ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Brian Anderson, Executive Director
Prairie Research Institute

Geoff Levin, Director
Illinois Natural History Survey
1816 South Oak Street
Champaign, IL 61820-6964
217-333-6830

Waterbird and Wetland Monitoring at The Emiquon Preserve

Annual Report 2014

Christopher S. Hine,
Heath M. Hagy,
Aaron P. Yetter,
Michelle M. Horath,
and
Joshua M. Osborn

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

Prepared for:
The Nature Conservancy
Contract Number: C07-032

UNIVERSITY OF ILLINOIS
at Urbana-Champaign

INHS Technical Report 2015 (21)
Date of Issue: 3 September 2015

ACKNOWLEDGEMENTS

Funding for this project was provided by The Nature Conservancy's Illinois River Project Office, contract number C07-032. We would like to thank the staff of the Illinois River Program Office: D. Blodgett, J. Beverlin, T. Hobson, M. Lemke, and S. McClure and J. Walk of the Peoria Office for their input and guidance in our monitoring and research activities. We also appreciate our colleagues at the Illinois Natural History Survey's (INHS) Illinois River Biological Station and University of Illinois Springfield Therkildsen Field Station for use of field and laboratory equipment. We thank A. Gilbert, K. Hardy, M. Jochheim, C. Morse, R. Nutter, K. Point, J. Potter and S. Vanderhorst of INHS for their assistance in conducting brood surveys and processing samples. Finally, we thank M. Cruce for providing flight services during waterfowl inventories and L. Robinson (USGS) for aerial imagery.

INTRODUCTION

The Nature Conservancy (TNC) identified key ecological attributes (hereafter, KEAs) of specific biological characteristics or ecological processes that could indicate restoration success and trajectory at the Emiquon Preserve (hereafter Emiquon; The Nature Conservancy 2006). Because of the historic importance of the Illinois River valley to waterfowl and other waterbirds, several conservation targets and associated KEAs at Emiquon were related to waterbird communities and their habitats (Appendix A). 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 vegetation and waterbirds to restoration efforts at Emiquon during 2014 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 autumn aerial counts and spring ground counts; 2) productivity by waterfowl and other waterbirds through brood counts; 3) plant seed and invertebrate biomass to estimate energetic carrying capacity for waterfowl during migration and breeding periods; and 4) composition and arrangement of wetland vegetation communities and associated cover types through geospatial 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 during spring, we enumerated waterbirds by species (Table 1) with a spotting scope and binoculars from fixed vantage points and while traveling between vantage points. We assumed ground counts from elevated vantage points approximated total population size of selected species and guilds. Spring surveys were conducted weekly from approximately mid-February through mid-April, during the peak of waterfowl migration. Although our ground inventories were designed to monitor waterfowl, we also recorded abundances 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 inventories (Havera 1999). Aerial inventories were conducted approximately weekly (weather permitting) during fall and 5 times during 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. 2007). A single observer estimated abundances of American coots, American white pelicans, bald eagles, double-crested cormorants, and waterfowl abundance by species (except wood ducks). Spring aerial inventories were conducted as part of a separate project to monitor diving duck migration in Illinois. Consequently, aerial inventories began in early March, thereby capturing only a portion of the spring waterfowl migration.

We converted abundance estimates to use days (UDs) to evaluate overall waterbird use of Emiquon (Stafford et al. 2007). Use days are estimates of abundances 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 and can be used to calculate energetic carrying capacity needs. We used INHS aerial inventory data to calculate fall waterfowl UDs in order to make these estimates comparable to other aerially surveyed locations in the IRV. Conversely, we used ground inventory data to derive spring waterfowl UDs, because ground surveys were conducted throughout spring migration, whereas aerial inventories covered only a portion of spring migration. Lastly, we expressed duck use estimates as UDs per ha of wetland (UDs/ha) to standardize for wetland size for comparison with past years.

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 at least 50 individuals of the same species, in the same flock or within close proximity, and recording the behavior and gender of each individual. Behavioral categories included feeding, resting, social (e.g., courtship and aggression), locomotion (e.g., swimming, walking, and flying), and other (e.g., comfort and preening). We attempted to prevent underestimation of diving duck foraging behavior by modifying our scan sampling methodology (Hine et al. 2010). We observed each diving duck for ≤10 seconds during the scan to capture feeding behavior, essentially creating a series of short focal samples. We contend that this method should better represent the foraging behavior of diving ducks than unmodified scan sampling. We narrated all observations into a hand-held voice recorder for subsequent transcription. We attempted to conduct 10 scan samples during each ground count on 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), distances between observation points and waterbird concentrations, and difficulty in approaching flocks undetected, occasionally prevented us from conducting all 10 scan samples during some ground counts.

Brood Observations

We monitored waterbird production at Emiquon in 2014 through passive brood observations (Rumble and Flake 1982). We conducted bi-weekly brood surveys between mid-May and late-August using 4 observers at fixed points (Fig. 1). This approach was used to maximize coverage and minimize double counting and disturbance associated with a single observer moving between points. 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, distance from observer, and brood age class of all waterbirds (Gollop and Marshall 1954).

Aquatic Invertebrates

We collected sweep-net samples in mid-August to estimate abundance of nektonic invertebrates for nesting and brood-rearing waterbirds. We collected samples with a 454 cm^2 (~0.05 m^2) D-frame sweep-net (500 μm; Voigts 1976, Kaminski and Murkin 1981) in shallow water (≤46 cm) from random locations equally divided between Thompson and Flag lakes. We preserved samples in 10% buffered formalin solution containing rose bengal until processing. In the laboratory, we decanted preservative and excess water and 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), dried at 60–70° C to constant mass, and weighed to the nearest 0.1 mg (Smith et al. 2012). We sampled a portion (25%) of the invertebrate taxa in each sweep-net sample using a Folsom plankton splitter to reduce processing time. We converted invertebrate biomass estimates to per-unit-volume (mg/m^3) to account for different volumes of water sampled at various water depths.

Moist-soil Plant Seeds

During early fall prior to peak waterbird migration, 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 30 randomly-allocated points along the shores of Thompson and Flag lakes (Stafford et al. 2006, Kross et al. 2008, Stafford et al. 2011). We 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 #18 (1.0 mm) and #60 (250 μm) sieves and allowed them to air dry at room temperature. We classified seeds as large if they were retained by the #18 sieve (e.g., barnyardgrass, smartweed) and small if they remained in the #60 sieve (e.g., nutgrass, pigweed). We separated all large seeds from debris by hand and weighed to the nearest 0.1 mg. Due to the extensive processing time, we sub-sampled a portion (25% by mass) of small seed samples and multiplied the subsample mass by the reciprocal of the proportion subsampled to estimate biomass. We separated all seeds by taxa and dried them to constant mass at approximately 80° C for 24 hours prior to weighing (Manley et al. 2004, Greer et al. 2007, Stafford et al. 2011). We corrected seed abundances for recovery biases (Hagy et al. 2011) and only included seeds that were known duck foods (Havera 1999, Smith 2007, Hitchcock 2009). We combined small and large seed masses and extrapolated totals to estimate overall moist-soil plant seed density (kg/ha; dry mass; Stafford et al. 2011) and energetic use days (EUD). A EUD is defined as the number of days that a given area could support a mallard-sized duck (Reinecke et al. 1989, Stafford et al. 2011). We used 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 dabbling ducks (337 kcal/day) for EUD calculations (Stafford et al. 2011).

Energetic Carrying Capacity

During fall, we collected seeds, invertebrates, and plants at random locations within each of the 4 dominant cover types at Emiquon (i.e., aquatic bed, hemi-marsh, persistent emergent, and open water) to estimate total energetic carrying capacity for waterfowl. At each location, we recorded plant species composition within a 1-m^2 plot and sampled seeds, tubers, and benthic invertebrates using a 6 cm x 10 cm core sampler (universal core sampler, Rickly Hydrological Company, Columbus, OH). Immediately following collection, core samples were washed through a #35 (500 µm) sieve bucket in the field and preserved in a 10% buffered formalin solution. In the laboratory, we removed and identified invertebrates to the lowest practical taxonomic level (i.e., Order or Family; Pennak 1978, Merritt and Cummins 1996) from a 25% subsample from each core. Aquatic macroinvertebrates (e.g., chironomids, dytiscids, gastropods, etc.) were dried at 60–70° C to constant mass and weighed by taxa to the nearest 0.1 mg (Smith et al. 2012), whereas aquatic microinvertebrates (e.g., cladocerans, ostracods, copepods, etc.) were counted and multiplied by a constant average mass for each taxon. Following removal of invertebrates, we allowed the remainder of the subsample to air dry at room temperature for ≥12 hours. We removed seeds and tubers by hand and identified each to Order or Family. Lastly, we dried seeds and tubers for ≥24 hours at 60° C and weighed them by taxa to the nearest 0.1 mg.

In addition to core samples, we collected aquatic plants (submersed and floating-leaved), seeds, and invertebrates using a modified Gerking box sampler (Sychra and Adamek 2010). The box sampler (25 cm wide x 45 cm long x 65 cm deep) was constructed of sheet metal and designed with a sliding door on the bottom to cut through vegetation and a 500-µm screen along one wall for water drainage. We used the box sampler to collect food items within the top 45 cm of water (approximate depth available to dabbling ducks) at random locations within each of the 4 dominant cover types and froze samples in individually labeled bags until processing. In the laboratory, we thoroughly washed aquatic plants in a #35 sieve to remove seeds and invertebrates. We identified aquatic plants by species, dried each for 24–48 hours at 60° C, and weighed them to the nearest 0.1 mg. We enumerated and identified aquatic invertebrates to the lowest practical taxonomic level from a 25% subsample of each box sample. Macroinvertebrates were dried at 60–70° C to constant mass and weighed by taxa to the nearest 0.1 mg (Smith et al. 2012). Microinvertebrates were counted and average masses were calculated for each taxon. We combined density estimates (kg/ha) of seeds and tubers, aquatic invertebrates, and plants from benthic cores, box samples, and moist-soil cores to estimate total energetic carrying capacity for waterfowl, expressed as EUDs. We calculated diving duck energetic carry capacity by combining forage estimates from all sampling gear, assuming all forage was available to diving ducks; however, we only included forage estimates from gear (i.e., box sampler and moist-soil core sampler) which sampled within a 45-cm depth (the foraging range of most dabbling ducks) when calculating energetic carrying capacity for dabbling ducks.

Wetland Covermapping

We mapped all wetland vegetation, mudflat, and areas containing surface water in Thompson and Flag lake basins at Emiquon (Havera et al. 2003) to document changes in wetland area, plant species composition, vegetation communities, and other cover types during fall 2014. We traversed east-west transects spaced at 500-m intervals on foot, ATV, or by boat and delineated changes in vegetation communities (e.g., moist-soil, hemi-marsh) using a handheld field computer (Archer Field PC, Juniper Systems, Inc.) with global positioning system (GPS;

Bowyer et al. 2005, Stafford et al. 2010). We recorded plant species encountered (Table 2) along transect lines and delineated vegetation communities and other cover types (e.g., open water, mudflat) between transects. We digitized wetland vegetation in ArcGIS 10.2.2 using field notes and GPS waypoints overlaid on high-resolution color infrared aerial photographs from the U.S. Geological Survey (Upper Midwest Environmental Sciences Center, La Crosse, WI; Bowyer et al. 2005, Stafford et al. 2010).

Our classifications of wetland vegetation communities and other cover types at Emiquon generally followed conventions of 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 (i.e., cattails and bulrushes with >70% horizontal coverage), mudflats, floating-leaved aquatic vegetation (e.g., American lotus and watershield), aquatic bed (e.g., coontail), hemi-marsh (i.e., open water or aquatic bed interspersed with 30%–70% coverage of persistent emergent vegetation; 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 non-wetland associated vegetation (e.g., goldenrod and foxtail) growing within the wetland basin that had been inundated with surface water (i.e., Upland-wet).

RESULTS

Waterfowl Abundance

Spring–Fall, 2014. We conducted 9 ground inventories from 18 February to 17 April (Table 3) and 4 aerial inventories from 17 March to 23 April 2014 (Table 4). Peak waterfowl abundance reached 83,422 during a ground inventory on 20 March and 108,150 on 17 March during an aerial inventory. We observed 25 species of waterfowl during spring (19 duck species, 3 goose species, and 3 swan species). Lesser snow geese were the most abundant species during ground inventories, accounting for 33% of total waterfowl abundance, followed by lesser scaup (13%) and ruddy ducks (12%). Diving ducks were more abundant than dabbling ducks, accounting for 36% and 29% of the total waterfowl abundance, respectively. Spring waterfowl use-days (UDs) were 1,521,275 in 2014 (Table 5). Diving ducks (535,848 UDs; Fig. 2) contributed 35% of the spring waterfowl use and 54% of the duck use at Emiquon, while dabbling ducks (453,127 UDs; Fig. 2) accounted for 30% of the waterfowl use and 46% of the spring duck use.

