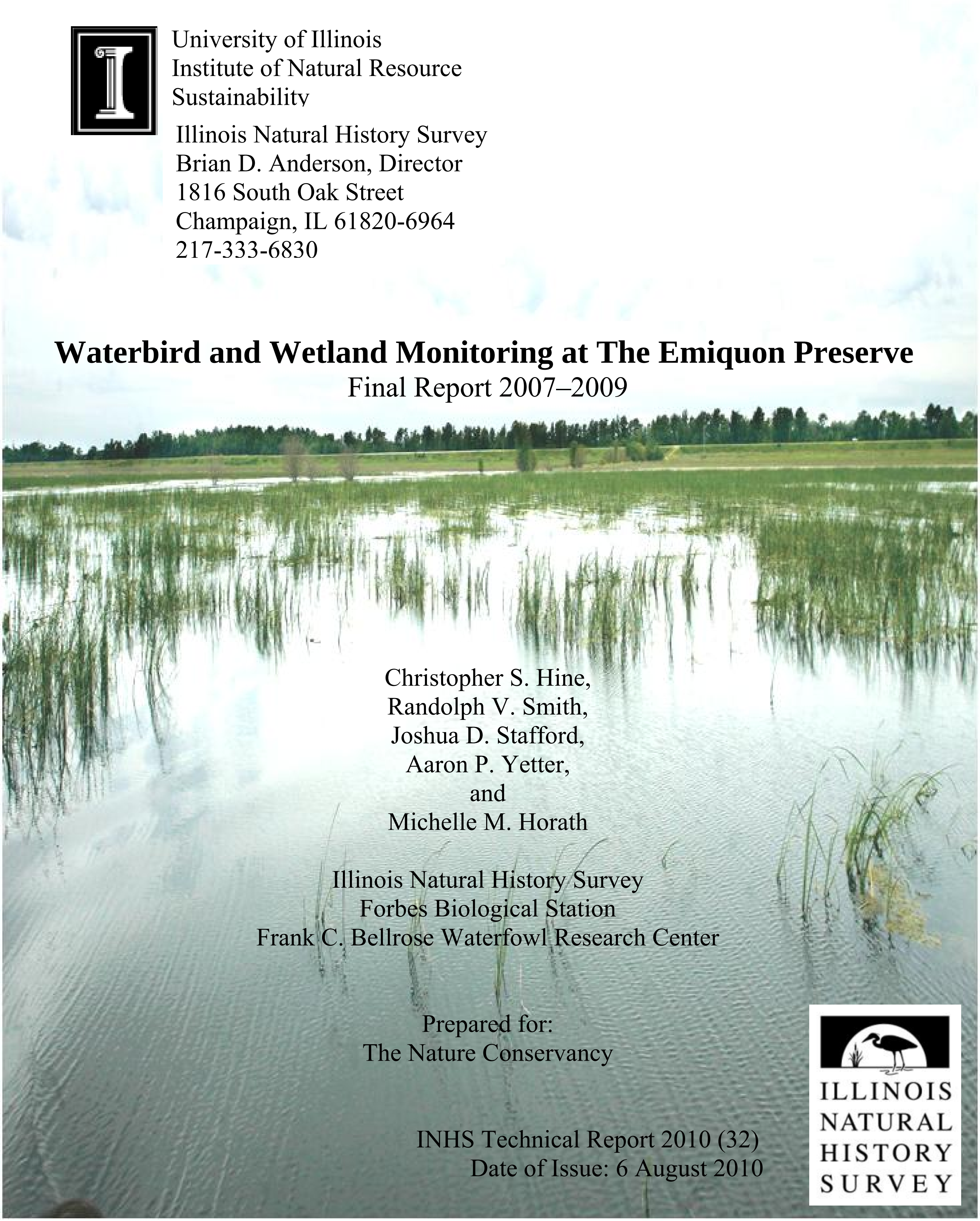

University of Illinois
Institute of Natural Resource Sustainability

Illinois Natural History Survey
Brian D. Anderson, Director
1816 South Oak Street
Champaign, IL 61820-6964
217-333-6830

Waterbird and Wetland Monitoring at The Emiquon Preserve

Final Report 2007–2009

Christopher S. Hine,
Randolph V. Smith,
Joshua D. Stafford,
Aaron P. Yetter,
and
Michelle M. Horath

Illinois Natural History Survey
Forbes Biological Station
Frank C. Bellrose Waterfowl Research Center

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INTRODUCTION

Historically, the wetlands of the Illinois River valley (IRV) provided extensive and valuable habitat to migrating waterbirds and other wetland-dependent wildlife in the Upper Midwest. For example, 1.6 million mallards (scientific names presented in Tables 1–2) were counted during aerial inventories in the IRV in 1948, and peak numbers of lesser scaup exceeded 500,000 prior to the mid-1950's (Havera 1999:227–236). Unfortunately, extensive leveeing and drainage has eliminated 53% of the natural wetlands in the IRV and existing wetlands have been further degraded by sedimentation, exotic species, and eutrophication (Havera 1999).

Despite dramatic anthropogenic alterations, the IRV remains a critical ecoregion for migratory birds. For example, the Upper Mississippi River and Great Lakes Region Joint Venture of the North American Waterfowl Management Plan considers the IRV a focus region to provide habitat for millions of waterfowl during spring and fall migrations (Soulliere et al. 2007). Fortunately, restoration and reclamation efforts are ongoing in attempts to return structure and function to backwater wetlands in the region. Of these, The Nature Conservancy's Emiquon Preserve (hereafter, Emiquon) is the most substantial effort to date, directly restoring, enhancing, or protecting more than 2,700 ha of former wetlands and uplands in the central IRV.

To inform and guide the restoration process at Emiquon, The Nature Conservancy identified key ecological attributes (hereafter, KEAs) of specific biological characteristics or ecological processes that would indicate success (The Nature Conservancy 2006). Because of the region's historic importance to waterfowl and other waterbirds, several conservation targets and associated KEAs at Emiquon were related to waterbird communities and their habitats. Indeed, use of wetlands by waterbirds may serve as an indicator of landscape condition or a measure of restoration success (Austin et al. 2001; Gawlik 2006). Therefore, we monitored the response of wetland habitats and waterbirds to restoration efforts at Emiquon during 2007–2010 to evaluate restoration success relative to desired conditions under the relevant KEAs. Our primary efforts included evaluating: 1) abundance, diversity, and behavior of waterfowl and other waterbirds through counts and observations; 2) productivity by waterfowl and other waterbirds through brood counts; 3) plant seed and invertebrate biomass to understand foraging carrying capacity for waterfowl during migration and breeding, and; 4) composition and arrangement of the vegetation community through geospatial wetland covermapping. Herein, we report results of our monitoring efforts and interpret them as a means of evaluating restoration activities at Emiquon with respect to desired conditions under the KEAs.

METHODS

Avian Abundance

To estimate abundance of avifauna at Emiquon, we enumerated waterbirds by species (Table 1) with a spotting scope and binoculars from fixed vantage points. We also counted birds while traveling between vantage points. As the wetland area at Emiquon increased, we moved vantage points and routes to maximize coverage and maintain efficiency. We initiated fall inventories in early September each year and terminated them following freeze-up. Spring inventories began when ice receded (February or March) and concluded around 15 April each year, after most migrants had departed. We conducted inventories weekly during 2007, 2008, and spring of 2009, and bi-weekly during fall 2009 and spring 2010. Although our ground inventories were designed to monitor waterfowl, we recorded abundance of raptors and other waterbirds encountered incidentally.

We also counted waterbirds aerially at Emiquon as part of the Illinois Natural History Survey's (INHS) fall waterfowl surveys (Havera 1999). Aerial inventories were conducted approximately weekly (weather permitting) during fall and 4 times each spring from a fixed-wing, single-engine aircraft at altitudes of 60–140 m and speeds of 160–240 km/hr (Havera 1999:186, Stafford et al. 2008). A single observer estimated American coots and waterfowl abundances by species (except wood ducks).

We converted abundance estimates to use-days to evaluate overall waterbird use of Emiquon (UDs; Stafford et al. 2008). Use-days are estimates of total use extrapolated over a period of interest (i.e., fall or spring). For example, 100 birds using a wetland for 10 days equates to 1,000 UDs. This method is useful for comparing waterbird use among sites, years, and seasons.

Waterfowl Behavior

We conducted behavioral observations using scan sampling to evaluate the functional response of ducks to wetland restoration and habitat change at Emiquon (Altmann 1974). This method allowed for a rapid assessment of waterfowl behavior (Paulus 1988) that could be conducted simultaneously with ground counts. One behavioral sample consisted of observing 50 individuals of the same species, in the same flock or within close proximity, and recording the behavior (e.g., feeding, resting) and gender of each. We narrated observations into a hand-held voice recorder for subsequent transcription. We conducted 10 scan samples during each ground count, regardless of season. We attempted to observe species that were present at the wetland throughout the migration period to maximize sample sizes and inference. However, lack of visibility (e.g., dense vegetation), increasing distances between observation points and waterbird concentrations, and difficulty in approaching flocks undetected prevented us from observing all species.

Brood Observations

We monitored waterbird production at Emiquon in 2008 and 2009 through passive brood observations and active flush counts (Rumble and Flake 1982). We conducted bi-weekly brood surveys between mid-June and late-August using 4 observers at fixed points spaced along the east and west shores of Thompson Lake and the north levee. This approach intended to maximize coverage and minimize double counting and disturbance associated with a single observer moving between points. All fixed-point surveys began at sunrise and lasted for one hour to coincide with a period of increased brood activity (Ringelman and Flake 1980, Rumble and Flake 1982). During each survey, we continually scanned wetland habitat using spotting scopes and binoculars and documented species, number of young and adults, and brood age class of all waterbirds (Gollop and Marshall 1954).

Because broods are often secretive and difficult to detect, we evaluated the utility of active flush counts twice during 2008, immediately following fixed-point surveys. During flush surveys, we simultaneously used 2 observers on all-terrain vehicles (ATVs) to drive along opposite lake margins and flush broods from cover to open water. We used 2 observers to minimize double-counting by pushing broods from one side of the lake to the other. Similar to the fixed-point surveys, we documented all waterbird broods observed during flush counts. We compared results of passive and flush-count surveys to determine which method provided the best index of waterbird production at Emiquon relative to effort and disturbance.

Aquatic Invertebrates

We collected 20 sweep-net samples bi-monthly during waterbird breeding and brood-rearing periods (i.e., April–August) in 2008 and 2009 (n = 120 total samples) to estimate abundance of nektonic invertebrates. We collected samples from randomly chosen locations with a 454 cm^2 (~0.05 m^2) D-frame sweep-net (Voigts 1976, Kaminski and Murkin 1981) in shallow water (≤46 cm) along the margins of Thompson Lake, and preserved them in 10% buffered formalin solution containing Rose Bengal until processing. In the laboratory, we rinsed samples through a 500 μm sieve to remove substrate and vegetation. Invertebrates were removed from samples by hand, identified according to the lowest practical taxonomic level (e.g., Family; Pennak 1978, Merritt and Cummins 1996). Invertebrate samples were then dried at 70^o C to constant mass and weighed to the nearest 0.1 mg using a Mettler electronic balance. Samples containing >200 individuals of a single invertebrate taxa were sub-sampled (up to ¼) using a Folsom plankton splitter. We converted invertebrate biomass estimates to per-unit-volume (mg/m^3) to account for different volumes of water sampled with each net sweep.

Moist-soil Plant Seeds

During 2007–2009, we estimated above- and below-ground biomass of moist-soil plant seeds by extracting a 10-cm diameter x 5-cm depth soil core in standing vegetation at 20 randomly-allocated points along the shores of Thompson Lake (Stafford et al. 2006, Kross et al. 2008, Stafford et al. 2008). We collected soil cores during fall following seed maturation and froze samples in individually labeled bags until processing. Prior to sorting, we thawed core samples at room temperature and soaked them in a 3% solution of hydrogen peroxide (H_2O_2) to dissolve clays (Bohm 1979:117, Kross et al. 2008). We washed samples with water through a #60 (250 μm) sieve and dried for 24 hours at 87^{o}C (Greer et al. 2007, Stafford et al. 2008). We then threshed dried materials over a series of 4−5 sieves (mesh sizes 14 [1.40 mm], 18 [1.00 mm], 35 [500 μm], 45 [355 μm], and 60 [250 μm]) to further separate seeds from debris (Greer et al. 2007). We classified seeds as large if they were retained by the 14, 18 or 35 sieve (e.g., barnyardgrass*,* smartweed) and small if they remained in the 45 or 60 sieves (e.g., nutgrass, pigweed). We separated all large seeds from debris by hand and weighed to the nearest 0.1 mg using an electronic balance. Due to the extensive processing time, we sub-sampled a portion (≥2.5% by mass) of some small seed samples to estimate biomass. The percent composition of seeds and debris in the subsample was multiplied by the small-seed sample mass to extrapolate total small seed abundance in the core. We combined small and large seed masses to estimate total seed biomass per core (Stafford et al. 2008). We used biomass data from core samples to estimate overall moist-soil plant seed abundance (kg/ha; dry mass) at Thompson Lake using PROC MEANS in SAS v9.2 (SAS Institute, Inc., Cary, NC).

We used our overall estimates of forage abundance to calculate estimates of energetic carrying capacity for waterfowl, expressed as energetic use-days (EUD). An EUD is defined as the number of days an area of land could support a mallard-sized duck (Reinecke et al. 1989). Our EUD calculations assumed an average true metabolizable energy of 2.5 kcal/g for moist-soil plant seeds (Kaminski et al. 2003) and an average daily energy expenditure of a mallard of 292 kcal/day (Prince 1979, Reinecke et al. 1989).

Wetland Covermapping

We mapped all wetted areas of Thompson and Flag lakes to document changes in wetland area, plant species composition, and habitat assemblages on 7–8 November 2007, 11–18 September 2008, and 15–23 September 2009. We traversed east-west transects spaced at 500 m intervals on foot, ATV, or by boat and delineated changes in vegetation composition (e.g., moist-soil, hemi-marsh) using a handheld global positioning system (GPS) (Bowyer et al. 2005, Stafford et al. 2010). We recorded plant species encountered (Table 2) along transect lines and delineated habitat assemblages or other physical features (e.g., vegetation islands, ditches) outside transects using a GPS and hand-drawn maps. We digitized wetland vegetation in

ArcGIS 9.3 using field notes and the GPS waypoints overlaid on 2007 aerial photos obtained from Department of Agriculture's Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/) and 2008 and 2009 high-resolution aerial photographs from Sanborn Map Company, Chesterfield, MO (Bowyer et al. 2005, Stafford et al. 2010).

Our classifications of wetland habitats at Emiquon generally followed those defined by Cowardin et al. (1979) and Suloway and Hubbell (1994). Woody vegetation was classified as bottomland forest if trees were >6 m in height or scrub-shrub if trees were ≤6 m tall (Cowardin et al. 1979). Other wetland classifications included non-persistent emergent vegetation (e.g., moist-soil plants; Fredrickson and Taylor 1982), persistent emergent vegetation (e.g., cattails and bulrushes), mud flats, floating-leaved aquatic vegetation (e.g., American lotus), aquatic bed (e.g., coontail), hemi-marsh (open water interspersed with persistent emergent; Weller and Spatcher 1965), and open water (flooded habitat without vegetation; Cowardin et al. 1979, Suloway and Hubbell 1994, Stafford et al. 2010). We also included a category to account for areas of upland vegetation (e.g., goldenrod and foxtail) growing within the wetland basin that had been inundated or insular.

