STATUS, DISTRIBUTION, AND HABITAT SELECTION OF SECRETIVE MARSH BIRDS IN THE DELTA OF ARKANSAS

STATUS, DISTRIBUTION, AND HABITAT SELECTION OF SECRETIVE MARSH BIRDS IN THE DELTA OF ARKANSAS

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Master of Science

By

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ABSTRACT

The status and distribution of secretive marsh birds in Arkansas is not well known. Most marsh bird populations are in decline and are listed as species of management concern by federal, state, and local agencies. I surveyed the Delta during the summers of 2005 and 2006 using call-playback surveys and multiple repeat visits at each site to determine the current status of secretive marsh birds. I surveyed 190 sites overall for 2005 and 2006 and found that secretive marsh birds were uncommon in this region. All breeding species were detected at less than 22% of sites surveyed. I found that most secretive marsh bird species occurred more frequently in the southern region of the Delta. I modeled habitat selection of the least bittern (*Ixobrychus exilis*) and pied-billed grebe (*Podilymbus podiceps*) as they were the only species detected at enough sites to permit analysis. I used program PRESENCE, which accounts for imperfect detection, to model habitat selection. Model selection provided substantial support for the least bittern's selection of wetlands with increasing amounts of emergent vegetation and minimal amounts of forest adjacent to the wetland. Model selection did not provide support for habitat selection by the pied-billed grebe.

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CHAPTER 1: STATUS AND DISTRIBUTION OF SECRETIVE MARSH BIRDS IN THE DELTA OF ARKANSAS.

INTRODUCTION

The lower Mississippi alluvial valley of Arkansas, hereafter referred to as the Delta, was once part of a vast wetland area comprised of mostly bottomland hardwoods as well as emergent, and submergent wetlands, and prairie. Between the 1950s and the 1970s, much of this land was cleared and converted to agriculture and aquaculture facilities (King and Keeland 1999). Along with this change in land use has been an unknown change in the use of those wetlands by secretive marsh birds.

Secretive marsh birds include all species that primarily inhabit marshes (e.g., marsh-dependent species). Primary species of concern in North America include the yellow rail (*Coturnicops noveboracensis*), American coot (*Fulica americana*), common moorhen (*Gallinula chloropus*), black rail (*Laterallus jamaicensis*), purple gallinule (*Porphyrula martinica*), sora (*Porzana carolina*), king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), clapper rail (*Rallus longirostris*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), and pied-billed grebe (*Podilymbus podiceps*).

The U.S. Fish and Wildlife Service (USFWS) has identified the black rail, least bittern, and American bittern as species of special concern because they are relatively rare and we lack basic information on status and trends in most areas (USFWS 2002). Many U.S. states consider these species threatened or of special concern for similar reasons. In addition, Canada has listed king rails as endangered provincially (James 2000), and least bitterns are considered threatened provincially (James 1999).

Because rails and bitterns consume a wide variety of aquatic invertebrates, populations may be affected by accumulation of environmental contaminants in wetland substrates (Eddleman et al. 1988, Gibbs et al. 1992, Conway 2003). Marsh birds are also vulnerable to reduced wetland quality by wetland invaders such as purple loosestrife (*Lythrum salicaria*) (Gibbs et al. 1992, Meanley 1992). Hence, marsh birds represent "indicator species" for assessing wetland ecosystem quality, and their presence can be used as one measure of the success of wetland restoration efforts (Conway 2003).

Several rails are game species in many states yet we lack reliable population surveys on which to base harvest limits (Conway 2003). Recently, the Webless Shorebird committee of the Mississippi Flyway Technical Section raised concerns over the season framework and bag limit of the king rail (D.G. Krementz, U.S. Geological Survey, personal communication). In addition, the daily harvest limits for the common moorhen and purple gallinule in Arkansas is 15 over a 70-day season (AGFC 2007). These liberal bag limits have not been justified through population estimates, or surveys.

The current status of secretive marsh birds in Arkansas is mostly unknown (K. Rowe, Arkansas Game and Fish Commission (AGFC), personal communication). Meanley (1969) conducted extensive fieldwork on rails and other wetland dependent birds in the Delta. At that time, marsh birds in the vicinity of Stuttgart were "common". The Breeding Bird Survey (BBS) has routes in the Delta that have been run for a number of years (Sauer et al. 2005), but two aspects of the BBS do not lend themselves well for surveying secretive marsh birds. First, secretive marsh birds are by nature difficult to detect, and usually can only be detected using call-playback methods, which is not part of the BBS protocol. Second, the surveys rely on roads, which typically are not located in or near extensive marshes where these species occur. Evidence of the difficulty in detecting secretive marsh birds is the absence of secretive marsh birds showing up on Arkansas wetland bird trend analyses for 1966-2004 censuses (Sauer et al. 2005).

Estimates of abundance traditionally are used as a measure of population status; however abundance estimation often requires more expense and effort than site occupancy (MacKenzie et al 2002). Estimating the proportion of sites occupied, denoted as Ψ, by a target species is important in long-term monitoring programs (Mackenzie et al. 2003). In a monitoring context, the proportion of monitored sites (e.g., wetlands, or habitat patches) within a region where the species is present can be used as a surrogate for population size or species abundance; this is particularly true for cryptic, low-density, and/or territorial species (MacKenzie 2005). The underlying logic is that changes in Ψ will be correlated with changes in population size (MacKenzie 2005, MacKenzie et al. 2003). An important, commonly overlooked fact is that the species often will not be detected even when present at a site, and failing to account for imperfect detectability will result in underestimates of site occupancy (MacKenzie 2003). Site occupancy estimates can be used to monitor marsh bird populations in the Delta over time if the method proves useful.

I chose to survey in the Delta because previous work on secretive marsh birds there indicated that the Delta harbored many species and had good numbers (Meanley 1969, 1992). By studying in the Delta, I could evaluate the methods used to estimate occupancy and determine if the methods could be implemented across the rest of the state.

My objectives were to: 1) determine the current status and distribution of secretive marsh birds in the Delta, 2) define areas suitable for future marsh bird research, and 3) to evaluate the methods used to estimate occupancy.

STUDY AREA

I performed this study in the Arkansas Delta (Fig.1). The Delta is a distinct physiographic province of the southeastern United States and is treated as a unique Bird Conservation Region by the Partners in Flight bird conservation initiative (Williams and Pashley 2000). The Delta occupies the eastern part of the state, bounded on the southwest by the Coastal Plain and on the northwest by the Ouachita Mountains and the Ozark Mountains. In the Delta the work of large rivers has been dominant in forming the character of the land. The Arkansas River, the White, the St. Francis, and the Mississippi have flowed through this region, cutting away older deposits and building up deposits of sand, gravel, and clay (Crow 1974). According to Crow (1974), the elevation of the Delta varies only about 46-m in the entire 402-km length of the division, bounded by Missouri on the north, and Louisiana on the south. This region is dominated by extensive agriculture with fragments of remnant bottomland hardwood forest (King et al. 2006).

Wetland habitat types surveyed included bottomland hardwood stands, cypress (*Cyperus spp*.) bayous, buttonbush (*Cephalanthus spp*.) swamps, willow (*Salix spp*.) swamps, cattail (*Typha spp.)* marshes, reservoirs with minimal vegetation, and wetlands with a mixture of habitat types. Sites ranged from large wetland areas, such as National Wildlife Refuges (NWR), Wildlife Management Areas (WMA) managed by the AGFC, and Wetland Reserve Program lands (WRP), to isolated wetlands typically found on private land.

In 2006, I targeted WRP lands since my 2005 data indicated that they might provide appropriate habitat for marsh birds. WRP is a voluntary program implemented by the Natural Resources Conservation Service (NRCS) in the U.S. Department of Agriculture. Under program guidelines, eligible landowners are provided financial incentives to restore wetlands and retire marginal farmlands, sometimes permanently, from agricultural production (King et al. 2006). Surveying WRP lands allowed me to assess restoration efforts and determine their suitability for marsh birds.

I surveyed at 190 sampling points, hereafter referred to as sites, throughout the Delta in 2005 and 2006 (Figs. 2-5), 80 of which were surveyed in 2005 (Table 1), and 110 were surveyed in 2006 (Table 3). Overall, I surveyed 88 sites in the southern region, 61 in the central, and 41 in the northern. In 2005, 32 sites were on NWRs, 14 on private land, 15 on WRP lands, 16 on WMAs, 2 on Army Corp of Engineer (ACOE) lands, and 1 was on National Park Service (NPS) land. In 2006, 26 sites were on NWRs, 63 on private land, 16 on WRP lands, and 5 were co-managed as a WMA/WRP. In 2005, I surveyed Big Lake, Bald Knob, Cache River, Overflow and its subunit Oakwood, White River, and Wapanonca NWRs. In 2006, I surveyed Bald Knob, Cache River, Overflow and its subunit Oakwood, White River, and Wapanonca NWRs. In 2005, the WRP sites were owned by 3 different landowners and were managed independently of each other. In 2006, the WRP sites were owned by 5 different landowners and were managed independently of each other. In 2005, I surveyed Bayou Meto, Bayou DeView, Black

River, Cut-off Creek, and Mallard Lake WMAs. In 2006, I surveyed the Raft Creek WMA, which was also managed as a WRP.

METHODS

Site selection - I used a random sample to select wetlands based on 3 main strata: 1) large vs. small wetland area, 2) marsh vs. swamp and, 3) a large forest area vs. small forest area adjacent to the wetland.

I split the Delta into 3 main regions: 1) Northern, 2) Central, and 3) Southern, as it was the most logistically feasible approach, allowing me to work out of a central location in each region. I split the Delta into these 3 regions based on approximate equal area. I used a Geographic Information System (GIS) and assigned each county per region a number. I randomly generated a number using MS® Excel to determine which county I would further refine the selection from. I then split the county into approximately equal quarters based on area after I selected a county, and assigned each quarter a number, 1- 4. I then randomly generated a number to determine which quarter section to select. I repeated this step once more, to where the previous quarter section was split into four sections again. I set the aerial image of that section to a 1:100,000 scale, which allowed me to view wetland types. I overlaid a transparent grid, which was numbered 1-28 in x and y directions, over the aerial image once at this scale. I randomly generated two numbers in MS® Excel, ranging from 1-28, to determine which grid cell to choose from. I used the center of the selected cell as the location of the site. I selected the wetland closest to that cell if a wetland was not located in that exact cell. I used a handheld Global Positioning System (GPS) to find the wetlands once in the field.

I repeated this method in 2005 and 2006 until I had approximately 50 sites per each region per year, and an approximately equal distribution of the 3 main variables of interest. I used this method because the National Wetlands Inventory (NWI), or an assessment of available wetland habitats, has not been completed for the Delta. NWI data is typically available through the USFWS in a digital format, but has only been digitized for a small region of the Delta. In addition, these data were compiled in the 1970s and 1980s and are out of date.

Wetland area was based on the proportion of a 400-m radius circle, centered at the sampling point, that was covered in water, with >50% being a large wetland area, 10-50% being a medium sized wetland area, and <10% being a small wetland area. These scales also indicate the degree of isolation. A marsh is a wetland characterized by herbaceous hydrophytic vegetation, and a swamp is defined as a wetland containing ≥30% woody vegetation (Cowardin et al. 1979). Forest area was based on the proportion of a 400-m radius circle that was covered in woody vegetation ≥6-m in height, with >50% being a large forested area, 10-50% being a moderate amount of forest area, and <10% being minimal amounts of adjacent forest area.

During my selections, I discovered that not all combinations of variables were possible and some sites were selected non-randomly as a result. I selected large wetland areas containing emergent vegetation non-randomly as they usually only existed at NWRs and WRP lands. I selected several sites haphazardly due to logistical problems, or because designated wetlands no longer existed. In that instance, I selected the wetlands closest to the randomly selected wetland.

Marsh bird surveys – I spent ~10 days in each region with ~ 20 days between each round of surveys. I repeated this process 3 times; so three 10-day sampling periods were conducted for each region with ~ 20 days between each period.

I conducted surveys from 16 April to 8 July 2005, and from 3 April to 21 June 2006. I assumed that the earliest nesting marsh bird was the king rail, which breeds in early April (Meanley 1953), and based on detection rates during the summer, I assumed the first round of nesting ended in late June. The birds were likely still at the sites but were not vocalizing, which potentially leads to false absences. I assumed that the sampled sites were closed to immigration and emigration during the survey period each year (MacKenzie et al. 2006).

I conducted surveys following the North American Marsh Bird Monitoring Protocol (Conway 2003). I trained and tested observers on the calls of secretive marsh birds before surveying. I broadcasted the breeding and territorial calls of the following species in the following order: least bittern, Virginia rail, king rail, common moorhen, purple gallinule, and the pied-billed grebe. Audio recordings were obtained from C. J. Conway (USGS Arizona Cooperative Fish and Wildlife Research Unit). The broadcast consisted of: 5, 1-min segments of silence, and for each species: 30 sec of breeding and territorial calls, followed by 30 sec of silence. I recorded when an individual was detected in respect to the segment of the broadcast it responded to, and the type of detection (e.g. auditory, visual, auditory and visual) (Conway 2003).

I also recorded distribution data of the sora, American bittern, American coot, and for these non-secretive marsh birds: mottled duck (*Anas fulvigula*), black-bellied whistling duck (*Dendrocygna autumnalis*), fulvous whistling duck (*Dendrocygna* *bicolor*), white ibis (*Eudocimus albus*), white-faced ibis (*Plegadis chihi*), glossy ibis (*Plegadis falcinellus*), wood stork (*Mycteria americana*), yellow-crowned night heron (*Nyctanassa violacea*), and black-crowned night heron (*Nycticorax nycticorax*). The AGFC was interested in the current distribution of these non-secretive marsh birds.

I conducted surveys 30 min before sunrise to 2 hrs after, and from 2 hrs before sunset to 30 min after (Conway 2003). I did not conduct surveys during heavy rain, heavy fog, or wind speeds $\geq$19 km/hr. I broadcast breeding and territorial calls from portable audio devices (volume = 80-90 db at 1-m from source) to elicit responses from the birds. I separated sites by ≥200-m to avoid double counting individuals (Conway 2003).

I recorded on each survey: the species present, numbers detected, and the distance to each individual. Distance was estimated visually from the sampling point to the point where the bird was first heard or seen. Birds were only counted if found occupying the selected site. If I located marsh birds on adjacent wetland units, or during travel among sites, I recorded the species, count, and UTM coordinates as opportunistic detections. Results are reported as birds detected at randomly selected sites first, followed by opportunistic detections for each species.

If a site dried out between visits, I still conducted one or two more surveys, as marsh birds sometimes nest in dry areas (Meanley 1953). Also, any wetlands found near the original site that dried up were surveyed and added as new sites.

In 2005, since I did not have information on detection probabilities for these species in the Delta, I attempted to make 15 visits to each site. According to Conway et al. (2004) conducting 15 repeats would be the maximum needed to ensure >90%

probability of detecting the species given it is present. During each 10 day period I completed 5 visits, giving 15 visits overall. In 2006, the numbers of repeat visits were reduced to 9 based on 2005 results, as 9 would provide approximately the same amount of uncertainty as 15 (MacKenzie and Royle 2005). Scaling back to 9 visits also allowed for an increase in the number of sites surveyed. In 2006, I conducted 4 visits during the first 10-day period, 3 during the second, and 2 during the third. I put more emphasis on surveying earlier in the season in case another drought occurred, as in 2005.

I qualitatively compared calling rates of morning versus evening surveys, for breeding marsh birds, by summing up the number of morning and evening surveys where the species was detected. I made this comparison to investigate if any species are more likely to be detected during one period than the other. I used the number of individuals of each breeding marsh bird species detected during each visit to determine the number of responses that were auditory, visual, or both auditory and visual. I used this summary to emphasize the importance of knowing species by their vocalizations. I recorded at which segment of the survey when individuals were detected, and summed for each species, the number of responses for each segment of the broadcast to investigate the effectiveness of call-broadcasts. I used the maximum number of individuals detected during any one visit at each site to determine the number of individuals counted overall for each marsh bird species (Paracuellos and Telleria 2004). I counted the number of individuals to estimate the average number of individuals found at occupied sites, as well as the maximum, and the mode. The total number of individuals counted overall is not an abundance estimate, but an estimate of the minimum number of individuals encountered. In addition, I summarized the number of detections in each of the 3 regions to investigate any regional effects and to determine where future wetland restoration efforts and secretive marsh bird studies should focus.

DATA ANALYSIS

Detection estimation - I used program PRESENCE 2.0 (available for download at http://www.mbr-pwrc.usgs.gov/software.html) to estimate detection probabilities, or the probability of detecting a species given that it is present (Bailey et al. 2004, MacKenzie et al. 2002). I used the detection probability for each species to estimate the probability of a false absence using the formula: $(1-p)^k$, where p equals the detection probability and k equals the average number of visits conducted (MacKenzie et al. 2006). I used this estimate to determine if the number of repeat visits adequately determined species presence/absence. I assumed the number of repeat visits was adequate if the probability of a false absence was ≤ 0.2.

Occupancy estimation – I used program PRESENCE 2.0 to estimate occupancy rates, or the proportion of sites occupied (Ψ), for breeding secretive marsh birds. Assumptions of occupancy estimation are that: 1) the sites are closed to emigration and immigration, and 2) the probability of site occupancy is independent of other sites (MacKenzie et al. 2006). This method involves visiting sites multiple times within a season where a target species is either detected, with probability p, or not detected. The goal is to estimate Ψ, knowing the species is not always detected, even when present (Bailey et al. 2004). This type of model, analogous to capture-recapture models, enable the inclusion of site variables (e.g., habitat type, wetland size), as well as time varying covariates (e.g., air temperature, cloud cover) to explain variation in occupancy and/or detection probabilities (Bailey et al. 2004, MacKenzie et al. 2002). In the most general form, the modeling approach of MacKenzie et al. (2002) could be considered as performing simultaneous logistic regression analyses on both occupancy and detection probabilities (MacKenzie and Royle 2005)

For most animal sampling situations, detection of a species is indicative of “presence”, but non-detection of the species is not equivalent to absence (MacKenzie et al. 2002). Thus, most estimates of Ψ are negatively biased to some unknown degree because species can go undetected when present (MacKenzie et al. 2002). Program PRESENCE accounts for non-detection and provides a more realistic estimate of Ψ. Non-detection of a species can mean the species was present but not detected, or that the species was truly absent from the site.

Since several species were surveyed it is likely that the timing of surveys may be appropriate for one species, but too early for other species (Rehm and Baldassarre 2007, Gibbs and Melvin 1993). This was true for the least bittern in 2006, as they arrived later in the season. I truncated the least bittern data by including only the data after the date of first detection. Truncating the data in this manner ensures that the species was available to be detected throughout that portion of the monitoring period, thus satisfying the closure assumption (MacKenzie et al. 2002). As a result, the sample size for the least bittern analysis was smaller. In addition, the sample size for the pied-billed grebe was smaller than the other species as a result of omitting sites that were irrigation ditches. Irrigation ditches provide minimum suitable habitat for the least bittern and king rail, but not for the pied-billed grebe

In several cases site independence was questionable because multiple points occurred in larger wetlands. I collapsed detection histories into one history if sites were in the same wetland, and all habitat covariates were the same, to deal with this issue (D. MacKenzie, Proteus Wildlife Research Consultants, personal communication). For example, if 3 sites were in the same large wetland, and the habitat was consistent at all 3 sites, their histories were collapsed. If the detection histories at the 3 sites read, 0100, 0010, 0011, given 4 visits at each site, the collapsed history would read 0111. A 0 indicates the species was not detected, and a 1 indicates the species was detected. By collapsing multiple site histories into one history, it is likely that the detection probabilities would be inflated. To account for this problem, I used a covariate to indicate the number of sites that were collapsed (D. MacKenzie, Proteus Wildlife Research Consultants, personal communication), which would be 3 in the previous example. This method satisfies the assumption that the probability of sites being occupied are independent of each other.

As a result of collapsing, the sample size in the occupancy estimation is smaller than the actual number of sites surveyed. I also eliminated sites with fewer than 5 visits in 2005, and 4 visits in 2006. I chose these cutoffs, as it is roughly half of the average number of visits overall for the respective year.

Program PRESENCE can test for observer effects. If observer effects were significant, I included them and the number of sites collapsed variable to explain the variation in *p*. I assumed that the National Marsh Bird Protocol accounted for the other variables known to influence *p*, such as temperature, wind speed, rain, etc. I did not include a variable for morning vs. evening surveys since exploratory analysis did not indicate an effect. I compared the number of morning observations to evening observations for the exploratory analysis.

RESULTS

In 2005, 21% of the sites were surveyed 15 times (AVG. = 10, SE = 0.44). In 2005 wetland permanence was a major issue as the Delta experienced a drought. The drought resulted in several sites (n = 33) completely drying before surveying them 15 times. In 2006, 86% of the sites were surveyed 9 times (AVG. = 8.45, SE = 0.14). The average number of visits for least bitterns after satisfying the site closure assumption was 6 (SE = 0.19).

In 2005, 54% of sites had ≥1 species of secretive marsh bird, and 28% of sites had >1 species. The average number of species per occupied wetland was 1.9 (SE = 0.16). The maximum number of marsh bird species found at any one site was 5, which occurred at 1 site.

In 2006, 46% of sites had ≥1 species of secretive marsh bird and 56% of sites had >1 species. The average number of species per occupied wetland was 2.3 (SE = 0.21). The maximum number of marsh bird species found at any one site was 6, which occurred at 1 site.

SPECIES ACCOUNTS

Pied-billed grebe – In 2005 I detected the pied-billed grebe at 9 sites and counted 28 individuals (AVG. = 2.8, SE = 0.59, max. = 6, mode = 1). I opportunistically detected the pied-billed grebe at 3 additional sites (Table 2). In 2006 I detected the pied-billed grebe at 20 sites and counted 53 individuals (AVG. = 2.5, SE = 0.44, max. = 10, mode = 1) (Table 3). I opportunistically detected the pied-billed grebe at 10 additional sites (Table 4). Of the 29 randomly selected sites occupied by pied billed grebes in 2005 and

2006, 11 were on federal land, 7 on WRP land, 10 on private land, and 1 on a WMA. I detected the pied-billed grebe at 15 sites in the southern region, 11 in the central, and 3 in the northern region overall in 2005 and 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 6).

When I detected the pied-billed grebe, I also detected the American coot 43% of the time, 43% of the time I also detected the least bittern, while other species were not associated as frequently (Table 5). Aural observations accounted for 72% of all detections, 23% were both aural and visual, and 20% were visual only (Table 6). The average distance to each observation was 91.4-m (SE = 3.3, max. = 350, mode = 100).

In 2005, I detected the pied-billed grebe at 29 out of 369 morning surveys and 28 out of 412 evening surveys. In 2006, I detected the pied-billed grebe during 43 out of 411 morning surveys and during 31 out of 476 evening surveys. Detection rates were steady throughout the 2005 and 2006 season (Fig. 7). I detected more pied-billed grebes after its breeding and territorial calls were broadcast (Fig. 8).

In 2005, a brood consisting of 3 young was detected at Cache River NWR (Table 1). In 2006, one nest and a brood, consisting of 3 young were detected at Wallace Trust WRP (Table 4).

Least bittern – In 2005, I detected least bitterns at 15 sites, and counted 20 individuals (AVG. = 1, SE = 0.21, max. = 4, mode = 1) (Table 1). I opportunistically detected least bitterns at 2 additional sites (Table 2). In 2006, I detected least bitterns at 20 sites and counted 37 individuals (AVG. = 1.9, SE = 0.25, max. = 5, mode = 1) (Table 3). I opportunistically detected the least bittern at 6 additional sites (Table 4). Of the 25 randomly selected sites occupied by least bitterns for 2005 and 2006, 14 were on federal land, 8 on WRP land, 2 on private land, and 1 on a WMA. I detected the least bittern at 22 sites in the southern region, 7 in the central, and 5 in the northern region overall in 2005 and 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 9).

When I detected the least bittern I also detected the sora 46% of the time, 37% of the time I also detected the pied-billed grebe, while other species were not associated as frequently (Table 5). Aural observation accounted for 86% of all observations, 4% were both aural and visual, and 10% were visuals (Table 6). The average distance to each observation was 58.3-m (SE = 2.42, max. = 150, mode = 70).

In 2005, I detected the least bittern during 26 out of 376 morning surveys and 16 out of 412 evening surveys. In 2006, I detected the least bittern during 30 out of 351 morning surveys and 36 out of 394 evening surveys. In 2005, detection rates increased as the season progressed (Fig. 7). In 2006, detection rates increased from April to May then decreased through June (Fig. 7). I detected more least bitterns after its breeding and territorial calls were broadcast (Fig. 10).

Two active nests and two initiated nests were found on 6 June 2006 at the Wallace trust WRP. On 7 June 2006 4 eggs were found in an active nest on the Chicot County WRP site. This nest was later found destroyed in late June. All nests, and initiated nests were found in patches of square stem spike-rush (*Eleocharis quadrangulata*). Several individuals were flushed from this same habitat and appeared to have been nest building as stems were bent over into a bowl characteristic of active nests.

American bittern - In 2005, I detected the American bittern at 5 sites and counted 9 individuals (AVG = 1.6, SE = 0.6, max. = 4, mode = 1) (Table 1). In 2006, I detected the American bittern at 16 sites and counted 24 individuals (AVG. = 1.5, SE = 0.33, max. = 6, mode = 1) (Table 3). I opportunistically detected the American bittern at 8 additional sites (Table 4). Of the 21 randomly selected sites occupied by the American bittern for 2005 and 2006, 10 were on federal land, 5 were on WRP land, 5 were on private land, and 1 site was managed as a WRP/WMA. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 11). I did not detect American bitterns after 18 May 2006.

When I detected the American bittern I also detected the sora 52% of the time, 38% of the time I also detected the pied-billed grebe, while other species were not associated as frequently (Table 5). Aural detections accounted for 21% of all observations, 9% were both aural and visual, and 70% were visual (Table 6).

Sora – In 2005, I detected soras at 21 sites and counted 43 individuals (AVG = 2.0, SE = 0.66, max. = 15, mode = 1) (Table 1). I opportunistically detected the sora at 7 additional sites (Table 2). In 2006, I detected the sora at 29 sites and counted 45 individuals (AVG. = 1.6, SE = .17, max. = 5, mode = 1) (Table 3). I opportunistically detected the sora at 15 additional sites (Table 4). Of the 50 randomly selected sites occupied by the sora, 18 were on federal land, 15 on WRP land, 14 on private land, and 3 were co-managed as a WRP/WMA. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 12). The latest record for the sora was 27 May 2005.

When I detected the sora I also detected the least bittern 32% of the time, while other species were not associated as frequently (Table 5). Aural observations accounted for 63% of all detections, 2% were both aural and visual, and 27% were visual (Table 6). The average distance to each observation was 48.2-m (SE = 2.71, max. = 150, mode = 20).

Virginia rail – In 2005 I detected the Virginia rail at 5 sites, and counted 6 individuals (AVG. = 1.2, SE = 0.2, max = 2, mode = 1) (Table 1). I opportunistically located the Virginia rail at 1 additional site (Table 2). In 2006, I detected the Virginia rail at 9 sites with 10 individuals counted (AVG. = 1.11, SE = 0.11, max = 2, mode =1) (Table 3). I opportunistically located the Virginia rail at 4 additional sites (Table 4). Of the 14 randomly selected sites occupied by the Virginia rail, 8 were on federal land, 1 was on WRP land, 4 were on private land, and 1 was co-managed as a WRP/WMA. The last Virginia rail observation was made on 7 May 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 13).

When I detected the Virginia rail I also detected the sora 79% of the time, 50% of the time I also detected the American bittern, and 43% of the time the king rail, while other species were not associated as frequently (Table 5). Aural detections accounted for 75% of all responses, 0% was both aural and visual, and 25% were visual (Table 6). The average distance to each observation was 30.8-m (SE = 4.2, max. = 60, mode = 30).