We conducted 16 aerial inventories at Emiquon from 3 September 2014 to 8 January 2015 (Table 6). We observed 20 species of waterfowl (17 duck species, 2 goose species, and unidentified swan species) with a peak abundance of 94,135 on 5 November. Mallard (16.9%) was the most abundant species, followed by gadwall (16.3%), northern pintail (11.3%), American green-winged teal (10.9%), and northern shoveler (9.8%). Estimated waterfowl UDs at Emiquon totaled 1,855,803 during fall (Table 5). Dabbling ducks (1,466,053 UDs; Fig. 3) accounted for 78% of UDs, whereas 20% of waterfowl UDs was attributable to diving ducks (384,945 UDs).

Non-Waterfowl Abundance

Spring–Fall, 2014. We documented 13 waterbird and raptor species during ground counts in spring 2014. Peak abundance of non-waterfowl species observed during ground inventories was 32,780 individuals on 5 April (Table 7), whereas aerial inventories revealed a peak of 34,022 individuals on 9 April (Table 8). American coots were the most common species observed and accounted for 98% of non-waterfowl abundance based on both ground and aerial inventories. American coot abundance peaked at 32,510 (33,825 via aerial inventories), while their overall use of Emiquon totaled 802,928 UDs (Fig. 2).

American coots were the most abundant species during 16 aerial inventories in fall 2014, representing 98.5% of non-waterfowl abundance (Table 9). Likewise, American coots (3,195,468 UDs) accounted for 98.7% of non-waterfowl use, followed by double-crested cormorants (0.7%) and American white pelicans (0.5%). The peak estimate of American coots from aerial inventories was 119,280 on 16 October.

Duck Behavior

We conducted behavior observations (*n* = 2,579 observations) between 20 March and 10 April 2014. Species observed included canvasback, gadwall, lesser scaup, mallard and ruddy duck. These species spent most of their time feeding (36%), followed by locomotion (27%) and resting (26.7%). Dabbling ducks spent 27% of their time feeding, while diving ducks spent 40% of their time feeding (Table 10; Fig. 4). This was the largest proportion of time allocated to feeding by diving ducks observed at Emiquon during the 2008–2014 monitoring period.

Brood Observations

We conducted fixed-point brood surveys (*n* = 7) bi-weekly from 15 May to 12 August 2014 and observed 55 waterbird broods comprised of 6 species, including the state-threatened common gallinule (Table 11). The most abundant broods recorded in 2014 were Canada geese (*n* = 25) and wood ducks (*n* = 22). Brood observations peaked (*n* = 10) on 23 July. Average age classes of broods increased throughout the observation period indicating recruitment at Emiquon.

Aquatic Invertebrates

We collected invertebrates via sweep net (*n* = 40 samples) on 12 August along the margins of Thompson and Flag lakes in water depths ≤46 cm. Mean water volume sampled per sweep was 1.5 m^3, and invertebrate biomass averaged 111.3 mg/m^3 of water. We identified 54 invertebrate taxa in 2014 with Chironomidae, Oligochaeta, and Cladocera occurring in the most samples. Planorbidae (14.6 mg/m^3), Oligochaeta (7.2 mg/m^3) and Amphipoda (5.1 mg/m^3) accounted for the greatest biomass per volume (Table 12).

Moist-soil Plant Seeds

We collected soil cores (*n* = 30) at the terminus of transect lines along the east shore of Flag Lake and the west shore of Thompson Lake during 29 September–6 October to estimate seed density (kg/ha) and energetic carrying capacity of moist-soil plants for waterfowl. Average moist-soil plant seed density was 1,115.5 kg/ha (dry mass; Table 13, Fig. 6a). Large seeds contributed 754.5 kg/ha, whereas small seeds accounted for 361.0 kg/ha. The estimated energetic carrying capacity from moist-soil plant seeds in 2014 was 8,275.4 EUDs/ha (Fig. 6b).

Energetic Carrying Capacity

We collected benthic core (*n* = 10) and box samples (*n* = 10) from random locations within each of 4 dominant cover types (*n* = 80 samples total) during 29 September–3 October to estimate total energetic carrying capacity for waterfowl from invertebrates, seeds, and plant material. Hemi-marsh (7,996.9 kg/ha) produced the greatest amount of waterfowl forage per unit area, followed by aquatic bed (6,392.2 kg/ha), moist-soil (1,115.5 kg/ha), persistent emergent (1,045.7 kg/ha), and open water (234.1 kg/ha). Likewise, the hemi-marsh community provided the highest energetic carrying capacity per unit area with 34,140.7 EUDs/ha, followed by aquatic bed (23,348.0 EUDs/ha), moist-soil (8,275.4 EUDs/ha), persistent emergent (6,097.1 EUDs/ha), and open water (1,543.1 EUDs/ha; Table14, Fig. 7). Overall energetic carrying capacity for waterfowl during fall 2014 totaled 34,152,212 EUDs at Emiquon. Aquatic bed (25,447,002 EUDs) contributed the most overall forage, followed by hemi-marsh (6,097,529 EUDs), persistent emergent (1,815,099 EUDs), open water (513,700 EUDs), and moist-soil plants (278,882 EUDs).

Wetland Covermapping

We mapped all wetland vegetation, open water and areas containing surface water in Thompson and Flag lake basins during 4–16 September 2014 (Fig. 8). Aquatic bed (1,054.8 ha) was most abundant, followed by open water (332.9 ha), persistent emergent (297.7 ha), hemi-marsh (178.6 ha), floating-leaved aquatic (i.e, American lotus, watershield; 35.0 ha), and non-persistent emergent (33.7 ha; Table 15). We covermapped 1,944.2 ha and documented 71 plant taxa at Emiquon in 2014.

Species composition data from randomly-selected 1-m^2 plots indicated 39.0% of the aquatic bed community contained longleaf pondweed, followed by Eurasian water milfoil (32.0%), coontail (18.5%), naiads (8.0%), and sago pondweed (2.5%). The hemi-marsh community contained mostly longleaf pondweed (38.0%), cattail (19.5%), and Eurasian watermilfoil (18.0%), with lesser proportions of coontail (13.0%), naiads (10.5%) and sago pondweed (1.0%). Non-persistent emergent vegetation at Emiquon was mostly comprised of rice cutgrass (24.7%), barnyardgrass (17.0%), ferruginous flatsedge (9.7%), nodding beggarticks (8.8%), and reed canarygrass (8.8%). Lastly, the persistent emergent vegetation community was dominated by cattail (96.0%), while nodding smartweed (2.5%) and naiads (1.5%) were much less common.

DISCUSSION

Waterfowl Abundance

Spring

Current KEAs do not specify goals for spring waterfowl abundance at Emiquon; therefore, we provide only a general quantitative discussion here. Spring 2014 was late following the 4th coldest winter on record (Angel 2014). February (-6.7° C) and March (-3.9° C) temperatures were well below normal, delaying ice-out at Emiquon. Furthermore, Emiquon did not become completely ice free until our ground count on 20 March, which was halfway through the spring monitoring period. Accordingly, duck use (992,037 UDs) of Emiquon in spring 2014 was similar to the low observed in 2013 (982,985 UDs) and 22% below the long-term average (1,276,075 UDs). This decline in duck use was attributable to reductions in dabbling duck (-30%) and non-mallard dabbling duck (-26%) use from spring 2013.

We proposed to use the simple mean of diving duck UDs/ha during 2008–2013 to assess spring diving duck abundance at Emiquon (App. A). Diving duck use in spring 2014 (270 UDs/ha) increased 59% from the low in 2013, but remained 31% below the long-term average (392 UDs/ha). Likewise, overall spring diving duck UDs in 2014 (535,848 UDs) were 16% below the 2008–2013 average but represented 54% of all duck use compared to only 34% in spring 2013.

Fall

Waterfowl UDs at Emiquon in fall 2014 declined 48% from 2013 (3,548,098 UDs) and were the lowest since 2007 (1,416,082 UDs). Dabbling duck UDs (-54%) contributed to most of the decline in waterfowl use at Emiquon in fall 2014, while diving duck use increased (+15%) over 2013 estimates (dabbling ducks – 3,195,675 UDs; diving ducks – 334,490 UDs). Total duck UDs/ha in fall 2014 (n = 933) ranked poor according to current KEA goals and represented the lowest estimate since monitoring began. Duck density in fall 2014 was 47% less than 2013 and 51% lower than 2012 (App. A). The decline observed in fall 2014 was likely attributable to freezing temperatures occurring in mid-November, which was approximately a month earlier than the average initial freeze-up (18 December) at Emiquon during 2007–2013 (A.P. Yetter, unpublished data). Duck abundance never recovered to the level observed prior to the initial freeze-up in fall 2014. Overall duck use was largely comprised of non-mallard dabbling ducks (64%), such as gadwall (18%), northern pintail (12%), and American green-winged teal (11%). The proportion of total duck use in the IRV occurring at Emiquon was 11.8%, which was similar to 2013 (11.9%), but the lowest proportion observed at Emiquon since restoration (Fig. 3).

Non-mallard dabbling duck density in fall 2014 (598 UDs/ha) declined 57% from fall 2013 (1,391 UDs/ha) and fell 37% below the mean of the top 5 locations in the IRV during fall 2014, representing the lowest density of non-mallard dabbling ducks observed at Emiquon since restoration (App. A). Furthermore, 2014 was the second consecutive year non-mallard dabbling ducks dropped below the desired KEA level; although, non-mallard dabbling duck UDs in the IRV during fall 2014 (7,572,495 UDs) also declined substantially (-46%) from fall 2013 (13,895,848 UDs). The proportion of IRV non-mallard dabbling ducks using Emiquon during fall 2014 (15.7%) was the lowest observed during any year since restoration (Fig. 3). Relatively good forage quality at Chautauqua National Wildlife Refuge (CNWR) supported the highest non-mallard dabbling duck density (1,545 UDs/ha) in the IRV and the early freeze up (~12 November) likely contributed to the observed declines at Emiquon in fall 2014.

Diving duck density (194 UDs/ha) at Emiquon in fall 2014 ranked fair according to the KEA desired range and increased 16% from the fall 2013 density (167 UDs/ha) and 13% from the 2007–2013 average (171 UDs/ha). Furthermore, diving duck density at Emiquon surpassed (+5%) the mean diving duck density of the top 5 locations in the IRV during fall 2014. Emiquon had not reached this KEA goal since fall 2011. The proportion of diving ducks in the IRV using Emiquon (20.7%) during fall 2014 was 46% greater than 2013, but 15% below average (Fig. 3). Increases in ruddy duck, lesser scaup, and ring-necked duck abundances prior to freezing temperatures and persistence of late-migrating common mergansers and common goldeneye following freeze-up apparently contributed to the greater diving duck use observed at Emiquon during fall 2014.

Non-waterfowl Abundance

Spring

Abundances of non-waterfowl avifauna did not appear to be influenced by the late spring conditions as much as waterfowl in 2014. The peak ground count of non-waterfowl avifauna (5 April) occurred nearly 2 weeks earlier than the exceptionally late 2013 peak (17 April) but almost 2 weeks later than the 2012 peak (23 March), and peak abundance increased more than 200% from the 2013 peak (10,838). Aerial inventories also indicated similar timing (9 April) and peak abundance (34,022) of non-waterfowl avifauna in spring 2014. Non-waterfowl abundance increased 192% from the low observed in spring 2013 (Table 7). Likewise, American coot use (802,928 UDs) increased 297% from 2013 (202,128 UDs) and 33% over the 2008–2013 average (605,044 UDs). We observed a 33% increase in double-crested cormorant use in 2014 (6,408 UDs) over the 2013 estimate (4,798 UDs), but cormorant use remained well below (-54%) the long-term average (14,109 UDs). Moreover, American white pelicans exhibited a modest increase (+7%) in use of Emiquon in spring 2014 (-66%), but similar to cormorants, fell below (-46%) the 2008–2013 average (12,393 UDs). Conversely, bald eagle use (524 UDs) at Emiquon declined significantly (-73%) in spring 2014, falling 38% below the long-term average (43 UDs). The spring 2014 UD estimate for bald eagles was the lowest since 2010. During years of moderately-late springs, coots, cormorants, and pelicans may migrate late enough for their abundances to be less adversely affected, while bald eagles may be forced to more open water of the Illinois River to find sufficient forage.

