in the Lower Mississippi Delta.

**1.2 Waterbirds in Louisiana**

Much of the land at risk in coastal Louisiana is extremely valuable habitat for resident birds and the millions of migratory birds that traverse the Mississippi Flyway each year. Over 400 species of birds, including a variety of wading birds, shorebirds, waterfowl, colonial nesters, and Neotropical migrants, are known to occur in Louisiana (Gosselink et al. 1998, Lowery 1974). Many of these birds use coastal wetland habitats for at least part of the year, either as stop-over sites for spring and fall migrations, wintering grounds, or breeding grounds (Gosselink et al. 1998, Wiedenfeld and Swan 2000). The Louisiana coastal marshes provide winter habitat for more than two-thirds of the entire Mississippi Flyway waterfowl population, supporting a larger population of wintering ducks than any other state in the nation (Chabreck et al. 1989). Of all the wetlands habitats in the state, freshwater marsh represents the most valuable waterfowl habitat (Palmisano 1973). Louisiana's freshwater marshes are important wintering habitats to Greater White-fronted Geese (*Anser albifrons*), American Green-winged Teal (*Anas crecca*), Mallards (*A. platyrhynchos*), Northern Pintails (*A. acuta*), Blue-winged Teal (*A. discors*), Northern Shovelers (*A. clypeata*), gadwells (*A. strepera*), American Wigeons (*A. Americana*), Canvasbacks (*Aythya valisineria*), Ring-necked Ducks (*A. colaris*), Lesser Scaup (*A. affinis*), and Hooded Mergansers (*Lophodytes cucullatus*) (Chabreck et al. 1989). These areas also provide important year-round habitat for Mottled Ducks (*A. fulvigula*), and important pre- and post-breeding habit for Fulvous Whistling Ducks (*Dendrocygna bicolor*) (CPRA 2012, Chabreck et al. 1989). Chabreck noted that historically, an excess of available habitat existed in Louisiana for waterfowl, but that with continued land loss, competition for habitat may increase and population decline could occur (Chabreck et al. 1989).

Habitats used by waterfowl are shared with other types of waterbirds as well (Lowery 1974, O'Connell 2006, O'Connell and Nyman 2010, Wiedenfeld and Swan 2000). Four species recognized as endangered by the State of Louisiana – Brown Pelican (*Pelecanus occidentalis*), Piping Plover (*Charadrius melodus*), Peregrine Falcon (*Falco peregrinus*) and Bald Eagle (*Haliaeetus leucocephalus*) – are found in Lower Mississippi Delta region, along with 10 other bird species identified as being at risk of becoming threatened or endangered primarily due to habitat loss (Louisiana Department of Wildlife and Fisheries 2012). The potential negative ecological impacts of coastal land loss to waterbirds are now widely acknowledged by researchers and the state government, alike (CPRA 2012b, Gosselink et al. 1998, O'Connell et al. 2005). Studies from the 2000's found that the colonies of most wading bird and seabird species in Louisiana have declined (Green et al. 2006, Michot et al. 2003). Declining waterbird populations, particularly waterfowl, resulting from habitat loss could also have a major economic impact on the state. Waterfowl are of great importance to the state's culture and economy. Recreational hunting has an annual economic impact of $62 million and supports over 1 million jobs (CPRA 2012), increasing significantly over the estimated annual economic impact of $10 million in 1993 (Gosselink et al. 1998).

**1.3 Wetland Restoration Techniques**

Various construction techniques and designs have been used in wetlands restoration projects in Louisiana. We use the term wetlands restoration broadly to refer to any action taken by humans to enhance the ecosystem functions of existing wetlands, to rebuild wetlands that have eroded or subsided, or to build new wetlands. Marsh terraces (fig. 1, fig. 2), beneficial use of dredged material (fig. 3), and sediment diversions (often in the form of man-made crevasse splays) (fig. 4) are three common restoration techniques used in the region and are included in this study. The construction of marsh terraces and beneficial use of dredged material marshes attempts to mimic the structure of natural marshes, but are not methods of restoring natural wetland processes. Marshes built using these two techniques are commonly referred to as created marshes in Louisiana. Both types of created marshes have been observed to erode or subside over time (Nyman and Chabreck 2012), primarily in areas absent

of freshwater and sediment influxes. In contrast, sediment diversions aim to intentionally and specifically recreate wetland structure and processes (CPRA 2012, Simenstad et al. 2006).

The marsh terracing technique (fig. 1, fig. 2) has been shown to be effective in providing valuable habitat and increasing bird and nekton density in open ponds of brackish and intermediate marshes of Louisiana and Texas (La Peyre et al. 2007, Llewellyn and La Peyre 2011, Merino et al. 2010, O'Connell and Nyman 2010, Rozas and Minello 2001). Some of these previous studies have also found that marsh terraces can provide habitat equivalent to natural edge in brackish marshes for some fish and waterbird species (La Peyre et al. 2007, O'Connell and Nyman 2010). The effects of marsh terracing on waterbirds in freshwater marshes has not yet been studied.

Figure 1. Marsh terraces in Alexis Bay, Plaquemines Parish, Louisiana, USA. These terraces were constructed in 2005 before Hurricane Katrina and sustained extensive damage in the storm. Many of the terraces become submerged after the hurricane. Photo taken August 18, 2014.

Figure 2. Marsh terraces and a small crevasse splay in Buoy Pond, Delta National Wildlife Refuge, Louisiana, USA. These terraces were completed in the spring of 2013. Photo taken August 18, 2014.

The use of dredged material from nearby channel bottoms (fig. 3), often mined for navigational improvement activities, is another structural habitat restoration technique used in Louisiana (Turner and Steever 2002). The channel-bottom sediment is pumped from the dredge vessel through non-permanent pipelines to fill in nearby shallow open water areas. Heavy machinery moves the material to form islands or large areas of land adjoining existing marsh. Marshes constructed in this fashion may produce simplified habitats, suffering from a lack of structural complexity, particularly a lack of cover-to-water interspersion (Melvin and Webb 1998). While research on this restoration technique is limited, there is evidence that dredged material marshes differ from natural wetlands in terms of many commonly measured wetland attributes, such as soil characteristics, elevation, and nekton communities (Streever 2000). Previous studies from other states have shown that this technique may not provide habitat comparable to natural marsh for waterbirds (Brusati et al. 2001, Darnell and Smith 2004, Erwin and Beck

2007, Melvin and Webb 1998), though one study in Aransas National Wildlife Refuge, Texas, recorded significantly higher abundances of shorebirds, rails, and bitterns on dredged marshes (Darnell et al. 1997).

Figure 3. Constructed wetlands located north of Pass a Loutre on private land and land within the Delta National Wildlife Refuge. Beneficial use of dredged material has been used to create land in shallow basins near main channels of the Mississippi River. Taken August 18, 2014.

Crevasses and river diversions can also benefit waterbirds and nekton. Crevasse splays (fig. 4) are formed through openings of natural levees allowing river waters and sediments to be delivered to the shallow basins between distributaries (Gammill and Quershi 1990, Paola et al. 2011) building a fan-shaped extension of the levee surface flanking the channel (Roberts 1997). Crevasse splays can be either naturally occurring from breaks in levees following a flood, or man-made. Over years of deposition of river sediments, new land is built in the splay, supporting vegetation (White 1993) and wildlife (Bielefeld and Afton 1992). Crevasses, also referred to as subdeltas, have a cycle of deposition and deterioration that mimics the delta lobe cycle (Coleman and Gagliano 1964, Roberts 1997), but operate on small spatial and temporal scale (Roberts 1997, Turner and Streever 2002). Small crevasse splays may be active for

anywhere between 10 and 150 years (Coleman and Gagliano 1964, Roberts 1997, Turner and Streever 2002), whereas a delta lobe may be active for 1000-2000 years (Roberts 1997). Engineered sediment diversions function similarly to crevasses, but would be constructed to carry a large volume of water with control structures to allow for strategic flooding and sediment delivery (Allison and Meselhe 2010, CPRA 2012). Based on these previous studies on subdelta dynamics, we decided to use crevasse splays in the Bird's Foot Delta as models for the type of habitats sediment diversions will create.

Figure 4. Numerous subdeltas make up the wetlands of the Bird's Foot Delta, including this one that flows into Sawdust Bend in Pass a Loutre State Wildlife Management Area, Louisiana, USA. Land slowly builds on the sides on the crevasse splay's channels and out into the basin through the deposition of sediment carried in river water. Photo taken August 18, 2014.

Chabreck hypothesized in 1989 that habitat for waterfowl could be enhanced by large-scale river diversions. By reducing water salinity and adding nutrients through the use of diversions, plant growth and species diversity would increase, and the value of the marsh and adjacent water bodies would improve for fish and wildlife (Chabreck et al. 1989). Most studies on diversion-created wetlands in Louisiana, however, are focused on the "accidently" created Atchafalaya River Delta and the neighboring Wax Lake Delta – the only area of Louisiana that is experiencing net land gain (Couvillion et al. 2011). Both deltas grew as the unintended result of flood control projects on the Mississippi River (McPhee

1990, Roberts 1997). However, the Wax Lake Delta has been identified as a model for the design of future large-scale sediment diversions (Paola et al. 2011). Scientific studies have found that the land created in the Atchafalaya Delta serves as valuable habitat for nekton (Castellanos and Rozas 2001) and the region supports a large number of waterbird colonies (Green et al. 2010, Wiedenfeld and Swan 2000). Sportsmen have also found that these deltas provide excellent hunting and fishing opportunities (Marshall 1998). Comparative studies of bird communities in crevasses splays or subdeltas verses other wetland habitat types could not be found. However, unpublished U.S. Fish and Wildlife Service data from aerial surveys in Louisiana sited by Turner and Steever (2002) found that 100 percent of geese and 80 percent of duck activity occurs on crevasse splays during the fall.

### 1.4 Tidal Freshwater Marsh Restoration in the Bird's Foot Delta

In the Bird's Foot Delta, the portion of Louisiana that protrudes furthest into the Gulf of Mexico, several wetland mitigation and habitat restoration projects have been completed. This section of the Mississippi River Delta provides a study area where multiple habitat restoration and creation techniques have been utilized in close proximity to each other. This region is also the only area of active land building, though still not achieving net land gain, along the lower Mississippi River. The Bird's Foot Delta is a dynamic environment where new land is rapidly built through sediment deposition in active crevasse splays, and then quickly converted back to open water through the forces of submergence and erosion when the river abandons one crevasse for another channel (Cahoon et al. 2011, Gammill and Quershi 1990). The land building of crevasses in the Bird's Food Delta (Boyer et al. 1997, Cahoon et al. 2011, Castellanos and Rozas 2001, CPRA 2012, Gammill and Quershi 1990, Paola et al. 2011) and vegetative succession which takes place in these environments (CPRA 2014, Steyer et al. 2003, White 1993) is well documented, but studies of habitat value using indicator species, primarily waterbirds, are lacking for the lower Mississippi River Delta.

A number of created marshes, often constructed as required mitigation projects for wetlands degraded by industrial and navigational activities under the Clean Water Act (CWA), have been built in the area using dredged material (Turner and Steever 2002). These sites are planted with native marsh grasses after construction to reduce erosion, encourage organic accretion, and provide habitat for wetland animals (Nyman and Chabreck 2012). Some of these created marshes in the area have maximized edge habitat through the use of the marsh terracing technique, while other created marshes, such as those made from pumped-in sediment, have been built to maximize area without emphasizing edge habitat.

Past studies have surveyed bird abundance and identified the species present in parts of the Bird's Foot Delta, demonstrating the importance of the region for waterbirds (Fortier et al. 2011, Wiedenfeld and Swan 2000). However, these studies have not looked at how birds are using particular habitats within the region. The U.S. Fish and Wildlife Service (USFWS) Southeastern Louisiana (SELA) Refuge Complex staff have been conducting mid-winter aerial surveys of waterfowl for the Delta National Wildlife Refuge since the 2006 (Fortier et al. 2011). Numbers of individuals, identified by species, and the unit of the refuge in which they were observed are included in these datasets. On January 11, 2011, 84,495 dabbling ducks, 22,070 diving ducks, 14,900 geese, and 7,775 American Coots (*Fulica americana*) were observed in the refuge (Fortier et al. 2011). The Louisiana Breeding Bird Atlas Project surveyed all breeding bird species in the state from 1994 to 1996, examining species present in quads of 7.5 x 7.5 minutes of latitude and longitude (Wiedenfeld and Swan 2000). This study identified 50 species using habitats for breeding in the Lower Mississippi River Delta region between February 15 and July 15 during the survey years, but does not include enough location detail to determine what type of habitats the birds were utilizing within the quads.

Our study of waterbird use of edge habitat in the marshes in the Bird's Food Delta provides some insight into the potential impacts of the proposed projects of the Coastal Master Plan on wildlife. Experts predict that the sediment diversions will create freshwater marshes in southeastern Louisiana similar to those currently found in the Bird's Foot Delta (CPRA 2012, Paola et al. 2011), but in areas with slower

subsidence rates and thus longer-lasting results than in the Bird's Foot Delta. Additionally, some of the land-building techniques that have been proposed for use in Coastal Master Plan projects, such as marsh terracing and beneficial use of dredged material, are currently being used for habitat restoration projects in the Bird's Foot Delta. The delta is an open system and its large population of waterbirds can move with relative ease throughout the region to reach the preferred habitats for foraging, breeding, and socializing, therefore significant differences in habitat value among these different types of land building projects could be detected by surveying waterbird abundance, density, and species distribution at multiple restoration projects within the season. Waterbirds are recognized as a group of wildlife notably sensitive to environmental change, and therefore often used to evaluate the effectiveness of wetland restoration projects (Hua et al. 2012, O'Connell 2006). The waterbird response to restoration projects in the Bird's Foot Delta could help establish habitat restoration targets for the planned projects upriver. The consideration of the impacts of various coastal restoration techniques on wildlife, such as waterbirds, along with their respective land-building potential, could help managers select the correct restoration method, or suite of methods, to benefit both humans and the natural environment. In this study of waterbird response to deltaic wetland restoration, we hypothesis that 1) there is no difference in bird density, species richness, or foraging guild richness among different habitat types, and 2) bird abundance will be highest within 10m of the marsh edge regardless of restoration technique used to the build the marsh.

# CHAPTER 2: STUDY AREA

The Mississippi River Delta (29° 10'N, 89° 12'W) covers 12,271 $km^2$ and is located in southwest Louisiana, United States. The major active delta of the river, referred to as the Bird's Foot Delta or Balize Delta, extends out from the deltaic plain into the Gulf of Mexico. The Bird's Foot Delta, which drains the majority of the Mississippi River, is degrading due to natural geologic forces compounding upon anthropogenic forces of hydrological alternation and sea-level rise (Roberts 1997). This active delta has prograded to the edge of the continental shelf, reaching the peak of the delta cycle (Roberts 1997) and is entering into a stage of rapid delta deterioration as the Atchafayala River begins capturing more of the discharge of the Mississippi River (McPhee 1998, Roberts 1997).

The study area is part of the Deltaic Coastal Marshes and Barrier Island level IV ecoregion, defined by marshes with low topography of 0-10 feet above sea level (Daigle et al. 2006). The climate is warm and humid, with average rainfall of 59.36 inches and average temperature of 54.3 F in January and 82.9 F in July (Southern Regional Climate Center 2014). The marshes of Bird's Foot Delta are defined as fresh marsh near the river and its distributaries, and intermediate marsh in areas with less direct river input (Sasser et al. 2014). Water salinity varies greatly through the deltaic marshes (0-15 ppt), influenced by river flow, storms, tides, and draughts, therefore vegetation communities are typically used to define marsh types in Louisiana (Chabreck 1970, Sasser et al. 2014). The fresh marshes (generally 0-5 ppt) of south Louisiana are typically dominated by *Panicum hemitomon, Sagittaria lancifolia, Eleocharis baldwinii,* or *Cladium jamaicense*, and intermediate marshes are frequently dominated by *Leptochloa fusca, Panicum virgatum, Paspalum vaginatum, Phragmites australis,* or *Schoenoplectus americanus* (Sasser et al. 2014).

Surveyed sites were located within either the Delta National Wildlife Refuge (DNWR) (29° 10.814'N, 89° 13.288'W) or the Pass a Loutre State Wildlife Management Area (29° 7.126'N, 89° 12.406'W) near the Head of Pass (river mile 0). Within these managed areas, a number of habitat

restoration and enhancement projects have been constructed. Subsections of the study area were selected for their ability to act as representative surrogates for the sediment diversions and constructed marsh projects prescribed by the Louisiana Coastal Protection and Restoration Authority (CPRA) in the 2012 Coastal Master Plan (CPRA 2012). Crevasses allow sediment from the river waters to be delivered to the shallow basins between distributaries (Gammill and Quershi 1990). The sediment diversions proposed in the 2012 Coastal Master Plan will be constructed to fulfill a similar process, but will be constructed on a much larger scale with control structures to allow for strategic flooding (Allison and Meselhe 2010, CPRA 2012). In our study, crevasse splays are representative of sediment diversions. The pumped-in marshes and marsh terraces are examples of marsh creation processes that have been mentioned in the 2012 Coastal Master Plan or proposed through subsequent discussions on coastal restoration (CPRA 2012).

The study area contains crevasse splays, marsh terraces, and marshes created from dredged material located within the two refuges (Fig. 5). From each of three types of restored habitats, three unique experimental units (plots) were randomly selected from a map for monitoring. Survey sites were modified during the first two field visits because some of the selected areas were inaccessible by boat. Plots were located at least 1000m apart from each other. Survey sites where no habitat enhancement actions had taken place in the last three decades ("old edge" and "open water" plots) were randomly selected from a map within 2000 m of the experimental sites to help insure accessibility by boat, though some of these plots also had to be moved upon the first site visit. The restored habitat (crevasse, terrace, and beneficial use of dredged material) and old edge study plots were 1200m$^2$, measuring 30m long across the marsh edge and 40m out from the marsh edge. The plots were then divided into four zones of 0-10m (zone 1), 10-20m (zone 2), 20-30m (zone 3), and 30-40m (zone 4) extending out of the marsh edge into the adjacent open water, marked off using PVC pipe. Open-water plots were 300m$^2$, measuring 30m x 10m (the size of zone 1), and located at least 40m from any edge habitat.

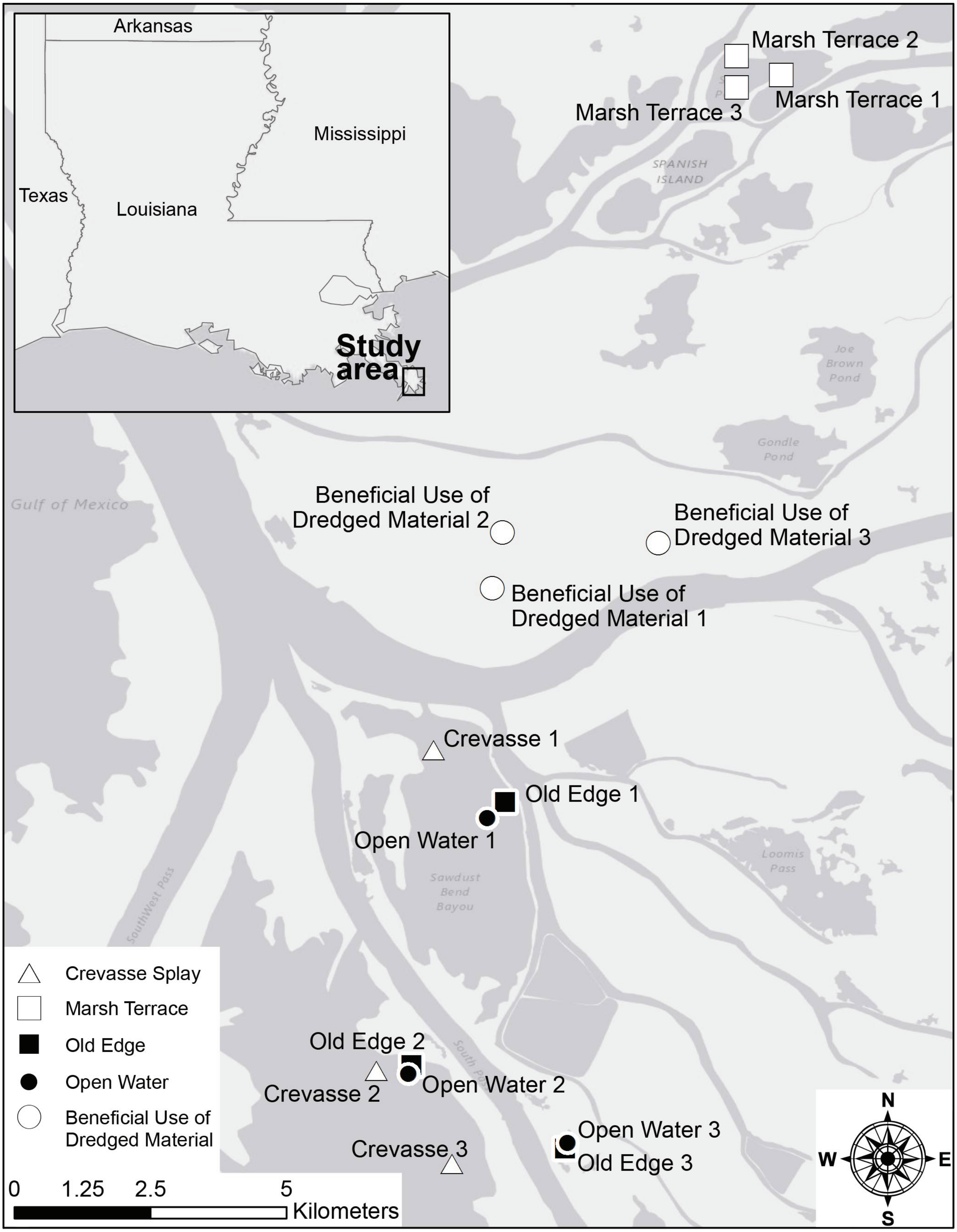



Figure 5. Map of the study area and experimental plots in the Mississippi River Delta, Louisiana, USA.

# CHAPTER 3: FIELD METHODS

## 3.1 Sampling Period

From March 2013 to October 2014, we conducted bird surveys, vegetation surveys, and collected water and environmental data at the study plots. Plots were randomly selected for sampling and visited seasonally, with at least one plot from each treatment habitat type being surveyed each season. When sampling began in the spring of 2013, construction was not completed at the marsh terrace and beneficial use of dredged material marsh sites and access was not granted until the summer of 2013. Those study plots were selected and set-up in August 2013. Sampling began at the beneficial use of dredged material marsh plots in October 2013 and at the marsh terraces in January 2014. There were 82 total sampling trips conducted from March 2013 to October 2014. Crevasse splay sites were sampled 20 times. Old edge sites were sampled 19 times. Beneficial use of dredged material and marsh terrace sites were sampled 12 times. Open water sites were sampled 19 times. When possible, sampling of two nearby sites would take place at the same time, with one person surveying one plot and another surveying the second. We also attempted to sample a combination of plot habitat types within the same day, weather and boating conditions permitting. To avoid conflicts with hunters over study site access, surveys were not conducted during waterfowl hunting season. Hunting pressure has been found to cause waterfowl to abandon a habitat or to concentrate in refuges where hunting is banned (Chabreck et al. 1989), potentially skewing study results.

## 3.2 Bird Surveys

Bird surveys to estimate avian density, species richness, and microhabitat utilization were modeled after the methods used by O'Connell (2006) during a similar study in southwestern Louisiana. Bird surveys began at various times during daylight hours, with the goal of conducting counts during the morning, afternoon, and early evening for each habitat type for every season over the course of the study. Bird counts were conducted in 15 minute intervals, for 6 counts over a total of 90 minutes, each day a plot was observed (O'Connell 2006, O'Connell and Nyman 2010). During some site visits, counts were

replicated only 4 or 5 times due to poor weather conditions.

Observations took place either from a small boat pushed up against marsh vegetation and draped with camouflage blind material or while the observer is hidden in emergent vegetation at least 50m from the nearest edge of the plot. After arriving at a plot and setting up a temporary blind on the boat or in the marsh, a 20-minute settling time was observed to allow birds to return to the plot after disturbance (O'Connell 2006). Surveys consisted primarily of visual counts using spotting scopes and binoculars. If calls from secretive marsh birds (such as rails and gallinules) or small, difficult to see passerines such as wrens and sparrows, were heard in the area of the plot but not immediately seen, the individual bird was identified by its call and species abundance was estimated based on the number of birds heard calling from inside the plot zone. Generally, over the course of a survey, secretive marsh birds and small passerines indentified by call were also seen during at least one of the counts. Observers recorded where the birds were spotted in the plot in relation to the marsh edge, marking all zones each bird or flock of birds used. Behavior details, classified as forage, fly, loaf, perch, swim, and fight, and plot zones traveled through were recorded as well for each individual bird or flock of birds.

The greatest number of birds of a given species observed during any one count interval of a survey was used as the estimate of total abundance for that species for that survey. Abundance estimates of observed species within plot zones were made using the data from the count with the greatest number of observed individuals of that species. This avoided double-counting birds that revisited a plot during multiple counts of a survey. To determine the total all-species bird abundance for a survey, the estimated bird abundance for each species observed was summed.

**3.3 Environmental Sampling and Vegetation Surveys**

After each bird survey, wind speed and air temperature were recorded using a handheld weather meter (Brunton ADC Summit, Brunton Group, Boulder, CO) and direction was determined using a compass within 10m of the marsh edge (or center of the plot for open water plots). Notes on cloud cover,

precipitation, wave action, and changes in the weather over the course of the survey were recorded. Water depth, temperature, conductivity, salinity, and pH were measured following each survey to reduce disturbance to the site. Salinity, conductivity, pH, and water temperature are measured within 10m from the marsh edge using a YSI model 63 m (Yellow Springs Instruments Inc., Yellow Springs, OH). Measurements of water depth are taken at 0m, 10m, 20m, 30m, and 40m from the marsh edge using a meter stick. In open water plots, water quality measurements and water depth were recorded in the center of the plot.

We compared the availability of emergent vegetation and submerged aquatic vegetation (SAV) in the plots because they are important food and/or cover sources for many waterbirds (O'Connell 2006). We began collecting detailed surface cover data in October 2013 and continued until the completion of the survey in October 2014. Past research and some CRMS sites have recorded detailed surveys of vegetation in the study region (CPRA 2015, Steyer et al. 2003, White 1993), but recent, detailed surveys were not available for all sites. Floating vegetation (non-rooted species) was also sampled. Vegetation species were grouped as either emergent, floating, or SAV based on observed growth form. Total surface area cover of each zone of the plot was recorded, divided into emergent vegetation, floating vegetation, SAV, mudflat (unvegetated bare ground), and open water. Species composition was recorded for emergent, floating, and submerged aquatic vegetation communities within the four plot zones. Stem cover was used to estimate total cover for emergent and SAV plant species. SAV was sampled using a rake, drug along a diagonal across each zone to expose vegetation in deep or turbid waters. Total surface area covered by both the stems and leaves of floating plants was used to estimate total cover for those species.

# CHAPTER 4: METHODS FOR DATA ANALYSIS

## 4.1 Biodiversity - Species and Guild Richness

Using the bird abundance data, several statistical operations were performed to analyze the avian communities at each plot and then make comparisons between the habitat types of crevasse splays, marsh terraces, beneficial use of dredged material marshes, old edge, and open water. Total species richness for a plot was defined as the number of species observed during the entire survey. Species richness is a well-recognized measure of Alpha biodiversity (Whittaker 1972) and was analyzed to test which type of habitat supported the greatest biodiversity compared to all other treatment sites and control sites. Foraging guild richness, defined by the number of foraging guilds represented by species observed during a survey, was also analyzed as measure of biodiversity. For avian management, groups of similar species are commonly organized into foraging guild groups based on their food sources and foraging behaviors (De Graaf et al. 1985, O'Connell and Nyman 2010, Takekawa et al. 2001). This metric of biodiversity not only describes what type of birds were indentified at a site, but could also assists managers in predicting what other similar species might use the area. Measures of guild richness can be useful when management decisions are made to improve habitat suitability for certain groups of birds, such as waterfowl or shorebirds, rather than for all birds in general.

### 4.1.1 Foraging Guild Classification Scheme

The foraging guild classification of North American waterbirds proposed by De Graaf et al. (1985) was used as a guide to develop a simplified guild classification scheme tailored to the bird communities we observed. If we followed De Graaf's (1985) detailed classification scheme, 37 guilds actively used the plots. The following guild classification system (table 1) was developed to encapsulate the different foraging techniques and food sources used by individual species, and group them with other species that were observed using microhabits of the plots in similar ways. Unidentified birds by genus and family are also placed into appropriate guilds. There was not an equal distribution of represented species or

observed abundance in our guild classification system, but it accurately represents the distinctive foraging behaviors of the observed species included in the study (table 1).

For all datasets, birds identified as a Clapper Rail (*Rallus longirostis*) or King Rail (*Rallus elegens*) were classified as a Clapper Rail x King Rail hybrid and grouped with Marsh Foragers and Gleaners. Our study site lies in part of southern Louisiana recognized as a hybrid zone of the Clapper Rail and King Rail species. In intermediate marshes, hybridization is not uncommon (Maley 2012). Using visual identification through binoculars and scopes alone is often insufficient to distinguish between pure Clapper Rails, pure King Rails, and hybrids due to subtle plumage color variations (Maley 2012). All rails of the genus *Rallus* counted during our sampling were assumed to be Clapper Rail-King Rail hybrids and considered one species (specifically, *Rallus elegans* × *Rallus longirostris,* alpha code: CLRAxKIRA) because we did not capture birds to confirm their species through DNA sampling or morphological measurements.

Table 1. Foraging guild designations for avian species observed in marsh edge study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Foraging guild | Guild code | Included species |
|---|---|---|
| Aerial Insectivores | AI | Eastern Kingbird, Tree Swallow, Barn Swallow, Orchard Oriole, unidentified swallow |
| Carnivorous Hawkers and Plungers | CHP | American Kestrel, Bald Eagle, Northern Harrier, Peregrine Falcon |
| Dabblers and Grubbers | DG | American Coot, American Wigeon, Black-bellied Whistling Duck, Blue-winged Teal, Gadwall, Mottled Duck, Northern Pintail, Snow Goose, unidentified dabbling duck |
| Marsh Foragers and Gleaners | MFG | Black-necked Stilt, Boat-tailed Grackle, Clapper Rail x King Rail, Common Gallinule, Marsh Wren, Mourning Dove, Purple Gallinule, Red-winged Blackbird, Savannah Sparrow, Sedge Wren, Sora, Swamp Sparrow, Yellow-rumped Warbler, unidentified passerine, unidentified rail, unidentified sparrow, unidentified wren |
| Mudflat Probers and Gleaners | MPG | Glossy Ibis, Killdeer, Least Sandpiper, Lesser Yellowlegs, Long-billed Dowitcher, Roseate Spoonbill, Stilt Sandpiper, White Ibis, White-faced Ibis, Willets, unidentified plover, unidentified sandpiper |
| Piscivore Plungers and Divers | PPD | Anhinga, Belted Kingfisher, Brown Pelican, Caspian Tern, Common Tern, Double-crested Cormorant, Forster's Tern, Least Tern, Osprey, Royal Tern, Sandwich Tern, unidentified tern |
| Scavengers, Food Pirates, and Generalists | SFPG | Herring Gull, Laughing Gull, Magnificent Frigatebird, Ring-billed Gull, unidentified gull |
| Wading Ambushers | WA | Black-crowned Night Heron, Great Blue Heron, Great Egret, Greater Yellowlegs, Green Heron, Least Bittern, Little Blue Heron, Snowy Egret, Tricolored Heron, Yellow-crowned Night Heron |
| Water Bottom Foragers and Divers | WBFD | Canvasback, Lesser Scaup, Pied-billed Grebe |
| Water Surface Gleaner | WSG | American White Pelican, Black Skimmer, Black Tern, Bonaparte's Gull, Gull-billed Tern |

### 4.1.2 Species and Guild Frequency

To illustrate which species and guilds were most often present in each habitat type, we constructed frequency tables (PROC FREQ, SAS version 9.4, SAS, Inc., Cary, NC). Each bird counted was identified by species, or at least by genus or family if species was unknown, and assigned the appropriate guild for its species. Two data sets were created for species frequency – one including all birds, and another including only birds actively using the plot. “Active use” includes birds that were observed foraging, loafing, perching, swimming, or fighting while in the plot. Species frequency tables were developed for all birds in all plots and active use birds in all plots. These two tables were also made for each habitat type. The same tables were made for guild frequencies.

### 4.1.3 Species and Guild Richness

To test the hypothesis that there was no difference in species richness among the five habitat types, we performed a generalized linear mixed model to implement an analysis of covariance with two covariates (year and season) and interactions among explanatory variables and covariables (PROC GLIMMIX, SAS version 9.4, SAS, Inc., Cary, NC). Only birds actively using the plots were included in this analysis. To decrease small sample bias, the Laplace approach was used for estimations of maximum likelihood (Gbur et al. 2012). We tested goodness of fit of possible link transformations and error term distributions within the model (identity normal, log normal, poisson, gamma, exponential, and negative binomial) by comparing the following fit statistics: Akaike’s Information Criterion and Pearson Chi-Square/degrees of freedom (Gbur et al. 2012). The significant covariate, or combination of covariates, was determined based on the results of the type III tests of fixed effects. We calculated the least square means for species richness by habitat type (or combination of habitat type, year, and/or season) to describe the differences between significant treatment X covariate interactions and identify statistically significant differences by conservative T groupings (Gbur et al. 2012). The marginal linear predictor statistics (Schabenberger 2005) were grouped by habitat type and graphed to illustrate the differences in

species richness between habitat types by season. The same model was used to test for significant differences in guild richness.

**4.2 Total Bird Density**

We compared total bird density between habitat types for all birds (including flyover birds) and active-use birds only (excluding flyover birds). Total bird density was estimated by dividing the total bird abundance for each count by plot area (1200 $m^2$ for edge plots, 300 $m^2$ for open water plots). To test if there was a significant difference in total bird density for between the habitat types, we performed a generalized linear mixed model to implement an analysis of covariance with two covariates (year and season) and interactions among explanatory variables (habitat type) and covariables (year, season) (PROC GLIMMIX, SAS version 9.4, SAS, Inc., Cary, NC). To decrease small sample bias, the Laplace approach was used for estimations of maximum likelihood (Gbur et al. 2012). We tested goodness of fit of possible link transformations and error term distributions within the model (identity normal, log normal, poisson, gamma, exponential, and negative binomial) by comparing the following fit statistics: Akaike's Information Criterion and Pearson Chi-Square/degrees of freedom (Gbur et al. 2012). The significant covariate, or combination of covariates, was determined based on the results of the type III tests of fixed effects. We calculated the least square means for density by habitat type (or combination of habitat type, year, and/or season) to describe the differences between significant treatment X covariate interactions and identify statistically significant differences by conservative T groupings (Gbur et al. 2012). The marginal linear predictor statistics (Schabenberger 2005) were grouped by habitat type and graphed to illustrate the differences in habitat types by season, or by season and year. We also analyzed active-use bird density by comparing only marsh edge plots (crevasse splay, marsh terrace, beneficial use of dredged material, and old edge), excluding open water plots from the dataset. We recorded extremely high bird densities during two open water surveys; open water plots were excluded to improve the accuracy of the model for predicting density in edge plots.

**4.3 Species of Concern**

The same methods were used to analyze the density of bird species of concern and species in steep decline, as identified by the State of the Birds Report 2014 (North American Bird Conservation Initiative 2014, Rosenberg 2014). Only species of concern and species in steep decline were used in the species variable. From this data set, we ran tests to see if there was a significant difference in bird density between habitat types for these birds. Only one species was frequently counted enough to analyze independently - Black Tern, a common species in steep decline. Just using Black Terns for the species variable, we carried out the same test for bird density to determine if there was a significant difference between habitat types.

**4.4 Bird Density by Foraging Guild**

Similar to the analysis of total bird density, for analyzing foraging guilds, individual birds for each survey were summed by guild and divided by plot area for a density estimate. For the first set of tests, we only included birds actively using the plots. To test if there was a significant difference in total bird density for each guild between the plot types, we performed a guild-specific generalized linear mixed model to implement an analysis of covariance with two covariates (year and season) and interactions among explanatory variables (habitat type) and covariables (year, season) (PROC GLIMMIX, SAS version 9.4, SAS, Inc., Cary, NC). To decrease small sample bias, the Laplace approach was used for estimations of maximum likelihood (Gbur et al. 2012). We tested goodness of fit of possible link transformations and error term distributions within the model (identity normal, log normal, poisson, gamma, exponential, and negative binomial) by comparing the following fit statistics: Akaike's Information Criterion and Pearson Chi-Square/degrees of freedom (Gbur et al. 2012). The significant covariate, or combination of covariates, was determined based on the results of the type III tests of fixed effects. We calculated the least square means for density by habitat type (or combination of habitat type, year, and/or season) to describe the differences between significant treatment X covariate interactions and identify statistically significant differences by conservative T groupings (Gbur et al. 2012). The marginal

linear predictor statistics (Schabenberger 2005) were grouped by habitat type and graphed to illustrate the differences in habitat types by season, or by season and year.

For the second set of test of bird density by foraging guild, we focused only on waterfowl. We combined the two guilds that include duck and geese species – Dabblers and Grubbers and Water Bottom Foragers and Divers – to conduct additional analysis of bird density between the plots Because waterfowl species are the focus on much management activity in the Lower Mississippi Alluvial Valley (US Fish and Wildlife Service et al. 2011),. Many of the waterfowl counted were flying over the plots, not foraging or exhibiting some over active use behavior. Many of these birds flew low over the plot then took off and often landed in similar habitat types a couple hundred meters away. We hypothesize that waterfowl species, which are under pressure from hunting in the area, are more aware of people in the marsh and responded to our presence as a threat. Despite the use of camouflage material and trying to hide the boat in the marsh vegetation, we were not completely disguised. To improve the density models to represent what we believe are more accurate estimates for habitat use by waterfowl, we kept flyover birds in our analysis of waterfowl density. Waterfowl seemed to be more sensitive to the presence of researchers, often flying low over the plots but taking off when they saw our makeshift boat blind. In a second test of waterfowl density, we only included edge plots in our analysis to focus on response to marsh management and restoration actions. During one of our winter surveys, a large flock of 90 American Coots swam through an open water plot, but during no other survey did open water plots support such large abundance of Dabbler and Grubber birds. We excluded open water plots from this test in an attempt to improve the model's ability to accurately estimate density within marsh edge plots.

**4.5 Edge Effect Among Habitat Types**

To test if the physical extent of the edge effect (Chabreck et al. 1989, O'Connell and Nyman 2010, Weller and Spatcher 1965) differed between the four types of edge habitats studied, we compared bird abundance among the zones within the plots coming out from the emergent marsh edge. When sampling, we noted what zone or zones each individual bird, or flock of birds, used during a count and this data was

used to determine bird abundance by zone. All individual birds observed actively using the plot (excluding flyovers by non-aerial foraging species) were grouped by zone(s) used were summed together to investigate overall trends in edge-dependent behavior. Zone 1 was defined as 0-10 m from the edge. Zone 2 was defined as 10-20 m from the edge. Zone 3 was defined as 20-30 m from the edge. Zone 4 was defined as 30-40 m from the edge. For example, if a flock of 10 Tree Swallows (*Tachycineta bicolor*) were foraging in a plot during a count but subgroups of these birds were using different areas, three individuals that were foraging exclusively in zone 4 would be listed separately from two individuals perched on vegetation in zone 1 and five individuals that were foraging throughout the plot. Individual birds using a group of zones were listed in the dataset by all zones used, such as 1234 for a bird that used the entire plot.

To test if there was a significant difference in total bird abundance by zone between the four types of edge plots, we performed a generalized linear mixed model to implement an analysis of covariance with two covariates (habitat type and season) and interactions among explanatory variables (plot zone) and covariables (PROC GLIMMIX, SAS version 9.4, SAS, Inc., Cary, NC). To decrease small sample bias, the Laplace approach was used for estimations of maximum likelihood (Gbur et al. 2012). We tested goodness of fit of possible link transformations and error term distributions within the model (identity normal, log normal, poisson, gamma, exponential, and negative binomial) by comparing the following fit statistics: Akaike's Information Criterion and Pearson Chi-Square/degrees of freedom (Gbur et al. 2012). The significant covariate, or combination of covariates, was determined based on the results of the type III tests of fixed effects. We calculated the least square means for abundance within each zone by habitat type and season to describe the differences between significant treatment X covariate interactions and identify statistically significant differences by conservative T groupings (Gbur et al. 2012). We modeled the probability of an individual bird utilizing each zone and combination of zones within a plot by season by grouping the marginal linear predictor statistics (Schabenberger 2005) by habitat type and creating graphs to illustrate the differences by season.

Much of the research on marsh edge effects on avian habitat use has focused on bird species that forage in the marsh or water, not in the air (Murkin et al. 1982, Waller and Spatcher 1965). After removing individuals from guilds that forage primarily from the air (AI, CHP, PPD, and SFPG) from the dataset, we used the previous model to test if there was a significant difference in bird abundance by zone for non-aerial foraging species.

**4.6 Environmental Conditions**

Canonical correspondence analysis (CCA), performed with the program CANOCO (CANOCO vers. 4.5, Microcomputer Power, Ithaca, NY), was used to determine the influence of environmental conditionals on the distribution of avian foraging guilds, and identify relationships between environmental variables and habitat types. CCA is a constrained ordination technique that incorporates the unimodal response of species to environmental variables, wherein linear combinations of environmental variables are selected to maximum dispersion of the species' distribution in the ordination space (Blair 1996, Ter Braak 1987). Each site visit was treated as a sample and only site visits conducted after October 12, 2013 (when vegetation surveying began) were included in the analysis. Environmental variables included in the analysis:

Depth at 0m – water depth at the marsh edge

Mean depth – average water depth of the study plot

Salinity – water salinity (ppt)

Mudflat percent cover – percent of surface area covered by mudflats

Water percent cover – percent of surface area covered by open water

Emergent vegetation percent cover – percent of surface area covered by emergent vegetation

Floating vegetation percent cover – percent of surface area covered by floating vegetation

SAV percent cover – percent of surface area covered by submerged aquatic vegetation

Emergent vegetation species richness – emergent vegetation species richness

Floating vegetation species richness – floating vegetation species richness

SAV species richness – submerged aquatic vegetation species richness

Two separate hypotheses were tested using CCA. First, we tested the hypothesis that habitat type (crevasse splay, marsh terrace, beneficial use of dredged material marsh, old edge marsh, open water) is not related environmental variables. CCA typically compares species (presence/absence or abundance) to environmental variables, but in this analysis, the variable "habitat type" was substituted for species and samples were assigned a value of 1 for the habitat type of the site surveyed, and 0 all other habitat types. Second, we tested the hypothesis that foraging guild density is not related to environmental variables (with guilds substituting for species).

# CHAPTER 5: RESULTS

## 5.1 Biodiversity - Species and Guild Richness

### 5.1.1 Species Frequencies

Over the entire study (March 2013-October 2014), we counted 74 species, plus 12 unidentified species (grouped by order, family, or genus) for a total of 2257 individual birds (table B.1). Tables for species frequencies are included in Appendix B. If we exclude flyovers, the number of individuals that actively utilized plots in the study site decreases to 1361 (table B.2). There were 16 fewer species actively using the study plots than all species moving through the plots. Some species were notably less abundant when flyovers were excluded from the data set, such as Blue-winged Teal. Fifty-five individual Blue-winged Teal were counted during the study (table B.1), but only 9 of those individuals were actively using the plots (table B.2).

In crevasse splay sites, 62 species (included unidentified birds by genus or family) were recorded, with the five most common being Tree Swallow (n=151), Red-winged Blackbird (n=106), Black Tern (n=46), White Ibis (n=39), and Boat-tailed Grackle (n=34) (table B.3). In marsh terrace sites, 52 species (included unidentified birds by genus or family) were recorded, with the five most common being Red-winged Blackbird (n=73), Black Tern (n=68), American Coot (n=57), unidentified dabbling duck (n=38), and Snow Goose (n=31) (table B.4). In beneficial use of dredged material sites, 53 species (included unidentified birds by genus or family) were recorded, with the five most common being Tree Swallow (n=71), Red-winged Blackbird (n=52), Boat-tailed Grackle (n=21), Royal Tern (n=11), and Caspian Tern (n=11), tied with Sandwich Tern (table B.5). Fewer species were recorded at the old edge plots than any of the restored edge plots. There were 44 species (included unidentified birds by genus or family) with the five most common being Tree Swallow (n=87), Boat-tailed Grackle (n=49), Red-winged Blackbird (n=39), American Coot (n=20), and Common Tern (n=18) (table B.6). The fewest species were recorded in the open water plots (n=32) (table B.7). The most common were American Coot (n=90), Tree Swallow (n=77), Black Tern (n=44), Common Tern (n=17), and Royal Tern (n=16).

The species frequencies changed when flyovers were removed (tables B.8, B.9, B.10, B.11, and B.12). More species were present at crevasse splay sites (n=48) than other restored edge plots (marsh terraces n=34 and beneficial use n=32). In crevasse splays sites, 48 species (included unidentified birds by genus or family) were recorded, with the five most common being Tree Swallow (n=149), Red-winged Blackbird (n=63), Black Tern (n=42), Forster's Tern (n=24), and Boat-tailed Grackle (n=20) (table B.8). White Ibis were the 8$^{th}$ most common species, rather than the 5$^{th}$ (table B.3), when flyovers were removed (table B.8). In marsh terrace sites, 34 species (included unidentified birds by genus or family) were recorded, with the five most common being Black Tern (n=67), American Coot (n=57), Red-winged Blackbird (n=25), Tree Swallow (n=15), and Forster's Tern (n=8) (table B.9). Notably, ducks and geese were more frequent when flyovers were included. No Snow Geese were recorded actively using the plots and the only other waterfowl actively using the plots were American Wigeon (n=1) and Lesser Scaup (n=1). In beneficial use sites, 32 species (included unidentified birds by genus or family) were recorded, with the five most common being Tree Swallow (n=56), Red-winged Blackbird (n=26), Royal Tern and Sandwich Tern (both n=9), and Caspian Tern (n=8) (table B.10). As when flyovers were included, fewer species were recorded at the old edge plots than crevasse splays or marsh terraces, though the same number as beneficial use of dredged material marshes. There were 32 species (included unidentified birds by genus or family) recorded, with the five most common being Tree Swallow (n=84), Boat-tailed Grackle (n=23), American Coot (n=19), Red-winged Blackbird (n=15), and Common Tern (n=14) (table B.11). Far fewer species were present in open water plots when flyovers were excluded, dropping from 32 (table 7) to 15 (table B.12). However, the most common species remained the same, but decreased in number. The five most common were again American Coot (n=90), Tree Swallow (n=75), Black Tern (n=40), Common Tern (n=17), and Royal Tern (n=14).

#### 5.1.2 Guild Frequencies

We created guild frequency tables for all plots including all birds (table 2) and only birds actively using the plots (table 3). All ten guilds were included in both datasets. Notably marsh foragers and

gleaners (n=450) and dabblers and grubbers (n=429), the two most frequently counted guilds (table 2), were far less abundant when flyovers were excluded from the data set (marsh foragers and gleaners n=222, dabblers and grubbers n=212) (table 3).

Table 2. Frequency of foraging guilds detected within all study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| MFG | 450 | 19.94 | 450 | 19.94 |
| DG | 429 | 19.01 | 879 | 38.95 |
| AI | 425 | 18.83 | 1304 | 57.78 |
| PPD | 327 | 14.49 | 1631 | 72.26 |
| WSG | 224 | 9.92 | 1855 | 82.19 |
| MPG | 182 | 8.06 | 2037 | 90.25 |
| WA | 124 | 5.49 | 2161 | 95.75 |
| SFPG | 64 | 2.84 | 2225 | 98.58 |
| CHP | 18 | 0.8 | 2243 | 99.38 |
| WBFD | 14 | 0.62 | 2257 | 100 |

Table 3. Frequency of foraging guilds detected within all study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| AI | 402 | 29.54 | 402 | 29.54 |
| PPD | 230 | 16.9 | 632 | 46.44 |
| MFG | 222 | 16.31 | 854 | 62.75 |
| DG | 212 | 15.58 | 1066 | 78.32 |
| WSG | 175 | 12.86 | 1241 | 91.18 |
| WA | 39 | 2.87 | 1280 | 94.05 |
| MPG | 37 | 2.72 | 1317 | 96.77 |
| SFPG | 17 | 1.25 | 1334 | 98.02 |
| CHP | 16 | 1.18 | 1350 | 99.19 |
| WBFD | 11 | 0.81 | 1361 | 100 |

Crevasse splay sites supported the most guilds, with all 10 being present at some time over the study (table 4). Marsh terrace (table 5), beneficial use of dredged material (table 6), old edge (table 7) plots all supported 9 guilds. These three habitat types hosted no Mudflat Probers and Gleaners. Aerial

Foragers were the most frequent guild for crevasse splays (n=158), beneficial use (n=64), and old edge (n=85) plots, but Water Surface Gleaners (n=74) were the most frequent guild at the marsh terraces. Dabblers and Grubbers, the guild that include waterfowl species many refuges actively manage habitat for, were also more frequent in the marsh terraces (n=58) than any other edge plots. Open water plots (table 8), which supported only 5 guilds, hosted more Dabblers and Grubbers than all over plots (n=90), but the guild was represented by only one species – American Coot (Appendix B, table B.12).