King rail - In 2005, I detected the king rail at 11 sites and counted 24 individuals (AVG = 2.18, SE = 0.46, max. = 6, mode = 1). In 2006, I detected the king rail at 6 sites and counted 18 individuals (AVG. = 3.0, SE = 0.68, max. = 6, mode = 2). I opportunistically detected the king rail at 5 additional sites (Table 4). Of the 17 randomly selected sites occupied by the king rail, 6 were on federal land, 8 were on WRP land, 2 were on private, and 1 was managed as a WRP/WMA. I detected the king rail at 12 sites in the southern region, 4 in the central, and at 1 in the northern region overall, in 2005 and 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 14).

When I detected the king rail I also detected a sora 76% of the time, 35% of the time I also detected a Virginia rail, and 35% of the time the least bittern, while other species were not associated as frequently (Table 5). Aural detections accounted for 85% of all detections, 2% were both aural and visual, and 13% were visual only (Table 6). The average distance to each observation was 39.3-m (SE = 2.5, max. = 100, mode = 60).

In 2005, I detected the king rail during 14 out of 369 morning surveys and 15 out of 412 evening surveys. In 2006, I detected the king rail during 7 out of 420 morning surveys and 13 out of 490 evening surveys. In 2005 and 2006, detection rates for the king rail were highest in April and May (Fig 8). I detected more king rails after its breeding and territorial calls were broadcast (Fig 15).

I observed one brood on 6 June 2006 at Hogwallow WRP. There were 5 young with 1 adult and the young were ~ 60% of the adult's size. According to Meanley (1958) this put the young at a conservative estimate of 30 days old. Backdating would put the start of incubation at 15 April.

Purple gallinule – In 2005, I detected the purple gallinule at 2 sites and counted 3 individuals (AVE. = 1.5, SE = 0.5, max. = 2) (Table 1). I did not detect the purple gallinule in 2006. I made 1 opportunistic detection in 2006, however it was in the same location as in 2005. I detected the purple gallinule at 2 sites in the southern region, and at 0 sites in the central and northern regions overall in 2005 and 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 16).

I did not make enough detections to determine seasonal changes in detection rates, or to compare morning versus evening surveys.

Common moorhen – In 2005, I detected the common moorhen at 2 sites and counted 6 individuals (AVE. = 2.8, SE = 2.0, max. = 5) (Table 1). I opportunistically located moorhens at 2 additional sites (Table 2). In 2006, I detected the common moorhen at 4 and counted 11 individuals (AVE. = 2.8, SE = 0.48, max = 4, mode = 2) (Table 3). Of the 6 randomly selected sites for 2005 and 2006, 2 were on federal land, 1 on WRP land, and 3 on private land. I detected the common moorhen at 5 sites in the southern region, 0 in the central, and at 1 in the northern region overall in 2005 and 2006. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 17).

Aural detections accounted for 86% of all observations, 6% were both aural and visual, and 7% were visual (Table 6). I did not detect the common moorhen in April and detections reached their maximum in May (Fig. 8). Common moorhens responded the most during the 3rd minute of silence and during the broadcast of the breeding and territorial calls of the pied-billed grebe, however very few individuals were detected and this trend warrants further investigation (Fig.18). The average distance to each observation was 70.9-m (SE = 8.0, max. = 350, mode = 50).

Three nests were found at Wallace Trust WRP (Table 4). All 3 nests were constructed in square-stem spike-rush (*Eleocharis quadrangulata*) and contained 12, 8, and 2 eggs.

American coot – In 2005, I detected the American coot at 6 sites and counted 27 individuals (AVG. = 4.5, SE = 2.9, max. = 19, mode = 1) (Table 1). I opportunistically detected the American coot at 7 additional sites (Table 2). In 2006, I detected the American coot at 13 sites with 204 individuals counted (AVG = 17.5, SE = 6.98, max. = 80, mode = 1) (Table 3). I opportunistically detected the American coot at 6 additional sites (Table 4). Of the 19 randomly selected sites occupied by the American coot, 4 were on federal land, 9 on WRP land, and 6 on private land. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 19).

When I detected the American coot, I also detected the pied-billed grebe 68% of the time, 47% of the time I also detected the least bittern, and 47% of the time the sora, while other species were not associated as frequently (Table 5). All observations from both seasons were visual (Table 6). The latest observation was on 24 June 2006, however this individual was crippled. The next latest observation was on 22 June 2005, however this individual showed symptoms of avian botulism along with several waterfowl in the same wetland. The latest observation of a healthy coot was on 18 May 2006.

Other birds of interest

Mottled duck – In 2005, I detected the mottled duck at 10 sites (Table 1). In 2006 I detected the mottled duck at 1 site (Table 3). I opportunistically detected the mottled duck at 3 additional sites. I observed one female mottled duck with 8 fledglings at the Chicot County WRP site on 19 May 2005. Of these 14 detections, 10 were in the southern region of the Delta. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 20).

Black-bellied whistling duck – In 2005, I detected black-bellied whistling ducks at 1 site (Table 1). I opportunistically detected the black-bellied whistling duck at 2 additional sites (Table 2). In 2006, I detected the black-bellied whistling duck at 2 sites (Table 3). I opportunistically detected the black-bellied whistling duck at 3 additional sites (Table 4). All detections were in the southern region of the Delta. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 21).

Fulvous whistling duck – I did not detect any fulvous-whistling ducks in either field season.

White ibis – In 2005, I detected the white ibis at 0 sites (Table 1). I opportunistically detected the white ibis at 3 sites (Table 2). In 2006, I detected the white ibis at 1 site (Table 3). I opportunistically detected the white ibis at 2 additional sites (Table 4). All detections of the white ibis were in the southern region of the Delta. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 22).

White-faced ibis – In 2005, I detected the white-faced ibis at 2 sites (Table 1). I opportunistically detected the white-faced ibis at 1 additional site (Table 2). In 2006, I detected the white-faced ibis at 1 site (Table 3). I opportunistically detected the white-faced ibis at 1 site (Table 4). All observations included a single individual. Of the 4 detections, 2 were in the southern region, and 2 were in the central region. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 23).

Glossy ibis – I opportunistically detected 1 glossy ibis in Stuttgart in 2006. This was the only detection for 2005 and 2006.

Black-crowned night heron – In 2005, I detected the black-crowned night heron at 1 site (Table 1). I opportunistically detected the black-crowned night heron at 2 additional sites (Table 2). In 2006, I detected the black-crowned night heron at 3 sites (Table 3). I opportunistically detected the black-crowned night heron at 2 additional sites (Table 4). The detections were scattered throughout the Delta. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 24).

Yellow-crowned night heron – In 2005, I detected the yellow-crowned night heron at 2 sites (Table 1). I opportunistically detected the yellow-crowned night heron at 3 additional sites (Table 2). In 2006, I opportunistically detected the yellow-crowned night heron at 1 site (Table 4). The detections were limited to Wapanonca NWR in the central region, and Black River WMA in the northern region. I produced a map of their distribution in the Delta using occupied sites from 2005 and 2006, as well as all opportunistic sites (Fig. 25).

Wood stork – I did not detect the wood stork.

OCCUPANCY ESTIMATION

Pied-billed grebe – In 2005, 9 sites out of 69 were occupied, giving a naïve estimate of 0.13. After accounting for observer effects, which were significantly different based on 95% confidence intervals (obs1 p = 0.582 - 0.825, obs2 p = 0.216 - 0.464), the Ψ estimate was 0.13 (SE = 0.04). The overall p for observer 1 was 0.70 (SE = 0.06), and 0.34 (SE = 0.06) for observer 2. The average probability of a false absence was 0.00065.

In 2006, 17 out of 84 sites were occupied giving a naïve estimate of 0.20. Observer effects were not significant based on 95% confidence intervals (obs1 p = 0.08 – 0.52, obs2 p = 0.29 – 0.53, obs3 p = 0.19 – 0.47) and the Ψ estimate was 0.21 (SE = 0.05). The overall p was 0.39 (SE = 0.04) and the probability of a false absence was 0.01.

Least bittern – In 2005, least bitterns occupied 15 sites giving a naïve estimate of 0.22. Observer effects were not significantly different based on 95% confidence intervals (obs1 p = 0.11 – 0.24, obs2 p = 0.04 – 0.22) and the Ψ estimate was 0.27 (SE = 0.06) for 2005. The overall p was 0.16 (SE = 0.04) and the probability of a false absence was 0.17.

In 2006, 16 out of 88 sites were occupied giving a naïve estimate of 0.18. Observer effects were not significantly different based on 95% confidence intervals (obs1 p = 0.53 – 0.94, obs2 p = 0.19 – 0.58, obs3 p = 0.34 – 0.71), and the Ψ estimate was 0.18 (SE = 0.04). The overall p was 0.58 (SE = 0.05) and the probability of a false absence was 0.003.

King rail - In 2005, 10 out of 69 sites were occupied making the naïve estimate for king rails 0.14. Observer effects were significantly different based on 95% confidence intervals (obs1 p = 0.13 – 0.29, obs2 p = 0.00 – 0.07), and the Ψ estimate was 0.22 (SE = 0.07). The overall p for observer 1 was 0.21 (SE = 0.04), and 0.03 (SE = 0.02) for observer 2. The probability of a false absence was 0.16.

In 2006, 5 sites out of 88 were occupied by king rails making the naïve estimate 0.057. Observer effects could not be assessed due to a sparse data set and the model would not converge when attempted. The Ψ estimate, which does not include an observer effect, was 0.058 (SE = 0.03). The overall p was 0.39 (SE = 0.08). The probability of a false absence was 0.01.

DISCUSSION

STATUS AND DISTRIBUTION

I confirmed the breeding of the pied-billed grebe, king rail, least bittern, common moorhen, and purple gallinule in Arkansas. Nests or broods were observed for all of these species except for the purple gallinule. However, I did observe them carrying nesting material at Arkansas Post NP, and AAS records report broods being observed at this site in previous years (AAS 2007).

Breeding secretive marsh birds are uncommon across the Delta, with the common moorhen and purple gallinule being the most uncommon breeding marsh bird. I detected common moorhens at only 6 randomly selected sites combined for 2005 and 2006. Currently the common moorhen is not listed as in need of management or as a species of concern by the state of Arkansas. Since the common moorhen occurs at fewer sites than the least bittern and king rail, I feel that the status of this species in Arkansas, especially as a game species, needs to be reviewed. Two of the earliest bird census summaries for Arkansas have failed to list the common moorhen, which may reflect the rarity of this species at that time in Arkansas (Howell 1911, Wheeler 1924). Arkansas Audubon Society (AAS 2007) records reflect the rarity of this species as well, where common moorhens have only been recorded at 4 sites in the Delta during the breeding season. James and Neal (1986) report scattered nesting records in the Grand Prairie region of the Delta, however I failed to detect the common moorhen in this region during my surveys. My results indicate that the southern region of the Delta is currently an important area for the common moorhen, and future wetland restoration efforts should focus their attention in this region.

I detected the purple gallinules at only 2 sites overall for 2005 and 2006 combined. I detected the purple gallinule at Arkansas Post National Park and the Wrape Plantation unit of Bayou Meto WMA, which are also the only reported breeding site records for the purple gallinule in the Delta for the past 10-15 years (AAS 2007). Though the purple gallinule was detected at only 2 sites in the Delta, their status in Arkansas does not warrant a review, as they are non-native to the state (Crow 1974). Crow (1974) states that this species is at the northern limits of its range, and likely expanded its range into Arkansas as rice farming expanded.

I detected least bitterns at more sites than expected given their status as a species of concern. I found several least bitterns at the Wallace Trust WRP and at Baxter Farms, which are in the southern region of the Delta. At Baxter farms, a large reservoir (32ha) was lined by a band of cattails about 50-m wide, and for every 100-m linear stretch of cattails there was 2-3 least bitterns. Large numbers, up to 25, have been reported at Baxter farms by the landowner in previous years (AAS 2007). I counted at least 10 individuals at Wallace Trust WRP and also located a nest. These 2 sites are separated by ~ 7.5-Km in the southern region of the Delta. In addition, Overflow NWR, its subunit Oakwood, and the Chicot County WRP, were all occupied by more than one least bittern in both 2005 and 2006, and are also located in the southern region of the Delta. Least bitterns have been detected at these sites in previous years, with juveniles being detected at Overflow and Oakwood in 1995 and 2003 (AAS 2007). I located one nest at the Chicot County WRP but it was later found destroyed. The largest concentrations occur in the southern region and future wetland restoration efforts, and least bittern studies should focus their attention in this region. The least bittern was found more frequently on NWRs and WRPs than on private wetlands, indicating their preference for managed wetlands.

As early as the 1920s the pied-billed grebe population in Arkansas was known to be in danger due to the drainage of wetlands and the demand for grebe feathers by milliners (Wheeler 1924). Howell (1911) reported the pied-billed grebe as being rare during the nesting season with only one nesting observation in the southern region of the Delta. Wheeler (1924) reported that pied-billed grebes nested only in the Sunken Lands in the northeastern portion of the Delta, and at Wilmot in the southern region. The Arkansas Area Natural Plan indicates that pied-billed grebes have never been a common species due to a lack of extensive permanent wetland complexes (Crowley 1974), a notion also reiterated in James and Neal (1986). The results suggest that pied-billed grebes can be found more often in the southern and central regions of the Delta. In addition, the grebe nests and broods located during this study were in the southern and central regions. AAS records, and historical data, also indicate that the pied-billed grebe is found more often in the southern and central regions of the Delta during the breeding season (Howell 1911, Wheeler 1924, AAS 2007).

Historically, king rails were considered common in the Stuttgart region of Arkansas (Meanley 1969). Rice farms dominate this region, and very few natural wetlands exist there today. I surveyed along the same routes as Meanley (1953), as well as several rice fields in that area, but failed to detect the king rail. The surveys in this area were not part of the routine sampling effort, but more of a focused effort to determine if king rails could be found in this area. I did not detect any king rails in Stuttgart and I feel that very few may still exist in this region. Several changes, such as the continued loss of wetlands in this area, changes in agricultural practices, and chemical use have likely impacted the king rail in this area. Changes in agricultural practices include the dredging of irrigation ditches to keep them clear of vegetation, the planting of earlier maturing rice varieties, and the mowing of field edges (F. Lee, Univ. of Ark., Rice Research and Extension Center, personal communication). These changes have resulted in less cover available for nesting, and seclusion from predators. This may have also affected other marsh bird species such as the least bittern and purple gallinule, which were known to nest in irrigation ditches around Stuttgart (Meanley 1969).

The Oakwood unit of Overflow NWR, St. Francis WRP, Hogwallow WRP, and the Chicot County WRP are areas of interest for future marsh bird research, most notably for the king rail. For the past 2 seasons the St. Francis WRP and Chicot County WRP sites have held king rails as well as other marsh birds. King rail broods have been observed at the Oakwood unit in 1995, 1996, and 1997 (AAS 2007), as well as at Hogwallow in 2006. The last known area where king rails could consistently be found was at Big Lake NWR (Crow 1974), this site is also mentioned as a king rail breeding area in the 1920s (Wheeler 1924). I did detect king rails at Big Lake NWR in 2005 at one site. The largest numbers of king rails were detected in the southern region of the delta with 12 out of 16 occupied sites occurring in this region compared to 4 in the central region and 1 in the northern region. Future king rail recovery efforts, and wetland restoration efforts in Arkansas, should focus on this region to stabilize the population. The king rail was found more frequently on NWRs and WRPs than on private wetlands, indicating their preference for managed wetlands.

Managing for one marsh bird species will benefit multiple species of marsh birds. My results show that when king rails are present; soras are often found at the same site. This association may be deceptive however, as soras are found at several wetland types. King rail sites overlap with least bitterns, Virginia rails, and American bitterns as well. In addition, at sites where least bitterns were present, they showed an association with the pied-billed grebe. Several marsh bird species were found to frequently occur in the southern region; management of these species, and wetland restoration efforts should target this region to stabilize their populations. In addition, wetland restoration efforts in the southern region would benefit non-secretive marsh bird species such as: the white ibis, mottled duck, and black-bellied whistling ducks, as they were found to occur more often in the southern region of the Delta.

CHAPTER 2: HABITAT SELECTION OF SECRETIVE MARSH BIRDS IN THE DELTA OF ARKANSAS.

INTRODUCTION

Secretive marsh birds include all species that primarily inhabit marshes, and are dependent upon wetlands to carry out their entire life cycle. Their generally secretive nature, the endangered status of several races and populations, and continued loss of habitat, warrant an examination of their habitat needs and the establishment of management guidelines (Eddleman et al. 1988).

Breeding secretive marsh birds in Arkansas include: the least bittern (*Ixobrychus exilis*), pied-billed grebe (*Podilymbus podiceps*), common moorhen (*Gallinula chloropus*), purple gallinule (*Porphyrula martinica*), and king rail (*Rallus elegans*). Of these breeding marsh birds, only the pied-billed grebe, least bittern, and king rail are found in sufficient numbers to investigate their habitat requirements.

The U.S. Fish and Wildlife Service (USFWS) identified the least bittern as a species of special concern because they are relatively rare and basic information on status and trends in most areas is lacking (USFWS 2002). The king rail is classified as threatened or endangered in 13 states and its status throughout its range is not well understood (Cooper 2006). In addition, Canada has listed the least bittern as threatened (James 1999), and the king rail as endangered provincially (James 2000).

Habitat uses for these species are poorly understood in Arkansas. Habitat use for the king rail has been documented in various parts of its range; however, habitat use may vary geographically (Cooper 2006). Habitat data exists in various parts of each species' range, but there is a lack of understanding of habitat requirements in Arkansas. The only previous marsh bird study in Arkansas was by Brooke Meanley in the early 1950s

(Meanley 1969). This study was located in the rice-growing region of Stuttgart, AR and consisted of opportunistic king rail sightings.

Previous marsh bird studies that investigated habitat requirements have failed to account for imperfect detection of these species, leading to spurious results. Due to their cryptic coloration, secretive nature, and rare status, marsh birds are easily missed during surveys. By failing to account for imperfect detection rates, results may be biased to an unknown degree, resulting in false conclusions about resource selection (MacKenzie 2006). Without explicitly accounting for detectability, any modeling of the data is simply a representation of the observer's ability to find the species in the resource units, not necessarily which resource units are being used by the species (MacKenzie 2006).

Pied-billed grebes are wetland area dependent, and associated with areas containing large wetlands (Brown and Dinsmore 1986, Naugle et al. 1999, Fairbairn and Dinsmore 2001, Hay 2006, Rehm 2006). Naugle et al. (1999) concluded that pied-billed grebe presence was related to wetland area. Fairbairn and Dinsmore (2001) found that pied-billed grebes preferred larger wetland sizes, and that pied-billed grebes were negatively correlated to increasing perimeters. Hay (2006) found that least bittern was not wetland area dependent. Brown and Dinsmore (1986) stated that the least bittern is possibly wetland area dependent, and the king rail also appears to be wetland area dependent (Reid 1989). It was predicted that the probability of a wetland being occupied should increase with increasing wetland area for all species studied.

Previous studies provide conflicting results on the influence of woody vegetation on least bittern occupancy. Kirk et al. (2001) found woody vegetation to be a negative predictor of least bittern occupancy and Hay (2006) found that least bittern occupancy increased with the presence of woody vegetation. Woody vegetation, such as small trees and shrubs, provide perches for avian predators and likely discourages marsh birds from using sites containing increasing amounts of woody vegetation. Similarly, the amount of forest adjacent to the site should have a negative influence on marsh bird occupancy, as large forest areas support avian and mammalian predators (Pierluissi 2006). It was predicted that the probability of site occupancy will decrease as the amount of woody vegetation and adjacent forest increases.

Most marsh bird species use emergent vegetation for nesting material and cover. The king rail prefers fairly uniform stands of emergent vegetation, e.g. sedges (*Cyperaceae*), rushes (*Juncaceae*), and cattail (*Typha*) (Sikes 1984, Eddleman 1988, Reid 1989, Meanley 1992). Fairbairn and Dinsmore (2001) found a significant relationship between least bittern densities and the amount of emergent vegetation, and several other studies report that least bittern presence is positively associated with increasing amounts of emergent vegetation (Weller and Spatcher 1965, Kirk et al. 2001, Bogner and Baldassarre 2002, Hay 2006, Winstead and King 2006). In addition, Faaborg (1976) and Weller and Spatcher (1965) showed that the pied-billed grebe was associated with wetlands containing large areas of emergent vegetation. Emergent vegetation is typically managed against at NWRs and state WMAs, and research is needed to determine the benefits of emergent vegetation in Arkansas for marsh birds (Lake Lewis, USFWS, personal communication). It was predicted that the probability of a wetland being occupied will increase as the amount of emergent vegetation increases.

Most large wetland areas, or wetland complexes, are usually on public lands in the form of National Wildlife Refuges or WMAs (Reid 1989). In Arkansas, most of this habitat exists on public lands, as well as Wetland Reserve Program (WRP) lands, but on these lands the primary management goal is for waterfowl. Though marsh birds are found on public lands, it is only in areas that have not been actively managed (personal observation). Current waterfowl management practices are not compatible with marsh birds, and research is needed to design management practices that will benefit both groups. In addition, managers lack information and guidelines on how to provide marsh bird habitat and which approaches have the least negative impact on wintering populations of waterfowl.

The WRP program is an important conservation program that could potentially provide optimal habitats for marsh birds if properly managed. The WRP is a voluntary program implemented by the Natural Resources Conservation Service (NRCS) in the U.S. Department of Agriculture. Under program guidelines, eligible landowners are provided financial incentives to restore wetlands and retire marginal farmlands, sometimes permanently, from agricultural production (King et al. 2006). WRP management varies from one easement to the next, with some easements containing several marsh birds, and some being devoid of marsh birds. By identifying WRP management practices that provide optimal marsh bird habitat, easements can be designed to promote these species.

The objectives in this chapter are to 1) determine habitat selection of breeding marsh birds in the Delta, and 2) to provide management recommendations for these species.

STUDY AREA

I performed this study in the Arkansas Delta (Fig.1). The Delta is a distinct physiographic province of the southeastern United States and is treated as a unique Bird Conservation Region by the Partners in Flight bird conservation initiative (Williams and Pashley 2000). The Delta is bounded on the southwest by the Coastal Plain, on the northwest by the Ouachita Mountains and the Ozark Mountains, and on the east by the Mississippi River. In the Delta the work of large rivers has been dominant in forming the character of the land. The Arkansas River, the White, the St. Francis, and the Mississippi have flowed through this region, cutting away older deposits and building up deposits of sand, gravel, and clay (Crow 1974). According to Crow (1974), the elevation of the Delta varies only about 46-m in the entire 402-km length of the division (Crow 1974). This region is dominated by extensive agriculture with fragments of remnant bottomland hardwood forest (King et al. 2006).

Wetland habitat types surveyed included bottomland hardwood stands, cypress (*Cyperus spp*.) bayous, buttonbush (*Cephalanthus spp*.) swamps, willow (*Salix spp*.) swamps, cattail (*Typha spp.)* marshes, reservoirs with minimal vegetation, and wetlands with a mixture of habitat types. Sites ranged from large wetland areas, such as National Wildlife Refuges (NWR), Wildlife Management Areas (WMA) managed by the AGFC, and Wetland Reserve Program lands (WRP), to isolated wetlands typically found on private land. Wetland area was considered to be small if the surrounding 400-m contained less than 50% water.

I surveyed at 190 sampling sites, throughout the Delta in 2005 and 2006 (Figs. 2-6), 80 of which were surveyed in 2005 (Table 1), and 110 were surveyed in 2006 (Table

2). In 2005, 32 sites were on NWRs, 14 on private land, 15 on WRP lands, 16 on WMAs, 2 on Army Corp of Engineer (ACOE) lands, and 1 was on National Park Service (NPS) land. In 2006, 26 sites were on NWRs, 63 on private land, 16 on WRP lands, and 5 were co-managed as a WMA/WRP. In 2005, I surveyed Big Lake, Bald Knob, Cache River, Overflow and its subunit Oakwood, White River, and Wapanonca NWRs. In 2006, I surveyed Bald Knob, Cache River, Overflow and its subunit Oakwood, White River, and Wapanonca NWRs. In 2005, the WRP sites were owned by 3 different landowners and were managed independently of each other. In 2006, the WRP sites were owned by 5 different landowners and were managed independently of each other. In 2005, I surveyed Bayou Meto, Bayou DeView, Black River, Cut-off Creek, and Mallard Lake WMAs. In 2006, I surveyed the Raft Creek WMA, which was also managed as a WRP.

METHODS

STUDY DESIGN AND FIELD METHODS

Site selection - I used a stratified random sample to select wetlands based on 3 strata: 1) large vs. small wetland area, 2) marsh vs. swamp and, 3) a large forest area vs. small forest area adjacent to the wetland.

I split the Delta into 3 main regions: 1) Northern, 2) Central, and 3) Southern, as it was the most logistically feasible approach, allowing me to work out of a central location in each region. I used a Geographic Information System (GIS) and assigned each county per region a number. I randomly generated a number to determine which county I would further refine the selection from. I then split the county into approximately equal quarters after I selected a county, and assigned each quarter a number, 1- 4. I then randomly generated a number to determine which quarter section to select. I repeated this step once more, to where the previous quarter section was split into four sections again. I set the aerial image of that section to a 1:100,000 scale, which allowed me to view wetland types. I overlaid a transparent grid, which was numbered 1-28 in x and y directions, over the aerial image once at this scale. I randomly generated two numbers, ranging from 1-28, to determine which cell to choose from. I selected the wetland closest to that cell if a wetland was not located in that exact cell. I used a handheld Global Positioning System (GPS) to find the wetlands once in the field.

I repeated this method in 2005 and 2006 until I had approximately 50 sites per each region, and an approximately equal distribution of the 3 main variables of interest. I used this method since the National Wetlands Inventory (NWI), or assessment of wetland habitats available, had not been completed for the Delta.

During my selections, I discovered that not all combinations of variables were possible and some sites were selected non-randomly as a result. I selected large wetland areas containing emergent vegetation non-randomly as they usually only existed at NWRs and WRP lands. I selected several sites haphazardly due to logistical problems, such as not getting a response from a landowner in due time, or because designated wetlands no longer existed. In that instance, I selected the wetlands closest to the randomly selected wetland.

Marsh bird surveys – I conducted surveys following the North American Marsh Bird Monitoring Protocol (Conway 2003). I trained and tested observers on the calls of secretive marsh birds before surveying. I broadcasted the breeding and territorial calls of the following species in the following order: least bittern, Virginia rail, king rail, common moorhen, purple gallinule, and the pied-billed grebe. Audio recordings were obtained from C. J. Conway (USGS Arizona Cooperative Fish and Wildlife Research Unit). The broadcast consisted of: 5, 1-min segments of silence, and for each species: 30 sec of breeding and territorial calls, followed by 30 sec of silence.

I conducted surveys from 16 April to 8 July 2005, and from 3 April to 21 June 2006. I chose this sampling period because king rails begin breeding in Arkansas in early April, and most marsh birds cease responding to playback calls in late June (C. Conway, USGS, personal communication). I assumed that the sampled sites were closed to immigration and emigration during the survey period each year (MacKenzie et al. 2006). All sampling points were separated by ≥200-m to avoid double counting individuals (Conway 2003).

I surveyed for 10 days in the southern region, then moved to the central region and surveyed for 10 days, and then moved to the northern region for 10 days. I repeated this process 3 times; so three 10-day sampling periods were conducted for each region with 20 days in between each period.

MODEL SET AND DATA ANALYSIS

I used Program PRESENCE 2.0 (available for download at http://www.mbr-pwrc.usgs.gov/software.html) to investigate habitat selection of breeding secretive marsh birds in the Delta. Program PRESENCE permits estimation of the probability of site occupancy, denoted as Ψ, when detection probabilities are <1 (MacKenzie et al. 2002). This method involves visiting sites multiple times within a season where a target species is either detected, with probability *p*, or not detected. The goal is to estimate Ψ, knowing the species is not always detected, even when present (Bailey et al. 2004). This type of model, analogous to capture-recapture models, enables the inclusion of site variables (e.g., habitat type, wetland size), as well as time varying covariates (e.g., air temperature, cloud cover) that explain variation in p and Ψ (Mackenzie 2002). In the most general form, the modeling approach of Mackenzie et al. (2002) could be considered as performing simultaneous logistic regression analyses on both occupancy and detection probabilities (MacKenzie and Royle 2005).