We attempted to be as descriptive as possible when categorizing wetland vegetation and, as such, it was possible for some vegetation assemblages to occur in different categories. For instance, the aquatic plant, cattail, was present in 3 habitat categories: hemi-marsh, persistent emergent, and cattail. We categorized cattail as hemi-marsh if there was a more-or-less even interspersion of cattail and open water or aquatic bed. We classified cattails as persistent emergent when they were accompanied by at least one other persistent emergent species (e.g., bulrush, bur reed, prairie cordgrass). Finally, our cattail category included only those areas that were dominated by dense, monotypic stands.

RESULTS

Waterfowl Abundance

We conducted 35 ground inventories during falls 2007–2009. American green-winged teal, gadwall, and northern shoveler were the most abundant waterfowl species, accounting for 14.9%, 13.9%, and 12.9% of total abundance, respectively. We conducted 22 ground inventories during springs 2008–2010; the most abundant species among all years and seasons were lesser scaup (15.7%), ring-necked duck (13.6%), and northern shoveler (13.2%).

Fall 2007−Spring 2008. −We conducted 16 ground inventories between 6 September 2007 and 9 January 2008 (Table 3). Additionally, waterfowl were counted aerially 12 times from 10 September 2007 to 9 January 2008 (Table 4). Peak abundance of waterfowl was 20,405 on 4 October via ground inventory. Peak abundance via aerial inventory occurred on 26 September (24,220). We observed 17 species of ducks and 3 species of geese at Emiquon during fall 2007 (Table 3). American green-winged teal were the most abundant duck, accounting for 25% of all waterfowl use, followed by northern pintail (20%) and northern shoveler (15%). Dabbling ducks accounted for 98.8% of duck use. Estimated UDs for fall 2007 totaled 1,249,860 (Table 5).

We conducted 8 ground inventories between 19 February and 14 April 2008 (Table 6), and 4 aerial surveys between 10 March and 2 April 2008 (Table 7). Peak abundance reached 64,228 via ground count and 69,020 via aerial count on 10 March. We observed 19 species of ducks and 3 species of geese during spring 2008, including 20 species (17 duck, 3 goose) on 10 March alone. During spring 2008, diving ducks accounted for 56.2% of the estimated waterfowl abundance while dabbling ducks comprised 41.9%; the remaining 1.9% were classified as unidentified ducks. Lesser scaup were the most abundant species, accounting for 21.2% of all duck use, followed by ring-necked ducks (17.8%) and American green-winged teal (16.5%). Use-days totaled 1,421,670 during spring 2008 (Table 5).

Fall 2008−Spring 2009. −During fall 2008 we conducted 11 ground inventories from 2 September until freeze-up on 8 December (Table 8). Peak abundance was 34,855 ducks on 10 October via ground inventory and 50,260 on 10 November via aerial inventory (Tables 8-9). We observed 17 species of ducks during ground surveys; American green-winged teal were the most abundant, accounting for 18.0% of all ducks observed at the site. Northern pintail (16.4%) and gadwall (13.7%) were the second and third most abundant species, respectively, followed by mallards (11.6%) and northern shovelers (11.4%). Dabbling ducks accounted for 87.6% of total abundance. Estimated UDs from ground surveys totaled 1,686,963 (Table 5), which represented a 35.0% increase over fall 2007.

We conducted 8 ground inventories between 10 February and 14 April 2009 (Table 10) and 4 aerial inventories from 13 March to 3 April 2009 (Table 11). Peak abundance was 50,208 via ground inventory on 17 February and 46,310 via aerial inventory on 3 April, however, aerial inventories were not instituted until mid-March. Lesser snow geese comprised 46% of our early peak ground-inventory estimate. We recorded 20 species of ducks, 3 species of geese, and 3 species of swans during spring 2009. Proportional use by dabbling (51.2%) and diving ducks (48.9%) was similar. Northern shovelers (18.5%) were the most abundant species observed, followed by lesser scaup (16.4%) and ring-necked ducks (14.8%). Waterfowl UDs from ground surveys totaled 1,872,144, representing a 31.7% increase over spring 2008 (Table 5).

Fall 2009−Spring 2010. −We conducted 8 ground inventories between 2 September and freeze-up on 11 December 2009 (Table 12). Peak waterfowl abundance was 70,074 on 23 November via ground inventory and 63,123 on 11 November via aerial inventory (Tables 12–

13). We observed 20 species of waterfowl during ground inventories, comprised of 16 duck, 3 goose, and 1 swan species. Ring-necked ducks were most abundant and accounted for 16.9% of all ducks, followed by gadwall (16.0%), ruddy ducks (14.1%), and mallards (13.3%). Dabbling ducks were most abundant and accounted for 65.9% of total duck abundance; diving ducks contributed the remaining 34.1%. Use-days totaled 3,006,678, representing a 140.6% and 78.2% increase over the 2007 and 2008 UD estimates, respectively (Table 5).

We conducted 5 ground inventories from 3 March to 20 April 2010 (Table 14) and 4 aerial inventories from 15 March to 5 April 2010 (Table 15). Peak abundance reached 42,056 via ground inventory on 23 March and 87,145 on 29 March via aerial inventory. We observed 23 species of waterfowl during spring 2010 (19 species of ducks, 3 species of geese and 1swan species). Northern shoveler was the most abundant species, accounting for 22.1% of total waterfowl use, followed by lesser scaup (15.2%), and ruddy ducks (15.0%). Diving ducks were slightly more abundant than dabbling ducks, accounting for 54.6% and 45.4% of use, respectively. We estimated total UDs of 1,074,691 during spring 2010 based on ground inventories. This was our lowest UD estimate since inventories began, representing a 42.6% decrease from spring 2009 and a 24.4% decrease from spring 2008.

Non-Waterfowl Abundance

Fall 2007−Spring 2008. −We observed 22 non-waterfowl bird species at Emiquon during fall 2007 ground inventories (Table 16), totaling 138,711 individuals. Of these, 98.9% were American coots. Coot abundance peaked at 28,560 on 29 October and coot UDs were 914,204 during fall. Other commonly observed wetland species included ring-billed gull, pied-billed grebe, black-crowned night heron, great egret, and great blue heron. Commonly observed raptors included northern harrier, bald eagle, and red-tailed hawk.

During spring 2008 ground inventories, we observed 16 non-waterfowl bird species totaling 61,847 individuals (Table 17). The majority of these were American coots (98.7%). Coot abundance peaked at 19,545 on 14 April and totaled 392,108 UDs. Other commonly observed waterbirds included American white pelicans, ring-billed gulls, and double-crested cormorants. Common raptors included: bald eagles, northern harriers, and red-tailed hawks.

Fall 2008−Spring 2009. −We recorded 21 non-waterfowl bird species during fall 2008 ground inventories (Table 18). Similar to fall 2007 and spring 2008, American coots comprised the vast majority of birds observed (98.7%). Peak abundance of coots was 57,405 on 20 October (Table 18) and coot UDs totaled 2,313,994 during fall, a 153.1% increase over fall 2007. Other commonly observed waterbird species included pied-billed grebes, ring-billed gulls, and double-crested cormorants. Commonly observed raptors included northern harriers, red-tailed hawks, and bald eagles.

During spring 2009, we observed 16 non-waterfowl bird species, mostly comprised of American coots (98.7%, Table 19). Peak abundance of non-waterfowl avifauna totaled 58,110 on 26 March, which coincided with peak coot abundance of 57,825. Coot UDs during spring 2009 totaled 1,307,203. Other commonly observed waterbirds included ring-billed gulls, American white pelicans, pied-billed grebes, and double-crested cormorants. Commonly observed raptors included bald eagles, red-tailed hawks, and northern harriers.

Fall 2009−Spring 2010. −We documented 17 species of non-waterfowl avifauna during fall 2009 ground inventories (Table 20). American coots were again the most numerous species (97.0%) and peaked at 100,071 on 23 November. Coot UDs totaled 4,802,621, representing a 107.6% increase over fall 2008 and a 425.3% increase over fall 2007. Other waterbird species commonly encountered were pied-billed grebes, American white pelicans, and double-crested cormorants. Commonly observed raptors included bald eagles, northern harriers, and red-tailed hawks. Bald eagle abundance peaked at 167 on 11 December 2009.

We observed a reduction in non-waterfowl bird use and diversity during spring 2010. We documented 11 species and a peak abundance of 26,535 individuals, which was similar to our 2008 estimate of 20,071, but 54.3% less than in 2009 (Table 21). American coots remained the most abundant species, accounting for 85.7% of use. However, peak coot abundance (25,888) and spring UDs (650,588) were considerably less in spring 2010 than the previous fall. Other common species observed were American white pelicans, double-crested cormorants, and pied-billed grebes.

Duck Behavior

Fall 2007−Spring 2008. −We conducted behavioral observations of mallard, gadwall, northern pintail, northern shoveler, blue-winged teal, and American green-winged teal on 14 days during waterfowl inventories from 6 September 2007 to 9 January 2008. During September, October, and November waterfowl spent the majority of time feeding (49–58%, Table 22). We conducted 4 behavioral observations on dabbling (mallard, northern pintail, American green-winged teal) and diving ducks (lesser scaup, ring-necked duck, and ruddy duck) from 7 March to 14 April, 2008. Dabbling ducks spent similar amounts of time feeding (31.6%), resting (31.1%), and in motion (26.5%, Table 23). Dabbling ducks fed more in March (40.4%) than April (5.4%), although the April sample size was small (n = 5 observations). Diving ducks spent less time feeding (14.8%) and more time resting (66.2%) than dabbling ducks and fed more in March (18.6%) than in April (9.6%, Table 23).

Fall 2008−Spring 2009. −We recorded dabbling duck (mallard, gadwall, northern shoveler, American green- and blue-winged teal) behavior 7 times from 9 September to 24

November 2008. Dabbling ducks spent the greatest proportion of time feeding (50.5%, Table 22), which declined slightly from September (53.8%) to October (48.6%) to November (47.5%).

We conducted 11 behavioral observations of dabbling (e.g., mallards and northern shovelers) and diving ducks (e.g., lesser scaup, ring-necked duck, and ruddy duck) between 10 February and 7 April 2009 (Table 23). Dabbling ducks spent more than twice as much time feeding (57.4%) than resting (21.4%), and allocated 81.6% more time feeding in spring 2009 than in 2008 (31.6%). Time spent feeding by dabbling ducks increased as spring progressed with a peak in April (87.6%; Table 23).

Estimates of diving duck behavior in spring 2009 indicated similar proportions of time spent feeding (36.3%) and resting (40.2%). Diving ducks rested more and fed less than dabbling ducks in spring 2009. Overall, ducks spent substantially more time feeding (45.9%) but less time resting (31.8%) in spring 2009 than spring 2008 (Table 23).

Fall 2009−Spring 2010. −We conducted 13 scan samples between 2 September and 23 November 2009. Species observed included: mallard, blue-winged teal, American green-winged teal, northern pintail, northern shoveler, American wigeon, and gadwall. We were unable to observe diving ducks during fall 2009. Dabbling ducks devoted most of their time to feeding (58.6%), followed by resting (20.0%), locomotion (16.0%), self-maintenance (i.e., other, 4.9%), and social (0.5%) behaviors (Table 22). Foraging behavior peaked in October (67.1%), whereas the proportion of time spent resting was greatest in November (31.1%).

We conducted behavior observations on 4 days between 10 March and 20 April 2010. Species observed included northern shoveler, gadwall, lesser scaup, ring-necked duck, and ruddy duck. Overall, these species spent most time feeding (58.1%), followed by locomotion (20.9%; Table 23). However, when considered by guild, dabbling ducks spent 81.2% time feeding, whereas diving ducks only spent 19.7% time feeding. Locomotion (38.3%) and resting (30.6%) were the most common activities of diving ducks.

Brood Observations

2008. −We conducted 6 fixed-point brood surveys between 5 June and 20 August 2008 and 2 flush counts on 22 July and 20 August 2008. We observed 111 waterbird broods comprised of 8 species during fixed-point surveys (Table 24). The most abundant broods recorded were wood ducks (n = 53), followed by American coots (n = 24), and mallards (n = 19). Estimated brood abundance peaked at 31 broods on 20 August, and age classes of observed broods increased throughout summer with many fully feathered or flighted broods observed during the last counts. During active flush surveys, we recorded 62 broods comprised of 7 species (Table 25). The most abundant species encountered during flush surveys were American coots (n = 24), wood ducks (n = 17), and mallards (n = 10). Since results between survey techniques were similar and disturbance to wetland habitat and wildlife was greater using the active-flush approach, we discontinued flush counts in 2009.

2009. −We conducted 6 fixed-point brood surveys between 11 June and 25 August 2009 and recorded 114 waterbird broods comprised of 7 species (Table 26). We incidentally documented ruddy duck broods during subsequent fall ground inventories. The most abundant broods recorded were wood ducks (n = 67), followed by mallards (n = 14) and American coots (n = 13). Brood observations peaked (n = 30) on 21 July and, similar to 2008, age classes of broods increased throughout the spring-summer observation period.

Aquatic Invertebrates

2008. −We collected 20 sweep-net samples on 30 April, 17 June, and 7 August 2008 (n = 60 total samples). Mean volume sampled per sweep was 1.3 m^3. Mean invertebrate biomass (mg/m^3; dry mass) per sample increased during each sampling period (April - 18.7 mg/m^3, June - 112.0 mg/m^3, August - 247.3 mg/m^3) as invertebrate communities developed. We identified 26 taxa, and the most common by percent occurrence were Copepods (91.7%), followed by Cladocerans, (86.7%) and Chironomid larvae (81.7%; Table 27). The most abundant invertebrates by biomass were snails from the Families Physidae (72.0 mg/m^3) and Planorbidae (20.4 mg/m^3), Chironomid larvae (6.3 mg/m^3), and Cladocerans (6.1 mg/m^3; Table 27). Biomass per sample over the 3 sampling periods averaged 126.0 mg/m^3.

2009. −We collected 20 sweep-net samples on 5 May, 23 June, and 6 August (n = 60 total samples). Mean volume sampled per sweep was 1.5 m^3. Mean invertebrate biomass (mg/m^3; dry mass) increased between the first and second sampling periods but declined during the last sampling period (May - 22.6 mg/m^3, June - 302.5 mg/m^3, August - 141.7 mg/m^3). We identified 39 taxa in our samples; Oligochaetes (96.7%) were the most common invertebrates, followed by Cladocerans (95.0%), and Chironomid larvae (90.0%; Table 27). Snails (Physidae - 72.3 mg/m^3, Planorbidae - 55.3 mg/m^3) provided the greatest biomass per volume, followed by Chironomid larvae (6.6 mg/m^3), Oligochaetes (4.5 mg/m^3), and Corixids (4.2 mg/m^3; Table 27). Biomass per sample over the 3 sampling periods averaged 155.6 mg/m^3.

Moist-soil Plant Seeds

2007. −We collected 20 soil core samples on 1 November 2007 at Emiquon to estimate moist-soil plant seed abundance. Overall, moist-soil plant seed biomass averaged 992.4 kg/ha (Table 28). Large seeds contributed 748.2 kg/ha, whereas small seeds accounted for 244.2 kg/ha of the biomass. The overall biomass estimate indicated that the moist-soil area at Emiquon could support 8,496 EUDs/ha.