Fall

American coot UDs in fall 2014 declined 16% from fall 2013 (3,823,533 UDs) but represented the 3rd highest estimate since monitoring began and contributed 63% of all waterbird use (including waterfowl) during fall at Emiquon. The proportion of American coots in the IRV using Emiquon (55%) increased slightly over 2013 (51%), but remained well below the long-term average (71%; Fig. 3). The proportion of coots using Emiquon compared to the rest of the IRV has exhibited a downward trend since 2008. Furthermore, some of the decline in proportional use in the last 2 years may be attributed to the restoration efforts at Hennepin and Hopper lakes, which contributed 22% and 25% of the American coot UDs in the IRV during 2013 and 2014, respectively. Bald eagle use of Emiquon in fall 2014 (722 UDs) increased 76% from 2013 and represented the 2nd highest UD estimate since monitoring began. Moreover, bald eagle use in 2013 surpassed the long-term average (306 UDs) by 136% and represented 22% of the eagle use in the IRV, which equaled the high in 2010. Double-crested cormorant UDs (23,968) in 2014 increased 31% from 2013 (18,290 UDs), exhibiting the 2nd highest fall UD estimate for cormorants at Emiquon and readily exceeding the 2007–2013 average (13,033 UDs). Cormorant use of Emiquon represented 37% of the cormorant use in the IRV in 2014, which was greater than the long-term average (30%). Conversely, American white pelican UDs dropped for a second consecutive year from the highest (82,083 UDs) to the lowest observed at Emiquon (16,855 UDs). Pelican use declined 19% from fall 2013 and was 51% below the long-term average (34,769 UDs).

Duck Behavior

The conditions stipulated under the KEA addressing spring waterfowl foraging include the presence of shallowly inundated areas (<50 cm) over residual vegetation. 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 dabbling ducks only spent about 27% of their time foraging during spring 2014 (Table10; Fig 4). This was the lowest proportion of time allocated to feeding by dabbling ducks since monitoring began in 2008 and was 56% below the long-term average (61%). Conversely, time spent in motion (36%) by dabbling ducks in spring 2014 was the highest observed at Emiquon and more than doubled the 2008–2013 average (16%). Observations of dabbling ducks were conducted only in the month of April in 2014 due to late ice-out, lower abundance, and difficulty locating observation points within suitable distances to dabbling duck concentrations. Thus, the sample size of dabbling ducks observations (*n* = 698) was reduced in spring 2014 and may not have been representative of most dabbling duck activity. Nevertheless, social activity (4.9%) was higher than average (2.4%) and the significant amount of time spent in motion may indicate an increase in courtship behavior, possibly explaining the reduction in foraging behavior. As 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 followed by suitable inundation will contribute to the fall and spring food base for migrating dabbling ducks that use the preserve. In particular, summer drawdown to encourage moist-soil plant production combined with a late winter or spring inundation would complement other wetland management in the IRV and provide forage in spring when it is assumed to be limited.

Diving ducks foraged an average of 40% of their time during spring 2014 (Table 10; Fig. 4), which was similar to published estimates (Paulus 1988, Bergan et al. 1989). Time allocated to feeding by diving ducks in 2014 was the highest observed at Emiquon and exceeded the long-term average (26%) by 51%. Conversely, the time spent resting (30%) by diving ducks in spring 2014 was the lowest observed at Emiquon and fell 28% below the 2008–2013 average (40%). All other activities were similar to their long-term means. The combination of submersed aquatic vegetation and associated seeds and invertebrates around these plants and in the benthos likely provided a reliable food source for spring-migrating diving ducks. Some research suggests that diving ducks, like dabbling ducks, will readily consume seeds during spring migration (Smith 2007, Strand et al. 2008, Hitchcock 2008). Furthermore, diets of diving ducks collected at Emiquon during springs 2014–2015 contained mostly plant material ($\bar{x} = 61\%$ aggregate mass) dominated by seeds (INHS, unpublished data). Thus, residual moist-soil and aquatic plant seeds can provide important food sources for diving ducks during spring. Our behavior observations were generally consistent with those from other time-activity studies of Anatids (Paulus 1984, 1988, Bergan et al. 1989, Crook et al. 2009).

Brood Observations

KEAs addressed availability of nesting habitats for waterbirds, such as upland grasses and tree cavities; however, we did not specifically monitor or map potential nesting habitats. Few mature trees with suitable nesting cavities exist within the wetland area, but wood ducks that presumably nested in surrounding bottomland and upland forests were the most abundant duck species observed during brood surveys at Emiquon in 2014. Total brood observations in

2014 were similar to the low observed in 2013 (*n* = 53) and 52% below the 2008–2013 average (116 observations). Cold conditions in early spring for a second consecutive year may have delayed nest initiation and reduced nest success of some waterbird species. Conversely, we documented the highest number of brood observations at Emiquon (*n* = 157) in 2012, a spring characterized by above normal temperatures. 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 may have observed individual broods more than once during multiple surveys. Thus, we suggest these counts are most useful for assessing trends among years as habitat conditions change at Emiquon.

In order to better utilize our data to quantify waterbird response to wetland quality indicators, we proposed some revisions of KEAs associated with nesting waterbirds at Emiquon (App. A.). The brood species richness indicator for waterbirds (other than waterfowl) suggested a desired range of >5 species = good, 3–4 species = fair, and <3 species = poor. Accordingly, waterbird brood species richness in 2014 (*n* = 3) rated fair. This indicator has remained steady since 2011 and has never exceeded more than 3 species since brood monitoring began in 2008. The Illinois threatened common gallinule has been a noteworthy addition to this indicator since 2011. Furthermore, we proposed an American coot brood density of >1 brood/km^2 as an indicator of waterbird nesting at Emiquon (App. A). The most notable change in brood observations during 2014 (*n* = 1) was the 94% drop in American coot broods from their apparent recovery in 2013 (*n* = 16), returning to the 2011 and 2012 level. We did not detect any American coot broods in 2010 and densities remained very low in 2011 and 2012 (0.1 broods/km^2, respectively). Brood density of American coots increased substantially in 2013 (1.0 brood/km^2) to near the proposed goal, but fell again in 2014 to the lowest density (0.04

brood/km^2) observed since 2010. Reasons for the fluctuations are unclear, but timing of our survey period may partially explain these changes as American coots appear to be late nesters at Emiquon. Timing of brood surveys may need to be adjusted to accommodate later nesting species such as American coots, pied-billed grebes, and common gallinules. Lastly, we suggested an annual peak waterfowl brood density of >0.15 broods/ha (15 broods/km^2). Waterfowl brood densities at Emiquon averaged only 4 broods/km^2 in 2014, which was similar to 2013 and resulted in the lowest brood density observed during any year of monitoring (App. A). For comparison, Yetter (1992) reported a waterfowl brood density of 0.7 brood/km^2 in northeastern Illinois, and Wheeler and March (1979) reported 1.0 brood/km^2 in southern Wisconsin. Conversely, Evans and Black (1956) reported a brood density of 9.1 broods/km^2 in South Dakota, and Hudson (1983) documented substantially higher waterfowl brood densities ranging from 4.7–10.7 broods/ha in stock ponds in Montana. While brood densities at Emiquon have declined 78% from the high in 2010 (18 broods/km^2), they remained within the range of other published estimates.

Aquatic Invertebrates

The KEA associated with waterbird food resources during the breeding season identified the presence of epiphytic and benthic invertebrates. Taxonomic richness of aquatic invertebrates (*n* = 54 taxa) in 2014 was slightly less than the high in 2013 (*n* = 57 taxa) but remained 32% above the long-term average at Emiquon (*n* = 41 taxa; Table 12). Invertebrate biomass per volume declined 30% from 2013 (158.1 mg/m^3) and remained 33% below the average of samples taken in August (167 mg/m^3). Likewise, total invertebrate biomass in 2014 (5,897 mg) was 10% less than that of 2013 (6,560.4 mg) and 59% below the peak observed in 2009 (14,476.6 mg). Nonetheless, we reduced the number of samples taken in 2013 and 2014 (*n* = 40) and collected all samples during the typical period of peak invertebrate abundance (mid-August) compared to collecting a total of 60 samples equally divided between 3 periods (April, June, and August) during 2008–2012. Furthermore, we extended our sampling area beginning in 2013 to include Flag Lake, whereas invertebrate collection had been confined to Thompson Lake in previous years. We were interested in investigating differences in invertebrate abundance between the two lakes. Contrary to 2013, we collected over twice the invertebrate biomass per unit volume of water from Thompson Lake (153.2 mg/m^3) than Flag Lake (71.3 mg/m^3) from an equal number of samples (n = 20) at each location. For comparison, Flag Lake (176.7 mg/m^3) produced more invertebrate biomass than Thompson Lake (139.5 mg/m^3) in 2013. Amphipods (7.5 mg/m^3), oligochaets (6.5 mg/m^3), and bryozoan statoblasts (4.5 mg/m^3) contributed the most invertebrate biomass at Thompson Lake, while planorbids (27.8 mg/m^3), oligochaets (7.8 mg/m^3), and physids (7.6 mg/m^3) provided most of the biomass from Flag Lake in 2014. During 2013, snails were most abundant at both Thompson (Physidae – 45.6 mg/m^3, Planorbidae – 40.9 mg/m^3) and Flag (Physidae – 69.2 mg/m^3, Planorbidae – 34.1 mg/m^3) lakes. Aside from the substantial change in invertebrate abundances in Thompson and Flag lakes between 2013 and 2014, the decline in snail taxa was probably the most dramatic change in the composition of our 2014 invertebrate samples. Total snail abundance in 2014 (19 mg/m^3) was 80% less than 2013 (95 mg/m^3) and 71% below the 2008–2013 average (65 mg/m^3). Nonetheless, snail abundances have exhibited extreme fluctuations throughout the monitoring period (range, 9–128 mg/m^3).

Moist-soil Plant Seeds

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. Moist-soil plant seed abundance in 2014 (1,115.5 kg/ha) exceeded the desired range and represented a 76% increase over the 2013 seed estimate (633.9

kg/ha; Table 13, App A). Moreover, seed abundance nearly equaled the high in 2011 (1,116.2 kg/ha) and surpassed the 2007–2013 average (660.8 kg/ha) by 69%. The Upper Mississippi River and Great Lakes Region Joint Venture (UMRGLRJV) of The North American Waterfowl Management Plan uses a moist-soil seed abundance estimate of 578 kg/ha for waterfowl conservation planning in this region. Moist-soil seed abundance at state waterfowl management areas in Illinois ranged from 501.5 to 1,030.0 kg/ha and averaged 691.3 kg/ha during 2005–2007 (Stafford et al. 2011). Furthermore, Bowyer et al. (2005) reported average seed abundance of 790 kg/ha for moist-soil plants at Chautauqua National Wildlife Refuge (CNWR) during 1999−2001. Thus, moist-soil plant seed abundance at Emiquon in 2014 exceeded the averages of these published estimates (Table 13). We suggest that the current KEA range for moist-soil plant seed abundance (App. A) be revised to reflect the biologically relevant values (691–790 kg/ha) used by other conservation partners and shown to be achievable on managed wetlands in Illinois (Bowyer et al. 2005, Stafford et al. 2011).

EUD estimates for CNWR averaged 6,760 EUD/ha and ranged from 2,815−10,536 EUDs/ha during 1999−2001 (Bowyer et al. 2005). Energetic carrying capacity of moist-soil communities at Illinois Department of Natural Resources waterfowl management areas ranged from 3,720 to 7,641 EUDs/ha and averaged 5,128 EUD/ha during 2005−2007 (Stafford et al. 2011). Thus, energetic carrying capacity of the moist-soil community at Emiquon in 2014 (8,275.4 EUDs/ha) exceeded these published estimates for this region (Table 13). Like moist-soil plant seed abundance, EUDs increased 76% from the 2013 estimate (4,702.5 EUDs/ha) and ranked second to the energy value in 2011 (8,280.4 EUDs/ha).