I used Akaike's Information Criterion (AIC) corrected for small sample size (AICc) for the least bittern and pied-billed grebe data set. A small sample size correction is necessary when n / k <40, where n is the number of sites visited, and k is the number of parameters (Burnham and Anderson 2002). I compared models using AIC for the king rail data set as 2 years of data were combined and a small sample size adjustment was not needed. I used the AICc weights of candidate models to obtain a weighted average of each individual parameter (MacKenze et al. 2006). AICc weights were calculated using the formula $\frac{e^{(-1/2\Delta AIC_c)}}{\sum e^{(-1/2\Delta AIC_c)}}$ (Burnham and Anderson 2002). I ran 10,000 bootstrap samples to test the fit of the global model (MacKenzie et al. 2006). I calculated quasi-likelihood corrected form of AIC to account for possible overdispersion (Burnham and Anderson 2002).

Covariates – I based wetland area (W4) on the percent of a 400-m radius circle, centered at the sampling point, that was covered in water, with >50% being a large wetland area, 10-50% being a moderate sized wetland area, and <10% being a small wetland area. These scales also indicate the degree of isolation. I based forest area (F4) on the percent of a 400-m radius circle, centered at the sampling point, that was covered in woody vegetation ≥6-m in height, with >50% being a large forested area, 10-50% being a moderate amount of forested area, and <10% being a small forested area. I based the amount of emergent vegetation (EV) and woody vegetation (WV) on the rank abundance of each type 100-m in front of the direction the call-playback speakers faced (Table 7). A site containing <10% EV or WV would have minimal or no EV or WV coverage. A site containing 10-50% would have moderate coverage of EV or WV, and >50% would be moderate to dense coverage.

I recorded habitat covariates based on a rank abundance scale that I thought would reduce observer bias. I used the following scales for each variable: 0-10%, 11-50%, 51-100%. I coded habitat variables in PRESENCE using the midpoint of the intervals, 0.5, 3, and 7.5. I coded observers using 2 sampling covariate spreadsheets following methods recommended by MacKenzie et al. (2006).

In several cases site independence was questionable. I collapsed detection histories into one history, if sites were in the same wetland and all habitat covariates were the same, to deal with this issue. For example, if 3 sites were in the same large wetland, and the habitat was consistent at all 3 sites, their histories were collapsed. If the detection histories at the 3 sites read, 0100, 0010, 0011, given 4 visits at each site, the collapsed history would read 0111. A 0 indicates the species was not detected, and a 1 indicates the species was detected. By collapsing multiple site histories into one history, it is likely that the detection probabilities would be inflated. I used a covariate (#_Pooled) to indicate the number of sites that were collapsed (D. MacKenzie, Proteus Wildlife Research Consultants, personal communication) to account for this issue. In the previous example the covariate for #_Pooled would be 3. As a result, the sample size included in the analysis is smaller than the number of sites surveyed. Sample sizes in the analysis are smaller than the overall number of sites visited as I eliminated sites with fewer than 5 visits in 2005, and 4 visits in 2006. I chose these cutoffs, as it was roughly half of the average number of visits per site for the respective year.

I used the 2006 data set for the least bittern and pied-billed grebe, as it was the best data set for these species. I combined both years for the king rail, as both seasons were too sparse on their own to permit analysis. Combining both years of data assumes that the probability of occupancy is not significantly different between years. Since a severe drought occurred between seasons (http://www.ncdc.noaa.gov/nadm.html), I feel that the occupancy probabilities were different, and warn the reader that the king rail analysis should be used with caution.

Candidate models - I assumed the probability of occupancy would increase for the pied-billed grebe as the amount of wetlands within 400-m increased. I assumed the probability of occupancy for the pied-billed grebe would decrease as the amount of forest within 400-m increased. I assumed that the number of sites pooled (#_Pooled) and observers (Obs) influenced the probability of detection the pied-billed grebe. My global model was Ψ (W4 + F4), *p* (#_Pooled + Obs). My most constrained model (1 group constant *p*) assumed that occupancy and the probability of detection were constant across sites.

I assumed the probability of occupancy for the least bittern would increase as the amount of wetlands within 400-m (W4) and the amount of emergent vegetation (EV) increased. I assumed that the probability of occupancy for the least bittern would decrease as the amount the amount of forest within 400-m (F4), and amount of woody vegetation increased (WV). I assumed that the number of sites pooled (#_Pooled) and observers (Obs) influenced the probability of detection the least bittern. I used the #_Pooled and Observer variables for all models, except the constant model, as I noticed a difference in each observer's ability to detect the least bittern. The global model was Ψ(EV +WV + W4 + F4), *p*(#_Pooled + Obs). My most basic model (1 group constant *p*) assumed that occupancy and the probability of detection were constant.

I assumed *a priori* that the variables influencing occupancy for the king rail were the amount of wetlands within 400-m (W4), the amount of forest within 400-m (F4), and the amount of emergent vegetation (EV). I assumed the probability of occupancy would increase as the amount of wetlands within 400-m, and emergent vegetation increased. I assumed that the number of sites pooled (#_Pooled) influenced the probability of detection. The global model was Ψ(EV + W4 + F4), *p*(#_Pooled). I believe that observers had an influence on the probability of detection; however, I could not assess this affect due to a sparse data set. My most basic model (1 group constant *p*) assumed that occupancy and the probability of detection were constant.

I determined the significance of variables by calculating their odds ratios (MacKenzie et al. 2006). I determined the odds ratio by using a one-sided 90% confidence interval and transforming it to the logit scale. The side of the interval used depended on my *a priori* assumption of how I thought that variable would influence occupancy. If I assumed *a priori* that a variable would have a negative effect on occupancy then I calculated the lower limit. Conversely, if I assumed *a priori* that a variable had a positive effect on occupancy then I calculated the upper limit. An odds ratio that included 1 indicated that the variable had no effect (MacKenzie et al. 2006).

RESULTS

In 2005, I surveyed 69 sites throughout the Delta. Of these 69 sites, 2 were comprised of >1 sampling point. I surveyed 9 sites with <10%, 22 sites with 11-50%, and 38 with >50% emergent vegetation. I surveyed 24 sites with <10%, 31 with 11-50%, and 17 with >50% woody vegetation. I surveyed 4 sites with <10%, 30 with 11-50%, and 35 with >50% of the surrounding 400-m containing wetlands. I surveyed 22 sites with <10%, 30 with 11-50%, and 17 having >50% of the surrounding 400-m containing forest. In 2005, I detected the king rail at10 of 69 sites. I did not use the 2005 data for the pied-billed grebe, or the least bittern.

In 2006, I surveyed 88 sites throughout the Delta. Of these 88 sites 13 were comprised of >1 sampling point. I surveyed larger wetlands in 2006 which resulted in more sites having >1 sampling point compared to 2005. I surveyed 51 sites with <10%, 22 with 11-50%, and 15 with >50% emergent vegetation. I surveyed 41 sites with <10%, 31 with 11-50%, and 16 with >50% woody vegetation. I surveyed 15 sites with <10%, 48 with 11-50%, and 25 with >50% of the surrounding 400-m having wetlands. I surveyed 23 sites with <10%, 50 with 11-50%, and 15 having >50% of the surrounding 400-m having forest. Of these 88 sites, 5 were occupied by the king rail, and 16 were occupied by the least bittern.

For the pied-billed grebe, I removed 4 sites from analysis as they were irrigation ditches and the pied-billed grebe has not been documented to use this habitat type. Of the

4 sites removed, 2 were in the category of <10% wetlands within 400-m, and 2 were in the category of 10-50% wetlands within 400-m. In addition, 2 of these 4 sites had <10% forest in the surrounding 400-m, and 2 had 10-50% forest in the surrounding 400-m. Of these 84 sites, 17 were occupied by the pied-billed grebe.

Of the 17 sites occupied by the pied-billed grebe no pattern emerged based on wetland area, as 1 site had 0-10%, 7 had 11-50%, and 9 had >50% wetlands in the surrounding 400-m. In addition, proportionately fewer sites were occupied as the amount of adjacent forest area increased. Four sites had <10%, 12 had 11-50%, and 1 had >50% forest within 400-m.

Of the 16 sites occupied by the least bittern, 4 had <10%, 7 had 11-50%, and 5 had >50% emergent vegetation. Also, 2 sites had <10%, 5 had 11-50%, and 9 had >50% wetlands within 400-m. Also, 8 sites had <10%, 8 had 11-50%, and 0 sites with >50% forest within 400-m. In addition 7 sites had <10%, 6 had 11-50%, and 3 had >50% woody vegetation.

Of the15 sites occupied by the king rail for 2005 and 2006, 1 had <10%, 6 had 11-50%, and 8 had >50% emergent vegetation. Also, 0 sites <10%, 4 had 11-50%, and 11 had >50% wetlands in the surrounding 400-m. In addition, 7 sites had <10%, 8 had 11-50%, and 0 sites had >50% forest within 400-m.

MODEL SELECTION

Pied-billed grebe – My goodness of fit test did not indicate lack of fit (p=0.43), so I did not include any adjustment factors in the models. Model selection did not favor any one particular model. The null model, *1 group constant P*, was separated from the best model by 0.21 AICc units (Table 8). After summing model weights, the amount of wetlands adjacent to the sampling point had a weak influence on occupancy. The summed model weights were: wetlands within 400-m: 47%; and forest within 400-m: 16%.

Using the model Ψ(W4), *p*(#_Pooled) the odds ratio for wetlands within 400-m was (1.03, ∞). As 1 was not included in the interval, the amount of wetlands within 400-m of the sampling point had a positive effect on site occupancy. However, the magnitude of the effect of wetlands on occupancy was poorly known.

Least Bittern -My goodness-of-fit test did not indicate lack of fit (p=0.41), and I did not include any adjustment factors in the models. The top model, Ψ(EV+F4), *p*(#_Pooled + Obs), was separated by ≥2 AICc units from the next top ranking model indicating substantial support for this model (Table 9). This model indicated that least bittern occupancy was related to the amount of emergent vegetation and the amount of forest within 400-m. The summed model weights were; wetlands within 400-m: 28%, forest within 400-m: 86%; emergent vegetation: 77%; and woody vegetation: 22%. Model weights showed strong support that emergent vegetation and the amount of forest within 400-m influenced the probability of site occupancy.

Using the top model, the odds ratio for emergent vegetation was (1.00, ∞), and (0, 0.9) for the amount of forest within 400-m. The odds ratio for emergent vegetation indicated that this variable had a significant influence on occupancy (MacKenzie 2006). The odds ratio for the amount of forest within 400-m indicated that this variable had a significant influence on occupancy as the odds ratio does not include 1. I surveyed all combinations of the 2 variables, however not all combinations had the same number of sites (Table 10).

King rail – My goodness-of-fit test indicated lack of fit (p=0.009), and the $\hat{C}$ estimate (18.6) indicated over-dispersion. I did not continue with occupancy analysis as a result.

DISCUSSION

Previous studies concluded that the pied-billed grebe is wetland area dependent (Hay 2006, Rehm 2006, Fairbairn and Dinsmore 2001, Naugle et al. 1999, Brown and Dinsmore 1986). In particular, Fairbairn and Dinsmore (2001) have shown that the pied-billed grebe prefers larger wetland sizes, and that they are negatively correlated to increasing perimeters. Qualitatively, the results show a pattern of more sites being occupied by the pied-billed grebe as the amount of wetlands within 400-m increases. Few sites were occupied by the pied-billed grebe when the amount of forest within 400-m exceeded 50%. Previous pied-billed grebe research has been conducted in areas that lack forested areas, so their response in those areas is unknown. Their response to adjacent forested areas is not clear and requires further research.

Brown and Dinsmore (1986) and Hay (2006) did not show a significant relationship between least bitterns and wetland area. The model selection results, and previous research, indicate that the probability of a wetland being occupied is not significantly different as the amount of wetlands in the immediate area increase. However, qualitatively it would appear that the least bittern is wetland area dependent as more wetlands were occupied as wetland area increased. I believe that the least bittern can tolerate isolated wetland conditions; however, a large wetland area will be the most beneficial.

Fairbairn and Dinsmore (2001) found a significant relationship between least bittern densities and the amount of emergent vegetation, and several other studies report the association between least bitterns and areas of emergent vegetation (Hay 2006, Winstead and King 2006, Bogner and Baldassarre 2002a, Kirk et al. 2001, Weller and Spatcher 1965). My results also show that the least bittern requires wetlands that contain emergent vegetation. Emergent vegetation, typically cattails, sedges, and rushes, are used for nesting and as feeding platforms by the least bittern.

The amount of woody vegetation did not appear to influence least bittern occupancy. Previous studies provide conflicting results on the influence woody vegetation has on least bitterns. Kirk et al. (2001) found woody vegetation to be a negative predictor of least bittern occupancy and Hay (2006) found a positive association of the least bittern and woody vegetation. I found the least bittern using wetlands that were dominated by buttonbush, and other wetlands containing intermediate amounts of young cypress trees <3-m in height on multiple occasions (n=4). Least bitterns frequently perched in the cypress trees and vocalized and displayed. I also observed least bitterns using buttonbush as a platform for foraging. I feel that the least bittern is tolerable of woody vegetation if it is interspersed, or near areas of emergent vegetation.

My results indicated that as the amount of forest adjacent to the sampling point increased, the probability of a wetland being occupied by the least bittern decreased. The sites that were occupied actually had ≤30% forest in the surrounding 400-m, however the intervals used did not capture this effect. Winstead and King (2006) reported that sites with least bitterns tended to have fewer tall trees and Kirk et al. (2001) found that trees/shrubs in a wetland had a negative influence on least bittern abundance. This is likely a result of least bitterns avoiding forested areas, as they tend to harbor mammalian and avian predators (Pierluissi 2006).

Model selection results showed substantial support for the model with emergent vegetation and forest within 400-m as variables influencing the probability of site occupancy by the least bittern. I feel that since we have sites with all possible combinations of these 2 variables that model selection results are valid. However, only 2 sites were surveyed at the 51-100% categories and this may limit the effectiveness of the results. Because of land use practices in the Delta, very few wetlands occur with these 2 variables.

I combined both seasons of data to investigate habitat affinities for the king rail. This approach may not be the most accurate, as combining both seasons requires the assumption that occupancy probabilities are the same in both years. Towards the end of the first field season most of my wetland sites were drying, or already dry. This drought lasted into the next season and likely influenced the probability of site occupancy. Habitat requirements for the king rail are poorly known, and the only way to model their requirements for our study was to pool years (Cooper 2006). However, my model selection results were not used, as analysis indicated a lack of fit. Qualitatively my results suggest that the king rail is associated with certain habitat variables.

I did not find the king rail at sites where <10% of the surrounding 400-m contained wetlands, suggesting they are wetland area dependent. Previous king rail studies have been conducted in large wetland areas, or in rice growing regions which act as wetlands for several species (Pierluissi 2006, Reid 1989, Sikes 1984, Baird 1974, Meanley 1969). By studying in these areas it was not possible to test for the king rails use of isolated wetlands. Further research is needed to determine how size, isolation, and configuration impact the king rail (Reid 1989).

King rails prefer fairly uniform stands of emergent vegetation, i.e. sedges (*Cyperaceae*), rushes (*Juncaceae*), and cattail (*Typha*) (Sikes 1984, Eddleman 1988, Reid 1989, Meanley 1992). Though model weights do not reflect the importance of emergent vegetation, my observations suggest it is a requirement for the king rail. The areas that held the largest numbers of king rails were large wetland areas comprised of cattails, and soft-rush (*Juncus effuses*). I surveyed approximately the same number of sites that had <10% emergent vegetation as sites that had >50% emergent vegetation, however only 1 site was occupied in the <10% category, whereas 8 sites were occupied in the >50% category. In addition, the other sites occupied by the king rail all contained moderate amounts of emergent vegetation, indicating that the king rail requires emergent vegetation. My intervals did not capture the range of emergent vegetation that may be most beneficial to the king rail. If most detections were in the 40-60% emergent vegetation range, or in a hemi-marsh state, the intervals used would not have captured this information. Using smaller and equal sized intervals would provide managers with a better idea of how much emergent vegetation to provide for the king rail and other marsh birds. The optimal range of emergent vegetation for the king rail requires further investigation.

Pierluissi (2006) found that king rail nesting densities decreased as the proportion of trees near the perimeter of the site increased. All of my king rail observations were at sites where the amount of forest within 400-m was <50%. The intervals did not capture the appropriate information, as these observations were at sites with <30% forest in the surrounding 400-m, further showing the importance of this variable. In addition, the Grand Prairie region of Arkansas, near Stuttgart, historically held large numbers of king rails (Meanley 1969). This area lacks forested tracts and may be the reason why they were historically common in that area. Other sites where I found king rails were reminiscent of a prairie, where wetlands were bordered by grasslands, and usually included a wet meadow zone. Future restoration efforts and king rail recovery efforts should focus on areas having minimal amounts of forest.

NWRs, state WMAs and WRP lands, currently are managed primarily for waterfowl. However, management for waterfowl can be compatible with marsh bird management (Eddleman 1988). Brennan (2006) and Murkin et al. (1997) found that percent emergent vegetation had a positive influence on dabbling duck abundance in the fall, and abundance was greatest at intermediate (50%) levels of emergent vegetation. Weller and Spatcher (1965) found least bittern abundance was highest when wetlands reached a 50:50 ratio of emergent vegetation to open water. Several studies have mentioned the importance of emergent vegetation for marsh birds, and managers should seek to provide areas of emergent vegetation, preferably in a hemi-marsh state (e.g. cattails, sedges, and rushes) (Bogner and Baldassarre 2006, Arnold 2005, Meanley 1992, Reid 1989, Weller and Spatcher 1965).

MANAGEMENT RECOMMENDATIONS

Most refuges have at least one moist soil unit that cannot be managed for waterfowl every year due to budget constraints, or lack of water control (Lake Lewis, USFWS, personal communication). After 3-4 years there is a tendency for wetlands to become dense monotypic stands, making it difficult to set back succession (Lake Lewis, USFWS, personal communication). I encourage managers to rotate these units every 3-4 years to set back secession before they become too dense. Another option is to rotate a few units, including those that have effective water control structures, every 3-4 years. Leaving a few units or sections of units, to remain for 3-4 years would allow for a portion of each refuge to always contain marsh bird habitat.

These areas should be managed for hemi-marsh conditions as it positively influences waterfowl abundance and marsh bird occupancy rates. In addition, NWR's, WMA's, and WRP's are large wetland areas with several hectares of wetlands existing at most. Large wetland areas are the most attractive to marsh birds and significantly influence species richness and diversity (Brennan 2006, Fairbairn and Dinsmore 2001, Craig and Beal 1992, Brown and Dinsmore 1986). Large wetlands with a low perimeter to area ratio are optimal, as increased amounts of edge increase predation rates (Reid 1989).

Nesting and foraging habitats for marsh birds demand more semi-permanent than seasonal water regimes. Areas of marsh bird habitat should not be artificially drained during the breeding season (April-June). Allowing wetlands to dry naturally as the summer progresses will provide foraging areas for adults and their broods (Reid 1989).

Wetland restoration efforts should focus on areas of low forest coverage, as these areas likely hold common nest predators such as raccoons (*Procyon lotor*), red fox (*Vulpes vulpes*), and crows (*Corvus spp*.). WRP lands appear to be important for all marsh birds as they typically have several wetlands that contain emergent vegetation and a variety of habitats. In addition, they usually have grassy areas bordering the wetlands, or wet meadow zones similar to prairie wetlands. However, several WRP lands I found to be important for marsh birds have been planted with the saplings of mast producing trees such as oaks (*Quercus sp*.). As the trees mature it is likely that these areas will no longer be productive for marsh birds. Future wetland restoration efforts should seek to provide areas that will not be reforested, in addition to those that are to be reforested.

Areas dominated by rice farming, as well as NWR's, WMA's, and WRP's, should allow their irrigation ditches/canals to succeed into emergent vegetation. Historically, king rails were commonly associated with ditches comprised of emergent vegetation in Arkansas (Meanley 1992), and are currently found in ditches associated with rice fields in Louisiana (Pierluissi 2006). Sikes (1984) and Meanley (1969) reported that ditches containing emergent vegetation were important to king rails for travel, cover, and nesting. Management of ditches may provide minimal suitable habitat for marsh birds during migration, as well as facilitate early nesters in Arkansas. This would allow adults to later move broods into rice fields where aquatic insects may be abundant, and where they can also produce a second brood. Least bitterns and purple gallinules are also known to use these types of ditches, so this practice would benefit multiple species of marsh birds.

By following these practices, managers can evaluate their effectiveness in providing breeding habitat for marsh birds in Arkansas. Future marsh bird surveys should be designed to evaluate their compatibility with wintering waterfowl as well.

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Table 1. Site names, ownership, UTM coordinates, species present at each site, and number of individuals detected during the 2005 field season in the Delta of Arkansas, USA. See Appendix 4 for 4-letter species codes.

SITE NAME	OWNERSHIP	EASTING	NORTHING	SPECIES PRESENT (No. detected)
ARKCO4	Private	663911	3799769	
ARKCO5	Private	664869	3798163	KIRA(1), LEBI(1)
ARKCO	Private	668480	3796545	SORA(1)
ARK. POST	NPS[a]	652289	3766230	COMO(5), LEBI(1), PBGR(1), PUGA(2)
ASHRD1	Private	630499	3662049	SORA(2)
BAYOU DE VIEW	WMA[b]	659928	3886264	
BAYOU DE VIEW	WMA	663636	3881369	
BALD KNOB 1	NWR[c]	631521	3903308	AMBI(4), AMCO(3), PBGR(5), SORA(15), VIRA(1), WFIB(1)
BALD KNOB 2	NWR	629860	3899733	LEBI(1)
BALD KNOB 3	NWR	636273	3896796	
BIG LAKE 1	NWR	759558	3971237	AMCO(1)
BIG LAKE 2	NWR	759456	3971431	
BIG LAKE 7	NWR	760113	3972041	LEBI(1)
BIG LAKE 8	NWR	759732	3972159	KIRA(1), SORA(1)
BIG LAKE 9	NWR	759582	3971931	LEBI(1), SORA(1)
BIG LAKE 1	NWR	760106	3974234	COMO(1)
BIG LAKE 2	NWR	759370	3972004	
BIG LAKE 3	NWR	759358	3975111	LEBI(1)
BIG LAKE 4	NWR	760236	3971963	AMBI(1), BCNH(1), LEBI(4)
BLACK RIVER 1	WMA	712245	4023050	
BLACK RIVER 2	WMA	712025	4023054	MODU(2)
BLACK RIVER 3	WMA	711895	4023141	
BLACK RIVER 4	WMA	711878	4023434	
BLACK RIVER B	WMA	711642	4023230	
BLACK RIVER 5	WMA	702104	4016406	YCNH(3)
BLACK RIVER 6	WMA	702164	4016136	YCNH(5)
BAYOU METO 1	WMA	645810	3787981	
BAYOU METO 2	WMA	631545	3787064	LEBI(1), PBGR(1), PUGA(1)
BAYOU METO 3	WMA	631860	3787639	
BAYOU METO 4	WMA	631183	3787648	

a = National Park Service, b = Wildlife Management Area, c = National Wildlife Refuge
d = Army Corps of Engineers, e = Wetland Reserve Program

Table 1 cont.

SITE NAME	OWNERSHIP	EASTING	NORTHING	SPECIES PRESENT (No. detected)
BPARK	ACOE[d]	651191	3766185	
BPARK2	ACOE	651191	3766185	PBGR(1)
CACHE RIVER 1	NWR	656445	3883412	
CACHE RIVER 2	NWR	651659	3881994	
CACHE RIVER 3	NWR	652133	3883089	
CACHE RIVER 4	NWR	655744	3870858	PBGR(6)
CACHE RIVER B	NWR	648592	3893807	
CHICOT WRP	WRP[e]	648535	3677639	MODU(15)
CHICOT WRP 1	WRP	649081	3676039	KIRA(1), MODU(3), SORA(3)
CHICOT WRP 3	WRP	648403	3677868	KIRA(6), MODU(2), SORA(2), VIRA(2)
CHICOT WRP 4	WRP	648472	3677087	KIRA(3), MODU(2), SORA(3)
CUT OFF CREEK	WMA	638369	3702729	
GRICE	Private	633578	3668569	AMBI(1)
LAWRE1	Private	663568	3975806	
LAWRE2	Private	663726	3976967	
LINCON2	Private	627788	3759213	
MALLARD LAKE 1	WMA	762404	3976820	
MALLARD LAKE 2	WMA	762063	3979516	
MILL1	Private	601783	3787448	
OVERFLOW 1	NWR	627039	3664398	KIRA(3), LEBI(1), MODU(2), VIRA(1)
OVERFLOW 2	NWR	626850	3662889	AMCO(2)
OVERFLOW 3	NWR	627163	3664947	LEBI(1)
OAKWOOD 1	NWR	652760	3745649	MODU(2), SORA(1)
OAKWOOD 2	NWR	652684	3744847	KIRA(3), SORA(1)
OAKWOOD 3	NWR	651978	3746153	SORA(1)
OAKWOOD 4	NWR	652450	3746429	BBWD(2), PBGR(2)
POTLATCH1	WRP	648066	3654962	SORA(1)
POTLATCH2	WRP	648279	3655295	SORA(2)
POTLATCH3	WRP	648285	3654144	LEBI(1), SORA(1)
POTLATCH4	WRP	648066	3654962	KIRA(2), SORA(1)
POTLATCH5	WRP	648075	3654859	
POTLATCH6	WRP	647511	3653989	KIRA(1), LEBI(1)
POTLATCH8	WRP	647885	3654179	
ROADS1	Private	660763	3879480	LEBI(2)
SIS1	Private	601437	3791297	SORA(1), VIRA(1)
ST. FRANCIS 1	WRP	712472	3881195	AMCO(1), KIRA(2), LEBI(1), SORA(1)
ST. FRANCIS 2	WRP	715022	3881275	AMCO(1), LEBI(2), PBGR(3)
ST.FRANCIS 3	WRP	717087	3880843	AMBI(1), AMCO(19), MODU(5), PBGR(4), SORA(1)
ST.FRANCIS 4	WRP	716579	3881323	MODU(5), PBGR(4)
WAPANONCA 1	NWR	753981	3913317	KIRA(1), SORA(1)
WAPANONCA 2	NWR	752169	3917047	
WAPANONCA 3	NWR	751990	3917024	SORA(2), VIRA(1)
WAPANONCA 4	NWR	751851	3917033	AMBI(1), PBGR(1), SORA(1)
WAPANONCA 5	NWR	753062	3915822	
WAPANONCA 6	NWR	753706	3915310	
WAPANONCA Z	NWR	754364	3914085	
WHITE RIVER 1	NWR	672591	3790646	
WODRUF	Private	650673	3885714	
WODRUF2	Private	645447	3892386	MODU(1)
WODRUF3	Private	645112	3890461	

Table 2. 2005 opportunistic sites listing the date of observation, species, number of individuals detected, and UTM coordinates. See Appendix 4 for 4-letter species codes.