Table 4. Frequency of foraging guilds detected within crevasse splay study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| AI | 158 | 34.73 | 158 | 34.73 |
| MFG | 90 | 19.78 | 248 | 54.51 |
| PPD | 67 | 14.73 | 315 | 69.23 |
| WSG | 46 | 10.11 | 361 | 79.34 |
| DG | 39 | 8.57 | 400 | 87.91 |
| MPG | 32 | 7.03 | 432 | 94.95 |
| WA | 16 | 3.52 | 448 | 98.46 |
| CHP | 3 | 0.66 | 451 | 99.12 |
| SFPG | 3 | 0.66 | 454 | 99.78 |
| WBFD | 1 | 0.22 | 455 | 100 |

Table 5. Frequency of foraging guilds detected within marsh terrace study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| WSG | 74 | 30.71 | 74 | 30.71 |
| DG | 58 | 24.07 | 132 | 54.77 |
| MFG | 47 | 19.5 | 179 | 74.27 |
| PPD | 21 | 8.71 | 200 | 82.99 |
| AI | 19 | 7.88 | 219 | 90.87 |
| CHP | 10 | 4.15 | 229 | 95.02 |
| WA | 5 | 2.07 | 234 | 97.1 |
| SFPG | 4 | 1.66 | 238 | 98.76 |
| WBFD | 3 | 1.24 | 241 | 100 |

Table 6. Frequency of foraging guilds detected within beneficial use of dredged material study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| AI | 64 | 39.26 | 64 | 39.26 |
| MFG | 40 | 24.54 | 104 | 63.8 |
| PPD | 38 | 23.31 | 142 | 87.12 |
| SFPG | 6 | 3.68 | 148 | 90.8 |
| WA | 4 | 2.45 | 152 | 93.25 |
| WSG | 4 | 2.45 | 156 | 95.71 |
| CHP | 3 | 1.84 | 159 | 97.55 |
| DG | 2 | 1.23 | 161 | 98.77 |
| WBFD | 2 | 1.23 | 163 | 100 |

Table 7. Frequency of foraging guilds detected within old edge study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| AI | 85 | 35.71 | 85 | 35.71 |
| PPD | 50 | 21.01 | 135 | 56.72 |
| MFG | 45 | 18.91 | 180 | 75.63 |
| DG | 23 | 9.66 | 203 | 85.29 |
| WA | 14 | 5.88 | 217 | 91.18 |
| WSG | 8 | 3.36 | 225 | 94.54 |
| WBFD | 5 | 2.1 | 230 | 96.64 |
| MPG | 4 | 1.68 | 234 | 98.32 |
| SFPG | 4 | 1.68 | 238 | 100 |

Table 8. Frequency of foraging guilds detected within open water study plots, excluding non-foraging flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Guild | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| DG | 90 | 34.09 | 90 | 34.09 |
| AI | 76 | 28.79 | 166 | 62.88 |
| PPD | 54 | 20.45 | 220 | 83.33 |
| WSG | 43 | 16.29 | 263 | 99.62 |
| MPG | 1 | 0.38 | 264 | 100 |

### 5.1.3 Species Richness

Species richness was significantly different based on the interaction of habitat type and season ($F_{12,61}$=2.23, p=0.021). We used the log link transformation and Poisson distribution for this dataset based on analysis of best fit. Despite counting less species total in old edge plots (Appendix B, table B.11) than all the other edge plot types, old edge plots were estimated to have the highest species richness in winter (mu=2.4455 [log transformed]) and summer (mu=2.2512 [log transformed]) compared to all other edge habitat types during those season, although the differences were not significant (table 9). When we break up species richness by season and year using means from the main effects model, we can more easily evaluate the differences among habitat types (fig. 6). Over all sampling periods, open water plots had significantly lower species richness than all types of edge plots ($\alpha \leq 0.05$). With the exception of summer 2013, winter 2014, and summer 2014 when old edge plots had the highest species richness, these non-restored marshes had significantly lower species richness than all three types of restored edge plots during the same sampling period ($\alpha \leq 0.05$). There was no significant difference among the three restored habitat types – crevasse splays, beneficial use of dredged material, and marsh terraces – in any of the 2014 sampling periods (fig. 6).

Table 9. Conservative T Grouping for mean species richness by season*habitat type Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014.

| Conservative T Grouping for season*habitat type Least Squares Means (Alpha=0.05)[a] | | | | | |
|---|---|---|---|---|---|
| Season | Habitat type | Estimate | Groupings | | |
| Winter | old edge | 2.4455 | | A | |
| Summer | old edge | 2.2512 | | A | |
| Winter | pump-in[b] marsh | 2.2449 | B | A | |
| Summer | terrace marsh | 2.1877 | B | A | |
| Fall | terrace | 2.1271 | B | A | |
| Spring | pump-in | 2.1271 | B | A | |
| Summer | crevasse | 2.1154 | B | A | |
| Fall | crevasse | 2.0357 | B | A | C |
| Winter | crevasse | 1.9935 | B | A | C |
| Summer | pump-in | 1.8935 | B | A | C |
| Fall | pump-in marsh | 1.818 | B | A | C |
| Winter | terrace | 1.7216 | B | A | C |
| Spring | crevasse marsh | 1.6979 | B | | C |
| Spring | terrace | 1.5881 | B | | C |
| Summer | open water | 1.4710 | B | | C |
| Fall | old edge | 1.2894 | | | C |
| Spring | old edge | 1.1917 | | | C |
| Fall | open water | 0.7016 | | | C |
| Spring | open water | 0.0931 | | | C |
| Winter | open water | 0.0476 | | | C |

[a]LS-means with the same letter grouping are not significantly different.

[b]Beneficial use of dredged material marshes are also referred to as “pump-in” marshes.

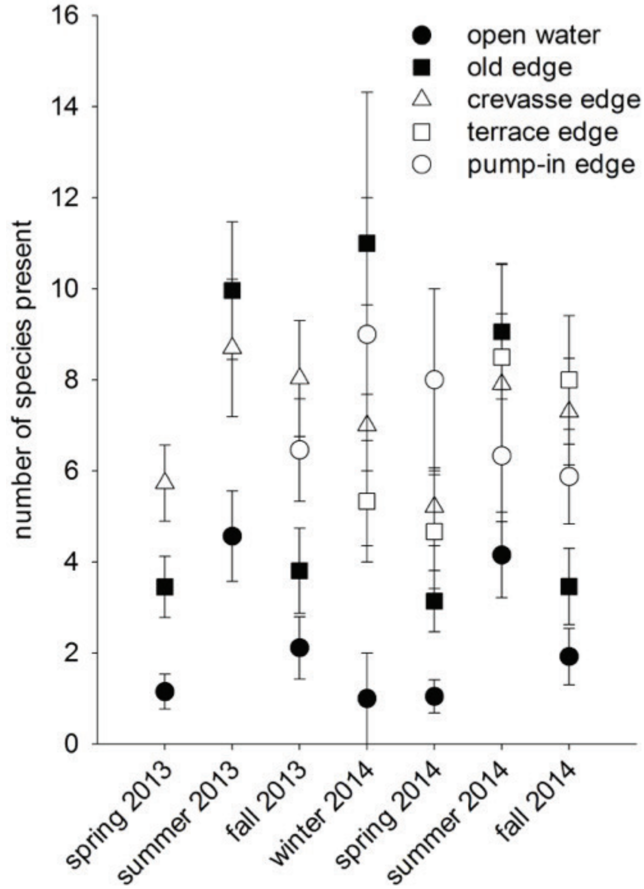



Figure 6. Model predicted means and standard deviations of species richness for each type of habitat site studied in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. No surveys were done at marsh terrace or pump-in (beneficial use of dredged material) sites during the spring and summer of 2013. Marsh terraces were also not surveyed during the fall of 2013.

### 5.1.5 Guild Richness

Guild richness differed significantly among habitat types ($F_{4,73}$=15.35, p<0.0001). We used the identity link function and normal (Guassian) distribution for this dataset based on analysis of best fit. Guild richness was generally similar among all types of edge habitat plots. Guild richness was greatest in

crevasse splay sites (mu=4.59) during all sampling periods (fig. 7), but the estimated mean was only significantly different from old edge (p=0.005) and open water plots (p<0.001) (table 10). Marshes constructed through the beneficial use of dredged material (mu=4.23) and marsh terracing (mu=4.18) did not support significantly greater guild richness than unrestored, old edge plots (mu=3.45, $\alpha \leq 0.05$). All edge plots supported significantly greater guild richness than open water plots (mu=1.72, p<0.001) (fig. 7).

Table 10. T Grouping of mean guild richness estimates for habitat type Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014.

| T Grouping for habitat type least squares means (alpha=0.05)[a] | | | |
|---|---|---|---|
| Habitat type | Estimate | Groupings | |
| Crevasse | 4.5944 | | A |
| Pump-in[b] | 4.2305 | B | A |
| Marsh terrace | 4.1751 | B | A |
| Old edge | 3.4533 | B | |
| Open water | 1.7165 | | C |

[a]LS-means with the same letter grouping are not significantly different.

[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

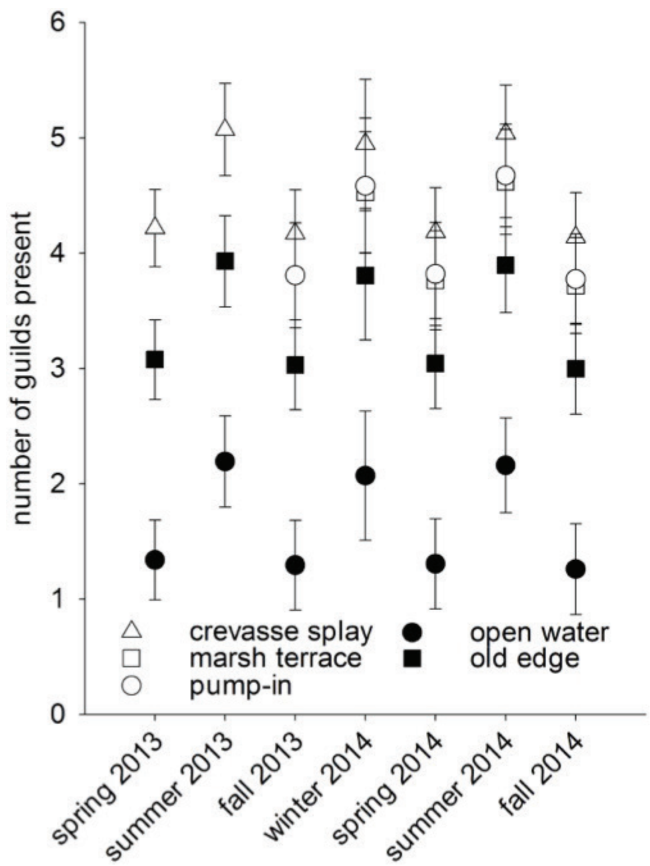



Figure 7. Model predicted means and standard deviations of guild richness for each type of habitat site studied in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. No surveys were done at marsh terrace or pump-in (beneficial use of dredged material) sites during the spring and summer of 2013. Marsh terraces were also not surveyed during the fall of 2013.

**5.2 Total Bird Density**

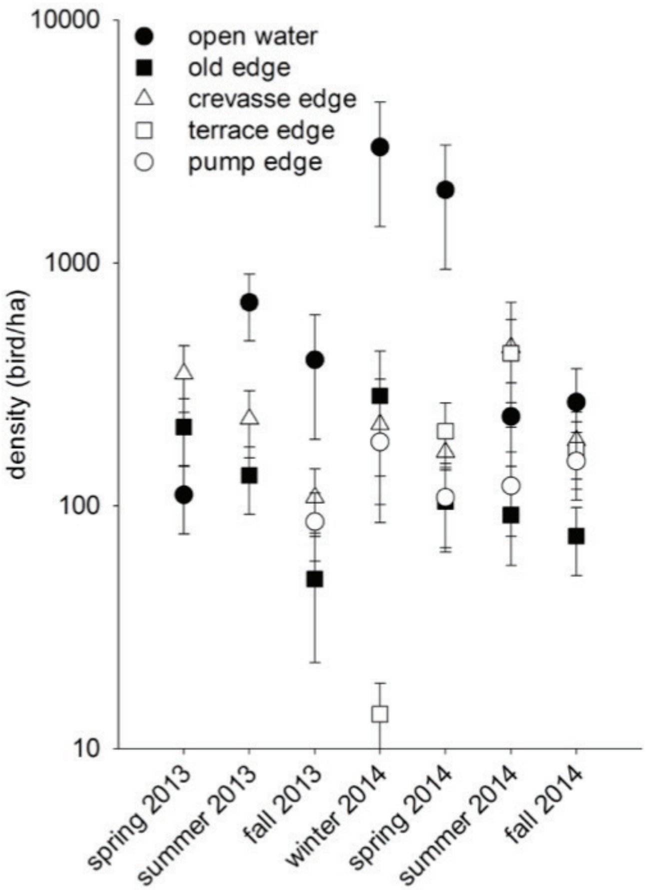
The interaction among habitat type, year, and season was found to be the significant covariate ($F_{4,40}$=6.14, p=0.0006) for total bird density. We used the log link transformation and negative binomial distribution for this dataset based on analysis of best fit. Open water plots hosted significantly higher bird density during the winter of 2014 than all other sites regardless of season and year, aside from open water in the spring of 2014 (table 11). When we compare data for active use birds only, the results remained similar. The interaction between habitat type, year, and season was again found to be the significant covariate ($F_{4,37}$=8.02, p<0.0001) for predicting bird density. In summer 2013, fall 2013, winter 2014, and spring 2014, open water plots had a significantly higher bird density than any other habitat type for those sampling periods (fig. 8). Marsh terraces had a significantly lower bird density than all other habitat types in the winter of 2014. However, during all other sampling periods the bird density among all four types of edge habitat plots were not significantly different (fig. 8).

The difference among the four types of edge habitat plots are more apparent if open water plots are excluded from the analysis of total density of active use birds. This removed outliers resulting from large flocks of American Coots swimming through open water plots. The interaction between habitat type and season was found to be the significant covariate ($F_{9,38}$=4.30, p=0.0007) for total bird density. We used the log link transformation and negative binomial distribution for this dataset based on analysis of best fit. Marsh terraces in the summer supported the highest density of birds (mu=6.0521±0.4267 [log transformed]), but was not significantly different from crevasse splays in the same season (mu=5.3783±0.6053, p=0.4429). Bird density in the summer was significantly different between these two habitat types and old edge and beneficial use of dredged material marshes (p<0.05). In the spring and fall, bird densities were not significantly different between the four types of edge habitat plots. In the winter, however, marsh terraces supported significantly lower bird density than all other habitat types (p<0.05) (fig. 9).

Table 11. T Grouping of mean total bird density per hectare estimates for season, year, and habitat type interaction Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013-2014. Means have been log transformed.

| Conservative T Grouping for season*year*habitat type Least Squares Means (alpha=0.05) [a] | | | | | | | |
|---|---|---|---|---|---|---|---|
| Season | Habitat type[b] | Year | Estimate | Groupings | | | |
| Winter | open water | 14 | 8.0174 | | | A | |
| Spring | open water | 14 | 7.0619 | B | | A | |
| Summer | open water | 13 | 6.6126 | B | | C | |
| Winter | crevasse | 14 | 6.451 | B | | C | D |
| Summer | crevasse | 14 | 6.4243 | B | | C | D |
| Spring | crevasse | 13 | 6.3495 | B | | C | D |
| Summer | marsh terrace | 14 | 6.3099 | B | | C | D |
| Fall | marsh terrace | 14 | 6.1092 | B | | C | D |
| Fall | open water | 13 | 6.0715 | B | E | C | D |
| Fall | open water | 14 | 6.0715 | B | E | C | D |
| Fall | crevasse | 14 | 5.9416 | B | E | C | D |
| Summer | open water | 14 | 5.9045 | B | E | C | D |
| Winter | old edge | 14 | 5.8579 | B | E | C | D |
| Summer | crevasse | 13 | 5.7038 | | E | C | D |
| Summer | pump-in | 14 | 5.6898 | | E | C | D |
| Fall | pump-in | 14 | 5.6268 | | E | C | D |
| Spring | old edge | 13 | 5.5755 | | E | C | D |
| Spring | marsh terrace | 14 | 5.5649 | | E | C | D |
| Fall | crevasse | 13 | 5.5325 | | E | C | D |
| Winter | pump-in | 14 | 5.4876 | | E | C | D |
| Spring | old edge | 14 | 5.4345 | | E | | D |
| Spring | crevasse | 14 | 5.4284 | | E | | D |
| Fall | old edge | 14 | 5.4284 | | E | | D |
| Spring | pump-in | 14 | 5.3589 | | E | | D |
| Summer | old edge | 13 | 5.2701 | | E | | D |
| Fall | pump-in | 13 | 5.2412 | | E | | D |
| Spring | open water | 13 | 5.1805 | | E | | |
| Winter | marsh terrace | 14 | 5.1805 | | E | | |
| Summer | old edge | 14 | 5.0647 | | E | | |
| Fall | old edge | 13 | 3.912 | | | F | |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as “pump-in” marshes.



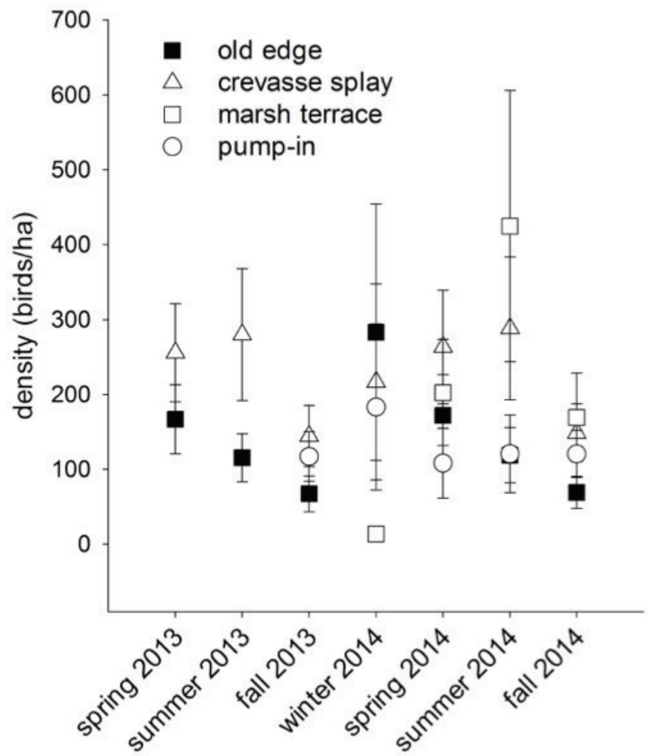




Figure 8. Model predicted means and standard deviations of bird density, excluding flyovers, in each habitat type by season and year in the Mississippi River Delta, Louisiana, USA, 2013-2014. The y-axis is a logrimthic scale.

Figure 9. Model predicted means and standard deviations of bird density, exlcuding flyovers, in each edge habitat type by season and year in the Mississippi River Delta, Louisiana, USA, 2013-2014.

**5.3 Species of Concern**

We encountered seven species of concern from the 2014 The State of the Birds Watch List (Rosenberg et al. 2014). The only Red Watch List species found in our study plots was the Mottled Duck. Mottled Ducks are non-migratory and nest along the Gulf Coast. This species was counted 29 times during surveys (table 12) and commonly spotted when traveling through the study area between study plots. Yellow Watch List species encountered during surveys include the Magnificent Frigatebird (n=3), King Rail (recorded as King Rail x Clapper Rail, n=3), Lesser Yellowlegs (n=4), Willet (n=37), Gull-billed Tern (n=9), Black Skimmer (n=8). While not yet included on either watch list, Northern Pintail (n=42), American Wigeon (n=1), Purple Gallinule (n=1), Herring Gull (n=8), and Black Tern (n=178) are all recognized as common species in steep decline (Rosenberg et al. 2014). Black Tern was

one of the forth most frequently counted species in our study (n=178), commonly seen foraging in areas with dense SAV coverage.

For all birds counted during the study, crevasse splays hosted the greatest total number of individual birds belonging to a species of concern watchlist or identified as species in steep decline (n=130), followed by marsh terraces (n=101), open water (n=51), old edge (n=22), and beneficial use of dredged material marshes (n=19). Only Black Terns and Herring Gulls were counted in every habitat type during our study (table 16). When flyovers were excluded (table 13), the number of species of concern decreased (n=9) along with frequency at which species of concern were counted decreased for each habitat type. More of these birds were counted at marsh terraces (n=76) rather than crevasse splays (n=60) when only birds actively using the plots were counted. Open water sites hosted the third highest number of these birds (n=44), followed by old edge plots (n=12), and beneficial use of dredged material marshes (n=7).

Table 12. Frequency of species of concern and species in steep decline by habitat type, including flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Frequency by habitat type | | | | |
|---|---|---|---|---|---|
| Species | Crevasse splay | Marsh terraces | Pump-in | Old edge | Open water |
| AMWI | 0 | 1 | 0 | 0 | 0 |
| BLSK | 0 | 7 | 1 | 0 | 0 |
| BLTE | 46 | 68 | 9 | 11 | 44 |
| CLRAxKIRA | 0 | 1 | 2 | 0 | 0 |
| GBTE | 3 | 0 | 1 | 2 | 3 |
| HERG | 1 | 2 | 1 | 2 | 2 |
| LEYE | 4 | 0 | 0 | 0 | 0 |
| MAFR | 0 | 0 | 0 | 2 | 1 |
| MODU | 21 | 4 | 4 | 0 | 0 |
| NOPI | 24 | 18 | 0 | 0 | 0 |
| PUGA | 0 | 0 | 1 | 0 | 0 |
| WILL | 31 | 0 | 0 | 5 | 1 |
| Total | 130 | 101 | 19 | 22 | 51 |

Table 13. Frequency of species of concern and species in steep decline by habitat type, excluding flyovers, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Frequency by habitat type | | | | |
|---|---|---|---|---|---|
| Species | Crevasse splay | Marsh terraces | Pump-in | Old edge | Open water |
| AMWI | 0 | 1 | 0 | 0 | 0 |
| BLSK | 0 | 7 | 0 | 0 | 0 |
| BLTE | 42 | 67 | 3 | 6 | 40 |
| CLRAxKIRA | 0 | 1 | 2 | 0 | 0 |
| GBTE | 3 | 0 | 1 | 2 | 3 |
| LEYE | 4 | 0 | 0 | 0 | 0 |
| MODU | 8 | 0 | 0 | 0 | 0 |
| PUGA | 0 | 0 | 1 | 0 | 0 |
| WILL | 3 | 0 | 0 | 4 | 1 |
| Total | 60 | 76 | 7 | 12 | 44 |

Habitat type was the significant covariate in predicting bird density ($F_{4,34}$=5.93, p=0.001) of species of concern when flyovers were included. We used the log link transformation and negative binomial distribution for this dataset based on analysis of best fit. Despite crevasse splays and marsh terraces having higher total bird abundance for species of concern, they did not have highest estimated bird density. Open water plots, which were smaller than the edge plots, supported the highest density of these species (mu=4.9305 [log transformed]), but were not significantly different from the mean bird density in crevasse splay (mu=4.4905 [log transformed]) (p=0.3371) or marsh terrace plots (mu=4.2746 [log transformed]) (p=0.2013) (table 18). Beneficial use of dredged material marsh and old edge site supported the lowest density and were not significantly different from each other (table 14).

Habitat type was also the significant covariate in predicting bird density ($F_{4,20}$=10.01, p<0.001) of species of concern when flyovers were excluded. Estimated mean bird densities changed when flyovers were excluded, along with the ranking of habitat types from highest density to lowest. Again water plots supported the highest density of these species (mu=4.92 [log transformed]), but not significantly different from the mean bird density in marsh terrace plots (mu=4.79 [log transformed]) (p=0.8440). Marsh terraces ranked second in highest density, followed by crevasse splays (table 15). However, the mean

estimated density of species of concern in marsh terraces was also not significantly different from that of crevasse splay sites (mu=3.67 [log transformed]). Old edge and beneficial use of dredged material sites hosted the lowest mean bird density for species of concern. The mean density of these two types of plots was significantly different from open water, marsh terraces, and crevasse splays ($p \leq 0.05$).

Table 14. T Grouping of mean density estimates of species of concern, including flyovers, for habitat type Least Squares Means (alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| T grouping for habitat type least squares means (alpha=0.05)[a] | | |
|---|---|---|
| Habitat type | Estimate | Groupings |
| Open water | 4.9305 | A |
| Crevasse | 4.4905 | A |
| Marsh terrace | 4.2746 | A |
| Pump-in[b] | 3.0301 | B |
| Old edge | 2.9815 | B |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

Table 15. T Grouping of mean density estimates of species of concern, excluding flyovers, for habitat type Least Squares Means (alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| T grouping for habitat type least squares means (alpha=0.05)[a] | | | |
|---|---|---|---|
| Habitat type | Estimate | Groupings | |
| Open water | 4.9196 | | A |
| Marsh terrace | 4.7942 | B | A |
| Crevasse | 3.6725 | B | |
| Old edge | 2.5735 | | C |
| Pump-in[b] | 2.2276 | | C |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

### 5.3.1 Black Terns

Black Terns and Mottled Ducks were counted frequently enough to conduct statistical testing to estimate if certain habitat types supported greater densities of these species than others. Black Terns, a migratory species, were only counted during the summer and fall, and their density significantly differed between habitat types ($F_{4,10}$=11.24, p=0.0010), not seasons ($F_{1,10}$=0.45, p=0.5179). We used the log link transformation and negative binomial distribution for this dataset based on analysis of best fit. Marsh terraces supported the highest density of Black Terns and were significantly different from the density in beneficial use of dredged material (p=0.0202) and old edge sites (p=0.0005), but not significantly different from open water (p=0.8587) and crevasse splay sites (p=0.2013). Old edge plots supported the smallest estimated Black Tern density, being significantly different than all other habitat types ($p<0.05$).

The results of from the main effects model give an estimated mean and standard deviation for Black Tern density between habitat types by season (fig. 10).

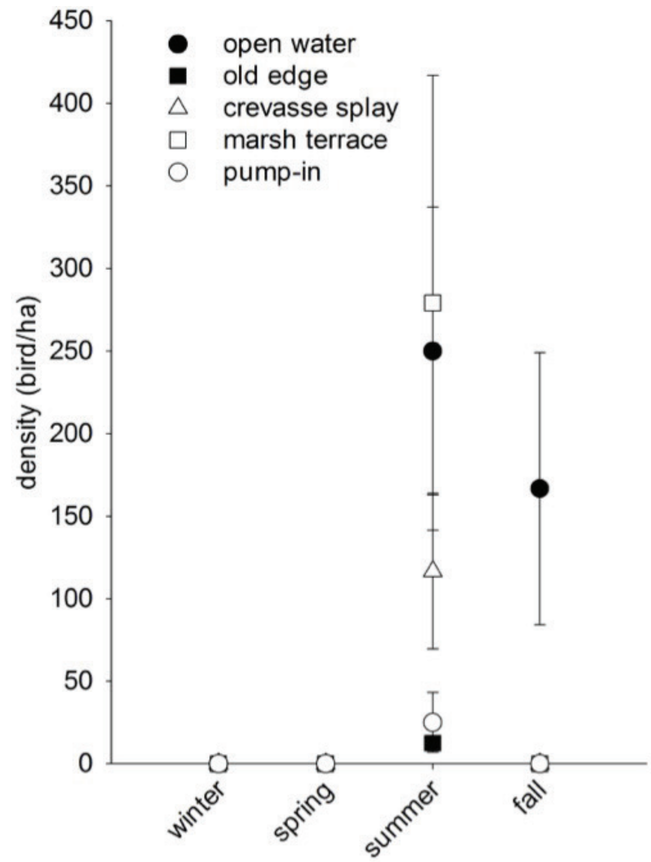



Figure 10. Model predicted means and standard deviations for Black Tern density in each habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

### 5.3.2 Mottled Ducks

The density of Mottled Ducks, coastal Louisiana's only year-round resident duck species, varied significantly by season and habitat type ($F_{3,51}$=4035.90, p<0.0001). We included all counted Mottled Ducks, including flyovers to account for the species' sensitivity to our presence in the area, and used the log link transformation and exponential distribution for these data based on analysis of best fit. Crevasse splays in the fall supported a significantly higher density of Mottled Ducks (mu=20.83±8.51 birds/ha) than all other sites in that season (p<0.05) (fig. 11). Marsh terraces supported significantly higher density (mu=2.78±1.60 birds/ha) than all other habitat types in the winter (p<0.05) (fig. 11). In the spring, crevasse splays, marsh terraces, and beneficial use of dredged material marsh supported higher Mottled Duck density than old edge and open water. Beneficial use of dredged material marshes supported the

highest density in the summer (mu=8.33±5.89 bird/ha), but were not significantly different from the crevasse splays (mu=2.08±1.04 birds/ha). Mottled ducks were completely absent from old edge and open water plots throughout the study (table 20).

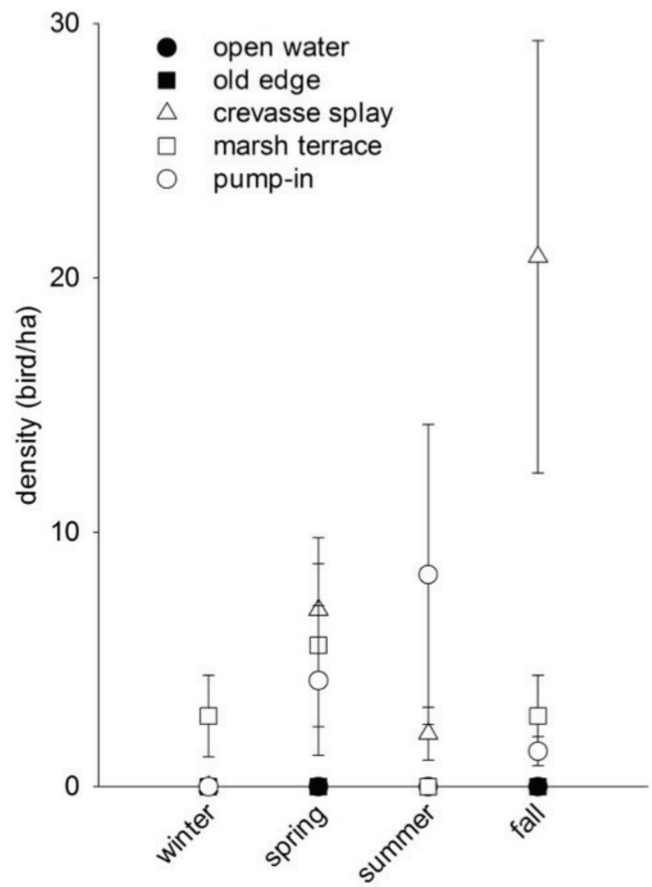



Figure 11. Model predicted means and standard deviations for Mottled Duck density in each habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

## 5.4 Bird Density by Foraging Guild

### 5.4.1 Aerial Foragers (AI)

For Aerial Foragers, there was a significant difference in bird density by habitat type and season ($F_{9,49}$=2049.29, p<0.0001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. Of the 70 total surveys conducted, there were 37 surveys were no aerial foragers were observed. Tree Swallows were the most frequently counted member of this guild and migrate through the area in the spring and fall. Aerial forager density was highest during the spring in open water, crevasse splay, and old edge plots, and was significantly higher than all other interactions of

habitat type and season (α=0.05) other than beneficial use of dredged material marshes in the winter (table 16). Aerial forager density in open water plots was much lower during all other seasons (fig. 12).

Table 16. Conservative T Grouping of mean bird density per hectare estimates for the aerial foraging guild for season, year, habitat type interaction Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| Conservative T grouping for season*habitat type least squares means (alpha=0.05)[a] | | | | | |
|---|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | | |
| Spring | open water | 6.1312 | | A | |
| Spring | crevasse | 5.1727 | B | A | |
| Spring | old edge | 4.8803 | B | A | |
| Winter | pump-in[b] | 4.6852 | B | A | C |
| Spring | pump-in | 3.9921 | B | | C |
| Fall | open water | 3.912 | B | | C |
| Fall | pump-in | 3.8839 | B | | C |
| Winter | crevasse | 3.7297 | B | D | C |
| Winter | old edge | 3.7297 | B | D | C |
| Fall | crevasse | 3.5474 | | D | C |
| Fall | marsh terrace | 3.3242 | | D | C |
| Spring | marsh terrace | 2.8134 | | D | C |
| Summer | pump-in | 2.5257 | | D | C |
| Summer | marsh terrace | 2.5257 | | D | C |
| Summer | open water | 1.8971 | E | D | |
| Summer | crevasse | 0.734 | E | F | |
| Summer | old edge | 0.5108 | | F | |
| Winter | open water | -90.7321 | | G | |
| Fall | old edge | -101.29 | | H | |
| Winter | marsh terrace | -146.98 | | I | |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

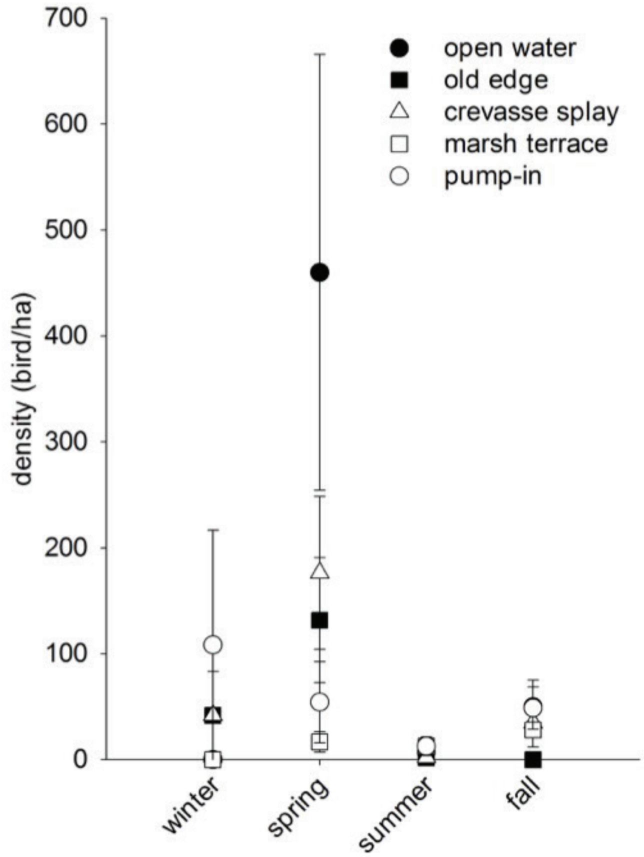



Figure 12. Model predicted means and standard deviations for bird density of aerial foragers in each edge habitat type by season and year in the Mississippi River Delta, Louisiana, USA, 2013-2014.

**5.4.2 Carnivorous Hawkers and Plungers (CHP)**

Carnivorous Hawkers and Plungers were commonly seen during our surveys, but always in low numbers, not exceeding one or two birds per a count. While we made an effort to determine which raptors were foraging and which were just passing over a plot, that determination was difficult to make accurately based on the foraging behaviors of these birds. Therefore, flyovers were not removed from the dataset for this analysis. When examining all CHP birds counted, there was a significant difference in density by habitat type ($F_{2,65}$=9684.17, p<0.0001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. The density of these birds was highest at the marsh terrace sites (mu=2.02±0.30 bird/ha [log transformed]), and significantly different from all over habitat types based on T groupings for least squares means (α=0.05). Bird density for these species was not significant different between beneficial use of dredged material marshes and crevasse splays, but was different from open water and old edge plots. Estimated mean density by habitat type from the main

effects model was 7.56±2.28 bird/ha for marsh terrace sites, 3.03±0.91 bird/ha for beneficial use of dredged material marsh sites, 1.96±0.48 bird/ha for crevasse splays, and 0 bird/ha for old edge and open water sites.

#### 5.4.3 Dabblers and Grubbers (DG)

For Dabblers and Grubbers, there was a significant difference in bird density for the interactions of habitat type and season ($F_{2,49}$=536.05, $p<0.0001$,) as the significant covariate for our analysis. We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. For the interaction of habitat type, season, and year, the F value was infinity, so the previous most specific interaction was used. Dabbler and Grubber density was highest in open water plots (mu=8.28±1.03 bird/ha [log transformed]) during the winter and significantly different from all other habitat type*season combinations based on conservative T groupings for Least Square Means ($\alpha$=0.05) (table 17). No habitat types supported positive bird density for this foraging guild in the summer. Results for the Dabblers and Grubbers guild, combined with Water Bottom Foragers and Gleaners, are further investigated later in this chapter to include open water plots and flyovers.

Table 17. Conservative T Grouping of mean bird density per hectare estimates for Dabbler and Grubber foraging guild for season, year, habitat type interaction Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| Conservative T grouping for season*habitat type least squares means (alpha=0.05)[a] | | | | |
|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | |
| Winter | open water | 8.2825 | | A |
| Winter | old edge | 5.3922 | | B |
| Spring | marsh terrace | 5.3583 | | B |
| Winter | crevasse | 4.8814 | C | B |
| Spring | crevasse | 3.069 | C | D |
| Fall | crevasse | 2.7883 | C | D |
| Spring | old edge | 1.7331 | | D |
| Spring | pump-in[b] | 1.7033 | E | D |
| Fall | pump-in | 0.05231 | E | |
| Winter | marsh terrace | -42.6176 | | F |
| Spring | open water | -43.557 | | F |
| Fall | open water | -44.15 | | F |
| Winter | pump-in | -52.3132 | | G |
| Fall | old edge | -66.8267 | | H |
| Summer | open water | -83.0678 | | I |
| Fall | marsh terrace | -98.8689 | | J |
| Summer | crevasse | -101.22 | | J |
| Summer | old edge | -105.71 | | K |
| Summer | marsh terrace | -133.17 | | L |
| Summer | pump-in | -142.86 | | M |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as “pump-in” marshes.

### 5.4.4 Marsh Foragers and Gleaners (MFG)

For Marsh Foragers and Gleaners, there was a significant difference in bird density for the interaction of season and habitat type ($F_{9,50}$=19.17, p<0.001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. Marsh terraces during the fall supported the highest bird density for this guild (mu=4.66±0.58 bird/ha [log transformed]), but the mean density during this sampling period was not significantly different from any other habitat type*season combination aside from old edges in the fall and spring, beneficial use of dredged material marshes in the spring, marsh terraces in the spring and winter, and open water sites during all seasons (table 18). Some

significant differences among habitat types are revealed when estimated bird densities for each habitat type from the main effects model are examined by season. Despite some types of edge plots supporting much higher densities of MFG birds, there was not a significant difference among any type of edge habitat plots in spring or summer (fig. 13). In the fall, marsh terraces supported a significantly different bird density than old edge plots (p=0.01), but there was no difference between the three types of restored marshes. In the winter, there was no significant difference between crevasse splay, old edge, and beneficial use of dredged material marshes. However, old edge and beneficial use of dredged material plots supported significantly higher bird density for the MFG guild than marsh terraces (p=0.006 and p=0.036). The estimated mean bird density for Marsh Foragers and Gleaners was 0 for open water during all seasons (fig. 13). Bird density in open water plots during all seasons was significantly different than the bird density in all edge plots during all seasons (α=0.05).

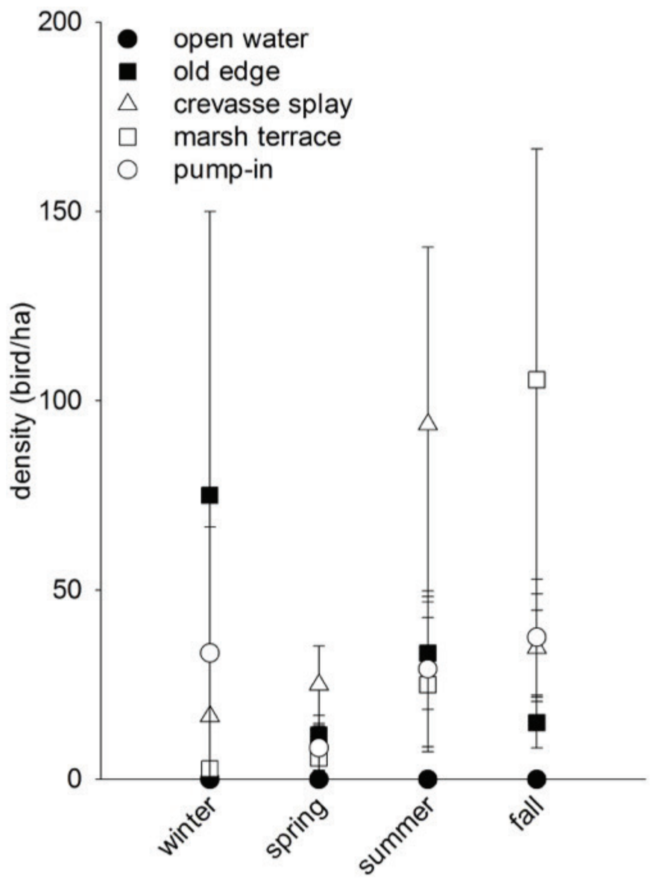



Figure 13. Estimated mean bird density for marsh foragers and gleaners in each edge habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

Table 18. Conservative T Grouping of mean bird density per hectare estimates for marsh foragers and gleaners foraging guild for season*habitat type interaction Least Squares Means (alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| Conservative T grouping for season*habitat type least squares means (alpha=0.05) | | | | | | |
|---|---|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | | | |
| Fall | marsh terrace | 4.6592 | | | A | |
| Summer | crevasse | 4.5406 | | | A | |
| Winter | old edge | 4.3175 | B | | A | |
| Fall | pump-in[b] | 3.6243 | B | | A | |
| Fall | crevasse | 3.5474 | B | | A | |
| Summer | old edge | 3.5066 | B | | A | |
| Winter | pump-in | 3.5066 | B | | A | C |
| Summer | pump-in | 3.373 | B | | A | C |
| Spring | crevasse | 3.2189 | B | | A | C |
| Summer | marsh terrace | 3.2189 | B | | A | C |
| Winter | crevasse | 2.8134 | B | D | A | C |
| Fall | old edge | 2.7081 | B | D | | C |
| Spring | old edge | 2.4567 | B | D | | C |
| Spring | pump-in | 2.1203 | B | D | | C |
| Spring | marsh terrace | 1.7148 | | D | | C |
| Winter | marsh terrace | 1.0217 | | D | | |
| Winter | open water | -43.9881 | | | E | |
| Fall | open water | -54.1149 | | | F | |
| Spring | open water | -56.1021 | | | G | |
| Summer | open water | -56.9904 | | | G | |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as “pump-in” marshes.

### 5.4.5 Mudflat Probers and Gleaners (MPG)

Birds belonging to the Mudflat Probers and Gleaners guild were not often seen actively using our study plots, though members of this guild, especially White Ibises, were commonly seen flying high over the plots. Only 7 of our 70 surveys included MPG birds actively using the plots. These birds were only seen at crevasse splay sites during low tide when subaerial portions of the delta front were shallow enough to allow for foraging. Despite the low sample size, convergence criterion was satisfied to perform a guild-specific generalized linear mixed model to implement an analysis of covariance (ANCOVA) (PROC GLIMMIX, SAS vers 9.4, SAS, Inc., Cary, NC). We used the log link transformation and

exponential distribution for this dataset based on analysis of best fit. We found a significant difference in MPG bird density by habitat type ($F_{2,65}$=21.7, p<0.001). Crevasse splays supported the highest density of 15.69±3.80 birds/ha as estimated by the main effects model. Bird density for this guild was significant different in crevasse splay sites from all other habitat types (p<0.001). Estimated MPG bird density at open water sites was 2.22±0.57 birds/ha and 2.22±0.52 birds/ha at old edge sites. These two habitat types were not significantly different from each other (p=0.89). Bird density estimates for this guild were 0 bird/ha for beneficial use of dredged material marshes and marsh terraces.

### 5.4.6 Piscivore Plungers and Divers (PPD)

Piscivore Plungers and Divers were one of the most commonly encountered foraging guilds during our study. Only 19 of our 70 surveys included no individuals belonging to this guild. For Piscivore Plungers and Divers, there was a significant difference in bird density for all covariates (p<0.001), so we used the interactions of habitat type, season, and year ($F_{3,40}$=570.09, p<0.0001) as the significant covariate for our analysis. We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. Open water plots supported the highest bird density for this guild during summer 2013, which was significantly different from all combinations of habitat type, season, and year except for open water plots in the fall 2013 and fall 2014 (α=0.05) based on conservative T groupings for season*year*habitat type least squares means.

When PPD bird densities were divided by sampling period, some habitat types had significantly different densities than others (fig. 14). During 2014, all types of plots were sampled every season, so we focused on differences in habitat types during that year. In the winter of 2014, PPD birds were only counted at crevasse splay and marsh terrace sites. Bird density at crevasse splays (mu=2.81±1 [log transformed]) was significantly different from these old edge, open water, and beneficial use of dredged material marsh sites with no birds, and from marsh terraces (mu=1.02±0.58 [log transformed]) (p<0.001). Piscivore Plunger and Diver bird density was also significantly different between marsh terraces and the three habitat types with no birds recorded (p<0.001). In the spring of 2014, open water sites, with a

density of 0 birds/ha estimated from the main effects model, were significantly different from all other habitat types. Among edge plots, only the bird densities of beneficial use of dredged material marshes (mu=41.67±29.46 birds/ha) and marsh terraces (mu=5.56±3.21 birds/ha) were significantly different (p=0.033). No habitat type was significantly different in the summer of 2014. Open water plots supported the highest PPD guild bird density in the fall of 2014 (mu=88.89±51.32 birds/ha), but was only significantly different from marsh terrace plots (mu=5.56±3.21 bird/ha) (p=0.002). Marsh terraces also supported a significant different (and lower) bird density than crevasse splay sites (mu=52.78±30.47 birds/ha) during this survey period, but all other habitat types were not significantly different.

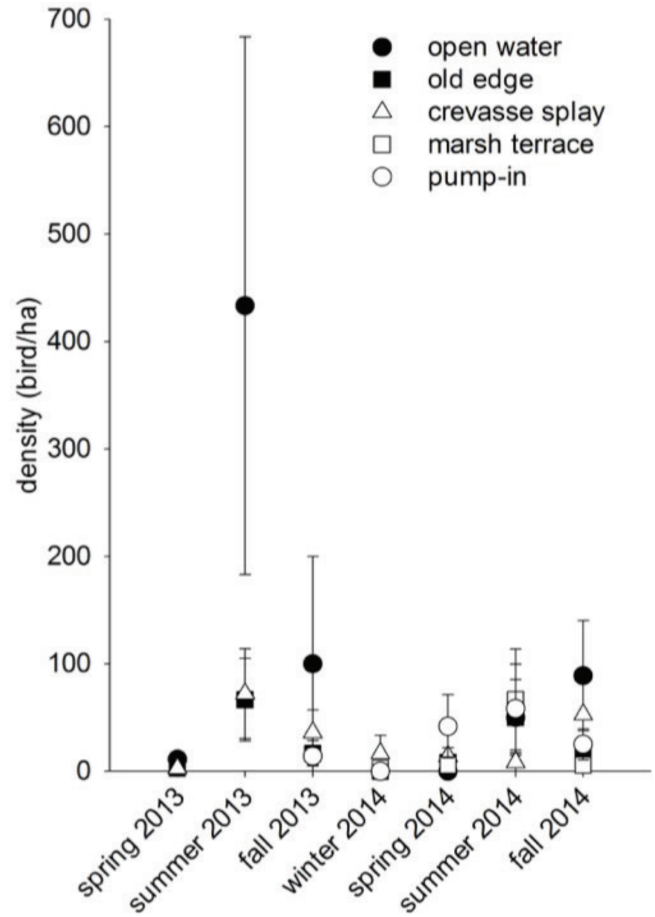



Figure 14. Model predicted means and standard deviations for bird density for the piscivore plunger and diver guild in each edge habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

### 5.4.7 Scavengers, Food Pirates, and Generalists (SFPG)

For the Scavengers, Food Pirates, and Generalists, it was not possible to model bird density. These birds were only counted as actively using a study plot during 8 of the 70 surveys. No distribution provided a good fit for the data without over-specifying the model. During at least one sampling period over the course of the study, SFPG birds were spotted actively using each edge habitat type. We never saw a SFPG bird actively use an open water plot during the study. While birds belonging to this foraging guild were counted flying high over a plot during 29 of the 70 surveys, we decided not to test for differences in density using flyovers. When we saw these species foraging during site visits, it was usually in large channels following fishing boats, not in other similar marsh edge habitats.

### 5.4.8 Wading Ambushers (WA)

The density of Wading Ambushers was significantly different ($F_{3,50}$=1915.91, p<0.0001) among habitat types by season. We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. No one habitat type supported the highest WA bird density for all seasons, but open water sites supported a density of 0 birds/ha for this guild during all seasons (fig. 15) and were significantly different from all other habitat types in each season. In winter, marsh terrace plots supported a significantly higher density of wading ambushers (mu=2.78±1.60 birds/ha) than all other habitat types (p<0.001) which all had a density of 0 birds/ha for that season. Crevasse splay sites supported a significantly higher density of birds from this guild in the spring (mu=12.5±5.10 birds/ha) than all other habitat types (p<0.001) which all had a density of 0 birds/ha for that season. In the summer, there was no significant difference between wading ambusher bird density in all the edge plots, but guild density in open water plots (mu=0 birds/ha) was significantly different from all other plots (p<0.001). In fall, old edge plots supported the highest WA bird density (mu=15±6.71 birds/ha), but were not significantly different the density supported by crevasse splay plots (mu=6.94±2.84 birds/ha). The density supported by crevasse splays was not significantly different from the density supported by marsh terrace or beneficial use of dredged material sites, as well.

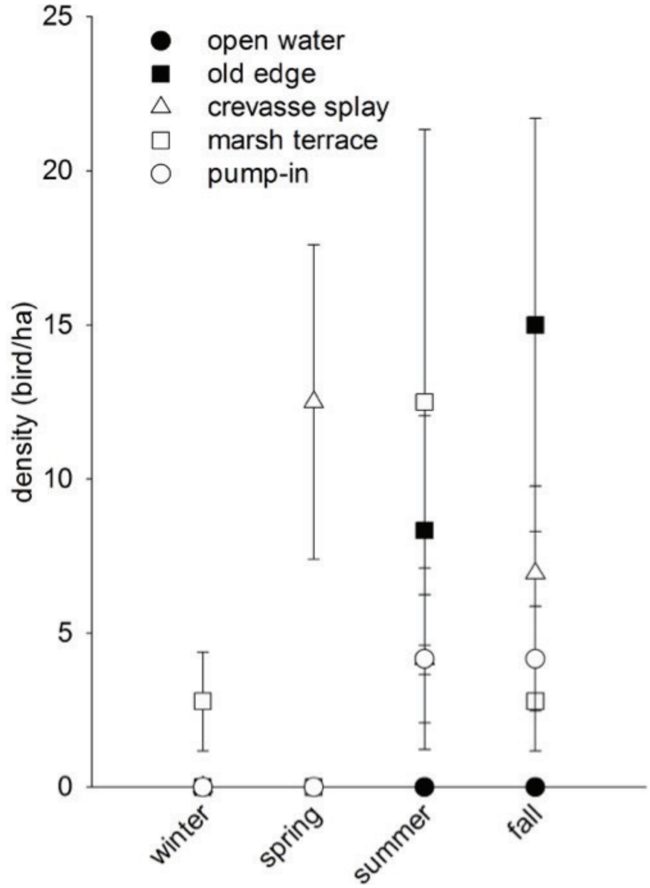



Figure 15. Model predicted means and standard deviations of bird density for wading ambushers in each edge habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

### 5.4.9 Water Bottom Foragers and Divers (WBFG)

The Water Bottom Forager and Diver guild was the least counted guild, with only 14 birds sighted actively using the study plots over the entire study period. While we found a significant difference in bird density for this guild by habitat type ($F_{3,65}$ =7342.31, p<0.0001), using the log link transformation and exponential distribution for this dataset based on analysis of best fit, we were not able to detect statistically significant differences among the four marsh edge types due to such a small sample size. However, open water plots, with a density of 0 birds/ha, were significantly different than all other habitat types based on bird density for this guild based on T groupings for habitat type least squares means (α=0.05).