2008. −We extracted 20 random core samples at Emiquon on 3 October 2008. Average moist-soil plant seed biomass was 495.4 kg/ha (dry mass; Table 28), a decline of 50.1% from 2007. Of the total estimate, the majority (435.8 kg/ha) was classified as large seeds. Estimated energetic carrying capacity based on 2008 seed yields was 4,241 EUDs/ha.

2009. −We collected another 20 core samples from random locations at Emiquon on 22 September 2009. Moist-soil plant seed abundance in 2009 averaged 235.3 kg/ha, and nearly all biomass was represented by large seeds (221.7 kg/ha; Table 28). Estimated energetic carrying capacity was correspondingly low as well, equating to 2,015 EUDs/ha. This represented a 52.3% decline from the 2008 EUD estimate.

Wetland Covermapping

2007. −We documented 12 habitat categories during 2 days (7−8 November 2007) of wetland mapping at Emiquon. Open water (106.4 ha) was the dominant habitat type with non-persistent emergent (50.7 ha), hemi-marsh (29.9 ha), cattail (25.5 ha), and ditch (18.7 ha) comprising most of the remaining wet area (Table 29, Fig. 1). The total wetland area mapped in 2007 was 254.7 ha (Table 29).

2008. −We mapped the wetted area of Thompson, Flag and Seebs lakes over 6 days (11−18 September 2008) and documented 14 habitat categories. Much of the wetland area was classified as open water (275.1 ha), followed by aquatic bed (238.1 ha), hemi-marsh (220.5 ha), upland–wet (i.e., flooded upland vegetation, 147.9 ha), and non-persistent emergent (127.3 ha; Table 29, Fig. 2). The entire wetland area mapped in 2008 was 1,077.2 ha (Table 29).

2009. −We completed wetland mapping in 7 days (15−23 September 2009) and documented 13 habitat categories. In 2009, we also included coontail in aquatic bed estimates. Aquatic bed (1,185.7 ha) increased substantially and was clearly the most abundant habitat type, followed by hemi-marsh (290.4 ha), open water (221.3 ha), and cattail (38.1 ha; Table 29, Fig. 3). The total wetted area mapped was 1,803.9 ha in 2009, considerably larger than in the previous 2 years. Over all 3 years of mapping, we documented 80 plant species at the site (Table 2).

DISCUSSION

Waterfowl Abundance

Disturbance.−The KEA for waterfowl disturbance specifies that ≥50% of the wetland area at Emiquon have restricted access with an acceptable level of human disturbance. We did not specifically evaluate this KEA, but believe our experiences can be used to address it qualitatively. Currently, public access is limited to approximately the western half of Emiquon (IL Route 78 to center of Thompson Lake bed). This configuration leaves considerable wetland area, likely > 50% that is relatively disturbance-free (i.e., no disturbance other than staff and researchers). As wetland size has increased at the site, we believe that disturbance of waterfowl has become less of a concern. When the wetland was relatively small (e.g., ≤300 ha), a single boat could displace thousands of waterfowl from the wetland. This was especially true for diving ducks, which are more susceptible to disturbance (Thornburg 1973, Korschgen et al. 1985, Knapton et al. 2000), and would regularly depart in flocks of several thousand when approached by a boat during spring 2008. The wetland is now large enough that fewer waterbirds are typically encountered in any given boat trip (i.e., reduced UD/ha), and disturbed birds can quickly resettle in another part of the wetland.

Fishing and waterfowl hunting activities limited to the western half and western shore of the wetland, respectively, likely disturb and redistribute waterbirds at the site. However, the wetland has increased substantially in size, and we typically observe birds simply moving away from the disturbed area, but not leaving altogether. Further evidence for the utility of the refuge area at Emiquon includes the greater numbers of waterbirds observed on the east side of the wetland during ground and aerial inventories. Additionally, during fall 2009 we attached VHF radio transmitters to 71 mallards at Emiquon. Many of these ducks moved throughout the region (i.e., >16 km), but others stayed at Emiquon for days or weeks after radio attachment. Radioed birds were located daily, and those found at Emiquon were typically on the eastern side of the wetland. After hunting season began, hunting activities at the site seemed to have little effect on their movements or location. Thus, we conclude that the KEA for waterfowl disturbance is currently within the desired range, but disturbance may need to be re-evaluated should wetland area decrease.

Use-days.−The criteria for evaluating the KEA for UDs have not been established; therefore, we provide only a qualitative discussion of UDs here. UDs at Emiquon increased steadily from initiation of surveys during fall 2007 (1,249,860 UDs) through fall 2009 (3,006,678 UDs; Table 5). During spring 2010, UDs declined for the first time and were the lowest since survey initiation (1,074,691 UDs). Because the size of the wetland changed considerably, we also expressed duck use estimates as densities (UD/ha). Duck-use densities were highest during fall 2007 (4,902 UD/ha) and lowest during spring 2010 (553 UD/ha). Clearly, duck use in fall 2007 was exceptional given the small wetland size, which led to the high density estimate. We suspect that the high waterbird concentration present during fall 2007 may have depleted food resources. For example, many ducks and coots left the wetland prior to peak migration in the rest of the IRV. However, this coincided with the opening of duck season; thus, this emigration event was confounded with disturbance. Additionally, we did not detect extensive beds of submersed aquatic vegetation during mid-fall 2007 habitat covermapping, which were abundant and visible during summer months. The low UD/ha estimate for spring 2010 was somewhat surprising given that fall 2009 UDs were the highest to date. Ice melt was late during spring 2010 and inventories did not begin until 3 March, whereas in prior years they began mid-February. It is possible that spring migration was compressed in 2010 and duck concentrations did not reach that of previous springs.

We also calculated UD/ha for nearby Chautauqua National Wildlife Refuge (CNWR) for the period of 1991−2008 as a means to compare waterfowl use at Emiquon to another local wetland of importance (Havera 1999). During this period, use-density ranged from 133−9,925 UD/ha and averaged 2,632 UD/ha at CNWR. These estimates were calculated from fall aerial inventories only; thus, only our fall estimates at Emiquon are likely comparable. Regardless, our estimates for Emiquon fell within this relatively wide range, but only fall 2007 was greater than the average use-density at CNWR. This is not surprising given that much of CNWR was intensively managed to produce moist-soil vegetation, which can theoretically support more ducks per-unit-area than the habitats typical of Emiquon (e.g., aquatic bed, hemi-marsh; Soulliere et al. 2007: 34). The diversity of habitat types and complex management objectives at Emiquon likely preclude intensive moist-soil management. Therefore, we suggest it is reasonable to set UD/ha goals for Emiquon at some level less than the average observed at CNWR. It is worth noting, however, that 52−84% of UDs at CNWR were attributable to mallards. By contrast, Emiquon supported a more diverse waterfowl community, and mallards comprised only 6−13% of total UDs during falls 2007−2009. Thus, we recommend maintaining diverse habitat communities that are currently rare in the IRV but attract and support non-mallard duck species. Further, diversity of waterfowl species that use Emiquon during migration may be as (or more) useful of an indicator of ecological function than abundance.

Other Considerations.–Changing wetland conditions at Emiquon presented challenges to accurately inventorying waterbirds, and we adjusted our methodology accordingly. Thus, our techniques were comparable, but not identical, among inventory periods. We observed birds from fixed vantage points, but vantage points changed as the wetland grew, as did our route of travel between points. We had to move further from the wetland edge, therefore, the number of ducks encountered and our ability to detect waterbirds and uncommon species declined. For example, in fall 2007 the wetland was circled on an ATV in the wetland margins and many birds were encountered between points. However, as wetland area increased in subsequent seasons, we needed to use an automobile to travel between observation points along the levee and, hence, encountered fewer birds. The larger wetland size also created several areas that were largely inaccessible and not possible to inventory from the ground. Since these areas were visible from the air and not the ground, discrepancies arose between ground and aerial surveys when large numbers of waterfowl used these isolated areas.

Additionally, the time required to complete the inventory increased as wetland size increased. Thus, we reduced our survey frequency from weekly to bi-weekly. This change may have affected the total number of birds observed in a season, especially if significant changes in waterfowl abundance were missed between surveys, and emphasizes the importance of relying on UDs to evaluate waterfowl use within and among seasons. A potential negative effect of reducing the number of inventories in a season is missing peak migration, which may have occurred in spring 2010. The peak migration occurred in late March and was captured by aerial inventory, but fell between ground inventories. Missing peak migration will lead to reduced UD estimates for a season.

We have completed ground inventories for 3 migration cycles (fall and spring migration) and have observed 20 duck, 3 goose, and 3 swan species. This diversity highlights the positive response of waterfowl to this wetland restoration. Although all species observed were generally considered common to the region, they are rarely seen in the quantity documented at Emiquon.

Over the past several decades, wetland habitat in the IRV has incurred many anthropogenically induced changes and become less diverse as a result (Mills et al. 1966, Bellrose et al. 1983, Havera 1999, Stafford et al. 2010). Because of these changes, several habitat types have been lost or nearly-so in IRV wetlands, especially submersed (e.g., sago pondweed) and floating-leaved aquatic vegetation (e.g., American lotus; Stafford et al. 2010). The loss of these specific habitats has been associated with regional declines in duck species that are considered foraging specialists when compared to the mallard; particularly diving ducks of the Tribe Aythyini (e.g., lesser scaup) and non-mallard dabbling ducks (e.g., gadwall; Tribe Anatini). Diving ducks were historically abundant throughout the IRV but declined drastically during the 1950's following the loss of their preferred foraging habitats and foods (Mills et al. 1966). In contrast, these species were abundant at Emiquon.

To evaluate the importance of Emiquon to diving and non-mallard dabbling ducks, we compared UDs from Emiquon to the entire IRV. For this comparison we used aerial inventory data because ground inventories were not conducted at other wetlands. Additionally, we did not have recent abundance data for other IRV wetlands during spring, so our comparison is limited to fall. Diving duck abundance at Emiquon was low in fall 2007, comprising only 1% UDs in the IRV. This was expected based on wetland characteristics in that year. However, as the wetland area increased, diving duck use increased substantially, accounting for 36% of all diving duck UDs in the IRV in 2008 and 42% in 2009. These results were encouraging given the recent history and trends in diving duck numbers in the IRV and their susceptibility to disturbance.

Correspondingly, non-mallard dabbling duck use also increased at Emiquon compared to the rest of the IRV. In 2007, Emiquon accounted for 33% of non-mallard dabbling ducks UDs in the IRV, increasing to 46% in 2008 and 51% in 2009. Furthermore, although we do not have data from other IRV wetlands to evaluate recent UDs during spring, these duck groups were typically more abundant in spring than fall at Emiquon. Continued increases in diving duck and non-mallard dabbling duck abundance emphasize the importance of Emiquon in providing wetland habitat types, such as submersed aquatic vegetation and hemi-marsh, which are rare in the IRV.

Non-waterfowl Abundance

Disturbance.−We did not specifically monitor disturbance of waterbirds, but spent sufficient time observing birds at Emiquon to qualitatively evaluate this KEA. Non-waterfowl waterbirds were primarily American coots, although we did observe many other species. As with waterfowl, effects of disturbance decreased as the wetland size increased and birds could move away from disturbances and resettle in other parts of the wetland. The current practice of allowing fishing and hunting only on the western half of Thompson Lake appears to effectively limit disturbance. Additionally, several secretive species that typically avoid disturbed areas have been observed at Emiquon, indicating that disturbance levels were acceptable. As with waterfowl, if the wetland were to significantly decrease in size, disturbance levels may need to be re-evaluated.

Other Considerations.–American coots have been increasing in abundance at Emiquon since surveys began in 2007. This result was not surprising given the large surface area of the wetland and the abundance of hydrophytes, a major food source for this species (Brisbin et al. 2002). However, the intensity of the numerical response observed was greater than expected. To highlight the growing importance of this wetland to coots, we compared UDs calculated from aerial inventories at Emiquon to the rest of the IRV during falls 2007−2009. In 2007, coot UDs totaled 1,159,833 for the entire IRV, of which Emiquon accounted for 50.1%. In 2008, total coot UDs in the IRV rose to 1,723,993, with Emiquon accounting for 93.0% of the total. Finally, in 2009, coot UDs in the IRV increased substantially to 5,019,803, with Emiquon accounting for 4,249,563 UDs (84.7%) and a peak abundance of 99,425 on 11 November. In comparison, nearby CNWR only surpassed 1 million coot UDs once between 1991 and 2008; clearly emphasizing the exceptional use Emiquon has received. We note that coot use declined in spring 2010 (Table 21), but waterfowl use declined as well. We suspect coot use will remain high in subsequent years if the wetland remains large and dense growths of submersed aquatic vegetation persist. However, the relative abundance of coots may be an indicator of ecosystem function and further declines should be noted and investigated.

Duck Behavior

Feeding, Fall.−The evaluation criteria for the KEA related to fall feeding by dabbling ducks desires the presence of shallowly flooded mature moist-soil plants, in combination with productive epiphyte and benthic invertebrate communities. Although moist-soil plant communities have developed each year at Emiquon, they have not been extensive. This is largely due to the increasing size and depth of the wetland, because moist-soil plant communities develop as water recedes (Fredrickson and Taylor 1982). Despite the lack of extensive moist-soil habitat, large numbers of dabbling ducks have congregated at Emiquon each fall, likely due to large, shallow areas supporting submersed aquatic and emergent vegetation where they regularly fed. Behavioral observations revealed dabbling ducks spent an average of 53.9% of time feeding during falls 2007−2009 (Table 22). This estimate fell within a range of other published estimates for time spent foraging by non-breeding dabbling ducks (Paulus 1988). Additionally, dabbling ducks may spend a greater percentage of time feeding when consuming leafy aquatic vegetation (Paulus 1984), a likely occurrence at Emiquon. Although few areas of shallowly flooded moist-soil plants existed at Emiquon during falls 2007−2009, behavioral observations and duck abundances indicated that food resources were plentiful.

The evaluation criteria for the KEA related to fall diving duck foraging habitat includes the presence of areas with water depths of 1-5 meters and <10% emergent vegetation. Our wetland mapping suggested that large areas with these characteristics were present (Figures 1-3), and diving duck use increased over time. Unfortunately, we have been unable to conduct behavioral observations of diving ducks during fall because low abundances prior to fall 2009 and visual impediments (e.g., distance, glare, waves) precluded successful observation. We speculate that quality diving duck foraging habitat exists at Emiquon, but cannot directly address this topic until diving duck abundance during fall increases.

Feeding, Spring.−The conditions desired under the KEA addressing spring waterfowl foraging includes the presence of shallowly flooded areas over residual vegetation and invertebrates. Although we did not specifically evaluate spring foraging habitat, these areas do exist along the wetland periphery and in shallow areas in the center of the wetland along ridges and spoil piles. Such areas were more appropriate for foraging dabbling ducks than diving ducks, which prefer slightly deeper areas. Our behavioral observations revealed that, on average, dabbling ducks spent 56.7% of time foraging during spring (Table 23). This estimate varied by year and month, occasionally dipping below published estimates, but also rising above them (see

Paulus 1988). We suggest this provided evidence that quality foraging habitat existed for spring migrating dabbling ducks at Emiquon. Additionally, several species of dabbling ducks readily consume plant seeds throughout spring migration (Smith 2007, Hitchcock 2008). Increasing the area and quality of moist-soil plants at Emiquon will contribute to the fall and spring food base for migrating dabbling ducks that use the site.