DATE	SPECIES	No.	UTM EASTING	UTM NORTHING
22-Apr-2005	AMCO	7	627163	3664947
26-Apr-2005	AMCO	4	629907	3897273
26-Apr-2005	AMCO	11	629913	3897719
28-Apr-2005	AMCO	2	639504	3871730
3-May-2005	AMCO	1	712415	3881197
3-May-2005	AMCO	1	717091	3881197
3-May-2005	AMCO	8	717181	3880939
22-Jun-2005	AMCO	1	625566	3797471
14-Apr-2005	BBWD	4	633578	3668569
15-Jun-2005	BBWD	9	636773	3685603
22-Apr-2005	BCNH	8	651283	3746300
3-May-2005	BCNH	5	715024	3881276
14-Apr-2005	COMO	2	664610	3731110
13-Jun-2005	COMO	2	643992	3701116
15-Jun-2005	LEBI	2	636773	3685603
22-Jun-2005	LEBI	2	625566	3797471
14-Apr-2005	PBGR	6	664610	3731110
19-Apr-2005	PBGR	4	647346	3653733
6-May-2005	PBGR	1	755676	3915090
19-Apr-2005	SORA	1	647470	3653891
19-Apr-2005	SORA	1	648071	3654060
19-Apr-2005	SORA	1	647920	3654088
19-Apr-2005	SORA	1	648094	3653964
21-Apr-2005	SORA	1	651348	3745275
5-May-2006	SORA	1	754328	3914161
6-May-2005	SORA	1	755288	3915203
16-Apr-2005	VIRA	1	627026	3664381
22-Apr-2005	WFIB	1	652584	3745868
17-Apr-2005	WHIB	4	627323	3663756
15-Jun-2005	WHIB	1	636773	3685603
14-Jun-2005	WHIB	15	627323	3663756
22-Jun-2005	WHIB	14	625566	3797471
28-May-2005	YCNH	1	754357	3914129
29-May-2005	YCNH	4	753970	3913297
29-Jun-2005	YCNH	1	751066	3917017

Table 3. Site names, ownership, UTM coordinates, species present at each site, and number of individuals detected during the 2006 field season in the Delta of Arkansas, USA. See Appendix 4 for 4-letter species codes.

SITE NAME	OWNERSHIP	UTM EASTING	UTM NORTHING	SPECIES PRESENT (No. detected)
AGG FARMS 1	Private	621213	3753605	
AGG FARMS 2	Private	619070	3754301	BBWD(2)
AGG FARMS 3	Private	619054	3754771	
ALLEN FARMS	Private	648043	3954982	
ALLEN FARMS 1	Private	649758	3958710	SORA(1)
ALLEN FARMS 2	Private	649517	3957629	
ALLEN FARMS 3	Private	648960	3958819	AMBI(1), VIRA(1)
SIDNEY 1	Private	646987	3698796	
SIDNEY 2	Private	647174	3698796	
SIDNEY 3	Private	648257	3697108	AMCO(64), PBGR(2),
SIDNEY 4	Private	648035	3697125	AMCO(23), BCNH(1), LEBI(3), PBGR(4), SORA(1)
BANK1	WRP[a]	735509	3958923	AMBI(1), SORA(1)
BANK2	WRP	734961	3958838	
BANK3	WRP	735374	3958212	
BANK4	WRP	735919	3959631	PBGR(1)
BAXTER FARMS 1	Private	658243	3729748	
BAXTER FARMS 2	Private	658241	3729963	
BAXTER FARMS 3	Private	658203	3729553	AMCO(9), COMO(2), LEBI(2), PBGR(2), SORA(1)
BAXTER FARMS 4	Private	658202	3729368	AMCO(80), COMO(3), LEBI(2), PBGR(2)
BAXTER FARMS 5	Private	658848	3730983	LEBI(1)
BAXTER FARMS 6	Private	659453	3731095	COMO(2), LEBI(4), PBGR(1), SORA(2)
BAXTER FARMS 7	Private	659669	3731115	SORA(1)
BAXTER FARMS 8	Private	659751	3728298	
BENN1	Private	667260	3824191	AMBI(1), KIRA(2), SORA(2), VIRA(1)
BYO1	Private	721526	3881353	
CACHE RIVER 01	NWR[b]	670525	3898167	
CACHE RIVER 02	NWR	671001	3897991	SORA(1)
CACHE RIVER 03	NWR	661185	3910241	
CACHE RIVER 04	NWR	661228	3910569	
CACHE RIVER 05	NWR	661320	3910941	
CACHE RIVER 06	NWR	661439	3911123	
CBURR1	Private	737366	3965316	PBGR (1)
CBURR2	Private	737127	3964891	
CHIC35	Private	649442	3666238	
DITCH1	Private	649585	3746647	VIRA(1)
DONOV	Private	662031	3848514	

a = Wetland Reserve Program, b = National Wildlife Refuge

Table 3 cont.

SITE NAME	OWNERSHIP	UTM EASTING	UTM NORTHING	SPECIES PRESENT (No. detected)
DONOV	Private	659825	3848585	AMCO(5), PBGR(1), SORA(1)
DRJOE1	WRP	678395	3955282	AMCO(1), SORA(1)
DRJOE2	WRP	678638	3954274	
DRJOE3	WRP	678470	3954769	
EDMON1	Private	718960	3908884	
EDMON2	Private	720463	3908000	
EDMON3	Private	720344	3907277	
EDMON4	Private	720408	3907200	AMBI(1)
FRENCH 1	WRP	655023	3721755	
FRENCH 2	WRP	654862	3722198	
GANT1	Private	699850	3946971	SORA(3)
GUS1	Private	663694	3964096	SORA(1)
GUS2	Private	663914	3965705	LEBI(1)
GUS3	Private	664027	3963913	
HARW1	Private	671083	3670329	
HARW2	Private	670817	3670228	
HOGWALLOW 1	WRP	631796	3677706	AMBI(1), LEBI(1), MODU(2), PBGR(4), SORA(1)
HOGWALLOW 2	WRP	631488	3677211	AMBI(1), AMCO(1), KIRA(4)
HOGWALLOW 3	WRP	630807	3677257	AMCO(10)
HWY17	Private	660495	3842452	LEBI(2), SORA(5)
KANL1	Private	669062	3817687	
BALD KNOB 01	NWR	626355	3902882	
BALD KNOB 02	NWR	627671	3903008	AMBI(6), PBGR(2), SORA(2), VIRA(1)
BALD KNOB 03	NWR	629890	3901652	SORA(2)
BALD KNOB 04	NWR	627889	3902363	AMBI(1), BCNH(1), PBGR(1)
BALD KNOB 05	NWR	630343	3906374	AMBI(3), LEBI(1), PBGR(3), SORA(2)
LAND1	Private	584286	3825546	LEBI(2)
LAND2	Private	583315	3825921	
LAND3	Private	580405	3827114	
LEGOR	Private	735006	3876710	
LIG1A	Private	690985	3839434	
LIG1B	Private	690821	3839541	
LIG2	Private	689847	3838030	
LINWOOD PT 1	Private	667575	3699256	BCNH(1)
LINWOOD PT 2	Private	667720	3699213	
LUX1	Private	782558	3962483	
LUX2	Private	781657	3962263	PBGR(2)

Table 3 cont.

SITE NAME	OWNERSHIP	UTM EASTING	UTM NORTHING	SPECIES PRESENT (No. detected)
LUX3	Private	781218	3962246	
LUX4	Private	780524	3962208	
WAPANONCA 01	NWR	752459	3914449	AMBI(2)
WAPANONCA 02	NWR	752321	3914185	PBGR(10)
OAKWOOD 01	NWR	651314	3745808	AMBI(1), KIRA(7), LEBI(2), SORA(3), VIRA(2)
OAKWOOD 02	NWR	651814	3745768	LEBI(1), SORA(1), VIRA(1)
OAKWOOD 03	NWR	651561	3745796	AMBI(1), KIRA(2), LEBI(1), SORA(1), VIRA(1)
OVERFLOW 01	NWR	627528	3662369	SORA(1)
OVERFLOW 02	NWR	627563	3662624	AMBI(1), PBGR(1)
OVERFLOW 03	NWR	627194	3662511	
OVERFLOW 04	NWR	626864	3661378	
OVERFLOW 05	NWR	627168	3661389	
OVERFLOW 06	NWR	627585	3661833	
OVERFLOW 07	NWR	627947	3662132	WHIB(3), WFIB(1)
OVERFLOW 08	NWR	626723	3662486	AMCO(12), BBWD(7), LEBI(2), PBGR(3), SORA(1), VIRA(1
OVERFLOW 09	NWR	626406	3662610	
OTTER LAKE 1	Private	668172	3675313	AMCO(14), PBGR(2)
OTTER LAKE 2	Private	668028	3675459	PBGR(1)
RAFT CREEK 1	WMA[c]/WRP	634608	3886808	AMBI(1),KIRA(2), SORA(2), VIRA(1)
RAFT CREEK 2	WMA/WRP	634965	3886404	SORA(1)
RAFT CREEK 3	WMA/WRP	635327	3886470	
RAFT CREEK 4	WMA/WRP	632401	3884569	
RAFT CREEK 5	WMA/WRP	632624	3884589	SORA(1)
SCHAR1A	Private	670375	3804676	AMBI(1), LEBI(1)
SCHAR1B	Private	670575	3804596	
SIGL1	Private	654978	3778799	
SIGL2	Private	655015	3778700	
SIGL3	Private	655472	3778775	LEBI(1), SORA(1)
STDTCH	Private	638064	3817802	
TEX1	Private	656937	3781730	
TYRZ1	Private	740252	3928450	
TYRZ2	Private	740134	3928218	
WALLACE TRUST 1	WRP	662159	3721073	AMBI(1), AMCO(5), COMO(4), LEBI(2), PBGR(4), SORA(1)
WALLACE TRUST 2	WRP	661983	3721055	KIRA(2), SORA(2)
WALLACE TRUST 3	WRP	661733	3720685	AMCO(3), LEBI(3), PBGR(3)
WALLACE TRUST 4	WRP	661915	3720545	AMCO(1), LEBI(5), PBGR(3), SORA(1)
WHITE RIVER	NWR	671702	3789969	LEBI(1)

Table 4. Opportunistic detections of species of interest listing the date of observation, species, number of individuals detected, and UTM coordinates from the 2006 field season in the Delta of Arkansas, USA. See Appendix 4 for 4-letter species codes.

DATE	SPECIES	No.	UTM EASTING	UTM NORTHING
31-Mar-2006	AMBI	1	648574	3677971
3-Apr-2006	AMBI	1	627069	3664387
3-Apr-2006	AMBI	1	631784	3677177
20-Apr-2006	AMBI	1	716902	3881241
20-Apr-2006	AMBI	1	714224	3881327
20-Apr-2006	AMBI	1	712472	3881195
25-Apr-2006	AMBI	1	660841	3910693
18-May-2006	AMBI	1	631488	3677211
20-Apr-2006	AMCO	7	716743	3881316
5-May-2006	AMCO	10	631488	3677211
6-May-2006	AMCO	10	614077	3830507
8-May-2006	AMCO	6	662346	3721403
18-May-2006	AMCO	3	631488	3677211
24-Jun-2006	AMCO	1	626723	3662486
9-Jun-2006	BBWD	2	619071	3754301
9-Jun-2006	BBWD	2	619071	3754301
24-Jun-2006	BBWD	1	636773	3685603
19-May-2006	BCNH	1	629093	3902889
5-May-2006	COMO	2	631488	3677211
8-May-2006	COMO	1	646611	3759896
8-May-2006	COMO	2	662346	3721403
18-May-2006	COMO	1	631488	3677211
7-Jun-2006	COMO	nest	662400	3720998
7-Jun-2006	COMO	nest	662407	3721065
7-Jun-2006	COMO	nest	662385	3721080
1-Apr-2006	KIRA	4	661958	3721005
20-Apr-2006	KIRA	1	712472	3881195
15-May-2006	KIRA	2	714452	3881262
18-May-2006	KIRA	2	631488	3677211
6-Jun-2006	KIRA	1	631488	3677211
7-Jun-2006	KIRA	1	631488	3677211
9-Jun-2006	KIRA	1	662346	3721403
24-Jun-2006	KIRA	2	648403	3677868
25-Jun-2006	KIRA	3	648403	3677868

Table 4. Cont.

DATE	SPECIES	No.	UTM EASTING	UTM NORTHING
4-Apr-2006	LEBI	1	631488	3677211
18-May-2006	LEBI	1	631488	3677211
5-May-2006	LEBI	3	631488	3677211
24-Jun-2006	LEBI	2	636773	3685603
7-Jun-2006	LEBI	nest	648317	3677996
7-May-2006	LEBI	1	651709	3745857
9-May-2006	LEBI	1	659295	3729055
8-Jun-2006	LEBI	1	662255	3720873
8-Jun-2006	LEBI	1	662313	3721376
8-May-2006	LEBI	3	662346	3721403
7-Jun-2006	LEBI	nest	662394	3721079
14-Jun-2006	LEBI	2	714452	3881262
31-Mar-2006	MODU	2	627040	3664399
31-May-2006	MODU	2	626960	3661889
31-May-2006	MODU	2	626960	3661889
8-Jun-2006	MODU	2	627039	3664398
8-Jun-2006	MODU	2	648403	3677868
31-Mar-2006	PBGR	2	648574	3677971
31-Mar-2006	PBGR	3	627040	3664399
1-Apr-2006	PBGR	1	661958	3721005
5-Apr-2006	PBGR	11	626960	3661889
16-Apr-2006	PBGR	1	628905	3822877
20-Apr-2006	PBGR	1	716902	3881241
2-May-2006	PBGR	6	752321	3914185
5-May-2006	PBGR	2	631488	3677211
8-May-2006	PBGR	4	662346	3721403
18-May-2006	PBGR	3	631488	3677211
8-Jun-2006	PBGR	1	662255	3720873
9-Jun-2006	PBGR	7	662346	3721403

Table 4. Cont.

DATE	SPECIES	No.	UTM EASTING	UTM NORTHING
5-May-2006	SORA	1	614077	3830507
5-May-2006	SORA	3	631488	3677211
17-Apr-2006	SORA	5	647101	3832397
17-Apr-2006	SORA	1	648349	3832366
31-Mar-2006	SORA	2	648574	3677971
1-Apr-2006	SORA	2	659878	3729171
1-Apr-2006	SORA	3	661958	3721005
21-Apr-2006	SORA	4	670267	3898147
1-May-2006	SORA	1	678467	3955515
27-Apr-2006	SORA	3	703147	3945124
20-Apr-2006	SORA	5	712472	3881195
20-Apr-2006	SORA	6	714224	3881327
20-Apr-2006	SORA	1	716743	3881316
20-Apr-2006	SORA	4	716902	3881241
16-May-2006	SORA	1	731454	3877234
31-Mar-2006	VIRA	2	648574	3677971
17-Apr-2006	VIRA	1	647101	3832397
19-Apr-2006	VIRA	1	665263	3854993
7-May-2006	VIRA	1	650182	3746323
2-May-2006	WFIB	1	752321	3914185
24-Jun-2006	WHIB	15	626723	3662486
25-Jun-2006	WHIB	11	648403	3677868
3-May-2006	YCNH	1	749638	3917147

Table 5. Species associations showing how frequently one secretive marsh bird species was detected at the same site as another secretive marsh bird species in the Delta of Arkansas, USA. Associations were determined by combining 2005 and 2006 data, where the parentheses indicate the number of sites where the species was detected and the other numbers indicates the percentage of time the species in the first column was detected with each species in the top row. See appendix 4 for four letter species codes.

	KIRA	**SORA**	**VIRA**	**PUGA**	**COMO**	**LEBI**	**AMBI**	**PBGR**
KIRA (17)	-	76	35	0	0	35	29	0
SORA (50)	26	-	22	0	2	32	22	22
VIRA (14)	43	79	-	0	0	36	50	21
PUGA (2)	0	0	0	-	50	100	0	100
COMO (6)	0	17	0	17	-	83	17	83
LEBI (35)	17	46	14	6	14	-	20	37
AMBI (21)	24	52	33	0	5	33	-	38
PBGR (29)	0	34	10	7	24	45	28	-
AMCO (19)	11	47	11	0	26	47	21	68

Table 6. The number of detections in 2005 and 2006 which were visual only, aural only, and both aural and visual for each breeding secretive marsh bird detected in the Delta of Arkansas, USA. Determined by summing responses from each individual detected during each visit. See Appendix 1 for 4-letter species codes.

	Visual		Aural		Aural and Visual	
Species	No.	%	No.	%	No.	%
PBGR	56	20	23	8	201	72
LEBI	15	10	126	86	6	4
SORA	54	27	127	63	5	2
KIRA	11	13	75	85	2	2
PUGA	13	87	0	0	2	13
COMO	6	7	70	86	5	6

Table 7. Operational definitions for variables thought to influence occupancy of secretive marsh birds in the Delta of Arkansas, USA.

Abbreviation	Operational definition
EV	The rank abundance of emergent vegetation, e.g. cattails (*Typha spp*.), sedges (*Carex spp*.), and rushes (*Juncus spp*.), within 100-m of the sampling point facing the direction of the call-playback speakers
WV	The rank abundance of woody vegetation $\leq$6m in height, e.g. buttonbush (*Cephalanthus spp*.), and willows (*Salix spp*.), within 100-m of the sampling point facing the direction of the call-playback speakers
W4	The rank abundance of wetlands within 400-m of the sampling point in all directions
F4	The rank abundance of forest, or woody vegetation $\geq$6-m in height, within 400-m of the sampling point in all directions

Table 8. Performance of site occupancy (Ψ) models after correcting for detection probability (p) for the pied-billed grebe during the summer of 2006 in the Delta of Arkansas, USA, w = model weight, -2*LogLike = -2 * LogLikelihood, and Npar = number of parameters.

Model	AICc	Δ AICc	w	Npar	(-2*LogLike)
ψ(W4),p(#_Pooled)	288.06	0.00	0.307	4	279.549
1 group, Constant P	288.16	0.10	0.292	2	284.007
ψ(.),p(#_Pooled)	289.40	1.34	0.157	3	283.102
ψ(W4+F4),p(#_Pooled)	290.29	2.23	0.100	5	279.525
ψ(F4),p(#_Pooled)	291.38	3.32	0.058	4	278.331
ψ(W4),p(Obs+#_Pooled)	291.42	3.36	0.057	6	282.868
ψ(.),p(Obs+#_Pooled)	292.68	4.62	0.030	5	281.915

W4 = Wetlands within 400-m, F4 = Forest within 400-m, Obs = Observer, #_Pooled = Number of sites collapsed into one site.

Table 9. Performance of site occupancy (Ψ) models after correcting for detection probability (p) for the least bittern during the summer of 2006 in the Delta of Arkansas, USA, w = model weight, -2*LogLike = -2 * LogLikelihood, and Npar = number of parameters.

Model	AICc	Δ AICc	w	Npar	(-2*LogLike)
ψ(EV+F4),p(#_Pooled+Obs)	207.56	0.00	0.483	7	192.16
ψ(EV+W4+F4),p(#_Pooled+Obs)	209.84	2.28	0.158	8	192.02
ψ(WV+F4),p(#_Pooled+Obs)	210.21	2.65	0.128	7	194.81
ψ(WV+F4+W4),p(#_Pooled+Obs)	211.79	4.23	0.046	8	194.49
ψ(.),p(#_Pooled+Obs)	212.18	4.62	0.045	5	201.45
ψ(EV+WV+W4+F4),p(#_Pooled+Obs)	212.31	4.75	0.047	9	192.01
ψ(EV),p(#_Pooled+Obs)	212.32	4.76	0.057	6	198.75
ψ(EV+W4),p(#_Pooled+Obs)	213.61	6.05	0.024	7	198.21
1 group, Constant P	214.85	7.29	0.011	2	210.71

W4 = Wetlands within 400-m, F4 = Forest within 400-m, EV = Emergent Vegetation, WV = Woody Vegetation, Obs = Observer, #_Pooled = Number of sites collapsed into one site.

Table 10. Number of sites surveyed for each combination of emergent vegetation (EV) and forest within 400-m (F4) in 2006 for the least bittern surveys in the Delta of Arkansas, USA.

		EV		
		0-10%	11-50%	51-100%
F4	0-10%	13	32	6
	11-50%	5	10	7
	51-100%	5	8	2

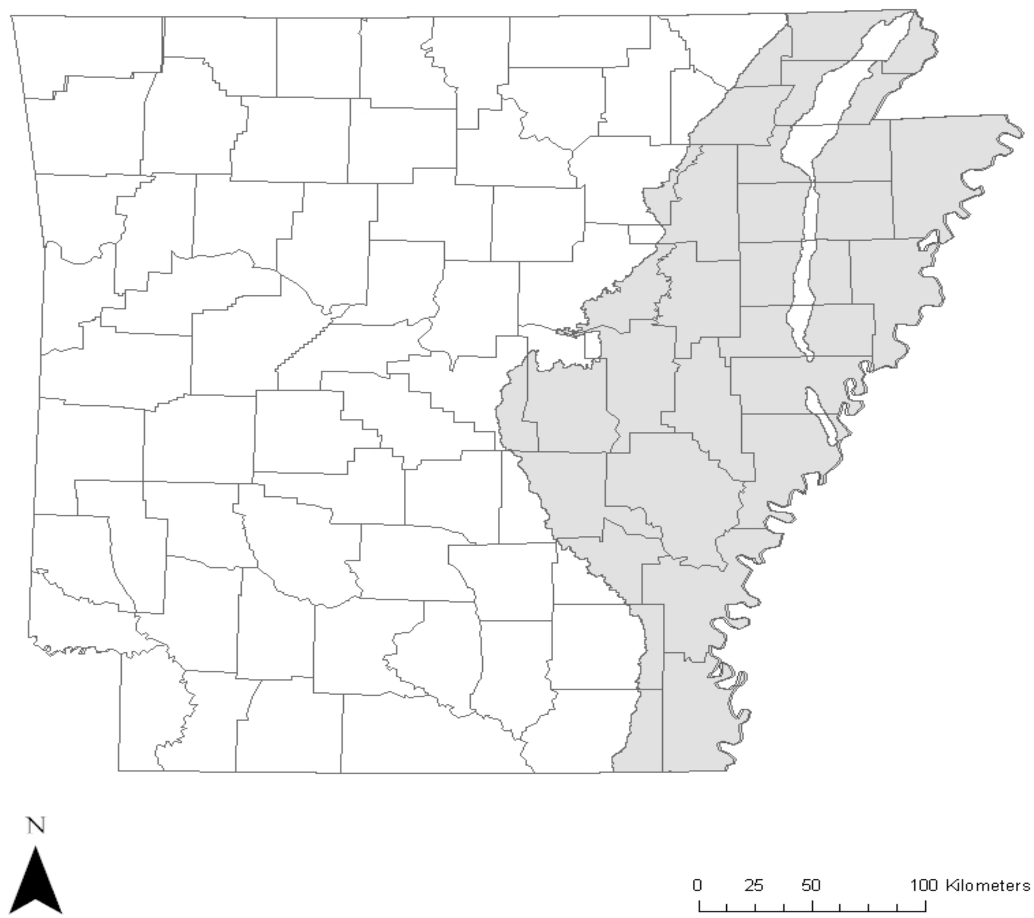

Fig. 1. Secretive marsh bird data were collected in the Delta of Arkansas, USA (highlighted in gray) during the breeding season in 2005 and 2006.

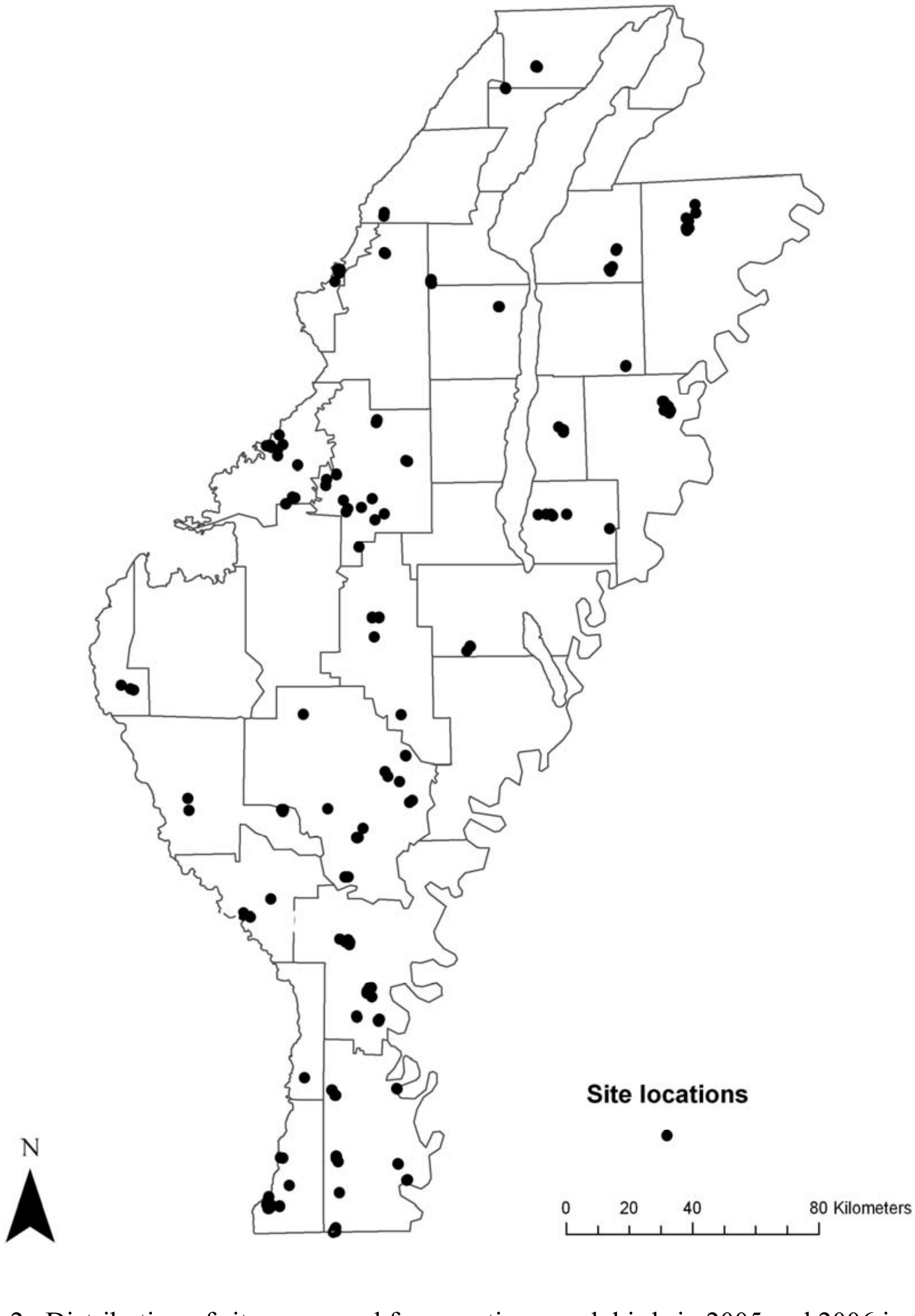

Fig. 2. Distribution of sites surveyed for secretive marsh birds in 2005 and 2006 in the Delta of Arkansas, USA.