### 5.4.10 Water Surface Gleaners (WSG)

The density of Water Surface Gleaners, a guild dominated by Black Terns in our study, varied significantly among the habitat type and season combinations ($F_{2,50}$=18.22, p<0.0001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. This guild included no resident species and no members of the guild were counted during spring or winter for any habitat type. Water Surface Gleaner density was highest in marsh terrace sites during the summer (mu=308.33±218.02 bird/ha) (fig. 16), but was not significantly different from open water or crevasse splays during the same season, nor open water sites during the fall (table 19). However, bird density for this guild was significantly different between marsh terrace, open water, and crevasses splay sites and the bird density for beneficial use of dredged material marsh and old edge sites during the summer (p<0.05) (fig. 16). During fall, WSG birds were only present in open water (mu=83.33±41.67 birds/ha), crevasse splays (mu=4.17±1.70 birds/ha), and beneficial use of dredged material marshes (mu=1.39±0.57 birds/ha) plots. Bird density in open water plots for the fall was significantly different from all other habitat types during that season (p<0.001). There was no significant different between WSG bird density in crevasse splay and beneficial use of dredged material marshes in the fall (p=0.063) (table 19).

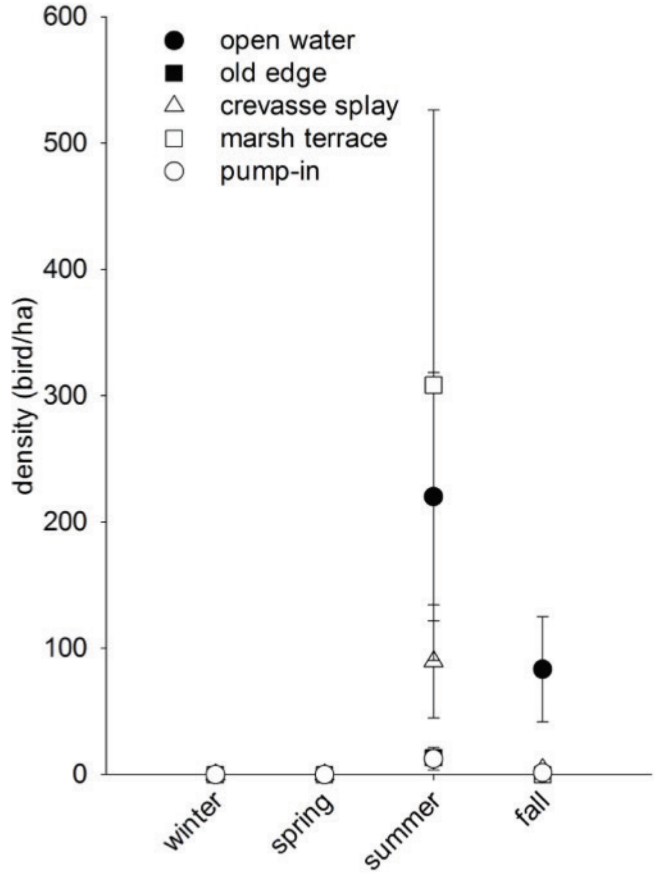


Figure 16. Model predicted means and standard deviations of bird density for water surface gleaners in each edge habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

Table 19. T Grouping of mean bird density per hectare estimates for the water surface gleaner foraging guild for season, habitat type interaction Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| T grouping for season*habitat type least squares means (alpha=0.05)[a] | | | | |
|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | |
| Summer | marsh terrace | 5.7312 | | A |
| Summer | open water | 5.3936 | | A |
| Summer | crevasse | 4.4952 | | A |
| Fall | open water | 4.4228 | | A |
| Summer | old edge | 2.5903 | | B |
| Summer | pump-in[b] | 2.5257 | | B |
| Fall | crevasse | 1.4271 | C | B |
| Fall | pump-in | 0.3285 | C | |
| Fall | old edge | -44.8565 | | D |
| Fall | marsh terrace | -45.6486 | | D |
| Winter | open water | -49.6355 | | E |
| Winter | pump-in | -54.0931 | | F |
| Winter | crevasse | -57.7669 | | G |
| Winter | old edge | -71.8602 | | H |
| Winter | marsh terrace | -72.3627 | | H |
| Spring | open water | -118.47 | | I |
| Spring | pump-in | -129.49 | | J |
| Spring | crevasse | -146.27 | | K |
| Spring | marsh terrace | -151.03 | | L |
| Spring | old edge | -157.09 | | M |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as “pump-in” marshes.

### 5.4.11 Waterfowl Foraging Guilds (DG and WBFG)

The density of Dabblers and Grubbers combined with Water Bottom Foragers and Gleaners, representing all waterfowl and allied birds counted in the study, varied significantly by habitat type and season combinations ($F_{7,50}$=17001.7, p<0.0001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit. Total DG and WBFG bird density was generally highest in the winter, however, few surveys were conducted that sampling period. Marsh terraces were sampled three times, but all other habitat types were only sampled once. Waterfowl density was highest in open water plots in the winter, but not significantly different from waterfowl density in crevasse splay or old edge plots in the same season (table 20). Density was also not significantly different among crevasse splay, old edge, and marsh terrace sites for the winter (table 20), but all habitat types were significantly different from beneficial use of dredged material sites which supported an estimated 0 bird/ha (fig. 17).

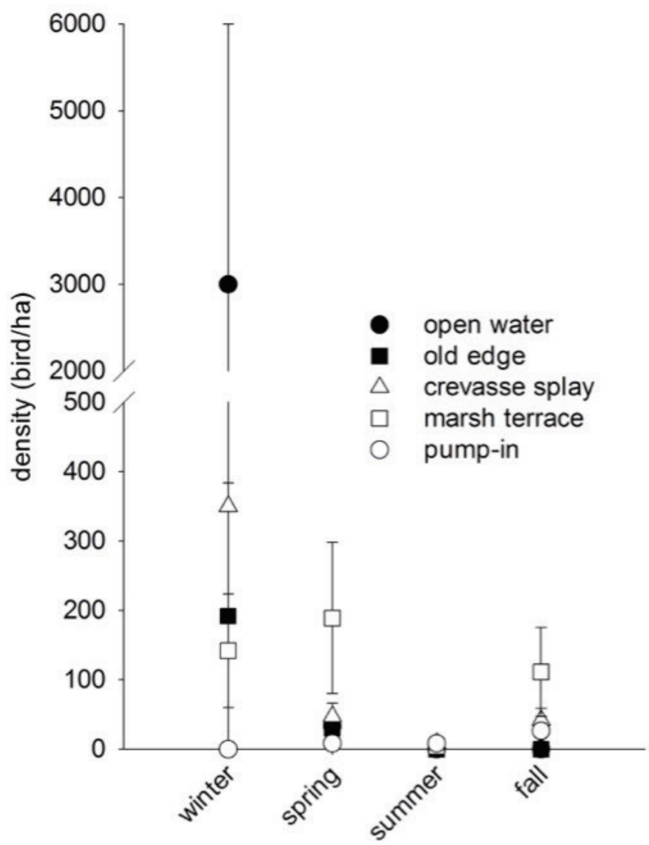



Figure 17. Model predicted means and standard deviations dabbler and grubber and water bottom forager and gleaner bird density in each habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

Table 20. Conservative T grouping of mean bird density per hectare estimates for dabbler and grubber and water bottom forager and gleaner foraging guilds for season*habitat type interaction Least Squares Means (alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| Conservative T grouping for season*habitat type least squares means (alpha=0.05)[a] | | | | | |
|---|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | | |
| Winter | open water | 8.0064 | | A | |
| Winter | crevasse | 5.9045 | B | A | |
| Winter | old edge | 5.2558 | B | A | C |
| Spring | marsh terrace | 5.2412 | B | | C |
| Winter | marsh terrace | 4.9919 | B | | C |
| Fall | marsh terrace | 4.7593 | B | | C |
| Spring | crevasse | 3.8549 | B | | C |
| Fall | crevasse | 3.7625 | B | | C |
| Spring | old edge | 3.6463 | | D | C |
| Spring | open water | 3.5066 | | D | C |
| Fall | pump-in[b] | 3.373 | | D | C |
| Spring | pump-in | 2.1203 | E | D | |
| Summer | crevasse | 2.1203 | E | D | |
| Summer | pump-in | 2.1203 | E | D | |
| Summer | marsh terrace | 1.4271 | E | | |
| Winter | pump-in | -52.8188 | | F | |
| Summer | open water | -55.2489 | | F | |
| Summer | old edge | -105.43 | | G | |
| Fall | open water | -251.28 | | H | |
| Fall | old edge | -301.46 | | I | |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

In the spring, marsh terraces supported the highest waterfowl density (mu=188.89±109.06 birds/ha) (fig. 17), but were only significantly different from beneficial use of dredged material marshes (mu=8.33±5.89 birds/ha) based on the conservative T groupings of mean bird density for season and habitat type interactions least squares means (table 20). Waterfowl densities were generally low in the summer. The three restored marsh habitats did not support significantly different bird densities in the summer from each other, but they were all significantly different from the unrestored old edge and open water plots (table 20) which had an estimated density of 0 bird/ha that season. In the fall, densities were highest in marsh terrace plots (mu=111.11±64.15 birds/ha), but were not significantly different from

crevasse splays (mu=41.67±17.01 birds/ha) or beneficial use of dredged material marshes (mu=26.39±10.77 birds/ha). The old edge and open water plots again had an estimated density of 0 bird/ha that season (fig. 17). All types of restored marsh sites supported significantly higher waterfowl densities than the unrestored sites in the fall (table 20).

If open water plots are excluded from the model, differences in waterfowl density between habitat types are easier to distinguish on a graph, but statistically significant differences did not change (fig. 18). Like in the previous model, waterfowl bird density varied significantly by habitat type*season combination ($F_{6,39}$=689, p<0.0001). We used the log link transformation and exponential distribution for this dataset based on analysis of best fit.

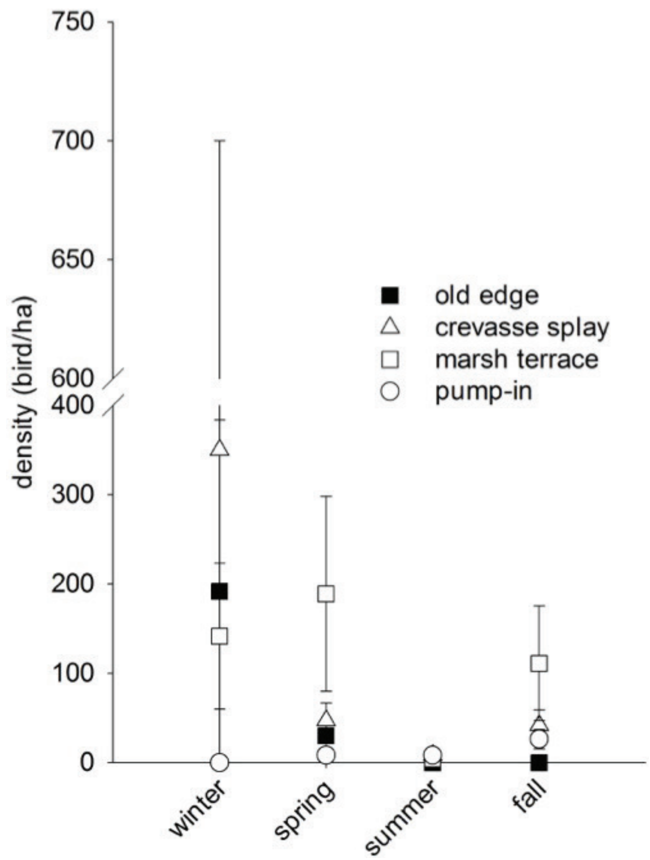



Figure 18. Model predicted means and standard deviations dabbler and grubber and water bottom forager and gleaner bird density in each edge habitat type by season in the Mississippi River Delta, Louisiana, USA, 2013-2014.

Crevasse splays supported the highest waterfowl density in the winter, but were not significantly different from old edge or marsh terraces sites for the same season (table 21). In the spring, marsh terraces supported the highest waterfowl density (mu=188.89±109.06 bird/ha) (fig. 18), which was significantly different from both old edge and beneficial use of dredged material marshes based on the first conservative T grouping of mean bird density for season and habitat type interactions least squares means (table 21), but not different from old edge based on the B grouping. In the summer, only old edge sites were significantly different from the other habitat types (table 29). Marsh terraces supported the highest density again in the fall, but were not statistically different from crevasse splays (p=0.1665) nor beneficial use of dredged material sites (p=0.0571).

Table 21. Conservative T grouping of mean bird density per hectare estimates for dabbler and grubber and water bottom forager and gleaner foraging guilds, excluding open water plots, for season*habitat type interaction Least Squares Means (Alpha=0.05) in the Mississippi River Delta, Louisiana, USA, 2013 and 2014. Means have been log transformed.

| Conservative T grouping for season*habitat type least squares means (alpha=0.05)[a] | | | | | |
|---|---|---|---|---|---|
| Season | Habitat type | Estimate | Grouping | | |
| Winter | crevasse | 5.9045 | | A | |
| Winter | old edge | 5.2558 | B | A | |
| Spring | marsh terrace | 5.2412 | B | A | |
| Winter | marsh terrace | 4.9919 | B | A | |
| Fall | marsh terrace | 4.7593 | B | A | |
| Spring | crevasse | 3.8549 | B | A | |
| Fall | crevasse | 3.7625 | B | A | C |
| Spring | old edge | 3.6463 | B | | C |
| Fall | pump-in[b] | 3.373 | B | D | C |
| Spring | pump-in | 2.1203 | E | D | C |
| Summer | pump-in | 2.1203 | E | D | C |
| Summer | crevasse | 2.1203 | E | D | |
| Summer | marsh terrace | 1.4271 | E | | |
| Winter | pump-in | -55.1702 | | F | |
| Fall | old edge | -70.3094 | | G | |
| Summer | old edge | -71.0294 | | G | |

[a]LS-means with the same letter grouping are not significantly different.
[b]Beneficial use of dredged material marshes are also referred to as "pump-in" marshes.

### 5.5 Edge Effect Among Habitat Types

When analyzing the data for all birds counted, excluding birds observed simply flying over a plot, we found a significant difference in bird abundance with the interaction of season, habitat type, and plot zone ($F_{99,114}$=2.71, $p < 0.0001$) (fig. 19, 20, 21, and 22; appendix G). We used the log link transformation and gamma distribution for this dataset based on analysis of best fit. Regardless of habitat type, birds commonly utilized microhabitats near the marsh edge – 31.59% of all observed individual species used only the first 10m of the plot. However, many other individuals we observed utilizing the first 10m from the edge also utilized some other area of the plot. Of the 1361 individual birds observed actively utilizing one of the study plots, 1018 birds (74.8%) utilized some combination of plot zones including zone 1.

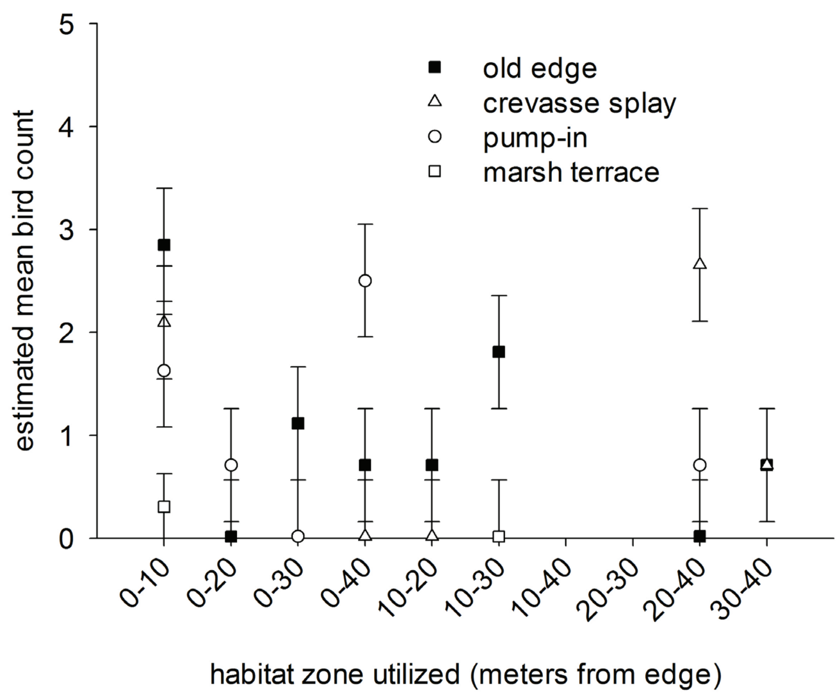



Figure 19. Model predicted means and standard deviations of bird abundance by plot zone during the winter in the Mississippi River Delta, Louisiana, USA, 2013-2014.

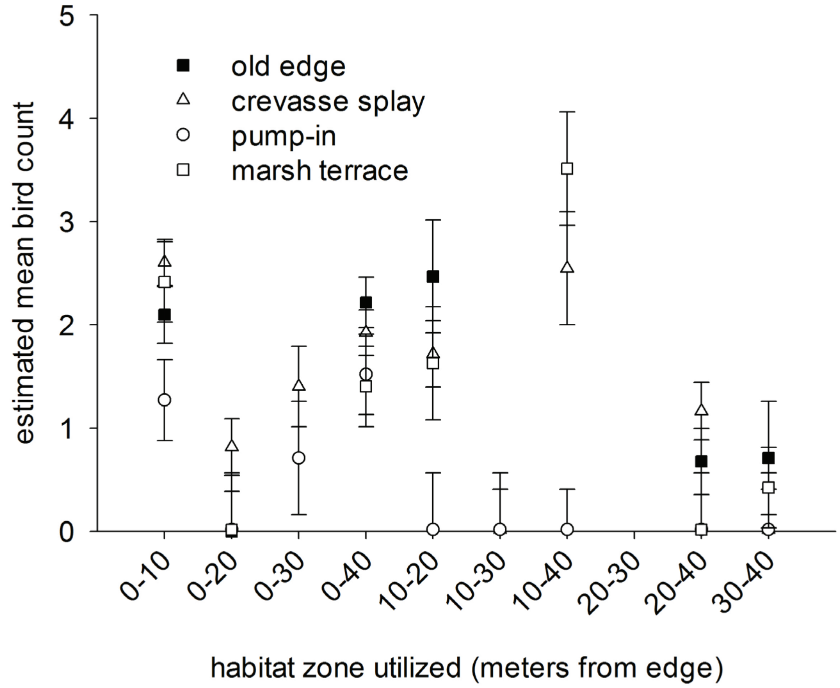



Figure 20. Model predicted means and standard deviations of bird abundance by plot zone during the spring in the Mississippi River Delta, Louisiana, USA, 2013-2014.

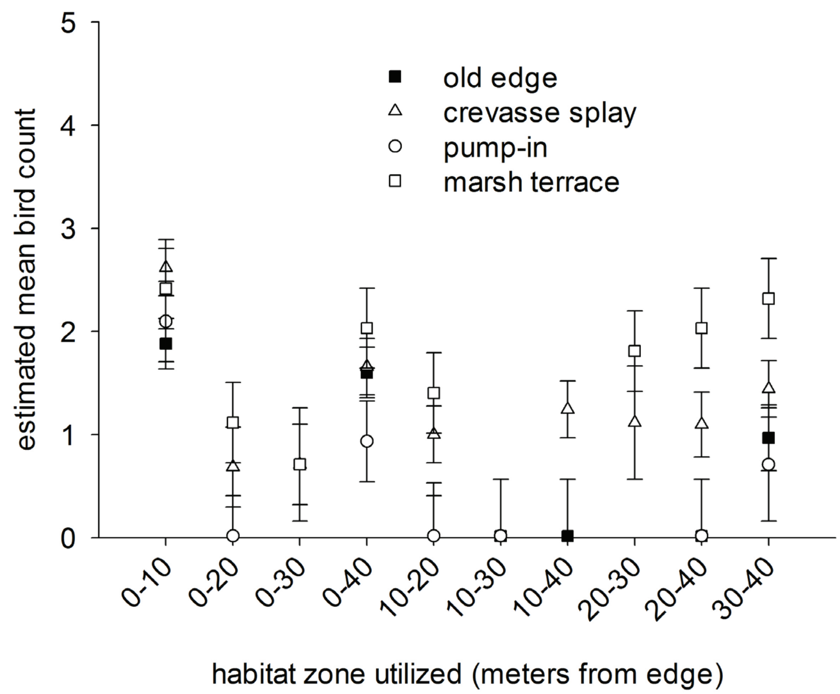



Figure 21. Model predicted means and standard deviations of bird abundance by plot zone during the summer in the Mississippi River Delta, Louisiana, USA, 2013-2014.

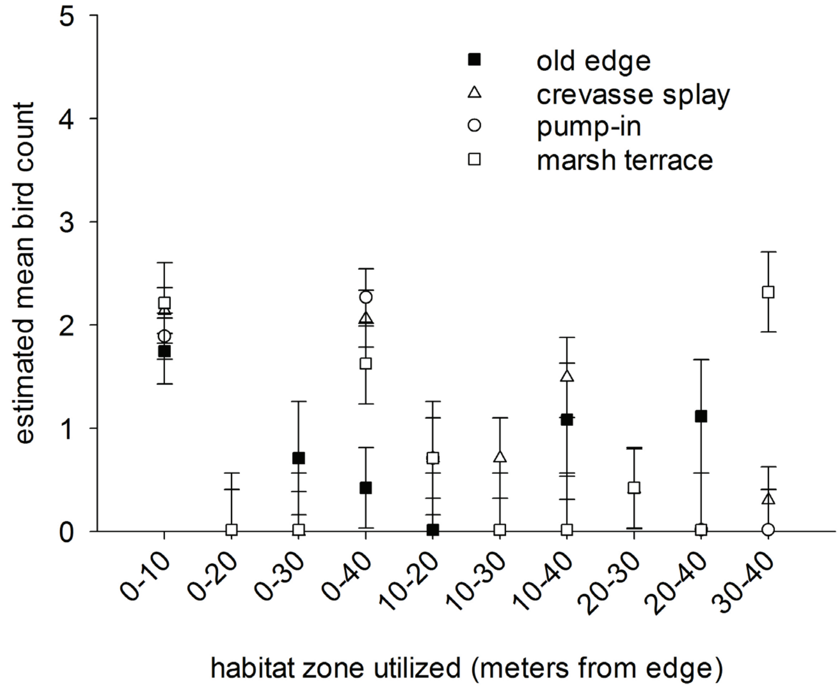



Figure 22. Model predicted means and standard deviations of bird abundance by plot zone during the fall in the Mississippi River Delta, Louisiana, USA, 2013-2014.

### 5.5.1 Edge Effect Among Habitat Types – Excluding Aerial Guilds

If aerial guilds (AI, CHP, PPD, and SFPG) were excluded from the model, the results changed slightly. The interaction among season, habitat type, and the distance of an individual from the marsh edge was still significant ($F_{49,50}$=2.58, p=0.0005), but the edge effect theory that waterbirds are more abundant within 10m of the emergent vegetation-open water interface (O'Connell and Nyman 2010, Weller and Spatcher 1965) did not hold true for all habitat types in all seasons. The abundance of birds in zone 1 (0-10m of the edge) was not always significantly different from the abundance of birds further from the edge. We used the log link transformation and Poisson distribution for this dataset based on analysis of best fit. The model predicted means for bird abundance by zone in marsh terraces (table 23), crevasse splays (table 24), beneficial use of dredged material (table 25), and old edge marshes (table 26) illustrate the different frequencies at which birds were counted by zone in each type of habitat, along with predicted mean abundance by zone for the season.

For marsh terraces, in particular, the edge effect was blurred (table 22). For the spring season, there was no significant difference between the estimated mean number of birds using the first 10 meters

of the plot (zone 1) (mu=3.0445±0.2182 [log transformed]) and the birds in utilizing 10-40 meters from the edge (zones 2,3,4) (mu=3.4965±0.1741 [log transformed]). For the summer, there was no significant difference between the number of birds in zone 1 (mu=2.3026±0.2236 [log transformed]), zones 3 and 4 (mu=1.7018±0.2887 [log transformed]), zone 4 (mu=2.0794±0.25 [log transformed]). However, we did find a significant difference between the estimated mean bird count in zone 1 and zone 2 (p=0.0332) and zone 1 and zone 3 (p=0.0332). When the marsh terraces were resampled in the fall of 2014, only zone 1 and zone 2 (location of the borrow pits) were significantly different (p=0.0445).

Table 22. Model predicted mean non-aerial foraging bird abundance for marsh terraces in the Mississippi River Delta, Louisiana, USA, 2014.

| Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|
| Fall | 2 | 1 | 5 | 6.50 | 1.80 |
| Fall | 3 | 1 | 8 | 6.50 | 1.80 |
| Fall | 1 | 2 | 1 | 2.00 | 1.00 |
| Fall | 2 | 2 | 3 | 2.00 | 1.00 |
| Fall | 2 | 3 | 2 | 2.00 | 1.41 |
| Fall | 1 | 4 | 4 | 10.00 | 2.24 |
| Fall | 2 | 4 | 16 | 10.00 | 2.24 |
| Fall | 1 | 12 | 1 | 1.00 | 1.00 |
| Fall | 1 | 23 | 1 | 1.00 | 1.00 |
| Spring | 2 | 1 | 21 | 21.00 | 4.58 |
| Spring | 2 | 2 | 5 | 5.00 | 2.24 |
| Spring | 3 | 4 | 1 | 1.00 | 1.00 |
| Spring | 2 | 234 | 33 | 33.00 | 5.74 |
| Summer | 2 | 1 | 10 | 10.00 | 2.24 |
| Summer | 3 | 1 | 10 | 10.00 | 2.24 |
| Summer | 2 | 2 | 2 | 4.00 | 1.41 |
| Summer | 3 | 2 | 6 | 4.00 | 1.41 |
| Summer | 2 | 3 | 3 | 4.00 | 1.41 |
| Summer | 3 | 3 | 5 | 4.00 | 1.41 |
| Summer | 2 | 4 | 5 | 8.00 | 2.00 |
| Summer | 3 | 4 | 11 | 8.00 | 2.00 |
| Summer | 2 | 12 | 1 | 3.00 | 1.22 |
| Summer | 3 | 12 | 5 | 3.00 | 1.22 |
| Summer | 2 | 34 | 1 | 6.00 | 1.73 |
| Summer | 3 | 34 | 11 | 6.00 | 1.73 |
| Summer | 2 | 123 | 1 | 2.00 | 1.00 |
| Summer | 3 | 123 | 3 | 2.00 | 1.00 |
| Summer | 2 | 1234 | 5 | 4.50 | 1.50 |
| Summer | 3 | 1234 | 4 | 4.50 | 1.50 |
| Winter | 2 | 1 | 2 | 1.50 | 0.87 |
| Winter | 3 | 1 | 1 | 1.50 | 0.87 |

In crevasse splay sites (table 23), there also was not always a significant difference between bird abundance near the marsh edge and further out into the water. In the fall, there was a significant difference between the mean estimated bird count in zone 1 and zones 2 and 3 ($p=0.0116$), but not between zone 1 and zone 3 alone ($p=0.0838$). For spring and summer, no significant difference was detected for zone 1 and zones 1-4 (spring $p=0.0572$, summer $p=0.0524$). For all other zones not including zone 1, zone 1 alone did support a significantly different number of birds ($p<0.05$) in the summer. In the winter, there was no significant difference between the estimated number of birds in each zone, and zone 3-4 supported the highest count ($mu=2.3026\pm0.3162$ [log transformed]), followed by zone 1 ($mu=1.7918\pm0.4082$ [log transformed]).

Table 23. Model predicted mean non-aerial foraging bird abundance for crevasses splays in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 7 | 7.17 | 1.09 |
| 13 | fall | 2 | 1 | 6 | 7.17 | 1.09 |
| 13 | fall | 3 | 1 | 12 | 7.17 | 1.09 |
| 14 | fall | 1 | 1 | 3 | 7.17 | 1.09 |
| 14 | fall | 2 | 1 | 10 | 7.17 | 1.09 |
| 14 | fall | 3 | 1 | 5 | 7.17 | 1.09 |
| 14 | fall | 3 | 3 | 2 | 2.00 | 1.41 |
| 14 | fall | 2 | 23 | 1 | 1.50 | 0.87 |
| 14 | fall | 3 | 23 | 2 | 1.50 | 0.87 |
| 13 | spring | 1 | 1 | 9 | 7.17 | 1.09 |
| 13 | spring | 2 | 1 | 9 | 7.17 | 1.09 |
| 13 | spring | 3 | 1 | 9 | 7.17 | 1.09 |
| 14 | spring | 1 | 1 | 10 | 7.17 | 1.09 |
| 14 | spring | 2 | 1 | 1 | 7.17 | 1.09 |
| 14 | spring | 3 | 1 | 5 | 7.17 | 1.09 |
| 13 | spring | 2 | 12 | 2 | 3.00 | 1.22 |
| 14 | spring | 1 | 12 | 4 | 3.00 | 1.22 |
| 13 | spring | 1 | 1234 | 1 | 1.00 | 1.00 |
| 13 | summer | 1 | 1 | 12 | 12.75 | 1.79 |
| 13 | summer | 2 | 1 | 3 | 12.75 | 1.79 |
| 13 | summer | 3 | 1 | 13 | 12.75 | 1.79 |
| 14 | summer | 3 | 1 | 23 | 12.75 | 1.79 |
| 13 | summer | 2 | 2 | 1 | 2.00 | 0.82 |
| 13 | summer | 3 | 2 | 3 | 2.00 | 0.82 |
| 14 | summer | 3 | 2 | 2 | 2.00 | 0.82 |
| 14 | summer | 3 | 3 | 3 | 3.00 | 1.73 |
| 13 | summer | 2 | 4 | 2 | 4.33 | 1.20 |
| 13 | summer | 3 | 4 | 5 | 4.33 | 1.20 |
| 14 | summer | 3 | 4 | 6 | 4.33 | 1.20 |
| 13 | summer | 3 | 12 | 3 | 2.00 | 1.00 |
| 14 | summer | 3 | 12 | 1 | 2.00 | 1.00 |
| 13 | summer | 3 | 34 | 3 | 3.50 | 1.32 |
| 14 | summer | 3 | 34 | 4 | 3.50 | 1.32 |
| 14 | summer | 3 | 123 | 2 | 2.00 | 1.41 |
| 13 | summer | 3 | 234 | 4 | 3.50 | 1.32 |
| 14 | summer | 3 | 234 | 3 | 3.50 | 1.32 |
| 13 | summer | 3 | 1234 | 5 | 7.00 | 1.87 |
| 14 | summer | 3 | 1234 | 9 | 7.00 | 1.87 |
| 14 | winter | 1 | 1 | 6 | 6.00 | 2.45 |
| 14 | winter | 1 | 2 | 1 | 1.00 | 1.00 |
| 14 | winter | 1 | 4 | 2 | 2.00 | 1.41 |
| 14 | winter | 1 | 34 | 10 | 10.00 | 3.16 |

In beneficial use of dredged material marshes, birds belonging to non-aerial foraging guilds were not typically detected outside of the fall season (table 24). While the predicted mean for bird abundance in zone 1 exceeded all other zones for the fall, spring, and summer, there was not enough data to detect a significant difference between bird abundance in zone 1 and all other zones.

In the non-restored old edge marsh sites, the predicted mean bird abundance was also higher for zone 1 than all other zones for fall, summer and winter (table 25). However, only during the winter season was there a significant difference between bird abundance in zone 1 and other zones, including zones 123, 1234, 2, and 4 ($p < 0.05$).

Table 24. Model predicted mean non-aerial foraging bird abundance for beneficial use of dredged material marshes in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 9 | 5.33 | 0.94 |
| 13 | fall | 2 | 1 | 2 | 5.33 | 0.94 |
| 13 | fall | 3 | 1 | 13 | 5.33 | 0.94 |
| 14 | fall | 1 | 1 | 1 | 5.33 | 0.94 |
| 14 | fall | 2 | 1 | 6 | 5.33 | 0.94 |
| 14 | fall | 3 | 1 | 1 | 5.33 | 0.94 |
| 14 | fall | 2 | 234 | 1 | 1.00 | 1.00 |
| 14 | fall | 3 | 4 | 1 | 1.00 | 1.00 |
| 14 | spring | 2 | 1 | 2 | 2.00 | 1.41 |
| 14 | spring | 1 | 2 | 1 | 1.00 | 1.00 |
| 14 | summer | 1 | 1 | 1 | 5.00 | 1.58 |
| 14 | summer | 3 | 1 | 9 | 5.00 | 1.58 |
| 14 | summer | 3 | 4 | 1 | 1.00 | 1.00 |
| 14 | winter | 3 | 1 | 4 | 4.00 | 2.00 |

Table 25. Model predicted mean non-aerial foraging bird abundance for old edge marshes in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 2 | 5.67 | 1.37 |
| 14 | fall | 1 | 1 | 7 | 5.67 | 1.37 |
| 14 | fall | 2 | 1 | 8 | 5.67 | 1.37 |
| 14 | fall | 1 | 12 | 1 | 1.00 | 1.00 |
| 14 | fall | 1 | 123 | 2 | 2.00 | 1.41 |
| 14 | fall | 1 | 2 | 1 | 1.00 | 1.00 |
| 14 | fall | 1 | 4 | 1 | 1.00 | 1.00 |
| 13 | spring | 1 | 1 | 3 | 3.00 | 1.00 |
| 13 | spring | 2 | 1 | 4 | 3.00 | 1.00 |
| 14 | spring | 2 | 1 | 2 | 3.00 | 1.00 |
| 13 | spring | 3 | 12 | 1 | 1.00 | 1.00 |
| 14 | spring | 2 | 1234 | 3 | 3.00 | 1.73 |
| 13 | spring | 2 | 34 | 1 | 1.00 | 1.00 |
| 14 | spring | 2 | 4 | 1 | 1.00 | 1.00 |
| 13 | summer | 1 | 1 | 5 | 6.00 | 1.22 |
| 13 | summer | 2 | 1 | 11 | 6.00 | 1.22 |
| 14 | summer | 1 | 1 | 4 | 6.00 | 1.22 |
| 14 | summer | 3 | 1 | 4 | 6.00 | 1.22 |
| 13 | summer | 1 | 1234 | 3 | 2.67 | 0.94 |
| 13 | summer | 2 | 1234 | 4 | 2.67 | 0.94 |
| 14 | summer | 3 | 1234 | 1 | 2.67 | 0.94 |
| 14 | summer | 1 | 234 | 1 | 1.00 | 1.00 |
| 14 | winter | 1 | 1 | 15 | 15.00 | 3.87 |
| 14 | winter | 1 | 123 | 3 | 3.00 | 1.73 |
| 14 | winter | 1 | 1234 | 1 | 1.00 | 1.00 |
| 14 | winter | 1 | 2 | 2 | 2.00 | 1.41 |
| 14 | winter | 1 | 23 | 6 | 6.00 | 2.45 |
| 14 | winter | 1 | 4 | 2 | 2.00 | 1.41 |

### 5.6 Environmental Conditions

We detected a significant relationship between habitat types and environmental variables using canonical correspondence analysis (CCA), indicating that conditions such as vegetation cover and diversity, salinity, and water depth varied by the type of habitat sampled (fig. 23). The first two ordination axes explain 19.4% and 31.7% of the variance in the habitat type data with canonical eigenvalues of 0.776 and 0.493 in comparison to the sum of all unconstrained eigenvalues of 4.000. The relationship between environmental variables (displayed as arrows) and habitat types (displayed as black

diamond points) along the first axis explains 49.3% of the variance of habitat type in respect to each environmental variable and 80.7% of the variance on the second axis. The first two axes have habitat type-environment correlations of 0.881 and 0.493, which measures how well the extracted variation in habitat type can be explained by the environmental variables (Ter Braak 1986). A Monte Carlo test using 499 permutations found the first canonical axis to be significant (p=0.002) and a significant relationship between habitat type and environment (trace=1.572, p=0.002).

The triplot ordination diagram of the CCA for habitat types (fig. 23) visualizes the correlation of environmental variables to the ordination axes and the position of a habitat type's (or foraging guild's as in fig. 24) distribution along each environmental variable (Ter Braak 1987). The distance between sample points (with habitat type indicated by shape and color) on the ordination diagram reflects the variance among samples of the same habitat type. Samples from similar habitat types are generally located in the same region of the diagram, indicating that the study plots of each habitat type have similar environmental conditions. However, there were some outlying samples. Outliers may be related to seasonal fluctuations in environmental variables such as SAV cover and salinity within plots (see appendix H).

We found the habitat type crevasse splay to be associated with high percentage of mudflat cover and emergent vegetation cover, high SAV species richness and emergent vegetation species richness, and low water depth at 0m from the edge and mean water depth, and low percentage of open water cover. Beneficial use of dredge material marshes ("pump-in") are also associated with high values for mudflat cover, emergent vegetation cover, SAV species richness, and emergent vegetation species richness, though not as high as with crevasse splays. Marsh terraces are associated with high percentage of floating vegetation cover, low SAV species richness, low salinity, and intermediate values for other environmental variables. Old edge marshes have high salinity, high water depth at 0m from the edge, and low emergent vegetation percent cover and species richness. Open water sites often have high water depth, low emergent vegetation species richness, and low percentage of emergent vegetation cover.

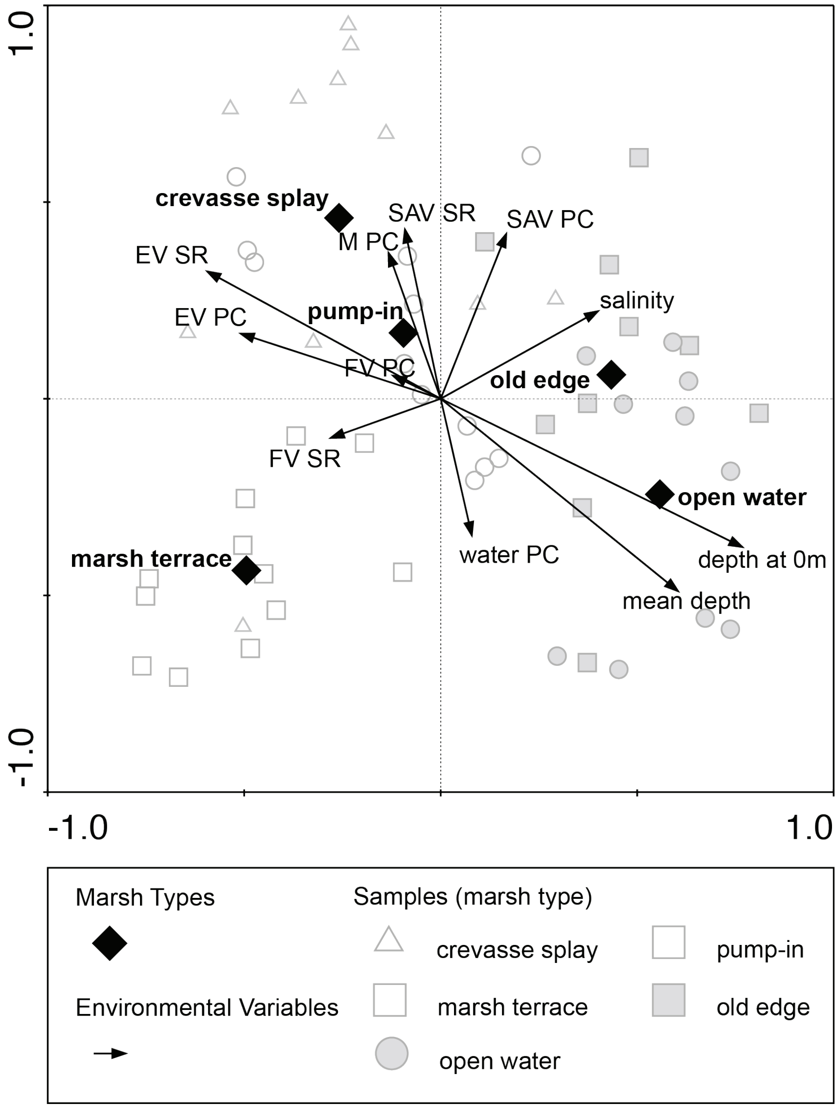



Figure 23. Triplot ordination diagram of axis one and two of the canonical correspondence analysis (CCA) showing the relationship of environmental variables to habitat type in the Mississippi River Delta, Louisiana, USA, 2013-2014. Environmental variables include water depth at 0m from the marsh edge, mean water depth, water salinity, percent surface area covered by mudflats (M PC), percent surface area covered by open water (water PC), percent surface area covered by emergent vegetation (EV PC), percent surface area covered by floating vegetation (FV PC), percent surface area covered by submerged aquatic vegetation (SAV PC), emergent vegetation species richness (EV SR), floating vegetation species richness (FV SR), and submerged aquatic vegetation species richness (SAV SR).

We also found a significant relationship between foraging guild density (birds/ha) and environmental variables using canonical correspondence analysis (CCA) (fig. 24). The first two ordination axes explain 15.2% and 27.0% of the variance in foraging guild data with canonical eigenvalues of 0.547 and 0.427 in comparison to the sum of all unconstrained eigenvalues of 3.604. The relationship between environmental variables (displayed as arrows) and the foraging guild (displayed as black diamond points) along the first axis explains 38.2% of the variance of habitat type in respect to each

environmental variable and 67.9% of the variance on the second axis. The first two axes have habitat type-environment correlations of 0.801 and 0.781. A Monte Carlo test using 499 permutations found the first canonical axis to be significant (p=0.01) and a significant relationship between density of foraging guilds and environment (trace=1.434, p=0.002).

From the ordination plot (fig. 24), we can make some inferences about the habitat associations of birds belonging to the ten foraging guilds. Wading Ambushers (WA), Piscivore Plungers and Divers (PPD), Marsh Foragers and Gleaners (MFG), and Carnivorous Hawkers and Plungers (CHP) are associated with diverse vegetation communities, higher salinities (salinity range=0.0 to 3.6 ppt), and high surface area coverage of emergent, floating, and submerged aquatic vegetation. These guilds are also related to lower open water percent cover. Mudflat Probers and Gleaners (MPG) are associated with high values for mudflat cover and low SAV cover. Aerial Insectivores (AI) and Scavengers, Food Pirates, and Generalists (SFPG) are associated with high mean water depth and low SAV cover. Dabblers and Grubbers (DG) and Water-bottom Foragers and Gleaners (WBFG) are associated with high SAV cover, but SAV species richness is not strongly related to the density of these guilds. Water surface gleaners (WSG) are associated with high SAV and floating vegetation cover, and high emergent and floating vegetation species richness.

We found a range in the degree of sample scores variation within foraging guilds. For guilds where foraging behavior is closely related to specific environmental conditions, such as MPG (fig. 25 a), samples had similar scores with few outliers. On the other end of the spectrum, guilds with many generalist species or species that live in a variety of habitats, such as MFG (fig. 25 c), had a more diffuse distribution across the two axes. For most guilds, the samples followed a pattern similar to that of WSG (fig. 25 b), with most samples reflecting similar relationships to important environmental variables, but not without smaller groups of outliers. The variation in most guilds may be a reflection of seasonal changes in habitat use, with birds keying in on certain environmental factors during one point in their annual cycle but not during other seasons. As demonstrated previously, we found evidence of seasonal

variations in the densities of many foraging guilds, but season was not included as an environmental variable in the CCA. The variation may also be a reflection of birds responding to unmeasured variables.

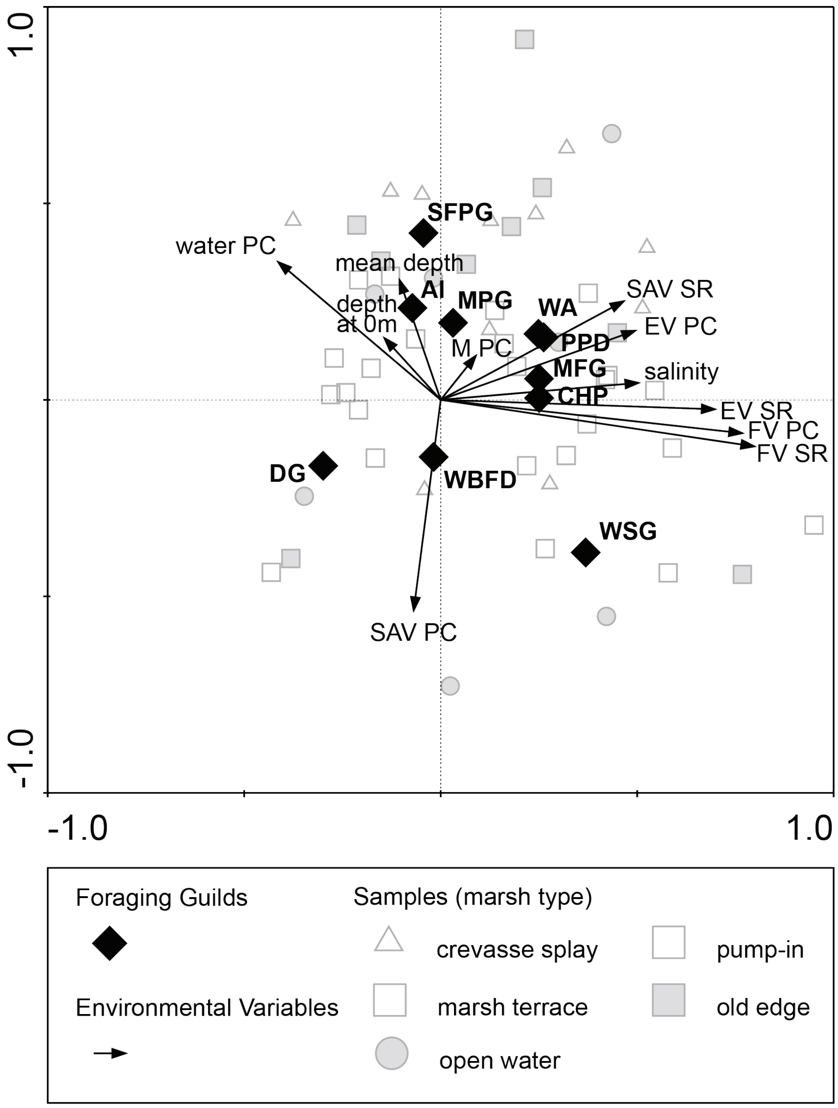



Figure 24. Triplot ordination diagram of axis one and two of canonical correspondence analysis (CCA) showing the relationship of environmental factors to avian foraging guild density in the Mississippi River Delta, Louisiana, USA, 2013-2014.

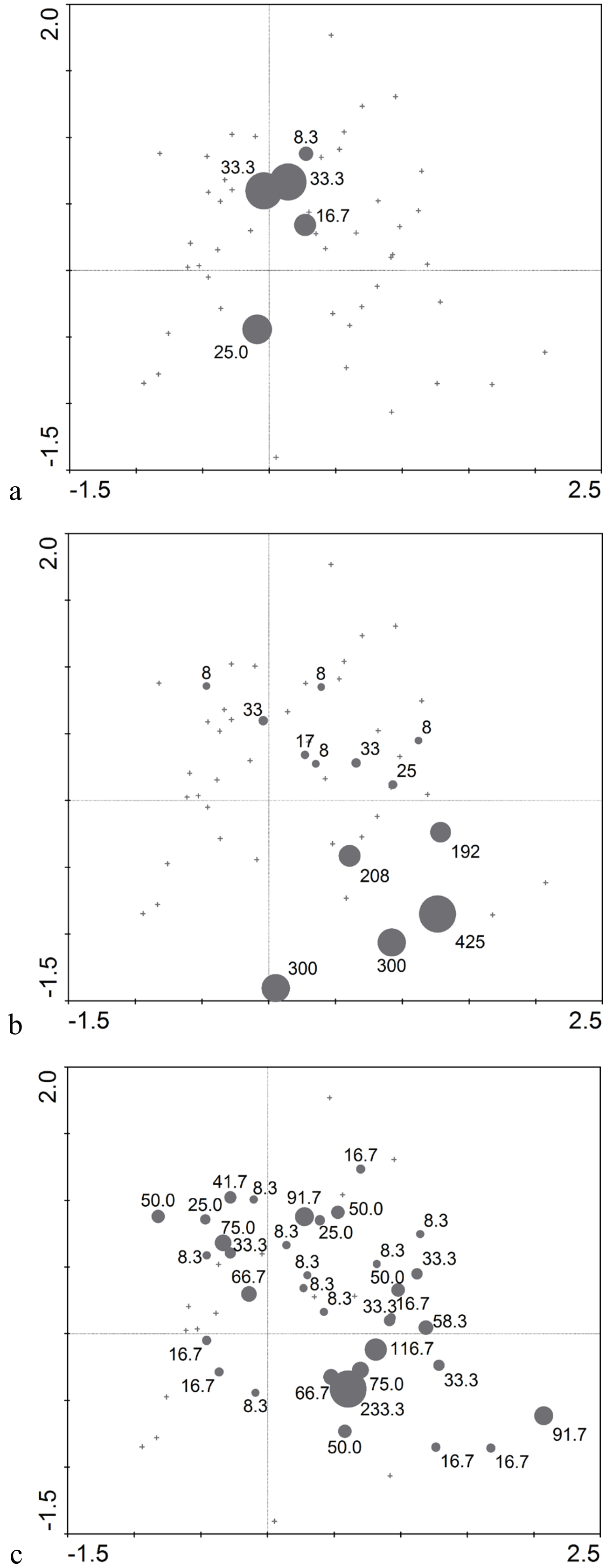



Figure 25. Symbol attribute plots for three foraging guilds – (a) Mudflat Probers and Gleaners, (b) Water Surface Gleaners, and (c) Marsh Foragers and Gleaners.