Diving ducks spent an average of 25.8% of time foraging during spring, which was similar to published estimates (Paulus 1988, Bergan et al. 1989). As with dabbling ducks, estimates varied by month and year, likely an artifact of small sample sizes. We did not estimate abundance of diving duck foods, but suggest that the combination of vegetation parts (e.g., tubers) and seeds from submersed aquatic vegetation, and the associated invertebrates that live on and around these plants and in the benthos, provided a reliable food source for spring-migrating diving ducks. Furthermore, recent research suggests that diving ducks, like dabbling ducks, will readily consume seeds during spring migration (Smith 2007, Strand et al. 2008, Hitchcock 2008). Thus, residual moist-soil plant seeds can provide an additional food source for diving ducks during spring.

Behavioral studies of waterfowl that employ scan sampling may underestimate the foraging time of diving ducks (Hohman 1984, Baldassarre et al. 1988) because individuals that are actively feeding, but observed on the surface during the "inter-dive loaf", are incorrectly classified as resting, and birds underwater are missed entirely. We attempted to account for this by using a modified method in which each diving duck was watched for a short period of time (≤10 seconds) during the scan to capture feeding behavior, essentially creating a series of very short focal samples. Time constraints prevented us from evaluating our method, but we contend that it should better represent the foraging behavior of diving ducks than if we had used simple scan sampling.

Brood Observations

The total number of broods observed at Emiquon was similar among years; however, incidence of wood duck broods increased 26% from 2008 to 2009, whereas mallard and American coot brood abundance declined 26% and 46%, respectively (Tables 24 and 26). Late-spring phenology and rising water levels in 2009 may have influenced these declines by creating less favorable nesting conditions, although brood abundance peaked one month earlier (21 July) in 2009 than in 2008. We suspect this was partially due to the abundance of early-nesting wood ducks, which constituted two-thirds of the broods observed during the peak 2009 count. As cavity nesters, wood ducks may have been less influenced by the late spring conditions than upland nesting ducks.

As anticipated, age classes of broods during both years increased throughout the spring-summer observation periods (Tables 24 and 26). Many broods were fully feathered and flighted by the last counts, making them difficult to distinguish from adults. Our observations indicated that Emiquon provided quality brood-rearing habitat capable of sustaining young waterbirds to fledging.

Several KEAs address availability of nesting habitats for waterbirds (e.g., upland, tree cavities). We did not specifically monitor or map potential nesting habitats, but it is reasonable to assume that upland nesting cover declined substantially in 2009 due to rising water levels. Few mature trees with suitable nesting cavities exist on the area, but wood ducks that presumably nested elsewhere used Emiquon during brood rearing. In fact, over half of all broods observed during 2008−2009 were wood ducks. We acknowledge that our brood observations should be considered only as an index of waterbird production. We clearly did not document all broods that used the site, and we likely observed individual broods more than once during multiple surveys. Thus, we suggest these counts will be most useful for assessing trends among years as habitat conditions change at Emiquon.

Waterbird Forage

Aquatic Invertebrates.–Breeding waterfowl rely extensively on aquatic macroinvertebrates prior to and during the reproductive period. Insects are particularly important to breeding females, specifically larvae and nymphs of the orders Diptera (flies), Coleoptera (beetles), Odonata (dragonflies and damselflies), and Trichoptera (caddis flies), as are crustaceans (Cladocera), snails (Gastropoda), and amphipods (Amphipoda) (Swanson et al. 1979, Eldridge 1990). Swanson et al. (1985) reported the diets of laying female mallards in North Dakota consisted of insects (27.1%), gastropods (16.4%), crustaceans (12.9%), and annelids (12.8%).

The KEA related to waterbird food resources during the breeding season identified the presence of epiphytic and benthic invertebrates. Results of our sampling indicated a 50% increase in overall diversity and 23% increase in biomass per sample of nektonic invertebrates between 2008 and 2009. The most abundant invertebrates in both years were cladocerans, copepods, chironomids, oligochaetes, and physids, while most of the biomass was produced from physids, planorbids, and chironomids. Although important orders, such as Coleoptera, Odonata, Trichoptera, Ephemeroptera, and Amphipoda were not the most abundant taxa, they still were well represented in samples (Table 27). The relatively high occurrence and biomass of nektonic invertebrates important to breeding waterfowl likely indicates sufficient availability of invertebrate foods to meet the dietary needs of breeding waterbirds at Emiquon, thereby satisfying the relevant KEA objectives for 2008 and 2009.

Moist-soil Plant Seeds.–Moist-soil plant seed production was variable at Emiquon during 2007−2009. The KEA goal was to achieve at least 578 kg/ha of moist-soil plant seed, with ≥800 kg/ha considered to be very good production. In this context, moist-soil plant seed yield at Emiquon was very good (992 kg/ha) in 2007, fair (495.4 kg/ha) in 2008, and poor (235.3 kg/ha) in 2009 (Table 28). The Upper Mississippi River and Great Lakes Region Joint Venture of The North American Waterfowl Management Plan uses moist-soil seed abundance estimate of 514 kg/ha for waterfowl conservation planning in this region. During 2005−2007, moist-soil seed abundance estimates at state waterfowl management areas in Illinois ranged from 501.5 to 1,030.0 kg/ha and averaged 691.3 kg/ha (Stafford et al. 2008). Bowyer et al. (2005) reported average seed abundance of 790 kg/ha for moist-soil plants at CNWR during 1999−2001. Thus, seed production at Emiquon typically fell below these published estimates, which was almost certainly a function of water levels in 2008 and 2009. In these years, little or no mud flats were exposed during the growing season to allow for plant germination. Nonetheless, estimated seed production in 2007 emphasizes the potential of this area to produce abundant waterfowl forage. Community composition goals for moist-soil vegetation desired forbs to comprise ≥10% of the coverage. Although we did not estimate coverage of specific moist-soil plants, our general observations indicated approximately equal percentages of forbs and grasses.

Naturally, EUD estimates (derived from forage abundance estimates) at Emiquon followed the same pattern as moist-soil plant seed estimates. That is, energetic carrying capacity was very good in 2007 (8,496 EUD/ha), but declined substantially in 2008 (4,241 EUD/ha) and 2009 (2,015 EUD/ha) (Table 28). For comparison, EUD estimates for CNWR averaged 6,760

EUD/ha and ranged from 2,815−10,536 EUD/ha during 1999−2001 (Bowyer et al. 2005). Energetic carrying capacity of moist-soil areas at Illinois Department of Natural Resources waterfowl management areas ranged from 4,294 to 8,819 EUD/ha and averaged 5,919 EUD/ha during 2005−2007 (Stafford et al. 2008). Although estimated energetic carrying capacity of moist-soil areas at Emiquon declined in 2008 and 2009, the annual estimates fell within the range of other important waterfowl areas in Illinois.

Wetland Covermapping

Community Composition.–The wetland area mapped at Emiquon increased more than 600% from 2007 to 2009, as the site developed into a diverse mix of open water and 15 habitat types (Table 29). Vegetation assemblages occurred as distinct stands, but were also interspersed among other vegetation types, such as submersed aquatic plants growing within hemi-marsh habitat. Further, habitat composition was dynamic as water levels increased. For instance, the area of aquatic bed grew substantially, expanding from just 1% of the wetland area in 2007 to 65.7% in 2009. However, our 2007 aquatic bed estimate may be biased low due to late season mapping and suspected depletion by foraging waterbirds. The area classified as hemi-marsh also grew markedly, especially between 2007 and 2008. In contrast, non-persistent emergent vegetation declined from nearly 20% of the wetland in 2007 to only 1.3% in 2009. Likewise, as the area of aquatic bed expanded, open water declined from nearly 42% to 12.3% of the wetland area.

Invasive Species.–The criteria for KEAs related to habitat composition stipulate <10% invasive species coverage and 100% exclusion of purple loosestrife. We encountered relatively few invasive or undesirable wetland plant species during wetland mapping; however, we did document areas with the following exotic species: curly pondweed, Eurasian water milfoil, reed canarygrass, and common reed. Additionally, we found purple loosestrife on the preserve for the first time during 2009. Although we did not estimate the size of areas occupied by invasive plant species, they likely were less abundant than the 10% specified under the KEA. We note, however, that curly pondweed and Eurasian water milfoil beds could expand substantially under current wetland conditions, whereas areas of reed canarygrass and common reed may increase if water levels recede. Thus, vigilance against the expansion of these and other invasive plants should be exercised as wetland conditions continue to change.

Shorebird Habitat.–The amount of shorebird foraging habitat was variable at Emiquon during 2007–2009 as water levels increased and flooded large areas that were previously dry. These wet conditions resulted in broad, shallow areas where water depths were suitable for foraging by some species of shorebirds, although standing vegetation may have deterred use by some species. Further, many species of shorebirds prefer to forage on mud flats, but we did not encounter mud flat in 2008 and 2009. Anecdotally, shorebird use was extensive in sparsely vegetated shallow water in 2008. With respect to shorebird KEA goals, we considered foraging habitat quality and abundance to be good in 2007, fair in 2008, and poor in 2009. Nonetheless, the overall diversity of wetland habitats at Emiquon supported many waterbird guilds during 2007−2009.

To compare contemporary wetland habitat categories at Emiquon to historical characteristics of IRV wetlands (1938−1942; Bellrose 1941, Bellrose et al. 1979), we consolidated habitats into 8 categories: bottomland forest, non-persistent emergent, open water, aquatic bed, floating-leaved aquatic, mud flat, persistent emergent, and scrub shrub (Stafford et al. 2010, Table 30). For example, areas of American lotus were included in the floating-leaved aquatic category, coontail was categorized as aquatic bed, cattail and hemi-marsh were grouped with persistent emergent, and willow was considered as scrub-shrub. According to Stafford et al. (2010), open water (38.7%) was the dominant habitat type of IRV wetlands during 1938−1942, followed by floating-leaved aquatic (14.9%), non-persistent emergent (12.4%), and persistent emergent (12.3%), and aquatic bed (11.2%). Habitat composition at Emiquon varied annually, but averaged across all years, aquatic bed (29.7%), open water (26.5%), and persistent emergent (22.2%) were most prevalent. Average proportions of Emiquon categorized as non-persistent emergent, mud flat, and scrub shrub were similar to that of historical wetlands in the IRV, but floating-leaved aquatic vegetation and bottomland forest were lacking compared to historical conditions. Overall, the habitat composition at Emiquon during 2007−2009 somewhat approximated historical contexts and continued monitoring may reveal a balancing of habitat proportions as the wetland matures and hydrology varies.

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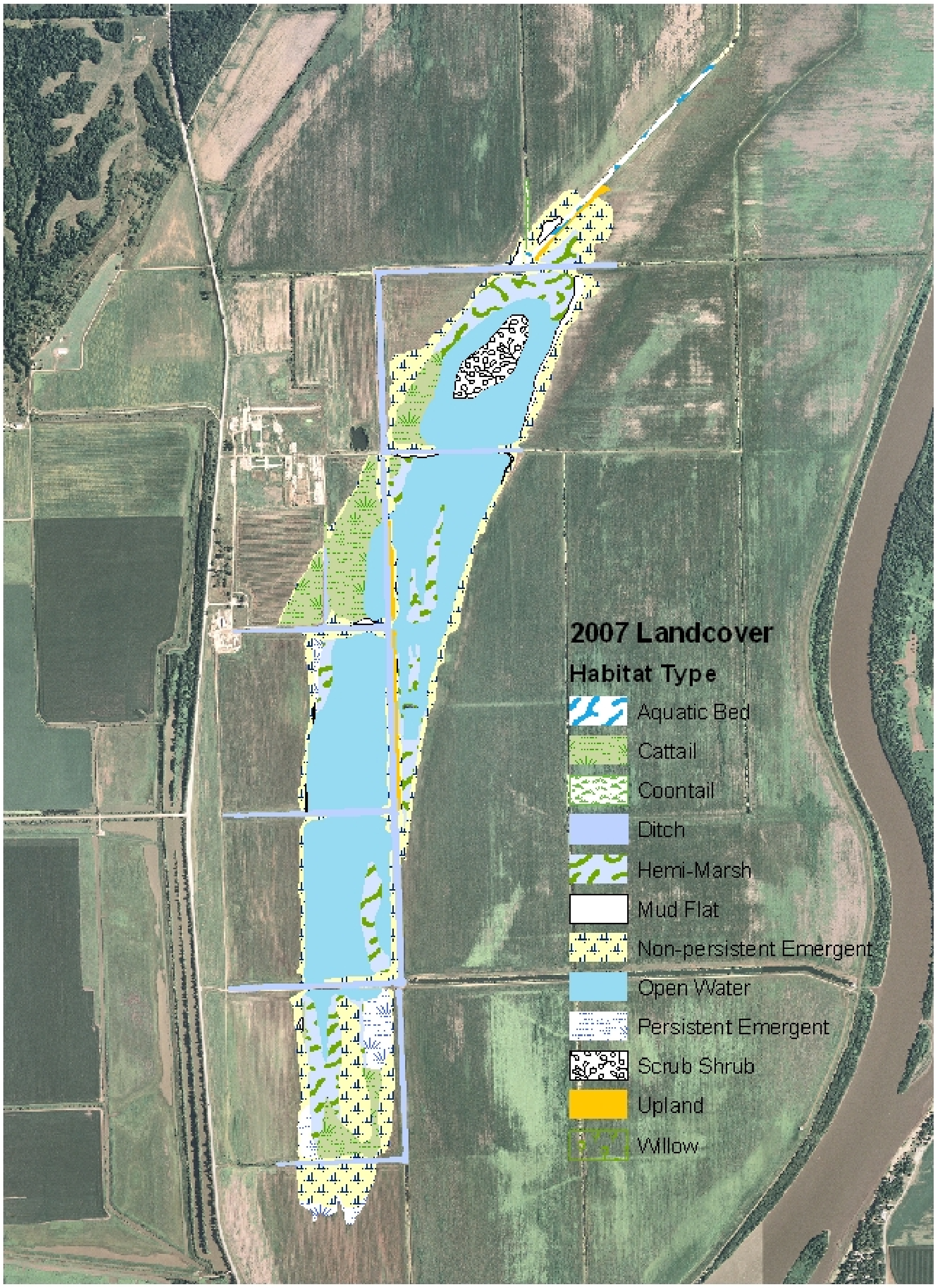

Figure 1. Wetland habitat map of The Emiquon Preserve, 7–8 November 2007.