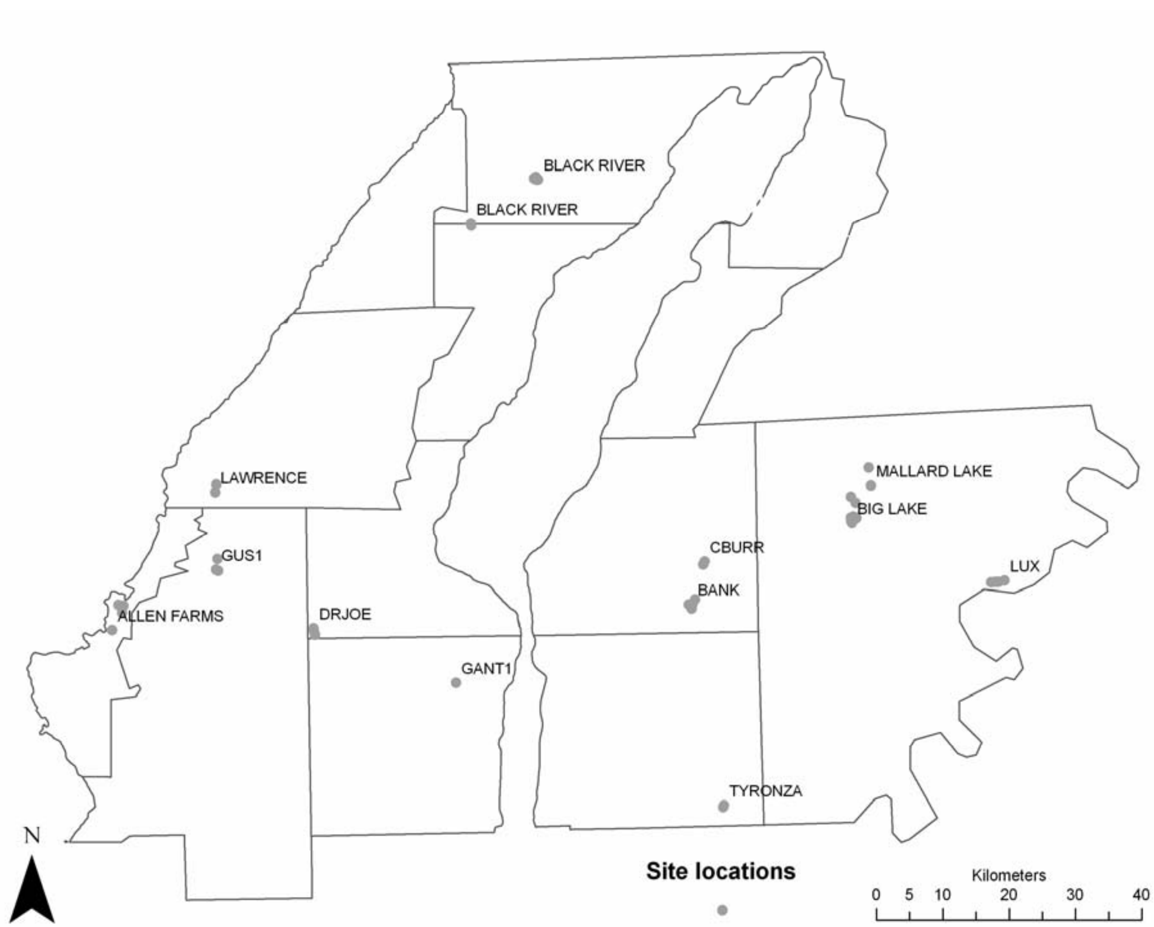

Fig. 3. Site names and locations of sites surveyed for secretive marsh birds in 2005 and 2006 in the northern sampling region of the Delta of Arkansas, USA.

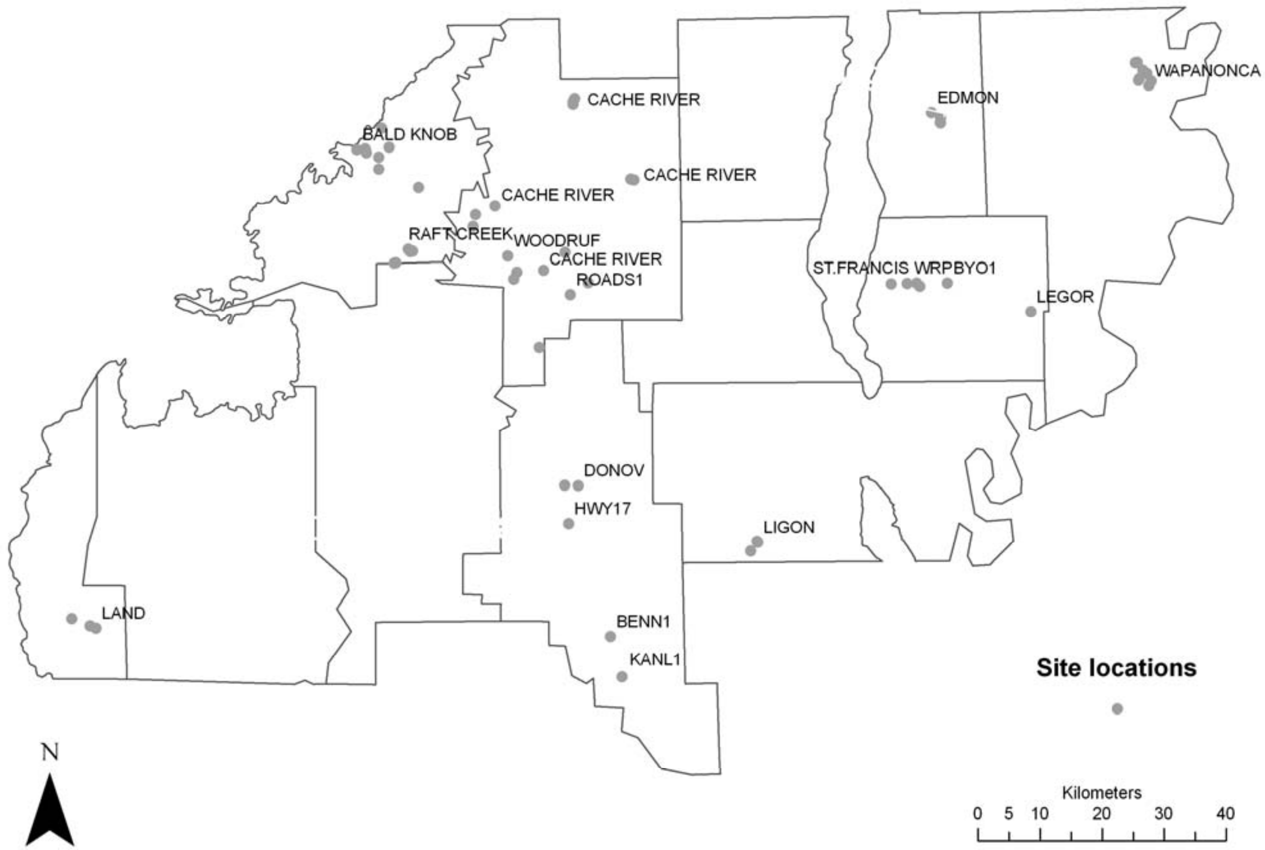

Fig. 4. Site names and locations of sites surveyed for secretive marsh birds in 2005 and 2006 in the central sampling region of the Delta of Arkansas, USA.

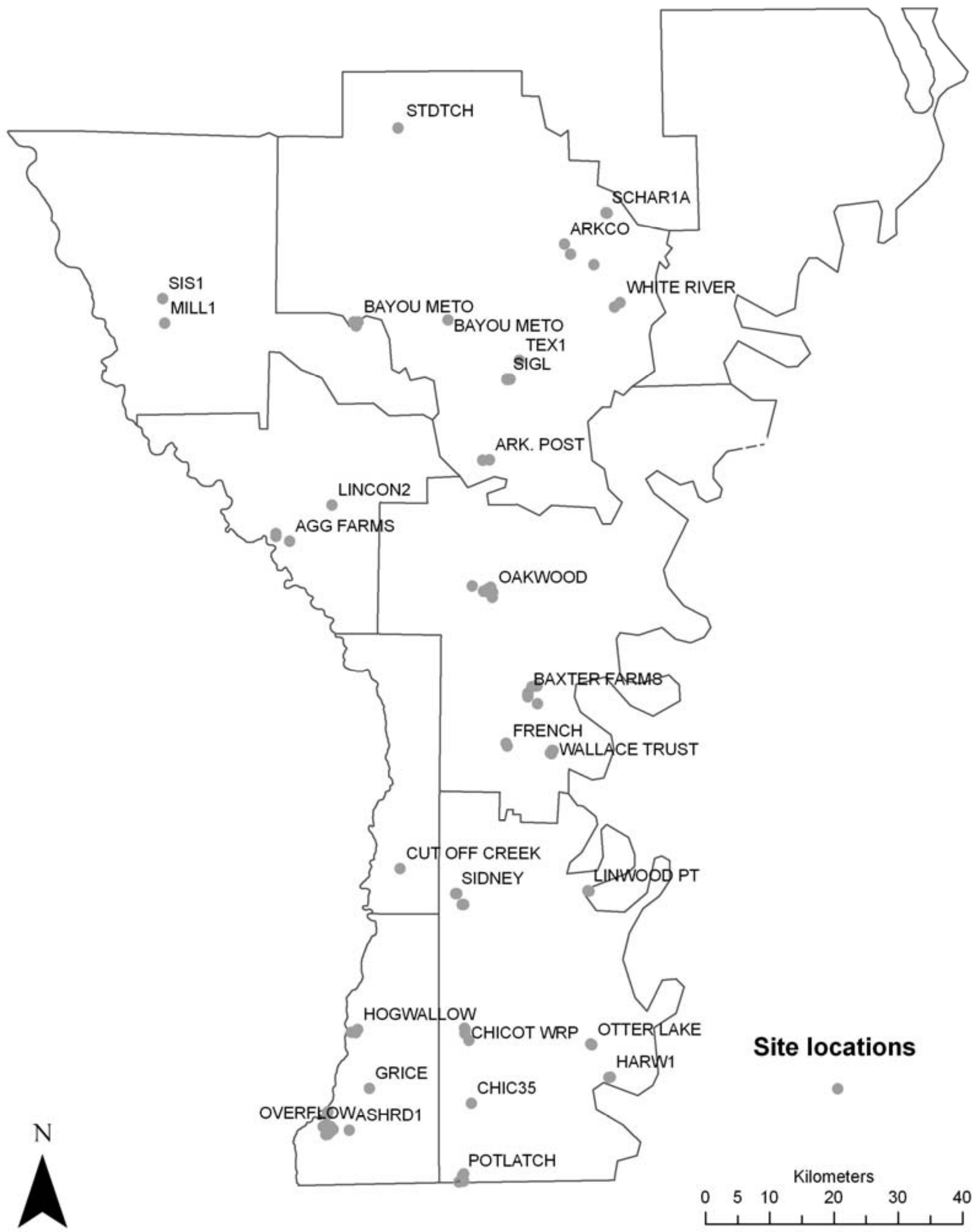

Fig. 5. Site names and site locations of sites surveyed for secretive marsh birds in 2005 and 2006 in the southern sampling region of the Delta of Arkansas, USA.

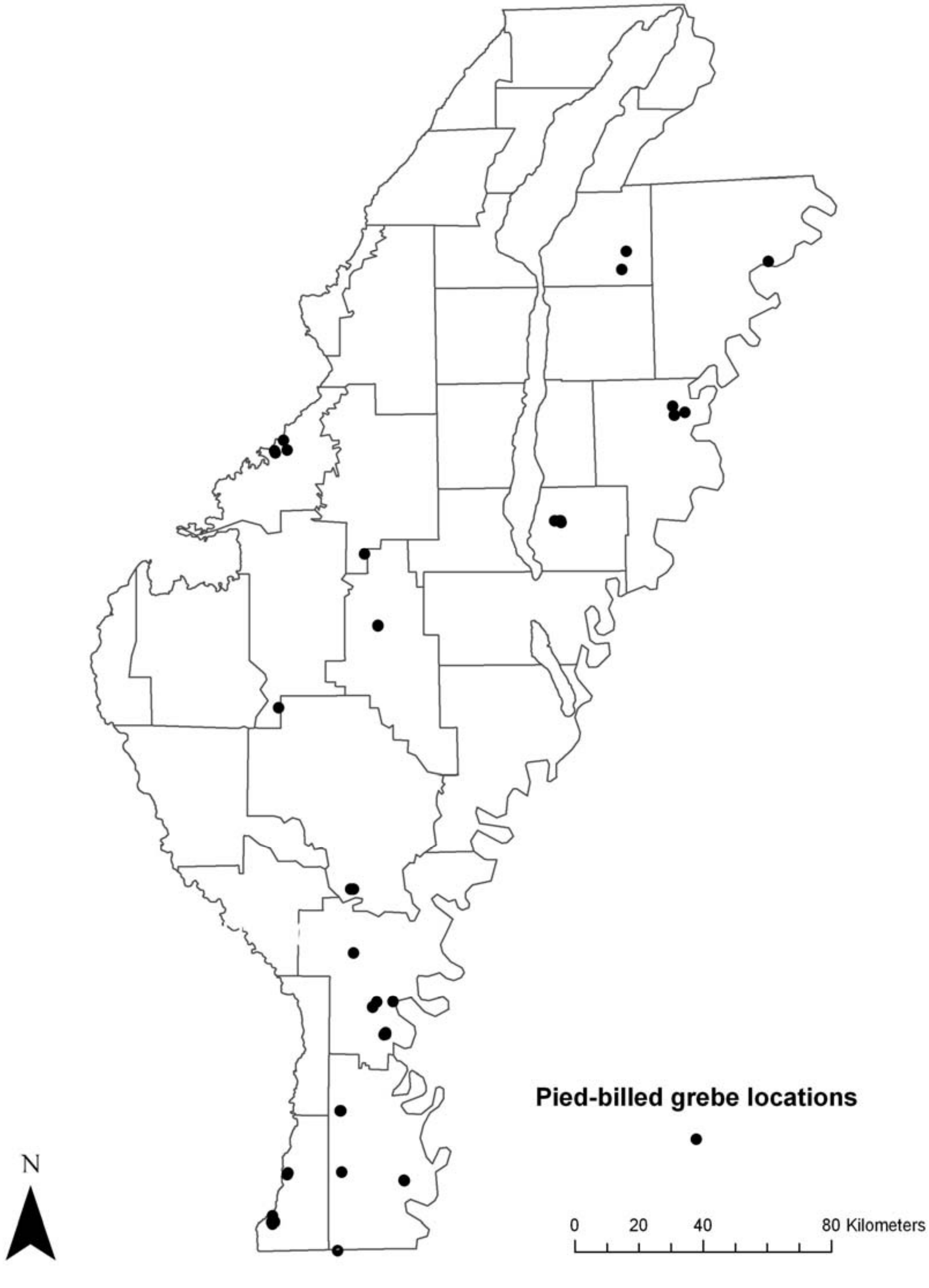

Fig. 6. Distribution of the pied-billed grebe using detections from randomly selected sites and opportunistic detections from 2005 and 2006 marsh bird surveys in the Delta of Arkansas, USA.

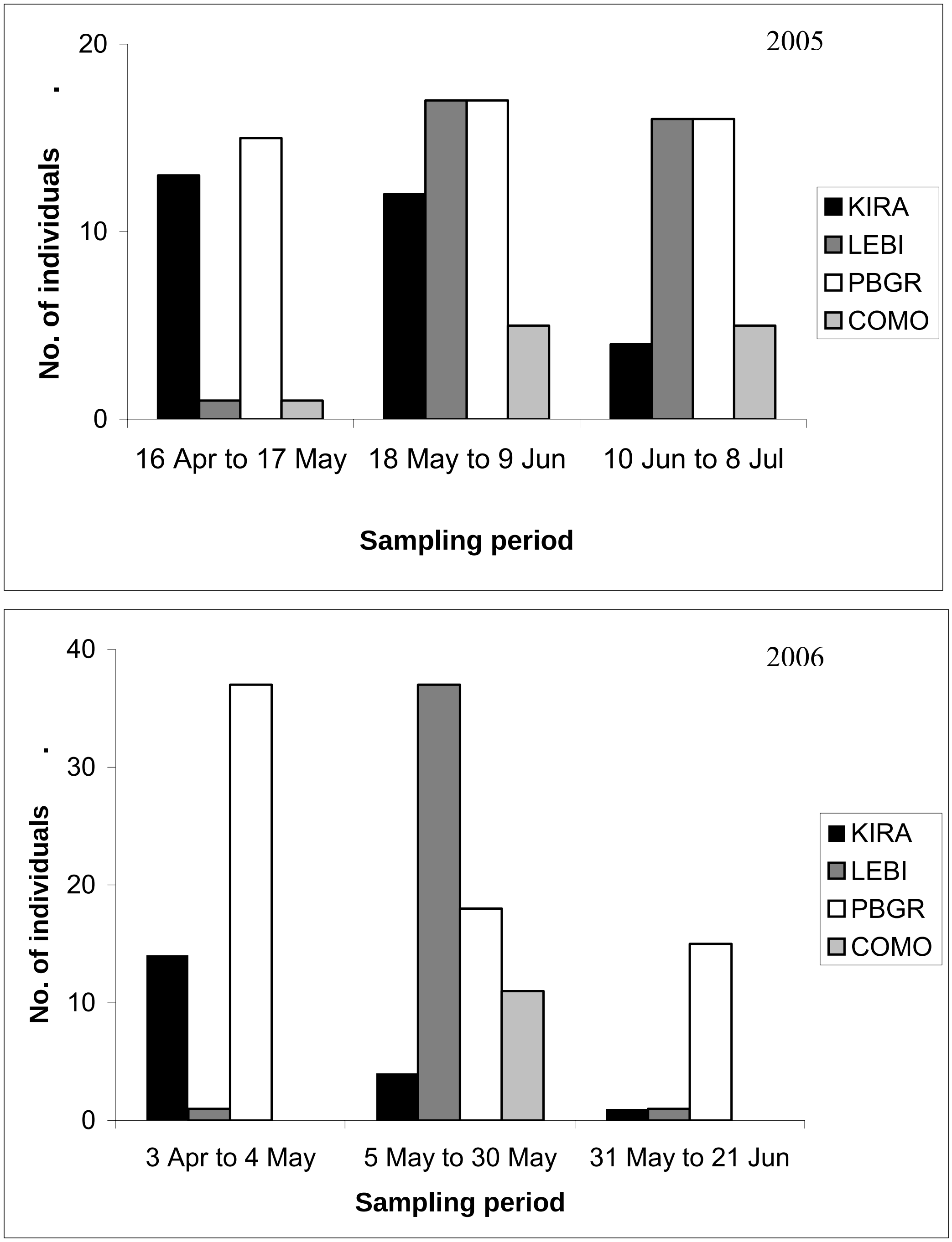

Fig. 7. Changes in secretive marsh bird detections over time in 2005 and 2006. Based on the number of individuals detected during each sampling period in the Delta of Arkansas, USA. One sampling period equals one pass from south to north through the Delta.

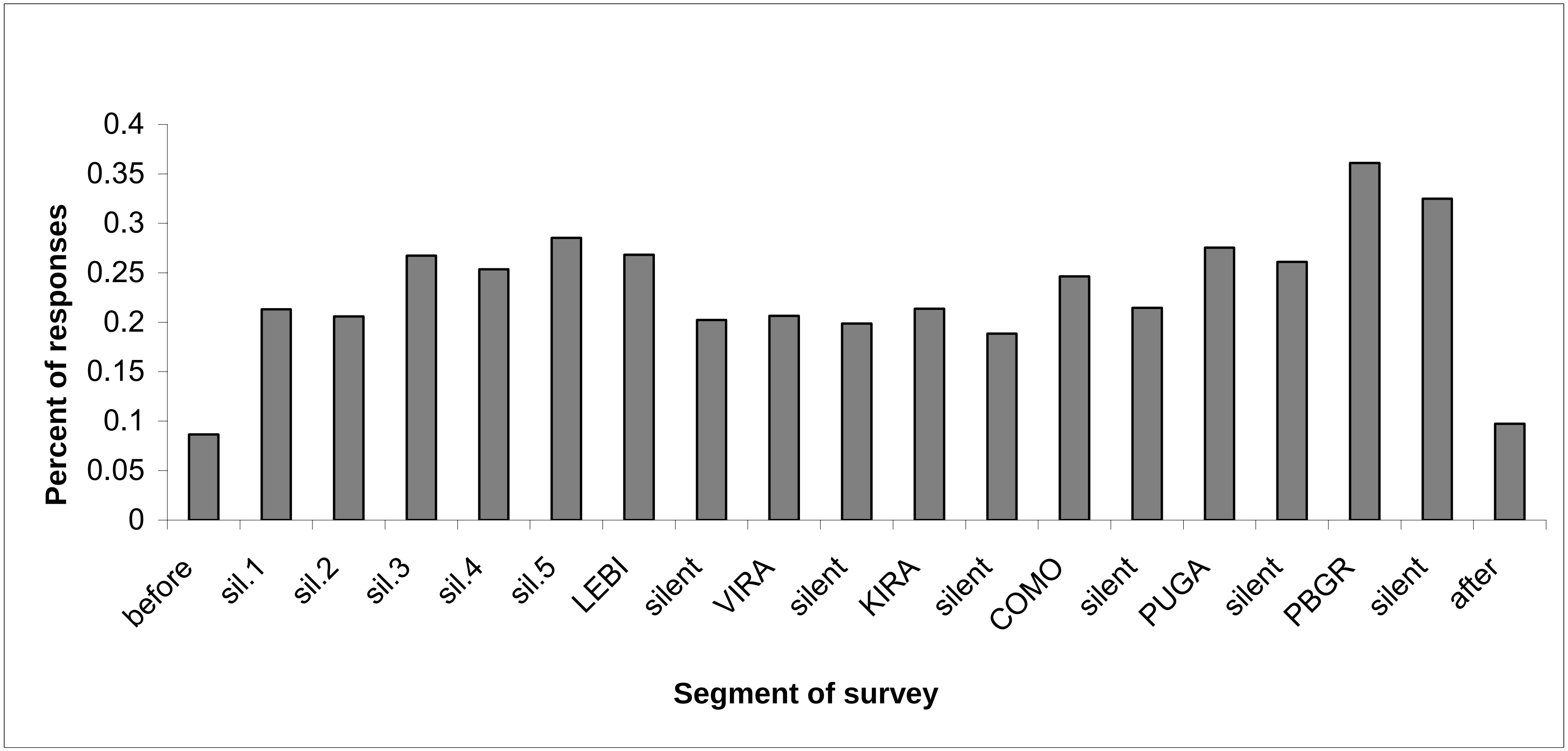

Fig. 8. Percent of responses from 2005 and 2006 combined, for the pied-billed grebe during each segment of the call-broadcast survey. The percent of responses was determined by dividing the number of individuals that responded during each segment of the survey by the total number of pied-billed grebes that responded overall during secretive marsh bird surveys in the Delta of Arkansas, USA.

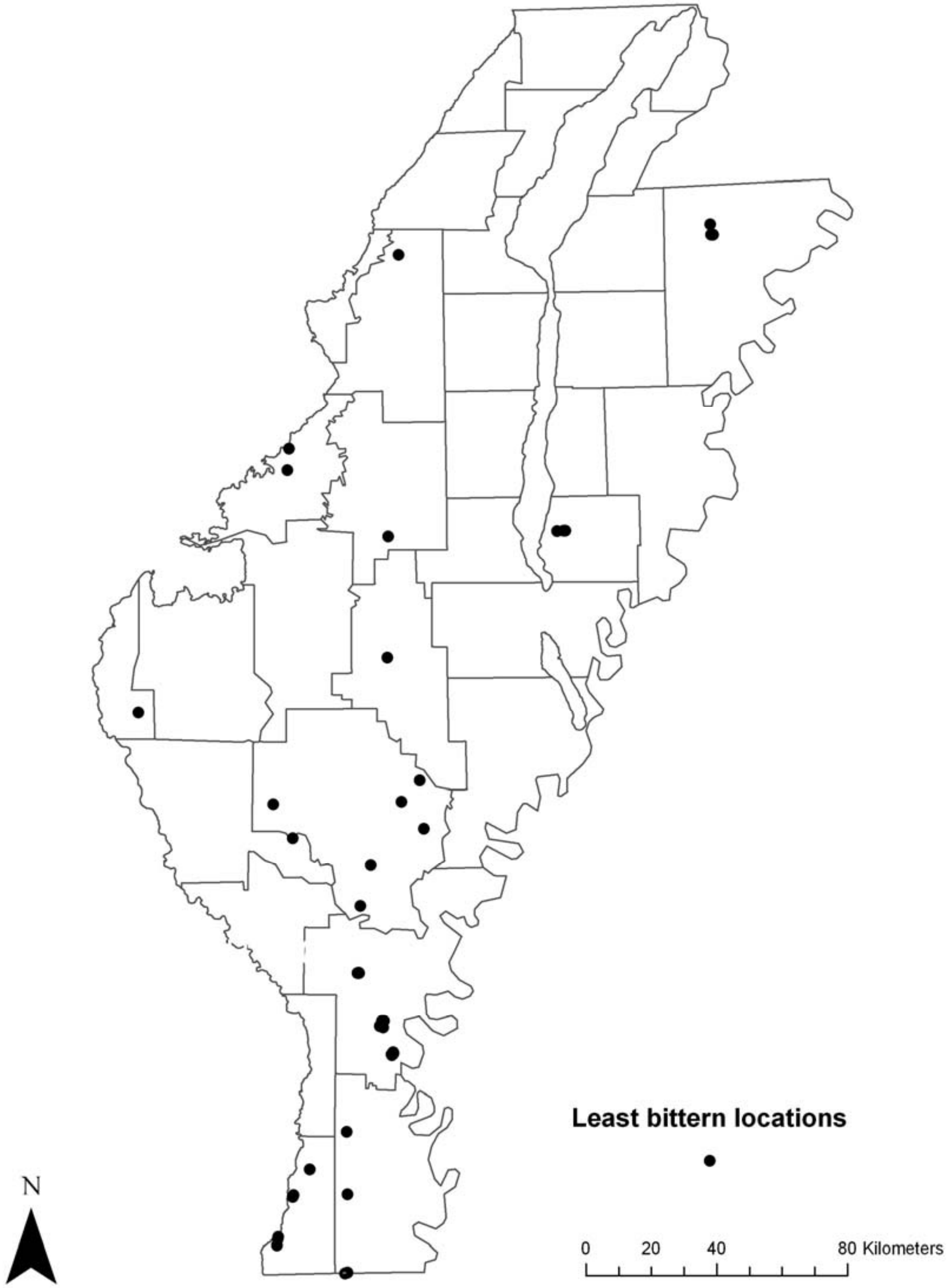

Fig. 9. Distribution of the least bittern using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

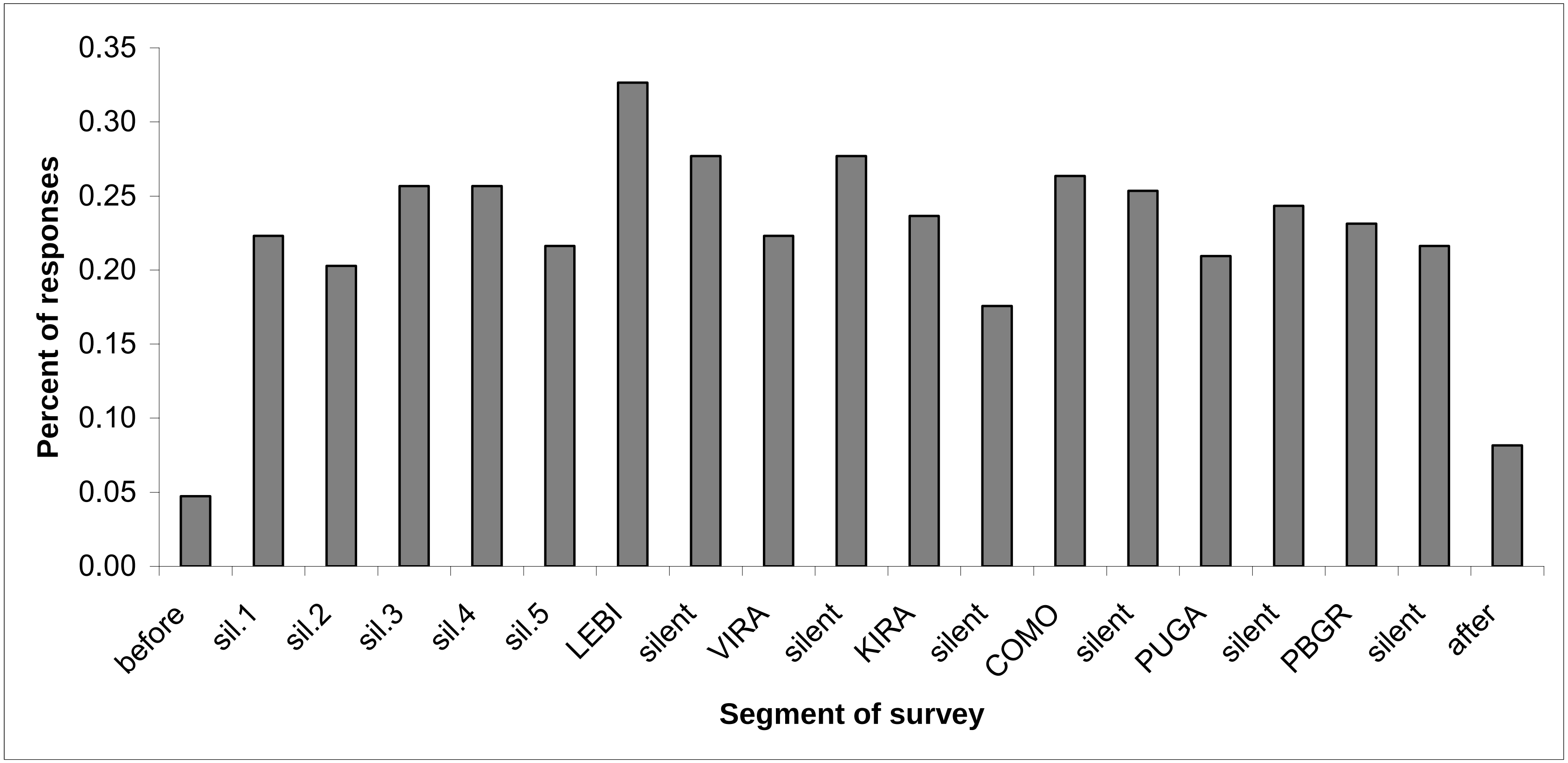

Fig. 10. Percent of responses from 2005 and 2006 combined, for the least bittern during each segment of the call-broadcast survey. The percent of responses was determined by dividing the number of individuals that responded during each segment of the survey by the total number of least bitterns that responded overall during secretive marsh bird surveys in the Delta of Arkansas, USA.