We expanded our moist-soil plant seed sampling to include portions of Flag Lake in 2013. Flag Lake samples (1,122.3 kg/ha) in 2014 averaged slightly more seed than those collected in Thompson Lake (1,108.7 kg/ha). Seed abundance from both lakes increased substantially over their 2013 estimates. Flag Lake encountered a 57% increase in moist-soil seed production from 2013 (713.3 kg/ha), while Thompson Lake nearly doubled (+96%) its seed abundance from the 2013 estimate (564.5 kg/ha). Furthermore, Thompson and Flag lake seed estimates exceeded the 2007–2013 average (660.8 kg/ha) by 68% and 70%, respectively. Like their seed abundance estimates, corresponding energetic carrying capacities were similar for Thompson (8,225.1 EUDs/ha) and Flag (8,325.8 EUDs/ha) lakes, exhibiting substantial increases over 2013 estimates (Thompson – 4,832.8 EUDs/ha; Flag – 6,107.2 EUDs/ha).

Community composition goals for moist-soil vegetation specified forbs comprise ≥10% of the coverage, <10% composition of exotic species, <50% composition of non-woody invasives (e.g., goldenrod, cocklebur), and <25% coverage of woody invasives (App. A). Species composition data from random 1-m^2 plots indicated that the moist-soil plant community at Emiquon was within these KEA goals with the possible exception of barnyardgrass, which comprised 17% of the moist-soil plant composition. Common barnyardgrass (*Echinochloa crus-galli*) is exotic and rough barnyardgrass (*E. muricata*) is native, but both look very similar in the field, and we did not distinguish between the two species in our surveys. Nonetheless, both species of barnyardgrass provide important forage for waterfowl. The most invasive species observed was reed canarygrass, which increased from 6.3% to 8.8% of the moist-soil area from 2013 to 2014. This species can quickly create a monotypic stand and become difficult to eradicate. Thus, we strongly recommend continued vigilance over this plant to prevent further expansion on the preserve.

Energetic Carrying Capacity

We began estimating energetic carrying capacity of the dominant vegetation communities at Emiquon for fall-migrating waterfowl in 2013. We sampled invertebrates, submersed aquatic plants and their seeds, and seeds and tubers of non-persistent emergent plants from aquatic bed, hemi-marsh, open water, persistent emergent, and moist-soil communities to determine EUDs for dabbling ducks and diving ducks (Fig. 7; Table 14).

We found invertebrate abundances to be highest from benthic cores taken in aquatic bed (100.4 kg/ha) and from samples taken in hemi-marsh (87.8 kg/ha) vegetation, which represented 67% of the invertebrate biomass collected in all vegetation communities. Consequently, energetic carrying capacity generated from invertebrates was highest in aquatic bed (283.0 EUDs/ha) and in hemi-marsh (247.5 EUDs/ha). Overall invertebrate abundance averaged 70.6 kg/ha, providing 198.9 EUDs/ha. Invertebrates contributed 435,625 EUDs, or 1.3% of the total energetic carrying capacity at Emiquon. Energetic carrying capacity from invertebrates in 2014 declined 56% from the 2013 estimate (995,821 EUDs).

Hemi-marsh (5,236.0 kg/ha) and aquatic bed (4,952.5 kg/ha) communities produced the most submersed aquatic vegetation, and accounted for 97% of this vegetation type in all communities sampled. Submersed aquatic vegetation provided 14,915.7 EUDs/ha and 14,108.1 EUDs/ha in hemi-marsh and aquatic bed, respectively. Abundance of submersed aquatic vegetation averaged 2,621.4 kg/ha across all vegetation communities, representing 7,467.4 EUDs/ha. Submersed aquatic vegetation accounted for 53.6% (18,292,195 EUDs) of the total energetic carrying capacity in fall 2014, representing a 14% decline from the 2013 estimate (21,183,570 EUDs).

Seed and tuber abundances were highest in hemi-marsh (2,673.0 kg/ha) and aquatic bed (1,339.3 kg/ha) communities, representing 67% of the biomass from seeds and tubers in all communities. Furthermore, hemi-marsh produced 18,977.5 EUDs/ha and the aquatic bed community provided 8,957.0 EUDs/ha from seeds and tubers. Abundance of seeds and tubers averaged 1,203.3 kg/ha for all vegetation communities and contributed 8,547.8 EUDs/ha. Finally, seeds and tubers contributed a total of 15,424,393 EUDs, or 45.2% of the energetic carrying capacity for waterfowl, an increase of 232% over the 2013 estimate for seeds and tubers (4,638,486 EUDs).

We calculated energetic carrying capacity for dabbling ducks and diving ducks based on the amount of forage available to each guild. For instance, diving ducks have a larger foraging range (some >10 m depth) than dabbling ducks (45 cm depth), affording them greater access to food. Therefore, we assumed that forage collected from all 3 sampling gear (benthic cores, moist-soil cores, and box samples) was available to diving ducks, whereas food items sampled in only the moist-soil cores and box sampler were used to calculate energetic carrying capacity for dabbling ducks. Consequently, energetic carrying capacity for diving ducks (34,152,212 EUDs) was over 2.5 times more than that of dabbling ducks (13,317,405 EUDs) at Emiquon in fall 2014 (Table 14). For comparison, Hagy et al. (2012) estimated the south pool of CNWR contributed a total of 7,630,963 EUDs available to dabbling and diving ducks during fall 2012. Energetic carrying capacity at Emiquon in fall 2014 increased 27% for diving ducks over 2013 (26,817,878 EUDs), while the energetic carrying capacity for dabbling ducks in 2014 declined 38% from the 2013 estimate (21,577,059 EUDs).

Wetland Covermapping

The spatial coverage of wetland vegetation (1,944.2 ha) at Emiquon remained nearly the same as 2013 (1,943.6 ha) and represented the largest area mapped since 2010 (Table 15). Likewise, the area of aquatic bed (including American lotus) in 2014 was nearly the same as

2013 and was 39% above the 2007–2013 average (784.2 ha). Open water increased 7% from 2013 and 25% above the long-term average (266.2 ha). The spatial extent of persistent emergent vegetation in 2014 increased slightly from 2013 (294.3 ha) and remained 89% above the 2007–2013 average (157.6 ha). Hemi-marsh increased in 2014 (+32%) for a second consecutive year after experiencing a decline since 2009 and surpassed the long-term average (140.9 ha) by 27%. We continue to observe areas of persistent emergent vegetation transition to hemi-marsh as water levels increase along with apparent increases in muskrat (*Ondatra zibethicus*) herbivory. Finally, the area of non-persistent emergent vegetation in 2014 declined 67% from 2013 and 69% below the long-term average (108.1 ha).

The criteria for KEAs related to community composition stipulate <10% invasive species coverage and 100% exclusion of purple loosestrife. Encounters with common reed increased in 2014 (n = 30) compared to 2013 (n = 24). This was the highest number of encounters we've had with common reed, occurring in persistent emergent, non-persistent emergent and scrub-shrub vegetation communities. Increasing water levels may hinder TNC staff from controlling this invasive species. We did not encounter purple loosestrife at Emiquon during cover mapping operations in 2014, likely a result of wetland managers' persistent vigilance and removal of this plant from the preserve. Reed canarygrass appeared to decline on Emiquon in 2014 as our encounters (n = 33) were 47% less than those in 2013 (n = 62). 2012 (n = 24). Overall, the proportion of vegetation polygons from the 2014 cover map containing invasive species declined slightly from the high of 45% in 2013 to 40% in 2014. Lastly, we documented plant species composition data at random locations across Emiquon in fall 2014. Eurasian watermilfoil declined from 52% of the hemi-marsh community in 2013 to 18% in 2014, but increased from 27–32% in the aquatic bed community from 2013–2014. Although we've observed some apparent reduction in milfoil, it continued to be a prominent component of the aquatic vegetation communities at Emiquon in 2014.

The evaluation criteria for the KEA related to fall feeding by dabbling ducks stipulates the presence of shallowly flooded mature moist-soil plants, in combination with productive epiphytic and benthic invertebrate communities. Although moist-soil plant communities have developed each year at Emiquon, they have not been extensive compared to the overall area. 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 (34 ha in 2014), 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. Furthermore, 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 in 2014 documented that large areas with these characteristics were present (Table 15; Figs. 8 and 9).

The KEA related to foraging habitat for fall-migrating shorebirds declared the need for mudflat adjacent to shallowly inundated areas (<5 cm deep) from 1 July–31 August. Water levels have remained high throughout the summer and fall since 2013, thereby eliminating most of the desired shorebird foraging habitat (i.e. mudflat). Overall, shorebird foraging habitat was limited by high water levels at Emiquon in 2014.

To compare contemporary wetland vegetation categories at Emiquon to historical characteristics of IRV wetlands (1938−1942; Bellrose 1941, Bellrose et al. 1979), we consolidated vegetation communities and other cover types into 8 categories: bottomland forest, non-persistent emergent, open water, aquatic bed, floating-leaved aquatic, mudflat, persistent emergent, and scrub shrub (Stafford et al. 2010). 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%), persistent emergent (12.3%), and aquatic bed (11.2%). Habitat composition at Emiquon in 2014 was dominated by aquatic bed (54.3%), open water (17.1%), and persistent emergent (15.3%; Fig. 9). Persistent emergent was the only vegetation community in 2014 that was comparable to historical conditions in the IRV (historical persistent emergent – 12.3%). Although, high water eliminated all mudflats at Emiquon in 2014 and floating-leaved aquatic vegetation (i.e. longleaf pondweed, watershield, and American lotus) has actually increased at Emiquon since 2011, but most of the increase has been obscured within the aquatic bed category. For instance, longleaf pondweed spread extensively throughout the aquatic bed community, but since it's intermixed with submersed aquatic plants, we did not delineate it from the aquatic bed community.

SUMMARY

Overall waterfowl use in fall 2014 was the lowest observed since restoration began, and non-mallard dabbling duck UDs declined for the second consecutive year. These declines were likely due to the relatively early initial freeze-up in 2014, but the expanded waterfowl hunting program has probably resulted in lower densities of waterfowl in fall as evident by the downward trend since 2012. Total duck use at Emiquon in spring 2014 was similar to the low observed in 2013 and was below the long-term average. This decline was attributable to reductions in dabbling duck and non-mallard dabbling duck use from spring 2013, while diving duck use increased substantially at Emiquon during spring 2014, and American coot use was above the long-term average. American coot UDs in fall 2014 were the 3rd highest since restoration began, but the proportion of coots at Emiquon compared to the rest of the IRV has declined since 2008. Energetic carrying capacity probably exceeded the capability of ducks to exploit all resources during fall, and in spring most of the forage is likely on the lake bottoms and available only to diving ducks, which may explain their increased use during spring. Moist-soil plant seed production in 2014 was the second highest since restoration began, but the area of moist-soil was limited due to high water, precluding this vegetation community from significantly contributing to the overall energy produced at Emiquon. The area of hemi-marsh increased for a second consecutive year, likely a result of extended high water and increased muskrat herbivory, making this increase unsustainable. Furthermore, declines in total waterbird broods, particularly American coots, and in invertebrate densities coupled with increased open water area suggests a possible decline in wetland productivity and the need for a prolonged (possibly multi-year) drawdown to perturbate the system and reset the marsh cycle. Nonetheless, the aquatic vegetation communities, particularly submersed and floating-leaved aquatic vegetation, continue to make Emiquon a highly-unique wetland complex in the IRV.

LITERATURE CITED

Altmann, J. 1974. Observational study of behavior: sampling methods. Behavior 49:227–267.

Angel, J. 2014. March cold and dry in Illinois. Illinois State Water Survey. 1 April 2014. https://climateillinois.wordpress.com/2014/04/01/march-cold-and-dry-in-illinois/. Accessed 8 August 2015.

Austin, J. E., T. K. Buhl, G. R. Guntenspergen, W. Norling, and H. T. Sklebar. 2001. Duck populations as indicators of landscape condition in the Prairie Pothole Region. Environmental Management and Assessment 69:29–47.

Bellrose, F. C. 1941. Duck food plants of the Illinois River valley. Illinois Natural History Survey Bulletin 21:235–280.

Bellrose, F. C., F. L. Paveglio, Jr., and D. W. Steffeck. 1979. Waterfowl populations and the changing environment of the Illinois River valley. Illinois Natural History Survey Bulletin 32:1. 53 pp.

Bergan, J. F., L. M. Smith, and J. J. Mayer. 1989. Time-activity budgets of diving ducks wintering in South Carolina. Journal of Wildlife Management 53:769–776.

Bohm, W. 1979. Methods of studying root systems. Springer-Verlag, Berlin, Germany.