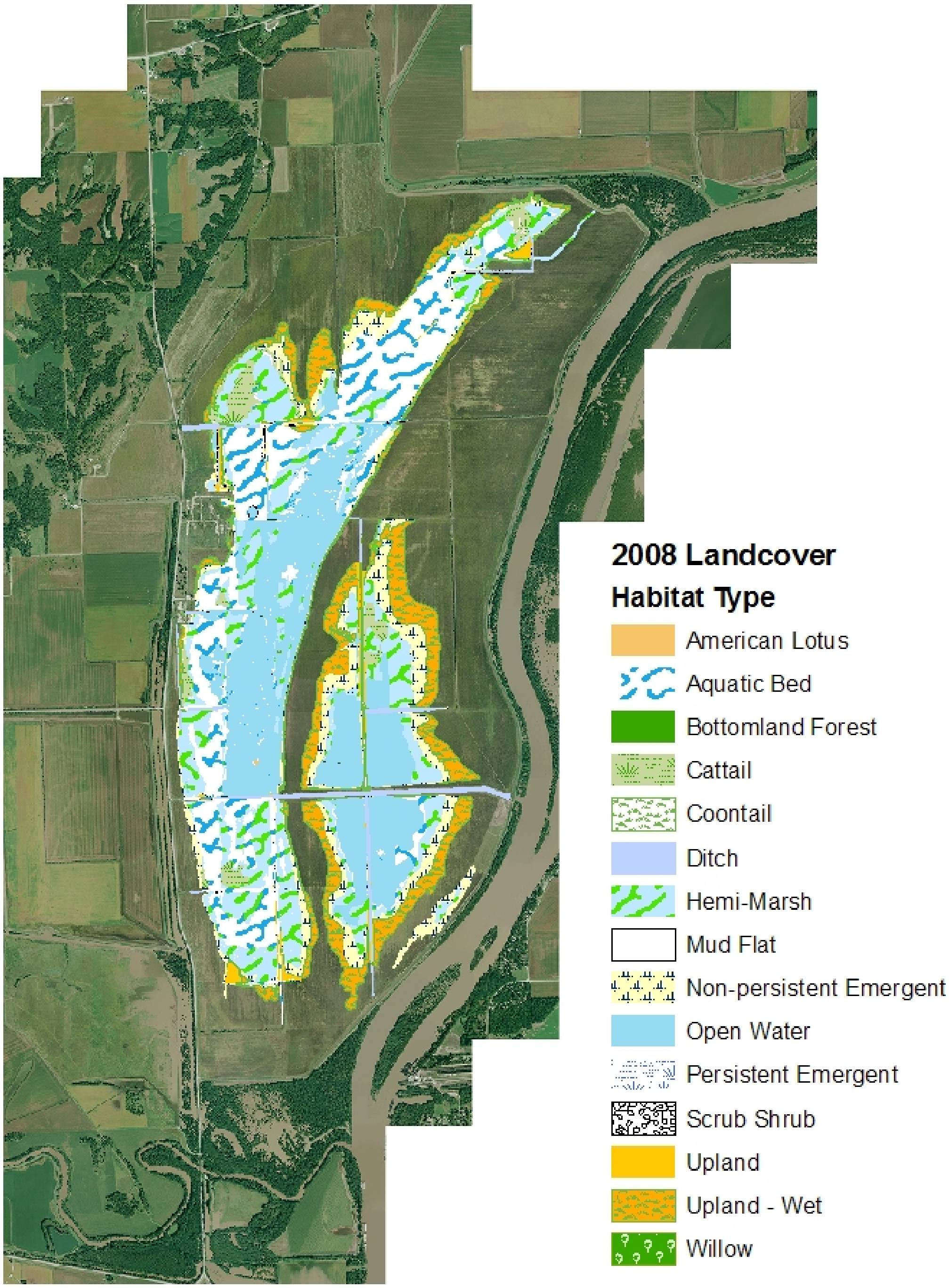

Figure 2. Wetland habitat map of The Emiquon Preserve, 11–18 September 2008.

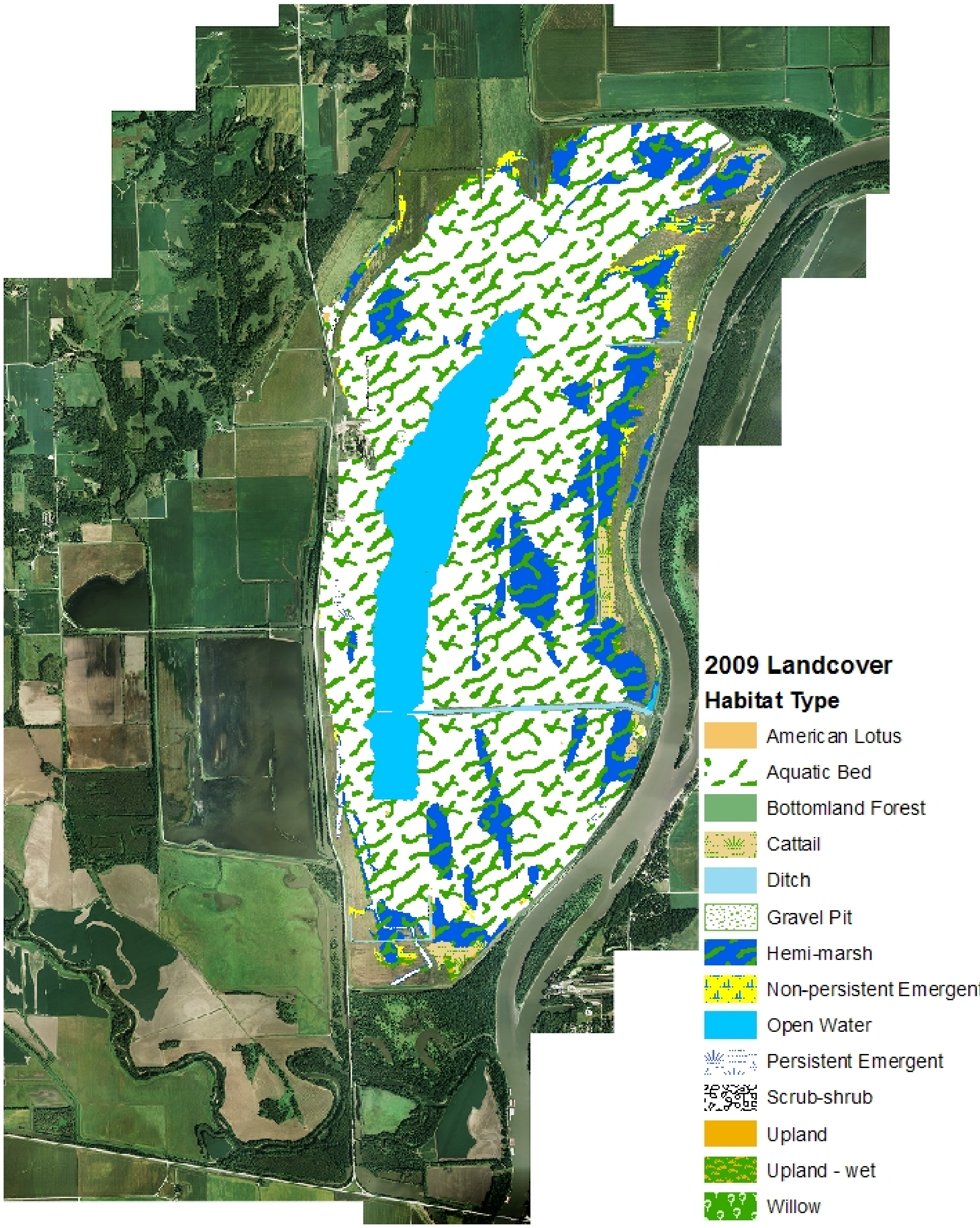

Figure 3. Wetland habitat map of The Emiquon Preserve, 15–23 September 2009.

Table 1. Avian species observed during monitoring activities at The Emiquon Preserve, 2007–2009.

AOU Code	Common Name	Scientific Name
ABDU	American Black Duck	*Anas rubripes*
AGWT	American Green-winged Teal	*Anas crecca*
AMBI	American Bittern	*Botaurus lentiginosus*
AMCO	American Coot	*Fulica americana*
AMWI	American Wigeon	*Anas americana*
AWPE	American White Pelican	*Pelecanus erythrorhynchos*
BAEA	Bald Eagle	*Haliaeetus leucocephalus*
BCNH	Black-crowned Night Heron	*Nycticorax nycticorax*
BEKI	Belted Kingfisher	*Megaceryle alcyon*
BLTE	Black Tern	*Chlidonias niger*
BNST	Black-necked Stilt	*Himantopus mexicanus*
BOGU	Bonaparte's Gull	*Chroicocephalus philadelphia*
BUFF	Bufflehead	*Bucephala albeola*
BWTE	Blue-winged Teal	*Anas discors*
CAEG	Cattle Egret	*Bubulcus ibis*
CAGO	Canada Goose	*Branta canadensis*
CANV	Canvasback	*Aythya valisineria*
COGO	Common Goldeneye	*Bucephala clangula*
COHA	Cooper’s Hawk	*Accipiter cooperii*
COLO	Common Loon	*Gavia immer*
COME	Common Merganser	*Mergus merganser*
COSN	Common Snipe	*Gallinago gallinago*
COTE	Common Tern	*Sterna hirundo*
DCCO	Double-crested cormorant	*Phalacrocorax auritus*
EAGR	Eared Grebe	*Podiceps nigricollis*
FRGU	Franklin’s Gull	*Leucophaeus pipixcan*
GADW	Gadwall	*Anas strepera*
GBHE	Great Blue Heron	*Ardea herodias*
GHOW	Great Horned Owl	*Bubo virginianus*
GREG	Great Egret	*Ardea alba*
GRHE	Green Heron	*Butorides virescens*
GWFG	Greater White-fronted Goose	*Anser albifrons*
HOGR	Horned Grebe	*Podiceps auritus*
HOME	Hooded Merganser	*Lophodytes cucullatus*
KILL	Killdeer	*Charadrius vociferus*
LBHE	Little Blue Heron	*Egretta caerulea*
LESC	Lesser Scaup	*Aythya affinis*
LSGO	Lesser Snow Goose	*Chen caerulescens*
MAGO	Marbled Godwit	*Limosa fedoa*

Table 1. Continued.

AOU Code	Common Name	Scientific Name
MALL	Mallard	*Anas platyrhynchos*
MUSW	Mute Swan	*Cygnus olor*
NOHA	Northern Harrier	*Circus cyaneus*
NOPI	Northern Pintail	*Anas acuta*
NSHO	Northern Shoveler	*Anas clypeata*
NSHR	Northern Shrike	*Lanius excubitor*
OSPR	Osprey	*Pandion haliaetus*
PBGR	Pied-billed Grebe	*Podilymbus podiceps*
PEFA	Peregrine Falcon	*Falco peregrinus*
RBGU	Ring-billed Gull	*Larus delawarensis*
RBME	Red-breasted Merganser	*Mergus serrator*
REDH	Redhead	*Aythya americana*
RLHA	Rough-legged Hawk	*Buteo lagopus*
RNDU	Ring-necked Duck	*Aythya collaris*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RUDU	Ruddy Duck	*Oxyura jamaicensis*
SORA	Sora	*Porzana carolina*
TRUS	Trumpeter Swan	*Cygnus buccinator*
TUSW	Tundra Swan	*Cygnus columbianus*
WIPH	Wilson's Phalarope	*Phalaropus tricolor*
WODU	Wood Duck	*Aix sponsa*
WWSC	White-winged Scoter	*Melanitta fusca*
YHBL	Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*

Table 2. Plant species encountered during wetland covermapping at The Emiquon Preserve, 2007−2009.

Common Name	Scientific Name
American Lotus	*Nelumbo lutea*
Arrowhead	*Sagittaria* spp.
Ash	*Fraxinus* spp.
Aster	*Aster spp.*
Barnyardgrass	*Echinochloa crus-galli*
Bidens	*Bidens* spp.
Black Willow	*Salix nigra*
Boneset	*Eupatorium* spp.
Brasenia (Watershield)	*Brasenia schreberi*
Brittle Naiad	*Najas minor*
Broadleaf Cattail	*Typha latifolia*
Bur Reed	*Sparganium spp.*
Buttonweed	*Diodia virginiana*
Canada Wild Rye	*Elymus canadensis*
Carex	*Carex spp.*
Cattail	*Typha spp.*
Chufa	*Cyperus esculentus*
Cocklebur	*Xanthium strumarium*
Common Reed	*Phragmites spp.*
Coontail	*Ceratophyllum demersum*
Creeping Water Primrose	*Ludwigia peploides*
Curly Pondweed	*Potamogeton crispus*
Dandelion	*Taraxacum officinale*
Devil's Beggartick	*Bidens frondosa*
Dogwood	*Cornus spp.*
Eastern Cottonwood	*Populus deltoides*
Elm	*Ulmus spp.*
Elodea	*Elodea canadensis*
Eurasian Water Milfoil	*Myriophyllum spicatum*
Fall Panicum	*Panicum dichotomiflorum*
Ferruginous Flatsedge (Rusty Nut Sedge)	*Cyperus ferruginescens*
Fescue	*Festuca spp.*
Foxtail	*Setaria spp.*
Giant Ragweed	*Ambrosia trifida*
Goldenrod	*Solidago spp.*
Horseweed	*Conyza spp.*
Largeseed Smartweed	*Polygonum pensylvanicum*

Table 2. Continued.

Common Name	Scientific Name
Lemna (Duckweed)	*Lemna minor*
Lesser Ragweed	*Ambrosia artemisiifolia*
Locust	*Robinia spp.*
Longleaf Pondweed	*Potamogeton nodosus*
Long-leaved Ammania	*Ammania coccinea*
Maple	*Acer spp.*
Marestail	*Conyza spp.*
Milfoil	*Myriophyllum spp.*
Morning Glory	*Ipomoea spp.*
Mullein	*Verbascum thapsus*
Naiad	*Najas* spp.
Narrowleaf Cattail	*Typha angustifolium*
Nodding Beggartick	*Bidens cernua*
Nodding Smartweed	*Polygonum lapathifolium*
Oak	*Quercus spp.*
Pecan	*Carya ilinoinensis*
Pigweed	*Amaranthus spp.*
Prairie Cordgrass	*Spartina pectinata*
Purple Loosestrife	*Lythrum salicaria*
Ragweed	*Ambrosia spp.*
Red-rooted Nutgrass	*Cyperus erythrorhizos*
Reed Canarygrass	*Phalaris arundinacea*
Ribbonleaf Pondweed	*Potamogeton epihydrus*
Rice Cutgrass	*Leersia oryzoides*
River Birch	*Betula nigra*
River Bulrush	*Scirpus fluviatilis*
Rush	*Juncus spp.*
Sago Pondweed	*Stuckenia pectinata*
Shattercane	*Sorghum bicolor*
Silver Maple	*Acer saccharinum*
Small Pondweed	*Potamogeton pusillis*
Smooth Brome	*Bromus inermis*
Softstem Bulrush	*Schoenoplectus tabernaemontani*
Spikerush	*Eleocharis spp.*
Sprangletop	*Leptochloa fusca*
Spurge	*Euphorbia spp.*
Switchgrass	*Panicum virgatum*
Thistle	*Cirsium spp.*

Table 2. Continued.

Common Name	Scientific Name
Walter's Millet	*Echinochloa walteri*
Water Smartweed	*Polygonum amphibium*
Willow	*Salix* spp.
Wolffia (Watermeal)	*Wolffia spp.*
Woolgrass	*Scirpus cyperinus*

Table 3. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2007.