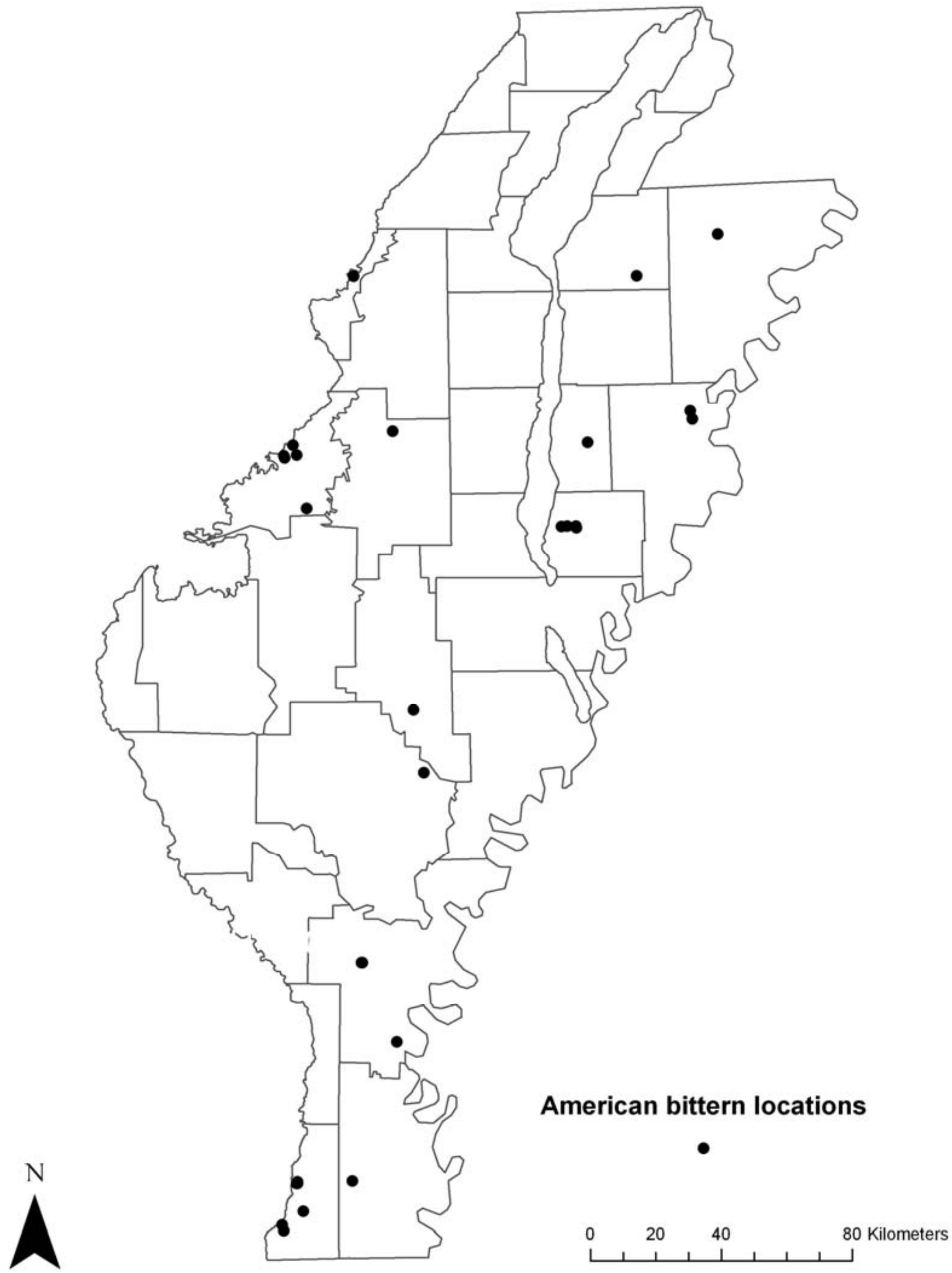

Fig. 11. Distribution of the American bittern using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

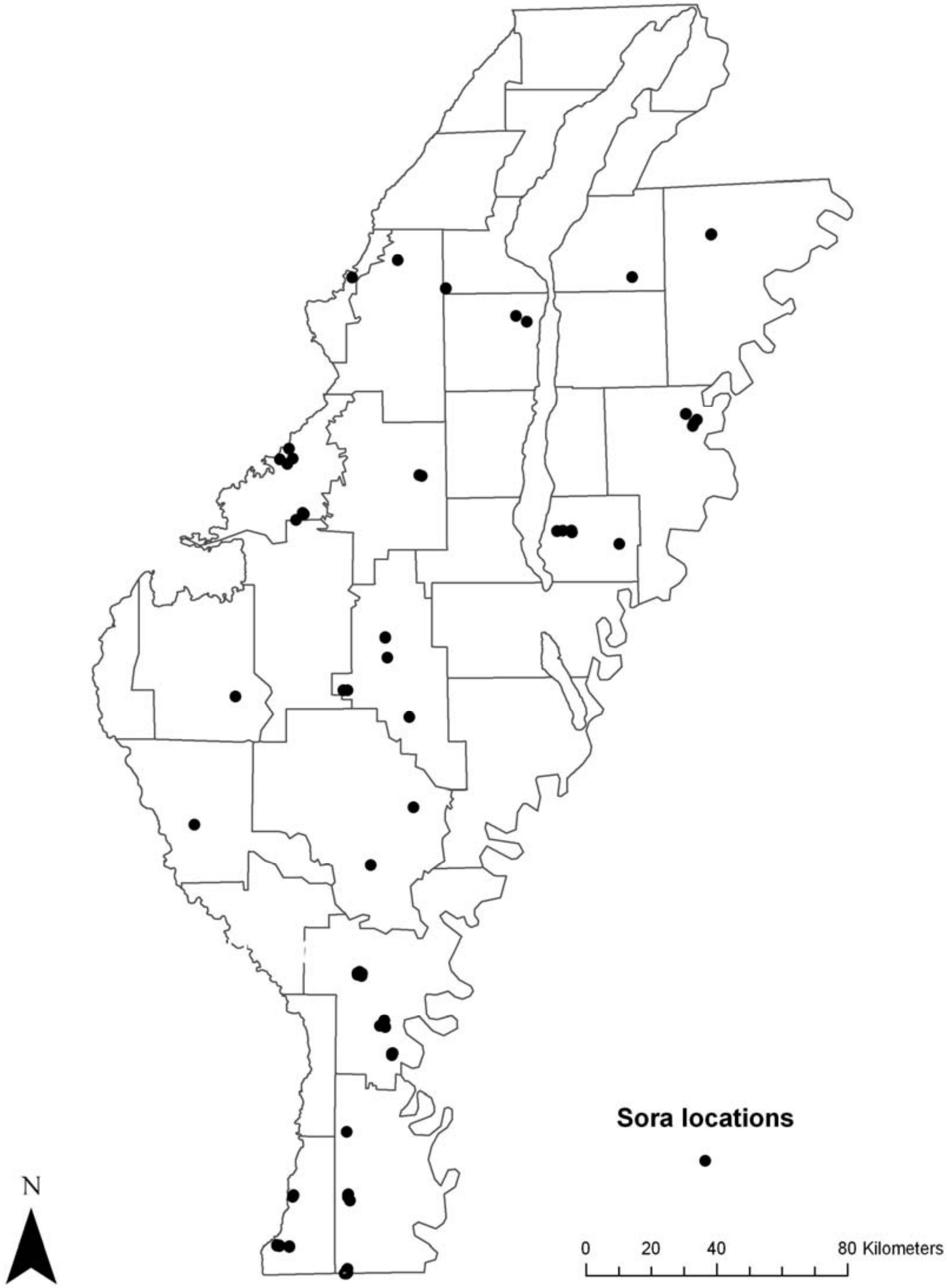

Fig. 12. Distribution of the sora coot using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

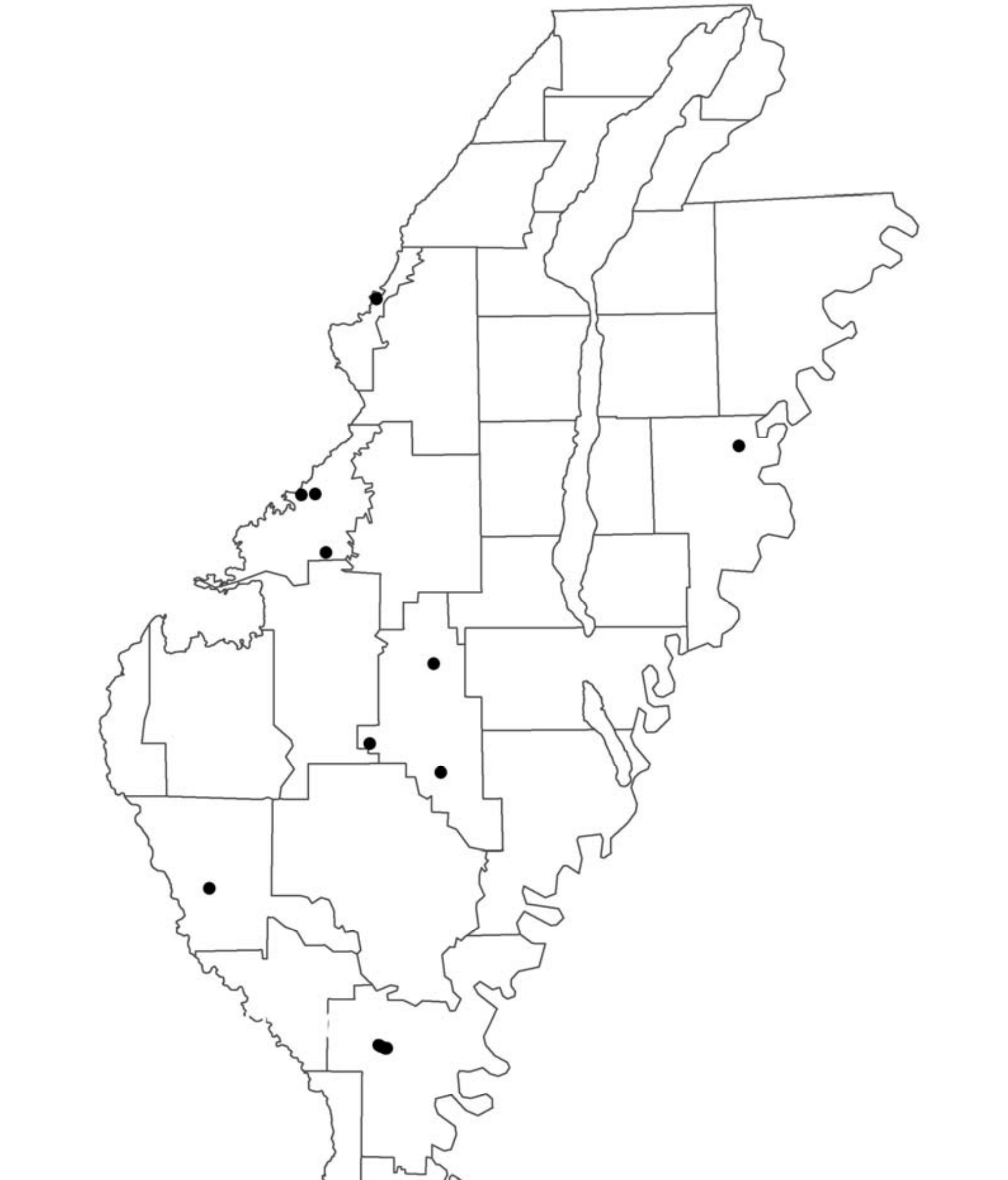

Fig. 13. Distribution of the Virginia rail using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

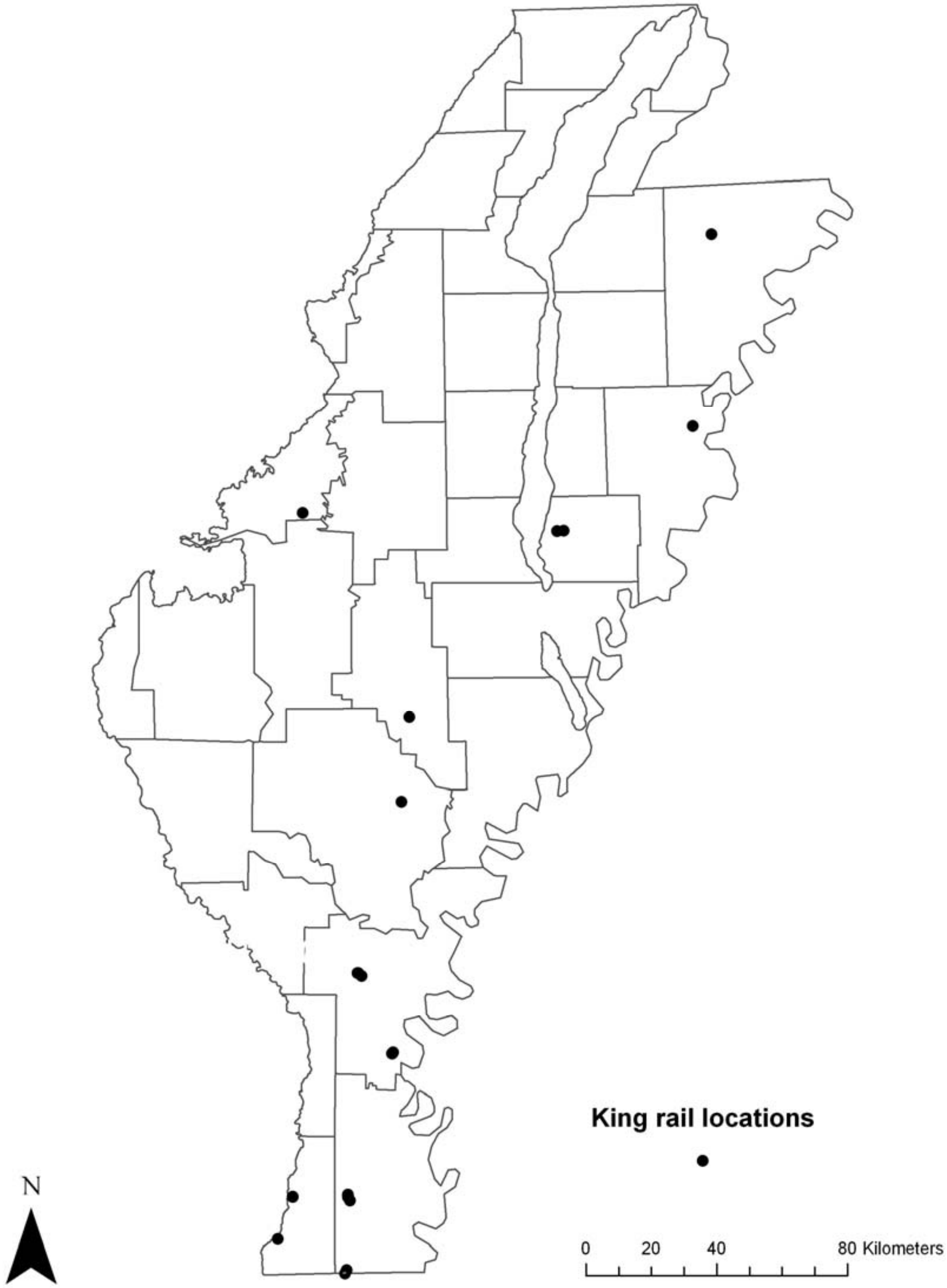

Fig. 14. Distribution of the king rail using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

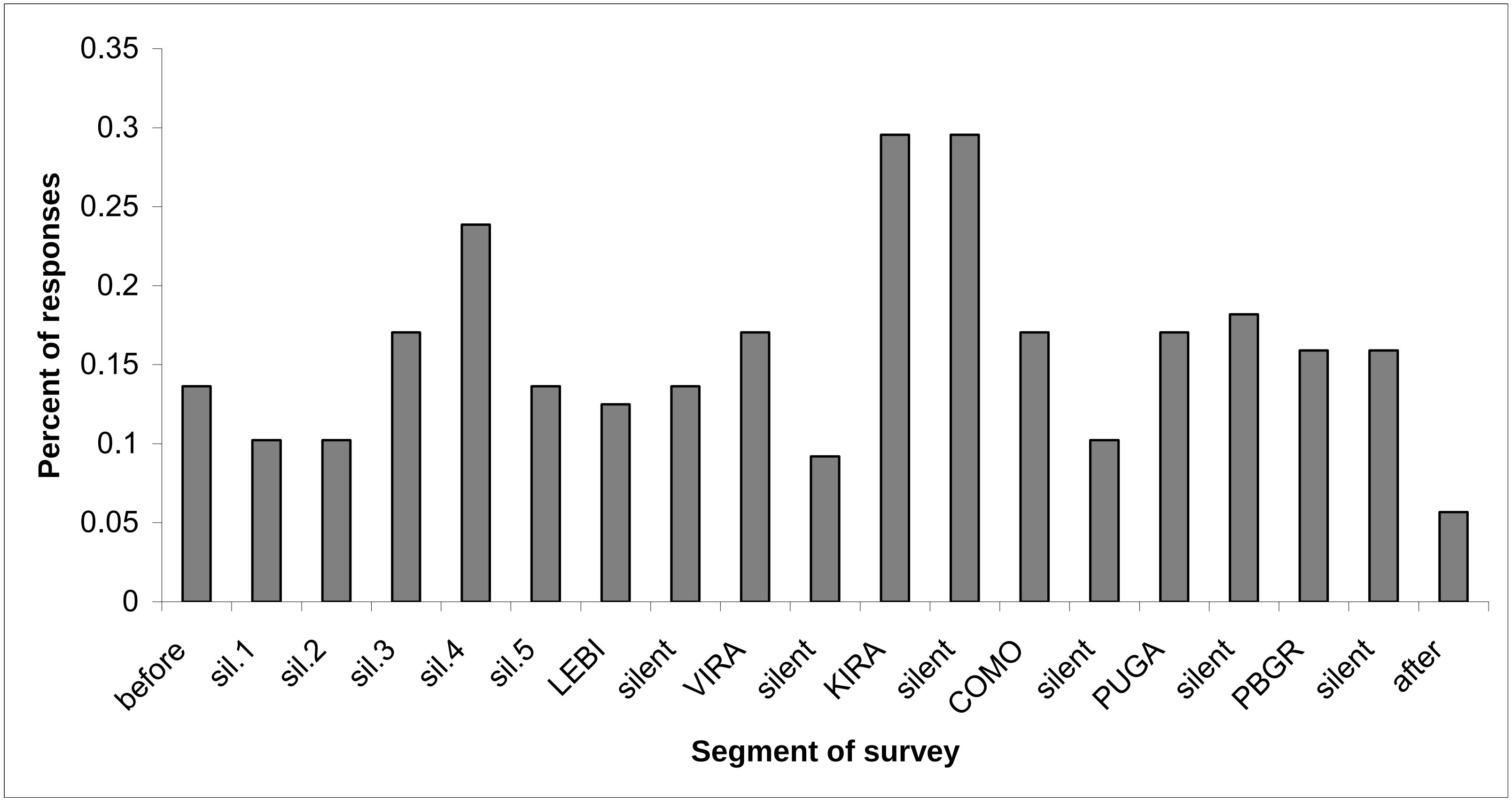

Fig. 15. Percent of responses from 2005 and 2006 combined, for the king rail during each segment of the call-broadcast survey. The percent of responses was determined by dividing the number of individuals that responded during each segment of the survey by the total number of king rails that responded overall during secretive marsh bird surveys in the Delta of Arkansas, USA.

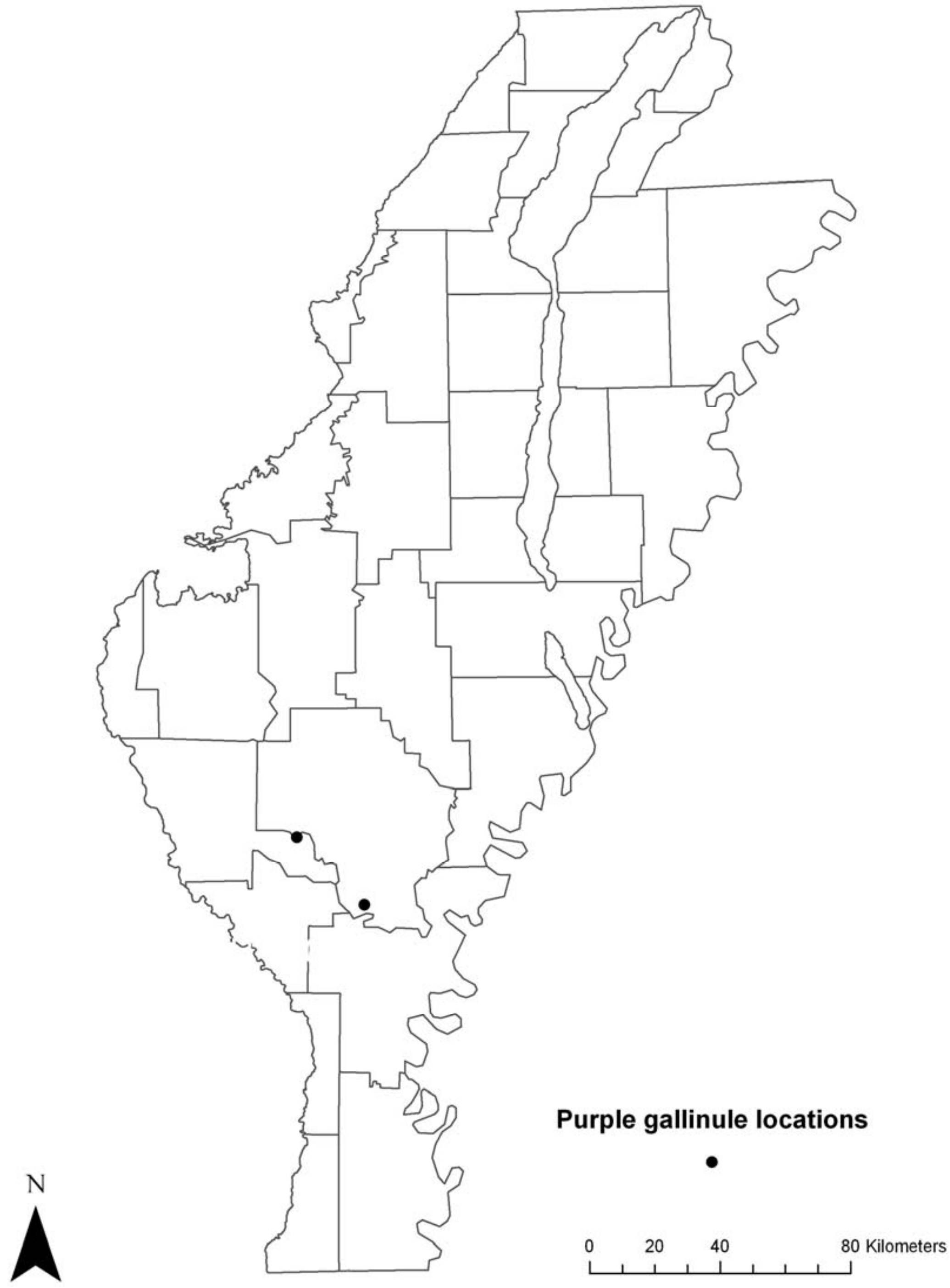

Fig. 16. Distribution of the purple gallinule using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

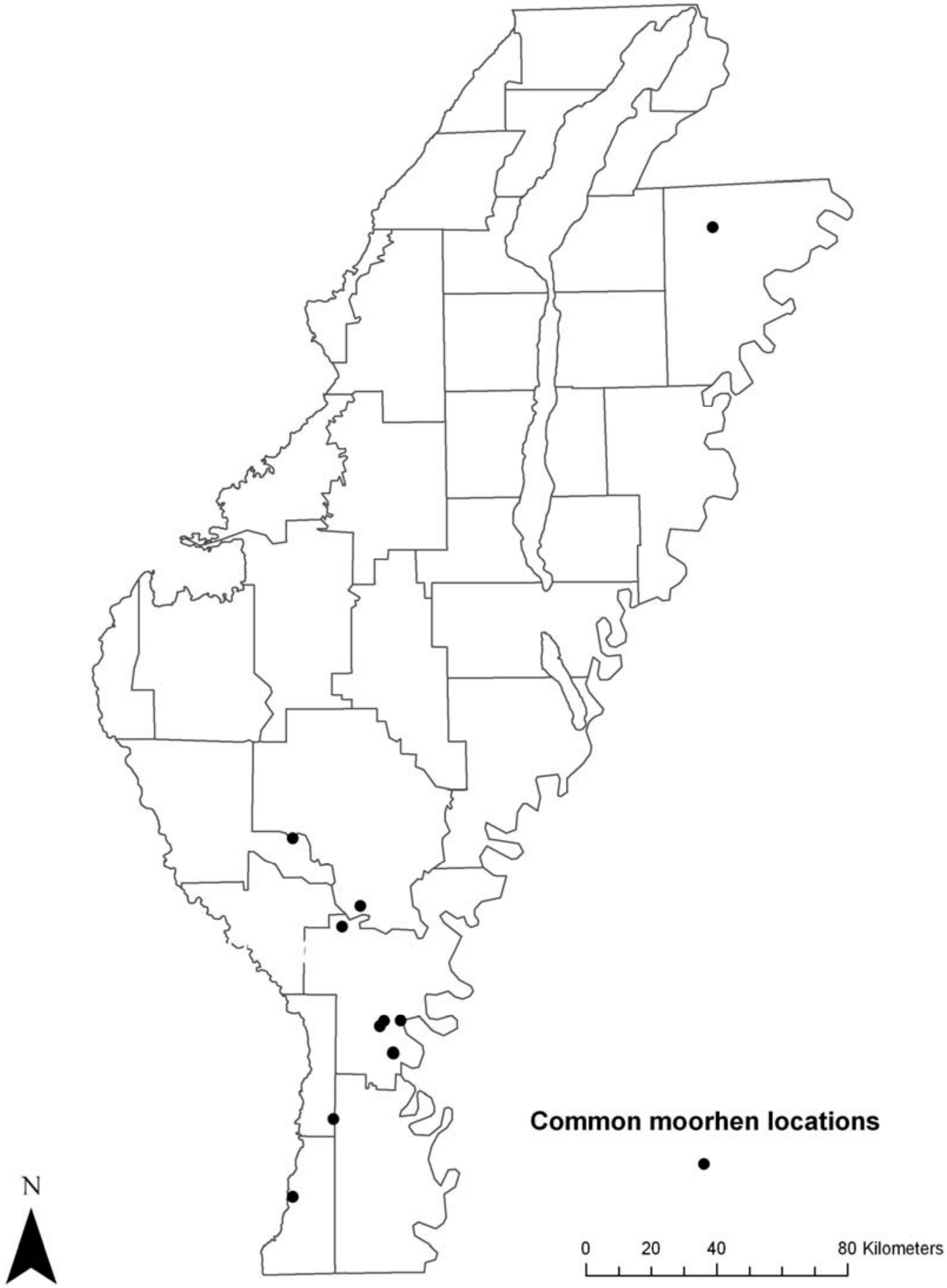

Fig. 17. Distribution of the common moorhen using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