Bowyer, M. W., J. D. Stafford, A. P. Yetter, C. S. Hine, M. M. Horath, and S. P. Havera. 2005. Moist-soil plant seed production for waterfowl at Chautauqua National Wildlife Refuge, Illinois. American Midland Naturalist 154:331–341.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. FWS/OBS 79/31. Washington, D.C: U.S. Government Printing Office.

Crook, S.L., W.C. Conway, C.D. Mason, and K.J. Kraai. 2009. Winter time-activity budgets of diving ducks on eastern Texas reservoirs. Waterbirds 32(4):548−558.

Evans, C.D. and K.E. Black. 1956. Duck production studies on the prairie potholes of South Dakota. U.S. Fish and Wildlife Service, Special Scientific Report, Wildlife No. 32. 59 pp.

Fredrickson, L. H., and T. S. Taylor. 1982. Management of seasonally flooded impoundments for wildlife. United States Department of the Interior, Fish and Wildlife Service Resource Publication 148. Washington, District of Columbia.

Gawlik, D. E. 2006. The role of wildlife science in wetland ecosystem restoration: lessons from the Everglades. Ecological Engineering 26:70–83.

Gollop, J.B., and W.H. Marshall. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Technical Section Report. 14pp.

Greer, A. K., B. D. Dugger, D. A. Graber, and M. J. Petrie. 2007. The effects of seasonal flooding on seed availability for spring migrating waterfowl. Journal of Wildlife Management 71:1561–1566.

Hagy, H.M., J.N. Straub, and R.M. Kaminski. 2011. Estimation and correction of seed recovery bias from moist-soil cores. Journal of Wildlife Management 75:959–966.

Hagy, H.M., R.V. Smith, A.P. Yetter, C.S. Hine, and M.M. Horath. 2012. Vegetation assessment of the south pool of Chautauqua National Wildlife Refuge. INHS Technical Report 2012 (34). 14 pp.

Havera, S. P. 1999. Waterfowl of Illinois: status and management. Illinois Natural History Survey Special Publication 21.

Havera, S.P., K.E. Roat, and L.L. Anderson. 2003. The Thompson Lake/Emiquon story: the biology, drainage, and restoration of an Illinois River bottomland lake. Illinois Natural History Survey Special Publication 25. 40 pp.

Hine, C.S., R.V. Smith, J.D. Stafford, A.P. Yetter, and M.M. Horath. 2010. Waterbird and wetland monitoring at the Emiquon Preserve. Final Report 2007–2009. INHS Technical Report 2010 (32). 75 pp.

Hine, C.S., H.M. Hagy, A.P. Yetter, M.M. Horath, R.V. Smith, and J.D. Stafford. 2013. Waterbird and wetland monitoring at the Emiquon Preserve. Final Report 2007–2013. INHS Technical Report 2013 (20). 200 pp.

Hitchcock, A. N. 2008. Diets of spring-migrating waterfowl in the Upper Mississippi River and Great Lakes region. M.S. Thesis. Southern Illinois University, Carbondale, USA.

Hudson, M.S. 1983. Waterfowl production on three age-classes of stock ponds in Montana. Journal of Wildlife Management 47(1):112–117.

Kaminski, R.M., and H. R. Murkin. 1981. Evaluation of two devices for sampling nektonic invertebrates. Journal of Wildlife Management 45(2):493–496.

Kaminski, R. M., J. B. Davis, H. W. Essig, P. D. Gerard, and K. J. Reinecke. 2003. True metabolizable energy for wood ducks from acorns compared to other waterfowl foods. Journal of Wildlife Management 67:542–550.

Kross, J., R. M. Kaminski, K. J. Reinecke, E. J. Penny, and A. T. Pearse. 2008. Moist-soil seed abundance in managed wetlands in the Mississippi Alluvial Valley. Journal of Wildlife Management 72:707–714.

Manley, S.W., R.M. Kaminski, K.J. Reinecke, P.D. Gerrard. 2004. Waterbird foods in winter-managed ricefields in Mississippi. Journal of Wildlife Management 68:74–83.

Merritt, R. W. and K. W. Cummins. eds. 1996. An introduction to the aquatic insects of North America. Kendal/Hunt, Dubuque, IA, USA.

Naylor, L. W., J. M. Eadie, W. D. Smith, M. Eichholz, and M. J. Gray. 2005. A simple method to predict seed yield in moist-soil habitats. Wildlife Society Bulletin 33:1335–1341.

Paulus, S. L. 1984. Activity budgets of nonbreeding gadwalls in Louisiana. Journal of Wildlife Management 48:371–380.

Paulus, S. L. 1988. Time-activity budgets of nonbreeding Anatidae: a review. Pages 135–149 *in* M. W. Weller, editor. Waterfowl in winter. University Minnesota Press, Minneapolis, Minnesota, USA.

Pennak, R.W. 1978. Fresh-water invertebrates of the United States. 2nd ed. John Wiley and Sons, Inc., New York. 803 pp.

Reinecke, K. J., R. M. Kaminski, K. J. Moorehead, J. D. Hodges, and J. R. Nassar. 1989. Mississippi Alluvial Valley. Pages 203–247 *in* L.M. Smith, R.L. Pederson, and R.M. Kaminski, editors. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press, Lubbock, Texas, USA.

Ringelman, J.K., and L.D. Flake. 1980. Diurnal visibility and activity of blue-winged teal and mallard broods. Journal of Wildlife Management 44:822–829.

Rumble, M.A., and L.D. Flake. 1982. A comparison of two waterfowl brood survey techniques. Journal of Wildlife Management 46(4):1048–1053.

SAS Institute. 2004. SAS/STAT user's guide. SAS Institute, Cary, North Carolina. USA.

Smith, R. V. 2007. Evaluation of waterfowl habitat and spring food selection by mallard and lesser scaup on the Swan Lake, Illinois habitat rehabilitation and enhancement project. M.S. Thesis. Southern Illinois University, Carbondale, USA.

Smith, R.V., J.D. Stafford, A.P. Yetter, M.M. Horath, C.S. Hine, and J.P. Hoover. 2012. Foraging ecology of fall-migrating shorebirds in the Illinois River valley. PLoS ONE 7(9): e45121. doi:10.1371/journal.pone.0045121.

Soulliere, G. J., B. A. Potter, J. M. Coluccy, R. C. Gatti, P. W. Brown, C. L. Roy Nielsen, M. W. Eichholz, and D. R. Luukkonen. 2007. Upper Mississippi River and Great Lakes Region

Joint Venture Waterfowl Habitat Conservation Strategy. U.S. Fish and Wildlife Service, Fort Snelling, MN. 112 pp.

Stafford, J. D., R. M. Kaminski, K. J. Reinecke, and S. W. Manley. 2006. Waste rice for waterfowl in the Mississippi Alluvial Valley. Journal of Wildlife Management 70:61–69.

Stafford, J. D., M. M. Horath, A. P. Yetter, C. S. Hine, and S. P. Havera. 2007. Wetland use by mallards during spring and fall in the Illinois and Central Mississippi River Valleys. Waterbirds 30:394–402.

Stafford, J.D., M.M. Horath, A.P. Yetter, R.V. Smith, and C.S. Hine. 2010. Historical and contemporary characteristics and waterfowl use of Illinois River valley wetlands. Wetlands 30:565–576.

Stafford, J.D., A.P. Yetter, C.S. Hine, R.V. Smith, and M.M. Horath. 2011. Seed abundance for waterfowl in wetlands managed by the Illinois Department of Natural Resources. Journal of Fish and Wildlife Management 2(1):3–11.

Strand, K. A., S. R. Chipps, S. N. Kahara, K. F. Higgins, and S. Vaa. 2008. Patterns of prey use by lesser scaup *Aythya affinis* (Aves) and diet overlap with fishes during spring migration. Hydrobiologia. 598: 389-398.

Suloway, L. and M. Hubbell. 1994. Wetland Resources of Illinois: An Analysis and Atlas. Illinois Natural History Survey Special Publication 15.

Sychra, J. and Z. Adamek. 2010. Sampling efficiency of Gerking sampler and sweep net in pond emergent littoral macrophyte beds – a pilot study. Turkish Journal of Fisheries and Aquatic Sciences 10:161–167.

Voigts, D.K. 1976. Aquatic invertebrate abundance in relation to changing marsh vegetation. American Midland Naturalist. 95:313–322.

Weller, M. W., and C. E. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa State University, Agriculture and Home Economics Experiment Station Special Report 43.

Wheeler, W.E. and J.R. March. 1979. Characteristics of scattered wetlands in relation to duck production in southeastern Wisconsin. WI Dept. of Natural Resources. Technical Bulletin No. 116. 61 pp.

Yetter, A.P. 1992. Population densities and use of palustrine wetlands by breeding waterfowl in northeastern Illinois. MS Thesis. Southern Illinois University. 196 pp.

Yetter, A.P., H.M. Hagy, M.M. Horath, C.S. Hine, J.M. Osborn., and M.P. Ward. 2014. Illinois waterfowl surveys and investigations W–43–R–61. Second Quarterly Report to Illinois Department of Natural Resources. 31 January. 11 pp.

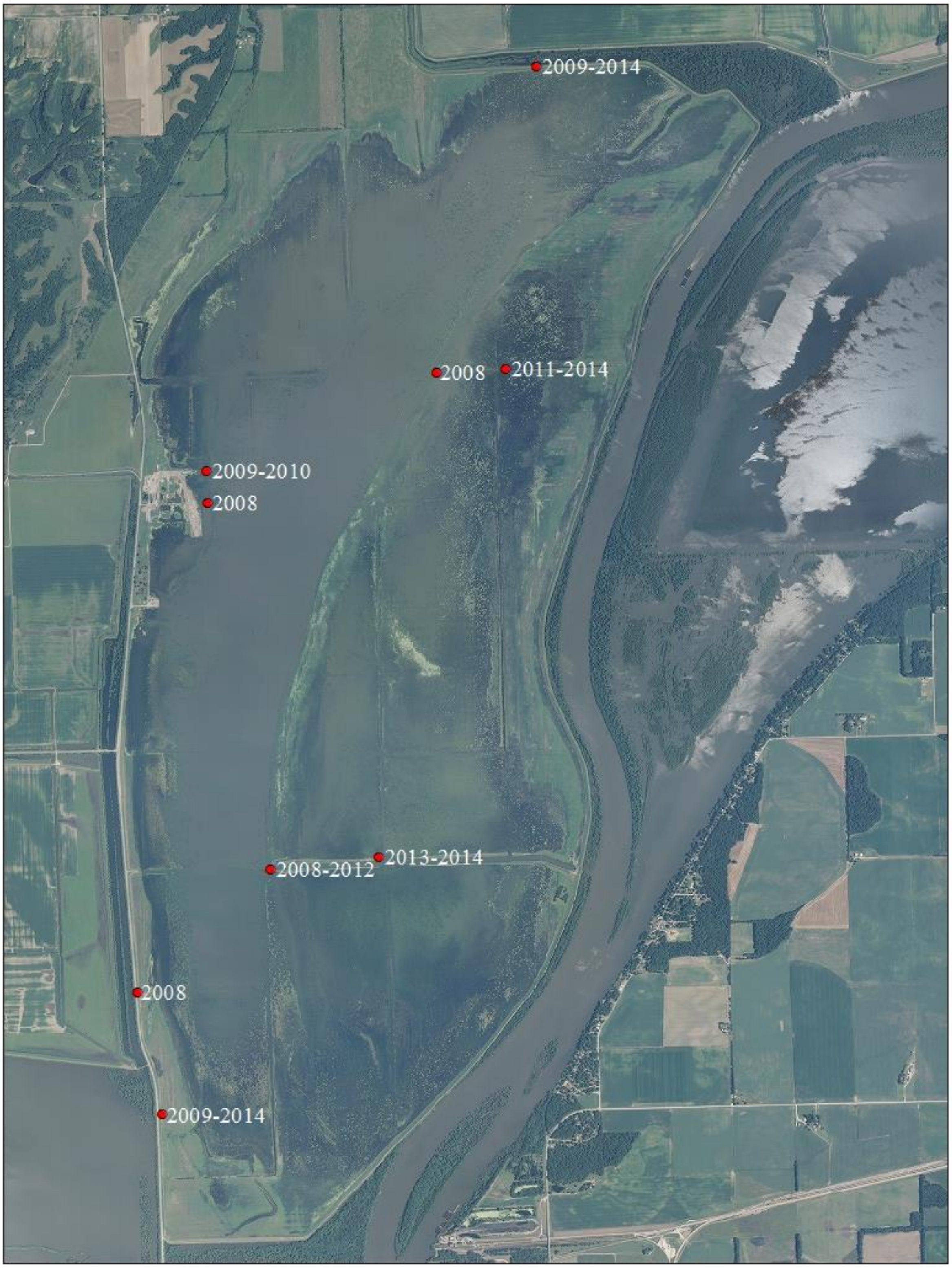


Figure 1. Brood observation locations by year at The Emiquon Preserve, summers 2008–2014. Observation points varied by year due to expanding water levels on the Preserve.