# CHAPTER 6: DISCUSSION

## 6.1 Avian Diversity and Density Among Habitat Types

Providing suitable habitat for waterbirds in managed marsh environments is a multi-step puzzle – it requires first identifying the habitat needs of targeted species, second, identifying places that can potentially provide for those needs, and then picking the right management strategy for those areas to maximize the amount of suitable habitat available. In regions such as coastal Louisiana where managers are trying to combat wetland loss due to sea-level rise or other factors, marsh creation and restoration are strategies used compensate for lost habitat. There are multiple restoration techniques that can be used; some restore the physical structure of marsh, while others restore the hydrological processes that allow new marsh to form. The resulting restored marshes vary greatly in appearance – from the orderly geometric patterns of marsh terraces to the chaotic collection of bifurcating channels and islands in crevasse splays – but do these marshes also vary in habitat suitability for waterbirds? Is it possible to predict the avian response to different habitat types in the landscape? With limited resources available to restore and manage wetland habitat, managers may want to focus on providing the "best" habitat type for supporting high diversity of species or high density of targeted species.

We found that bird abundance, diversity, and density differed among marsh edge types during some times of the year. We found no evidence to support the idea that one "best" habitat type provides superior habitat compared to other habitat types across all sampling periods. Habitat type (crevasse splay, marsh terrace, beneficial use of dredged material marsh, old edge marsh, and open water) alone did not explain variations avian diversity or abundance. Rather a combination of habitat type, environmental variables, and season seem to affect the avian community characteristics of a site based on the results of our study.

Season was a significant explanatory variable in many of our tests, which is not surprising since southeast Louisiana experiences seasonal variations in weather and water conditions and plant and animal

communities. The avian communities of southeastern coastal Louisiana change throughout the year, as the region provides habitat for breeding, over-wintering, and migratory birds along with year-round resident species (Gosselink et al. 1998, Lowery 1974). Additionally, resident waterbirds often use several types of wetlands within a larger complex to accomplish various goals, such as pairing, rearing young, and foraging (Weller 1999). Migrant birds commonly make use of temporary habitats that differ from their breeding or wintering grounds (Cody 1985, van der Winden 2014). Marshes in southeast Louisiana also experience seasonal changes in plant biomass and diversity (White et al. 1978, White 1992), likely affecting habitat suitability in terms of available food sources and cover (Rozas and Odum 1988, Stutzenbaker 2010). Therefore, as the habitat needs of Louisiana's resident and migrant birds change throughout their annual cycles, we can predict that avian distributions among habitat types change as well. We found that no single type of habitat consistently supported the highest or lowest diversity or density of waterbirds during all the sampling periods of the entire study period. Instead, the density and diversity of birds among habitat types varied seasonally as the species composition and habitat needs of birds changed.

### 6.1.1 Species Richness and Structural Complexity

For predicting avian species diversity at a site, previous avian studies have supported the theory that the number of species that pack into a habitat (α-diversity) is directly related to the structural diversity of the environment (Karr and Roth 1971, MacArthur and MacArthur 1961, Cody 1985). Structural diversity describes either resource diversity or the number of ways in which resources can be partitioned (Cody 1985) and typically quantified in measures of foliage height diversity for forested habitats (Karr and Roth 1971, MacArthur and MacArthur 1961). We hypothesized that bird diversity in marshes is likewise related to the structure complexity of the available habitat. To quantify the structural complexity of freshwater tidal marshes, we measured species richness for emergent, floating, and submerged aquatic vegetation, and surface area covered by these three types of vegetation, mudflats, and

open water at each study plot (fig. 23). Many studies have found that dense stands of single plant species are less attractive to a large variety of waterbird species than marshes with a variety of plant species, food sources, and abundant edge habitat (Kaminski and Prince 1984, Murkin et al. 1982, Weller 1998, Weller and Spatcher 1965). One could therefore predict that habitat types exhibiting structural complexity through a diversity of plant species, interspersed shallow water areas, and surface area divided among multiple microhabitats like mudflats and beds of submerged aquatic vegetation would support greater avian species diversity than degrading marshes with limited plant diversity and linear edges. Based on our canonical correlation analysis of habitat types and environmental variables (fig. 23), it appears that crevasse splays are the most structurally complex habitat type. Beneficial use of dredged material marshes and marsh terraces also exhibit characteristics of a structurally complex habitat, but to a lesser degree than crevasse splays. Old edge marshes and open water areas are associated with environmental variables indicating low structural diversity, such as high water depths and low emergent species richness and cover.

Our hypothesis that the structurally complex restored marsh habitats support greater species richness than old, degrading marshes did not hold true for all sampling periods. We found no significant difference in species richness among old edge marshes and any of the restored habitat types during summer and winter (table 9). The highest species richness over the entire study was found at old edge marshes (fig. 6), not at the more structurally complex marsh terraces or crevasse splays. However, this finding is not surprising when the life history of resident waterbird species is considered. Old edge marshes, dominated by dense monocultures of *Phragmites australis*, while commonly viewed as providing limited structural complexity and possibly less food sources, do provide dense, protective cover for many resident nesting birds in the summer and thermal cover in the winter (Olson 2007, Stutzenbaker 2010). Some old edge marsh sites had a variety of SAV species and dense SAV cover near the edge (see: appendix H - tables H.10.2, H.10.3, H.11.2, H.11.3), likely supporting an abundance of aquatic food sources (Castellanos and Rozas 2001). Red-winged Blackbirds and Boat-tailed Grackles are two species

we commonly recorded at old edge sites in, both known to nest in dense stands of tall grasses and reeds (Lowery 1974, Wiedenfeld and Swan 2000). For migratory birds stopping over in the spring or fall, old edge marshes appear to provide very little useful habitat based on our results. During migration in the spring and fall, species richness in old edge marshes was often significantly lower than that of the restored marshes (fig. 6). No one type restored marsh habitat supported statistically greater species richness for any of the sampling periods (fig. 6), despite counting the most species at crevasse splays (table B.8). Any type of edge habitat, however, can be expected to support greater species richness than open water areas during all seasons based on our findings (fig. 6) but not greater bird density.

### 6.1.2 Guild Richness and Structural Complexity

Structurally complex restored marsh habitats do appear to support higher bird diversity in terms of foraging guild richness. Using CCA, we found a significant relationship between foraging guilds and environmental variables and most guilds are associated with environmental variables related to structural complexity. Five guilds (MPG, WA, PPD, MFG, and CHP) clustered on the upper right side of the plot around six environmental variables included in our definition of complexity (fig. 24) can be expected to be more abundant in habitats with those features. Three guilds (DG, WBFD, and WSG) are only strongly associated with specific environmental variables factoring into structural complexity. Even the two guilds strongly associated with deep water and higher open water cover, associated with habitats lacking complexity, AI and SFPG, have an immediate association to most variables associated with complexity.

Unlike the ordination plot for the relationship of environmental variables to habitat types (fig. 23), in the foraging guild plot (fig. 24) samples from similar habitat types were not grouped together across the two axes. There was a significant relationship between the five habitat types we studied and environmental factor, and also a significant relationship between foraging guild density (birds/ha) and environmental factors. However, the distribution of samples along the environmental variables changed when the response variable in question was density of foraging guilds across an ecological gradient.

From these two diagrams, we can infer that environmental variables are related to both habitat type and foraging guild diversity and density, but the variable "habitat type" alone is not a perfect substitute for environmental conditions when trying to identify the source of all variation in avian community composition. Habitat type does, however, function as a useful predictor of guild richness.

In every sampling period, crevasse splay sites hosted the greatest guild richness (fig. 7). While guild richness was not significantly different among crevasses and the two other restored habitat types (marsh terraces and beneficial use of dredged material marshes), guild richness in crevasse splays was significantly different from non-restored habitats (old edge and open water) during every season. To understand the relationship between habitat type and guilds supported, guild frequencies need to be considered. Guild richness only compares the total number of guilds present. Guild frequency describes the proportion of guilds present in each habitat type, providing better insight into the habitat suitability of each habitat type for particular foraging guilds than guild richness alone. Beneficial use of dredged material marshes were not significantly different from crevasse splays in terms of guild richness, but only three out of the nine present foraging guilds represented >5% of total bird abundance throughout the study (table 6). In crevasse splay sites, six foraging guilds represented >5% of total bird abundance and all ten were present at some point in the study (table 4). Utilizing crevasse splays for marsh creation would likely create habitat that can be used by all foraging guilds for some needs, but may not provide the most ideal foraging conditions for some guilds all of the time. Dabblers and grubbers and water bottom foragers and gleaners were more frequent at marsh terrace sites than crevasse splays, but present at both. Notably missing from all habitat types except for crevasse splays are mudflat probers and gleaners.

**6.1.3 Total Bird Density**

One of the most surprising findings of our study was that bird density was highest in open water plots during four of the seven sampling periods, and significantly different from all other sampling periods during the winter and spring of 2014 (table 11). This finding is a stark contrast to that of O'Connell and Nyman (2010) who found that 74% of birds observed were in edge habitats rather than

shallow water and Weller and Spatcher (1965) who found waterbird density to peak when the ratio of emergent vegetation to water was 50:50. These results may be related to the small number of surveys conducted each season rather than a reflection of the suitability of open water as habitat for birds. In the winter of 2014, seven bird surveys were conducted and only one open water plot surveyed, as no boats were available to do a second trip that season. One large flock of American Coots swimming through the relatively small open water plot (300 $m^2$ compared to 1200 $m^2$ for edge plots) resulted in very high estimates of mean bird density (3000±1587.23 birds/ha). A similar situation occurred in the spring of 2014 when only one trip to the study area was possible due to limited boat access that season. One open water plot was surveyed and a flock of 60 Tree Swallows foraging over the open water resulted in a density of 2000±1058.47 birds/ha. The previous spring saw much lower bird densities in open water plots (111.11±34.46 birds/ha). Had we conducted more surveys during these periods, these large flocks may have been offset by other surveys of open water plots with lower abundance. Another issue may be that the smaller size of the open water plots compared to the edge plots resulted in over-counting of birds in the area. The majority of birds actively using open water plots were birds that often forage from the air - aerial foragers, piscivore plungers and divers, and water surface gleaners (table 8) – and their position relative to the plot poles can be difficult to distinguish from a distance.

We also found that along marsh edge plots, marsh terraces in the winter of 2014 had the lowest bird density along all sampling periods (fig. 8). The winter of 2014 was the first time we surveyed the terraces prior of the completion of construction and planting in the summer of 2013 and establishment of study plots in the fall of 2013. Surveys were done over only one day with thousands of Snow Geese present in the terraced pond outside of our plots, however we counted between 1-3 birds actively using our study plots. Vegetation was also very sparse on the terraces. During all later sampling periods in 2014, marsh terraces supported similar or higher bird density compared to the other types of edge habitat plots (fig. 9).

In general, total bird density may not be the best metric to use when comparing the suitability of different types of marsh habitat for waterbirds. It was not uncommon for large flocks of one or two species to make up the majority of bird abundance during a survey. This results a calculation of extremely high bird density, but only demonstrates that the plot in question provides habitat for the few dominate species. This was often the case with flocking species such as Tree Swallows, Red-winged Blackbirds, Black Terns, Boat-tailed Grackles, and American Coots in study plots of all habitat types during some point in the year.

#### 6.1.4 Guild Density

To address limitations of using total bird density to infer suitable habitat for waterbirds, we analyzed bird density for each foraging guild separately, and the two waterfowl guilds together. Managers are often trying to provide habitat for targeted species or groups of species when designing wetlands restoration projects. This analysis of bird distribution across the study area aims to identify which habitat types provide suitable habitat for each foraging guild across seasons.

With the exception of mudflat probers and gleaners, which were only recorded at crevasse splay sites, bird density by guild varied among habitat types seasonally. However, some habitat types did not provide suitable habitat for particular guilds during some or all seasons. The density of marsh foragers and gleaners was 0 bird/ha for open water plots during all seasons. This guild includes species and genera, such as Soras, Red-winged Blackbirds, Swamp Sparrows, and rails, that are extremely edge-dependent and associated with persistent herbaceous emergents (Lowery 1974, Rehm and Baldasserre 2007, Weller 1998, Weller and Spatcher 1965). Wading Ambushers also had a density of 0 birds/ha in open water plots year-round, and in all plot types aside from marsh terraces in the winter (though possibly skewed by the limited surveys conducted that season). Only marsh terraces, open water, and crevasse splays appear to provide suitable habitat for water surface gleaners (fig. 16). Over-wintering waterfowl (combined guilds of dabblers and grubbers and water bottom foragers and gleaners, including low flyovers) could be found in comparable high densities in the winter at all habitat types except beneficial

use of dredged material marshes. This low-density may be the results of high predator pressure at beneficial use sites. We often heard wild boar or saw signs of boar and coyotes while conducting surveys in that area. Migratory waterfowl were found at the highest densities at marsh terraces during the spring and fall. O'Connell and Nyman (2010, 2011) also observed higher abundance of waterfowl in ponds with marsh terraces than in ponds without marsh terraces during their study in southwestern Louisiana.

Piscivore plungers and divers, birds such as Osprey, Caspian Terns, and Double-Crested Cormorants often associated with deep open water (Cuthbert and Wires 1999, Dorr et al. 2014, Weller 1998), were present in significantly higher densities in open water than marsh edge habitats during the summer of 2013. During all other sampling periods, there was no significant difference between PPD guild density in open water and at least one type of edge habitat (fig. 14). It appears that even non-edge dependent foragers concentrate in marsh edge habitats and nearby open water areas at relatively high densities and may benefit from restored wetlands.

### 6.2 Edge Effect Among Marsh Habitat Types

Our finding that 74.8% of birds observed utilized edge habitats, either zone 1 (0-10m from the edge) exclusively or some combination of zones including zone 1, agrees with past studies that the area within 7 to 10m of the marsh edge is the most productive foraging area for wetland birds (Chabreck et al. 1989, O'Connell and Nyman 2010, Rehm and Baldassarre 2007, Weller and Spatcher 1965). We also found, however, there was often a lack of significant difference between bird abundance in the first 10 meters of a plot and other zones. Only 31.59% of birds observed during our surveys exclusively used near-edge habitats, while 25.2% utilized no edge habitat. For some of the habitat types, especially crevasse splays and marsh terraces, the relatively high abundance of birds outside the edge zone may be the result of difference in vegetation cover and water depth throughout the plots. Vegetation and water depth influence habitat suitability for many species (Weller 1999) and varied between habitat types (fig. 23) and among the sites within each habitat type (see: appendix H), but were analyzed separately from bird abundance by plot zone.

We found that marsh terraces and crevasse splays provided large areas of habitat for non-aerial foraging species beyond the perennial emergent marsh edge that was defined when the plots were established in December 2012 and March 2013. We did not find this to be the case at beneficial use of dredged material marshes and old edge marshes. Bird abundance at marsh terraces outside the edge zone was actually higher in the spring (33±5.74 birds between 10-40m) and fall (10±2.24 bird between 30-40m) and not significantly different from bird abundance at the edge during those seasons ($p<0.05$). Bird abundance in crevasse splays was only significantly different between the edge zone and non-edge zones in the summer ($p<0.05$). In contrast, at beneficial use of dredged material marshes, estimated non-aerial guild abundance in zones beyond 10m from the edge never exceeded 1±1 birds during any season (table 24). Old edge marshes also hosted relatively low bird abundance in zone beyond the first 10m of the plot (table 25), though during only one season was there a significant difference between zone 1 and all other zones.

The results from the marsh terrace sites indicate that the near edge habitat (<10 m) was no more suitable for non-aerial foraging guilds during the spring, summer, and fall than habitat >10 m from edge. This result does not make much sense in context of past research until we consider some site-specific characteristics of these marsh terraces. In the three terrace sites observed throughout the study, the borrow pit was located between 10 and 30m from the edge of the terrace, resulting in greater water depths, less SAV, and less emergent vegetation in this zone compared to the surrounding area (see appendix H). Beyond the borrow pit, the water depth decreased and emergent vegetation was often present during spring, summer, and fall surveys. Additionally, in the spring of 2014, wild rice (*Zizania aquatic)* began colonizing Buoy Pond and numerous other shallow ponds throughout the Bird's Foot Delta (personal observation). The area of our plots that were free of emergent vegetation in the fall of 2013 when plots were established and in the winter of 2014 during the first surveys, were hemi-marsh in spring of 2014, a relatively equal mix of open water and emergent vegetation (Waller and Spatcher 1965). Suitable foraging habitat for birds like Sora, Red-winged Black Bird, Marsh Wrens, and dabbling

ducks (Murkin et al. 1982, Waller and Spatcher 1965) then extended far past the constructed marsh terraces into what had previously been shallow open water (fig. 26). When the marsh terraces were resampled in the fall of 2014, only zone 1 and zone 2 (location of the borrow pits) were significantly different from each other.

Figure 26. *Zizania aquatic* colonized much of Bouy Pond, the location of our marsh terrace study plots, in 2014. The line of *Phragmites australis* (right and left) marks the edge of the constructed terrace and the visible PVC pipe marks the 30m (middle right) line of study plot Terrace 1. By October 2014, much of plot Terrace 1 and Terrace 2 were hemi-marsh dominated by *Z. aquatic*.

It could be argued that the typically defined edge effect extent of 10m still applies to these marsh terraces because zones 3 and 4 were typically hemi-marsh after the spring of 2014 and birds in these zones were utilizing edge habitat. What we can conclude from the data is that this particular restoration project created suitable habitat for a number of species well beyond a 10m periphery from the marsh terraces. The type of horizontal extension of vegetation out from the marsh edge we documented (see: appendix H) at our marsh terrace study plots is not typical of marsh terraces along the Gulf Coast, which

have been documented to often degrade and subside over time (Nyman and Chabreck 2012). Unlike previous marsh terrace projects, these terraces were constructed in the same pond as small man-made crevasses to provide freshwater inflow and sediment deposition (USFWS 2015). Therefore the rapid development of new emergent marsh outside the footprint of the 1,890 linear meters of man-made marsh terraces (USFWS 2015) should not be seen as an example of the terracing technique alone building new land, but of crevasse splays and marsh terraces working in conjunction to facilitate new land growth.

The other types of marshes investigated, including crevasse splays, beneficial use of dredged material marshes, and old edge marshes did not undergo extensive change from open-water to hemi-marsh, nor were impacted by artificially deep water areas like borrow pits. Some of the results, however, do challenge the 0-10m edge effect theory. Crevasse splays are dynamic habitat types, where seasonal flooding and storms often rework newly laid sediment to change water bottom elevations and create new land through deposition (Cahoon et al. 2011, Castellanos and Rozas 2001, Gammill and Quershi, 1990, Steyer et al. 2003, White 1993). During low tide or times of low river flow, crevasse splays had extensive shallow water areas and exposed mud flats (see: appendix H), providing suitable foraging habitat for a number of species well past the emergent marsh edge. Beneficial use of dredged material marshes were morphologically similar to old edge marshes and not influenced by crevasses. Hemi-marsh, shallow water, and exposed mud flat habitat were not present at old edge sites and most of the beneficial use of dredged material site. Only one beneficial use of dredged material site had bare ground when water levels were low (table H.9.2). The emergent marsh edge at these two types of sites was generally still well defined by the end of our study. Studies from other states also have concluded that created marshes similar to the beneficial use of dredged material sites in this study may not provide habitat comparable to natural marsh for waterbirds (Brusati et al. 2001, Erwin and Beck 2007, Streever 2000).

### 6.3 Providing Habitat for Species of Concern – Mottled Duck and Black Tern

Mottled Ducks, the only dabbling duck that is a year-round resident of coastal Louisiana, is the focus of much research and conservation in the state. The species is in steep decline (Rosenberg et al. 2014) and threatened by the loss of coastal nesting habitat. In the 2012 Coastal Master Plan, the Mottled Duck was one of the avian species modeled to predict wildlife response to land loss and restoration (CPRA 2012, Nyman et al. 2013). Whereas other waterfowl species used old edge marshes and open water areas (fig. 17, fig. 18), Mottled Ducks were never recorded in these habitat types. While the species was recorded at all three types of restored marsh, they were most frequently encountered at crevasse splays. Our finding that not all marsh edge habitats are suitable habitat for the Mottled Duck should be taken into consideration for future modeling exercises. Additional comparative studies of this species at restored and natural marshes could help improve habitat management strategies for this species along the southeastern Louisiana coast.

Black Terns are recognized common species in steep decline (Rosenberg et al. 2014), but one of the most abundant species in our study area during the summer and fall. The species has been in continual decline in North America since 1967, but total breeding population is unknown and estimates range from 100,000 to 500,000 (Health et al. 2009). Large flocks of these birds are rarely reported (Health et al. 2009), however, during our study flocks as large as 44 individuals were recorded within our 1200 $m^2$ plots (table C.3). In the area immediately outside of the plots, flocks exceeded 100 individuals during some survey periods and consisted primarily of juveniles based on plumage (fig. 27). We observed significantly higher densities of Black Terns in marsh terrace, crevasse, and open water plots than in old edge or beneficial use of dredged material marsh plots ($p>0.05$, fig. 10).

Figure 27. Juvenile Black Terns foraging along a crevasse (near study plot Crevasse 3) in August 2013.

The migratory patterns of North American Black Terns and their habitat use during migration are poorly understood and locations of pre-migratory and migratory stopover sites are not well documented (Naugle 2004). Spring migration is rapid, while fall migration between breeding grounds in the northern Midwest and Mid-Atlantic and wintering habitat in Central America can extend between July and October, with stopovers in inland and coastal wetlands (Health et al. 2009, Lowery 1974). Black Terns are not known to breed or over-winter in Louisiana, but do migrate through mainly the interior of the United States in spring and fall (Health et al. 2009). There is also evidence that the migratory patterns of adults and juveniles differ, as adults often leave the breeding grounds before juveniles (Van der Winder et al. 2014) and juveniles may not migrate as far north as breeding adults (Health et al. 2009). Lowery (1974) noted that nonbreeding Black Terns often occur along the Louisiana coast throughout the summer. We recorded Black Terns in our study plots between 3 August 2013 and 13 October in 2013 and between 9 July and 23 October in 2014 (we conducted no surveys in the months of June or September). Our

findings demonstrate that the coastal marshes of the Mississippi River Delta provide stopover habitat as adult birds prepare to migrant to Central America and summer habitat for young birds that are not breeding. However, it is unknown if the Black Terns utilizing our study area were multiple flocks moving through the region at different times throughout the summer and fall, or a single flock that spends extended time in the region. A recent study of satellite-tagged Black Terns migrating between Europe and western Africa found the species to be long-distance migrants with substantial individual variation in migration patterns, including stopover times and travel distances (Van der Winder et al. 2014). Much of the variation in migration routes and timing is believed to be related to variability in marine food resources, as these tagged individuals spent significant time in near-shore and off-shore environments. Neither satellite tagging, nor color-banding studies have been conducted in North America to reconstruct the migratory patterns of Black Tern populations on this continent. Findings from such studies could help managers select locations for targeted habitat management for Black Terns throughout their range.

### 6.4 Improving Methods for Future Research

Our study of avian response to wetland restoration could have been improved through some changes in field methods and incorporation of additional factors with data collection and analysis. A major shortcoming of this project was our ineffectiveness at measuring accurate waterfowl densities. Species under heavy hunting pressure such as Snow Geese, Northern Pintail, and Mottled Ducks seemed to be particularly weary of the temporary blinds we constructed for monitoring. We used PVC pipes, camouflage fabric, and surrounding vegetation to try to hide our boat from nearby birds (fig. 28). Despite our best efforts, waterfowl were often more aware of our presence than other birds, often flying into our study plots before quickly taking off to land a further distance from our boat within the same crevasse splay or pond. We were unable to construct a more permanent boat blind that might have provided better cover because we rarely used the same boat.

Figure 28. Temporary blinds were constructed from camouflage fabric and PVC poles before surveys began. While this method did decrease hide researchers and vessels, we were visible to birds flying overhead.

We used environmental, water quality, and vegetation cover data to characterize our study sites, but we did not factor these measures into all of our analyses of avian diversity and density among different habitat types. The relationships between environmental variables and habitat types, and environmental variables and foraging guilds was explored with our canonical correspondence analysis, but further analysis of environmental conditions and temporal changes in these conditions may have improved our ability to identify the significant explanatory variables influencing bird response. Vegetation composition and cover and abiotic features such as water depth, salinity, substrate, and morphology are important habitat features that may influence waterbird community composition and density (Weller 1999, Weller and Spatcher 1965). The age of restored marshes (time following completion of construction) or time since last major disturbance may also be a major factor in driving avian distribution, as recruitment of fishes and invertebrates can often take multiple years (Cheek et al. 2014). Vegetative succession can

change the habitat suitability of wetland many species of waterbirds (Arts et al. 2000, Weller and Spatcher 1965). Predator pressure was another important habitat suitability factor we did not measure, but is a recognized problem on dredge spoil wetlands and islands (Erwin and Beck 2007). We encountered wild boar, coyotes, Bald Eagles, Northern Harriers, and Peregrine Falcons in the study area (fig. 28). Longer-term projects with more robust surveying efforts may relieve that some habitat features more directly influence avian distribution among restored coastal marshes beyond the generalized variable of "habitat type."

Figure 29. Sightings and signs of potential mammalian predators were common throughout the study. These coyote tracks were found on a newly completed beneficial use of dredged material marsh site near study plot Beneficial Use of Dredge Material 2.

### 6.5 Conclusions

Through our two years of observation, it appears that all three restored habitat types studied, along with degrading marshes, in the Mississippi River Bird's Foot Delta provide comparably suitable foraging habitat for a diverse community of waterbirds. We found, however, that habitat type and season often have a significant affect on the composition of the avian community. There was a significant relationship between the five habitat types studied and environmental factors, and also a significant relationship between foraging guild density (birds/ha) and environmental factors. Habitat type functions as a useful predictor of guild richness, but alone is not a perfect substitute for environmental variables when trying to identify the source of all variation in avian community composition. The unexplained variation is possibly a reflection of seasonal changes in the habitat needs of many bird species. If the goal of wetland restoration is to provide habitat for the native wildlife of the region, then wetland complexes need to provide for these species during the points in their lifecycle where deltaic marshes are utilized. Providing a mix of habitat types may be the best strategy to meet the needs of Louisiana's waterbirds.

One of the strengths of this study for demonstrating differences in habitat preference is that all sites were located within the same delta system and the movement of most species from one habitat type to another was unrestricted. The distribution of birds is based on the habitat selection, whereas at least some individual birds are exposed to a variety of habitats in which just one is chosen for residence (Fretwell and Lucas 1970), or a few chosen for foraging, roosting, or breeding. Avian distribution may be considered a behavioral phenomenon and an evolutionary response to environmental factors (Fretwell and Lucas 1970). Analyzing avian response to different habitat types through the lens of foraging guild groupings, which incorporates behavior and general habitat needs of included species, maybe be a useful tool for modeling habitat suitability for targeted species. Examining seasonal changes in foraging guild densities across habitat types gives a more detailed picture of bird distribution than species richness or density alone.

However, it is important to consider the potential performance of different habitat types over decades, rather than just a couple years. As time after construction progresses, different avian communities may inhabit man-made wetlands, such as beneficial use of dredged material marshes, compared to natural wetlands or wetlands created through natural processes (Melvin and Webb 1998, Snell-Rood and Cristol 2003). Vegetative succession, subsidence, and other forces may result in habitat that is only suitable for a few seasons, and any improvement in avian density in the area resulting from restoration activities may be lost (Arts et al. 2000). Researchers in other delta systems have found that wetlands created by harnessing natural, dynamic alluvial and tidal processes provided suitable habitat for marsh birds over many years (Arts et al. 2000, Eertman et al. 2002). Other researchers have also cautioned that without on-going management, man-made wetlands such as beneficial use of dredged material marshes and marsh terraces, may fail in providing suitable habitat over many years (Arts et al. 2000, Darnell and Smith 2004, Erwin and Beck 2007, Nyman and Chabreck 2013). While much of the research on crevasses and managed sediment diversions in Louisiana has focused on the potential economic and environmental sustainability of this restoration method for maximizing land-building (Allison et al. 2010, CPRA 2012, Paola et al. 2011, Simenstad et al. 2006, Turner and Streever 2002), future long-term studies of this method of restoration for wildlife may demonstrate its worth for sustainable habitat restoration as well.

We found that crevasse splays supported the highest number of species (n=48) (table B.8), highest number of guilds (n=10) (table 4), highest guild richness (table 10), higher bird density in winter, spring, and summer compared to other edge types (table 11), highest number and density of species of concern (tables 12, 14), highest density of Mottled Ducks in the spring and fall (table 11), and highest density of mudflat probers and gleaners, though not always significantly different from other habitat types for these metrics. Marsh terraces also supported high densities of a number of foraging guilds throughout the year, but the terraces in our study were also influences by nearby crevasse splays. The beneficial use of dredge sediment sites rarely supported higher diversity or density of birds than other habitat types (table 9, fig. 11, fig. 12), though not often significantly different. With a larger sample size of study plots, more

replicates, longer study period, and more evaluation of environmental variables, significant differences in avian density and diversity among habitat types may be more frequently detected. The long-term affects of deltaic processes such as subsidence, deposition, and erosion, along with biotic processes such as vegetative succession and predator recruitment, on the habitat suitability of restored marshes for waterbirds was not measured in this study, but are recognized as important considerations for the management of coastal avian habitats (Arts et al. 2000, Darnell and Smith 2004, Erwin and Beck 2007).

### 6.6 Management Implications

Ecologically-informed design is vital to the survival and humans and wildlife (Browne and Chapman 2011) as engineers address new challenges resulting from climate change. Understanding the difference in habitat values for various types of waterbirds among marsh restoration techniques is essential for defining ecological restoration targets for wetland habitat enhancement projects (Miller and Hobbs 2007). Wetlands built using marsh terraces, beneficial use of dredged material, and crevasse splays all provide habitat for multiple foraging guilds of waterbirds throughout the year, however some types of restored habitat support higher densities of certain guilds than others. Even *Phragmites australis*-dominated old edge marsh supports high avian density in the summer and winter and open water areas provide loafing and foraging opportunities for some species. All types of marsh studied provided habitat for birds, but were not utilized by all bird species or foraging guilds, and bird communities often varied by season among the habitat types. Some habitat types provide more suitable habitat for some birds due to the types of forage and cover provided (mudflats, dense vegetation, open water, etc.). Mudflat probers and gleaners, for example, birds that depend on shallow water and mudflats for foraging, were only observed using crevasse splay sites. Current wetland wildlife models used in Louisiana do not consider differences in the quality of edge habitat amongst different restoration techniques and natural marshes (CPRA 2012, Nyman et al. 2013). Models of these differences in habitat value between marsh habitat types, when coupled with models of land building capacity of the proposed sediment diversions

and constructed marshes, could act as a tool allowing managers to make informed decisions as to which type of land building project, or combination of projects, should be built to achieve multi-faceted coastal restoration goals of efficient land building, flood protection, and maximum habitat value for wildlife. Data collected through this study could help set restoration targets that may be incorporated into the final design of the projects prescribed in the 2012 Coastal Master Plan for the Lower Mississippi Delta and future planning efforts (Nyman et al 2013).

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## APPENDIX A: AVIAN SPECIES ALPHA CODES

Table A.1. Standard alpha codes (Pyle and DeSante 2014) used for identified bird species and modified alpha codes for unidentified species grouped by order, family, or genus.

| Alpha code | Common name | Scientific name |
|---|---|---|
| AMCO | American Coot | *Fulica americana* |
| AMKE | American Kestrel | *Falco sparverius* |
| AMWI | American Wigeon | *Anas americana* |
| ANHI | Anhinga | *Anhinga anhinga* |
| AWPE | American White Pelican | *Pelecanus erythrorhychos* |
| BAEA | Bald Eagle | *Haliaeetus leucocephalus* |
| BARS | Barn Swallow | *Hirundo rustica* |
| BBWD | Black-bellied Whistling Duck | *Dendrocolaptes picumnus* |
| BCNH | Black-crowned Night-Heron | *Nycticorax nycticorax* |
| BEKI | Belted Kingfisher | *Megaceryle alcyon* |
| BLSK | Black Skimmer | *Rynchops niger* |
| BLTE | Black Tern | *Chlidonias niger* |
| BNST | Black-necked Stilt | *Himantopus mexicanus* |
| BOGU | Bonaparte's Gull | *Chroicocephalus philadelphia* |
| BRPE | Brown Pelican | *Pelecanus occidentalis* |
| BTGR | Boat-tailed Grackle | *Quiscalus major* |
| BWTE | Blue-winged Teal | *Anas discors* |
| CANV | Canvasback | *Aythya valisineria* |
| CATE | Caspian Tern | *Hydroprogne caspia* |
| CLRAxKIRA | Clapper Rail/King Rail hybrid | *Rallus longirostis x Rallus elegans* |
| COGA | Common Gallinule | *Gallinula galeata* |
| COTE | Common Tern | *Sterna hirundo* |
| DCCO | Double-crested Cormorant | *Phalacrocorax auritus* |
| EAKI | Eastern Kingbird | *Tyrannus tyrannus* |

(Table A.1 continued)

| Alpha code | Common name | Scientific name |
|---|---|---|
| FOTE | Forster's Tern | *Sterna forsteri* |
| GADW | Gadwall | *Anas strepera* |
| GBHE | Great Blue Heron | *Ardea herodias* |
| GBTE | Gull-billed Tern | *Gelochelidon nilotica* |
| GLIB | Glossy Ibis | *Plegadis falcinellus* |
| GREG | Great Egret | *Ardea alba* |
| GRHE | Green Heron | *Butorides virescens* |
| GRYE | Greater Yellowlegs | *Tringa melanoleuca* |
| HERG | Herring Gull | *Larus argentatus* |
| KILL | Killdeer | *Charadrius vociferus* |
| LAGU | Laughing Gull | *Leucophaeus atricilla* |
| LBDO | Long-billed Dowitcher | *Limnodromus scolopaceus* |
| LBHE | Little Blue Heron | *Egretta caerulea* |
| LEBI | Least Bittern | *Ixobrychus exilis* |
| LESA | Least Sandpiper | *Calidris minutilla* |
| LESC | Lesser Scaup | *Aythya affinis* |
| LETE | Least Tern | *Sternula antillarum* |
| LEYE | Lesser Yellowlegs | *Tringa flavipes* |
| MAFR | Magnificent Frigatebird | *Fregata magnificens* |
| MAWR | Marsh Wren | *Cistothorus palustis* |
| MODO | Mourning Dove | *Zenaida macroura* |
| MODU | Mottled Duck | *Anas fulvigula* |
| NOHA | Northern Harrier | *Circus cyaneus* |
| NOPI | Northern Pintail | *Anas acuta* |
| OROR | Orchard Oriole | *Icterus spurius* |
| OSPR | Osprey | *Pandion haliaetus* |

(Table A.1 continued)

| Alpha code | Common name | Scientific name |
|---|---|---|
| PBGR | Pied-billed Grebe | *Podilymbus podiceps* |
| PEFA | Peregrine Falcon | *Falco peregrinus* |
| PUGA | Purple Gallinule | *Porphyrio martinicus* |
| RBGU | Ring-billed Gull | *Larus delawarensis* |
| ROSP | Roseate Tern | *Platalea ajaja* |
| ROYT | Royal Tern | *Thalasseus maximus* |
| RWBL | Red-winged Blackbird | *Agelaius phoeniceus* |
| SATE | Sandwich Tern | *Thalasseus sandvicensis* |
| SAVS | Savannah Sparrow | *Passerculus sandwichensis* |
| SEWR | Sedge Wren | *Cistothorus platensis* |
| SNEG | Snowy Egret | *Ergetta thula* |
| SNGO | Snow Goose | *Chen caerulescens* |
| SORA | Sora | *Porzana carolina* |
| STSA | Stilt Sandpiper | *Calidris himantopus* |
| SWSP | Swamp Sparrow | *Melospiza georgiana* |
| TRES | Tree Swallow | *Tachycineta bicolor* |
| TRHE | Tricolored Heron | *Egretta tricolor* |
| UNDD[a] | Unidentified Dabbling Duck | *Anas* sp. |
| UNHE[a] | Unidentified Heron | Family: Ardeidae |
| UNIB[a] | Unidentified Ibis | Family: Threskiornithidae |
| UNLG | Unidentified *Larus* Gull | *Larus* sp. |
| UNPA[a] | Unidentified Passerine | Order: Passeriformes |
| UNPI[a] | Unidentified *Plegadis* Ibis | *Plegadis* sp. |
| UNPL[a] | Unidentified Plover | Family: Charadriidae |
| UNRA[a] | Unidentified Rail | *Rallus* sp. |
| UNSN[a] | Unidentified Sandpiper | Family: Scolopacidae |

(Table A.1 continued)

| Alpha code | Common name | Scientific name |
| --- | --- | --- |
| UNSP | Unidentified Sparrow | Family: Emberizidae |
| UNSW | Unidentified Swallow | Family: Hirundidae |
| UNTR[a] | Unidentified Tern | Family: Laridae |
| UNWA | Unidentified Warbler | Family: Parulidae |
| UNWR | Unidentified Wren | Family: Troglodytidae |
| WFIB | White-faced Ibis | *Plegadis chihi* |
| WHIB | White Ibis | *Eudocimus albus* |
| WILL | Willet | *Tringa semipalmata* |
| YCNH | Yellow-crowned Night-Heron | *Nyctanassa violacea* |
| YRWA | Yellow-rumped Warbler | *Setophaga coronata* |

[a]Non-standard alpha codes developed for unidentified birds encountered during this study.

# APPENDIX B: SPECIES FREQUENCY TABLES

Table B.1. Frequency of all avian species detected within all study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All Birds Counted in Study | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 401 | 17.77 | 401 | 17.77 |
| RWBL | 270 | 11.96 | 671 | 29.73 |
| AMCO | 192 | 8.51 | 863 | 38.24 |
| BLTE | 178 | 7.89 | 1041 | 46.12 |
| BTGR | 132 | 5.85 | 1173 | 51.97 |
| WHIB | 66 | 2.92 | 1239 | 54.90 |
| COTE | 56 | 2.48 | 1295 | 57.38 |
| BWTE | 55 | 2.44 | 1350 | 59.81 |
| UNDD | 54 | 2.39 | 1404 | 62.21 |
| FOTE | 48 | 2.13 | 1452 | 64.33 |
| ROYT | 44 | 1.95 | 1496 | 66.28 |
| NOPI | 42 | 1.86 | 1538 | 68.14 |
| SATE | 39 | 1.73 | 1577 | 69.87 |
| SNEG | 39 | 1.73 | 1616 | 71.60 |
| UNTR | 39 | 1.73 | 1655 | 73.33 |
| WILL | 37 | 1.64 | 1692 | 74.97 |
| SNGO | 32 | 1.42 | 1724 | 76.38 |
| LAGU | 29 | 1.28 | 1753 | 77.67 |
| MODU | 29 | 1.28 | 1782 | 78.95 |
| DCCO | 28 | 1.24 | 1810 | 80.19 |
| AWPE | 23 | 1.02 | 1833 | 81.21 |
| BEKI | 22 | 0.97 | 1855 | 82.19 |
| GADW | 20 | 0.89 | 1875 | 83.07 |
| GBHE | 19 | 0.84 | 1894 | 83.92 |
| CATE | 18 | 0.8 | 1912 | 84.71 |
| LBHE | 18 | 0.8 | 1930 | 85.51 |
| WFIB | 16 | 0.71 | 1946 | 86.22 |
| BRPE | 15 | 0.66 | 1961 | 86.89 |
| UNPL | 15 | 0.66 | 1976 | 87.55 |
| NOHA | 14 | 0.62 | 1990 | 88.17 |
| GLIB | 13 | 0.58 | 2003 | 88.75 |
| UNLG | 13 | 0.58 | 2016 | 89.32 |
| UNSN | 13 | 0.58 | 2029 | 89.90 |

(Table B.1 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| BARS | 11 | 0.49 | 2040 | 90.39 |
| GREG | 11 | 0.49 | 2051 | 90.87 |
| RBGU | 11 | 0.49 | 2062 | 91.36 |
| COGA | 10 | 0.44 | 2072 | 91.80 |
| PBGR | 10 | 0.44 | 2082 | 92.25 |
| TRHE | 10 | 0.44 | 2092 | 92.69 |
| UNSW | 10 | 0.44 | 2102 | 93.13 |
| GBTE | 9 | 0.40 | 2111 | 93.53 |
| OSPR | 9 | 0.40 | 2120 | 93.93 |
| BLSK | 8 | 0.35 | 2128 | 94.28 |
| HERG | 8 | 0.35 | 2136 | 94.64 |
| LETE | 8 | 0.35 | 2144 | 94.99 |
| YCNH | 8 | 0.35 | 2152 | 95.35 |
| BOGU | 6 | 0.27 | 2158 | 95.61 |
| KILL | 6 | 0.27 | 2164 | 95.88 |
| UNPA | 6 | 0.27 | 2170 | 96.15 |
| GRYE | 5 | 0.22 | 2175 | 96.37 |
| MAWR | 5 | 0.22 | 2180 | 96.59 |
| BBWD | 4 | 0.18 | 2184 | 96.77 |
| BCNH | 4 | 0.18 | 2188 | 96.94 |
| LEBI | 4 | 0.18 | 2192 | 97.12 |
| LEYE | 4 | 0.18 | 2196 | 97.30 |
| SORA | 4 | 0.18 | 2200 | 97.47 |
| BNST | 3 | 0.13 | 2203 | 97.61 |
| CANV | 3 | 0.13 | 2206 | 97.74 |
| GRHE | 3 | 0.13 | 2209 | 97.87 |
| CLRAxKIRA | 3 | 0.13 | 2212 | 98.01 |
| MAFR | 3 | 0.13 | 2215 | 98.14 |
| ROSP | 3 | 0.13 | 2218 | 98.27 |
| SWSP | 3 | 0.13 | 2221 | 98.40 |
| UNHE | 3 | 0.13 | 2224 | 98.54 |
| UNIB | 3 | 0.13 | 2227 | 98.67 |
| UNPI | 3 | 0.13 | 2230 | 98.80 |
| UNRA | 3 | 0.13 | 2233 | 98.94 |
| UNSP | 3 | 0.13 | 2236 | 99.07 |
| OROR | 2 | 0.09 | 2238 | 99.16 |
| PEFA | 2 | 0.09 | 2240 | 99.25 |

(Table B.1 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| UNWR | 2 | 0.09 | 2242 | 99.34 |
| AMKE | 1 | 0.04 | 2243 | 99.38 |
| AMWI | 1 | 0.04 | 2244 | 99.42 |
| ANHI | 1 | 0.04 | 2245 | 99.47 |
| BAEA | 1 | 0.04 | 2246 | 99.51 |
| EAKI | 1 | 0.04 | 2247 | 99.56 |
| LBDO | 1 | 0.04 | 2248 | 99.60 |
| LESA | 1 | 0.04 | 2249 | 99.65 |
| LESC | 1 | 0.04 | 2250 | 99.69 |
| MODO | 1 | 0.04 | 2251 | 99.73 |
| PUGA | 1 | 0.04 | 2252 | 99.78 |
| SAVS | 1 | 0.04 | 2253 | 99.82 |
| SEWR | 1 | 0.04 | 2254 | 99.87 |
| STSA | 1 | 0.04 | 2255 | 99.91 |
| UNWA | 1 | 0.04 | 2256 | 99.96 |
| YRWA | 1 | 0.04 | 2257 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.2. Frequency of avian species detected within all study plots, excluding flyovers of non-foraging birds, in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Birds Counted Actively Utilizing Plots in Study | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| TRES | 379 | 27.85 | 379 | 27.85 |
| AMCO | 186 | 13.67 | 565 | 41.51 |
| BLTE | 158 | 11.61 | 723 | 53.12 |
| RWBL | 129 | 9.48 | 852 | 62.60 |
| BTGR | 54 | 3.97 | 906 | 66.57 |
| COTE | 49 | 3.60 | 955 | 70.17 |
| FOTE | 41 | 3.01 | 996 | 73.18 |
| SATE | 37 | 2.72 | 1033 | 75.90 |
| ROYT | 35 | 2.57 | 1068 | 78.47 |
| UNTR | 22 | 1.62 | 1090 | 80.09 |
| BEKI | 20 | 1.47 | 1110 | 81.56 |
| CATE | 14 | 1.03 | 1124 | 82.59 |
| NOHA | 12 | 0.88 | 1136 | 83.47 |
| SNEG | 12 | 0.88 | 1148 | 84.35 |
| WHIB | 12 | 0.88 | 1160 | 85.23 |
| BARS | 11 | 0.81 | 1171 | 86.04 |
| LAGU | 10 | 0.73 | 1181 | 86.77 |
| PBGR | 10 | 0.73 | 1191 | 87.51 |
| BWTE | 9 | 0.66 | 1200 | 88.17 |
| COGA | 9 | 0.66 | 1209 | 88.83 |
| GBTE | 9 | 0.66 | 1218 | 89.49 |
| UNSW | 9 | 0.66 | 1227 | 90.15 |
| MODU | 8 | 0.59 | 1235 | 90.74 |
| WILL | 8 | 0.59 | 1243 | 91.33 |
| BLSK | 7 | 0.51 | 1250 | 91.84 |
| GADW | 6 | 0.44 | 1256 | 92.29 |
| RBGU | 6 | 0.44 | 1262 | 92.73 |
| GBHE | 5 | 0.37 | 1267 | 93.09 |
| KILL | 5 | 0.37 | 1272 | 93.46 |
| LBHE | 5 | 0.37 | 1277 | 93.83 |
| LETE | 5 | 0.37 | 1282 | 94.20 |
| MAWR | 5 | 0.37 | 1287 | 94.56 |
| TRHE | 5 | 0.37 | 1292 | 94.93 |
| YCNH | 5 | 0.37 | 1297 | 95.30 |
| BRPE | 4 | 0.29 | 1301 | 95.59 |

(Table B.2 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| LEBI | 4 | 0.29 | 1305 | 95.89 |
| LEYE | 4 | 0.29 | 1309 | 96.18 |
| SORA | 4 | 0.29 | 1313 | 96.47 |
| CLRAxKIRA | 3 | 0.22 | 1316 | 96.69 |
| OSPR | 3 | 0.22 | 1319 | 96.91 |
| SWSP | 3 | 0.22 | 1322 | 97.13 |
| UNPA | 3 | 0.22 | 1325 | 97.35 |
| UNRA | 3 | 0.22 | 1328 | 97.58 |
| GRHE | 2 | 0.15 | 1330 | 97.72 |
| OROR | 2 | 0.15 | 1332 | 97.87 |
| PEFA | 2 | 0.15 | 1334 | 98.02 |
| UNSN | 2 | 0.15 | 1336 | 98.16 |
| UNWR | 2 | 0.15 | 1338 | 98.31 |
| WFIB | 2 | 0.15 | 1340 | 98.46 |
| AMKE | 1 | 0.07 | 1341 | 98.53 |
| AMWI | 1 | 0.07 | 1342 | 98.60 |
| AWPE | 1 | 0.07 | 1343 | 98.68 |
| BAEA | 1 | 0.07 | 1344 | 98.75 |
| BCNH | 1 | 0.07 | 1345 | 98.82 |
| BNST | 1 | 0.07 | 1346 | 98.90 |
| EAKI | 1 | 0.07 | 1347 | 98.97 |
| GLIB | 1 | 0.07 | 1348 | 99.04 |
| LBDO | 1 | 0.07 | 1349 | 99.12 |
| LESA | 1 | 0.07 | 1350 | 99.19 |
| LESC | 1 | 0.07 | 1351 | 99.27 |
| PUGA | 1 | 0.07 | 1352 | 99.34 |
| SAVS | 1 | 0.07 | 1353 | 99.41 |
| SEWR | 1 | 0.07 | 1354 | 99.49 |
| SNGO | 1 | 0.07 | 1355 | 99.56 |
| STSA | 1 | 0.07 | 1356 | 99.63 |
| UNDD | 1 | 0.07 | 1357 | 99.71 |
| UNLG | 1 | 0.07 | 1358 | 99.78 |
| UNSP | 1 | 0.07 | 1359 | 99.85 |
| UNWA | 1 | 0.07 | 1360 | 99.93 |
| YRWA | 1 | 0.07 | 1361 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.3. Frequency of all avian species detected within all crevasse splay study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All Birds Counted – Crevasses Splays | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative Frequency | Cumulative Percent |
| TRES | 151 | 19.51 | 151 | 19.51 |
| RWBL | 106 | 13.7 | 257 | 33.2 |
| BLTE | 46 | 5.94 | 303 | 39.15 |
| WHIB | 39 | 5.04 | 342 | 44.19 |
| BTGR | 34 | 4.39 | 376 | 48.58 |
| WILL | 31 | 4.01 | 407 | 52.58 |
| FOTE | 30 | 3.88 | 437 | 56.46 |
| BWTE | 29 | 3.75 | 466 | 60.21 |
| NOPI | 24 | 3.1 | 490 | 63.31 |
| MODU | 21 | 2.71 | 511 | 66.02 |
| AMCO | 20 | 2.58 | 531 | 68.6 |
| AWPE | 19 | 2.45 | 550 | 71.06 |
| COTE | 15 | 1.94 | 565 | 73 |
| UNPL | 15 | 1.94 | 580 | 74.94 |
| SNEG | 14 | 1.81 | 594 | 76.74 |
| UNSN | 13 | 1.68 | 607 | 78.42 |
| UNTR | 13 | 1.68 | 620 | 80.1 |
| GADW | 12 | 1.55 | 632 | 81.65 |
| BEKI | 10 | 1.29 | 642 | 82.95 |
| SATE | 8 | 1.03 | 650 | 83.98 |
| UNLG | 8 | 1.03 | 658 | 85.01 |
| UNSW | 8 | 1.03 | 666 | 86.05 |
| WFIB | 8 | 1.03 | 674 | 87.08 |
| LAGU | 7 | 0.9 | 681 | 87.98 |
| BOGU | 6 | 0.78 | 687 | 88.76 |
| GBHE | 6 | 0.78 | 693 | 89.53 |
| KILL | 6 | 0.78 | 699 | 90.31 |
| DCCO | 5 | 0.65 | 704 | 90.96 |
| GLIB | 5 | 0.65 | 709 | 91.6 |
| BRPE | 4 | 0.52 | 713 | 92.12 |
| GREG | 4 | 0.52 | 717 | 92.64 |
| LETE | 4 | 0.52 | 721 | 93.15 |
| LEYE | 4 | 0.52 | 725 | 93.67 |
| ROYT | 4 | 0.52 | 729 | 94.19 |
| BBWD | 3 | 0.39 | 732 | 94.57 |
| GBTE | 3 | 0.39 | 735 | 94.96 |
| NOHA | 3 | 0.39 | 738 | 95.35 |
| TRHE | 3 | 0.39 | 741 | 95.74 |
| UNPI | 3 | 0.39 | 744 | 96.12 |
| BNST | 2 | 0.26 | 746 | 96.38 |
| CANV | 2 | 0.26 | 748 | 96.64 |
| COGA | 2 | 0.26 | 750 | 96.9 |
| LBHE | 2 | 0.26 | 752 | 97.16 |