	Inventory Date																
Species	6 Sept	11 Sept	21 Sept	26 Sept	4 Oct	12 Oct	17 Oct	24 Oct	29 Oct	5 Nov	14 Nov	19 Nov	28 Nov	3 Dec	13 Dec	9 Jan	Total (%)[a]
ABDU	0	0	0	0	0	0	2	0	0	0	1	9	12	0	0	19	43 (0.0)
AGWT	2,963	5,299	1,994	3,393	6,151	6,575	5,706	4,155	2,188	1,507	2,111	2,090	1,167	3	0	0	45,302 (25.0)
AMWI	0	0	0	506	1,340	1,325	825	2,345	1,349	275	524	228	45	0	0	1	8,763 (4.8)
BUFF	0	0	0	0	0	0	0	0	0	2	1	5	6	0	0	0	14 (0.0)
BWTE	4,460	9,202	2,111	1,934	310	0	1	1	6	0	0	0	0	0	0	0	18,025 (9.9)
CANV	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	3 (0.0)
COGO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4 (0.0)
GADW	0	0	145	10	901	3,585	2,160	3,285	3,964	3,114	1,685	1,807	274	43	0	25	20,998 (11.6)
HOME	0	0	0	0	0	0	0	0	4	0	0	0	2	0	0	0	6 (0.0)
LESC	1	0	0	0	0	0	0	0	20	0	2	15	12	0	0	0	50 (0.0)
MALL	470	1,524	548	789	1,173	895	943	1,145	1,016	917	2,260	1,995	6,167	4	1	2,372	22,219 (12.3)
NOPI	269	1,470	3,760	8,264	6,403	5,416	2,975	3,495	1,608	1,018	526	309	40	0	0	94	35,647 (19.7)
NSHO	813	1,975	4,126	4,058	4,117	2,550	3,035	3,165	1,685	875	583	620	153	2	0	0	27,757 (15.3)
REDH	0	0	0	0	3	1	3	300	145	4	6	13	0	0	0	0	475 (0.3)
RNDU	0	0	0	0	3	10	9	10	15	7	11	21	3	1	0	4	94 (0.1)
RUDU	3	2	0	0	0	1	8		173	77	460	468	242	5	8	0	1,447 (0.8)
WODU	295	20	57	7	4	18	76	25	10	0	5	6	2	0	0	0	525 (0.3)
Total	9,274	19,492	12,741	18,961	20,405	20,376	15,743	17,926	12,183	7,797	8,176	7,586	8,125	58	9	2,520	181,372 (100)

[a] Percent of total for fall 2007.

Table 4. Estimates of waterfowl abundance by species (see Table 1) from aerial inventories at The Emiquon Preserve during fall 2007.

	Inventory Date											
Species	10 Sept	26 Sept	12 Oct	23 Oct	29 Oct	13 Nov	23 Nov	27 Nov	4 Dec	18 Dec	9 Jan	Total (%)[a]
ABDU	0	0	0	0	0	0	0	20	0	0	0	20 (0.0)
AGWT	7,015	4,520	5,440	4,165	2,980	1,900	2,025	1,250	0	0	0	29,295 (23.7)
AMWI	0	0	535	270	900	200	0	0	0	0	0	1,905 (1.5)
BUFF	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
BWTE	7,960	3,000	0	0	0	0	0	0	0	0	0	10,960 (8.9)
CANV	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
COGO	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
GADW	0	0	535	3,010	7,450	3,190	880	495	0	0	200	15,760 (12.7)
HOME	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
LESC	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
MALL	2,040	4,550	2,720	5,520	2,980	1,880	2,230	6,865	0	0	2,860	31,645 (25.6)
NOPI	995	7,575	4,030	2,910	4,715	670	255	0	0	0	0	21,150 (17.1)
NSHO	1,890	4,575	1,385	1,355	2,230	670	255	50	0	0	0	12,410 (10.0)
REDH	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
RNDU	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
RUDU	0	0	0	0	0	490	0	0	0	0	0	490 (0.4)
WODU	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
Total	19,900	24,220	14,645	17,230	21,255	9,000	5,645	8,680	0	0	3,060	123,635 (100)

[a] Percent of total for fall 2007.

Table 5. Estimated duck use-days (UD) and UD per hectare (UD/ha) from ground inventories for The Emiquon Preserve during spring and fall migration.

	Spring		Fall	
Year	UD	UD/ha	UD	UD/ha
2007	.	.	1,249,860	4,902
2008	1,421,670	2,361	1,686,963	1,509
2009	1,872,144	1,327	3,006,678	1,625
2010	1,074,691	553	.	.

Table 6. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2008.

	Inventory Date									
Species	9 Jan	19 Feb	27 Feb	10 Mar	17 Mar	24 Mar	4 Apr	7 Apr	14 Apr	Total (%)[a]
ABDU	19	0	0	2	0	0	0	0	0	21 (0.0)
AGWT	0	0	0	7,199	2,375	7,621	4,127	4,018	5,215	30,555 (16.5)
AMWI	1	0	0	1,263	776	2,900	15	69	72	5,096 (2.8)
BUFF	0	17	3	117	179	1,748	877	570	1,355	4,866 (2.6)
BWTE	0	0	0	3	4	107	779	1,100	4,233	6,226 (3.4)
CANV	1	155	33	6,038	295	3	1	0	0	6,526 (3.5)
COGO	4	75	154	107	125	0	0	0	1	466 (0.3)
COME	0	195	25	29	5	0	0	0	0	254 (0.1)
GADW	25	22	2	2,805	1,356	3,764	338	150	254	8,716 (4.7)
HOME	0	14	4	30	2	0	0	0	0	50 (0.0)
LESC	0	162	122	12,489	8,866	7,117	4,627	1,655	4,149	39,187 (21.2)
MALL	2,372	120	85	7,089	292	271	289	85	80	10,683 (5.8)
NOPI	94	135	25	2,831	0	10	5	0	0	3,100 (1.7)
NSHO	0	0	0	502	954	3,027	1,934	3,235	3,468	13,120 (7.1)
RBME	0	0	0	0	0	0	0	1	0	1 (0.0)
REDH	0	5	40	2,823	793	207	0	0	0	3,868 (2.1)
RNDU	4	10	45	17,241	10,084	3,750	1,150	476	322	33,082 (17.9)
RUDU	0	5	0	460	1,140	5,617	2,606	1,641	4,280	15,749 (8.5)
Unk. Duck [b]	0	0	0	3,200	440	0	0	0	0	3,640 (2.0)
WODU	0	0	0	0	5	10	7	3	2	27 (0.0)
Total	2,520	915	538	64,228	27,691	36,152	16,755	13,003	23,431	185,233 (100)

[a] Percent of total for spring 2008.

[b] Species could not be determined.

Table 7. Estimates of waterfowl abundance by species (see Table 1) from aerial inventories at The Emiquon Preserve during spring 2008.

	Inventory Date				
Species	10 Mar	17 Mar	24 Mar	2 Apr	Total (%)[a]
AGWT	3,880	2,415	3,815	5,915	16,025 (11.3)
AMWI	0	130	380	680	1,190 (0.8)
BUFF	540	50	230	1,730	2,550 (1.8)
BWTE	0	0	210	1,460	1,670 (1.2)
CANV	1,895	1,165	150	0	3,210 (2.3)
COGO	0	200	0	0	200 (0.1)
COME	1,755	280	0	0	2,035 (1.4)
GADW	3,630	3,430	955	1,785	9,800 (6.9)
LESC	3,235	4,945	2,025	5,050	15,255 (10.8)
MALL	38,170	1,405	355	475	40,405 (28.5)
NOPI	9,030	0	0	0	9,030 (6.4)
NSHO	2,825	2,275	2,355	7,595	15,050 (10.6)
REDH	0	850	190	100	1,140 (0.8)
RNDU	4,060	8,875	5,180	895	19,010 (13.4)
RUDU	0	0	190	4,910	5,100 (3.6)
Total	69,020	26,020	16,035	30,595	141,670 (100)

[a] Percent of total for spring 2008.

Table 8. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2008.

	Inventory Date											
Species	2 Sept	9 Sept	16 Sept	22 Sept	29 Sept	14 Sept	20 Oct	27 Oct	10 Nov	24 Nov	8Dec	Total (%) [a]
ABDU	0	0	0	0	0	0	0	3	2	10	0	15 (0.0)
AGWT	251	2,148	1,243	1,484	2,173	3,782	3,215	4,590	6,503	4,680	1	30,070 (18.0)
AMWI	0	170	14	322	753	2,352	4,418	2,479	446	10	0	10,964 (6.5)
BUFF	0	0	0	0	0	0	0	4	10	125	0	139 (0.1)
BWTE	2,957	3,230	1,987	2,556	1,348	2,115	296	0	0	0	0	14,489 (8.7)
CANV	0	0	0	0	0	0	0	0	100	5	0	105 (0.1)
COGO	0	0	0	0	0	0	0	0	5	14	1	20 (0.0)
GADW	0	0	151	603	463	2,543	7,307	7,959	3,871	20	0	22,917 (13.7)
HOME	0	0	0	0	0	0	2	0	13	0	0	15 (0.0)
LESC	0	0	0	0	0	0	0	0	112	418	0	530 (0.3)
MALL	769	537	224	429	479	1,019	2,355	4,015	4,687	4,861	23	19,398 (11.6)
NOPI	1	250	339	1,737	1,916	3,397	6,110	8,844	4,831	12	1	27,438 (16.4)
NSHO	12	720	916	1,705	1,316	2,111	2,564	2,943	3,849	3,003	0	19,139 (11.4)
REDH	1	0	0	0	0	0	1	25	25	0	0	52 (0.0)
RNDU	0	0	0	2	0	102	3,493	2,657	4,105	877	0	11,236 (6.7)
RUDU	30	12	2	10	2	272	3,387	1,152	1,743	2,126	1	8,737 (5.2)
WODU	549	616	69	96	19	103	553	184	11	10	0	2,210 (1.3)
Total	4,570	7,683	4,945	8,944	8,469	17,796	33,702	34,855	30,313	16,171	27	167,475 (100)

[a] Percent of total for fall 2008.

Table 9. Estimates of waterfowl abundance by species (see Table 1) from aerial inventories at The Emiquon Preserve during fall 2008.

	Inventory Date													
Species	2 Sept	9 Sept	16 Sept	13 Oct	20 Oct	28 Oct	3 Nov	10 Nov	18 Nov	25 Nov	2 Dec	22 Dec	28 Dec	Total (%)[a]
ABDU	0	0	0	0	0	0	0	100	0	0	0	0	0	100 (0.0)
AGWT	3,800	475	1,220	4,360	4,000	4,800	1,415	7,500	5,230	3,000	1,200	0	0	37,000 (12.2)
AMWI	0	0	0	2,180	460	1,565	1,415	2,895	0	0	0	0	0	8,515 (2.8)
BUFF	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
BWTE	4,200	2,325	1,545	0	0	0	0	0	0	0	0	0	0	8,070 (2.7)
CANV	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
COGO	0	0	0	0	0	0	0	0	10	0	210	0	0	220 (0.1)
COME	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
GADW	0	0	0	4,460	8,480	6,575	5,250	9,800	4,585	450	0	0	0	39,600 (13.0)
HOME	0	0	0	0	0	0	0	0	10	0	0	0	0	10 (0.0)
LESC	0	0	0	0	0	0	0	0	0	100	0	0	0	100 (0.0)
MALL	400	75	725	2,230	4,230	10,825	4,210	21,760	32,935	18,600	15,520	0	110	111,620 (36.8)
NOPI	0	0	100	6,590	12,530	20,900	25,550	4,900	1,365	0	0	0	0	71,935 (23.7)
NSHO	0	0	100	2,130	4,025	2,055	1,175	2,625	1,915	1,800	500	0	0	16,325 (5.4)
REDH	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
RNDU	0	0	0	0	0	890	1,200	680	915	0	0	0	0	3,685 (1.2)
RUDU	0	0	0	0	0	1,180	2,600	0	1,930	300	500	0	0	6,510 (2.1)
Total	8,400	2,875	3,690	21,950	33,725	48,790	42,815	50,260	48,895	24,250	17,930	0	110	303,690 (100)

[a] Percent of total for fall 2008.

Table 10. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2009.

	Inventory Date								
Species	10 Feb	17 Feb	3 Mar	13 Mar	19 Mar	26 Mar	7 Apr	14 Apr	Total (%)[a]
ABDU	0	2	0	0	0	0	0	0	2 (0.0)
AGWT	0	208	2	1,537	2,887	2,581	4,704	2,240	14,159 (4.9)
AMWI	254	224	295	101	170	32	0	0	1,076 (0.4)
BUFF	0	0	339	824	1,350	1,688	1,690	956	6,847 (2.4)
BWTE	0	0	0	13	502	2,111	3,684	3,163	9,473 (3.3)
CAGO	2,009	181	369	19	21	25	18	26	2,668 (0.9)
CANV	0	2,005	1,402	303	114	46	25	2	3,897 (1.4)
COGO	280	1,218	695	107	12	2	1	1	2,316 (0.8)
COME	2	0	0	0	0	0	0	0	2 (0.0)
GADW	2	1,587	1,089	3,639	4,482	2,138	1,137	2,376	16,450 (5.7)
GWFG	2,821	2,050	701	166	11	20	0	0	5,769 (2.0)
HOME	0	5	7	132	22	18	0	22	206 (0.1)
LESC	142	2,678	5,300	6,635	6,545	8,983	4,374	1,210	35,867 (12.4)
LSGO	15,801	23,000	0	13,001	7,650	1,500	402	320	61,674 (21.4)
MALL	5,087	12,325	3,837	796	721	179	260	86	23,291 (8.1)
MUSW	0	0	2	0	0	0	0	0	2 (0.0)
NOPI	4,216	1,318	1,170	13	3	1	0	0	6,721 (2.3)
NSHO	0	1	187	4,923	7,739	8,918	11,631	7,157	40,556 (14.0)
RBME	0	0	0	1	0	0	10	65	76 (0.0)
REDH	0	2	739	2,042	416	137	1	2	3,339 (1.2)
RNDU	300	3,374	6,869	6,571	4,601	7,835	2,405	486	32,441 (11.2)
RUDU	0	0	76	2,697	3,907	6,839	5,521	2,670	21,710 (7.5)
TRUS	0	30	0	0	0	0	0	0	30 (0.0)
TUSW	0	0	12	0	3	0	0	0	15 (0.0)
WODU	0	0	0	61	18	112	0	6	197 (0.1)
WWSC	0	0	7	0	0	0	0	0	7 (0.0)
Total	30,914	50,208	23,098	43,581	41,174	43,165	35,863	20,788	288,791 (100)

[a] Percent of total for spring 2009.

Table 11. Estimates of waterfowl abundance by species (see Table 1) from aerial inventories at The Emiquon Preserve during spring 2009.

	Inventory Date				
Species	13 Mar	17 Mar	26 Mar	3 Apr	Total (%)[a]
ABDU	0	0	0	0	0 (0.0)
AGWT	0	4,805	3,885	6,060	14,750 (8.6)
AMWI	525	1,005	0	0	1,530 (0.9)
BUFF	2,535	2,460	0	2,220	7,215 (4.2)
BWTE	0	0	100	1,885	1,985 (1.2)
CAGO	145	45	20	60	270 (0.2)
CANV	300	475	0	0	775 (0.5)
COGO	0	0	0	0	0 (0.0)
COME	0	0	0	0	0 (0.0)
GADW	2,625	2,960	3,785	1,885	11,255 (6.5)
GWFG	0	0	0	0	0 (0.0)
HOME	1,015	0	0	0	1,015 (0.6)
LESC	12,555	8,025	5,300	6,835	32,715 (19.0)
LSGO	10,000	8,500	700	800	20,000 (11.6)
MALL	2,550	945	660	2,365	6,520 (3.8)
NOPI	1,460	475	100	0	2,035 (1.2)
NSHO	7,955	8,160	9,855	12,560	38,530 (22.4)
REDH	240	945	0	0	1,185 (0.7)
RNDU	3,360	3,215	9,070	7,025	22,670 (13.2)
RUDU	975	2,360	1,970	4,615	9,920 (5.8)
Total	46,240	44,375	35,445	46,310	172,370 (100)

[a] Percent of total for spring 2009.

Table 12. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2009.