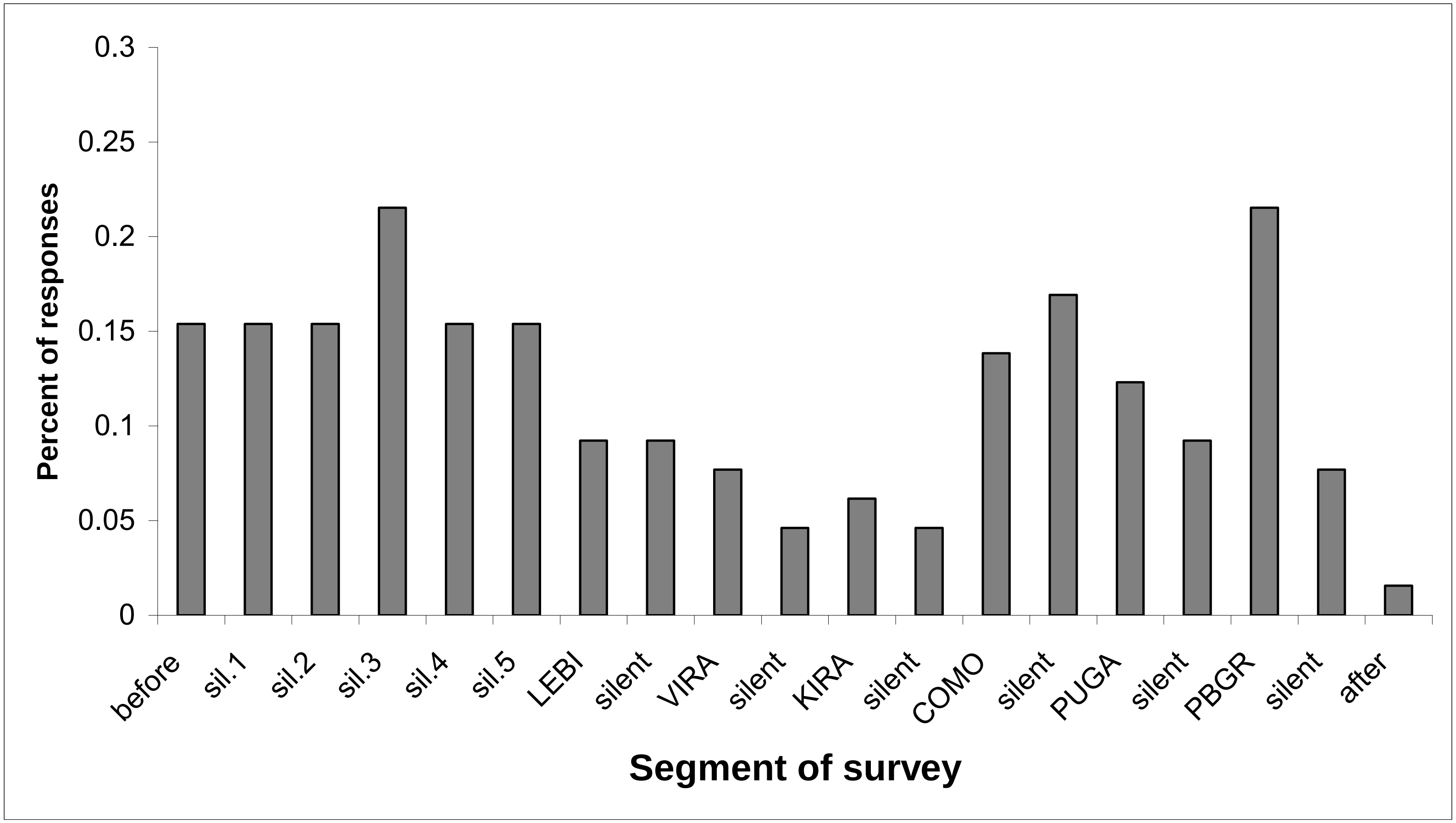

Fig. 18. Percent of responses from 2005 and 2006 combined, for the common moorhen during each segment of the call-broadcast survey. The percent of responses was determined by dividing the number of individuals that responded during each segment of the survey by the total number of common moorhens that responded overall during secretive marsh bird surveys in the Delta of Arkansas, USA.

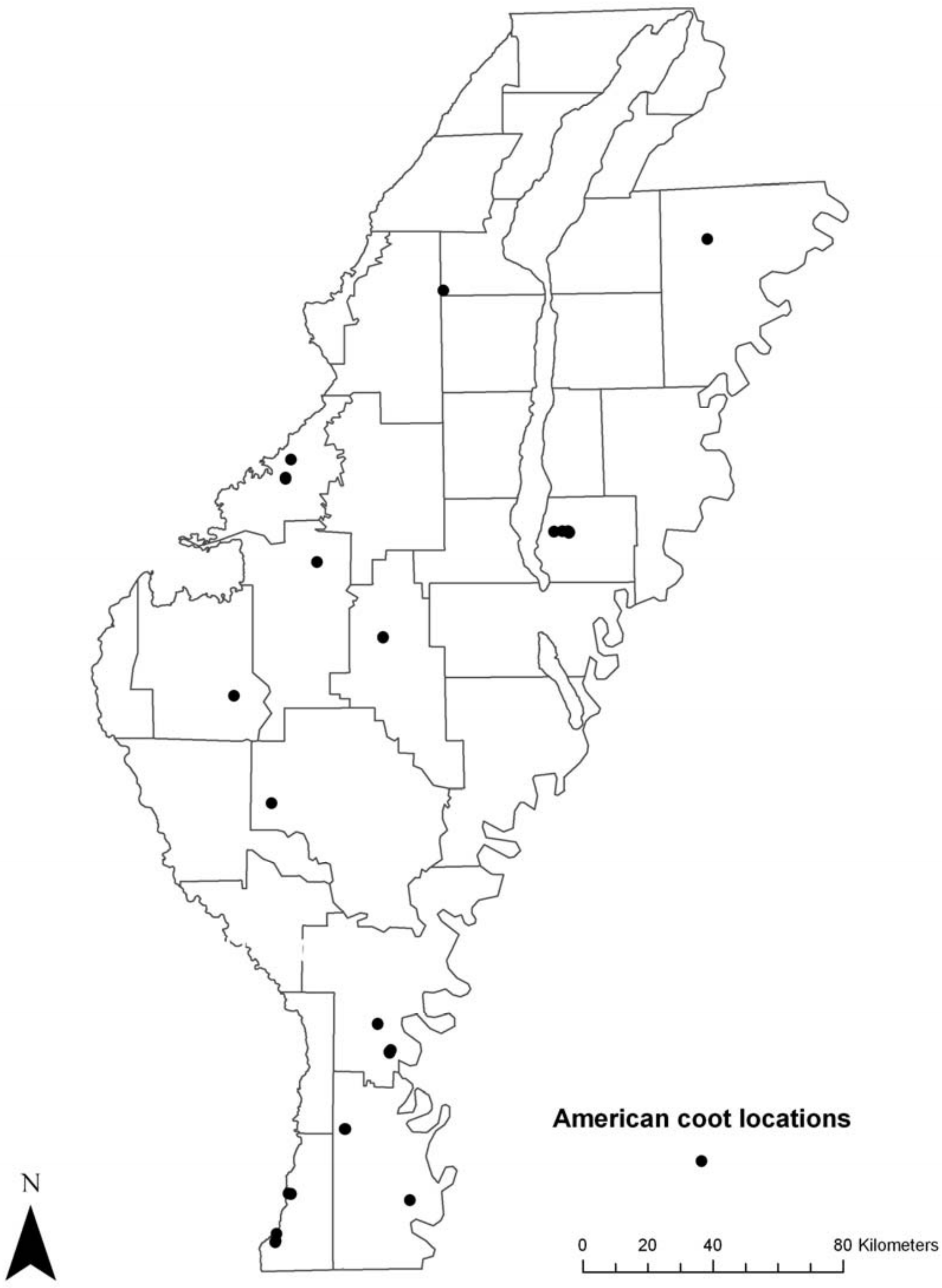

Fig. 19. Distribution of the American coot using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

Fig. 20. Distribution of the mottled duck using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

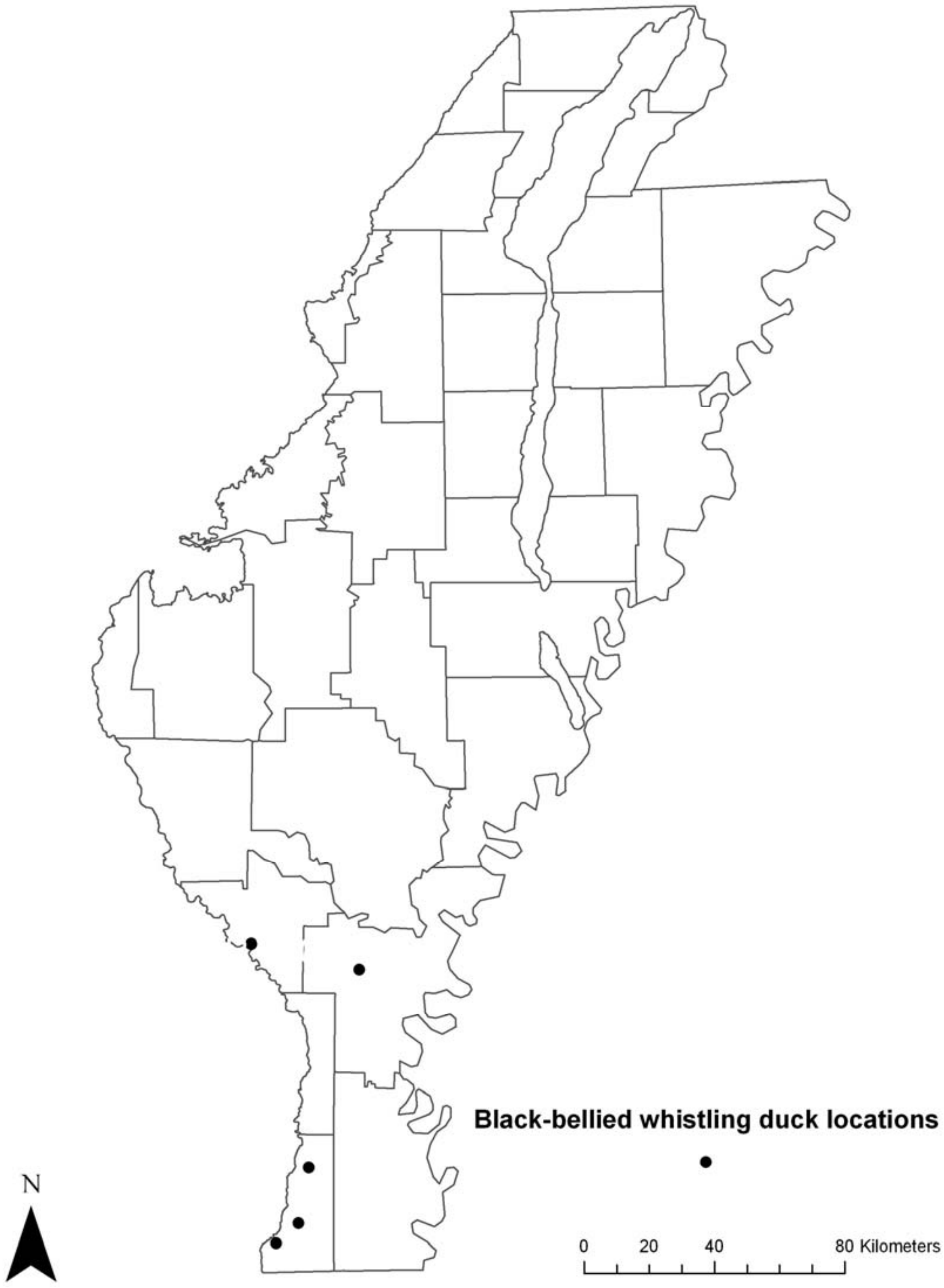

Fig. 21. Distribution of the black-bellied whistling duck using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

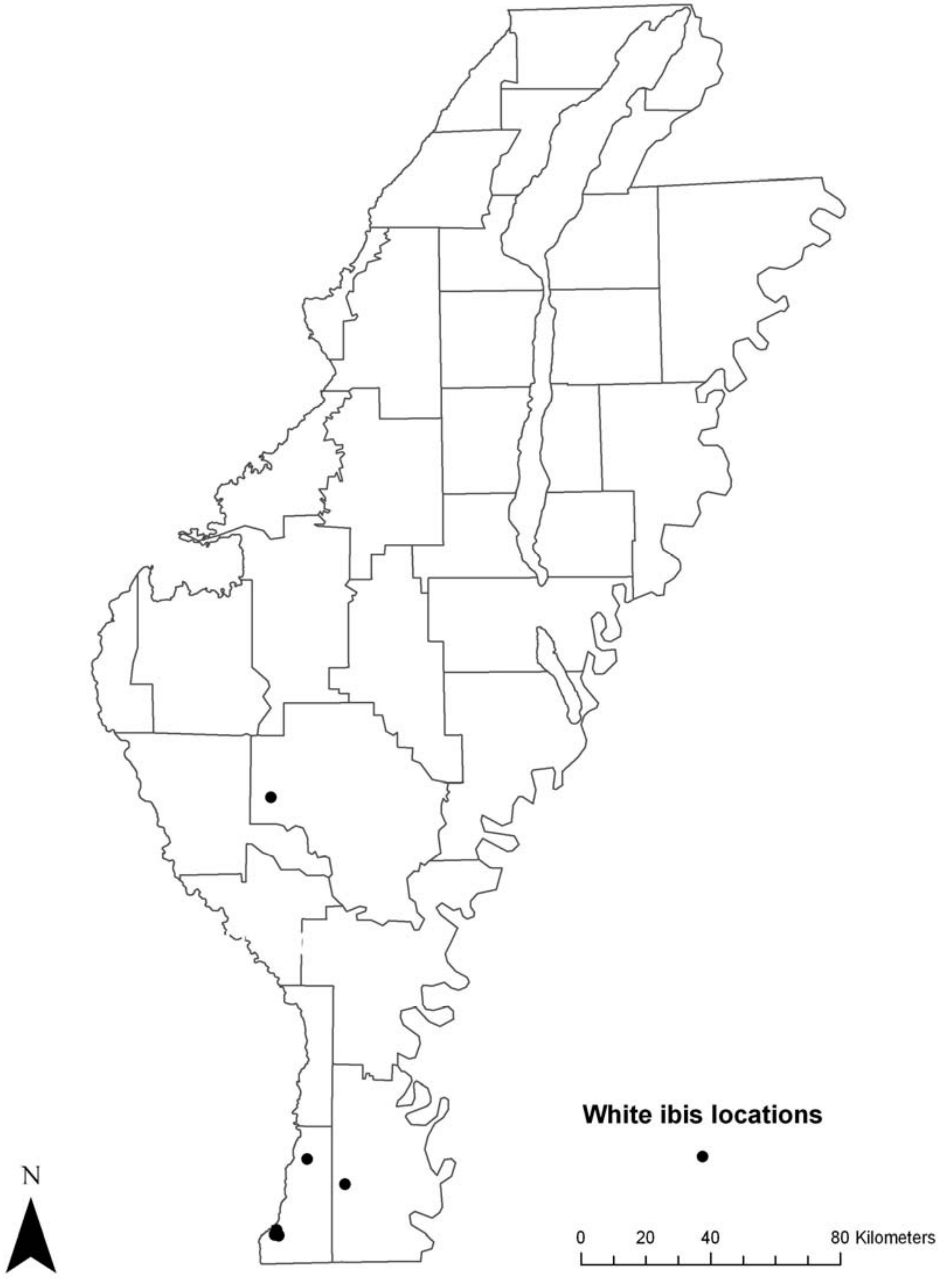

Fig. 22. Distribution of the white ibis using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

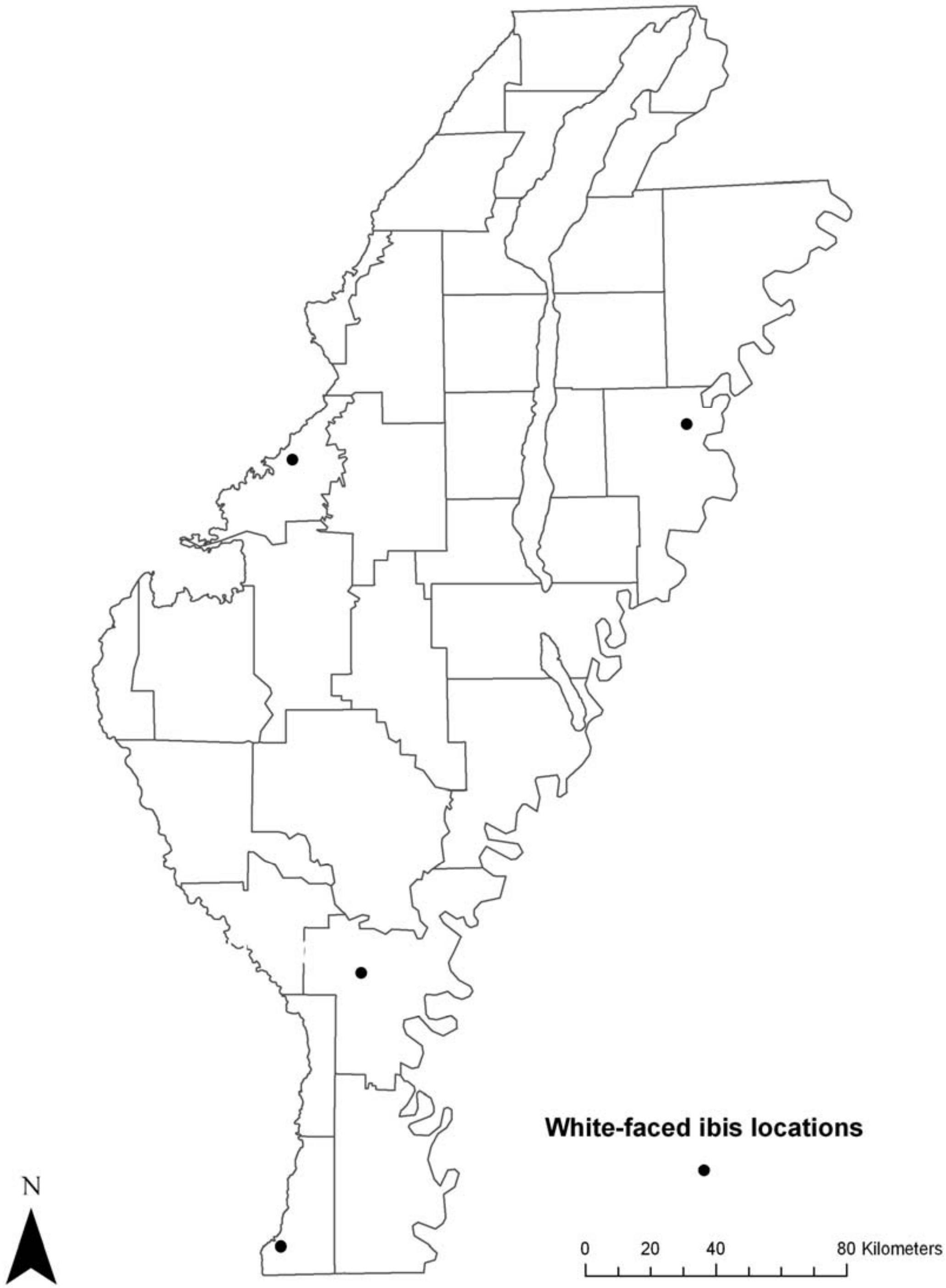

Fig. 23. Distribution of the white-faced ibis using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

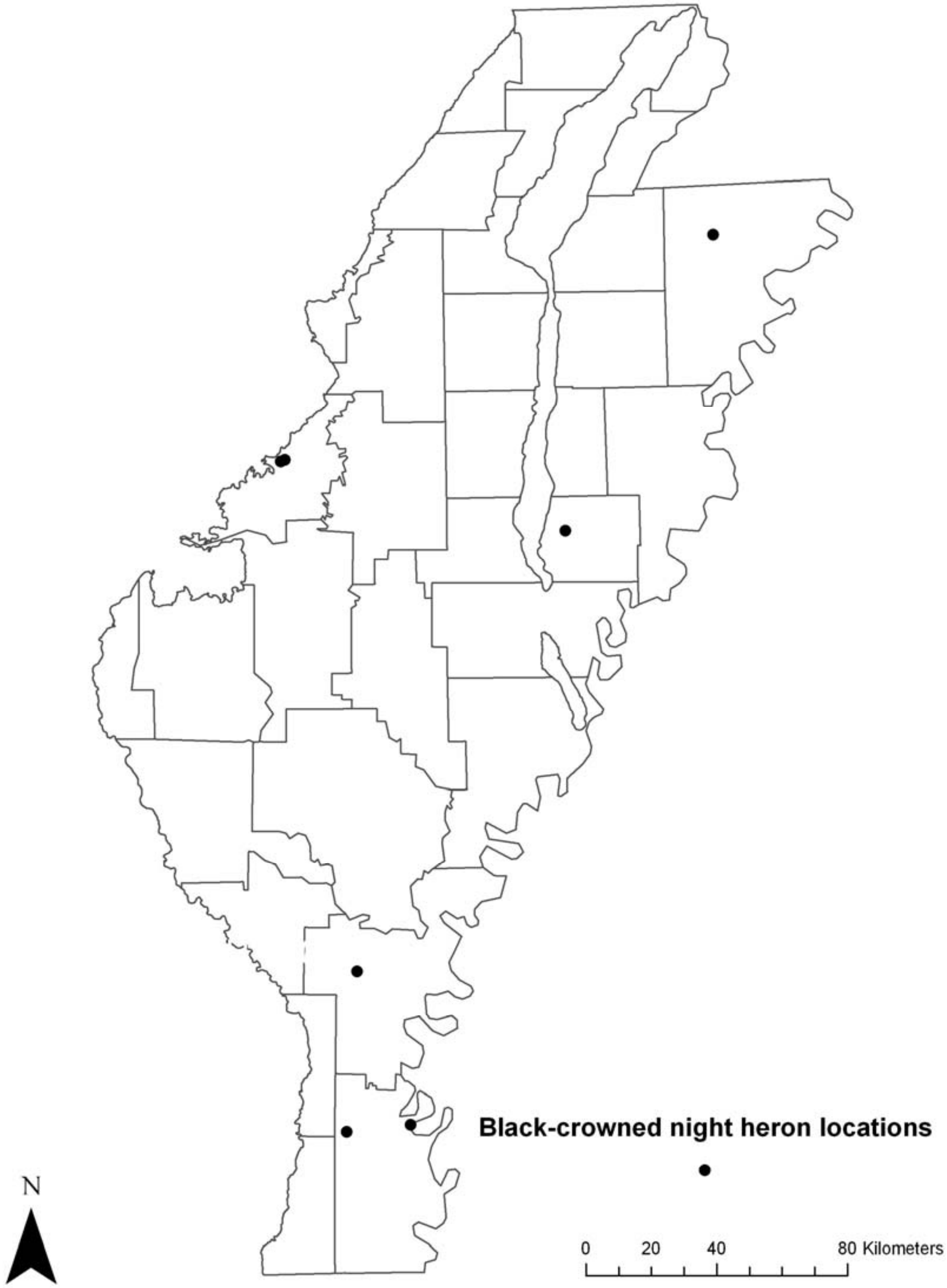

Fig. 24. Distribution of the black-crowned night heron using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

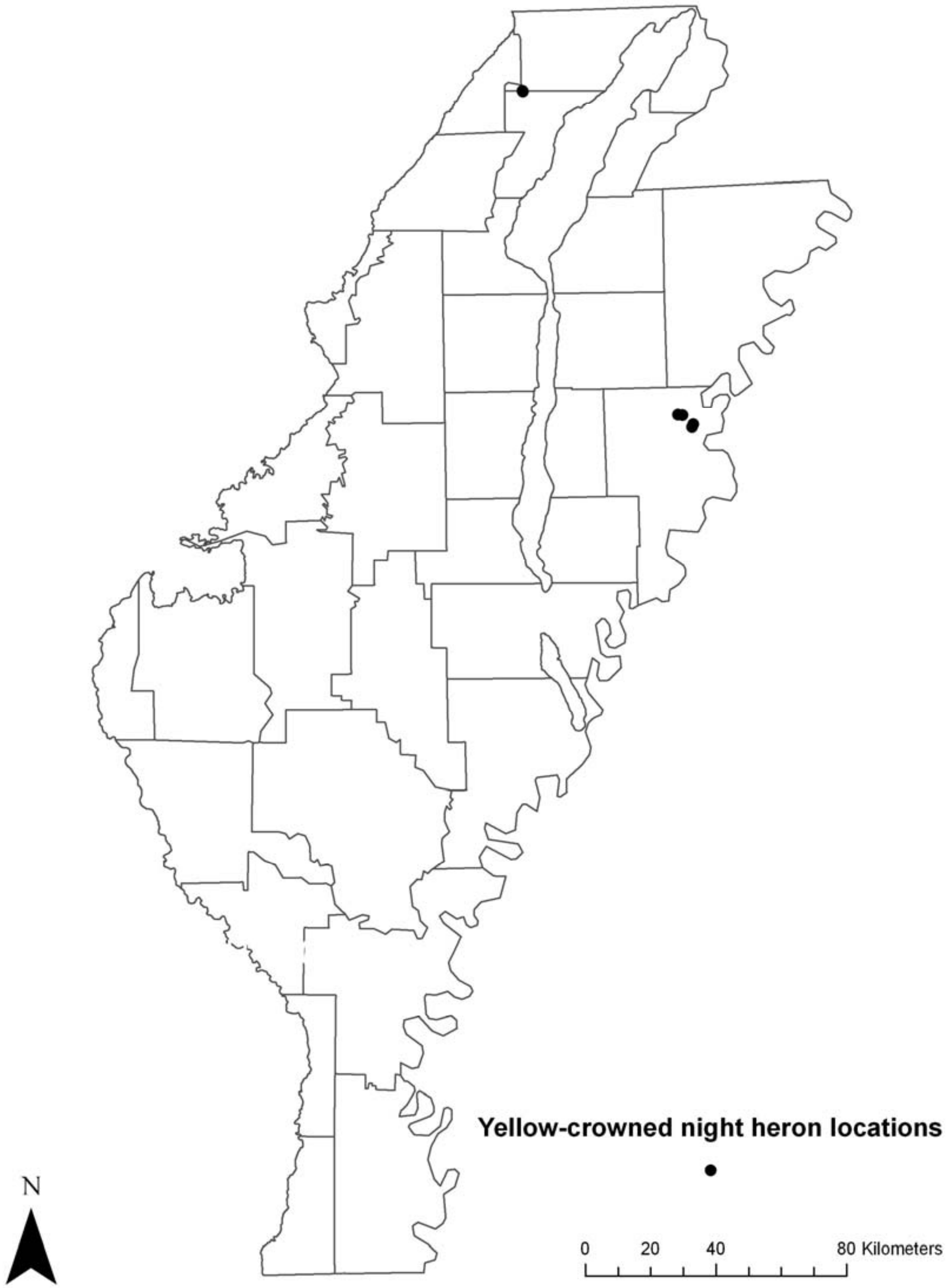

Fig. 25. Distribution of the yellow-crowned night heron using detections from randomly selected sites and opportunistic detections from 2005 and 2006 secretive marsh bird surveys in the Delta of Arkansas, USA.