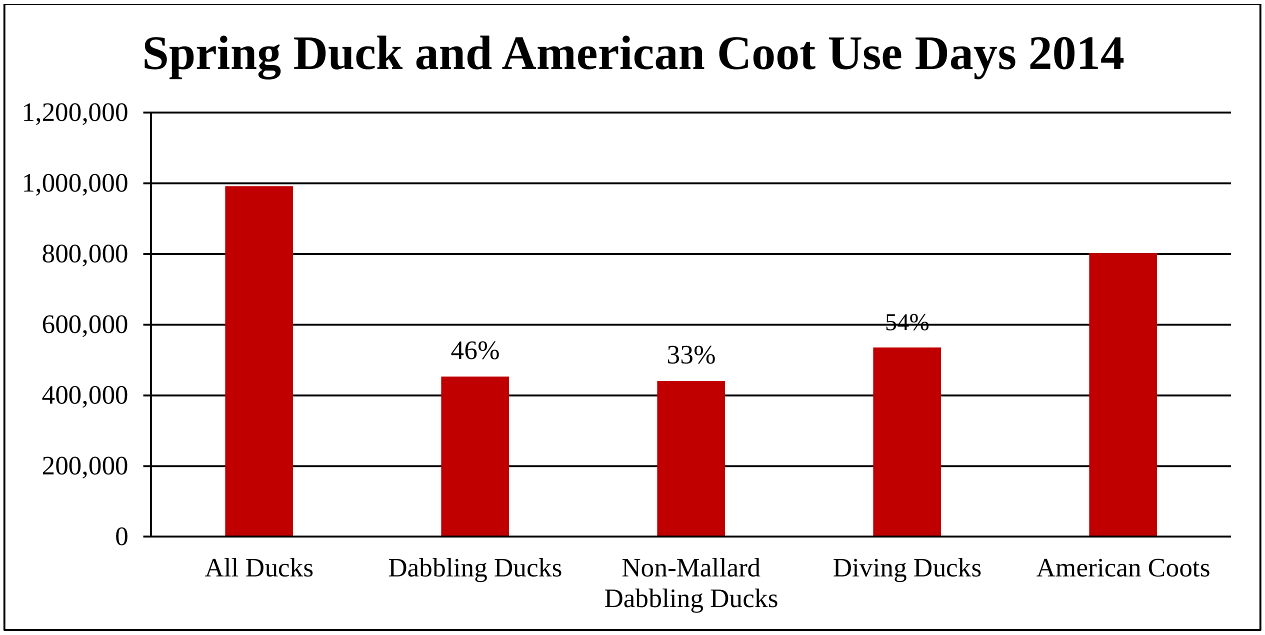


Figure 2. Use days of ducks and American coots at the Emiquon Preserve from ground inventories during spring 2014. Percentages represent proportions of total duck use days.

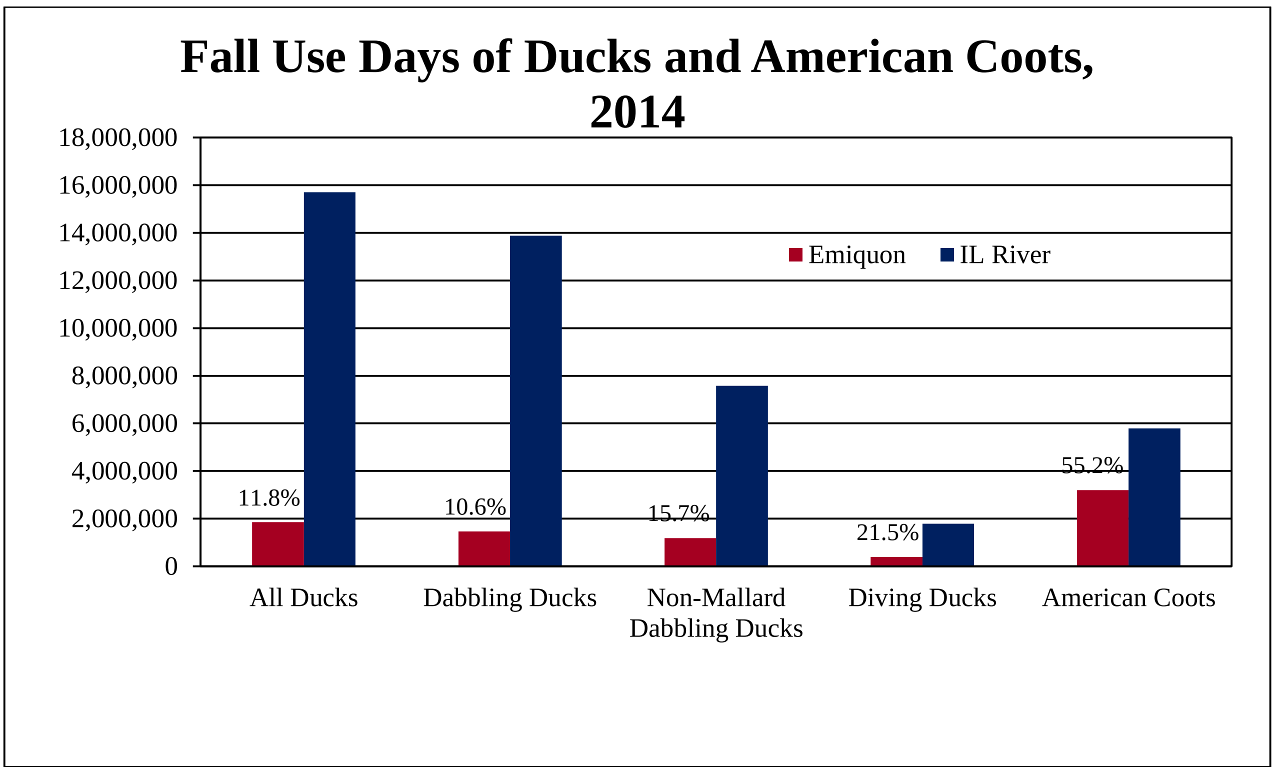


Figure 3. Use days of ducks and American coot at the Emiquon Preserve from aerial inventories during fall 2014. Percentages represent proportions of Illinois River use days.

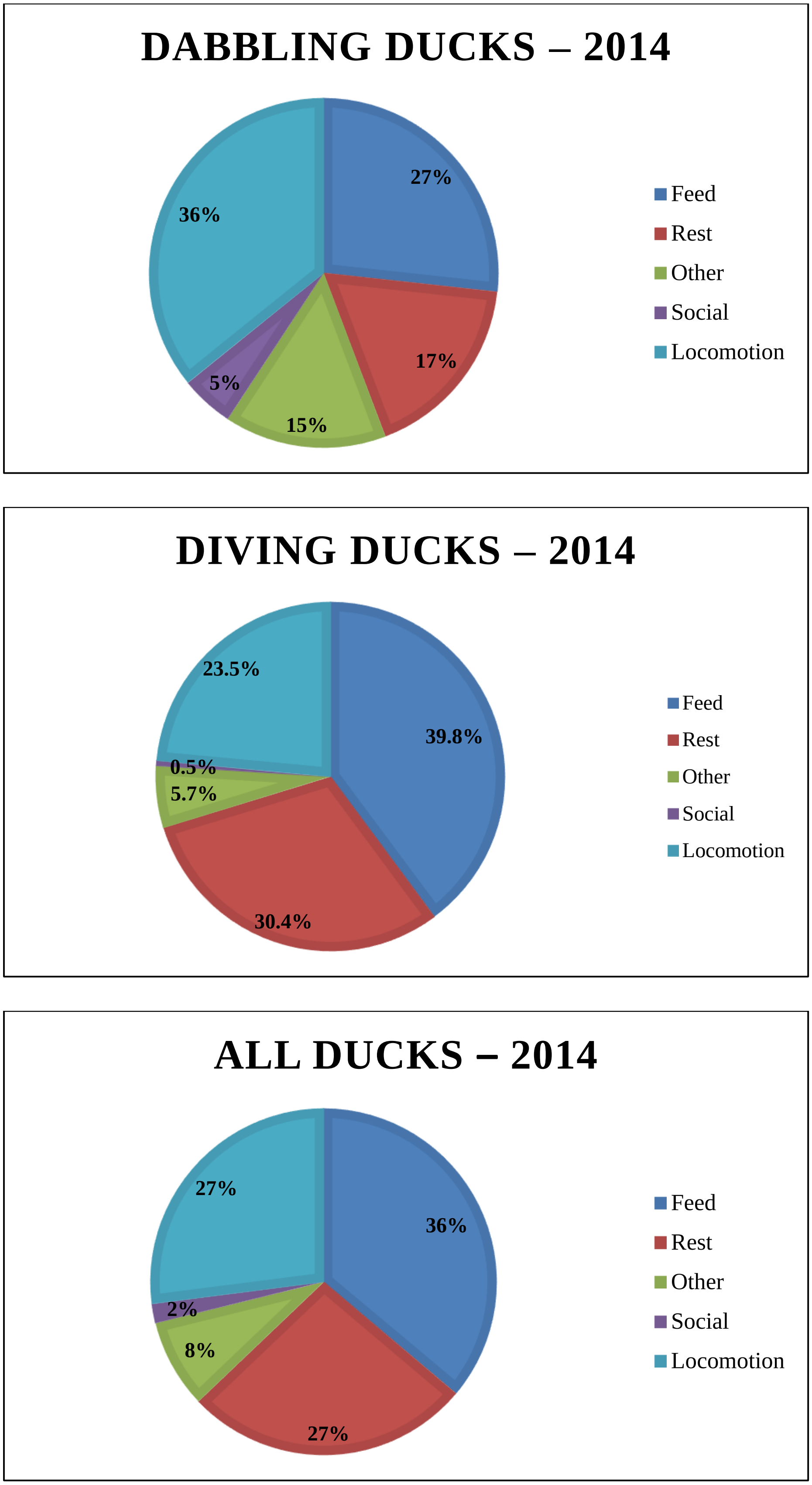


Figure 4. Time activity budgets of ducks at Emiquon Preserve during spring 2014.