	Inventory Date								
Species	2 Sept	14 Sept	29 Sept	12 Oct	28 Oct	9 Nov	23 Nov	11 Dec	Total (%)[a]
ABDU	0	0	0	0	0	0	2	0	2 (0.0)
AGWT	0	393	368	1,966	1,564	926	3,376	0	8,593 (4.0)
AMWI	0	15	193	1,912	4,415	4,285	8,434	0	19,254 (9.0)
BUFF	0	0	0	0	0	157	600	0	757 (0.4)
BWTE	1,570	1,632	864	281	155	0	6	0	4,508 (2.1)
CAGO	16	10	4	295	0	0	0	0	325 (0.2)
CANV	0	0	0	0	0	34	4,006	0	4,040 (1.9)
GADW	0	0	493	2,475	9,206	13,506	8,333	3	34,016 (15.9)
GWFG	0	0	0	0	100	0	0	0	100 (0.1)
HOME	0	0	0	0	0	25	8	0	33 (0.0)
LESC	0	0	0	0	0	81	709	0	790 (0.4)
LSGO	0	0	0	0	0	0	2	0	2 (0.0)
MALL	500	778	3,447	2,620	1,749	11,620	7,527	2	28,243 (13.2)
MUSW	2	0	0	0	0	3	0	0	5 (0.0)
NOPI	0	667	4,191	2,261	778	333	35	0	8,265 (3.9)
NSHO	60	571	732	4,084	6,023	12,083	2,146	6	25,705 (12.1)
REDH	0	0	0	0	2	21	1,000	0	1,023 (0.5)
RNDU	6	0	4	755	3,178	13,804	18,254	7	36,008 (16.9)
RUDU	2	6	13	401	2,479	11,208	15,636	231	29,976 (14.1)
TEAL[b]	0	2,603	3,816	2,268	0	0	0	0	8,687 (4.1)
WODU	643	1,282	859	231	0	0	0	0	3,015 (1.4)
Total	2,799	7,957	14,984	19,549	29,649	68,086	70,074	249	213,347 (100)

[a] Percent of total for fall 2009.

[b] Species could not be determined.

Table 13. Estimates of waterfowl abundance by species (see Table 1) from aerial inventories at The Emiquon Preserve during fall 2009.

	Inventory Date											
Species	2 Sept	9 Sept	14 Sept	13 Oct	20 Oct	2 Nov	11 Nov	23 Nov	1 Dec	7 Dec	15 Dec	Total (%)[a]
ABDU	0	0	0	0	0	0	0	0	50	0	0	50 (0.0)
AGWT	225	870	1,070	9,510	8,515	14,250	3,185	4,290	1,190	955	0	44,060 (12.9)
AMWI	0	0	0	0	2,105	1,380	4,875	1,480	0	0	0	9,840 (2.9)
BUFF	0	0	0	0	0	0	0	1,430	620	0	0	2,050 (0.6)
BWTE	11,160	5,540	2,320	1,145	2,105	0	0	0	0	0	0	22,270 (6.5)
CAGO	10	40	20	265	160	10	5	0	10	125	0	645 (0.2)
CANV	0	0	0	0	0	1,380	300	50	1,200	0	0	2,930 (0.9)
COGO	0	0	0	0	0	0	0	0	595	0	0	595 (0.2)
COME	0	0	0	0	0	0	0	0	0	200	10	210 (0.1)
GADW	0	225	40	1,570	7,415	7,200	13,035	14,900	6,335	2,790	0	53,510 (15.7)
GWFG	0	0	0	0	0	0	0	200	650	0	0	850 (0.3)
HOME	0	0	0	0	0	0	30	0	0	0	0	30 (0.0)
LESC	0	0	0	0	0	0	0	1,430	1,790	475	0	3,695 (1.1)
LSGO	0	0	0	0	0	0	0	0	400	0	0	400 (0.1)
MALL	235	1,420	1,045	2,625	5,310	5,670	16,020	14,350	11,955	4,780	0	63,410 (18.6)
NOPI	0	0	110	5,230	5,270	1,410	1,590	1,430	595	0	0	15,635 (4.6)
NSHO	100	225	90	5,250	10,570	9,810	7,960	2,860	2,980	1,435	0	41,280 (12.1)
REDH	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
RNDU	0	0	0	525	2,105	4,140	8,160	7,250	11,925	3,345	0	37,450 (11.0)
RUDU	0	0	0	525	3,155	6,900	7,960	7,150	9,045	7,170	0	41,905 (12.3)
SWN	0	0	0	0	0	0	3	0	0	4	0	7 (0.0)
Total	11,730	8,320	4,695	26,645	46,710	52,150	63,123	56,820	49,340	21,279	10	340,822 (100)

[a] Percent of total for fall 2009.

Table 14. Estimates of waterfowl abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2010.

	Inventory Date					
Species	3 Mar	10 Mar	23 Mar	8 Apr	20 Apr	Total (%)[a]
AGWT	0	60	23	2	8	93 (0.1)
AMWI	0	42	131	310	0	483 (0.5)
BUFF	38	348	926	828	140	2,280 (2.3)
BWTE	0	0	39	1,990	499	2,528 (2.6)
CAGO	175	96	39	7	24	341 (0.4)
CANV	75	334	234	1	0	644 (0.7)
COGO	150	210	3	0	0	363 (0.4)
COME	0	70	0	0	1	71 (0.1)
GADW	10	370	1,671	2,750	2,260	7,061 (7.3)
GWFG	0	52	0	0	0	52 (0.1)
HOME	10	0	52	0	2	64 (0.1)
LESC	150	1,061	10,220	2,922	401	14,754 (15.2)
LSGO	0	13,731	18	0	2	13,751 (14.2)
MALL	75	2,637	2,194	614	201	5721 (5.9)
MUSW	1	2	2	4	5	14 (0.0)
NOPI	0	168	4	0	0	172 (0.2)
NSHO	0	944	10,016	7,058	3,498	21,516 (22.1)
RBME	0	0	0	0	5	5 (0.0)
REDH	10	88	16	0	0	114 (0.1)
RNDU	225	1,430	8,617	2,085	42	12,399 (12.8)
RUDU	0	525	7,851	4,351	1,805	14,532 (15.0)
TRUS	3	7	0	0	0	10 (0.0)
Unk. Ducks	0	150	0	0	0	150 (0.2)
WODU	0	4	0	10	11	25 (0.0)
Total	922	22,329	42,056	22,932	8,904	97,143 (100)

[a] Percent of total for spring 2010.

Table 15. Estimates of waterfowl abundance by (see Table 1) species from aerial inventories at The Emiquon Preserve during spring 2010.

	Inventory Date				
Species	15 Mar	22 Mar	29 Mar	5 Apr	Total (%)[a]
ABDU	0	0	0	0	0 (0.0)
AGWT	425	440	4,390	4,250	9,505 (5.2)
AMWI	100	440	1,500	1,415	3,455 (1.9)
BUFF	200	875	7,315	200	8,590 (4.7)
BWTE	0	0	0	1,415	1,415 (0.8)
CANV	210	440	50	0	700 (0.4)
COGO	1,060	1,310	0	0	2,370 (1.3)
COME	100	0	0	0	100 (0.1)
GADW	1,060	2,185	7,315	7,085	17,645 (9.7)
HOME	0	0	0	0	0 (0.0)
LESC	1,695	8,740	29,255	11,335	51,025 (28.0)
MALL	3,180	2,185	5,850	2,835	14,050 (7.7)
NOPI	425	440	0	0	865 (0.5)
NSHO	2,120	10,925	14,630	14,170	41,845 (23.0)
REDH	100	100	750	200	1,150 (0.6)
RNDU	3,180	2,185	4,390	1,415	11,170 (6.1)
RUDU	2,120	200	11,700	4,250	18,270 (10.0)
Total	15,975	30,465	87,145	48,570	182,155 (100)

[a] Percent of total for spring 2010.

Table 16. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2007.

	Inventory Date															
Species	6 Sept	11 Sept	21 Sept	26 Sept	4 Oct	12 Oct	17 Oct	24 Oct	29 Oct	5 Nov	14 Nov	19 Nov	28 Nov	3Dec	13 Dec	Total (%)[a]
AMBI	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	4 (0.0)
AMCO	384	990	4,235	6,915	10,365	13,355	11,575	27,395	28,560	17,415	8,225	5,405	2,195	199	1	137,214 (98.9)
AWPE	10	0	12	0	0	0	0	0	0	0	0	0	0	0	0	22 (0.0)
BAEA	0	0	0	1	0	0	0	0	3	1	0	0	2	20	0	27 (0.0)
BCNH	61	27	16	15	14	5	2	1	0	0	0	0	0	0	0	141 (0.1)
COHA	0	0	0	0	0	1	2	0	0	0	2	0	2	0	0	7 (0.0)
COTE	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1 (0.0)
DCCO	2	3	7	3	1	1	3	0	0	0	0	0	0	0	0	20 (0.0)
GBHE	12	14	20	13	12	10	10	8	9	2	4	2	1	1	1	119 (0.1)
GREG	64	69	20	28	23	2	1	0	0	0	0	0	0	0	0	207 (0.1)
GRHE	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	3 (0.0)
HOGR	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	4 (0.0)
LBHE	2	0	0	0	1	0	0	1	0	0	0	0	0	0	0	4 (0.0)
NOHA	0	0	1	0	1	3	3	2	4	2	5	4	2	5	4	36 (0.0)
NSHR	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1 (0.0)
OSPR	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1 (0.0)
PBGR	35	43	24	53	49	31	26	10	3	2	4	0	0	0	0	280 (0.0)
PEFA	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1 (0.0)
RBGU	0	0	40	5	24	7	15	27	13	187	70	140	67	7	0	602 (0.4)
RTHA	0	0	0	0	0	0	0	0	1	4	3	2	1	0	2	13 (0.0)
SORA	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3 (0.0)
WIPH	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1 (0.0)
Total	573	1,150	4,377	7,037	10,491	13,416	11,637	27,444	28,594	17,613	8,315	5,554	2,270	232	8	138,711 (100)

[a] Percent of total for fall 2007.

Table 17. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2008.

	Inventory Date									
Species	9 Jan	19 Feb	27 Feb	10 Mar	17 Mar	24 Mar	4 Apr	7 Apr	14 Apr	Total (%)[a]
AMBI	0	0	0	0	0	0	2	0	0	2 (0.0)
AMCO	0	11	6	2,065	7,820	14,115	7,600	9,890	19,545	61,052 (98.7)
AWPE	0	0	0	0	0	0	0	7	400	407 (0.7)
BAEA	0	3	0	19	2	1	0	0	0	25 (0.0)
COHA	0	0	0	0	0	1	0	0	0	1 (0.0)
DCCO	0	0	0	0	0	0	1	1	36	38 (0.1)
EAGR	0	0	0	0	0	0	1	0	1	2 (0.0)
FRGU	0	0	0	0	0	0	0	0	26	26 (0.0)
GBHE	0	0	0	0	0	0	1	0	3	4 (0.0)
GHOW	0	0	0	0	0	1	0	1	0	2 (0.0)
KILL	0	0	0	5	0	0	0	0	0	5 (0.0)
MUSW	0	2	2	0	0	0	0	0	0	4 (0.0)
NOHA	1	3	6	5	4	5	0	4	2	30 (0.0)
PBGR	0	0	0	0	1	5	9	14	18	47 (0.1)
RBGU	0	0	0	118	0	20	0	17	39	194 (0.3)
RTHA	0	0	1	2	1	3	0	0	1	8 (0.0)
Total	1	19	15	2,214	7,828	14,151	7,614	9,934	20,071	61,847 (100)

[a] Percent of total for fall 2008.

Table 18. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2008.

	Inventory Date											
Species	2 Sept	9 Sept	16 Sept	22 Sept	29 Sept	14 Oct	20 Oct	27 Oct	10 Oct	24 Nov	8 Dec	Total (%)[a]
AMBI	0	2	0	3	5	0	0	0	0	0	0	10 (0.0)
AMCO	1,545	4,005	6,830	10,180	15,480	54,625	57,405	44,610	39,995	1,450	4	236,129 (98.7)
BAEA	0	0	0	0	0	0	0	0	0	17	17	34 (0.0)
BCNH	15	15	9	4	9	5	0	0	1	0	0	58 (0.0)
BLTE	20	20	0	0	0	0	0	0	0	0	0	40 (0.0)
BNST	18	4	0	6	0	0	0	0	0	0	0	28 (0.0)
COHA	0	0	0	0	1	0	0	0	0	0	0	1 (0.0)
COSN	4	0	0	0	0	0	0	0	0	0	0	4 (0.0)
DCCO	23	20	18	47	15	17	0	2	0	0	0	142 (0.1)
GBHE	26	22	14	18	11	5	3	2	2	0	0	103 (0.0)
GHOW	1	1	0	1	0	0	1	0	0	1	1	6 (0.0)
GREG	104	43	45	45	27	4	26	0	0	0	0	294 (0.1)
GRHE	0	0	2	0	2	0	0	0	0	0	0	4 (0.0)
LBHE	0	0	0	1	0	0	0	0	1	0	0	2 (0.0)
MAGO	1	0	0	0	0	0	0	0	0	0	0	1 (0.0)
NOHA	0	2	0	4	1	2	3	4	2	5	6	29 (0.0)
NSHR	0	0	0	0	0	0	0	1	0	0	0	1 (0.0)
PBGR	52	94	179	256	446	546	229	127	209	32	0	2,170 (0.9)
RBGU	0	155	0	0	0	0	0	0	0	25	0	180 (0.1)
RTHA	1	0	0	0	0	2	3	2	4	2	4	18 (0.0)
NSHR	0	0	0	0	0	0	0	1	0	0	0	1 (0.0)
PBGR	52	94	179	256	446	546	229	127	209	32	0	2,170 (0.9)
RBGU	0	155	0	0	0	0	0	0	0	25	0	180 (0.1)
RTHA	1	0	0	0	0	2	3	2	4	2	4	18 (0.0)
Total	1,810	4,383	7,097	10,565	15,997	55,206	57,670	44,748	40,214	1,532	32	239,254 (100)

[a] Percent of total for fall 2008.

Table 19. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2009.

Species	Inventory Date								Total (%)[a]
	10 Feb	17 Feb	3 Mar	13 Mar	19 Mar	26 Mar	7 Apr	14 Apr	
AMCO	0	50	1,020	16,965	29,255	57,825	29,525	30,750	165,390 (98.7)
AWPE	0	0	0	0	40	126	380	64	610 (0.4)
BAEA	2	19	5	2	0	0	0	0	28 (0.0)
BCNH	0	0	0	0	0	0	0	3	3 (0.0)
BOGU	0	0	0	0	0	0	0	11	11 (0.0)
COLO	0	0	0	0	0	0	0	1	1 (0.0)
DCCO	0	0	0	3	39	3	17	292	354 (0.2)
EAGR	0	0	0	0	0	1	1	6	8 (0.0)
GBHE	0	0	0	0	2	0	10	6	18 (0.0)
GHOW	0	0	0	1	0	0	0	0	1 (0.0)
GREG	0	0	0	0	0	2	2	26	30 (0.0)
NOHA	3	2	0	6	2	1	2	2	18 (0.0)
PBGR	0	0	0	27	22	121	121	146	437 (0.3)
RBGU	0	132	167	250	106	26	2	10	693 (0.4)
RLHA	1	0	0	0	0	0	0	0	1 (0.0)
RTHA	1	1	1	4	2	5	4	1	19 (0.0)
Total	7	204	1,193	17,258	29,468	58,110	30,064	31,318	167,622 (100)

[a]Percent of total for spring 2009.