(Table B.3 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| RBGU | 2 | 0.26 | 754 | 97.42 |
| SWSP | 2 | 0.26 | 756 | 97.67 |
| UNIB | 2 | 0.26 | 758 | 97.93 |
| BAEA | 1 | 0.13 | 759 | 98.06 |
| BARS | 1 | 0.13 | 760 | 98.19 |
| BCNH | 1 | 0.13 | 761 | 98.32 |
| CATE | 1 | 0.13 | 762 | 98.45 |
| GRHE | 1 | 0.13 | 763 | 98.58 |
| HERG | 1 | 0.13 | 764 | 98.71 |
| LBDO | 1 | 0.13 | 765 | 98.84 |
| LESA | 1 | 0.13 | 766 | 98.97 |
| MAWR | 1 | 0.13 | 767 | 99.1 |
| OSPR | 1 | 0.13 | 768 | 99.22 |
| PBGR | 1 | 0.13 | 769 | 99.35 |
| SORA | 1 | 0.13 | 770 | 99.48 |
| STSA | 1 | 0.13 | 771 | 99.61 |
| UNDD | 1 | 0.13 | 772 | 99.74 |
| UNPA | 1 | 0.13 | 773 | 99.87 |
| YCNH | 1 | 0.13 | 774 | 100 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.4. Frequency of all avian species detected within all marsh terrace study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All Birds Counted – Marsh Terraces | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| RWBL | 73 | 16.15 | 73 | 16.15 |
| BLTE | 68 | 15.04 | 141 | 31.19 |
| AMCO | 57 | 12.61 | 198 | 43.81 |
| UNDD | 38 | 8.41 | 236 | 52.21 |
| SNGO | 31 | 6.86 | 267 | 59.07 |
| BTGR | 20 | 4.42 | 287 | 63.50 |
| NOPI | 18 | 3.98 | 305 | 67.48 |
| TRES | 15 | 3.32 | 320 | 70.8 |
| DCCO | 11 | 2.43 | 331 | 73.23 |
| FOTE | 8 | 1.77 | 339 | 75.00 |
| GADW | 8 | 1.77 | 347 | 76.77 |
| LAGU | 8 | 1.77 | 355 | 78.54 |
| NOHA | 8 | 1.77 | 363 | 80.31 |
| BLSK | 7 | 1.55 | 370 | 81.86 |
| WHIB | 6 | 1.33 | 376 | 83.19 |
| COTE | 5 | 1.11 | 381 | 84.29 |
| SATE | 5 | 1.11 | 386 | 85.4 |
| BARS | 4 | 0.88 | 390 | 86.28 |
| MAWR | 4 | 0.88 | 394 | 87.17 |
| MODU | 4 | 0.88 | 398 | 88.05 |
| SNEG | 4 | 0.88 | 402 | 88.94 |
| UNTR | 4 | 0.88 | 406 | 89.82 |
| RBGU | 3 | 0.66 | 409 | 90.49 |
| ROSP | 3 | 0.66 | 412 | 91.15 |
| SORA | 3 | 0.66 | 415 | 91.81 |
| UNRA | 3 | 0.66 | 418 | 92.48 |
| BEKI | 2 | 0.44 | 420 | 92.92 |
| BWTE | 2 | 0.44 | 422 | 93.36 |
| COGA | 2 | 0.44 | 424 | 93.81 |
| GBHE | 2 | 0.44 | 426 | 94.25 |
| HERG | 2 | 0.44 | 428 | 94.69 |
| LBHE | 2 | 0.44 | 430 | 95.13 |
| PBGR | 2 | 0.44 | 432 | 95.58 |
| UNPA | 2 | 0.44 | 434 | 96.02 |
| AMKE | 1 | 0.22 | 435 | 96.24 |

(Table B.4 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| AMWI | 1 | 0.22 | 436 | 96.46 |
| ANHI | 1 | 0.22 | 437 | 96.68 |
| AWPE | 1 | 0.22 | 438 | 96.90 |
| BBWD | 1 | 0.22 | 439 | 97.12 |
| BNST | 1 | 0.22 | 440 | 97.35 |
| CANV | 1 | 0.22 | 441 | 97.57 |
| GLIB | 1 | 0.22 | 442 | 97.79 |
| GREG | 1 | 0.22 | 443 | 98.01 |
| CLRAxKIRA | 1 | 0.22 | 444 | 98.23 |
| LEBI | 1 | 0.22 | 445 | 98.45 |
| LESC | 1 | 0.22 | 446 | 98.67 |
| MODO | 1 | 0.22 | 447 | 98.89 |
| OSPR | 1 | 0.22 | 448 | 99.12 |
| PEFA | 1 | 0.22 | 449 | 99.34 |
| SAVS | 1 | 0.22 | 450 | 99.56 |
| UNSP | 1 | 0.22 | 451 | 99.78 |
| UNWR | 1 | 0.22 | 452 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.5. Frequency of all avian species detected within all beneficial use of dredged material study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All Birds Counted – Beneficial Use of Dredged Material Marshes | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 71 | 22.26 | 71 | 22.26 |
| RWBL | 52 | 16.3 | 123 | 38.56 |
| BTGR | 21 | 6.58 | 144 | 45.14 |
| ROYT | 11 | 3.45 | 155 | 48.59 |
| BLTE | 9 | 2.82 | 164 | 51.41 |
| CATE | 9 | 2.82 | 173 | 54.23 |
| SATE | 9 | 2.82 | 182 | 57.05 |
| UNDD | 9 | 2.82 | 191 | 59.87 |
| SNEG | 8 | 2.51 | 199 | 62.38 |
| UNTR | 8 | 2.51 | 207 | 64.89 |
| WFIB | 8 | 2.51 | 215 | 67.4 |
| WHIB | 8 | 2.51 | 223 | 69.91 |
| BEKI | 6 | 1.88 | 229 | 71.79 |
| GBHE | 6 | 1.88 | 235 | 73.67 |
| AMCO | 5 | 1.57 | 240 | 75.24 |
| BARS | 5 | 1.57 | 245 | 76.8 |
| GLIB | 5 | 1.57 | 250 | 78.37 |
| GRYE | 5 | 1.57 | 255 | 79.94 |
| LAGU | 5 | 1.57 | 260 | 81.5 |
| RBGU | 5 | 1.57 | 265 | 83.07 |
| BWTE | 4 | 1.25 | 269 | 84.33 |
| DCCO | 4 | 1.25 | 273 | 85.58 |
| MODU | 4 | 1.25 | 277 | 86.83 |
| TRHE | 4 | 1.25 | 281 | 88.09 |
| BRPE | 3 | 0.94 | 284 | 89.03 |
| NOHA | 3 | 0.94 | 287 | 89.97 |
| GREG | 2 | 0.63 | 289 | 90.6 |
| CLRAxKIRA | 2 | 0.63 | 291 | 91.22 |
| OROR | 2 | 0.63 | 293 | 91.85 |
| PBGR | 2 | 0.63 | 295 | 92.48 |
| YCNH | 2 | 0.63 | 297 | 93.1 |
| AWPE | 1 | 0.31 | 298 | 93.42 |
| BLSK | 1 | 0.31 | 299 | 93.73 |
| COGA | 1 | 0.31 | 300 | 94.04 |
| COTE | 1 | 0.31 | 301 | 94.36 |

(Table B.5 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| EAKI | 1 | 0.31 | 302 | 94.67 |
| FOTE | 1 | 0.31 | 303 | 94.98 |
| GBTE | 1 | 0.31 | 304 | 95.3 |
| GRHE | 1 | 0.31 | 305 | 95.61 |
| HERG | 1 | 0.31 | 306 | 95.92 |
| LBHE | 1 | 0.31 | 307 | 96.24 |
| OSPR | 1 | 0.31 | 308 | 96.55 |
| PEFA | 1 | 0.31 | 309 | 96.87 |
| PUGA | 1 | 0.31 | 310 | 97.18 |
| SEWR | 1 | 0.31 | 311 | 97.49 |
| SNGO | 1 | 0.31 | 312 | 97.81 |
| SWSP | 1 | 0.31 | 313 | 98.12 |
| UNHE | 1 | 0.31 | 314 | 98.43 |
| UNIB | 1 | 0.31 | 315 | 98.75 |
| UNLG | 1 | 0.31 | 316 | 99.06 |
| UNPA | 1 | 0.31 | 317 | 99.37 |
| UNWA | 1 | 0.31 | 318 | 99.69 |
| UNWR | 1 | 0.31 | 319 | 100 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.6. Frequency of all avian species detected within all old edge study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All Birds Counted – Old Edge Marshes | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 87 | 21.70 | 87 | 21.70 |
| BTGR | 49 | 12.22 | 136 | 33.92 |
| RWBL | 39 | 9.73 | 175 | 43.64 |
| AMCO | 20 | 4.99 | 195 | 48.63 |
| COTE | 18 | 4.49 | 213 | 53.12 |
| BWTE | 17 | 4.24 | 230 | 57.36 |
| ROYT | 13 | 3.24 | 243 | 60.60 |
| LBHE | 12 | 2.99 | 255 | 63.59 |
| PBGR | 12 | 2.99 | 267 | 66.58 |
| BLTE | 11 | 2.74 | 278 | 69.33 |
| SATE | 10 | 2.49 | 288 | 71.82 |
| SNEG | 10 | 2.49 | 298 | 74.31 |
| CATE | 8 | 2.00 | 306 | 76.31 |
| WHIB | 8 | 2.00 | 314 | 78.30 |
| BRPE | 7 | 1.75 | 321 | 80.05 |
| UNTR | 6 | 1.50 | 327 | 81.55 |
| COGA | 5 | 1.25 | 332 | 82.79 |
| FOTE | 5 | 1.25 | 337 | 84.04 |
| LAGU | 5 | 1.25 | 342 | 85.29 |
| WILL | 5 | 1.25 | 347 | 86.53 |
| YCNH | 5 | 1.25 | 352 | 87.78 |
| GBHE | 4 | 1.00 | 356 | 88.78 |
| UNDD | 4 | 1.00 | 360 | 89.78 |
| DCCO | 3 | 0.75 | 363 | 90.52 |
| GREG | 3 | 0.75 | 366 | 91.27 |
| LEBI | 3 | 0.75 | 369 | 92.02 |
| OSPR | 3 | 0.75 | 372 | 92.77 |
| AWPE | 2 | 0.50 | 374 | 93.27 |
| BCNH | 2 | 0.50 | 376 | 93.77 |
| BEKI | 2 | 0.50 | 378 | 94.26 |
| GBTE | 2 | 0.50 | 380 | 94.76 |
| HERG | 2 | 0.50 | 382 | 95.26 |
| LETE | 2 | 0.50 | 384 | 95.76 |
| MAFR | 2 | 0.50 | 386 | 96.26 |
| TRHE | 2 | 0.50 | 388 | 96.76 |
| UNLG | 2 | 0.50 | 390 | 97.26 |

(Table B.6 continued)

| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| UNPA | 2 | 0.50 | 392 | 97.76 |
| UNSP | 2 | 0.50 | 394 | 98.25 |
| UNSW | 2 | 0.50 | 396 | 98.75 |
| GLIB | 1 | 0.25 | 397 | 99.00 |
| GRHE | 1 | 0.25 | 398 | 99.25 |
| RBGU | 1 | 0.25 | 399 | 99.50 |
| UNHE | 1 | 0.25 | 400 | 99.75 |
| YRWA | 1 | 0.25 | 401 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.7. Frequency of all avian species detected within all open water study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | All birds counted – open water | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| AMCO | 90 | 28.3 | 90 | 28.3 |
| TRES | 77 | 24.21 | 167 | 52.52 |
| BLTE | 44 | 13.84 | 211 | 66.35 |
| COTE | 17 | 5.35 | 228 | 71.7 |
| ROYT | 16 | 5.03 | 244 | 76.73 |
| BTGR | 8 | 2.52 | 252 | 79.25 |
| UNTR | 8 | 2.52 | 260 | 81.76 |
| SATE | 7 | 2.2 | 267 | 83.96 |
| DCCO | 5 | 1.57 | 272 | 85.53 |
| WHIB | 5 | 1.57 | 277 | 87.11 |
| FOTE | 4 | 1.26 | 281 | 88.36 |
| LAGU | 4 | 1.26 | 285 | 89.62 |
| BWTE | 3 | 0.94 | 288 | 90.57 |
| GBTE | 3 | 0.94 | 291 | 91.51 |
| OSPR | 3 | 0.94 | 294 | 92.45 |
| SNEG | 3 | 0.94 | 297 | 93.4 |
| BEKI | 2 | 0.63 | 299 | 94.03 |
| HERG | 2 | 0.63 | 301 | 94.65 |
| LETE | 2 | 0.63 | 303 | 95.28 |
| UNDD | 2 | 0.63 | 305 | 95.91 |
| UNLG | 2 | 0.63 | 307 | 96.54 |
| BARS | 1 | 0.31 | 308 | 96.86 |
| BCNH | 1 | 0.31 | 309 | 97.17 |
| BRPE | 1 | 0.31 | 310 | 97.48 |
| GBHE | 1 | 0.31 | 311 | 97.8 |
| GLIB | 1 | 0.31 | 312 | 98.11 |
| GREG | 1 | 0.31 | 313 | 98.43 |
| LBHE | 1 | 0.31 | 314 | 98.74 |
| MAFR | 1 | 0.31 | 315 | 99.06 |
| TRHE | 1 | 0.31 | 316 | 99.37 |
| UNHE | 1 | 0.31 | 317 | 99.69 |
| WILL | 1 | 0.31 | 318 | 100 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.8. Frequency of avian species detected, excluding flyovers, within crevasse splay study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Active use birds counted – crevasse splays | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 149 | 32.75 | 149 | 32.75 |
| RWBL | 63 | 13.85 | 212 | 46.59 |
| BLTE | 42 | 9.23 | 254 | 55.82 |
| FOTE | 24 | 5.27 | 278 | 61.10 |
| BTGR | 20 | 4.40 | 298 | 65.49 |
| AMCO | 19 | 4.18 | 317 | 69.67 |
| COTE | 15 | 3.30 | 332 | 72.97 |
| WHIB | 12 | 2.64 | 344 | 75.60 |
| BEKI | 9 | 1.98 | 353 | 77.58 |
| MODU | 8 | 1.76 | 361 | 79.34 |
| SNEG | 8 | 1.76 | 369 | 81.10 |
| UNSW | 8 | 1.76 | 377 | 82.86 |
| SATE | 7 | 1.54 | 384 | 84.40 |
| UNTR | 7 | 1.54 | 391 | 85.93 |
| GADW | 6 | 1.32 | 397 | 87.25 |
| BWTE | 5 | 1.10 | 402 | 88.35 |
| KILL | 5 | 1.10 | 407 | 89.45 |
| LEYE | 4 | 0.88 | 411 | 90.33 |
| GBHE | 3 | 0.66 | 414 | 90.99 |
| GBTE | 3 | 0.66 | 417 | 91.65 |
| WILL | 3 | 0.66 | 420 | 92.31 |
| COGA | 2 | 0.44 | 422 | 92.75 |
| LAGU | 2 | 0.44 | 424 | 93.19 |
| NOHA | 2 | 0.44 | 426 | 93.63 |
| ROYT | 2 | 0.44 | 428 | 94.07 |
| SWSP | 2 | 0.44 | 430 | 94.51 |
| TRHE | 2 | 0.44 | 432 | 94.95 |
| UNSN | 2 | 0.44 | 434 | 95.38 |
| WFIB | 2 | 0.44 | 436 | 95.82 |
| AWPE | 1 | 0.22 | 437 | 96.04 |
| BAEA | 1 | 0.22 | 438 | 96.26 |
| BARS | 1 | 0.22 | 439 | 96.48 |
| BNST | 1 | 0.22 | 440 | 96.70 |
| BRPE | 1 | 0.22 | 441 | 96.92 |
| CATE | 1 | 0.22 | 442 | 97.14 |

(Table B.8 continued)

| Species | Frequency | Percent | Cumulative frequency | Cumulative percent |
|---|---|---|---|---|
| GLIB | 1 | 0.22 | 443 | 97.36 |
| GRHE | 1 | 0.22 | 444 | 97.58 |
| LBDO | 1 | 0.22 | 445 | 97.80 |
| LBHE | 1 | 0.22 | 446 | 98.02 |
| LESA | 1 | 0.22 | 447 | 98.24 |
| LETE | 1 | 0.22 | 448 | 98.46 |
| MAWR | 1 | 0.22 | 449 | 98.68 |
| PBGR | 1 | 0.22 | 450 | 98.90 |
| SORA | 1 | 0.22 | 451 | 99.12 |
| STSA | 1 | 0.22 | 452 | 99.34 |
| UNDD | 1 | 0.22 | 453 | 99.56 |
| UNLG | 1 | 0.22 | 454 | 99.78 |
| YCNH | 1 | 0.22 | 455 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.9. Frequency of avian species detected, excluding flyovers, within marsh terrace study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Active use birds counted – marsh terraces | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| BLTE | 67 | 27.80 | 67 | 27.80 |
| AMCO | 57 | 23.65 | 124 | 51.45 |
| RWBL | 25 | 10.37 | 149 | 61.83 |
| TRES | 15 | 6.22 | 164 | 68.05 |
| FOTE | 8 | 3.32 | 172 | 71.37 |
| NOHA | 8 | 3.32 | 180 | 74.69 |
| BLSK | 7 | 2.90 | 187 | 77.59 |
| BTGR | 5 | 2.07 | 192 | 79.67 |
| SATE | 5 | 2.07 | 197 | 81.74 |
| BARS | 4 | 1.66 | 201 | 83.40 |
| MAWR | 4 | 1.66 | 205 | 85.06 |
| LAGU | 3 | 1.24 | 208 | 86.31 |
| SORA | 3 | 1.24 | 211 | 87.55 |
| UNRA | 3 | 1.24 | 214 | 88.80 |
| UNTR | 3 | 1.24 | 217 | 90.04 |
| BEKI | 2 | 0.83 | 219 | 90.87 |
| COTE | 2 | 0.83 | 221 | 91.70 |
| PBGR | 2 | 0.83 | 223 | 92.53 |
| SNEG | 2 | 0.83 | 225 | 93.36 |
| UNPA | 2 | 0.83 | 227 | 94.19 |
| AMKE | 1 | 0.41 | 228 | 94.61 |
| AMWI | 1 | 0.41 | 229 | 95.02 |
| COGA | 1 | 0.41 | 230 | 95.44 |
| GBHE | 1 | 0.41 | 231 | 95.85 |
| CLRAxKIRA | 1 | 0.41 | 232 | 96.27 |
| LBHE | 1 | 0.41 | 233 | 96.68 |
| LEBI | 1 | 0.41 | 234 | 97.10 |
| LESC | 1 | 0.41 | 235 | 97.51 |
| OSPR | 1 | 0.41 | 236 | 97.93 |
| PEFA | 1 | 0.41 | 237 | 98.34 |
| RBGU | 1 | 0.41 | 238 | 98.76 |
| SAVS | 1 | 0.41 | 239 | 99.17 |
| UNSP | 1 | 0.41 | 240 | 99.59 |
| UNWR | 1 | 0.41 | 241 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.10. Frequency of avian species detected, excluding flyovers, within beneficial use of dredged material marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Active use birds counted – pump-in marshes | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 56 | 34.36 | 56 | 34.36 |
| RWBL | 26 | 15.95 | 82 | 50.31 |
| ROYT | 9 | 5.52 | 91 | 55.83 |
| SATE | 9 | 5.52 | 100 | 61.35 |
| CATE | 8 | 4.91 | 108 | 66.26 |
| BEKI | 6 | 3.68 | 114 | 69.94 |
| BTGR | 6 | 3.68 | 120 | 73.62 |
| BARS | 5 | 3.07 | 125 | 76.69 |
| RBGU | 5 | 3.07 | 130 | 79.75 |
| UNTR | 4 | 2.45 | 134 | 82.21 |
| BLTE | 3 | 1.84 | 137 | 84.05 |
| CLRAxKIRA | 2 | 1.23 | 139 | 85.28 |
| NOHA | 2 | 1.23 | 141 | 86.50 |
| OROR | 2 | 1.23 | 143 | 87.73 |
| PBGR | 2 | 1.23 | 145 | 88.96 |
| TRHE | 2 | 1.23 | 147 | 90.18 |
| AMCO | 1 | 0.61 | 148 | 90.80 |
| COGA | 1 | 0.61 | 149 | 91.41 |
| COTE | 1 | 0.61 | 150 | 92.02 |
| EAKI | 1 | 0.61 | 151 | 92.64 |
| FOTE | 1 | 0.61 | 152 | 93.25 |
| GBTE | 1 | 0.61 | 153 | 93.87 |
| LAGU | 1 | 0.61 | 154 | 94.48 |
| PEFA | 1 | 0.61 | 155 | 95.09 |
| PUGA | 1 | 0.61 | 156 | 95.71 |
| SEWR | 1 | 0.61 | 157 | 96.32 |
| SNEG | 1 | 0.61 | 158 | 96.93 |
| SNGO | 1 | 0.61 | 159 | 97.55 |
| SWSP | 1 | 0.61 | 160 | 98.16 |
| UNWA | 1 | 0.61 | 161 | 98.77 |
| UNWR | 1 | 0.61 | 162 | 99.39 |
| YCNH | 1 | 0.61 | 163 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.11. Frequency of avian species detected, excluding flyovers, within old edge study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Active use birds counted –old edge marshes | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| TRES | 84 | 35.29 | 84 | 35.29 |
| BTGR | 23 | 9.66 | 107 | 44.96 |
| AMCO | 19 | 7.98 | 126 | 52.94 |
| RWBL | 15 | 6.30 | 141 | 59.24 |
| COTE | 14 | 5.88 | 155 | 65.13 |
| ROYT | 10 | 4.20 | 165 | 69.33 |
| SATE | 9 | 3.78 | 174 | 73.11 |
| BLTE | 6 | 2.52 | 180 | 75.63 |
| CATE | 5 | 2.10 | 185 | 77.73 |
| COGA | 5 | 2.10 | 190 | 79.83 |
| PBGR | 5 | 2.10 | 195 | 81.93 |
| BWTE | 4 | 1.68 | 199 | 83.61 |
| FOTE | 4 | 1.68 | 203 | 85.29 |
| LAGU | 4 | 1.68 | 207 | 86.97 |
| WILL | 4 | 1.68 | 211 | 88.66 |
| LBHE | 3 | 1.26 | 214 | 89.92 |
| LEBI | 3 | 1.26 | 217 | 91.18 |
| YCNH | 3 | 1.26 | 220 | 92.44 |
| BRPE | 2 | 0.84 | 222 | 93.28 |
| GBTE | 2 | 0.84 | 224 | 94.12 |
| LETE | 2 | 0.84 | 226 | 94.96 |
| UNTR | 2 | 0.84 | 228 | 95.80 |
| BCNH | 1 | 0.42 | 229 | 96.22 |
| BEKI | 1 | 0.42 | 230 | 96.64 |
| GBHE | 1 | 0.42 | 231 | 97.06 |
| GRHE | 1 | 0.42 | 232 | 97.48 |
| OSPR | 1 | 0.42 | 233 | 97.90 |
| SNEG | 1 | 0.42 | 234 | 98.32 |
| TRHE | 1 | 0.42 | 235 | 98.74 |
| UNPA | 1 | 0.42 | 236 | 99.16 |
| UNSW | 1 | 0.42 | 237 | 99.58 |
| YRWA | 1 | 0.42 | 238 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

Table B.12. Frequency of avian species detected, excluding flyovers, within open water study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Active use birds counted – open water | | | |
|---|---|---|---|---|
| Species[a] | Frequency | Percent | Cumulative frequency | Cumulative percent |
| AMCO | 90 | 34.09 | 90 | 34.09 |
| TRES | 75 | 28.41 | 165 | 62.50 |
| BLTE | 40 | 15.15 | 205 | 77.65 |
| COTE | 17 | 6.44 | 222 | 84.09 |
| ROYT | 14 | 5.30 | 236 | 89.39 |
| SATE | 7 | 2.65 | 243 | 92.05 |
| UNTR | 6 | 2.27 | 249 | 94.32 |
| FOTE | 4 | 1.52 | 253 | 95.83 |
| GBTE | 3 | 1.14 | 256 | 96.97 |
| BEKI | 2 | 0.76 | 258 | 97.73 |
| LETE | 2 | 0.76 | 260 | 98.48 |
| BARS | 1 | 0.38 | 261 | 98.86 |
| BRPE | 1 | 0.38 | 262 | 99.24 |
| OSPR | 1 | 0.38 | 263 | 99.62 |
| WILL | 1 | 0.38 | 264 | 100.00 |

[a]Four-letter alpha code for avian species names (Pyle and DeSante 2014). See Appendix A.

# APPENDIX C: TOTAL BIRD DENSITY TABLES

Table C.1. The model-predicted mean density of birds actively using study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Year | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|---|
| Fall | 13 | crevasse | 108.33 | 33.61 |
| Fall | 13 | old edge | 50 | 27.37 |
| Fall | 13 | pump-in | 86.11 | 26.83 |
| Fall | 13 | open water | 400 | 212.45 |
| Fall | 14 | crevasse | 186.11 | 57.36 |
| Fall | 14 | old edge | 75 | 23.44 |
| Fall | 14 | pump-in | 152.78 | 47.18 |
| Fall | 14 | marsh terrace | 169.44 | 52.27 |
| Fall | 14 | open water | 266.67 | 100.37 |
| Spring | 13 | crevasse | 350 | 107.39 |
| Spring | 13 | old edge | 211.11 | 64.99 |
| Spring | 13 | open water | 111.11 | 34.46 |
| Spring | 14 | crevasse | 166.67 | 51.42 |
| Spring | 14 | old edge | 104.17 | 39.61 |
| Spring | 14 | pump-in | 108.33 | 41.17 |
| Spring | 14 | marsh terrace | 202.78 | 62.45 |
| Spring | 14 | open water | 2000 | 1058.47 |
| Summer | 13 | crevasse | 227.78 | 70.08 |
| Summer | 13 | old edge | 133.33 | 41.25 |
| Summer | 13 | open water | 688.89 | 210.85 |
| Summer | 14 | crevasse | 450 | 238.89 |
| Summer | 14 | old edge | 91.67 | 34.94 |
| Summer | 14 | pump-in | 120.83 | 45.84 |
| Summer | 14 | marsh terrace | 425 | 159.57 |
| Summer | 14 | open water | 233.33 | 87.91 |
| Winter | 14 | crevasse | 216.67 | 115.51 |
| Winter | 14 | old edge | 283.33 | 150.76 |
| Winter | 14 | pump-in | 183.33 | 97.88 |
| Winter | 14 | marsh terrace | 13.89 | 4.75 |
| Winter | 14 | open water | 3000 | 1587.23 |

Table C.2. The model-predicted mean density of birds actively using marsh edge study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 147.22 | 36.49 |
| Spring | crevasse | 259.72 | 64.11 |
| Summer | crevasse | 283.33 | 85.62 |
| Winter | crevasse | 216.66 | 131.14 |
| Fall | marsh terrace | 169.44 | 59.32 |
| Spring | marsh terrace | 202.78 | 70.89 |
| Summer | marsh terrace | 425.00 | 181.34 |
| Winter | marsh terrace | 13.89 | 5.28 |
| Fall | old edge | 68.75 | 21.09 |
| Spring | old edge | 168.33 | 45.65 |
| Summer | old edge | 116.67 | 31.75 |
| Winter | old edge | 283.33 | 171.24 |
| Fall | pump-in | 119.45 | 29.67 |
| Spring | pump-in | 108.33 | 46.66 |
| Summer | pump-in | 120.83 | 51.98 |
| Winter | pump-in | 183.33 | 111.09 |

Table C.3. Bird counts and densities, excluding flyovers, and model-predicted mean densities for each site survey conducted in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 29 Mar 2013 | crevasse | 2 | LEYE | 4 | 33.33 | 33.33 | 33.33 |
| 29 Mar 2013 | crevasse | 2 | TRES | 4 | 33.33 | 71.38 | 29.57 |
| 29 Mar 2013 | crevasse | 2 | GADW | 2 | 16.67 | 16.11 | 9.84 |
| 29 Mar 2013 | crevasse | 2 | LETE | 1 | 8.33 | 10.25 | 6.88 |
| 29 Mar 2013 | crevasse | 2 | SNEG | 1 | 8.33 | 11.02 | 4.64 |
| 29 Mar 2013 | crevasse | 3 | TRES | 8 | 66.67 | 67.34 | 26.69 |
| 29 Mar 2013 | crevasse | 3 | SNEG | 4 | 33.33 | 10.40 | 4.25 |
| 29 Mar 2013 | crevasse | 3 | GADW | 2 | 16.67 | 15.20 | 9.24 |
| 29 Mar 2013 | crevasse | 3 | RWBL | 2 | 16.67 | 22.83 | 8.81 |
| 29 Mar 2013 | crevasse | 3 | AMCO | 1 | 8.33 | 60.08 | 30.57 |
| 29 Mar 2013 | crevasse | 3 | NOHA | 1 | 8.33 | 7.53 | 3.48 |
| 29 Mar 2013 | old edge | 2 | BTGR | 2 | 16.67 | 10.34 | 4.21 |
| 29 Mar 2013 | old edge | 2 | RWBL | 2 | 16.67 | 18.93 | 7.80 |
| 29 Mar 2013 | old edge | 2 | AMCO | 1 | 8.33 | 49.82 | 26.38 |
| 29 Mar 2013 | open water | 2 | no birds | 0 | 0 | 0 | 0 |
| 30 Mar 2013 | crevasse | 1 | UNSW | 8 | 66.67 | 36.86 | 26.20 |
| 30 Mar 2013 | crevasse | 1 | TRES | 6 | 50.00 | 76.12 | 52.49 |
| 30 Mar 2013 | crevasse | 1 | BAEA | 1 | 8.33 | 8.33 | 8.33 |
| 30 Mar 2013 | crevasse | 1 | SNEG | 1 | 8.33 | 11.75 | 8.39 |
| 30 Mar 2013 | old edge | 1 | RWBL | 2 | 16.67 | 20.19 | 13.87 |
| 30 Mar 2013 | open water | 1 | no birds | 0 | 0 | 0 | 0 |
| 31 Mar 2013 | old edge | 3 | TRES | 31 | 258.33 | 114.47 | 66.88 |
| 31 Mar 2013 | old edge | 3 | PBGR | 1 | 8.33 | 15.39 | 10.71 |
| 31 Mar 2013 | open water | 3 | TRES | 4 | 133.33 | 660.42 | 410.35 |
| 01 Apr 2013 | crevasse | 1 | TRES | 32 | 266.67 | 104.81 | 35.34 |
| 01 Apr 2013 | crevasse | 1 | BWTE | 4 | 33.33 | 23.58 | 14.52 |
| 01 Apr 2013 | crevasse | 1 | BTGR | 2 | 16.67 | 19.40 | 7.69 |
| 01 Apr 2013 | crevasse | 1 | RWBL | 2 | 16.67 | 35.54 | 14.05 |
| 01 Apr 2013 | crevasse | 1 | MODU | 1 | 8.33 | 16.10 | 9.10 |
| 01 Apr 2013 | crevasse | 2 | TRES | 7 | 58.33 | 100.28 | 35.03 |
| 01 Apr 2013 | crevasse | 2 | WILL | 3 | 25.00 | 28.15 | 18.37 |
| 01 Apr 2013 | crevasse | 2 | GBHE | 1 | 8.33 | 12.22 | 7.34 |
| 01 Apr 2013 | crevasse | 3 | TRES | 29 | 241.67 | 94.60 | 32.93 |
| 01 Apr 2013 | old edge | 2 | TRES | 7 | 58.33 | 78.44 | 30.85 |
| 01 Apr 2013 | open water | 2 | OSPR | 1 | 33.33 | 49.53 | 35.81 |
| 01 Apr 2013 | open water | 2 | TRES | 1 | 33.33 | 452.54 | 185.21 |
| 02 Apr 2013 | old edge | 1 | TRES | 19 | 158.33 | 64.23 | 29.18 |
| 02 Apr 2013 | old edge | 1 | FOTE | 1 | 8.33 | 16.70 | 9.32 |
| 02 Apr 2013 | old edge | 1 | RWBL | 1 | 8.33 | 21.78 | 11.28 |
| 02 Apr 2013 | old edge | 3 | TRES | 9 | 75.00 | 57.98 | 27.58 |
| 02 Apr 2013 | open water | 1 | TRES | 4 | 133.33 | 370.58 | 186.69 |
| 02 Apr 2013 | open water | 3 | no birds | 0 | 0 | 0 | 0 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 04 Aug 2013 | crevasse | 2 | COTE | 6 | 50.00 | 38.48 | 14.40 |
| 04 Aug 2013 | crevasse | 2 | BLTE | 5 | 41.67 | 81.34 | 34.76 |
| 04 Aug 2013 | crevasse | 2 | RWBL | 1 | 8.33 | 38.96 | 14.76 |
| 04 Aug 2013 | old edge | 2 | COTE | 11 | 91.67 | 30.10 | 10.31 |
| 04 Aug 2013 | old edge | 2 | RWBL | 6 | 50.00 | 30.47 | 10.64 |
| 04 Aug 2013 | old edge | 2 | BLTE | 3 | 25.00 | 63.63 | 25.42 |
| 04 Aug 2013 | old edge | 2 | BTGR | 3 | 25.00 | 16.64 | 5.84 |
| 04 Aug 2013 | old edge | 2 | LETE | 2 | 16.67 | 12.91 | 7.71 |
| 04 Aug 2013 | old edge | 2 | ROYT | 2 | 16.67 | 18.01 | 7.28 |
| 04 Aug 2013 | old edge | 2 | COGA | 1 | 8.33 | 10.63 | 5.13 |
| 04 Aug 2013 | old edge | 2 | GRHE | 1 | 8.33 | 9.17 | 6.85 |
| 04 Aug 2013 | old edge | 2 | LEBI | 1 | 8.33 | 10.70 | 6.11 |
| 04 Aug 2013 | old edge | 2 | UNSW | 1 | 8.33 | 43.52 | 42.27 |
| 04 Aug 2013 | open water | 2 | COTE | 7 | 233.33 | 173.62 | 65.94 |
| 04 Aug 2013 | open water | 2 | BLTE | 3 | 100.00 | 367.08 | 156.64 |
| 04 Aug 2013 | open water | 2 | LETE | 2 | 66.67 | 74.45 | 45.47 |
| 05 Aug 2013 | crevasse | 3 | BLTE | 12 | 100.00 | 69.63 | 30.47 |
| 05 Aug 2013 | crevasse | 3 | WHIB | 10 | 83.33 | 51.97 | 37.07 |
| 05 Aug 2013 | crevasse | 3 | COTE | 6 | 50.00 | 32.93 | 15.05 |
| 05 Aug 2013 | crevasse | 3 | RWBL | 3 | 25.00 | 33.35 | 13.99 |
| 05 Aug 2013 | crevasse | 3 | UNTR | 3 | 25.00 | 17.43 | 7.79 |
| 05 Aug 2013 | crevasse | 3 | UNSN | 2 | 16.67 | 16.67 | 16.67 |
| 05 Aug 2013 | crevasse | 3 | WFIB | 2 | 16.67 | 16.67 | 16.67 |
| 05 Aug 2013 | crevasse | 3 | BNST | 1 | 8.33 | 8.33 | 8.33 |
| 05 Aug 2013 | crevasse | 3 | BTGR | 1 | 8.33 | 18.20 | 7.77 |
| 05 Aug 2013 | crevasse | 3 | GBTE | 1 | 8.33 | 13.68 | 7.41 |
| 05 Aug 2013 | crevasse | 3 | LAGU | 1 | 8.33 | 25.89 | 16.00 |
| 05 Aug 2013 | crevasse | 3 | LBDO | 1 | 8.33 | 8.33 | 8.33 |
| 05 Aug 2013 | crevasse | 3 | LESA | 1 | 8.33 | 8.33 | 8.33 |
| 05 Aug 2013 | crevasse | 3 | STSA | 1 | 8.33 | 8.33 | 8.33 |
| 05 Aug 2013 | crevasse | 3 | YCNH | 1 | 8.33 | 9.59 | 5.36 |
| 06 Aug 2013 | crevasse | 1 | RWBL | 8 | 66.67 | 34.57 | 10.59 |
| 06 Aug 2013 | crevasse | 1 | SATE | 6 | 50.00 | 24.93 | 8.68 |
| 06 Aug 2013 | crevasse | 1 | BTGR | 3 | 25.00 | 18.87 | 5.89 |
| 06 Aug 2013 | crevasse | 1 | COTE | 3 | 25.00 | 34.14 | 13.20 |
| 06 Aug 2013 | crevasse | 1 | FOTE | 2 | 16.67 | 26.51 | 9.77 |
| 06 Aug 2013 | crevasse | 1 | SNEG | 1 | 8.33 | 15.74 | 7.34 |
| 06 Aug 2013 | crevasse | 1 | TRES | 1 | 8.33 | 101.96 | 36.65 |
| 06 Aug 2013 | old edge | 1 | BTGR | 3 | 25.00 | 14.76 | 4.32 |
| 06 Aug 2013 | old edge | 1 | GBTE | 2 | 16.67 | 11.10 | 4.96 |
| 06 Aug 2013 | old edge | 1 | BLTE | 1 | 8.33 | 56.46 | 20.98 |
| 06 Aug 2013 | old edge | 1 | CATE | 1 | 8.33 | 16.28 | 7.17 |
| 06 Aug 2013 | old edge | 1 | COTE | 1 | 8.33 | 26.71 | 10.36 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 06 Aug 2013 | old edge | 1 | ROYT | 1 | 8.33 | 15.98 | 5.61 |
| 06 Aug 2013 | old edge | 1 | RWBL | 1 | 8.33 | 27.04 | 8.37 |
| 06 Aug 2013 | old edge | 1 | YCNH | 1 | 8.33 | 7.78 | 3.86 |
| 06 Aug 2013 | old edge | 3 | FOTE | 2 | 16.67 | 18.72 | 7.46 |
| 06 Aug 2013 | old edge | 3 | SATE | 2 | 16.67 | 17.60 | 6.46 |
| 06 Aug 2013 | old edge | 3 | COTE | 1 | 8.33 | 24.11 | 10.12 |
| 06 Aug 2013 | old edge | 3 | OSPR | 1 | 8.33 | 7.88 | 5.25 |
| 06 Aug 2013 | open water | 1 | BLTE | 17 | 566.67 | 325.75 | 113.10 |
| 06 Aug 2013 | open water | 1 | COTE | 9 | 300.00 | 154.08 | 57.07 |
| 06 Aug 2013 | open water | 1 | ROYT | 8 | 266.67 | 92.18 | 31.01 |
| 06 Aug 2013 | open water | 1 | GBTE | 3 | 100.00 | 64.02 | 28.61 |
| 06 Aug 2013 | open water | 1 | SATE | 3 | 100.00 | 112.51 | 38.70 |
| 06 Aug 2013 | open water | 1 | FOTE | 2 | 66.67 | 119.62 | 45.43 |
| 06 Aug 2013 | open water | 3 | UNTR | 3 | 100.00 | 73.59 | 29.79 |
| 06 Aug 2013 | open water | 3 | FOTE | 2 | 66.67 | 107.97 | 43.21 |
| 06 Aug 2013 | open water | 3 | SATE | 2 | 66.67 | 101.55 | 37.71 |
| 06 Aug 2013 | open water | 3 | COTE | 1 | 33.33 | 139.07 | 56.05 |
| 12 Oct 2013 | crevasse | 1 | BTGR | 3 | 25.00 | 13.85 | 4.89 |
| 12 Oct 2013 | crevasse | 1 | BEKI | 2 | 16.67 | 8.17 | 3.15 |
| 12 Oct 2013 | crevasse | 1 | BWTE | 1 | 8.33 | 16.84 | 11.19 |
| 12 Oct 2013 | crevasse | 1 | GBTE | 1 | 8.33 | 10.41 | 5.27 |
| 12 Oct 2013 | crevasse | 1 | GRHE | 1 | 8.33 | 7.64 | 5.61 |
| 12 Oct 2013 | crevasse | 1 | RWBL | 1 | 8.33 | 25.37 | 9.24 |
| 12 Oct 2013 | crevasse | 1 | UNTR | 1 | 8.33 | 13.26 | 5.49 |
| 13 Oct 2013 | crevasse | 2 | MODU | 2 | 16.67 | 15.01 | 8.31 |
| 13 Oct 2013 | crevasse | 2 | AMCO | 1 | 8.33 | 87.21 | 47.17 |
| 13 Oct 2013 | crevasse | 2 | BEKI | 1 | 8.33 | 10.67 | 4.64 |
| 13 Oct 2013 | crevasse | 2 | BTGR | 1 | 8.33 | 18.09 | 7.36 |
| 13 Oct 2013 | crevasse | 2 | COGA | 1 | 8.33 | 11.56 | 6.04 |
| 13 Oct 2013 | crevasse | 2 | UNDD | 1 | 8.33 | 8.33 | 8.33 |
| 13 Oct 2013 | old edge | 1 | SATE | 4 | 33.33 | 19.54 | 7.98 |
| 13 Oct 2013 | old edge | 1 | BTGR | 2 | 16.67 | 14.79 | 5.39 |
| 13 Oct 2013 | open water | 1 | BLTE | 9 | 300.00 | 326.36 | 141.46 |
| 13 Oct 2013 | open water | 1 | UNTR | 3 | 100.00 | 81.69 | 36.35 |
| 26 Oct 2013 | old edge | 3 | no birds | 0 | 0 | 0 | 0 |
| 27 Oct 2013 | crevasse | 3 | FOTE | 8 | 66.67 | 45.34 | 20.54 |
| 27 Oct 2013 | crevasse | 3 | RWBL | 7 | 58.33 | 59.14 | 24.22 |
| 27 Oct 2013 | crevasse | 3 | BTGR | 4 | 33.33 | 32.28 | 14.00 |
| 27 Oct 2013 | crevasse | 3 | BEKI | 1 | 8.33 | 19.04 | 8.46 |
| 27 Oct 2013 | crevasse | 3 | GLIB | 1 | 8.33 | 8.33 | 8.33 |
| 27 Oct 2013 | crevasse | 3 | UNLG | 1 | 8.33 | 8.33 | 8.33 |
| 27 Oct 2013 | pump-in | 3 | RWBL | 10 | 83.33 | 44.73 | 17.98 |
| 27 Oct 2013 | pump-in | 3 | BEKI | 2 | 16.67 | 14.40 | 6.42 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 27 Oct 2013 | pump-in | 3 | NOHA | 1 | 8.33 | 14.74 | 7.43 |
| 27 Oct 2013 | pump-in | 3 | SNGO | 1 | 8.33 | 8.33 | 8.33 |
| 27 Oct 2013 | pump-in | 3 | TRHE | 1 | 8.33 | 17.10 | 10.58 |
| 27 Oct 2013 | pump-in | 3 | UNWA | 1 | 8.33 | 8.33 | 8.33 |
| 28 Oct 2013 | pump-in | 1 | RWBL | 7 | 58.33 | 26.35 | 10.17 |
| 28 Oct 2013 | pump-in | 1 | BEKI | 1 | 8.33 | 8.48 | 3.29 |
| 28 Oct 2013 | pump-in | 1 | BTGR | 1 | 8.33 | 14.38 | 5.76 |
| 28 Oct 2013 | pump-in | 1 | TRHE | 1 | 8.33 | 10.07 | 5.88 |
| 28 Oct 2013 | pump-in | 1 | no birds | 0 | 0 | 0 | 0 |
| 28 Oct 2013 | pump-in | 2 | BEKI | 2 | 16.67 | 8.12 | 3.17 |
| 28 Oct 2013 | pump-in | 2 | BARS | 1 | 8.33 | 12.30 | 6.79 |
| 28 Oct 2013 | pump-in | 2 | BTGR | 1 | 8.33 | 13.76 | 5.69 |
| 28 Oct 2013 | pump-in | 2 | SNEG | 1 | 8.33 | 11.48 | 5.94 |
| 25 Jan 2014 | marsh terrace | 1 | OSPR | 1 | 8.33 | 6.57 | 4.51 |
| 25 Jan 2014 | marsh terrace | 2 | LBHE | 1 | 8.33 | 8.30 | 5.58 |
| 25 Jan 2014 | marsh terrace | 2 | NOHA | 1 | 8.33 | 6.42 | 3.88 |
| 25 Jan 2014 | marsh terrace | 2 | RWBL | 1 | 8.33 | 19.47 | 11.72 |
| 26 Jan 2014 | marsh terrace | 3 | LESC | 1 | 8.33 | 8.33 | 8.33 |
| 08 Feb 2014 | crevasse | 1 | AMCO | 7 | 58.33 | 154.80 | 61.90 |
| 08 Feb 2014 | crevasse | 1 | KILL | 3 | 25.00 | 31.08 | 24.04 |
| 08 Feb 2014 | crevasse | 1 | TRES | 3 | 25.00 | 173.50 | 69.58 |
| 08 Feb 2014 | crevasse | 1 | BEKI | 1 | 8.33 | 18.94 | 8.28 |
| 08 Feb 2014 | crevasse | 1 | SWSP | 1 | 8.33 | 13.82 | 9.23 |
| 08 Feb 2014 | old edge | 1 | AMCO | 16 | 133.33 | 121.09 | 46.56 |
| 08 Feb 2014 | old edge | 1 | TRES | 5 | 41.67 | 135.71 | 52.79 |
| 08 Feb 2014 | old edge | 1 | BWTE | 4 | 33.33 | 30.54 | 19.37 |
| 08 Feb 2014 | old edge | 1 | BTGR | 3 | 25.00 | 25.12 | 9.79 |
| 08 Feb 2014 | old edge | 1 | COGA | 3 | 25.00 | 16.05 | 7.60 |
| 08 Feb 2014 | old edge | 1 | RWBL | 1 | 8.33 | 46.02 | 18.23 |
| 08 Feb 2014 | old edge | 1 | UNPA | 1 | 8.33 | 10.78 | 7.00 |
| 08 Feb 2014 | old edge | 1 | YRWA | 1 | 8.33 | 8.33 | 8.33 |
| 08 Feb 2014 | open water | 1 | AMCO | 90 | 3000.00 | 698.57 | 259.69 |
| 09 Feb 2014 | pump-in | 3 | TRES | 13 | 108.33 | 99.31 | 51.93 |
| 09 Feb 2014 | pump-in | 3 | RBGU | 5 | 41.67 | 24.38 | 17.34 |
| 09 Feb 2014 | pump-in | 3 | CLRAxKIRA | 1 | 8.33 | 6.88 | 4.50 |
| 09 Feb 2014 | pump-in | 3 | SEWR | 1 | 8.33 | 8.33 | 8.33 |
| 09 Feb 2014 | pump-in | 3 | SWSP | 1 | 8.33 | 7.91 | 5.30 |
| 09 Feb 2014 | pump-in | 3 | UNWR | 1 | 8.33 | 8.95 | 6.90 |
| 08 Mar 2014 | crevasse | 2 | BRPE | 1 | 8.33 | 9.11 | 5.18 |
| 08 Mar 2014 | crevasse | 2 | BTGR | 1 | 8.33 | 25.86 | 11.55 |
| 08 Mar 2014 | crevasse | 2 | TRES | 1 | 8.33 | 139.69 | 55.77 |
| 08 Mar 2014 | crevasse | 2 | UNTR | 1 | 8.33 | 24.75 | 12.68 |
| 08 Mar 2014 | old edge | 2 | TRES | 12 | 100.00 | 109.26 | 41.20 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 08 Mar 2014 | old edge | 2 | PBGR | 4 | 33.33 | 14.69 | 6.96 |
| 08 Mar 2014 | old edge | 2 | AMCO | 2 | 16.67 | 97.49 | 45.56 |
| 08 Mar 2014 | old edge | 2 | BRPE | 1 | 8.33 | 7.13 | 3.91 |
| 08 Mar 2014 | open water | 2 | TRES | 60 | 2000.00 | 630.35 | 242.62 |
| 09 Mar 2014 | marsh terrace | 2 | AMCO | 56 | 466.67 | 110.25 | 44.66 |
| 09 Mar 2014 | marsh terrace | 2 | TRES | 6 | 50.00 | 123.56 | 51.77 |
| 09 Mar 2014 | marsh terrace | 2 | BTGR | 2 | 16.67 | 22.87 | 10.11 |
| 09 Mar 2014 | marsh terrace | 2 | AMWI | 1 | 8.33 | 8.33 | 8.33 |
| 09 Mar 2014 | marsh terrace | 3 | AMCO | 1 | 8.33 | 104.00 | 47.11 |
| 09 Mar 2014 | marsh terrace | 3 | NOHA | 1 | 8.33 | 13.03 | 6.88 |
| 09 Mar 2014 | marsh terrace | 3 | RBGU | 1 | 8.33 | 28.62 | 23.76 |
| 09 Mar 2014 | marsh terrace | 3 | SATE | 1 | 8.33 | 28.50 | 15.20 |
| 12 Apr 2014 | crevasse | 1 | TRES | 21 | 175.00 | 75.13 | 24.05 |
| 12 Apr 2014 | crevasse | 1 | AMCO | 5 | 41.67 | 67.04 | 29.23 |
| 12 Apr 2014 | crevasse | 1 | RWBL | 2 | 16.67 | 25.48 | 7.94 |
| 12 Apr 2014 | crevasse | 1 | TRHE | 2 | 16.67 | 9.74 | 5.22 |
| 12 Apr 2014 | crevasse | 1 | BTGR | 1 | 8.33 | 13.91 | 4.42 |
| 12 Apr 2014 | crevasse | 1 | CATE | 1 | 8.33 | 15.33 | 6.60 |
| 12 Apr 2014 | crevasse | 1 | COGA | 1 | 8.33 | 8.88 | 4.09 |
| 12 Apr 2014 | crevasse | 1 | MAWR | 1 | 8.33 | 6.85 | 3.51 |
| 12 Apr 2014 | crevasse | 1 | MODU | 1 | 8.33 | 11.54 | 6.00 |
| 12 Apr 2014 | crevasse | 1 | NOHA | 1 | 8.33 | 8.40 | 3.50 |
| 12 Apr 2014 | crevasse | 1 | SORA | 1 | 8.33 | 9.06 | 5.67 |
| 12 Apr 2014 | crevasse | 1 | UNTR | 1 | 8.33 | 13.31 | 5.25 |
| 12 Apr 2014 | old edge | 3 | LAGU | 4 | 33.33 | 13.97 | 7.09 |
| 12 Apr 2014 | old edge | 3 | FOTE | 1 | 8.33 | 13.79 | 6.10 |
| 12 Apr 2014 | old edge | 3 | TRES | 1 | 8.33 | 53.04 | 20.17 |
| 12 Apr 2014 | open water | 3 | no birds | 0 | 0 | 0 | 0 |
| 12 Apr 2014 | pump-in | 2 | TRES | 3 | 25.00 | 54.38 | 20.10 |
| 12 Apr 2014 | pump-in | 2 | CATE | 2 | 16.67 | 11.10 | 4.87 |
| 12 Apr 2014 | pump-in | 2 | BTGR | 1 | 8.33 | 10.07 | 3.87 |
| 12 Apr 2014 | pump-in | 2 | ROYT | 1 | 8.33 | 10.89 | 4.45 |
| 12 Apr 2014 | pump-in | 2 | RWBL | 1 | 8.33 | 18.44 | 6.65 |
| 13 Apr 2014 | pump-in | 1 | TRES | 6 | 50.00 | 77.60 | 29.96 |
| 13 Apr 2014 | pump-in | 1 | BARS | 4 | 33.33 | 12.84 | 5.89 |
| 13 Apr 2014 | pump-in | 1 | ROYT | 4 | 33.33 | 15.55 | 6.13 |
| 13 Apr 2014 | pump-in | 1 | CATE | 2 | 16.67 | 15.83 | 7.17 |
| 13 Apr 2014 | pump-in | 1 | AMCO | 1 | 8.33 | 69.24 | 34.02 |
| 13 Apr 2014 | pump-in | 1 | FOTE | 1 | 8.33 | 20.17 | 8.90 |
| 18 Apr 2014 | crevasse | 3 | TRES | 11 | 91.67 | 66.07 | 31.45 |
| 18 Apr 2014 | crevasse | 3 | RWBL | 5 | 41.67 | 22.41 | 10.46 |
| 18 Apr 2014 | crevasse | 3 | LAGU | 1 | 8.33 | 17.40 | 9.92 |
| 18 Apr 2014 | crevasse | 3 | ROYT | 1 | 8.33 | 13.24 | 6.80 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 18 Apr 2014 | marsh terrace | 1 | LAGU | 3 | 25.00 | 20.34 | 12.14 |
| 18 Apr 2014 | marsh terrace | 1 | FOTE | 1 | 8.33 | 20.08 | 12.32 |
| 09 Jul 2014 | marsh terrace | 3 | BLTE | 44 | 366.67 | 124.17 | 47.96 |
| 09 Jul 2014 | marsh terrace | 3 | BLSK | 7 | 58.33 | 58.33 | 58.33 |
| 09 Jul 2014 | marsh terrace | 3 | FOTE | 6 | 50.00 | 45.60 | 20.01 |
| 09 Jul 2014 | marsh terrace | 3 | SATE | 4 | 33.33 | 42.89 | 18.59 |
| 09 Jul 2014 | marsh terrace | 3 | BARS | 3 | 25.00 | 29.02 | 15.23 |
| 09 Jul 2014 | marsh terrace | 3 | UNTR | 3 | 25.00 | 31.08 | 14.01 |
| 09 Jul 2014 | marsh terrace | 3 | COTE | 2 | 16.67 | 58.73 | 27.90 |
| 09 Jul 2014 | marsh terrace | 3 | SNEG | 2 | 16.67 | 27.08 | 13.93 |
| 09 Jul 2014 | marsh terrace | 3 | BTGR | 1 | 8.33 | 32.47 | 13.18 |
| 09 Jul 2014 | marsh terrace | 3 | CLRAxKIRA | 1 | 8.33 | 12.15 | 8.27 |
| 10 Jul 2014 | pump-in | 3 | SATE | 3 | 25.00 | 13.81 | 6.40 |
| 10 Jul 2014 | pump-in | 3 | OROR | 2 | 16.67 | 16.67 | 16.67 |
| 10 Jul 2014 | pump-in | 3 | RWBL | 2 | 16.67 | 19.15 | 8.83 |
| 10 Jul 2014 | pump-in | 3 | BTGR | 1 | 8.33 | 10.45 | 4.83 |
| 10 Jul 2014 | pump-in | 3 | COGA | 1 | 8.33 | 6.68 | 3.52 |
| 10 Jul 2014 | pump-in | 3 | COTE | 1 | 8.33 | 18.91 | 9.94 |
| 10 Jul 2014 | pump-in | 3 | EAKI | 1 | 8.33 | 8.33 | 8.33 |
| 10 Jul 2014 | pump-in | 3 | UNTR | 1 | 8.33 | 10.01 | 4.99 |
| 11 Jul 2014 | crevasse | 3 | BLTE | 25 | 208.33 | 97.71 | 37.37 |
| 11 Jul 2014 | crevasse | 3 | RWBL | 24 | 200.00 | 46.80 | 15.51 |
| 11 Jul 2014 | crevasse | 3 | BTGR | 4 | 33.33 | 25.55 | 9.39 |
| 11 Jul 2014 | crevasse | 3 | SATE | 1 | 8.33 | 33.75 | 14.12 |
| 11 Jul 2014 | old edge | 1 | CATE | 3 | 25.00 | 24.41 | 11.85 |
| 11 Jul 2014 | old edge | 1 | BTGR | 2 | 16.67 | 22.14 | 8.68 |
| 11 Jul 2014 | old edge | 1 | BLTE | 1 | 8.33 | 84.68 | 35.92 |
| 11 Jul 2014 | old edge | 1 | ROYT | 1 | 8.33 | 23.96 | 10.74 |
| 11 Jul 2014 | old edge | 1 | RWBL | 1 | 8.33 | 40.56 | 15.94 |
| 11 Jul 2014 | old edge | 1 | SATE | 1 | 8.33 | 29.25 | 13.35 |
| 11 Jul 2014 | old edge | 1 | YCNH | 1 | 8.33 | 11.66 | 6.46 |
| 11 Jul 2014 | open water | 1 | BLTE | 9 | 300.00 | 488.51 | 212.35 |
| 12 Jul 2014 | marsh terrace | 2 | BLTE | 23 | 191.67 | 51.29 | 18.04 |
| 12 Jul 2014 | marsh terrace | 2 | RWBL | 3 | 25.00 | 24.57 | 8.57 |
| 12 Jul 2014 | marsh terrace | 2 | BTGR | 1 | 8.33 | 13.41 | 4.95 |
| 12 Jul 2014 | marsh terrace | 2 | FOTE | 1 | 8.33 | 18.83 | 8.01 |
| 12 Jul 2014 | marsh terrace | 2 | LEBI | 1 | 8.33 | 8.63 | 4.89 |
| 12 Jul 2014 | old edge | 3 | BTGR | 2 | 16.67 | 9.38 | 2.85 |
| 12 Jul 2014 | old edge | 3 | SATE | 2 | 16.67 | 12.39 | 4.18 |
| 12 Jul 2014 | old edge | 3 | UNTR | 2 | 16.67 | 8.98 | 3.22 |
| 12 Jul 2014 | old edge | 3 | BLTE | 1 | 8.33 | 35.87 | 12.96 |
| 12 Jul 2014 | old edge | 3 | CATE | 1 | 8.33 | 10.34 | 4.51 |
| 12 Jul 2014 | old edge | 3 | COTE | 1 | 8.33 | 16.97 | 7.07 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 12 Jul 2014 | old edge | 3 | LEBI | 1 | 8.33 | 6.03 | 3.16 |
| 12 Jul 2014 | old edge | 3 | ROYT | 1 | 8.33 | 10.15 | 3.77 |
| 12 Jul 2014 | old edge | 3 | RWBL | 1 | 8.33 | 17.18 | 5.61 |
| 12 Jul 2014 | open water | 3 | SATE | 2 | 66.67 | 71.47 | 27.30 |
| 12 Jul 2014 | open water | 3 | BARS | 1 | 33.33 | 48.36 | 25.67 |
| 12 Jul 2014 | open water | 3 | BLTE | 1 | 33.33 | 206.93 | 77.82 |
| 12 Jul 2014 | open water | 3 | ROYT | 1 | 33.33 | 58.56 | 23.13 |
| 12 Jul 2014 | pump-in | 1 | CATE | 2 | 16.67 | 11.08 | 4.75 |
| 12 Jul 2014 | pump-in | 1 | UNTR | 2 | 16.67 | 9.62 | 3.86 |
| 12 Jul 2014 | pump-in | 1 | LAGU | 1 | 8.33 | 14.29 | 8.64 |
| 12 Jul 2014 | pump-in | 1 | PUGA | 1 | 8.33 | 8.33 | 8.33 |
| 12 Jul 2014 | pump-in | 1 | SATE | 1 | 8.33 | 13.27 | 5.30 |
| 13 Jul 2014 | pump-in | 3 | SATE | 4 | 33.33 | 16.36 | 6.20 |
| 13 Jul 2014 | pump-in | 3 | BLTE | 3 | 25.00 | 47.36 | 19.85 |
| 13 Jul 2014 | pump-in | 3 | BTGR | 1 | 8.33 | 12.38 | 4.97 |
| 13 Jul 2014 | pump-in | 3 | RWBL | 1 | 8.33 | 22.68 | 9.08 |
| 13 Jul 2014 | pump-in | 3 | YCNH | 1 | 8.33 | 6.52 | 3.48 |
| 21 Oct 2014 | crevasse | 1 | TRES | 24 | 200.00 | 85.03 | 40.81 |
| 21 Oct 2014 | crevasse | 1 | GADW | 2 | 16.67 | 19.19 | 13.43 |
| 21 Oct 2014 | crevasse | 1 | BARS | 1 | 8.33 | 14.07 | 8.61 |
| 21 Oct 2014 | crevasse | 1 | BEKI | 1 | 8.33 | 9.28 | 4.90 |
| 21 Oct 2014 | crevasse | 1 | RWBL | 1 | 8.33 | 28.83 | 14.76 |
| 22 Oct 2014 | marsh terrace | 1 | RWBL | 2 | 16.67 | 36.63 | 12.83 |
| 22 Oct 2014 | marsh terrace | 1 | SORA | 2 | 16.67 | 13.02 | 7.90 |
| 22 Oct 2014 | marsh terrace | 1 | MAWR | 1 | 8.33 | 9.85 | 4.97 |
| 22 Oct 2014 | marsh terrace | 1 | NOHA | 1 | 8.33 | 12.07 | 5.14 |
| 22 Oct 2014 | marsh terrace | 1 | UNRA | 1 | 8.33 | 9.52 | 6.06 |
| 22 Oct 2014 | marsh terrace | 1 | UNSP | 1 | 8.33 | 8.33 | 8.33 |
| 22 Oct 2014 | marsh terrace | 2 | RWBL | 10 | 83.33 | 35.04 | 11.81 |
| 22 Oct 2014 | marsh terrace | 2 | BEKI | 1 | 8.33 | 11.28 | 4.51 |
| 22 Oct 2014 | marsh terrace | 2 | COGA | 1 | 8.33 | 12.22 | 5.93 |
| 22 Oct 2014 | marsh terrace | 2 | MAWR | 1 | 8.33 | 9.42 | 4.80 |
| 22 Oct 2014 | marsh terrace | 2 | NOHA | 1 | 8.33 | 11.55 | 4.92 |
| 22 Oct 2014 | marsh terrace | 2 | SAVS | 1 | 8.33 | 8.33 | 8.33 |
| 22 Oct 2014 | marsh terrace | 2 | UNPA | 1 | 8.33 | 8.21 | 5.14 |
| 22 Oct 2014 | old edge | 1 | BTGR | 6 | 50.00 | 14.82 | 4.81 |
| 22 Oct 2014 | old edge | 1 | LBHE | 2 | 16.67 | 11.58 | 6.47 |
| 22 Oct 2014 | old edge | 1 | BCNH | 1 | 8.33 | 8.33 | 8.33 |
| 22 Oct 2014 | old edge | 1 | GBHE | 1 | 8.33 | 9.76 | 5.59 |
| 22 Oct 2014 | old edge | 1 | LEBI | 1 | 8.33 | 9.54 | 5.44 |
| 22 Oct 2014 | old edge | 1 | ROYT | 1 | 8.33 | 16.04 | 6.33 |
| 22 Oct 2014 | old edge | 1 | YCNH | 1 | 8.33 | 7.81 | 4.03 |
| 22 Oct 2014 | open water | 1 | no birds | 0 | 0 | 0 | 0 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 22 Oct 2014 | pump-in | 1 | TRES | 4 | 33.33 | 77.44 | 29.87 |
| 22 Oct 2014 | pump-in | 1 | CATE | 2 | 16.67 | 15.80 | 7.04 |
| 22 Oct 2014 | pump-in | 1 | GBTE | 1 | 8.33 | 10.77 | 5.46 |
| 22 Oct 2014 | pump-in | 1 | SATE | 1 | 8.33 | 18.93 | 7.95 |
| 22 Oct 2014 | pump-in | 1 | UNTR | 1 | 8.33 | 13.72 | 5.82 |
| 23 Oct 2014 | crevasse | 2 | FOTE | 12 | 100.00 | 21.93 | 7.14 |
| 23 Oct 2014 | crevasse | 2 | RWBL | 6 | 50.00 | 28.61 | 8.59 |
| 23 Oct 2014 | crevasse | 2 | MODU | 2 | 16.67 | 12.96 | 6.10 |
| 23 Oct 2014 | crevasse | 2 | BEKI | 1 | 8.33 | 9.21 | 3.12 |
| 23 Oct 2014 | crevasse | 2 | LBHE | 1 | 8.33 | 12.20 | 6.83 |
| 23 Oct 2014 | crevasse | 2 | PBGR | 1 | 8.33 | 11.34 | 5.65 |
| 23 Oct 2014 | crevasse | 2 | ROYT | 1 | 8.33 | 16.90 | 6.34 |
| 23 Oct 2014 | crevasse | 2 | SNEG | 1 | 8.33 | 13.03 | 5.82 |
| 23 Oct 2014 | crevasse | 2 | UNTR | 1 | 8.33 | 14.95 | 5.99 |
| 23 Oct 2014 | crevasse | 3 | FOTE | 2 | 16.67 | 20.69 | 7.38 |
| 23 Oct 2014 | crevasse | 3 | GBHE | 2 | 16.67 | 9.70 | 5.25 |
| 23 Oct 2014 | crevasse | 3 | MODU | 2 | 16.67 | 12.22 | 6.00 |
| 23 Oct 2014 | crevasse | 3 | WHIB | 2 | 16.67 | 42.05 | 33.79 |
| 23 Oct 2014 | crevasse | 3 | AWPE | 1 | 8.33 | 8.33 | 8.33 |
| 23 Oct 2014 | crevasse | 3 | BEKI | 1 | 8.33 | 8.69 | 3.19 |
| 23 Oct 2014 | crevasse | 3 | GBTE | 1 | 8.33 | 11.07 | 5.55 |
| 23 Oct 2014 | crevasse | 3 | RWBL | 1 | 8.33 | 26.99 | 9.00 |
| 23 Oct 2014 | old edge | 2 | WILL | 4 | 33.33 | 18.52 | 10.98 |
| 23 Oct 2014 | old edge | 2 | BEKI | 1 | 8.33 | 7.20 | 2.65 |
| 23 Oct 2014 | old edge | 2 | COGA | 1 | 8.33 | 7.80 | 3.59 |
| 23 Oct 2014 | old edge | 2 | LBHE | 1 | 8.33 | 9.54 | 5.30 |
| 23 Oct 2014 | old edge | 2 | SNEG | 1 | 8.33 | 10.19 | 4.87 |
| 23 Oct 2014 | old edge | 2 | TRHE | 1 | 8.33 | 8.55 | 4.78 |
| 23 Oct 2014 | open water | 2 | TRES | 6 | 200.00 | 380.69 | 147.14 |
| 23 Oct 2014 | open water | 2 | BLTE | 1 | 33.33 | 269.51 | 111.35 |
| 23 Oct 2014 | open water | 2 | ROYT | 1 | 33.33 | 76.27 | 30.11 |
| 23 Oct 2014 | open water | 2 | WILL | 1 | 33.33 | 106.85 | 66.58 |
| 24 Oct 2014 | old edge | 3 | ROYT | 4 | 33.33 | 22.62 | 8.89 |
| 24 Oct 2014 | old edge | 3 | BRPE | 1 | 8.33 | 7.36 | 4.11 |
| 24 Oct 2014 | open water | 3 | ROYT | 4 | 133.33 | 130.48 | 52.00 |
| 24 Oct 2014 | open water | 3 | BEKI | 2 | 66.67 | 71.10 | 31.50 |
| 24 Oct 2014 | open water | 3 | BRPE | 1 | 33.33 | 42.49 | 24.77 |
| 24 Oct 2014 | pump-in | 2 | RWBL | 5 | 41.67 | 39.24 | 14.86 |
| 24 Oct 2014 | pump-in | 2 | ROYT | 4 | 33.33 | 23.18 | 9.00 |
| 24 Oct 2014 | pump-in | 2 | BTGR | 1 | 8.33 | 21.42 | 8.44 |
| 24 Oct 2014 | pump-in | 2 | PBGR | 1 | 8.33 | 15.56 | 7.89 |
| 24 Oct 2014 | pump-in | 3 | TRES | 30 | 250.00 | 109.17 | 38.72 |
| 24 Oct 2014 | pump-in | 3 | BEKI | 1 | 8.33 | 11.92 | 4.74 |