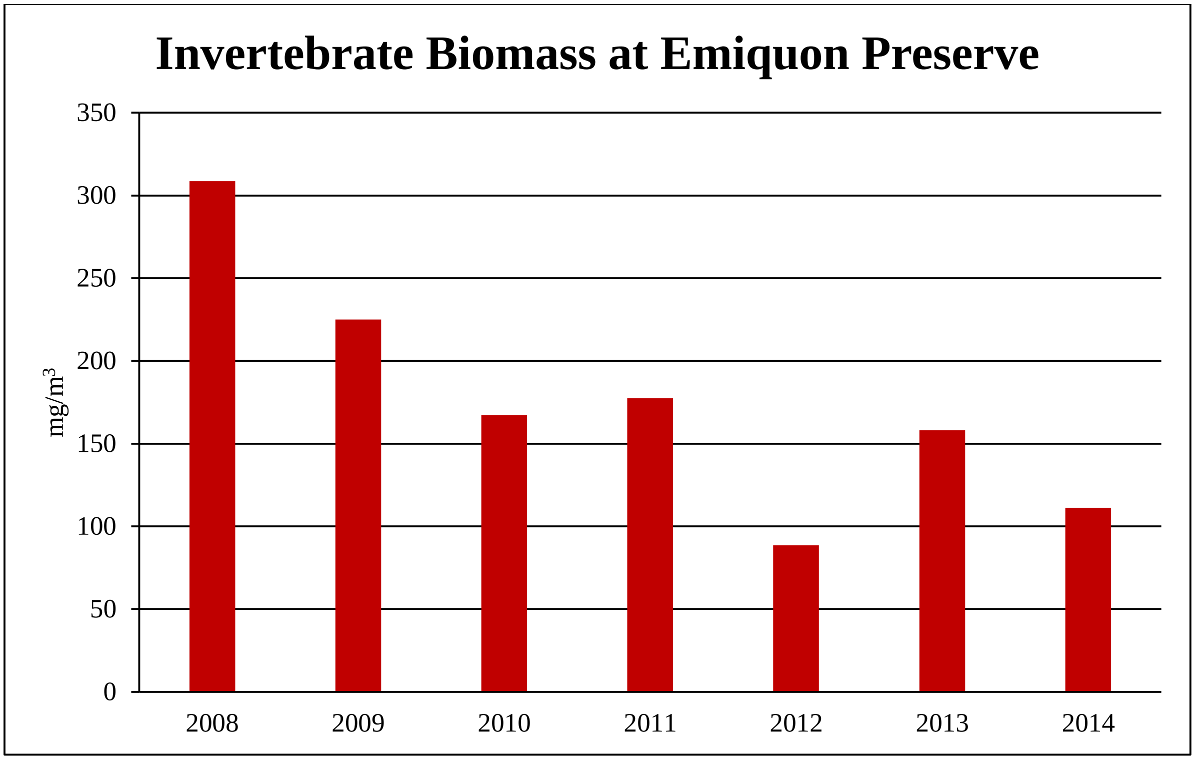
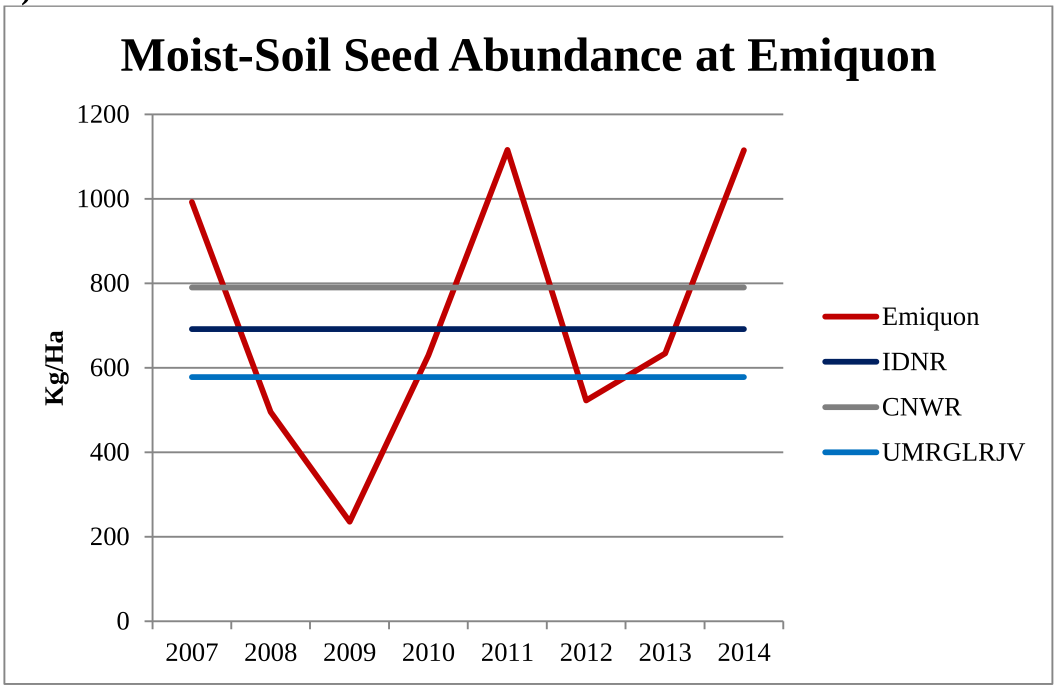


Figure 5. Mean mass of invertebrates collected in sweep nets during August at The Emiquon Preserve, 2008–2014.

A)



B)

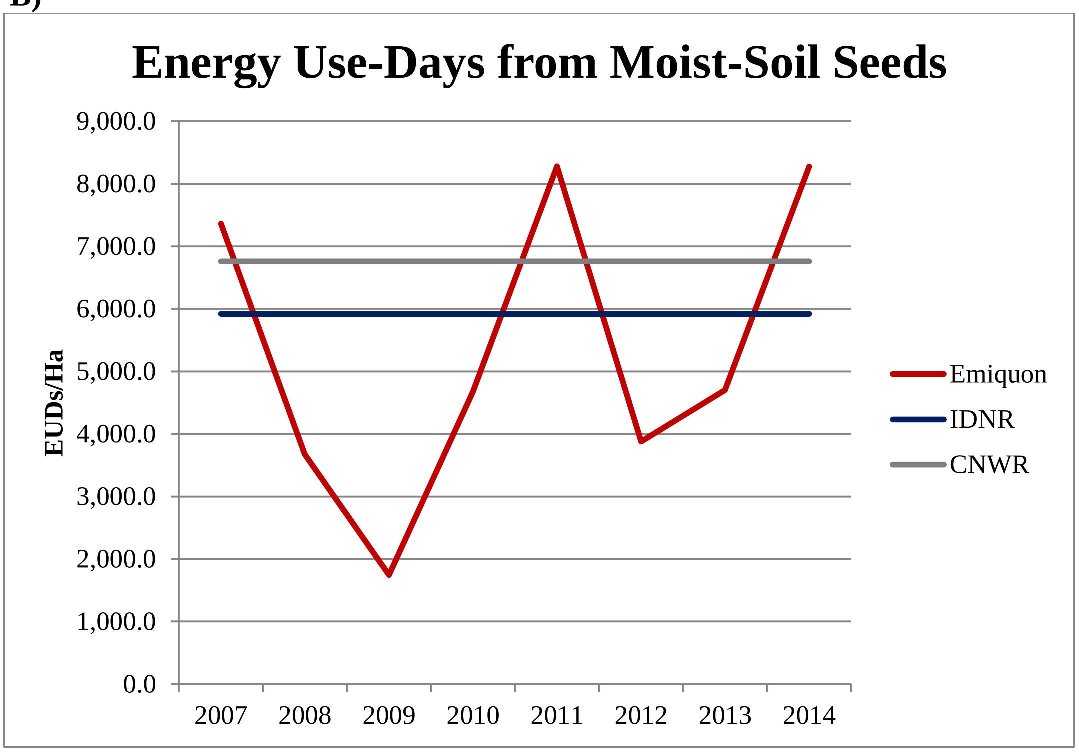


Figure 6. Moist-soil plant seed density (A) and energy use days (EUDs; B) from moist-soil plants at the Emiquon Preserve compared to estimates (constants) from wetlands at Illinois Department of Natural Resources (IDNR) sites, Chautauqua National Wildlife Refuge (CNWR), and carrying capacity goals of the Upper Mississippi River/Great Lakes Region Joint Venture (UMRGLRJV) of the North American Waterfowl Management Plan.

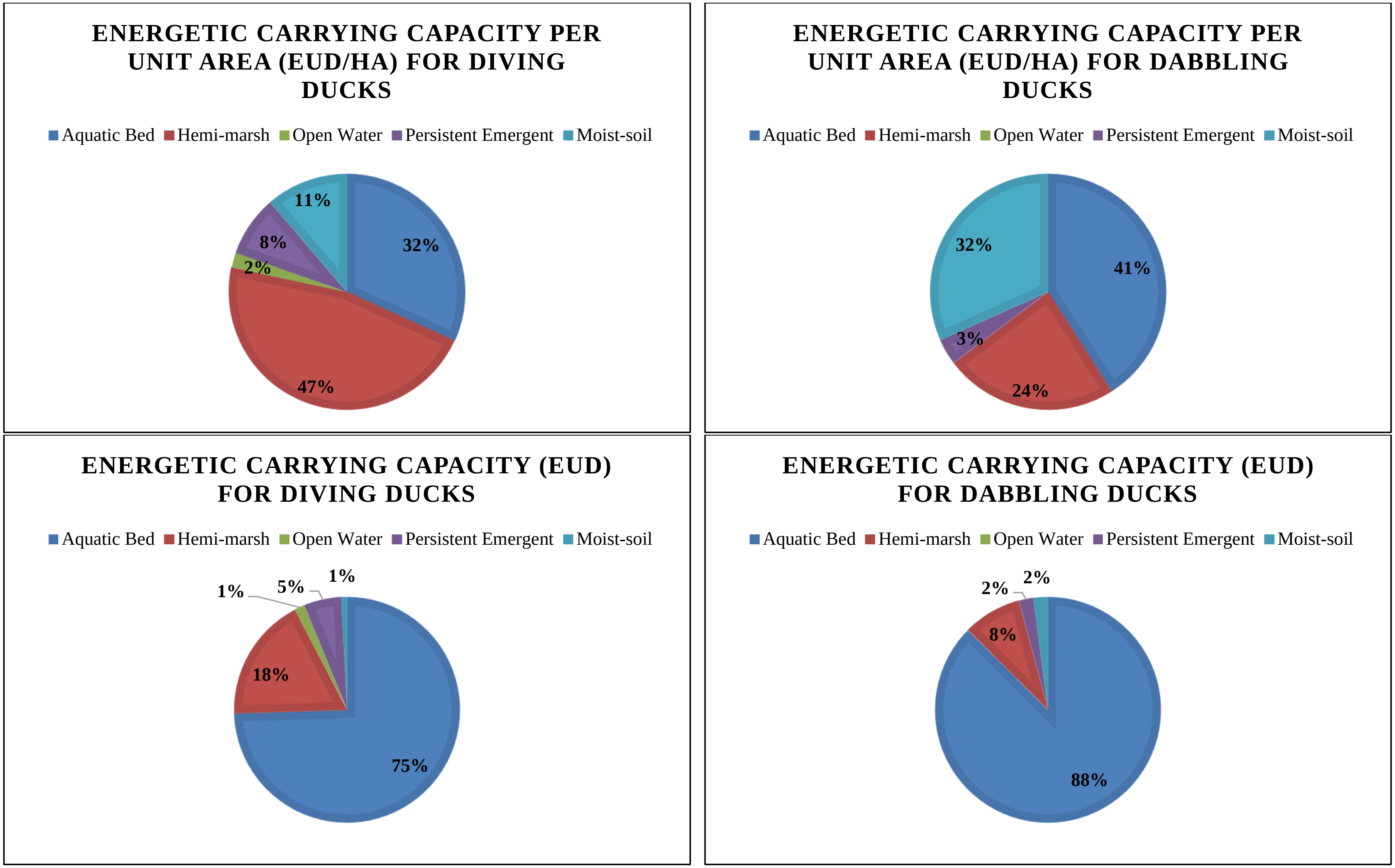


Figure 7. Energetic carrying capacity for diving ducks and dabbling ducks by vegetation community at Emiquon during fall 2014.

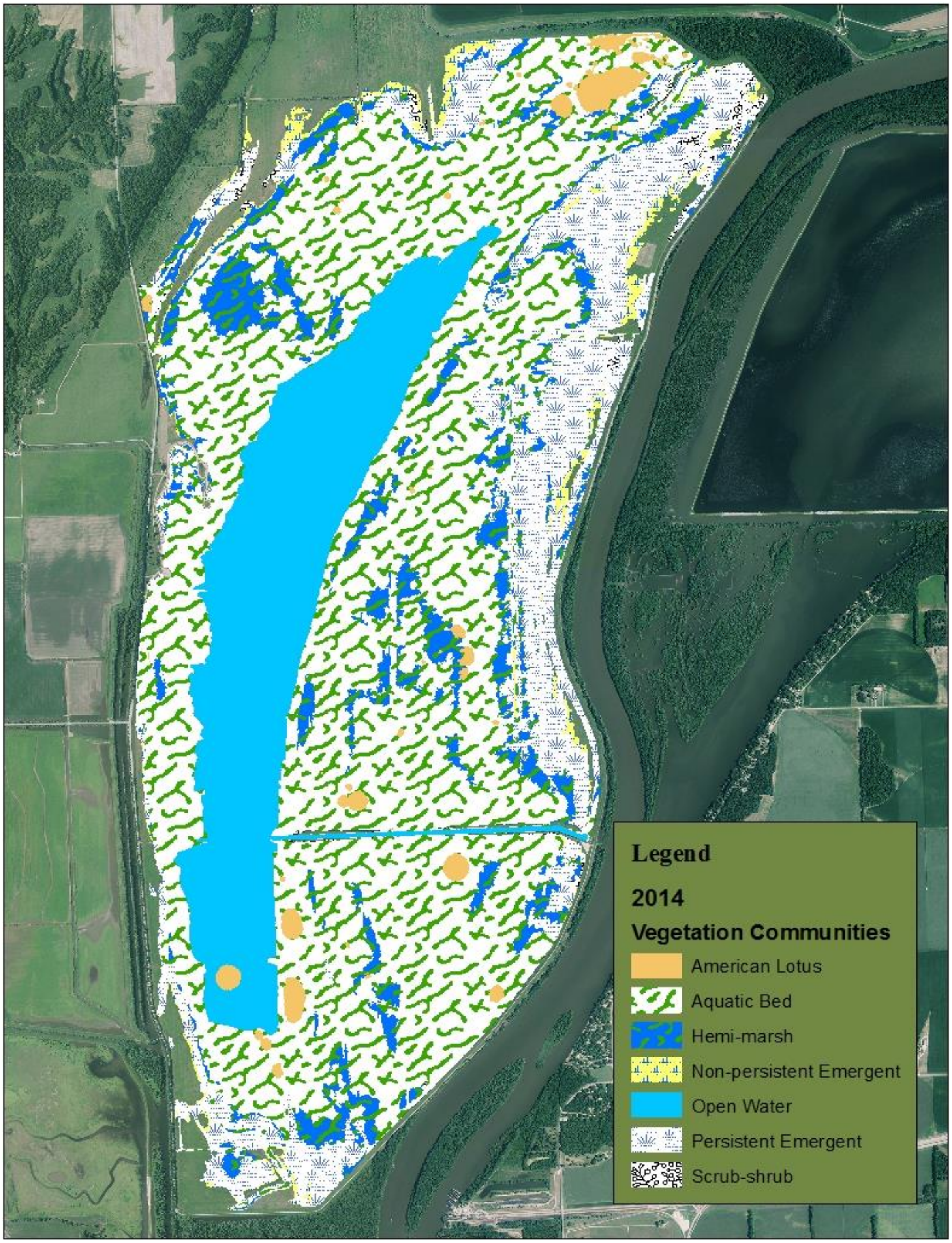


Figure 8. Wetland vegetation map of The Emiquon Preserve (1,944.2 ha), 4–16 September, 2014.