Table 20. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during fall 2009.

	Inventory Date								
Species	2 Sept	14 Sept	29 Sept	12 Oct	28 Oct	9 Nov	23 Nov	11 Dec	Total (%)[a]
AMCO	662	2,790	28,300	42,595	69,001	90,235	100,071	351	334,005 (97.0)
AWPE	1,005	500	195	1,630	113	68	4	0	3,515 (1.0)
BAEA	0	0	0	1	0	1	0	167	169 (0.1)
BCNH	3	2	0	0	0	0	0	0	5 (0.0)
BNST	11	13	5	0	0	0	0	0	29 (0.0)
CAEG	0	0	0	0	3	0	0	0	3 (0.0)
DCCO	857	286	330	215	140	35	0	1	1,864 (0.5)
GBHE	7	5	4	0	6	4	18	4	48 (0.0)
GREG	59	64	41	0	13	2	2	0	181 (0.1)
GRHE	1	1	0	0	0	0	0	0	2 (0.0)
HOGR	0	0	0	2	0	0	0	0	2 (0.0)
LBHE	10	27	4	0	0	0	0	0	41 (0.0)
NOHA	0	1	1	2	6	2	0	5	17 (0.0)
OSPR	0	1	0	0	0	0	0	0	1 (0.0)
PBGR	154	231	577	448	1,211	811	851	18	4,301 (1.3)
RTHA	0	0	0	0	1	0	2	2	5 (0.0)
YHBL	1	0	0	0	0	0	0	0	1 (0.0)
Total	2,770	3,921	29,457	44,893	70,494	91,158	100,948	548	344,189 (100)

[a]Percent of total for fall 2009.

Table 21. Estimates of waterbird and raptor abundance by species (see Table 1) from ground inventories at The Emiquon Preserve during spring 2010.

	Inventory Date					
Species	3 Mar	10 Mar	23 Mar	8 Apr	20 Apr	Total (%)
AMCO	1	1,164	25,888	14,781	9,342	51,176 (85.7)[a]
AWPE	0	0	435	2,096	930	3,461 (5.8)
BAEA	0	5	2	0	0	7 (0.0)
BEKI	0	0	0	0	2	2 (0.0)
DCCO	0	0	50	2,545	667	3,262 (5.5)
GBHE	0	0	0	8	96	104 (0.2)
GHOW	0	1	0	0	0	1 (0.0)
GREG	0	0	0	14	0	14 (0.0)
NOHA	0	0	0	3	1	4 (0.0)
PBGR	0	10	160	387	1,152	1,709 (2.9)
RTHA	0	0	0	1	1	2 (0.0)
Grand	1	1,180	26,535	19,835	12,191	59,742 (100)

[a] Percent of total for Spring 2010.

Table 22. Dabbling duck behavior (%) by month at The Emiquon Preserve during fall 2007−2009.

		Activity				
Year	Month	Feed	Rest	Other	Social	Locomotion
2007	September	48.7	29.9	5.2	0.0	16.2
	October	54.4	24.4	6.5	0.9	13.8
	November	58.0	25.4	6.5	0.6	9.6
	Average	53.8	26.4	6.1	0.6	13.2
2008	September	53.8	19.6	4.4	0.1	22.1
	October	48.6	27.4	3.1	1.9	19.1
	November	47.5	18.0	3.8	2.3	28.4
	Average	50.5	21.4	3.9	1.2	23.1
2009	September	62.9	20.5	4.5	0	12.1
	October	67.1	8.3	7.2	0.9	16.5
	November	44.5	31.1	3.2	0.6	20.5
	Average	58.6	20	4.9	0.5	16
Average		53.9	22.7	4.9	0.8	17.6

Table 23. Duck behavior (%) by month and guild at The Emiquon Preserve during spring 2008−2010.

			Activity				
Year	Group	Month	Feed	Rest	Other	Social	Locomotion
2008	Dabbling Ducks	March	40.4	25.8	6.2	5.9	25.1
		April	5.4	47.0	13.6	3.2	30.7
		Average	31.6	31.1	8.1	5.2	26.5
	Diving Ducks	March	18.6	67.8	5.3	0.0	8.3
		April	9.6	64.1	10.3	0.3	15.7
		Average	14.8	66.2	7.5	0.1	11.5
	2008 Average		21.9	52.7	7.1	2.1	17.2
2009	Dabbling Ducks	February	35.7	33.3	14.5	3.9	12.6
		March	54.6	24.4	8.4	0.7	11.9
		April	87.6	1.6	2.0	4.0	4.8
		Average	57.4	21.6	8.4	2.0	10.6
	Diving Ducks	February	41.5	31.5	8.3	0.4	18.3
		March	30.9	44.6	8.7	0.2	15.6
		April	34.6	42.3	13.7	0.0	2.0
		Average	36.3	40.2	9.5	0.2	13.8
	2009 Average		45.9	31.8	9.0	1.0	12.4
2010	Dabbling Ducks	March	95.6	0.0	0.8	1.8	1.7
		April	77.6	0.9	6.3	2.5	12.7
		Average	81.2	0.7	5.2	2.4	10.5
	Diving Ducks	Average	19.7	30.6	10.7	0.8	38.2
	2010 Average		58.1	11.9	7.2	1.8	20.9
2008−2010 Average	Dabbling Ducks		56.7	19.0	7.4	3.1	14.2
	Diving Ducks		25.8	46.8	9.5	0.3	16.4

Table 24. Waterbird brood observations by species (see Table 1) at The Emiquon Preserve, 2008.

	Inventory Date							
Species	5 Jun	17 Jun	9 Jul	22 Jul	7 Aug	20 Aug	Total Broods	%
MALL	1	1	4	4	4	5	19	17.1
RUDU	0	0	0	0	0	1	1	0.9
WODU	0	3	11	18	9	12	53	47.7
Unk. Duck	0	0	1	0	0	0	1	0.9
CAGO	0	0	0	1	1	1	3	2.7
AMCO	0	0	3	3	12	6	24	21.6
PBGR	0	0	3	1	0	5	9	8.1
BCNH	0	0	0	0	0	1	1	0.9
Total	1	4	22	27	26	31	111	
Average age [a]	1A	1B	2A	2C	2C	2C		

[a] Gollop and Marshall 1954

Table 25. Flush counts of waterbird broods by species (see Table 1) at The Emiquon Preserve, 2008.

	Inventory Date			
Species	22 Jul	20 Aug	Total Broods	%
BWTE	3	0	3	4.8
MALL	6	4	10	16.1
WODU	15	2	17	27.4
Unk. Duck	3	0	3	4.8
AMCO	10	14	24	38.7
PBGR	0	1	1	1.6
BNST	1	3	4	6.5
Total	38	24	62	

Table 26. Waterbird brood observations by species (see Table 1) at The Emiquon Preserve, 2009.

Species	Inventory Date						Total Broods	%
	11 Jun	23 Jun	8 Jul	21 Jul	6 Aug	25 Aug		
WODU	7	6	18	20	12	4	67	58.8
CAGO	1	6	0	0	0	0	7	6.1
MALL	0	5	2	5	2	0	14	12.3
AMCO	0	1	1	1	7	3	13	11.4
PBGR	0	0	2	4	3	2	11	9.6
HOME	0	1	0	0	0	0	1	0.9
BWTE	0	0	0	0	1	0	1	0.9
Total	8	19	23	30	25	9	114	
Average age [a]	2A	2B	2B	2B	2C	3		

[a] Gollop and Marshall 1954

Table 27. Abundance (mg/m^3, dry mass) and percent occurrence of aquatic invertebrates collected at The Emiquon Preserve, 2008−2009.

	2008		2009	
Taxa/Life Stage	Abundance (mg/m^3)	Percent Occurrence	Abundance (mg/m^3)	Percent Occurrence
Gastropoda				
Physidae	72.0	61.7	72.3	81.7
Planorbidae	20.4	46.7	55.3	38.3
Lymnaeidae	4.6	31.7	0.3	11.7
Ostracoda	0.0	0.0	0.0	6.7
Cladocera	6.3	86.7	1.9	95.0
Copepoda	0.8	91.7	0.5	80.0
Amphipoda	1.1	35.0	1.2	56.7
Isopoda	0.0	1.7	0.0	0.0
Coleoptera				
Chrysomelidae larvae	0.0	0.0	0.0	3.3
Curculionidae adult	0.0	0.0	0.0	1.7
Dytiscidae adult	0.2	8.3	0.1	20.0
Dytiscidae larvae	0.5	25.0	0.0	23.3
Elmidae adult	0.0	0.0	0.0	1.7
Haliplidae adult	0.6	5.0	0.7	10.0
Haliplidae larvae	0.7	26.7	0.4	16.7
Haliplidae nymph	0.0	0.0	0.0	1.7
Hydrophilidae adult	1.5	3.3	0.1	8.3
Hydrophilidae larvae	0.6	16.7	0.4	20.0
Hydroscaphidae adult	0.0	0.0	0.0	1.7
Unknown	0.0	0.0	0.0	1.7
Diptera				
Ceratopogonidae larvae	0.7	33.3	0.0	23.3
Ceratopogonidae pupae	0.0	0.0	0.0	6.7
Chironomidae adult	0.3	6.7	0.0	18.3
Chironomidae larvae	6.1	81.7	6.6	90.0
Chironomidae pupae	0.0	11.7	0.9	18.3
Culicidae larvae	0.0	5.0	0.0	0.0
Ephydridae pupae	0.0	0.0	0.0	1.7
Sciomyzidae larvae	0.0	0.0	0.0	1.7
Stratiomyidae larvae	1.2	30.0	1.5	15.0
Unknown	0.0	0.0	0.1	5.0
Ephemeroptera				
Baetidae larvae	0.0	0.0	0.5	15.0

Table 27. Continued.

Taxa/Life Stage	2008 Abundance (mg/m^3)	2008 Percent Occurrence	2009 Abundance (mg/m^3)	2009 Percent Occurrence
Ephemeroptera				
Baetidae nymph	0.8	18.3	0.2	8.3
Caenidae adult	0.0	0.0	0.0	1.7
Caenidae larvae	0.0	0.0	0.6	45.0
Caenidae nymph	0.7	61.7	0.1	20.0
Hemiptera				
Corixidae	0.7	26.7	4.2	60.0
Hebridae	0.0	0.0	0.0	1.7
Mesoveliidae	0.1	13.3	0.0	30.0
Notonectidae	0.0	0.0	0.0	1.7
Pleidae	0.0	0.0	0.0	3.3
Odonata				
Coenagrionidae larvae	0.0	0.0	1.0	35.0
Coenagrionidae nymph	0.5	36.7	0.8	16.7
Libellulidae nymph	0.2	8.3	0.1	6.7
Libellulidae adult	0.8	1.7	0.0	0.0
Trichoptera				
Hydroptilidae	0.0	0.0	0.0	1.7
Leptoceridae larvae	0.1	11.7	0.1	6.7
Hymenoptera				
Scelionidae	0.0	0.0	0.0	1.7
Turbellaria	0.4	20.0	0.1	16.7
Nematoda	0.0	0.0	0.0	11.7
Oligochaeta	2.6	60.0	4.5	96.7
Hirudinea	0.5	20.0	0.5	23.3
Hydrachnida	0.2	45.0	0.2	58.3
Hydra	0.1	26.7	0.2	41.7

Table 28. Moist-soil plant seed abundance (kg/ha, dry mass) and energetic use-days (EUD) per hectare at The Emiquon Preserve, 2007−2009.

	Seed		Abundance			EUDs	
Year	Size[a]	n	$\bar{x}$	SE	CV(%)	$\bar{x}$	SE
2007	Large	20	748.2	129.5	17.3	6,405.5	1,109.0
	Small	20	244.2	54.5	22.3	2,090.9	466.2
	Total	20	992.4	119.2	12.0	8,496.4	1,020.6
2008	Large	20	435.8	113.1	26.0	3,731.5	968.8
	Small	20	59.5	35.2	59.2	509.8	301.1
	Total	20	495.4	113.7	23.0	4,241.3	973.7
2009	Large	20	221.7	65.5	29.5	1,892.0	560.9
	Small	20	13.6	7.7	56.6	116.8	65.6
	Total	20	235.3	64.2	27.3	2,015.0	549.3
IDNR[b]	Large	735	383.6	89.7	23.4	3,284.7	768.0
	Small	735	308.6	66.4	21.5	2,642.2	568.6
	Total	735	691.3	56.4	8.2	5,918.3	483.3

[a] Moist-soil seeds were classified as large (e.g., millets; retained by a #35 sieve) or small (e.g., nutgrasses, retained by a #60 sieve).

[b] Moist-soil plant seed estimates from Illinois Department of Natural Resources waterfowl management areas, fall 2005–2007 (Stafford et al. 2008).

Table 29. Area and proportions of upland and wetland habitats estimated by covermapping at The Emiquon Preserve, 2007–2009.

	2007		2008		2009	
Habitat Category	Hectares	%	Hectares	%	Hectares	%
American Lotus	0.0	0.0	0.1	0.0	0.6	0.0
Aquatic Bed	2.6	1.0	238.1	22.1	1,185.7	65.7
Bottomland Forest	0.0	0.0	0.2	0.0	0.8	0.0
Cattail	25.5	10.0	33.1	3.1	38.1	2.1
Coontail	0.4	0.2	2.6	0.2	N/A[a]	N/A
Ditch	18.7	7.3	15.4	1.4	12.2	0.7
Hemi-marsh	29.9	11.7	220.5	20.5	290.4	16.1
Mud Flat	3.5	1.4	0.0	0.0	0.0	0.0
Non-persistent Emergent	50.7	19.9	127.3	11.8	23.6	1.3
Open Water	106.4	41.8	275.1	25.5	221.3	12.3
Persistent Emergent	7.4	2.9	0.2	0.0	6.2	0.3
Scrub Shrub	6.9	2.7	1.4	0.1	1.7	0.1
Upland	2.7	1.0	14.7	1.4	1.1	0.1
Upland - Wet	0.0	0.0	147.9	13.7	16.1	0.9
Willow	0.2	0.1	0.7	0.1	0.1	0.0
Total Area	254.7		1,077.2		1,803.9	

[a] Coontail was included with the aquatic bed category in 2009.

Table 30. Comparison of wetland habitat characteristics at The Emiquon Preserve (2007−2009) and historical (1938–1942) Illinois River valley wetlands.

	Percent of wetland area				
	Historical[a]	Emiquon			
Habitat Category	1938–1942	2007	2008	2009	Average
Bottomland Forest	8.8	0.0	<0.1	<0.1	<0.1
Non-persistent Emergent	12.4	19.9	11.8	1.3	11.0
Open Water	38.7	41.8	25.5	12.3	26.5
Aquatic Bed	11.2	1.2	22.3	65.7	29.7
Floating-leaved Aquatic	14.9	0.0	<0. 1	<0.1	<0.1
Mudflat	0.4	1.4	0.0	0.0	0.5
Persistent Emergent	12.3	24.6	23.6	18.5	22.2
Scrub Shrub	1.3	2.8	0.2	0.1	1.0

[a] Bellrose 1941, Bellrose et al. 1979, Stafford et al. 2010.

Submitted by:

Joshua D. Stafford, Ph.D.
Associate Research Professor
Illinois Natural History Survey
University of Illinois Urbana-Champaign

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