(Table C.3 continued)

| Date | Habitat type | Site | Species | Count | Density (birds/ha) | μ (birds/ha) | SE |
|---|---|---|---|---|---|---|---|
| 24 Oct 2014 | pump-in | 3 | CLRAxKIRA | 1 | 8.33 | 7.56 | 4.87 |
| 24 Oct 2014 | pump-in | 3 | NOHA | 1 | 8.33 | 12.20 | 5.46 |
| 24 Oct 2014 | pump-in | 3 | PBGR | 1 | 8.33 | 14.68 | 7.44 |
| 24 Oct 2014 | pump-in | 3 | PEFA | 1 | 8.33 | 9.43 | 7.00 |
| 25 Oct 2014 | marsh terrace | 2 | RWBL | 7 | 58.33 | 31.09 | 10.23 |
| 25 Oct 2014 | marsh terrace | 2 | TRES | 4 | 33.33 | 91.68 | 33.33 |
| 25 Oct 2014 | marsh terrace | 2 | NOHA | 3 | 25.00 | 10.25 | 3.98 |
| 25 Oct 2014 | marsh terrace | 2 | PBGR | 2 | 16.67 | 12.33 | 6.06 |
| 25 Oct 2014 | marsh terrace | 2 | AMKE | 1 | 8.33 | 8.33 | 8.33 |
| 25 Oct 2014 | marsh terrace | 2 | BEKI | 1 | 8.33 | 10.01 | 3.89 |
| 25 Oct 2014 | marsh terrace | 2 | GBHE | 1 | 8.33 | 11.17 | 6.40 |
| 25 Oct 2014 | marsh terrace | 2 | MAWR | 1 | 8.33 | 8.36 | 4.15 |
| 25 Oct 2014 | marsh terrace | 2 | UNRA | 1 | 8.33 | 8.08 | 4.87 |
| 25 Oct 2014 | marsh terrace | 3 | TRES | 5 | 41.67 | 86.49 | 32.37 |
| 25 Oct 2014 | marsh terrace | 3 | RWBL | 2 | 16.67 | 29.33 | 10.39 |
| 25 Oct 2014 | marsh terrace | 3 | BARS | 1 | 8.33 | 14.31 | 7.50 |
| 25 Oct 2014 | marsh terrace | 3 | BTGR | 1 | 8.33 | 16.01 | 6.15 |
| 25 Oct 2014 | marsh terrace | 3 | MAWR | 1 | 8.33 | 7.89 | 3.92 |
| 25 Oct 2014 | marsh terrace | 3 | NOHA | 1 | 8.33 | 9.67 | 3.79 |
| 25 Oct 2014 | marsh terrace | 3 | PEFA | 1 | 8.33 | 7.47 | 5.45 |
| 25 Oct 2014 | marsh terrace | 3 | SORA | 1 | 8.33 | 10.42 | 6.53 |
| 25 Oct 2014 | marsh terrace | 3 | UNPA | 1 | 8.33 | 6.87 | 4.24 |
| 25 Oct 2014 | marsh terrace | 3 | UNRA | 1 | 8.33 | 7.62 | 4.52 |
| 25 Oct 2014 | marsh terrace | 3 | UNWR | 1 | 8.33 | 7.80 | 5.89 |

# APPENDIX D: SPECIES OF CONCERN DENSITY TABLES

Table D.1. The model-predicted mean density of Mottled Ducks using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 20.83 | 8.51 |
| Spring | crevasse | 6.94 | 2.84 |
| Summer | crevasse | 2.08 | 1.04 |
| Winter | crevasse | 0 | 0 |
| Fall | old edge | 0 | 0 |
| Spring | old edge | 0 | 0 |
| Summer | old edge | 0 | 0 |
| Winter | old edge | 0 | 0 |
| Fall | pump-in | 1.39 | 0.57 |
| Spring | pump-in | 4.17 | 2.95 |
| Summer | pump-in | 8.33 | 5.89 |
| Winter | pump-in | 0 | 0 |
| Fall | marsh terrace | 2.78 | 1.60 |
| Spring | marsh terrace | 5.56 | 3.21 |
| Summer | marsh terrace | 0 | 0 |
| Winter | marsh terrace | 2.78 | 1.60 |
| Fall | open water | 0 | 0 |
| Spring | open water | 0 | 0 |
| Summer | open water | 0 | 0 |
| Winter | open water | 0 | 0 |

Table D.2. The model-predicted mean density of Black Terns using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Year | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|---|
| Fall | 13 | crevasse | 0 | 0 |
| Fall | 14 | crevasse | 0 | 0 |
| Spring | 13 | crevasse | 0 | 0 |
| Spring | 14 | crevasse | 0 | 0 |
| Summer | 13 | crevasse | 158.01 | 76.49 |
| Summer | 14 | crevasse | 98.62 | 40.56 |
| Winter | 14 | crevasse | 0 | 0 |
| Fall | 14 | marsh terrace | 0 | 0 |
| Spring | 14 | marsh terrace | 0 | 0 |
| Summer | 14 | marsh terrace | 279.17 | 133.18 |
| Winter | 14 | marsh terrace | 0 | 0 |
| Fall | 13 | old edge | 0 | 0 |
| Fall | 14 | old edge | 0 | 0 |
| Spring | 13 | old edge | 0 | 0 |
| Spring | 14 | old edge | 0 | 0 |
| Summer | 13 | old edge | 15.07 | 6.13 |
| Summer | 14 | old edge | 9.41 | 4.07 |
| Winter | 14 | old edge | 0 | 0 |
| Fall | 13 | open water | 177.16 | 85.51 |
| Fall | 14 | open water | 110.57 | 65.24 |
| Spring | 13 | open water | 0 | 0 |
| Spring | 14 | open water | 0 | 0 |
| Summer | 13 | open water | 300.26 | 115.14 |
| Summer | 14 | open water | 187.40 | 76.29 |
| Winter | 14 | open water | 0 | 0 |
| Fall | 13 | pump-in | 0 | 0 |
| Fall | 14 | pump-in | 0 | 0 |
| Spring | 14 | pump-in | 0 | 0 |
| Summer | 14 | pump-in | 25.00 | 17.53 |
| Winter | 14 | pump-in | 0 | 0 |

## APPENDIX E: FORAGING GUILD DENSITY TABLES

Table E.1. The model-predicted mean density of Aerial Insectivores using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Year | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|---|
| Fall | 13 | crevasse | 0 | 0 |
| Fall | 14 | crevasse | 69.44 | 40.09 |
| Spring | 13 | crevasse | 261.11 | 150.75 |
| Spring | 14 | crevasse | 91.67 | 52.92 |
| Summer | 13 | crevasse | 2.78 | 1.60 |
| Summer | 14 | crevasse | 0 | 0 |
| Winter | 14 | crevasse | 41.67 | 41.67 |
| Fall | 13 | old edge | 0 | 0 |
| Spring | 13 | old edge | 183.33 | 105.85 |
| Spring | 14 | old edge | 54.17 | 38.30 |
| Summer | 13 | old edge | 2.78 | 1.60 |
| Summer | 14 | old edge | 0 | 0 |
| Winter | 14 | old edge | 41.67 | 41.67 |
| Fall | 13 | pump-in | 2.78 | 1.60 |
| Fall | 14 | pump-in | 94.44 | 54.53 |
| Spring | 14 | pump-in | 54.17 | 38.30 |
| Summer | 14 | pump-in | 12.50 | 8.84 |
| Winter | 14 | pump-in | 108.33 | 108.33 |
| Fall | 14 | marsh terrace | 27.78 | 16.04 |
| Spring | 14 | marsh terrace | 16.67 | 9.62 |
| Summer | 14 | marsh terrace | 12.50 | 8.84 |
| Winter | 14 | marsh terrace | 0 | 0 |
| Fall | 13 | open water | 0 | 0 |
| Fall | 14 | open water | 66.67 | 38.49 |
| Spring | 13 | open water | 100.00 | 57.74 |
| Spring | 14 | open water | 1000.00 | 707.11 |
| Summer | 13 | open water | 0 | 0 |
| Summer | 14 | open water | 16.67 | 11.79 |
| Winter | 14 | open water | 0 | 0 |

Table E.2. The model-predicted mean density of Carnivorous Hawkers and Plungers using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 1.47 | 0.36 |
| Spring | crevasse | 1.47 | 0.36 |
| Summer | crevasse | 1.47 | 0.36 |
| Winter | crevasse | 1.47 | 0.36 |
| Fall | old edge | 0 | 0 |
| Spring | old edge | 0 | 0 |
| Summer | old edge | 0 | 0 |
| Winter | old edge | 0 | 0 |
| Fall | pump-in | 2.27 | 0.69 |
| Spring | pump-in | 2.27 | 0.69 |
| Summer | pump-in | 2.27 | 0.69 |
| Winter | pump-in | 2.27 | 0.69 |
| Fall | marsh terrace | 7.58 | 2.28 |
| Spring | marsh terrace | 7.58 | 2.28 |
| Summer | marsh terrace | 7.58 | 2.28 |
| Winter | marsh terrace | 7.58 | 2.28 |
| Fall | open water | 0 | 0 |
| Spring | open water | 0 | 0 |
| Summer | open water | 0 | 0 |
| Winter | open water | 0 | 0 |

Table E.3. The model-predicted mean density of Dabblers and Grubbers using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Year | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|---|
| Fall | 13 | crevasse | 13.89 | 8.02 |
| Fall | 14 | crevasse | 16.67 | 9.62 |
| Spring | 13 | crevasse | 27.78 | 16.04 |
| Spring | 14 | crevasse | 16.67 | 9.62 |
| Summer | 13 | crevasse | 0 | 0 |
| Summer | 14 | crevasse | 0 | 0 |
| Winter | 14 | crevasse | 100 | 100 |
| Fall | 14 | marsh terrace | 0 | 0 |
| Spring | 14 | marsh terrace | 161.11 | 93.02 |
| Summer | 14 | marsh terrace | 0 | 0 |
| Winter | 14 | marsh terrace | 0 | 0 |
| Fall | 13 | old edge | 0 | 0 |
| Fall | 14 | old edge | 0 | 0 |
| Spring | 13 | old edge | 2.78 | 1.6 |
| Spring | 14 | old edge | 8.33 | 5.89 |
| Summer | 13 | old edge | 0 | 0 |
| Summer | 14 | old edge | 0 | 0 |
| Winter | 14 | old edge | 166.67 | 166.67 |
| Fall | 13 | open water | 0 | 0 |
| Fall | 14 | open water | 0 | 0 |
| Spring | 13 | open water | 0 | 0 |
| Spring | 14 | open water | 0 | 0 |
| Summer | 13 | open water | 0 | 0 |
| Summer | 14 | open water | 0 | 0 |
| Winter | 14 | open water | 2999.99 | 2999.98 |
| Fall | 13 | pump-in | 2.78 | 1.6 |
| Fall | 14 | pump-in | 0 | 0 |
| Spring | 14 | pump-in | 4.17 | 2.95 |
| Summer | 14 | pump-in | 0 | 0 |
| Winter | 14 | pump-in | 0 | 0 |

Table E.4. The model-predicted mean density of Marsh Foragers and Gleaners using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 34.72 | 14.18 |
| Spring | crevasse | 25.00 | 10.21 |
| Summer | crevasse | 93.75 | 46.88 |
| Winter | crevasse | 16.67 | 16.67 |
| Fall | old edge | 15.00 | 6.71 |
| Spring | old edge | 11.67 | 5.22 |
| Summer | old edge | 33.33 | 14.91 |
| Winter | old edge | 75.00 | 75.00 |
| Fall | pump-in | 37.50 | 15.31 |
| Spring | pump-in | 8.33 | 5.89 |
| Summer | pump-in | 29.17 | 20.62 |
| Winter | pump-in | 33.33 | 33.33 |
| Fall | marsh terrace | 105.56 | 60.94 |
| Spring | marsh terrace | 5.56 | 3.21 |
| Summer | marsh terrace | 25.00 | 17.68 |
| Winter | marsh terrace | 2.78 | 1.60 |
| Fall | open water | 0 | 0 |
| Spring | open water | 0 | 0 |
| Summer | open water | 0 | 0 |
| Winter | open water | 0 | 0 |

Table E.5. The model-predicted mean density of Mudflat Probers and Gleaners using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Habitat type | μ (birds/ha) | SE |
|---|---|---|
| Crevasse | 15.69 | 3.80 |
| Old edge | 2.08 | 0.52 |
| Pump-in | 0 | 0 |
| Marsh terrace | 0 | 0 |
| Open water | 2.22 | 0.57 |

Table E.6. The model-predicted mean density of Piscivore Plungers and Divers using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Year | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|---|
| Fall | 13 | crevasse | 36.11 | 20.85 |
| Fall | 14 | crevasse | 52.78 | 30.47 |
| Spring | 13 | crevasse | 2.78 | 1.60 |
| Spring | 14 | crevasse | 13.89 | 8.02 |
| Summer | 13 | crevasse | 72.22 | 41.70 |
| Summer | 14 | crevasse | 8.33 | 8.33 |
| Winter | 14 | crevasse | 16.67 | 16.67 |
| Fall | 14 | marsh terrace | 5.56 | 3.21 |
| Spring | 14 | marsh terrace | 5.56 | 3.21 |
| Summer | 14 | marsh terrace | 66.67 | 47.14 |
| Winter | 14 | marsh terrace | 2.78 | 1.60 |
| Fall | 13 | old edge | 16.67 | 11.79 |
| Fall | 14 | old edge | 19.44 | 11.23 |
| Spring | 13 | old edge | 2.78 | 1.60 |
| Spring | 14 | old edge | 8.33 | 5.89 |
| Summer | 13 | old edge | 66.67 | 38.49 |
| Summer | 14 | old edge | 50.00 | 35.36 |
| Winter | 14 | old edge | 0 | 0 |
| Fall | 13 | open water | 100.00 | 100.00 |
| Fall | 14 | open water | 88.89 | 51.32 |
| Spring | 13 | open water | 11.11 | 6.42 |
| Spring | 14 | open water | 0 | 0 |
| Summer | 13 | open water | 433.33 | 250.19 |
| Summer | 14 | open water | 50.00 | 35.36 |
| Winter | 14 | open water | 0 | 0 |
| Fall | 13 | pump-in | 13.89 | 8.02 |
| Fall | 14 | pump-in | 25.00 | 14.43 |
| Spring | 14 | pump-in | 41.67 | 29.46 |
| Summer | 14 | pump-in | 58.33 | 41.25 |
| Winter | 14 | pump-in | 0 | 0 |

Table E.7. The model-predicted mean density of Scavengers, Food Pirates, and Generalists using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Habitat type | μ (birds/ha) | SE |
|---|---|---|
| Crevasse | 1.47 | 0.36 |
| Marsh terrace | 3.03 | 0.91 |
| Old Edge | 2.08 | 0.52 |
| Open water | 0 | 0 |
| Pump-in | 4.55 | 1.37 |

Table E.8. The model-predicted mean density of Wading Ambusher using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 6.94 | 2.84 |
| Spring | crevasse | 12.50 | 5.10 |
| Summer | crevasse | 4.17 | 2.08 |
| Winter | crevasse | 0 | 0 |
| Fall | marsh terrace | 2.78 | 1.60 |
| Spring | marsh terrace | 0 | 0 |
| Summer | marsh terrace | 12.50 | 8.84 |
| Winter | marsh terrace | 2.78 | 1.60 |
| Fall | old edge | 15.00 | 6.71 |
| Spring | old edge | 0 | 0 |
| Summer | old edge | 8.33 | 3.73 |
| Winter | old edge | 0 | 0 |
| Fall | open water | 0 | 0 |
| Spring | open water | 0 | 0 |
| Summer | open water | 0 | 0 |
| Winter | open water | 0 | 0 |
| Fall | pump-in | 4.17 | 1.70 |
| Spring | pump-in | 0 | 0 |
| Summer | pump-in | 4.17 | 2.95 |
| Winter | pump-in | 0 | 0 |

Table E.9. The model-predicted mean density of Water Bottom Foragers and Divers using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Habitat type | μ (birds/ha) | SE |
|---|---|---|
| Crevasse | 1.47 | 0.36 |
| Marsh terrace | 3.03 | 0.91 |
| Old edge | 2.60 | 0.65 |
| Open water | 0 | 0 |
| Pump-in | 1.52 | 0.46 |

Table E.10. The model-predicted mean density of Water Surface Gleaners using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 4.17 | 1.70 |
| Spring | crevasse | 0 | 0 |
| Summer | crevasse | 89.58 | 44.79 |
| Winter | crevasse | 0 | 0 |
| Fall | marsh terrace | 0 | 0 |
| Spring | marsh terrace | 0 | 0 |
| Summer | marsh terrace | 308.33 | 218.03 |
| Winter | marsh terrace | 0 | 0 |
| Fall | old edge | 0 | 0 |
| Spring | old edge | 0 | 0 |
| Summer | old edge | 13.33 | 5.96 |
| Winter | old edge | 0 | 0 |
| Fall | open water | 83.33 | 41.67 |
| Spring | open water | 0 | 0 |
| Summer | open water | 220.00 | 98.39 |
| Winter | open water | 0 | 0 |
| Fall | pump-in | 1.39 | 0.57 |
| Spring | pump-in | 0 | 0 |
| Summer | pump-in | 12.50 | 8.84 |
| Winter | pump-in | 0 | 0 |

Table E.11. The model-predicted mean density of waterfowl using marsh study plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Season | Habitat type | μ (birds/ha) | SE |
|---|---|---|---|
| Fall | crevasse | 41.67 | 17.01 |
| Spring | crevasse | 47.22 | 19.28 |
| Summer | crevasse | 8.33 | 4.17 |
| Winter | crevasse | 350 | 350 |
| Fall | marsh terrace | 111.11 | 64.15 |
| Spring | marsh terrace | 188.89 | 109.06 |
| Summer | marsh terrace | 4.17 | 2.95 |
| Winter | marsh terrace | 141.67 | 81.79 |
| Fall | old edge | 0 | 0 |
| Spring | old edge | 30 | 13.42 |
| Summer | old edge | 0 | 0 |
| Winter | old edge | 191.67 | 191.67 |
| Fall | open water | 0 | 0 |
| Spring | open water | 33.33 | 14.91 |
| Summer | open water | 0 | 0 |
| Winter | open water | 2999.99 | 2999.99 |
| Fall | pump-in | 26.39 | 10.77 |
| Spring | pump-in | 8.33 | 5.89 |
| Summer | pump-in | 8.33 | 5.89 |
| Winter | pump-in | 0 | 0 |

## APPENDIX F: BIRD ABUNDANCE BY PLOT ZONE TABLES

Table F.1. Model predicted means and standard deviations of bird abundance by plot zone in crevasse splay plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 7 | 8.50 | 1.88 |
| 13 | fall | 2 | 1 | 6 | 8.50 | 1.88 |
| 13 | fall | 3 | 1 | 13 | 8.50 | 1.88 |
| 14 | fall | 1 | 1 | 10 | 8.50 | 1.88 |
| 14 | fall | 2 | 1 | 10 | 8.50 | 1.88 |
| 14 | fall | 3 | 1 | 5 | 8.50 | 1.88 |
| 13 | fall | 2 | 123 | 1 | 1.00 | 0.38 |
| 14 | fall | 1 | 123 | 1 | 1.00 | 0.38 |
| 13 | fall | 1 | 1234 | 2 | 7.75 | 2.10 |
| 13 | fall | 3 | 1234 | 1 | 7.75 | 2.10 |
| 14 | fall | 1 | 1234 | 17 | 7.75 | 2.10 |
| 14 | fall | 2 | 1234 | 11 | 7.75 | 2.10 |
| 14 | fall | 2 | 2 | 2 | 2.00 | 1.09 |
| 14 | fall | 2 | 23 | 1 | 2.00 | 0.77 |
| 14 | fall | 3 | 23 | 3 | 2.00 | 0.77 |
| 13 | fall | 3 | 234 | 8 | 4.50 | 1.73 |
| 14 | fall | 3 | 234 | 1 | 4.50 | 1.73 |
| 13 | fall | 1 | 3 | 1 | 1.50 | 0.58 |
| 14 | fall | 3 | 3 | 2 | 1.50 | 0.58 |
| 14 | fall | 1 | 4 | 1 | 1.33 | 0.42 |
| 14 | fall | 2 | 4 | 2 | 1.33 | 0.42 |
| 14 | fall | 3 | 4 | 1 | 1.33 | 0.42 |
| 13 | spring | 1 | 1 | 21 | 13.67 | 3.03 |
| 13 | spring | 2 | 1 | 10 | 13.67 | 3.03 |
| 13 | spring | 3 | 1 | 31 | 13.67 | 3.03 |
| 14 | spring | 1 | 1 | 11 | 13.67 | 3.03 |
| 14 | spring | 2 | 1 | 1 | 13.67 | 3.03 |
| 14 | spring | 3 | 1 | 8 | 13.67 | 3.03 |
| 13 | spring | 1 | 12 | 2 | 2.50 | 0.68 |
| 13 | spring | 2 | 12 | 2 | 2.50 | 0.68 |
| 14 | spring | 1 | 12 | 5 | 2.50 | 0.68 |
| 14 | spring | 2 | 12 | 1 | 2.50 | 0.68 |
| 14 | spring | 1 | 123 | 7 | 4.00 | 1.54 |
| 14 | spring | 2 | 123 | 1 | 4.00 | 1.54 |
| 13 | spring | 1 | 1234 | 7 | 6.83 | 1.51 |
| 13 | spring | 2 | 1234 | 5 | 6.83 | 1.51 |
| 13 | spring | 3 | 1234 | 7 | 6.83 | 1.51 |
| 14 | spring | 1 | 1234 | 14 | 6.83 | 1.51 |
| 14 | spring | 2 | 1234 | 1 | 6.83 | 1.51 |
| 14 | spring | 3 | 1234 | 7 | 6.83 | 1.51 |

(Table F.1 continued)

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | spring | 1 | 2 | 10 | 5.67 | 1.78 |
| 13 | spring | 2 | 2 | 3 | 5.67 | 1.78 |
| 13 | spring | 3 | 2 | 4 | 5.67 | 1.78 |
| 14 | spring | 1 | 23 | 1 | 1.00 | 0.38 |
| 14 | spring | 3 | 23 | 1 | 1.00 | 0.38 |
| 13 | spring | 1 | 234 | 13 | 13.00 | 7.06 |
| 13 | spring | 1 | 34 | 4 | 3.25 | 0.88 |
| 13 | spring | 2 | 34 | 3 | 3.25 | 0.88 |
| 13 | spring | 3 | 34 | 5 | 3.25 | 0.88 |
| 14 | spring | 3 | 34 | 1 | 3.25 | 0.88 |
| 14 | spring | 3 | 4 | 1 | 1.00 | 0.54 |
| 13 | summer | 1 | 1 | 13 | 13.75 | 3.73 |
| 13 | summer | 2 | 1 | 4 | 13.75 | 3.73 |
| 13 | summer | 3 | 1 | 15 | 13.75 | 3.73 |
| 14 | summer | 3 | 1 | 23 | 13.75 | 3.73 |
| 13 | summer | 3 | 12 | 3 | 2.00 | 0.77 |
| 14 | summer | 3 | 12 | 1 | 2.00 | 0.77 |
| 14 | summer | 3 | 123 | 2 | 2.00 | 1.09 |
| 13 | summer | 1 | 1234 | 1 | 5.25 | 1.43 |
| 13 | summer | 2 | 1234 | 4 | 5.25 | 1.43 |
| 13 | summer | 3 | 1234 | 6 | 5.25 | 1.43 |
| 14 | summer | 3 | 1234 | 10 | 5.25 | 1.43 |
| 13 | summer | 1 | 2 | 3 | 2.75 | 0.75 |
| 13 | summer | 2 | 2 | 1 | 2.75 | 0.75 |
| 13 | summer | 3 | 2 | 5 | 2.75 | 0.75 |
| 14 | summer | 3 | 2 | 2 | 2.75 | 0.75 |
| 13 | summer | 1 | 234 | 4 | 3.50 | 0.95 |
| 13 | summer | 2 | 234 | 1 | 3.50 | 0.95 |
| 13 | summer | 3 | 234 | 6 | 3.50 | 0.95 |
| 14 | summer | 3 | 234 | 3 | 3.50 | 0.95 |
| 14 | summer | 3 | 3 | 3 | 3.00 | 1.63 |
| 13 | summer | 1 | 34 | 2 | 3.00 | 0.94 |
| 13 | summer | 3 | 34 | 3 | 3.00 | 0.94 |
| 14 | summer | 3 | 34 | 4 | 3.00 | 0.94 |
| 13 | summer | 1 | 4 | 1 | 4.25 | 1.15 |
| 13 | summer | 2 | 4 | 2 | 4.25 | 1.15 |
| 13 | summer | 3 | 4 | 8 | 4.25 | 1.15 |
| 14 | summer | 3 | 4 | 6 | 4.25 | 1.15 |
| 14 | winter | 1 | 1 | 4 | 4.00 | 2.17 |
| 14 | winter | 1 | 1234 | 1 | 1.00 | 0.54 |
| 14 | winter | 1 | 2 | 1 | 1.00 | 0.54 |
| 14 | winter | 1 | 34 | 7 | 7.00 | 3.80 |
| 14 | winter | 1 | 4 | 2 | 2.00 | 1.09 |

Table F.2. Model predicted means and standard deviations of bird abundance by plot zone in marsh terrace plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 14 | fall | 2 | 1 | 5 | 9.00 | 3.46 |
| 14 | fall | 3 | 1 | 13 | 9.00 | 3.46 |
| 14 | fall | 1 | 12 | 1 | 1.00 | 0.38 |
| 14 | fall | 2 | 12 | 1 | 1.00 | 0.38 |
| 14 | fall | 2 | 123 | 1 | 1.00 | 0.54 |
| 14 | fall | 2 | 1234 | 8 | 5.00 | 1.92 |
| 14 | fall | 3 | 1234 | 2 | 5.00 | 1.92 |
| 14 | fall | 1 | 2 | 1 | 2.00 | 0.77 |
| 14 | fall | 2 | 2 | 3 | 2.00 | 0.77 |
| 14 | fall | 1 | 23 | 1 | 1.00 | 0.54 |
| 14 | fall | 3 | 234 | 1 | 1.00 | 0.54 |
| 14 | fall | 1 | 3 | 1 | 1.50 | 0.58 |
| 14 | fall | 2 | 3 | 2 | 1.50 | 0.58 |
| 14 | fall | 2 | 34 | 1 | 1.00 | 0.54 |
| 14 | fall | 1 | 4 | 4 | 10.00 | 3.84 |
| 14 | fall | 2 | 4 | 16 | 10.00 | 3.84 |
| 14 | spring | 2 | 1 | 21 | 11.00 | 4.22 |
| 14 | spring | 3 | 1 | 1 | 11.00 | 4.22 |
| 14 | spring | 2 | 12 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 1234 | 3 | 4.00 | 1.54 |
| 14 | spring | 2 | 1234 | 5 | 4.00 | 1.54 |
| 14 | spring | 2 | 2 | 5 | 5.00 | 2.71 |
| 14 | spring | 2 | 234 | 33 | 33.00 | 17.92 |
| 14 | spring | 3 | 34 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 4 | 1 | 1.50 | 0.58 |
| 14 | spring | 3 | 4 | 2 | 1.50 | 0.58 |
| 14 | summer | 2 | 1 | 11 | 11.00 | 4.22 |
| 14 | summer | 3 | 1 | 11 | 11.00 | 4.22 |
| 14 | summer | 2 | 12 | 1 | 3.00 | 1.15 |
| 14 | summer | 3 | 12 | 5 | 3.00 | 1.15 |
| 14 | summer | 2 | 123 | 1 | 2.00 | 0.77 |
| 14 | summer | 3 | 123 | 3 | 2.00 | 0.77 |
| 14 | summer | 2 | 1234 | 5 | 7.50 | 2.88 |
| 14 | summer | 3 | 1234 | 10 | 7.50 | 2.88 |
| 14 | summer | 2 | 2 | 2 | 4.00 | 1.54 |
| 14 | summer | 3 | 2 | 6 | 4.00 | 1.54 |
| 14 | summer | 2 | 3 | 3 | 6.00 | 2.30 |
| 14 | summer | 3 | 3 | 9 | 6.00 | 2.30 |
| 14 | summer | 2 | 34 | 1 | 7.50 | 2.88 |
| 14 | summer | 3 | 34 | 14 | 7.50 | 2.88 |
| 14 | summer | 2 | 4 | 5 | 10.00 | 3.84 |
| 14 | summer | 3 | 4 | 15 | 10.00 | 3.84 |

(Table F.2 continued)

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 14 | winter | 1 | 1 | 1 | 1.33 | 0.42 |
| 14 | winter | 2 | 1 | 2 | 1.33 | 0.42 |
| 14 | winter | 3 | 1 | 1 | 1.33 | 0.42 |
| 14 | winter | 2 | 23 | 1 | 1.00 | 0.54 |

Table F.3. Model predicted means and standard deviations of bird abundance by plot zone in beneficial use of dredged material plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 10 | 6.67 | 1.48 |
| 13 | fall | 2 | 1 | 3 | 6.67 | 1.48 |
| 13 | fall | 3 | 1 | 15 | 6.67 | 1.48 |
| 14 | fall | 1 | 1 | 5 | 6.67 | 1.48 |
| 14 | fall | 2 | 1 | 6 | 6.67 | 1.48 |
| 14 | fall | 3 | 1 | 1 | 6.67 | 1.48 |
| 13 | fall | 2 | 1234 | 1 | 9.50 | 2.58 |
| 14 | fall | 1 | 1234 | 3 | 9.50 | 2.58 |
| 14 | fall | 2 | 1234 | 2 | 9.50 | 2.58 |
| 14 | fall | 3 | 1234 | 32 | 9.50 | 2.58 |
| 14 | fall | 2 | 2 | 2 | 2.00 | 1.09 |
| 13 | fall | 2 | 234 | 1 | 1.00 | 0.31 |
| 13 | fall | 3 | 234 | 1 | 1.00 | 0.31 |
| 14 | fall | 2 | 234 | 1 | 1.00 | 0.31 |
| 14 | fall | 3 | 34 | 1 | 1.00 | 0.54 |
| 14 | fall | 1 | 4 | 1 | 1.00 | 0.38 |
| 14 | fall | 3 | 4 | 1 | 1.00 | 0.38 |
| 14 | spring | 1 | 1 | 3 | 3.50 | 1.34 |
| 14 | spring | 2 | 1 | 4 | 3.50 | 1.34 |
| 14 | spring | 2 | 12 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 123 | 2 | 2.00 | 1.09 |
| 14 | spring | 1 | 1234 | 8 | 4.50 | 1.73 |
| 14 | spring | 2 | 1234 | 1 | 4.50 | 1.73 |
| 14 | spring | 1 | 2 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 23 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 234 | 1 | 1.00 | 0.38 |
| 14 | spring | 2 | 234 | 1 | 1.00 | 0.38 |
| 14 | spring | 1 | 34 | 1 | 1.00 | 0.54 |
| 14 | spring | 1 | 4 | 1 | 1.00 | 0.38 |
| 14 | spring | 2 | 4 | 1 | 1.00 | 0.38 |
| 14 | summer | 1 | 1 | 4 | 8.00 | 3.07 |
| 14 | summer | 3 | 1 | 12 | 8.00 | 3.07 |
| 14 | summer | 1 | 12 | 1 | 1.00 | 0.38 |
| 14 | summer | 3 | 12 | 1 | 1.00 | 0.38 |
| 14 | summer | 1 | 1234 | 1 | 2.50 | 0.96 |
| 14 | summer | 3 | 1234 | 4 | 2.50 | 0.96 |
| 14 | summer | 1 | 2 | 1 | 1.00 | 0.38 |
| 14 | summer | 3 | 2 | 1 | 1.00 | 0.38 |
| 14 | summer | 3 | 23 | 1 | 1.00 | 0.54 |
| 14 | summer | 3 | 34 | 1 | 1.00 | 0.54 |
| 14 | summer | 3 | 4 | 2 | 2.00 | 1.09 |
| 14 | winter | 3 | 1 | 5 | 5.00 | 2.71 |

(Table F.3 continued)

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 14 | winter | 3 | 12 | 2 | 2.00 | 1.09 |
| 14 | winter | 3 | 123 | 1 | 1.00 | 0.54 |
| 14 | winter | 3 | 1234 | 12 | 12.00 | 6.52 |
| 14 | winter | 3 | 34 | 2 | 2.00 | 1.09 |

Table F.4. Model predicted means and standard deviations of bird abundance by plot zone in old edge plots in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 13 | fall | 1 | 1 | 2 | 5.67 | 1.78 |
| 14 | fall | 1 | 1 | 7 | 5.67 | 1.78 |
| 14 | fall | 2 | 1 | 8 | 5.67 | 1.78 |
| 14 | fall | 1 | 12 | 1 | 1.00 | 0.54 |
| 14 | fall | 1 | 123 | 2 | 2.00 | 1.09 |
| 14 | fall | 2 | 1234 | 1 | 1.50 | 0.58 |
| 14 | fall | 3 | 1234 | 2 | 1.50 | 0.58 |
| 14 | fall | 1 | 2 | 1 | 1.00 | 0.54 |
| 14 | fall | 1 | 23 | 1 | 1.00 | 0.54 |
| 13 | fall | 1 | 234 | 3 | 3.00 | 1.63 |
| 14 | fall | 3 | 34 | 3 | 3.00 | 1.63 |
| 13 | fall | 1 | 4 | 1 | 1.00 | 0.38 |
| 14 | fall | 1 | 4 | 1 | 1.00 | 0.38 |
| 13 | spring | 1 | 1 | 6 | 8.25 | 2.24 |
| 13 | spring | 2 | 1 | 9 | 8.25 | 2.24 |
| 14 | spring | 2 | 1 | 3 | 8.25 | 2.24 |
| 13 | spring | 3 | 1 | 15 | 8.25 | 2.24 |
| 13 | spring | 3 | 12 | 1 | 1.00 | 0.38 |
| 14 | spring | 3 | 12 | 1 | 1.00 | 0.38 |
| 13 | spring | 1 | 1234 | 16 | 9.20 | 2.23 |
| 13 | spring | 2 | 1234 | 2 | 9.20 | 2.23 |
| 14 | spring | 2 | 1234 | 14 | 9.20 | 2.23 |
| 13 | spring | 3 | 1234 | 9 | 9.20 | 2.23 |
| 14 | spring | 3 | 1234 | 5 | 9.20 | 2.23 |
| 13 | spring | 3 | 2 | 12 | 12.00 | 6.52 |
| 13 | spring | 1 | 34 | 1 | 2.00 | 0.63 |
| 13 | spring | 2 | 34 | 1 | 2.00 | 0.63 |
| 13 | spring | 3 | 34 | 4 | 2.00 | 0.63 |
| 14 | spring | 2 | 4 | 2 | 2.00 | 1.09 |
| 13 | summer | 1 | 1 | 6 | 6.60 | 1.60 |
| 14 | summer | 1 | 1 | 4 | 6.60 | 1.60 |
| 13 | summer | 2 | 1 | 13 | 6.60 | 1.60 |
| 13 | summer | 3 | 1 | 2 | 6.60 | 1.60 |
| 14 | summer | 3 | 1 | 8 | 6.60 | 1.60 |
| 13 | summer | 1 | 1234 | 4 | 5.00 | 1.21 |
| 14 | summer | 1 | 1234 | 3 | 5.00 | 1.21 |
| 13 | summer | 2 | 1234 | 11 | 5.00 | 1.21 |
| 13 | summer | 3 | 1234 | 4 | 5.00 | 1.21 |
| 14 | summer | 3 | 1234 | 3 | 5.00 | 1.21 |
| 13 | summer | 2 | 2 | 1 | 1.00 | 0.54 |
| 14 | summer | 3 | 23 | 1 | 1.00 | 0.54 |
| 14 | summer | 1 | 234 | 1 | 1.00 | 0.54 |

(Table F.4 continued)

| Year | Season | Site | Plot zone | Individual birds (n) | μ | SE |
|---|---|---|---|---|---|---|
| 14 | summer | 1 | 34 | 1 | 1.00 | 0.54 |
| 13 | summer | 1 | 4 | 1 | 2.67 | 0.84 |
| 14 | summer | 1 | 4 | 1 | 2.67 | 0.84 |
| 13 | summer | 2 | 4 | 6 | 2.67 | 0.84 |
| 14 | winter | 1 | 1 | 17 | 17.00 | 9.23 |
| 14 | winter | 1 | 12 | 1 | 1.00 | 0.54 |
| 14 | winter | 1 | 123 | 3 | 3.00 | 1.63 |
| 14 | winter | 1 | 1234 | 2 | 2.00 | 1.09 |
| 14 | winter | 1 | 2 | 2 | 2.00 | 1.09 |
| 14 | winter | 1 | 23 | 6 | 6.00 | 3.26 |
| 14 | winter | 1 | 34 | 1 | 1.00 | 0.54 |
| 14 | winter | 1 | 4 | 2 | 2.00 | 1.09 |

## APPENDIX G: SAMPLE SAS CODE

The following is an example of the PROC GLIMMIX (SAS version 9.4, SAS, Inc., Cary, NC) procedure used to model species richness. Habitat type is represented by the variable "category."

```
data one;
infile 'L:\Lauren Sullivan Birds Foot Delta
Waterfowl\SAS\BirdData_SAS_abundance_by_site_visit_12_10_14.csv' DSD missover FIRSTOBS=2;
input day month year season $ category $ site $ species guild maxno starttime $ timelength timeofday;
run;
proc sort; by season year category site; run;
proc glimmix data = one method = laplace ic=q;
Title1 'proc glimmix main effects model - species richness';
class season year category site;
model species = season category season*category  / solution link=log dist=poisson;
lsmeans season*category/pdiff lines;
output out=speciesrichness pred(noblup ilink)=pred
stderr(noblup ilink)=stderr;
run;
ods tagsets.excelxp close;
proc gplot data = speciesrichness;
plot pred*category;
run;
```

## APPENDIX H: STUDY PLOT PROFILES

### H. 1 Crevasse 1

Location: 29° 7'54.96"N, 89°13'30.48"W

Figure H.1.1. The general area of study plot Crevasse 1. Photo taken August 18, 2014.