APPENDIX 1. Future Survey Methods

The Ψ estimates in the occupancy analysis were not much different from the naïve estimate, likely because of the high number of repeat visits. By conducting 9 repeat visits in 2006, and 15 in 2005, the probability of a false absence was small. Program PRESENCE tries to estimate Ψ given that some probability of a false absence exists. Since our probabilities of a false absence were small, it is likely the reason why the naïve and Ψ estimates are so similar. These results suggest making fewer visits and increasing the number of sites surveyed (MacKenzie and Royle 2005).

Given the rarity of these species, and low detection probabilities, it would be better to make fewer repeat visits and add more sites to the sample (MacKenzie et al. 2006). This would allow for an increase in the number of sites surveyed and require less survey effort. Since king rails are the least common breeding marsh bird that exist at numbers high enough to permit occupancy estimation, it is best suited to determine the adequate number of repeat visits based on this species. Using 2006 data, which is the most conservative estimate of the king rail population, the Ψ estimate for the king rail was 0.06 and the average detection probability was 0.4. Based on these numbers, 3-5 repeat visits are recommended for future surveys (MacKenzie and Royle 2005). This would allow for an accurate assessment of all breeding secretive marsh birds.

Previous studies have shown that call-broadcast methods are an effective approach for surveying secretive marsh birds (Gibbs and Melvin 1993, Conway and Gibbs 2005, Bogner and Baldssarre 2006b, Hay 2006, Pierluissi 2006). My results show that most secretive marsh bird species I studied, given those that had a sufficient sample size, were more likely to respond to their own call. The peaks in responses were after broadcasting conspecific breeding and territorial calls. The differences in the proportion of responses for each segment of the broadcast were not large in my study. However, it has been shown to be an effective method for surveying secretive marsh birds and future surveys in Arkansas should continue to utilize the call-playback method.

Observers need to be trained in a field setting with live birds. Even after training using audio recordings, a significant difference still existed between observers in their ability to detect several species. There is a large difference between the audio recordings and the actual calls heard in the field. Available audio recordings do not include enough varieties of calls, such as an alarm call, to where observers could easily miss detecting the species due to a lack of experience. In addition, several non-target avian species, and amphibians have calls similar to marsh birds and can easily be misidentified for secretive marsh birds. Having an experienced observer point out the calls in the field will be a great aid in training new observers.

Future survey efforts should attempt 3-5 visits at each site over a 90-day season, starting in early April. A 44-day season, which is recommended in the National Marsh Bird Protocol (Conway 2003), is too short of a season, as the peak in detection rates varies between species, resulting in some species being missed during the survey period (Lor and Malecki 2002, Rehm and Baldassarre 2007). Conducting surveys over a 90-day period would allow enough sampling time to detect king rails at the peak of their breeding season in mid-April, and still detect least bitterns, which peak later in the season. Repeat surveys should be separated by approximately 10 days and at least one survey should be conducted every 10 days. However, during any 10-day period, more than one visit could be made. These repeats, if conducted during the same trip, should be separated by at least 1 hour to satisfy independence of repeat visits (MacKenzie et al 2006). If more than one observer is available, then the minimum time between repeats is not an issue.

Very little information exists on wetland distribution and types in Arkansas. Parts of the Delta were inventoried through the National Wetlands Inventory (NWI), however this inventory is out of date and inaccurate based on my observations. In more than one instance where a wetland was supposed to occur based on NWI data, I found that no wetland existed. Completing a wetlands inventory for Arkansas would provide better information on the amount of potential habitat available for secretive marsh birds. In addition, it would allow for a more complete assessment of secretive marsh bird distributions and the status of their populations.

APPENDIX 2 – General site description for sites surveyed in the Delta of Arkansas, USA in 2005.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
ARKCO4	1	2	0	2	1	N/A
ARKCO5	1	3	1	2	1	60% *Typha spp.*, 10% *Polygonum spp*., 30% trees ca. 10m in height.
ARKCO	1	3	0	1	1	60% *Typha spp*., 40% *Polygonum spp*.
ARK. POST	7	1	0	2	1	40% open watwer, 50% *Alternanthera spp.*, <5% *Typha spp*., <5% woody veg. cattails and woody veg. line the wetland
ASHRD1	1	1	1	0	1	15% shrubs, 5-10% *Typha spp.* bordering wetland
BAYOU DE VIEW 1	1	1	2	2	2	80% cypress trees
BAYOU DE VIEW 2	1	1	2	2	2	Pond with thick sedges (*Carex* spp.) covering one side and light coverage on other
BALD KNOB 1	3	1	0	1	0	Rice field the previous year, mixture of rice and moist soil species
BALD KNOB 2	3	0	2	1	2	80% *Cephalanthus occidentalis,* 60% cypress trees
BALD KNOB 3	3	0	1	1	1	Cypress trees, little or no understory <5% *Cephalanthus occidentalis*
BIG LAKE 1	3	1	0	2	1	40% *Polygonum spp*., 10% *Cephalanthus occidentalis.*, 10 % *Nelumbo lutea*
BIG LAKE 2	3	2	1	2	0	*10% Sagittaria spp., 20% Typha spp., 20% Shrub, 20% Eleocharis spp.*
BIG LAKE 3	3	1	1	2	2	40% *Leersia spp*., 20% Cypress, 30% *Sagittaria latifolia*, 5% Potamogeton spp., 5% water willow
BIG LAKE 4	3	3	1	2	1	90% *Polygonum spp*.
BIG LAKE 5	3	1	1	3	1	40% *Leersia spp*., 20% *Potamogeton spp*., 20% *Cephalanthus occidentalis*.
BIG LAKE 6	3	2	1	2	1	80% *Sagittaria spp*., 15% *Nelumbo lutea*
BIG LAKE 7	3	2	2	2	1	60% *Sagittaria spp*., 40% *Cephalanthus occidentalis*
BIG LAKE 8	3	3	2	2	1	60% *Sagittaria spp*., 40% *Cephalanthus occidentalis*
BIG LAKE 9	3	1	1	2	1	10% *Sagittaria spp*., 20% *Nelumbo lutea*, 30% *Eleocharis spp*., 20% *Polygonum spp*.
BLACK RIVER 1	2	2	0	2	1	Sedges (*Carex spp.*) covering 70% of wetland edge and very open
BLACK RIVER 2	2	3	0	2	0	very open with sedges (*Carex spp*.) covering the entire perimeter
BLACK RIVER 3	2	2	1	2	0	small wetland with little or no veg
BLACK RIVER 4	2	3	0	2	0	*Typha spp*. and *Carex spp*. around the edge
BLACK RIVER 5	2	0	2	1	3	>90% oak and other hardwoods
BLACK RIVER 6	2	0	3	1	3	>90% oak and other hardwoods
BLACK RIVER B	2	0	3	1	2	bayou habitat with no shallow water for wading birds
BAYOU METO 1	1	1	2	2	2	flooded hardwoods
BAYOU METO 2	2	2	1	2	0	70% *Cephalanthus spp*., 20% *Nelumbo lutea*, 10% open water
BAYOU METO 3	2	1	3	3	0	10% *Carex spp.* around the edge. border is >90% forested with shrub understory
BAYOU METO 4	2	2	0	3	0	15% *Nelumbo lutea*, 85% open water
BPARK	6	1	0	1	2	20% *Hydrocotyle spp*., 50% unknown, riverine
BPARK2	6	1	1	1	2	20% Cypress, 40% *Polygonum spp*.
CACHE RIVER 1	3	0	2	1	2	flooded hardwoods
CACHE RIVER 2	3	0	0	1	1	flooded hardwoods
CACHE RIVER 3	3	0	0	1	0	flooded hardwoods

Ownership – 1= private, 2= AR Game and Fish Comm., 3 = US Fish and Wildlife Service, 4 = Wetland Reserve Program, 6 = Army Corp of Eng., 7 = Nat. Park. – For EV, WV, 1= 0-10%, 2= 11-50%, 3= 51-100% coverage w/in 100-m, and W4, and F4 1= 0-10%, 2= 11-50%, 3= 51-100% coverage w/in 400-m

Appendix 2 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
CACHE RIVER 4	3	0	1	1	3	moist soil unit, 60% *Polygonum spp*., 10% *Nelumbo lutea*, 10% *Salix spp.*
CACHE RIVER B	1	1	1	2	1	85% open water,some trees in the wetland, bayou type habitat
CHICOT WRP	4	2	0	2	0	*Typha spp*. and *Carex spp*. along border
CHICOT WRP 1	4	1	0	1	0	*Typha spp*. and *Carex spp*. along border
CHICOT WRP 3	4	1	2	2	0	*Typha spp*. and *Carex spp*. along border
CHICOT WRP 4	4	1	0	1	0	*Typha spp*. and *Carex spp*. along border
CUT OFF CREEK	2	1	2	1	3	bottomland hardwoods, oak/maple
GRICE	1	1	2	2	2	cypress bayou
LAWRE1	1	1	1	0	1	palustrine/ 50% *Ludwigia spp*. 30% *Cephalanthus occidentali*
LAWRE2	1	0	3	1	1	next to a bayou/ all shrub/cypress
LINCON2	3	2	1	1	0	50-60% *Polygonum spp*. and mixes of emergent veg.
MALLARD LAKE 1	2	0	0	1	2	80% *Salix spp*., border, 20% *Sesbania spp*., Hardwood border
MALLARD LAKE 2	2	0	1	1	2	20% Carex border, hardwood border
MILL1	1	2	1	2	1	*Typha spp.* bordering the wetland with some shrubs and trees
OVERFLOW 1	3	1	2	2	2	30% *Juncus effuses*, 60% *Cephalanthus occidentalis* and tree species <2m in height
OVERFLOW 2	3	3	1	2	1	>90% moist soil plants
OVERFLOW 3	3	2	2	2	1	60% *Juncus effuses*, 60% *Cephalanthus occidentalis* and tree species <2m in height
OAKWOOD 1	3	1	2	2	1	60% shrubs, 10% open, misc. veg.
OAKWOOD 2	3	1	1	2	1	60% shrubs, 10% open, misc. veg.
OAKWOOD 3	3	1	1	3	0	80% *Eleocharis spp.*, 12% woody veg/shrub, 5% *Carex spp.*
OAKWOOD 4	3	2	2	3	1	60% *Juncus effuses*, 60% unidentified shrub
POTLATCH1	4	2	1	1	0	30% *Juncus effuses*, 25% *Ludwigia spp.*
POTLATCH2	4	1	0	1	1	15% *Juncus effuses*
POTLATCH3	4	2	1	1	1	80% *Ludwigia spp.*, 20% *Carex spp*., 10% *Cephalanthus occidentalis*
POTLATCH4	4	3	1	2	0	70% *Juncus effuses*, 20% *Typha spp.*
POTLATCH5	4	2	1	2	0	60% *Carex spp.*, 30% *Eleocharis spp*., <10% *Typha spp.*.
POTLATCH6	4	2	1	2	0	20% *Polygonum spp*., 40% *Carex spp.*, 10% *Sesbania spp*., 30% shrubs
POTLATCH8	4	1	0	2	0	90% *Carex spp*., 10% *Sesbania spp.*
ROADS1	1	2	1	1	1	40% *Eleocharis spp.*, 40% *Ludiwgia spp.,* 20% *Polygonum spp*..
SIS1	3	3	0	1	2	95% *Alternanthera spp.*
ST. FRANCIS 1	4	1	0	2	0	25% *Typha spp*., 10% *Ranunculus spp.*
ST. FRANCIS 2	4	1	1	1	0	5% *Typha spp*., 20% *Ludwigia spp.*
ST. FRANCIS 3	4	2	1	2	0	50% *Typha spp*., 15% *Juncus effusus* & mixtures of other emergent veg. plants
ST. FRANCIS 4	4	2	0	1	0	>60% *Typha spp*., >15% *Carex spp.*, >10% *Juncus spp*.
WAPANONCA 1	3	3	0	2	1	80% *eleocharis spp*., 20 % *Polygonum spp.*,
WAPANONCA 2	3	0	0	2	0	N/A
WAPANONCA 3	3	3	0	2	1	N/A
WAPANONCA 4	3	2	0	1	0	N/A
WAPANONCA 5	3	3	1	1	1	N/A
WAPANONCA 6	3	1	1	1	1	N/A

Appendix 2 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
WAPANONA Z	3	2	1	2	2	N/A
WHITE RIVER 1	3	2	1	2	0	N/A
WODRUF	1	1	1	2	2	scattered shrubs and trees
WODRUF2	1	1	1	2	1	Open with some *Typha spp* . and trees bordering wetland
WODRUF3	1	2	2	2	1	70% *Alternanthera spp* ., some trees and shrubs bordering wetland

APPENDIX 3 – General site description for sites surveyed in the Delta of Arkansas, USA in 2006.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
AGG FARMS 1	1	0	3	0	1	Ditch bordered by rice and cotton
AGG FARMS 2	1	0	1	0	1	15% *Cephalanthus occidentalis* , 10% Cypress trees, 75% open water
AGG FARMS 3	1	0	0	1	1	Bayou barthelomew - cypress/other trees
ALLEN FARMS	1	0	0	1	1	Ditch survey, edges are grassy - floating veg = *Ludwigia spp.*
ALLEN FARMS 1	4	0	0	1	0	Moist soil plants, species unknown, *Polygonum spp* . and *Ranunculus spp* .= 40%
ALLEN FARMS 2	1	0	2	1	1	*Cephalanthus occidentalis f* orms perimeter and comprises 70% of the wetland, 30% open water
ALLEN FARMS 3	4	0	1	2	0	*Salix spp.* = 12%, *Polygonum spp.* = 25%, rest are moist soil plants, *Ranunculus spp* . = 40%, all short veg 1-1.5 meters high
SIDNEY 1	1	0	0	2	0	Reservoir--band of shrubby, half-submerged willows (*Salix spp* .) running parallel to bank about 6m out.
SIDNEY 2	1	0	0	2	0	N/A
SIDNEY 3	1	0	1	1	1	Patches of *Cephalanthus occidentalis* in eastern portion.
SIDNEY 4	1	0	1	1	1	Patches of *Cephalanthus* occidentalis
BANK1	4	0	1	1	1	Shallow pond in meadow. Meadow surrounded by forest. wetland open water, 5% *Eleocharis spp* .
BANK2	4	0	1	1	2	Flooded forest, 10% unknown *Polygonaceae,* some type of dock with narrow, lance-shaped leaves 1-1.5m tall.
BANK3	4	1	1	1	2	*Polygonum spp* . = 50%, *Salix spp. a* nd other shrubs=40%, rest dead cockleburr, *Poaceae* , *Carex spp* . (1%), *Eleocharis sp* p. (1%), open water.
BANK4	4	0	0	1	1	Ditch, 20-m wide with shrub patches (mostly *Cephalanthus occidentalis*).
BANK5	4	0	1	1	1	Main irrigation ditch 20-m wide with shrub patches (*Cephalanthus occidentalis and Salix spp* .)
BAXTER FARMS 1	1	2	1	2	0	Ditch
BAXTER FARMS 2	1	1	1	2	0	Ditch-25-m from reservoir.
BAXTER FARMS 3	1	1	1	2	0	Reservoir, lined with *Typha spp.* Ca. 60-m wide band of Typha around the edge of the entire reservoir
BAXTER FARMS 4	1	1	1	2	0	Reservoir, lined with *Typha spp.* Ca. 60-m wide band of Typha around the edge of the entire reservoir
BAXTER FARMS 5	1	0	0	2	1	Bayou with lots of floating *Polygonum spp* .
BAXTER FARMS 6	1	2	1	2	1	Reservoir, lined with *Typha spp.* Ca. 60-m wide band of Typha around the edge of the entire reservoir

Ownership – 1= private, 2= AR Game and Fish Comm., 3 = US Fish and Wildlife Service, 4 = Wetland Reserve Program, 6 = Army Corp of Eng., 7 = Nat. Park. – For EV, WV, 1= 0-10%, 2= 11-50%, 3= 51-100% coverage w/in 100-m, and W4, and F4 1= 0-10%, 2= 11-50%, 3= 51-100% coverage w/in 400-m

Appendix 3 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
BAXTER FARMS 7	1	2	1	2	1	Ditch
BAXTER FARMS 8	1	0	0	1	1	Catfish pond
BENN1	1	1	1	0	1	*Typha spp*. and patches of *Polygonum spp*.
BYO1	1	0	1	1	0	Bayou - *Cephalanthus occidentalis* /cypress sparsely covering wetland
CACHE RIVER 01	3	1	2	1	1	*Cephalanthus occidentalis = 30% Salix spp. = 20% Eleocharis spp. and Typha spp.* = 5-10%, 50% open water
CACHE RIVER 02	3	1	2	2	2	*Cephalanthus occidentalis* mixed with *Typha spp.,* and *Salix spp.*
CACHE RIVER 03	3	0	1	1	2	cypress bayou/flooded forest
CACHE RIVER 04	3	0	1	1	2	bayou/flooded forest--mix of cypress, tupelo, maple, buttonbush (*Cephalanthus occidentalis*). Forest mostly dry w/damp patches and linear bayoy-like stretches in low areas.
CACHE RIVER 05	3	0	1	1	2	tupelo, cypress, and *Cephalanthus occidentalis* bayou/flooded forest. Also a few maples and other trees. Took site photo at 1827.
CACHE RIVER 06	3	0	2	1	2	Flooded forest--tupelo, *Cephalanthus occidentalis*, cypress, maple (*Acer spp*.). Site photo taken at 1748.
CBURR1	1	1	1	1	1	Ditch 40-m wide.
CBURR2	1	1	1	1	1	Ditch 35-m wide.
CBURR3	4	0	1	0	1	Ditch
CHIC35	1	1	0	0	1	N/A
DITCH1	1	2	0	0	0	Ditch, 80% *Typha spp.*
DONOV 1	1	2	1	1	2	Bottomland stand bordered by *Typha spp*. and *Carex spp*.
DONOV 2	1	0	2	0	1	*Cephalanthus occidentalis* swamp - hardwood mixture as well
DRJOE1	4	0	0	2	0	*Carex spp*. around west side of wetland, some *Polygonum spp*.
DRJOE2	4	0	0	2	1	*Polygonum spp.* and moist soil plants
DRJOE3	4	0	0	2	1	vegetation around perimeter only, Ludwigia spp. - 40% edge, small patches of *Carex spp*. and *Polygonum spp*. = 30%
DRJOE4	4	0	0	2	0	moist soil plants, grasses (Poaceae)/smartweed (*Polygonum spp*.) and redvine (*Brunnichia cirrhosa*)
EDMON1	1	0	0	1	1	River (45-m wide) with strong current
EDMON2	1	0	0	1	1	River (45-m wide) with strong current
EDMON3	1	0	2	2	1	Swamp w/ *Salix spp.*, dead shrubs, *Polygonum spp.*
EDMON4	1	0	2	2	1	Swamp w/ *Salix spp.*, *Polygonum spp.*
FRENCH 1	4	0	0	0	1	open water/pond, no veg - grassy border
FRENCH 2	4	0	1	0	2	*Polygonum spp.* and *Ludwigia spp.* - bordered by *Cephalanthus occidentalis*

Appendix 3 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
GANT1	1	0	0	1	1	Reservoir with fine, fairly short *Carex spp.* around edges, small 1% patch of T*ypha spp*. on N side. Woods on N side. Completely encircled (except for 5m wide acccess at SE corner) by ditch 5m wide. Recent work on ditch: ditch dredged out and *Typha* removed from most of E side and half of S side. Reinforcing of banks at NE corner.
GUS1	1	2	0	1	1	*Typha spp. = 60%, Nelumbo spp. = 15%, Cephalanthus occidentalis = 5%*
GUS2	1	0	3	0	0	80% Cephalanthus occidentalis - open water = 20% - dead snags = 5%
GUS3	1	2	1	1	2	*Typha spp., Juncus spp.,* and *Polygonum spp.* Also *Cephalanthus occidentalis* and *Salix spp,* bordering, sparse woody cover in center of wetland
HARW1	1	0	1	1	1	Patch of woody vegetation in the middle and <10% coverage of *Sesbania spp.*
HARW2	1	0	0	1	1	Edges with shrubs/forest but relatively open in middle of wetland.
HOGWALLOW 1	4	1	0	2	0	Wetland bordered by *Carex spp* and *Eleocharis spp.* - island in middle
HOGWALLOW 2	4	2	0	2	1	*Eleocharis spp*. common - *Typha spp*. And *Juncus spp*. common
HOGWALLOW 3	4	0	2	3	0	*Sesbania spp*. <10% and Cypress trees dominate
HWY17	1	1	0	1	1	*Typha spp*. around edges, open in middle
KANL1	3	0	0	1	2	Big lake surrounded by forest, mainly cypress around edge.
BALD KNOB 01	3	1	0	1	2	*Juncus spp.*= 20% coverage
BALD KNOB 02	3	1	0	1	2	*Alternanthera philoxeroides* = 60%, sparse clumps of *Carex spp.*
BALD KNOB 03	3	3	0	1	0	Ditch
BALD KNOB 04	3	2	2	1	1	Juncus spp. mixed with *Carex spp*., dominated by *Cephalanthus occidentalis* = 70%
BALD KNOB 05	3	2	0	1	1	*Juncus spp*. = 60%, *Typha spp*. = 11%, *Polygonum spp*. = 30% - smartweed forms mats of residual vegetation
LAND1	1	2	2	0	0	*Cephalanthis spp*. = 60%, *Juncus spp*. = 20%, *Salix spp.* = 10%
LAND2	1	0	3	0	0	Bayou, *Cephalanthus occidentalis* and cypress
LAND3	1	0	0	0	0	flooded field, *Ranunculus spp*. = 70%, Poaceae =30%, spots of *Juncus spp*. and *Typha spp.*
LEGOR	1	0	0	0	0	Open water, reservoir
LIG1A	1	0	2	1	1	Bayou: Cephalanthus occidentalis =15%, cypress=5%, broadleaf (tupelo?)=40%.

Appendix 3 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
LIG1B	1	0	2	1	1	Bayou: cypress, tupelo, *Cephalanthus occidentalis* , *Polygonum spp* . =10%.
LIG2	1	0	0	1	1	Ditch.
LINWOOD PT 1	1	0	0	1	1	Forest/shrub edged open lake.
LINWOOD PT 2	1	0	1	1	1	Shrub/scrub wetland
LUX1	1	0	0	1	1	Ditch - 14m wide.
LUX2	1	0	1	1	1	Long lake with 40-50% *Salix spp* .
LUX3	1	0	1	1	1	*Salix spp* . = 40-50%
LUX4	1	0	1	1	1	Salix spp. on S side, *Acer* spp. On N side
WAPANONCA 01	3	1	2	2	2	emerg veg is a tall *Carex spp* ., edge of cypress stand, *Cephalanthus occidentalis* swamp. Cove to Lake wapanonca
WAPANONCA 01	3	0	2	2	2	*Cephalanthus occidentalis swamp bordered by cypress*
OAKWOOD 01	3	2	1	3	0	60% *Eleocharis spp* ., 20% *Sesbania spp.* , 30% P*olygonum spp* .
OAKWOOD 02	3	3	0	3	0	90% *Eleocharis spp.*
OAKWOOD 03	3	3	1	3	0	90% *Eleocharis spp* . and *Campsis radicans*
OVERFLOW 01	3	2	0	2	1	A lot of old, dead veg.--clumpy.
OVERFLOW 02	3	1	0	2	1	veg--small clumps
OVERFLOW 03	3	2	0	2	1	70% *Sesbania spp.*
OVERFLOW 04	3	1	0	1	2	N/A
OVERFLOW 05	3	2	0	1	2	Clumps of vegetation, moist soil plants
OVERFLOW 06	3	1	0	1	0	*Polygonum spp* . = 15%
OVERFLOW 07	3	1	0	1	2	Smartweed now=40%, before was about 15%. Lot's more water, maybe 3-4 inches more than first round of surveys.
OVERFLOW 08	3	1	0	1	1	*Leersia spp* . = 50%
OVERFLOW 09	3	0	0	2	1	Patches of rice cutgrass (*Leersia spp*) along edge, large patch of dead coffeebean in middle.
OTTER LAKE 1	1	0	1	2	1	Lake surrounded by forest, with clumps of *Cephalanthus occidentalis*
OTTER LAKE 2	1	0	2	2	1	Lake surrounded by forest, with clumps of *Cephalanthus occidentalis*
RAFT CREEK 1	4	0	0	1	1	*Eleocharis spp.* , *Carex spp.* = 5%, *Sesbania spp.* = 30%
RAFT CREEK 2	4	0	1	1	0	surrounded by *Salix spp* ., *Sesbania spp* . = 10% at one end.
RAFT CREEK 3	4	0	1	1	0	*Salix spp* . and *Cephalanthus spp.* , edge is *Salix spp* as well.
RAFT CREEK 4	4	0	1	1	1	Site is a ditch 10m wide. 10% *Cephalanthus occidentalis* , edge is a mix of shrubs and trees.
RAFT CREEK 5	4	0	1	1	1	Site: 5% S*esbania spp.* , 25% mixed shrubs, 10% S*alix spp* . Shrubby peninsula in middle.
SCHAR1A	1	2	1	1	1	*Typha spp* . = 60%, *Eleocharis spp.* = 10%, *Polygonum spp* . = 5%.

Appendix 3 cont.

SITE NAME	OWNER-SHIP	EV	WV	W4	F4	GENERAL DESCRIPTION
SCHAR1B	1	1	1	1	1	*Typha spp.* = 15%, *Eleochars spp.* = 5%, *Polygonum spp*. = 15%.
SIGL1	1	0	1	1	1	swamp surrounded by forest. Scattered clumps of E*leocharis spp*., patches of *Sagittaria spp*.
SIGL2	1	0	1	1	1	Reservoir surrounded by trees
SIGL3	1	1	0	1	1	*Typha spp*. = 15%, *Eleocharis spp.* =5%, *Polygonum spp.* = 5%.
STDTCH	1	0	0	1	0	Ditch
TEX1	1	1	0	0	2	*Eleocharis spp.* = 20%, *Sesbania spp*. = 10%
TYRZ1	1	0	1	0	1	Ditch, *Polygonum spp.* = 20%.
TYRZ2	1	0	1	0	1	Ditch, *Polygonum spp*. = 15%.
WALLACE TRUST 1	4	1	1	2	0	Reservoir with small cypress trees.
WALLACE TRUST 2	4	1	3	2	0	reservoir with small cypress trees. Trumpet creeper covered 95% of wetland later in season
WALLACE TRUST 3	4	0	2	3	0	Reservoir with small cypress trees.
WALLACE TRUST 4	4	0	2	3	0	Reservoir with small cypress trees.
WHITE RIVER	3	0	1	1	1	*Polygonum spp.* = 15%, shrubs = 11%

APPENDIX 4 – 4-letter abbreviation used for species surveyed in 2005 and 2006 in the Delta of Arkansas, USA

4- letter abbreviation	Species
AMBI	American bittern
AMCO	American coot
BBWD	black-bellied whistling duck
BCNH	black-crowned night heron
COMO	common moorhen
GLIB	glossy ibis
KIRA	king rail
LEBI	least bittern
MODU	mottled duck
PUGA	purple gallinule
SORA	sora
VIRA	Virginia rail
WFIB	white-faced ibis
WHIB	white ibis
YCNH	yellow-crowned night heron