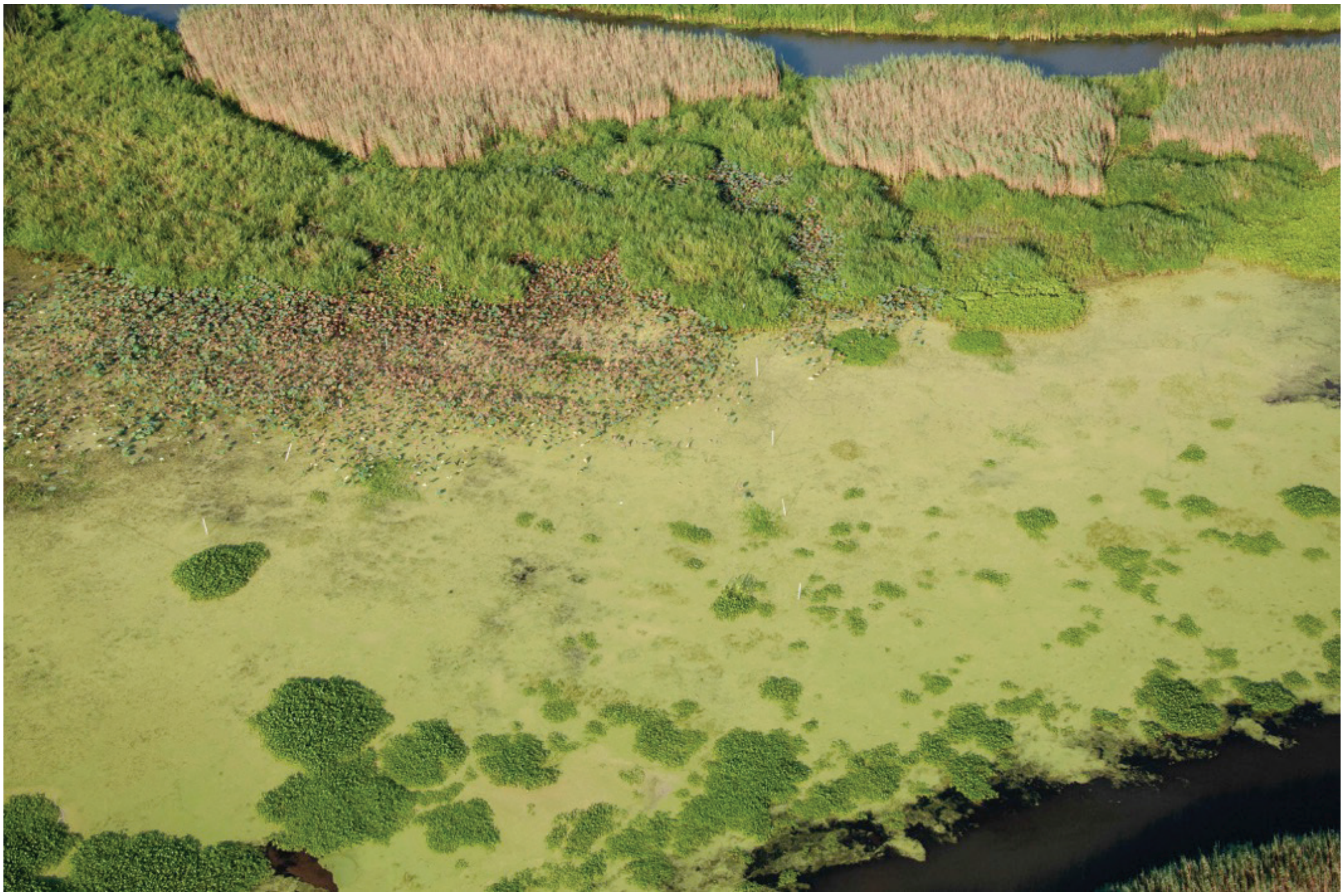

Figure H.1.2. Aerial view of plot Crevasse 1. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.1.1. Water and environmental conditions at study plot Crevasse 1in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 30 Mar 2013 | 16:21 | 20.7 | 9.7 | 180.0 | 18.2 | 0.2 | 7.00 | 326.8 | 21.6 | 33.0 | 47.0 | | 48.3 | 37.5 |
| 01 Apr 2013 | 9:40 | 24.3 | 10.5 | 0.0 | 21.1 | 0.2 | 7.15 | 243.7 | 43.2 | 48.3 | 63.5 | | 66.0 | 55.2 |
| 06 Aug 2013 | 11:10 | 35.4 | 12.7 | 315.0 | 34.0 | 0.2 | 7.54 | 573.0 | 20.0 | 41.0 | 57.0 | | 60.0 | 44.5 |
| 12 Oct 2013 | 13:55 | 25.7 | 5.6 | 202.5 | 31.2 | 2.0 | 6.67 | 3783.0 | 4.0 | 19.0 | 23.0 | 32.0 | 29.0 | 21.4 |
| 08 Feb 2014 | 14:36 | 17.6 | 8.0 | 90.0 | 11.3 | 0.3 | 7.99 | 632.0 | 14.0 | 31.1 | 45.1 | 41.3 | 57.2 | 37.7 |
| 12 Apr 2014 | 7:53 | 22.3 | 10.0 | 180.0 | 20.1 | 0.2 | 8.03 | 380.0 | 0.0 | 38.1 | 50.8 | 50.8 | 53.3 | 38.6 |
| 21 Oct 2014 | 14:40 | 22.6 | 6.4 | 40.0 | 24.2 | 0.7 | | 1324.0 | 25.0 | 46.0 | 57.0 | 58.0 | 63.0 | 49.8 |

Table H.1.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Crevasse 1in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 12 Oct 2013 | 8.25 | 57.50 | 26.50 | 7.75 | 0 | 5 | 1 | 4 |
| 08 Feb 2014 | 2.50 | 0 | 2.50 | 0 | 95.00 | 1 | 0 | 2 |
| 12 Apr 2014 | 1.25 | 11.25 | 0 | 0 | 87.50 | 2 | 4 | 0 |
| 21 Oct 2014 | 13.75 | 31.25 | 28.75 | 0 | 26.25 | 5 | 8 | 5 |

Table H.1.3. Vegetation species composition at study plot Crevasse 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation type | Species | Percent |
|---|---|---|---|---|
| 12 Oct 2013 | 1 | emergent | *Alternanthera philoxeroides* | 5 |
| | 1 | emergent | *Ludwigia sp.* | 5 |
| | 1 | emergent | *Nelumbo lutea* | 20 |
| | 1 | emergent | *Sagittaria lancifolia* | 60 |
| | 1 | emergent | *Zizaniopsis miliacea* | 10 |
| | 2 | emergent | *Alternanthera philoxeroides* | 60 |
| | 2 | emergent | *Nelumbo lutea* | 40 |
| | 3 | emergent | *Alternanthera philoxeroides* | 100 |
| | 4 | emergent | *Alternanthera philoxeroides* | 50 |
| | 4 | emergent | *Sagittaria lancifolia* | 50 |
| | 1 | floating | *Eichhornia crassipes* | 20 |
| | 1 | floating | *Lemna minor* | 60 |
| | 1 | floating | *Potamogeton nodosus* | 10 |
| | 1 | floating | *Salvinia minima* | 10 |
| | 2 | floating | *Eichhornia crassipes* | 10 |
| | 2 | floating | *Lemna minor* | 50 |
| | 2 | floating | *Nymphoides peltata* | 5 |
| | 2 | floating | *Potamogeton nodosus* | 25 |
| | 2 | floating | *Salvinia minima* | 10 |
| | 3 | floating | *Lemna minor* | 40 |
| | 3 | floating | *Nymphoides peltata* | 5 |
| | 3 | floating | *Potamogeton nodosus* | 40 |
| | 3 | floating | *Salvinia minima* | 15 |
| | 4 | floating | *Lemna minor* | 60 |
| | 4 | floating | *Nymphoides peltata* | 5 |
| | 4 | floating | *Potamogeton nodosus* | 25 |
| | 4 | floating | *Salvinia minima* | 10 |
| 08 Feb 2014 | 1 | emergent | *Zizaniopsis miliacea* | 100 |
| | 2 | emergent | *Zizaniopsis miliacea* | 100 |
| | 1 | floating | *Alternanthera philoxeroides*[a] | 50 |
| | 1 | floating | *Eichhornia crassipes* | 50 |
| | 2 | floating | *Alternanthera philoxeroides* | 50 |
| | 2 | floating | *Eichhornia crassipes* | 50 |
| 12 Apr 2014 | 1 | emergent | *Nelumbo lutea* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 95 |
| | 1 | SAV | *Myriophyllum spicatum* | 20 |
| | 1 | SAV | *Potamogeton crispus* | 40 |
| | 1 | SAV | *Ruppia maritima* | 40 |
| | 2 | SAV | *Ceratophyllum demersum* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 10 |

(Table H.1.3. continued)

| Date | Zone | Vegetation type | Species | Percent |
|---|---|---|---|---|
| 12 Apr 2014 | 2 | SAV | *Potamogeton crispus* | 20 |
| | 2 | SAV | *Ruppia maritima* | 60 |
| | 3 | SAV | *Ceratophyllum demersum* | 10 |
| | 3 | SAV | *Myriophyllum spicatum* | 40 |
| | 3 | SAV | *Ruppia maritima* | 50 |
| | 4 | SAV | *Potamogeton crispus* | 50 |
| | 4 | SAV | *Ruppia maritima* | 50 |
| | | | | |
| 21 Oct 2014 | 1 | emergent | *Alternanthera philoxeroides* | 10 |
| | 1 | emergent | *Ludwigia peploides* | 15 |
| | 1 | emergent | *Nelumbo lutea* | 5 |
| | 1 | emergent | *Sagittaria lancifolia* | 50 |
| | 1 | emergent | *Zizaniopsis miliacea* | 20 |
| | 2 | emergent | *Alternanthera philoxeroides* | 30 |
| | 2 | emergent | *Ludwigia peploides* | 70 |
| | 3 | emergent | *Alternanthera philoxeroides* | 50 |
| | 3 | emergent | *Ludwigia peploides* | 50 |
| | 4 | emergent | *Alternanthera philoxeroides* | 50 |
| | 4 | emergent | *Ludwigia peploides* | 45 |
| | 4 | emergent | *Sagittaria lancifolia* | 5 |
| | 1 | floating | *Eichhornia crassipes* | 45 |
| | 1 | floating | *Lemna minor* | 50 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 2 | floating | *Eichhornia crassipes* | 50 |
| | 2 | floating | *Lemna minor* | 50 |
| | 3 | floating | *Eichhornia crassipes* | 40 |
| | 3 | floating | *Lemna minor* | 50 |
| | 3 | floating | *Limnobium spongia* | 10 |
| | 4 | floating | *Eichhornia crassipes* | 30 |
| | 4 | floating | *Lemna minor* | 40 |
| | 4 | floating | *Limnobium spongia* | 10 |
| | 4 | floating | *Nymphoides peltata* | 5 |
| | 4 | floating | *Salvinia minima* | 10 |
| | 1 | SAV | *Ceratophyllum demersum* | 60 |
| | 1 | SAV | *Najas guadalupensis* | 15 |
| | 1 | SAV | *Potamogeton nodosus* | 10 |
| | 1 | SAV | *Potamogeton pusillus* | 15 |
| | 2 | SAV | *Ceratophyllum demersum* | 70 |
| | 2 | SAV | *Myriophyllum spicatum* | 10 |
| | 2 | SAV | *Potamogeton crispus* | 5 |
| | 2 | SAV | *Potamogeton nodosus* | 10 |
| | 2 | SAV | *Stuckenia pectinata* | 5 |
| | 3 | SAV | *Ceratophyllum demersum* | 60 |

(Table H.1.3. continued)

| Date | Zone | Vegetation type | Species | Percent |
|---|---|---|---|---|
| 21 Oct 2014 | 3 | SAV | *Heteranthera dubia* | 20 |
| | 3 | SAV | *Potamogeton nodosus* | 20 |
| | 4 | SAV | *Ceratophyllum demersum* | 30 |
| | 4 | SAV | *Heteranthera dubia* | 30 |
| | 4 | SAV | *Potamogeton crispus* | 5 |
| | 4 | SAV | *Potamogeton nodosus* | 30 |
| | 4 | SAV | *Potamogeton pusillus* | 5 |

[a]*Alternanthera philoxeroides,* a rooted-plant with floating stems and leaves, was classified as an emergent plants for most surveys, but as a floating plant in some surveys by assisting field researchers.

[b]*Potamogeton nodosus,* a submerged aquatic plant with floating and submerged leaves, was classified as a floating plant for some early surveys, but later classified as a SAV species.

**H.2 Crevasse 2**

Location: 29° 4'44.19"N, 89°14'4.50"W

Figure H.2.1. The general area of study plot Crevasse 2. Photo taken August 18, 2014.

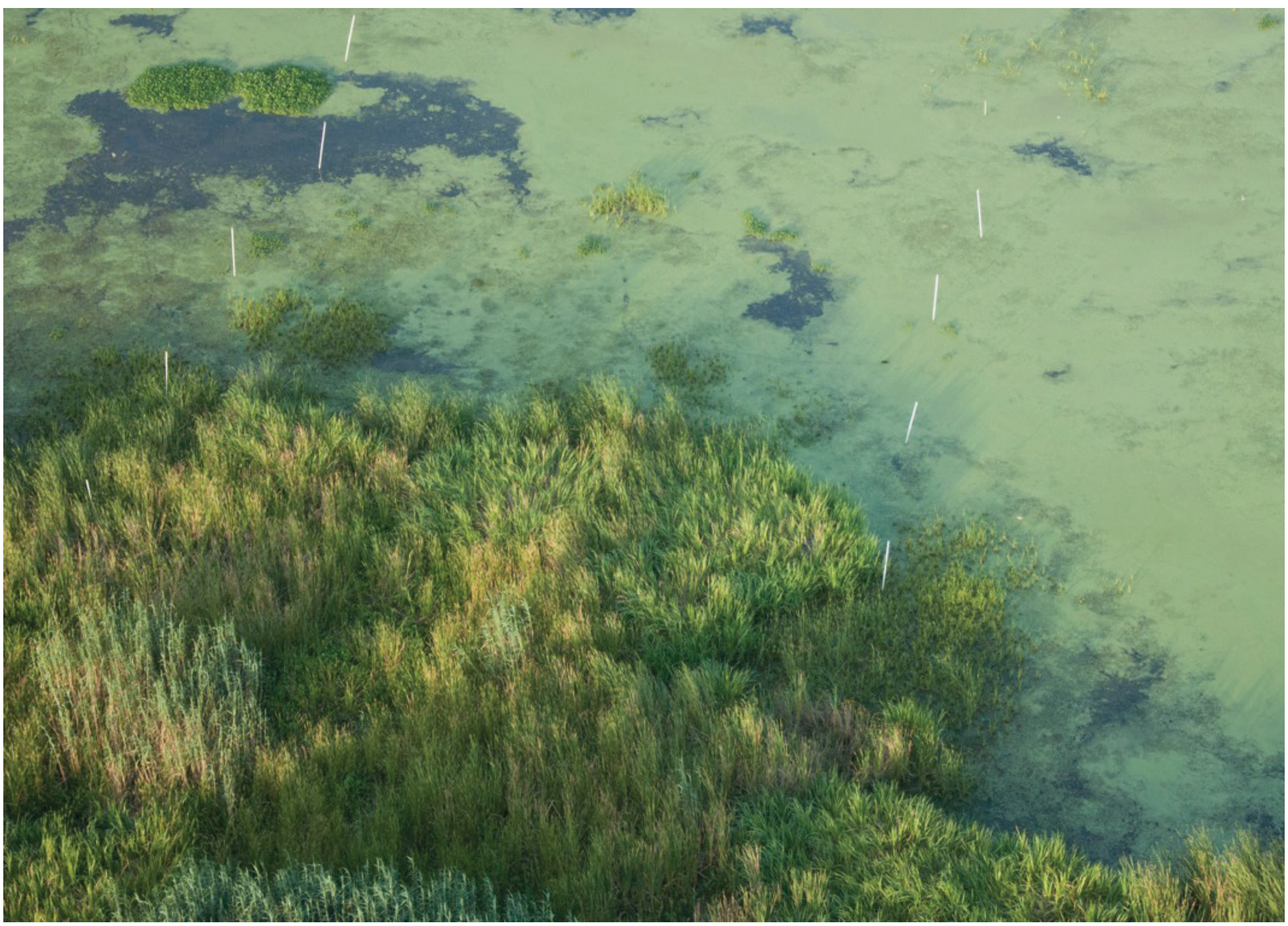

Figure H.2.2. Aerial view of plot Crevasse 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.2.1. Water and environmental conditions at study plot Crevasse 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 29 Mar 2013 | 15:06 | 21.8 | 12.3 | 135.0 | 20.1 | 0.2 | 7.04 | 318.5 | 3.0 | 3.2 | 5.1 | | 13.4 | 6.2 |
| 01 Apr 2013 | 17:34 | 17.5 | 1.9 | 45.0 | 14.1 | 0.2 | 7.06 | 308.1 | 16.5 | 24.1 | 29.2 | | 33.0 | 25.7 |
| 04 Aug 2013 | 12:38 | 35.0 | 6.5 | 337.5 | 36.1 | 0.1 | 7.50 | 424.7 | 5.0 | 5.0 | 15.0 | | 24.0 | 12.3 |
| 13 Oct 2013 | 9:40 | 29.6 | 8.9 | 157.5 | 29.3 | 2.6 | 6.60 | 4810.0 | 10.0 | 21.0 | 21.0 | 24.0 | 32.0 | 21.6 |
| 08 Mar 2014 | 13:07 | 25.3 | 16.4 | 90.0 | 19.5 | 0.2 | 7.40 | 427.8 | 11.4 | 15.2 | 16.5 | 20.3 | 27.9 | 18.3 |
| 23 Oct 2014 | 12:31 | 20.2 | 14.7 | 25.0 | 23.5 | 0.4 | | 860.0 | 24.0 | 32.0 | 42.0 | 44.0 | 43.0 | 37.0 |

Table H.2.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Crevasse 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 13 Oct 2013 | 20.00 | 11.75 | 19.00 | 0 | 49.25 | 4 | 2 | 2 |
| 08 Mar 2014 | 10.00 | 3.75 | 2.50 | 2.50 | 81.25 | 3 | 1 | 1 |
| 23 Oct 2014 | 31.25 | 20.00 | 15.00 | 0 | 33.75 | 6 | 4 | 2 |

Table H.2.3. Vegetation species composition at study plot Crevasse 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 13 Oct 2013 | 1 | emergent | *Sagitteria graminea* | 35 |
| | 1 | emergent | *Typha sp.* | 30 |
| | 1 | emergent | *Pontederia cordata* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 30 |
| | 1 | floating | *Eichhornia crassipes* | 20 |
| | 1 | floating | *Lemna minor* | 80 |
| | 1 | SAV | *Potamogeton nodosus* | 10 |
| | 1 | SAV | unknown species | 90 |
| | 2 | emergent | *Sagitteria graminea* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 40 |
| | 2 | floating | *Lemna minor* | 60 |
| | 2 | SAV | *Potamogeton nodosus* | 50 |
| | 2 | SAV | unknown species | 50 |
| | 3 | emergent | *Sagitteria graminea* | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Potamogeton nodosus* | 80 |
| | 3 | SAV | unknown species | 20 |
| | 4 | floating | *Eichhornia crassipes* | 10 |
| | 4 | floating | *Lemna minor* | 90 |
| | 4 | SAV | *Potamogeton nodosus* | 20 |
| | 4 | SAV | unknown species | 80 |
| 08 Mar 2014 | 1 | emergent | *Typha sp.* | 30 |
| | 1 | emergent | unknown species | 30 |
| | 1 | emergent | *Zizaniopsis miliacea* | 70 |
| | 1 | floating | *Eichhornia crassipes* | 100 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 23 Oct 2014 | 1 | emergent | *Pontederia cordata* | 10 |
| | 1 | emergent | *Sagittaria lancifolia* | 20 |
| | 1 | emergent | *Typha domingensis* | 45 |
| | 1 | emergent | *Typha latifolia* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 20 |
| | 2 | emergent | *Sagittaria lancifolia* | 20 |
| | 2 | emergent | *Typha domingensis* | 80 |
| | 3 | emergent | *Sagittaria graminea* | 100 |
| | 4 | emergent | *Sagittaria graminea* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 80 |
| | 1 | floating | *Lemna minor* | 20 |
| | 2 | floating | *Eichhornia crassipes* | 50 |

(Table H.2.3. continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 23 Oct 2014 | 2 | floating | *Lemna minor* | 50 |
| | 3 | floating | *Eichhornia crassipes* | 20 |
| | 3 | floating | *Lemna minor* | 80 |
| | 4 | floating | *Eichhornia crassipes* | 20 |
| | 4 | floating | *Lemna minor* | 80 |
| | 2 | SAV | *Ceratophyllum demersum* | 20 |
| | 2 | SAV | *Heteranthera dubia* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 10 |
| | 2 | SAV | *Potamogeton nodosus* | 60 |
| | 3 | SAV | *Ceratophyllum demersum* | 10 |
| | 3 | SAV | *Heteranthera dubia* | 10 |
| | 3 | SAV | *Myriophyllum spicatum* | 10 |
| | 3 | SAV | *Potamogeton nodosus* | 70 |
| | 4 | SAV | *Ceratophyllum demersum* | 10 |
| | 4 | SAV | *Heteranthera dubia* | 10 |
| | 4 | SAV | *Myriophyllum spicatum* | 10 |
| | 4 | SAV | *Potamogeton nodosus* | 70 |

**H.3 Crevasse 3**

Location: 29° 3'48.85"N, 89°13'19.28"W

Figure H.3.1. The general area of study plot Crevasse 3. Photo taken August 18, 2014.

Figure H.3.2. Aerial view of plot Crevasse 3. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.3.1. Water and environmental conditions at study plot Crevasse 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 29 Mar 2013 | 8:17 | 22.5 | 8.9 | 22.5 | 12.8 | 0.2 | 6.44 | 341 | 27.8 | 36.8 | 36.8 | | 43.2 | 36.2 |
| 01 Apr 2013 | 13:03 | 25.2 | 8.1 | 0 | 12.1 | 0.1 | 7.3 | 218.6 | 38.1 | 47.0 | 45.1 | | 50.8 | 45.2 |
| 05 Aug 2013 | 18:05 | | 8.1 | 315 | 30.5 | 0.3 | 7.2 | | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 Oct 2013 | 16:39 | 24.8 | 1.3 | 85.0 | 26.8 | 1.6 | 8.64 | 3022.0 | 0.0 | 19.5 | 20.0 | 25.0 | 28.0 | 18.5 |
| 18 Apr 2014 | 8:30 | 19.3 | 8.0 | 22.5 | 16.1 | 0.2 | 7.80 | 404.7 | 55.9 | 61.0 | 66.0 | 71.1 | 66.0 | 64.0 |
| 11 Jul 2014 | 7:37 | 34.4 | 6.1 | 337.5 | 29.2 | 0.2 | 7.44 | 406.8 | 45.7 | 39.4 | 43.2 | 43.2 | 45.7 | 43.4 |
| 23 Oct 2014 | 11:02 | 21.2 | 10.1 | 40.0 | 23.9 | 0.4 | | 762.0 | 22.0 | 23.5 | 23.0 | 29.0 | 37.0 | 26.9 |

Table H.3.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Crevasse 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 27 Oct 2013 | 15 | 3.75 | 33.75 | 0 | 47.5 | 3 | 2 | 5 |
| 18 Apr 2014 | 2.5 | 0 | 1.75 | 0 | 95.75 | 1 | 0 | 2 |
| 11 Jul 2014 | 6.5 | 22.5 | 42.5 | 0 | 28.5 | 4 | 2 | 4 |
| 23 Oct 2014 | 16.25 | 6.25 | 36.25 | 0 | 41.25 | 5 | 2 | 5 |

Table H.3.3. Vegetation species composition at study plot Crevasse 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 27 Oct 2013 | 1 | emergent | *Phragmites australis* | 10 |
| | 1 | emergent | *Sagittaria graminea* | 80 |
| | 1 | emergent | *Typha sp.* | 10 |
| | 1 | floating | *Eichhornia crassipes* | 50 |
| | 1 | floating | *Lemna minor* | 50 |
| | 1 | SAV | *Ceratophyllum demersum* | 5 |
| | 1 | SAV | *Myriophyllum spicatum* | 50 |
| | 1 | SAV | *Potamogeton nodosus* | 35 |
| | 1 | SAV | *Stuckenia pectinata* | 10 |
| | 2 | emergent | *Sagittaria graminea* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 5 |
| | 2 | floating | *Lemna minor* | 95 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | *Ceratophyllum demersum* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 10 |
| | 2 | SAV | *Potamogeton nodosus* | 70 |
| | 2 | SAV | *Stuckenia pectinata* | 10 |
| | 3 | SAV | *Ceratophyllum demersum* | 1 |
| | 3 | SAV | *Myriophyllum spicatum* | 3 |
| | 3 | SAV | *Potamogeton crispus* | 1 |
| | 3 | SAV | *Potamogeton nodosus* | 80 |
| | 3 | SAV | *Stuckenia pectinata* | 15 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 1 |
| | 4 | SAV | *Myriophyllum spicatum* | 1 |
| | 4 | SAV | *Potamogeton nodosus* | 78 |
| | 4 | SAV | *Stuckenia pectinata* | 20 |
| 18 Apr 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 50 |
| | 4 | SAV | *Myriophyllum spicatum* | 50 |
| 11 Jul 2014 | 1 | emergent | *Phragmites australis* | 25 |
| | 1 | emergent | *Sagittaria graminea* | 35 |
| | 1 | emergent | *Sagittaria platyphylla* | 15 |
| | 1 | emergent | *Typha domingensis* | 25 |
| | 1 | floating | *Eichhornia crassipes* | 10 |
| | 1 | floating | *Lemna minor* | 90 |
| | 1 | SAV | *Myriophyllum spicatum* | 5 |
| | 1 | SAV | *Potamogeton nodosus* | 90 |

(Table H.3.3.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 11 Jul 2014 | 1 | SAV | *Stuckenia pectinata* | 5 |
| | 2 | emergent | *Sagittaria graminea* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 50 |
| | 2 | floating | *Lemna minor* | 50 |
| | 2 | SAV | *Ceratophyllum demersum* | 5 |
| | 2 | SAV | *Potamogeton nodosus* | 90 |
| | 2 | SAV | *Stuckenia pectinata* | 5 |
| | 3 | emergent | *Phragmites australis* | 100 |
| | 3 | floating | *Eichhornia crassipes* | 10 |
| | 3 | floating | *Lemna minor* | 90 |
| | 3 | SAV | *Potamogeton nodosus* | 100 |
| | 4 | floating | *Eichhornia crassipes* | 10 |
| | 4 | floating | *Lemna minor* | 90 |
| | 4 | SAV | *Potamogeton nodosus* | 100 |
| | | | | |
| 23 Oct 2014 | 1 | floating | *Eichhornia crassipes* | 90 |
| | 1 | floating | *Lemna minor* | 10 |
| | 1 | SAV | *Myriophyllum spicatum* | 80 |
| | 1 | SAV | *Potamogeton nodosus* | 15 |
| | 1 | SAV | *Ruppia maritima* | 5 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | *Ceratophyllum demersum* | 5 |
| | 2 | SAV | *Myriophyllum spicatum* | 20 |
| | 2 | SAV | *Potamogeton crispus* | 20 |
| | 2 | SAV | *Potamogeton nodosus* | 55 |
| | 3 | floating | *Eichhornia crassipes* | 20 |
| | 3 | floating | *Lemna minor* | 80 |
| | 3 | SAV | *Myriophyllum spicatum* | 25 |
| | 3 | SAV | *Potamogeton crispus* | 5 |
| | 3 | SAV | *Potamogeton nodosus* | 75 |
| | 4 | floating | *Eichhornia crassipes* | 20 |
| | 4 | floating | *Lemna minor* | 80 |
| | 4 | SAV | *Ceratophyllum demersum* | 5 |
| | 4 | SAV | *Myriophyllum spicatum* | 45 |
| | 4 | SAV | *Potamogeton nodosus* | 45 |
| | 4 | SAV | *Ruppia maritima* | 5 |

**H.4 Marsh Terrace 1**

Location: 29°14'37.10"N, 89°10'3.50"W

Figure H.4.1. The general area of study plot Marsh Terrace 1. Photo taken August 18, 2014.

Figure H.4.2. Aerial view of plot Marsh Terrace 1. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Figure H.4.3. In August 2013, study plot Marsh Terrace 1 was completed void of emergent vegetation past the 0m pole. Planting was completed on the terraces in July 2013.

Table H.4.1. Water and environmental conditions at study plot Marsh Terrace 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 25 Jan 2014 | 12:27 | 23.7 | 4.0 | 0.0 | 11.9 | 0.2 | 7.77 | 323.3 | 28 | 60 | 55 | 155 | 60 | 72 |
| 18 Apr 2014 | 17:21 | 19.6 | 26.0 | 22.5 | 17.2 | 0.2 | 8.00 | 405.0 | 58.4 | 68.6 | 157.5 | 58.4 | 50.8 | 78.7 |
| 22 Oct 2014 | 9:07 | 23.1 | 11.4 | 25.0 | 22.8 | 0.4 | | 827.0 | 53 | 87 | 124 | 83 | 63 | 82 |

Table H.4.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Marsh Terrace 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 25 Jan 2014 | 1.25 | 0 | 6.25 | 0 | 92.5 | 2 | 0 | 1 |
| 18 Apr 2014 | 1.25 | 0 | 6.25 | 0 | 92.5 | | | |
| 22 Oct 2014 | 30 | 50 | 13.75 | 0 | 6.25 | 3 | 5 | 2 |

Table H.4.3. Vegetation species composition at study plot Marsh Terrace 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 25 Jan 2014 | 1 | emergent | *Phragmites australis* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 95 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| | | | | |
| 22 Oct 2014 | 1 | emergent | *Phragmites australis* | 10 |
| | 1 | emergent | *Sagittaria lancifolia* | 45 |
| | 1 | emergent | *Zizania aquatica* | 45 |
| | 1 | floating | *Eichhornia crassipes* | 10 |
| | 1 | floating | *Lemna minor* | 80 |
| | 1 | floating | *Spirodela polyrrhiza* | 10 |
| | 1 | SAV | *Myriophyllum spicatum* | 20 |
| | 1 | SAV | *Potamogeton nodosus* | 80 |
| | 2 | emergent | *Zizania aquatica* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 20 |
| | 2 | floating | *Lemna minor* | 70 |
| | 2 | floating | *Salvinia minima* | 5 |
| | 2 | floating | *Spirodela polyrrhiza* | 5 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | emergent | *Zizania aquatica* | 100 |
| | 3 | floating | *Azolla caroliniana* | 1 |
| | 3 | floating | *Eichhornia crassipes* | 30 |
| | 3 | floating | *Lemna minor* | 60 |
| | 3 | floating | *Salvinia minima* | 5 |
| | 3 | floating | *Spirodela polyrrhiza* | 4 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | emergent | *Zizania aquatica* | 100 |
| | 4 | floating | *Azolla caroliniana* | 1 |
| | 4 | floating | *Eichhornia crassipes* | 10 |
| | 4 | floating | *Lemna minor* | 80 |
| | 4 | floating | *Salvinia minima* | 5 |
| | 4 | floating | *Spirodela polyrrhiza* | 4 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |

**H.5 Marsh Terrace 2**

Location: 29°14'48.39"N, 89°10'30.12"W

Figure H.5.1. The general area of study plot Marsh Terrace 2. Photo taken August 18, 2014.

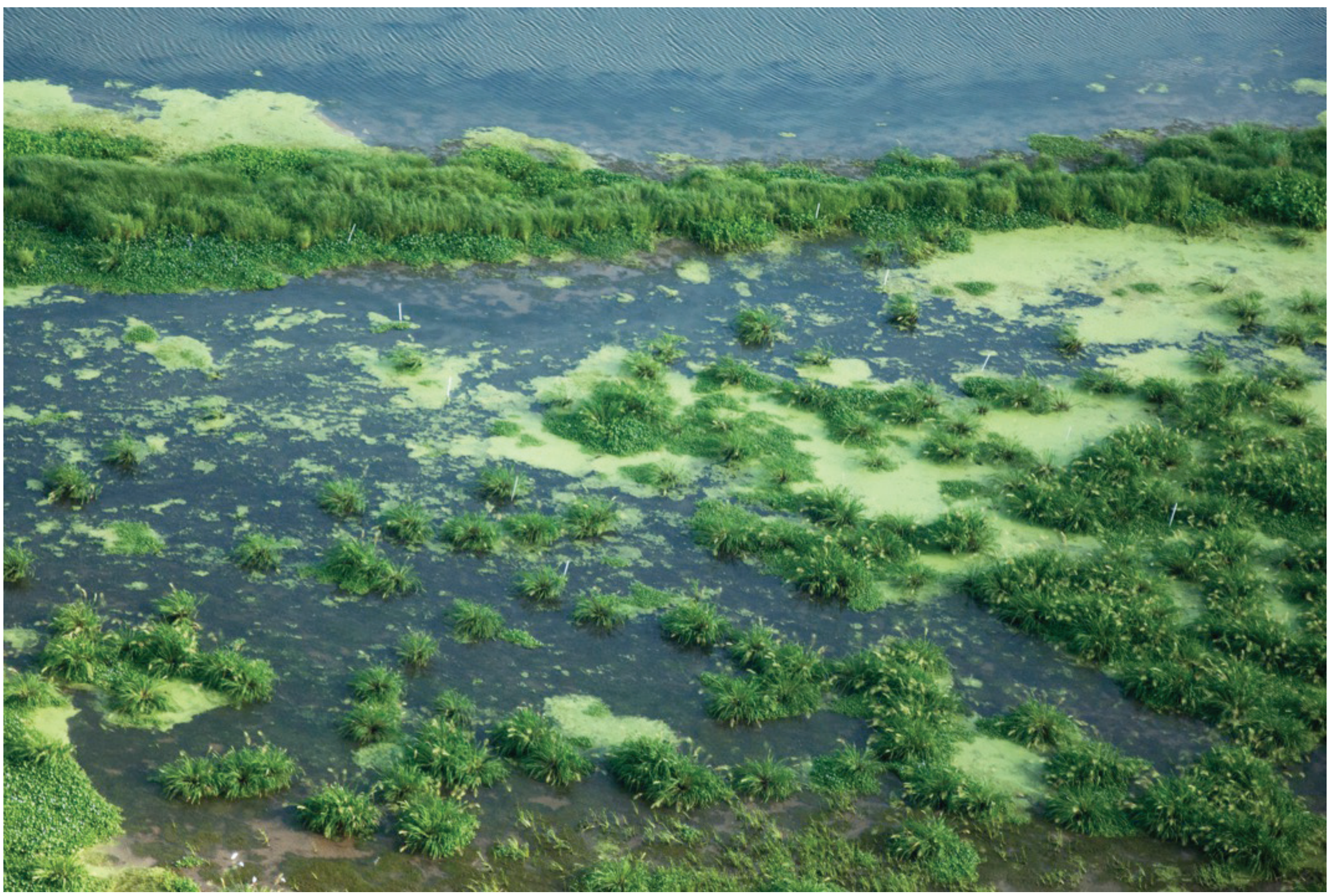

Figure H.5.2. Aerial view of plot Marsh Terrace 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.5.1. Water and environmental conditions at study plot Marsh Terrace 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 25 Jan 2014 | 15:08 | 14.2 | 6.9 | 315.0 | 9.9 | 0.1 | 7.78 | 312.6 | 35 | 70 | 68 | 67 | 58 | 60 |
| 09 Mar 2014 | 12:09 | 17.6 | 4.3 | 45.0 | 11.2 | 0.2 | 8.00 | 344.2 | 22.9 | 61.0 | 69.9 | 50.8 | 52.1 | 51.3 |
| 12 Jul 2014 | 9:02 | 30.0 | 15.4 | 0.0 | 29.9 | 0.2 | 7.69 | 425.6 | 45.1 | 63.5 | 63.5 | 63.5 | 83.8 | 63.9 |
| 22 Oct 2014 | 11:49 | 21.8 | 14.5 | 20.0 | 24.6 | 0.4 | | 878.0 | 51 | 105 | 88 | 79 | 77 | 80 |
| 25 Oct 2014 | 10:35 | 24.5 | 8.1 | 0.0 | 21.2 | 0.3 | | 452.2 | 24 | 61 | 65 | 54 | 48 | 50 |

Table H.5.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Marsh Terrace 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 25 Jan 2014 | 1.25 | 6.25 | 11.25 | 0 | 81.25 | 1 | 1 | 3 |
| 09 Mar 2014 | 1.25 | 1.25 | 6.25 | 0 | 91.25 | 1 | 1 | 1 |
| 12 Jul 2014 | 12.5 | 26.25 | 8.75 | 0 | 52.5 | 5 | 4 | 3 |
| 22 Oct 2014 | 31.25 | 25 | 16.25 | 0 | 27.5 | 4 | 5 | 2 |
| 25 Oct 2014 | 31.25 | 25 | 16.25 | 0 | 27.5 | 4 | 5 | 2 |

Table H.5.3. Vegetation species composition at study plot Marsh Terrace 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 25 Jan 2014 | 1 | emergent | *Spartina alterniflora* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 100 |
| | 1 | SAV | *Ceratophyllum demersum* | 50 |
| | 1 | SAV | *Myriophyllum spicatum* | 25 |
| | 1 | SAV | *Potamogeton sp.* | 25 |
| | 2 | SAV | *Ceratophyllum demersum* | 50 |
| | 2 | SAV | *Myriophyllum spicatum* | 50 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 09 Mar 2014 | 1 | emergent | *Spartina alterniflora* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 100 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 12 Jul 2014 | 1 | emergent | *Alternanthera philoxeroides* | 5 |
| | 1 | emergent | *Nelumbo lutea* | 5 |
| | 1 | emergent | *Sagittaria platyphylla* | 20 |
| | 1 | emergent | *Spartina alterniflora* | 70 |
| | 1 | floating | *Azolla caroliniana* | 5 |
| | 1 | floating | *Eichhornia crassipes* | 30 |
| | 1 | floating | *Lemna minor* | 50 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | floating | *Salvinia molesta* | 5 |
| | 1 | floating | *Spirodela polyrrhiza* | 5 |
| | 1 | SAV | *Ceratophyllum demersum* | 100 |
| | 2 | emergent | *Zizania aquatica* | 100 |
| | 2 | floating | *Azolla caroliniana* | 5 |
| | 2 | floating | *Eichhornia crassipes* | 20 |
| | 2 | floating | *Lemna minor* | 60 |
| | 2 | floating | *Salvinia minima* | 5 |
| | 2 | floating | *Salvinia molesta* | 5 |
| | 2 | floating | *Spirodela polyrrhiza* | 5 |
| | 2 | SAV | *Ceratophyllum demersum* | 30 |
| | 2 | SAV | *Heteranthera dubia* | 30 |
| | 2 | SAV | *Myriophyllum spicatum* | 40 |
| | 3 | emergent | *Zizania aquatica* | 100 |
| | 3 | floating | *Azolla caroliniana* | 10 |
| | 3 | floating | *Eichhornia crassipes* | 10 |
| | 3 | floating | *Lemna minor* | 55 |

(Table H.5.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 12 Jul 2014 | 3 | floating | *Salvinia minima* | 5 |
| | 3 | floating | *Salvinia molesta* | 5 |
| | 3 | floating | *Spirodela polyrrhiza* | 5 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | emergent | *Zizania aquatica* | 100 |
| | 4 | floating | *Azolla caroliniana* | 10 |
| | 4 | floating | *Eichhornia crassipes* | 10 |
| | 4 | floating | *Lemna minor* | 55 |
| | 4 | floating | *Salvinia minima* | 5 |
| | 4 | floating | *Salvinia molesta* | 5 |
| | 4 | floating | *Spirodela polyrrhiza* | 5 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 22 Oct 2014 | 1 | emergent | *Ludwigia peploides* | 5 |
| | 1 | emergent | *Sagittaria lancifolia* | 25 |
| | 1 | emergent | *Spartina alterniflora* | 45 |
| | 1 | emergent | *Zizania aquatica* | 25 |
| | 1 | floating | *Eichhornia crassipes* | 80 |
| | 1 | floating | *Lemna minor* | 15 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 2 | emergent | *Zizania aquatica* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 80 |
| | 2 | floating | *Lemna minor* | 10 |
| | 2 | floating | *Limnobium spongia* | 1 |
| | 2 | floating | *Salvinia minima* | 4 |
| | 3 | emergent | *Zizania aquatica* | 100 |
| | 3 | floating | *Eichhornia crassipes* | 80 |
| | 3 | floating | *Lemna minor* | 15 |
| | 3 | floating | *Salvinia minima* | 4 |
| | 3 | floating | *Spirodela polyrrhiza* | 1 |
| | 4 | emergent | *Zizania aquatica* | 100 |
| | 4 | floating | *Eichhornia crassipes* | 80 |
| | 4 | floating | *Lemna minor* | 15 |
| | 4 | floating | *Salvinia minima* | 4 |
| | 4 | floating | *Spirodela polyrrhiza* | 1 |

**H.6 Marsh Terrace 3**

Location: 29°14'29.80"N, 89°10'30.24"W

Figure H.6.1. The general area of study plot Marsh Terrace 3. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Figure H.6.2. Aerial view of plot Marsh Terrace 3. Photo taken August 18, 2014.

Table H.6.1. Water and environmental conditions at study plot Marsh Terrace 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 26 Jan 2014 | 12:27 | 21.0 | 0.0 | 135.0 | 7.7 | 0.2 | 7.69 | 318.8 | 25 | 50 | 68 | 61 | 58 | 52 |
| 09 Mar 2014 | 9:38 | 11.1 | 5.9 | 45.0 | 7.5 | 0.2 | 7.94 | 368.9 | 22.9 | 58.4 | 62.2 | 55.9 | 55.9 | 51.1 |
| 09 Jul 2014 | 16:37 | 33.1 | 9.0 | 292.5 | 29.6 | 0.1 | 8.22 | 202.0 | 5 | 5 | 5 | 5 | 5 | 5 |
| 25 Oct 2014 | 10:24 | 24.5 | 8.1 | 0.0 | 22.5 | 0.2 | | 483.9 | 7 | 58 | 38 | 42 | 33 | 36 |

Table H.6.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Marsh Terrace 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 26 Jan 2014 | 1.5 | 0 | 3.75 | 0 | 94.75 | 2 | 0 | 1 |
| 09 Mar 2014 | 1.25 | 0 | 0 | 0 | 98.75 | 1 | 0 | 0 |
| 09 Jul 2014 | 5 | 6.25 | 8.75 | 0 | 80 | 6 | 4 | 3 |
| 25 Oct 2014 | 11.25 | 9 | 8.75 | 0 | 71 | 4 | 4 | 3 |

Table H.6.3. Vegetation species composition at study plot Marsh Terrace 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 26 Jan 2014 | 1 | emergent | *Spartina patens* | 75 |
| | 1 | emergent | *Typha domingensis* | 25 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 09 Mar 2014 | 1 | emergent | *Spartina alterniflora* | 100 |
| 09 Jul 2014 | 1 | emergent | *Sagittaria lancifolia* | 75 |
| | 1 | emergent | *Sagittaria latifolia* | 5 |
| | 1 | emergent | *Sagittaria platyphylla* | 5 |
| | 1 | emergent | *Schoenoplectus americanus* | 5 |
| | 1 | emergent | *Spartina alterniflora* | 10 |
| | 1 | floating | *Azolla caroliniana* | 5 |
| | 1 | floating | *Lemna minor* | 90 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | floating | *Azolla caroliniana* | 15 |
| | 2 | floating | *Lemna minor* | 80 |
| | 2 | floating | *Salvinia minima* | 5 |
| | 2 | SAV | *Myriophyllum spicatum* | 95 |
| | 2 | SAV | *Potamogeton nodosus* | 5 |
| | 3 | floating | *Azolla caroliniana* | 5 |
| | 3 | floating | *Eichhornia crassipes* | 10 |
| | 3 | floating | *Lemna minor* | 80 |
| | 3 | floating | *Salvinia minima* | 5 |
| | 3 | SAV | *Ceratophyllum demersum* | 20 |
| | 3 | SAV | *Myriophyllum spicatum* | 80 |
| | 4 | emergent | *Polygonum sp.* | 100 |
| | 4 | floating | *Azolla caroliniana* | 15 |
| | 4 | floating | *Lemna minor* | 80 |
| | 4 | floating | *Salvinia minima* | 5 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 25 Oct 2014 | 1 | emergent | *Sagittaria lancifolia* | 90 |
| | 1 | emergent | *Spartina alterniflora* | 5 |
| | 1 | emergent | *Typha domingensis* | 5 |
| | 1 | floating | *Eichhornia crassipes* | 80 |
| | 1 | floating | *Lemna minor* | 10 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | floating | *Salvinia molesta* | 5 |

(Table H.6.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 25 Oct 2014 | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 95 |
| | 2 | floating | *Lemna minor* | 3 |
| | 2 | floating | *Salvinia minima* | 1 |
| | 2 | floating | *Salvinia molesta* | 1 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 10 |
| | 3 | SAV | *Myriophyllum spicatum* | 90 |
| | 4 | emergent | *Sagittaria graminea* | 100 |
| | 4 | floating | *Eichhornia crassipes* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 10 |
| | 4 | SAV | *Myriophyllum spicatum* | 50 |
| | 4 | SAV | *Potamogeton nodosus* | 40 |

**H.7 Beneficial Use of Dredged Material Marsh 1 (Pump-in 1)**

Location: 29° 9'31.56"N, 89°12'55.43"W

Figure H.7.1. Aerial view of plot Beneficial Use of Dredged Material Marsh 1. The white poles mark the edges of the plot. Some poles were knocked down over the course of the study. Photo taken August 18, 2014.

Table H.7.1. Water and environmental conditions at study plot Beneficial use of Dredged Material Marsh 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 28 Oct 2013 | 8:55 | 29.4 | 10.3 | 22.5 | 23.8 | 1.4 | 8.26 | 2741.0 | 30.0 | 43.0 | 45.0 | 56.0 | 60.0 | 46.8 |
| 13 Apr 2014 | 8:14 | 24.4 | 8.0 | 135.0 | 23.1 | 0.2 | 9.36 | 376.8 | 45.7 | 33.0 | 60.9 | 73.7 | 68.6 | 56.4 |
| 12 Jul 2014 | 14:10 | 33.4 | 5.5 | 202.5 | 32.2 | 0.2 | 8.52 | 416.1 | 54.6 | 64.8 | 71.1 | 67.3 | 69.9 | 65.5 |
| 22 Oct 2014 | 15:11 | 22.2 | 12.6 | 30.0 | 25.4 | 0.8 | | 1695.0 | 53.0 | 63.0 | 67.0 | 73.0 | 69.0 | 65.0 |

Table H.7.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Beneficial use of Dredged Material Marsh 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 28 Oct 2013 | 5 | 0 | 40 | 0 | 55 | 2 | 0 | 3 |
| 13 Apr 2014 | 5 | 0 | 50 | 0 | 45 | 1 | 0 | 1 |
| 12 Jul 2014 | 7.5 | 18.75 | 12.5 | 0 | 61.25 | 1 | 3 | 3 |
| 22 Oct 2014 | 6.25 | 10 | 21.25 | 0 | 62.5 | 1 | 3 | 3 |

Table H.7.3. Vegetation species composition at study plot Beneficial use of Dredged Material Marsh 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 28 Oct 2013 | 1 | emergent | *Sagittaria graminea* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 95 |
| | 1 | SAV | *Myriophyllum spicatum* | 99 |
| | 1 | SAV | *Ruppia maritima* | 1 |
| | 2 | SAV | *Myriophyllum spicatum* | 85 |
| | 2 | SAV | *Ruppia maritima* | 15 |
| | 3 | SAV | *Ceratophyllum demersum* | 15 |
| | 3 | SAV | *Ceratophyllum demersum* | 30 |
| | 3 | SAV | *Myriophyllum spicatum* | 70 |
| | 3 | SAV | *Myriophyllum spicatum* | 60 |
| | 3 | SAV | *Ruppia maritima* | 15 |
| | 3 | SAV | *Ruppia maritima* | 10 |
| 13 Apr 2014 | 1 | emergent | *Zizaniopsis miliacea* | 100 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 95 |
| | 2 | SAV | *Ruppia maritima* | 5 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 12 Jul 2014 | 1 | emergent | *Zizaniopsis miliacea* | 100 |
| | 1 | floating | *Lemna minor* | 90 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | floating | *Spirodela polyrrhiza* | 5 |
| | 1 | SAV | *Ceratophyllum demersum* | 5 |
| | 1 | SAV | *Myriophyllum spicatum* | 90 |
| | 1 | SAV | *Stuckenia pectinata* | 5 |
| | 2 | floating | *Lemna minor* | 60 |
| | 2 | floating | *Salvinia minima* | 30 |
| | 2 | floating | *Spirodela polyrrhiza* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 90 |
| | 2 | SAV | *Stuckenia pectinata* | 10 |
| | 3 | floating | *Lemna minor* | 60 |
| | 3 | floating | *Salvinia minima* | 30 |
| | 3 | floating | *Spirodela polyrrhiza* | 10 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | floating | *Lemna minor* | 60 |
| | 4 | floating | *Salvinia minima* | 30 |
| | 4 | floating | *Spirodela polyrrhiza* | 10 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |

(Table H.7.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 22 Oct 2014 | 1 | emergent | *Zizaniopsis miliacea* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 15 |
| | 1 | floating | *Lemna minor* | 80 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | SAV | *Ceratophyllum demersum* | 100 |
| | 2 | emergent | *Zizaniopsis miliacea* | 100 |
| | 2 | floating | *Lemna minor* | 80 |
| | 2 | floating | *Salvinia minima* | 10 |
| | 2 | SAV | *Ceratophyllum demersum* | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 90 |
| | 3 | SAV | *Najas guadalupensis* | 10 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 30 |
| | 4 | SAV | *Heteranthera dubia* | 30 |
| | 4 | SAV | *Najas guadalupensis* | 40 |

### H.8 Beneficial Use of Dredged Material Marsh 2 (Pump-in 2)

Location: 29°10'4.90"N, 89°12'49.41"W

Figure H.8.1. The general area of study plot Beneficial Use of Dredged Material Marsh 2. Photo taken August 18, 2014.

Figure H.8.2. Aerial view of plot Beneficial Use of Dredged Material Marsh 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.8.1. Water and environmental conditions at study plot Beneficial use of Dredged Material Marsh 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (μmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 28 Oct 2013 | 11:42 | 30.1 | 11.8 | 90.0 | 25.3 | 1.6 | 8.91 | 3146.0 | 23.0 | 30.5 | 35.0 | 40.0 | 45.0 | 34.7 |
| 12 Apr 2014 | 11:34 | 27.2 | 17.0 | 135.0 | 24.7 | 0.2 | 9.36 | 395.9 | 35.6 | 38.1 | 35.6 | 55.9 | 58.4 | 44.704 |
| 24 Oct 2014 | 11:37 | 22.8 | 16.1 | 330.0 | 22.8 | 0.8 | | 1484.0 | 34.0 | 37.0 | 41.0 | 54.0 | 55.5 | 44.3 |

Table H.8.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Beneficial use of Dredged Material Marsh 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 28 Oct 2013 | 2.5 | 15 | 67.5 | 0 | 15 | 3 | 2 | 7 |
| 12 Apr 2014 | 2.5 | 0 | 22.5 | 0 | 75 | 2 | 0 | 1 |
| 24 Oct 2014 | 3.75 | 13.75 | 55 | 0 | 27.5 | 4 | 3 | 5 |

Table H.8.3. Vegetation species composition at study plot Beneficial use of Dredged Material Marsh 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 28 Oct 2013 | 1 | emergent | *Phragmites australis* | 50 |
| | 1 | emergent | *Sagittaria graminea* | 10 |
| | 1 | emergent | *Zizaniopsis miliacea* | 40 |
| | 1 | floating | *Eichhornia crassipes* | 5 |
| | 1 | floating | *Lemna minor* | 95 |
| | 1 | SAV | *Heteranthera dubia* | 15 |
| | 1 | SAV | *Myriophyllum spicatum* | 50 |
| | 1 | SAV | *Potamogeton nodosus* | 5 |
| | 1 | SAV | *Potamogeton pusillus* | 25 |
| | 1 | SAV | *Ruppia maritima* | 5 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | *Heteranthera dubia* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 50 |
| | 2 | SAV | *Potamogeton nodosus* | 5 |
| | 2 | SAV | *Potamogeton pusillus* | 15 |
| | 2 | SAV | *Ruppia maritima* | 20 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 10 |
| | 3 | SAV | *Heteranthera dubia* | 10 |
| | 3 | SAV | *Myriophyllum spicatum* | 50 |
| | 3 | SAV | *Potamogeton crispus* | 5 |
| | 3 | SAV | *Potamogeton nodosus* | 5 |
| | 3 | SAV | *Potamogeton pusillus* | 15 |
| | 3 | SAV | *Ruppia maritima* | 5 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Heteranthera dubia* | 10 |
| | 4 | SAV | *Myriophyllum spicatum* | 60 |
| | 4 | SAV | *Potamogeton nodosus* | 5 |
| | 4 | SAV | *Potamogeton pusillus* | 10 |
| | 4 | SAV | *Ruppia maritima* | 15 |
| 12 Apr 2014 | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | emergent | *Phragmites australis* | 30 |
| | 4 | emergent | *Zizaniopsis miliacea* | 70 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 24 Oct 2014 | 1 | emergent | *Phragmites australis* | 48 |
| | 1 | emergent | *Salix nigra* | 2 |
| | 1 | emergent | *Typha latifolia* | 2 |
| | 1 | emergent | *Zizaniopsis miliacea* | 48 |

(Table H.8.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 24 Oct 2014 | 1 | floating | *Eichhornia crassipes* | 10 |
| | 1 | floating | *Lemna minor* | 70 |
| | 1 | floating | *Salvinia minima* | 20 |
| | 1 | SAV | *Ceratophyllum demersum* | 40 |
| | 1 | SAV | *Heteranthera dubia* | 50 |
| | 1 | SAV | *Myriophyllum spicatum* | 10 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | *Ceratophyllum demersum* | 5 |
| | 2 | SAV | *Heteranthera dubia* | 45 |
| | 2 | SAV | *Myriophyllum spicatum* | 40 |
| | 2 | SAV | *Najas guadalupensis* | 5 |
| | 2 | SAV | *Potamogeton pusillus* | 5 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 10 |
| | 3 | SAV | *Heteranthera dubia* | 20 |
| | 3 | SAV | *Myriophyllum spicatum* | 70 |
| | 4 | floating | *Eichhornia crassipes* | 10 |
| | 4 | floating | *Lemna minor* | 90 |
| | 4 | SAV | *Ceratophyllum demersum* | 5 |
| | 4 | SAV | *Heteranthera dubia* | 15 |
| | 4 | SAV | *Myriophyllum spicatum* | 85 |

**H.9 Beneficial Use of Dredged Material Marsh 3 (Pump-in 3)**

Location: 29° 9'58.60"N, 89°11'16.70"W

Figure H.9.1. The general area of study plot Beneficial Use of Dredged Material Marsh 3. Photo taken August 18, 2014.

Figure H.9.2. Aerial view of plot Beneficial Use of Dredged Material Marsh 3. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.9.1. Water and environmental conditions at study plot Beneficial use of Dredged Material Marsh 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 27 Oct 2013 | 9:45 | 30.5 | 9.7 | 45.0 | 20.6 | 2.2 | 7.13 | 4180.0 | 33.0 | 29.5 | 40.0 | 41.0 | 24.0 | 33.5 |
| 09 Feb 2014 | 9:02 | 18.4 | 8.9 | 135.0 | 15.4 | 0.0 | 7.65 | 28.5 | 0.0 | 11.4 | 27.9 | 36.8 | 14.0 | 18.0 |
| 10 Jul 2014 | 13:22 | 29.3 | 6.0 | 135.0 | 29.9 | 0.2 | 7.71 | 469.0 | 4.5 | 19.7 | 43.8 | 47.0 | 47.0 | 32.4 |
| 13 Jul 2014 | 9:10 | 25.9 | 16.2 | 225.0 | 28.2 | 0.2 | 7.81 | 410.8 | 8.5 | 23.7 | 47.8 | 51.0 | 51.0 | 36.4 |
| 24 Oct 2014 | 14:56 | 19.4 | 3.1 | 0.0 | 23.5 | 0.5 | | 1073.0 | 35.5 | 43.0 | 53.0 | 58.0 | 59.0 | 49.7 |

Table H.9.2. Mean surface area cover and vegetation species richness across all plot zones study plot Beneficial use of Dredged Material Marsh 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 27 Oct 2013 | 5 | 17.5 | 40 | 0 | 37.5 | 6 | 2 | 3 |
| 09 Feb 2014 | 2.5 | 0 | 5 | 2.5 | 90 | 4 | 0 | 1 |
| 10 Jul 2014 | 8.75 | 30 | 50 | 0 | 11.25 | 8 | 3 | 9 |
| 13 Jul 2014 | 8.75 | 30 | 50 | 0 | 11.25 | 8 | 3 | 9 |
| 24 Oct 2014 | 13 | 26.25 | 21.25 | 0 | 39.5 | 3 | 4 | 5 |

Table H.9.3. Vegetation species composition at study plot Beneficial use of Dredged Material Marsh 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 27 Oct 2013 | 1 | emergent | *Alternanthera philoxeroides* | 4 |
| | 1 | emergent | *Cyperus sp.* | 2 |
| | 1 | emergent | *Phragmites australis* | 10 |
| | 1 | emergent | *Sagittaria lancifolia* | 2 |
| | 1 | emergent | *Schoenoplectus tabernaemontani* | 2 |
| | 1 | emergent | *Typha sp.* | 80 |
| | 1 | floating | *Lemna minor* | 100 |
| | 1 | SAV | *Ceratophyllum demersum* | 20 |
| | 1 | SAV | *Myriophyllum spicatum* | 80 |
| | 2 | floating | *Eichhornia crassipes* | 20 |
| | 2 | floating | *Lemna minor* | 80 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 95 |
| | 3 | SAV | *Potamogeton nodosus* | 5 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 95 |
| | 4 | SAV | *Potamogeton nodosus* | 5 |
| 09 Feb 2014 | 1 | emergent | *Phragmites australis* | 10 |
| | 1 | emergent | *Schoenoplectus tabernaemontani* | 5 |
| | 1 | emergent | *Typha domingensis* | 80 |
| | 1 | emergent | *Zizaniopsis miliacea* | 5 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 10 Jul 2014 | 1 | emergent | *Phragmites australis* | 5 |
| | 1 | emergent | *Sagittaria platyphylla* | 5 |
| | 1 | emergent | *Schoenoplectus americanus* | 20 |
| | 1 | emergent | *Schoenoplectus tabernaemontani* | 10 |
| | 1 | emergent | *Spartina cynosuroides* | 15 |
| | 1 | emergent | *Typha domingensis* | 30 |
| | 1 | emergent | *Typha latifolia* | 5 |
| | 1 | emergent | *Zizaniopsis miliacea* | 10 |
| | 1 | floating | *Eichhornia crassipes* | 15 |
| | 1 | floating | *Lemna minor* | 80 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | SAV | *Ceratophyllum demersum* | 5 |
| | 1 | SAV | *Myriophyllum spicatum* | 10 |

(Table H.9.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 10 Jul 2014 | 1 | SAV | *Najas guadalupensis* | 55 |
| | 1 | SAV | *Potamogeton nodosus* | 10 |
| | 1 | SAV | *Potamogeton nodosus* | 5 |
| | 1 | SAV | *Potamogeton pusillus* | 10 |
| | 1 | SAV | *Stuckenia pectinata* | 5 |
| | 1 | SAV | *Vallisneria americana* | 5 |
| | 2 | floating | *Lemna minor* | 90 |
| | 2 | floating | *Salvinia minima* | 10 |
| | 2 | SAV | *Heteranthera dubia* | 10 |
| | 2 | SAV | *Myriophyllum spicatum* | 70 |
| | 2 | SAV | *Potamogeton diversifolius* | 5 |
| | 2 | SAV | *Potamogeton pusillus* | 5 |
| | 2 | SAV | *Vallisneria americana* | 5 |
| | 3 | emergent | *Sagittaria platyphylla* | 100 |
| | 3 | floating | *Lemna minor* | 90 |
| | 3 | floating | *Salvinia minima* | 10 |
| | 3 | SAV | *Ceratophyllum demersum* | 5 |
| | 3 | SAV | *Heteranthera dubia* | 5 |
| | 3 | SAV | *Myriophyllum spicatum* | 80 |
| | 3 | SAV | *Potamogeton nodosus* | 5 |
| | 3 | SAV | *Stuckenia pectinata* | 5 |
| | 4 | floating | *Lemna minor* | 90 |
| | 4 | floating | *Salvinia minima* | 10 |
| | 4 | SAV | *Ceratophyllum demersum* | 5 |
| | 4 | SAV | *Heteranthera dubia* | 5 |
| | 4 | SAV | *Myriophyllum spicatum* | 80 |
| | 4 | SAV | *Potamogeton nodosus* | 5 |
| | 4 | SAV | *Stuckenia pectinata* | 5 |
| 24 Oct 2014 | 1 | emergent | *Phragmites australis* | 20 |
| | 1 | emergent | *Typha domingensis* | 80 |
| | 1 | floating | *Eichhornia crassipes* | 60 |
| | 1 | floating | *Lemna minor* | 30 |
| | 1 | floating | *Salvinia minima* | 10 |
| | 1 | SAV | *Ceratophyllum demersum* | 10 |
| | 1 | SAV | *Myriophyllum spicatum* | 10 |
| | 1 | SAV | *Potamogeton pusillus* | 80 |
| | 2 | emergent | *Sagittaria graminea* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 5 |
| | 2 | floating | *Lemna minor* | 85 |
| | 2 | floating | *Salvinia minima* | 5 |
| | 2 | SAV | *Heteranthera dubia* | 5 |
| | 2 | SAV | *Myriophyllum spicatum* | 95 |

(Table H.9.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 24 Oct 2014 | 3 | emergent | *Sagittaria graminea* | 100 |
| | 3 | floating | *Lemna minor* | 80 |
| | 3 | floating | *Salvinia minima* | 15 |
| | 3 | floating | *Spirodela polyrrhiza* | 5 |
| | 3 | SAV | *Heteranthera dubia* | 5 |
| | 3 | SAV | *Myriophyllum spicatum* | 90 |
| | 3 | SAV | *Vallisneria americana* | 5 |
| | 4 | floating | *Lemna minor* | 80 |
| | 4 | floating | *Salvinia minima* | 15 |
| | 4 | floating | *Spirodela polyrrhiza* | 5 |
| | 4 | SAV | *Heteranthera dubia* | 20 |
| | 4 | SAV | *Myriophyllum spicatum* | 80 |

**H.10 Old Edge Marsh 1**

Location: 29° 7'24.30"N, 89°12'47.47"W

Figure H.10.1. The general area of study plot Old Edge 1. Photo taken August 18, 2014.

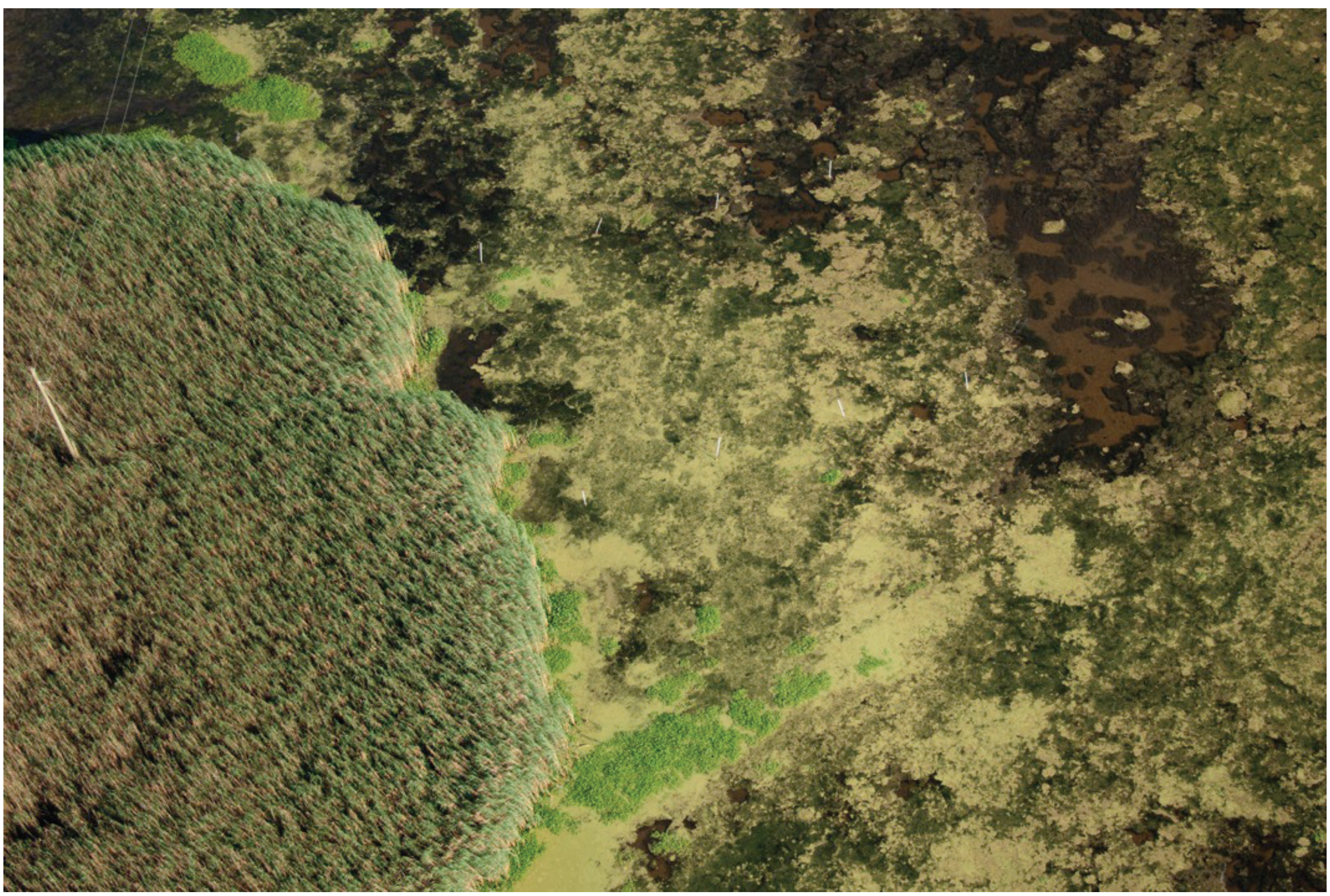

Figure H.10.2. Aerial view of study plot Old Edge 1. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.10.1. Water and environmental conditions at study plot Old Edge 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (μmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 30 Mar 2013 | 12:12 | 27.9 | 6.5 | 202.5 | 15.5 | 0.2 | 6.74 | 280.6 | 76.2 | 69.9 | 73.7 | | 73.7 | 73.3 |
| 02 Apr 2013 | 14:10 | 25.8 | 8.1 | 135.0 | 16.9 | 0.2 | 7.40 | 290.6 | 77.5 | 77.5 | 76.2 | | 86.4 | 79.4 |
| 06 Aug 2013 | 8:41 | 30.7 | 7.6 | 315.0 | 30.8 | 0.2 | 6.80 | 404.5 | 65.0 | 63.0 | 59.0 | | 58.0 | 61.3 |
| 13 Oct 2013 | 15:02 | 29.9 | 3.1 | 135.0 | 28.4 | 2.7 | 6.74 | 4980.0 | 38 | 38 | 38 | 46 | 40 | 40 |
| 08 Feb 2014 | 12:05 | 17.6 | 5.2 | 45.0 | 17.5 | 0.2 | 8.19 | 508.0 | 45.7 | 46.4 | 46.4 | 47.0 | 48.9 | 46.9 |
| 11 Jul 2014 | 14:06 | 30.2 | 4.0 | 202.5 | 29.3 | 0.2 | 7.33 | 497.0 | 35.6 | 45.7 | 45.7 | 48.3 | 45.7 | 44.2 |
| 22 Oct 2014 | 17:27 | 20.0 | 0.0 | 0.0 | 24.3 | 1.0 | | 1185.0 | 65 | 57 | 66 | 68 | 86 | 68 |

Table H.10.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Old Edge 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 13 Oct 2013 | 6.75 | 30.25 | 48 | 0 | 15 | 1 | 3 | 1 |
| 08 Feb 2014 | 7.5 | 0 | 6.25 | 0 | 86.25 | 1 | 0 | 1 |
| 11 Jul 2014 | 7.5 | 15 | 60 | 0 | 17.5 | 1 | 4 | 9 |
| 22 Oct 2014 | 7.5 | 42.5 | 32.5 | 0 | 17.5 | 1 | 2 | 3 |

Table H.10.3. Vegetation species composition at study plot Old Edge 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 13 Oct 2013 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | floating | *Lemna minor* | 90 |
| | 1 | floating | *Ludwigia peploides* | 5 |
| | 1 | floating | *Salvinia minima* | 5 |
| | 1 | SAV | unknown species | 100 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | unknown species | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | unknown species | 100 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | unknown species | 100 |
| 08 Feb 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | SAV | *Myriophyllum spicatum* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 11 Jul 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | floating | *Azolla caroliniana* | 5 |
| | 1 | floating | *Eichhornia crassipes* | 5 |
| | 1 | floating | *Lemna minor* | 85 |
| | 1 | floating | *Spirodela polyrrhiza* | 5 |
| | 1 | SAV | *Ceratophyllum demersum* | 30 |
| | 1 | SAV | *Heteranthera dubia* | 20 |
| | 1 | SAV | *Myriophyllum spicatum* | 20 |
| | 1 | SAV | *Najas guadalupensis* | 20 |
| | 1 | SAV | *Vallisneria americana* | 10 |
| | 2 | floating | *Azolla caroliniana* | 4 |
| | 2 | floating | *Eichhornia crassipes* | 1 |
| | 2 | floating | *Lemna minor* | 94 |
| | 2 | floating | *Spirodela polyrrhiza* | 1 |
| | 2 | SAV | *Ceratophyllum demersum* | 10 |
| | 2 | SAV | *Heteranthera dubia* | 5 |
| | 2 | SAV | *Najas guadalupensis* | 80 |
| | 2 | SAV | *Potamogeton pusillus* | 5 |
| | 3 | floating | *Azolla caroliniana* | 5 |
| | 3 | floating | *Eichhornia crassipes* | 5 |
| | 3 | floating | *Lemna minor* | 85 |
| | 3 | floating | *Spirodela polyrrhiza* | 5 |
| | 3 | SAV | *Ceratophyllum demersum* | 5 |
| | 3 | SAV | *Heteranthera dubia* | 5 |

(Table H.10.3 continued)

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 11 Jul 2014 | 3 | SAV | *Hydrilla verticillata* | 5 |
| | 3 | SAV | *Najas guadalupensis* | 80 |
| | 3 | SAV | *Stuckenia pectinata* | 5 |
| | 4 | floating | *Azolla caroliniana* | 5 |
| | 4 | floating | *Eichhornia crassipes* | 5 |
| | 4 | floating | *Lemna minor* | 85 |
| | 4 | floating | *Spirodela polyrrhiza* | 5 |
| | 4 | SAV | *Heteranthera dubia* | 5 |
| | 4 | SAV | *Myriophyllum spicatum* | 5 |
| | 4 | SAV | *Najas guadalupensis* | 80 |
| | 4 | SAV | *Potamogeton nodosus* | 5 |
| | 4 | SAV | *Stuckenia pectinata* | 5 |
| 22 Oct 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 70 |
| | 1 | floating | *Lemna minor* | 30 |
| | 1 | SAV | *Ceratophyllum demersum* | 25 |
| | 1 | SAV | *Heteranthera dubia* | 5 |
| | 1 | SAV | *Najas guadalupensis* | 70 |
| | 2 | floating | *Eichhornia crassipes* | 70 |
| | 2 | floating | *Lemna minor* | 30 |
| | 2 | SAV | *Ceratophyllum demersum* | 50 |
| | 2 | SAV | *Najas guadalupensis* | 50 |
| | 3 | floating | *Eichhornia crassipes* | 40 |
| | 3 | floating | *Lemna minor* | 60 |
| | 3 | SAV | *Ceratophyllum demersum* | 45 |
| | 3 | SAV | *Heteranthera dubia* | 10 |
| | 3 | SAV | *Najas guadalupensis* | 45 |
| | 4 | floating | *Eichhornia crassipes* | 30 |
| | 4 | floating | *Lemna minor* | 70 |
| | 4 | SAV | *Ceratophyllum demersum* | 50 |
| | 4 | SAV | *Najas guadalupensis* | 50 |

**H.11 Old Edge Marsh 2**

Location: 29° 4'47.70"N, 89°13'43.32"W

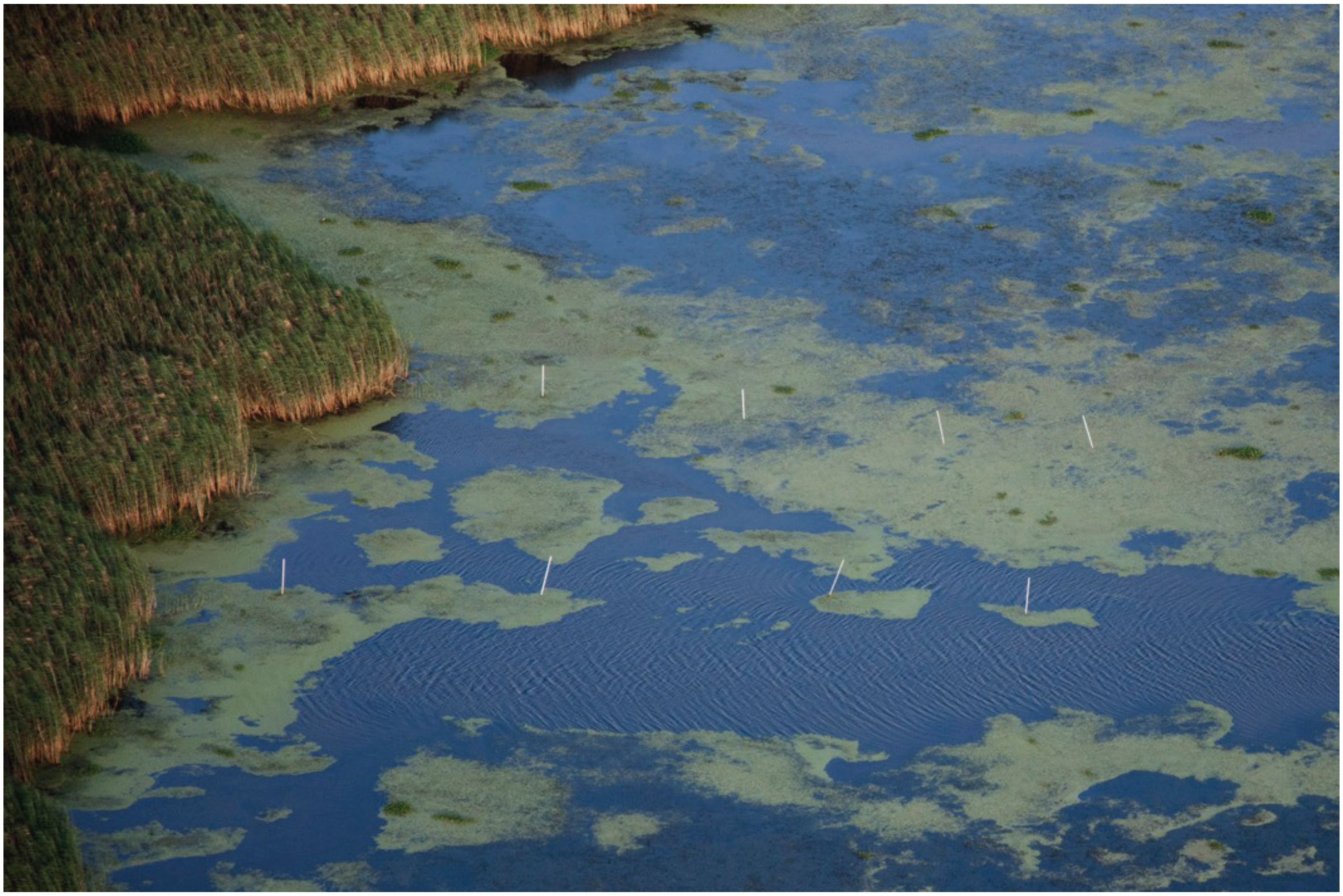

Figure H.11.1. Aerial view of study plot Old Edge 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.11.1. Water and environmental conditions at study plot Old Edge 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 29 Mar 2013 | 12:10 | 26.1 | 7.2 | 45.0 | 17.0 | 0.2 | 7.38 | 352.0 | 29.8 | 35.6 | 35.6 | | 36.8 | 34.4 |
| 01 Apr 2013 | 15:17 | 23.5 | 4.8 | 45.0 | 16.8 | 0.2 | 7.27 | 306.8 | 69.9 | 71.8 | 71.1 | | 78.7 | 72.9 |
| 04 Aug 2013 | 9:20 | 33.0 | 4.3 | 22.5 | 31.6 | 0.2 | 6.63 | 480.0 | 68 | 70 | 70 | | 79 | 72 |
| 08 Mar 2014 | 15:39 | 17.6 | 3.0 | 45.0 | 14.5 | 0.2 | 8.33 | 373.5 | 58.4 | 55.9 | 57.2 | 63.5 | 64.1 | 59.8 |
| 23 Oct 2014 | 14:00 | 23.0 | 5.6 | 20.0 | 22.7 | 0.8 | | 1521.0 | 67 | 72 | 73 | 72 | 71 | 71 |

Table H.11.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Old Edge 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 08 Mar 2014 | 6.25 | 0 | 52.5 | 0 | 41.25 | 1 | 0 | 1 |
| 23 Oct 2014 | 12.5 | 18.75 | 40 | 0 | 28.75 | 1 | 2 | 4 |

Table H.11.3. Vegetation species composition at study plot Old Edge 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 08 Mar 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 2 | SAV | *Myriophyllum spicatum* | 100 |
| | 3 | SAV | *Myriophyllum spicatum* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| | | | | |
| 23 Oct 2014 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | floating | *Eichhornia crassipes* | 50 |
| | 1 | floating | *Lemna minor* | 50 |
| | 1 | SAV | *Ceratophyllum demersum* | 95 |
| | 1 | SAV | *Myriophyllum spicatum* | 5 |
| | 2 | emergent | *Phragmites australis* | 100 |
| | 2 | floating | *Eichhornia crassipes* | 20 |
| | 2 | floating | *Lemna minor* | 80 |
| | 2 | SAV | *Ceratophyllum demersum* | 80 |
| | 2 | SAV | *Myriophyllum spicatum* | 10 |
| | 2 | SAV | *Ruppia maritima* | 10 |
| | 3 | floating | *Eichhornia crassipes* | 10 |
| | 3 | floating | *Lemna minor* | 90 |
| | 3 | SAV | *Ceratophyllum demersum* | 50 |
| | 3 | SAV | *Myriophyllum spicatum* | 40 |
| | 3 | SAV | *Najas guadalupensis* | 10 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 85 |
| | 4 | SAV | *Myriophyllum spicatum* | 10 |
| | 4 | SAV | *Najas guadalupensis* | 5 |

**H.12 Old Edge Marsh 3**

Location: 29° 3'58.21"N, 89°12'11.97"W

Figure H.12.1. North-facing view of Old Edge 3. The white poles mark the edges of the plot. Photo taken August 2013.

Table H.12.1. Water and environmental conditions at study plot Old Edge 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | Water depth (cm) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Distance from marsh edge (m) | | | | | |
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | 0 | 10 | 20 | 30 | 40 | Mean depth |
| 31 Mar 2013 | 15:18 | 21.1 | 9.7 | 247.5 | 18.0 | 0.3 | 7.20 | 597.0 | 132.08 | 134.62 | 138.43 | | 147.32 | 138.1125 |
| 02 Apr 2013 | 9:15 | 25.0 | 16.1 | 112.5 | 15.5 | 0.2 | 7.07 | 333.5 | 157.48 | 162.56 | 162.56 | | 167.64 | 162.56 |
| 06 Aug 2013 | 15:45 | 35.2 | 9.7 | 270.0 | 33.2 | 3.2 | 8.64 | 6030.0 | 116 | 123 | 137 | | 132 | 127 |
| 26 Oct 2013 | 14:53 | 25.5 | 11.4 | 67.5 | 23.4 | 2.9 | 7.76 | 5350.0 | 145 | 137 | 135 | 150 | 151 | 143.6 |
| 12 Apr 2014 | 15:28 | 21.8 | 17.0 | 135.0 | 23.5 | 1.0 | 9.24 | 2034.0 | 144.78 | 134.62 | 134.62 | 142.24 | 144.78 | 140.208 |
| 12 Jul 2014 | 18:52 | 29.5 | 0.0 | 0.0 | 30.2 | 0.8 | 7.36 | 1543.0 | 94.0 | 100.3 | 97.8 | 100.3 | 101.6 | 98.8 |
| 24 Oct 2014 | 7:58 | 18.7 | 16.6 | 20.0 | 21.9 | 1.1 | | 2137.0 | 127.0 | 143.0 | 148.0 | 137.5 | 142.0 | 139.5 |

Table H.12.2. Mean surface area cover and vegetation species richness across all plot zones at study plot Old Edge 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 26 Oct 2013 | 1.25 | 0 | 1.75 | 0 | 97 | 1 | 0 | 2 |
| 12 Apr 2014 | 0 | 0 | 2.5 | 0 | 97.5 | 0 | 0 | 2 |
| 12 Jul 2014 | 0 | 5 | 0.25 | 0 | 94.75 | 0 | 1 | 1 |
| 24 Oct 2014 | 0 | 5 | 1.25 | 0 | 93.75 | 0 | 1 | 1 |

Table H.12.3. Vegetation species composition at study plot Old Edge 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Zone | Vegetation types | Species | Percent |
|---|---|---|---|---|
| 26 Oct 2013 | 1 | emergent | *Phragmites australis* | 100 |
| | 1 | SAV | *Ceratophyllum demersum* | 50 |
| | 1 | SAV | *Myriophyllum spicatum* | 50 |
| | 3 | SAV | *Ceratophyllum demersum* | 50 |
| | 3 | SAV | *Myriophyllum spicatum* | 50 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 12 Apr 2014 | 1 | SAV | *Ceratophyllum demersum* | 10 |
| | 1 | SAV | *Myriophyllum spicatum* | 90 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 12 Jul 2014 | 1 | floating | *Lemna minor* | 100 |
| | 2 | floating | *Lemna minor* | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Myriophyllum spicatum* | 100 |
| 24 Oct 2014 | 1 | floating | *Lemna minor* | 100 |
| | 1 | SAV | *Ceratophyllum demersum* | 100 |
| | 2 | floating | *Lemna minor* | 100 |
| | 2 | SAV | *Ceratophyllum demersum* | 100 |
| | 3 | floating | *Lemna minor* | 100 |
| | 3 | SAV | *Ceratophyllum demersum* | 100 |
| | 4 | floating | *Lemna minor* | 100 |
| | 4 | SAV | *Ceratophyllum demersum* | 100 |

**H.13 Open Water 1**

Location: 29° 7'14.76"N, 89°12'58.40"W

Figure H.13.1. The general area of study plot Open Water 1. Photo taken August 18, 2014.

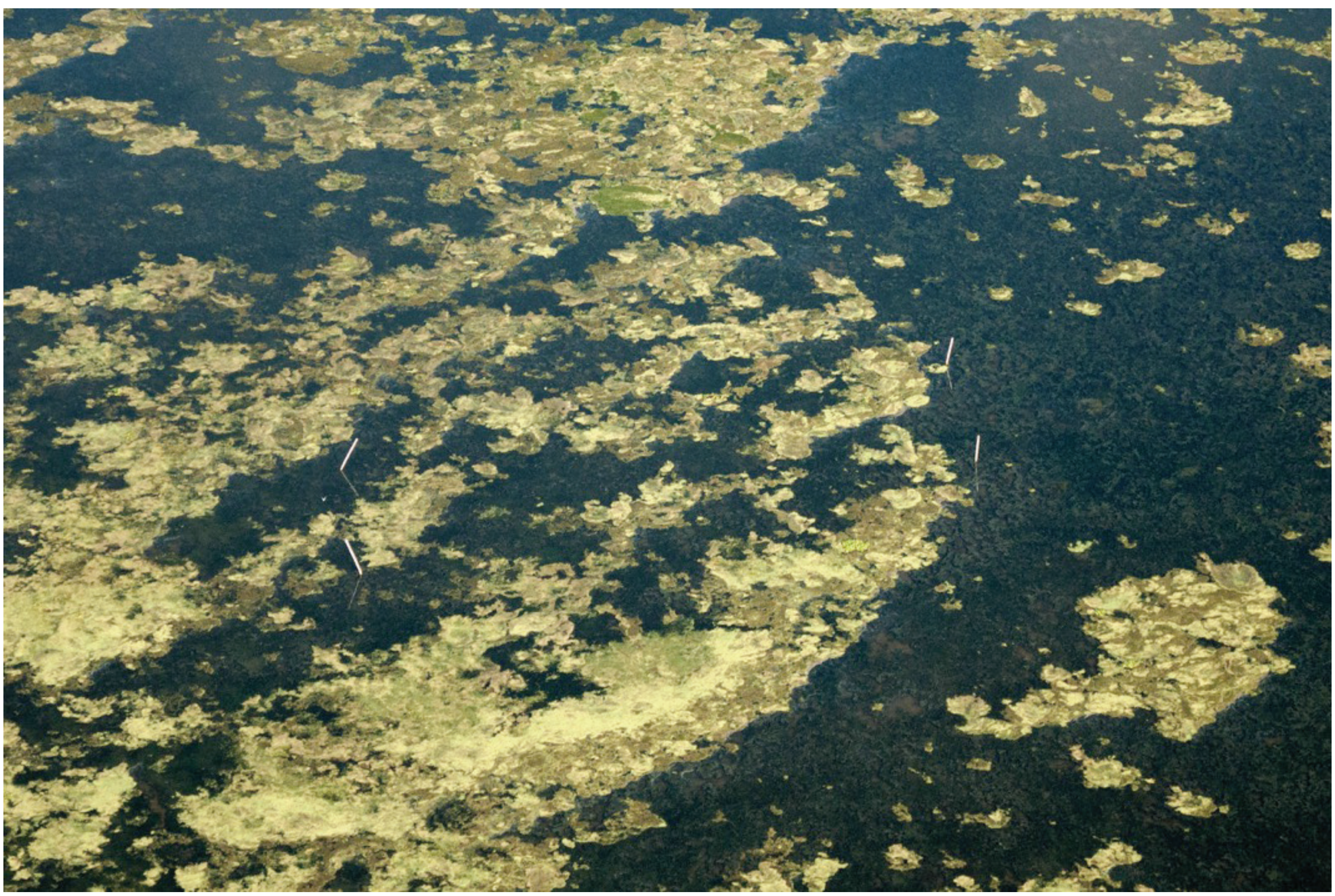

Figure H.13.2. Aerial view of study plot Open Water 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.13.1. Water and environmental conditions at study plot Open Water 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | Water depth (cm) |
| 30 Mar 2013 | 12:12 | 27.9 | 6.5 | 202.5 | 13.2 | 0.2 | 7.02 | 261.2 | 81.3 |
| 02 Apr 2013 | 14:10 | 25.8 | 8.1 | 135.0 | 15.8 | 0.2 | 7.51 | 282.1 | 86.4 |
| 06 Aug 2013 | 8:41 | 34.0 | 12.9 | 315.0 | 29.3 | 0.3 | 7.50 | 595.0 | 72.0 |
| 13 Oct 2013 | 15:02 | 29.9 | 7.1 | 135.0 | 30.5 | 2.3 | 8.75 | 4393.0 | 76.0 |
| 08 Feb 2014 | 12:05 | 20.6 | 11.3 | 45.0 | 14.7 | 0.2 | 8.23 | 470.0 | 58.4 |
| 11 Jul 2014 | 14:06 | 30.2 | 4.0 | 202.5 | 33.2 | 0.2 | 8.58 | 396.9 | 44.5 |
| 22 Oct 2014 | 17:27 | 20.0 | 0.0 | 0.0 | 24.1 | 0.5 | | 993.0 | 69.0 |

Table H.13.2. Surface area cover and vegetation species richness at study plot Open Water 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 13 Oct 2013 | 0 | 30 | 70 | 0 | 0 | 0 | 1 | 1 |
| 08 Feb 2014 | 0 | 0 | 40 | 0 | 60 | 0 | 0 | 1 |
| 11 Jul 2014 | 0 | 10 | 30 | 0 | 60 | 0 | 3 | 0 |
| 22 Oct 2014 | 0 | 20 | 30 | 0 | 50 | 0 | 3 | 4 |

Table H.13.3. Vegetation species composition at study plot Open Water 1 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Vegetation types | Species | Percent |
|---|---|---|---|
| 13 Oct 2013 | floating | *Lemna minor* | 100 |
| | SAV | unknown species | 100 |
| | | | |
| 08 Feb 2014 | SAV | *Myriophyllum spicatum* | 100 |
| | | | |
| 11 Jul 2014 | floating | *Azolla caroliniana* | 5 |
| | floating | *Lemna minor* | 90 |
| | floating | *Spirodela polyrrhiza* | 5 |
| | | | |
| 22 Oct 2014 | floating | *Eichhornia crassipes* | 5 |
| | floating | *Lemna minor* | 90 |
| | floating | *Salvinia molesta* | 5 |
| | SAV | *Ceratophyllum demersum* | 20 |
| | SAV | *Heteranthera dubia* | 10 |
| | SAV | *Myriophyllum spicatum* | 60 |
| | SAV | *Najas guadalupensis* | 10 |

## H. 14 Open Water 2

Location: 29° 4'42.60"N, 89°13'45.28"W

Figure H.14.1. Aerial view of study plot Open Water 2. The white poles mark the edges of the plot. Photo taken August 18, 2014.

Table H.14.1. Water and environmental conditions at study plot Open Water 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | Water depth (cm) |
| 29 Mar 2013 | 12:10 | 26.1 | 7.2 | 45.0 | 16.4 | 0.2 | 7.10 | 325.0 | 76.2 |
| 01 Apr 2013 | 15:17 | 23.5 | 4.8 | 45.0 | 18.4 | 0.2 | 7.39 | 344.9 | 78.7 |
| 04 Aug 2013 | 9:20 | 35.5 | 16.1 | 22.5 | 30.3 | 0.2 | 7.52 | 439.4 | 76.0 |
| 08 Mar 2014 | 15:39 | 17.4 | 8.6 | 45.0 | 14.3 | 0.2 | 8.43 | 371.5 | 66.0 |
| 23 Oct 2014 | 14:00 | 23.0 | 13.7 | 20.0 | 24.6 | 0.8 | | 1568.0 | 78.0 |

Table H.14.2. Surface area cover and vegetation species richness at study plot Open Water 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 08 Mar 2014 | 0 | 0 | 10 | 0 | 90 | 0 | 0 | 1 |
| 23 Oct 2014 | 0 | 5 | 30 | 0 | 65 | 0 | 1 | 3 |

Table H.14.3. Vegetation species composition at study plot Open Water 2 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Vegetation types | Species | Percent |
|---|---|---|---|
| 08 Mar 2014 | SAV | *Myriophyllum spicatum* | 100 |
| | | | |
| 23 Oct 2014 | floating | *Eichhornia crassipes* | 100 |
| | SAV | *Ceratophyllum demersum* | 35 |
| | SAV | *Heteranthera dubia* | 30 |
| | SAV | *Myriophyllum spicatum* | 35 |

**H. 15 Open Water 3**

Location: 29° 4'1.35"N, 89°12'10.59"W

Figure H.13.1. North-facing view of study plot Open Water 3. The white poles mark the edges of the plot. Photo taken August 3, 2013.

Table H.15.1. Water and environmental conditions at study plot Open Water 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | | Weather conditions | | | Water conditions | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Time | Temp (C*) | Wind speed (km/h) | Wind direction (degree) | Temp (C*) | Salinity (ppt) | pH | Conductivity (µmhos/cm) | Water depth (cm) |
| 31 Mar 2013 | 15:18 | 21.1 | 9.7 | 247.5 | 17.2 | 0.3 | 7.05 | 544.0 | 154.9 |
| 02 Apr 2013 | 9:15 | 25.0 | 16.1 | 112.5 | 15.1 | 0.2 | 7.26 | 336.6 | 177.8 |
| 06 Aug 2013 | 15:45 | 34.7 | 9.0 | | 33.3 | 3.3 | 8.57 | 6120.0 | 131.0 |
| 26 Oct 2013 | 14:53 | 24.1 | 9.3 | 22.5 | 23.5 | 3.6 | 8.05 | 6670.0 | 165.0 |
| 12 Apr 2014 | 15:28 | 21.8 | 17.0 | 135.0 | 23.5 | 1.1 | 9.17 | 2216.0 | 154.9 |
| 12 Jul 2014 | 18:52 | 29.5 | 0.0 | 0.0 | 30.5 | 0.7 | 7.66 | 1441.0 | 109.2 |
| 24 Oct 2014 | 7:58 | 18.7 | 17.4 | 20.0 | 22.3 | 1.3 | | 2469.0 | 158.8 |

Table H.15.2. Surface area cover and vegetation species richness at study plot Open Water 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| | Surface area percent cover | | | | | Species richness | | |
|---|---|---|---|---|---|---|---|---|
| Date | Emergent vegetation | SAV | Floating vegetation | Mudflat | Open water | Emergent vegetation | SAV | Floating vegetation |
| 26 Oct 2013 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 12 Apr 2014 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| 12 Jul 2014 | 0 | 5 | 0 | 0 | 95 | 0 | 2 | 0 |
| 24 Oct 2014 | 0 | 5 | 1 | 0 | 94 | 0 | 1 | 1 |

Table H.15.3. Vegetation species composition at study plot Open Water 3 in the Mississippi River Delta, Louisiana, USA, 2013-2014.

| Date | Vegetation types | Species | Percent |
|---|---|---|---|
| 12 Jul 2014 | floating | *Eichhornia crassipes* | 10 |
| | floating | *Lemna minor* | 90 |
| 24 Oct 2014 | floating | *Eichhornia crassipes* | 100 |
| | SAV | *Ceratophyllum demersum* | 100 |

# VITA

Lauren Rae Sullivan grew up in southwestern Ohio and received a Bachelor of Urban Planning from University of Cincinnati in 2009. While attending the University of Cincinnati, she interned as an urban planner in New Orleans and developed a passion for the protection and restoration of wetlands. She moved back to New Orleans after graduation and worked as a film location management assistant for multiple movies and television shows. Her long-term professional interests were still focused on natural resources, though. After attending local science conferences, reading countless journal articles, and speaking to researchers from across North America, her passion for Louisiana's wetlands lead her the lab of Dr. J. Andrew Nyman and the Coastal Sustainability Studio (CSS) at Louisiana State University. She worked as a graduate assistant for CSS from 2012-2014 exploring strategies for improving the resilience of small coastal communities in the state to hurricanes and sea-level rise. During her last part-time semesters at LSU in 2015, she assisted with shorebird surveys in Dauphin Island, Alabama and monitored a Caspian Tern breeding colony on the Oregon coast. After graduation, she will be pursuing opportunities in wetland management or wildlife research.