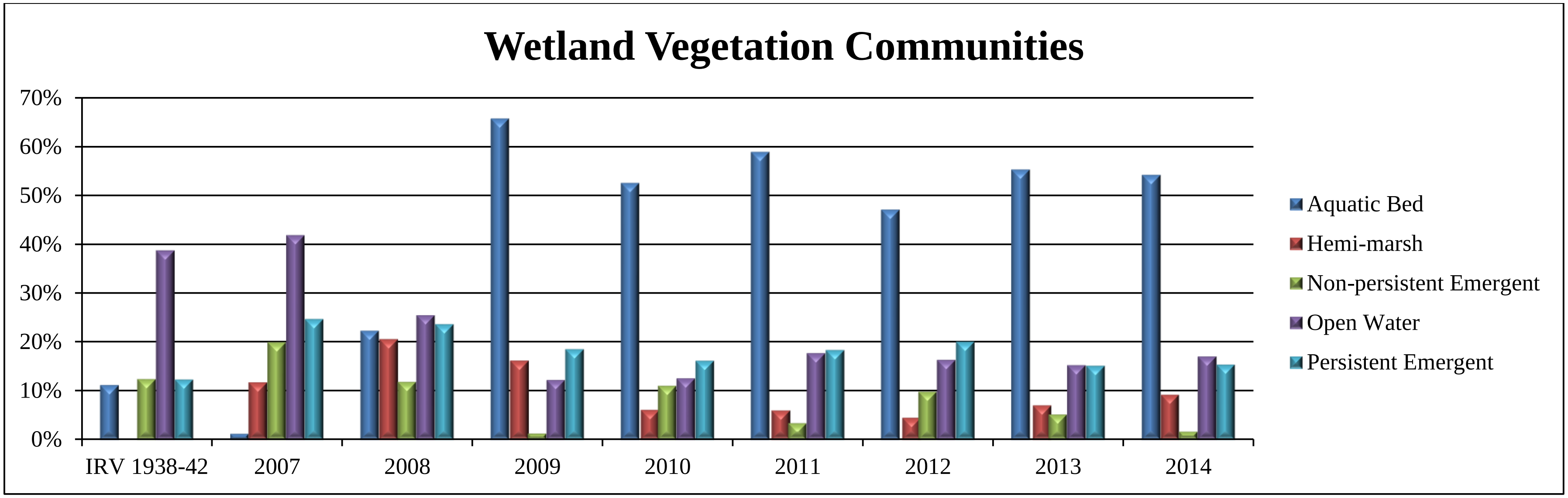


Figure 9. Proportional coverage of wetland vegetation communities at the Emiquon Preserve during early fall 2007–2014 and those historically present in IRV wetlands (1938–1942).

Table 1. Avian species observed during monitoring activities at The Emiquon Preserve, 2007–2014.

Species	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*
BLGO	Lesser snow goose (blue phase)	*Chen caerulescens*
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*
COGA	Common Gallinule	*Gallinula galeata*
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*

Table 1. Continued.

Species	Common Name	Scientific Name
LEBI	Least Bittern	*Ixobrychus exilis*
LESC	Lesser Scaup	*Aythya affinis*
LSGO	Lesser Snow Goose	*Chen caerulescens*
MAGO	Marbled Godwit	*Limosa fedoa*
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*
SACR	Sandhill Crane	*Grus canadensis*
SORA	Sora	*Porzana carolina*
TRUS	Trumpeter Swan	*Cygnus buccinator*
TUSW	Tundra Swan	*Cygnus columbianus*
WFIB	White-faced Ibis	*Plegadis chihi*
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, 2007−2014.

Common Name	Scientific Name
American Lotus	*Nelumbo lutea*
Arrowhead	*Sagittaria* spp.
Ash	*Fraxinus* spp.
Aster	*Aster spp.*
Barnyardgrass	*Echinochloa crus-galli*
Blackeyed Susan	*Rudbeckia hirta*
Black Willow	*Salix nigra*
Bog Bulrush	*Schoenoplectus mucronatus*
Boneset	*Eupatorium* spp.
Brittle Naiad	*Najas minor*
Broadleaf Cattail	*Typha latifolia*
Bur Reed	*Sparganium spp.*
Buttonweed	*Diodia virginiana*
Canada Wild Rye	*Elymus canadensis*
Cattail	*Typha spp.*
Chufa	*Cyperus esculentus*
Clover	*Trifolium spp.*
Cocklebur	*Xanthium strumarium*
Common Reed	*Phragmites spp.*
Coontail	*Ceratophyllum demersum*
Crabgrass	*Digitaria spp.*
Creeping Water Primrose	*Ludwigia peploides*
Curly Dock	*Rumex crispus*
Curly Pondweed	*Potamogeton crispus*
Dandelion	*Taraxacum officinale*
Decurrent False Aster	*Boltonia decurrens*
Devil's Beggartick	*Bidens frondosa*
Dogbane	*Apocynum* spp.
Dogwood	*Cornus spp.*
Duckweed	*Lemna minor*
Eastern Cottonwood	*Populus deltoides*
Elm	*Ulmus spp.*
Eurasian Watermilfoil	*Myriophyllum spicatum*
Fall Panicum	*Panicum dichotomiflorum*
Ferruginous Flatsedge (Rusty Nut Sedge)	*Cyperus ferruginescens*
Fescue	*Festuca spp.*

Table 2. Continued.

Common Name	Scientific Name
Fog Fruit	*Phyla spp.*
Foxtail	*Setaria spp.*
Giant Ragweed	*Ambrosia trifida*
Goldenrod	*Solidago spp.*
Hoary Vervain	*Verbena stricta*
Hooded Arrowhead	*Sagittaria calycina*
Hop Sedge	*Carex lupulina*
Horned Pondweed	*Zannichellia palustris*
Horseweed	*Conyza spp.*
Japanese Millet	*Echinochloa esculenta*
Lambsquarters	*Chenopodium album*
Largeseed Smartweed	*Polygonum pensylvanicum*
Lesser Ragweed	*Ambrosia artemisiifolia*
Locust	*Robinia spp.*
Longleaf Pondweed	*Potamogeton nodosus*
Long-leaved Ammania	*Ammania coccinea*
Maple	*Acer spp.*
Marestail	*Conyza spp.*
Marshpepper Smartweed	*Polygonum hydropiper*
Mint	*Mentha* spp.
Morning Glory	*Ipomoea spp.*
Mosquitofern	*Azolla spp.*
Mulberry	*Morus spp.*
Mullein	*Verbascum thapsus*
Muskgrass	*Chara spp.*
Naiad	*Najas* spp.
Narrowleaf Cattail	*Typha angustifolium*
Nodding Beggartick	*Bidens cernua*
Nodding Smartweed	*Polygonum lapathifolium*
Oak	*Quercus spp.*
Orange Jewelweed	*Impatiens capensis*
Panicum (Fall)	*Panicum dichotomiflorum*
Peach-leaved willow	*Salix amygdaloides*
Pecan	*Carya ilinoinensis*
Pigweed	*Amaranthus spp.*
Plantain	*Plantago spp.*
Pokeweed	*Phytolacca spp.*

Table 2. Continued

Common Name	Scientific Name
Prairie Cordgrass	*Spartina pectinata*
Prickly Sida	*Sida spinosa*
Purple Loosestrife	*Lythrum salicaria*
Ragweed	*Ambrosia spp.*
Rattlesnake Master	*Eryngium yuccifolium*
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*
Sedge	*Carex spp.*
Shallow Sedge	*Carex lurida*
Shattercane	*Sorghum bicolor*
Silver Maple	*Acer saccharinum*
Small Pondweed	*Potamogeton pusillis*
Smooth Brome	*Bromus inermis*
Softstem Bulrush	*Schoenoplectus tabernaemontani*
Sowthistle	*Sonchus spp.*
Spikerush	*Eleocharis spp.*
Sprangletop	*Leptochloa fusca*
Spurge	*Euphorbia spp.*
Switchgrass	*Panicum virgatum*
Tealgrass	*Eragrostis hypnoides*
Thistle	*Cirsium spp.*
Torrey's Rush	*Juncus torreyi*
Velvetleaf	*Abutilon spp.*
Walter's Millet	*Echinochloa walteri*
Watermeal	*Wolffia spp.*
Water Plantain	*Alisma spp.*
Watershield	*Brasenia schreberi*
Water Smartweed	*Polygonum amphibium*
Waterweed	*Elodea spp.*
White Turtlehead	*Chelone glabra linifolia*
Wild Carrot	*Daucus pusillus*
Willow	*Salix* spp.
Woolgrass	*Scirpus cyperinus*

Table 3. Estimates of waterfowl abundance from ground inventories at The Emiquon Preserve during spring 2014.

	Inventory Dates									
Species[a]	18 Feb	24 Feb	7 Mar	13 Mar	20 Mar	28 Mar	5 Apr	10 Apr	17 Apr	Total (%)
ABDU	0	0	0	0	0	0	0	0	2	2 (>0.1)
AGWT	0	0	0	0	225	3,661	5,776	766	2	10,430 (5.1)
AMWI	0	0	0	0	1,098	347	192	20	0	1,657 (0.8)
BUFF	0	0	0	385	694	366	553	926	43	2,967 (1.4)
BWTE	0	0	0	0	12	331	1,796	959	422	3,520 (1.7)
CAGO	45	0	475	122	30	70	38	36	17	833 (0.4)
CANV	0	0	0	577	4,295	3,607	2,270	390	33	11,172 (5.4)
COGO	0	0	250	1,115	537	20	0	1	0	1,923 (0.9)
COME	0	0	98	720	1,258	342	0	0	0	2,418 (1.2)
GADW	0	0	0	0	5,217	3,673	9,378	2,428	211	20,907 (10.1)
GWFG	0	0	2,020	250	375	600	0	200	0	3,445 (1.7)
HOME	0	0	0	110	238	203	0	0	0	551 (0.3)
LESC	0	0	38	3,228	9,403	3,639	6,336	3,002	349	25,995 (12.6)
LSGO	0	0	11,200	6,000	50,020	50	95	126	125	67,616 (32.8)
MALL	0	0	315	223	1,839	6,967	3,669	1,485	170	14,668 (7.1)
MUSW	0	0	0	2	10	7	8	6	4	37 (>0.1)
NOPI	0	0	0	198	250	0	0	1	0	449 (0.2)
NSHO	0	0	0	38	643	1,492	3,180	2,066	447	7,866 (3.8)
RBME	0	0	0	0	34	9	0	0	0	43 (>0.1)
REDH	0	0	0	0	192	1	4	0	0	197 (0.1)
RNDU	0	0	0	825	825	1,340	950	451	0	4,391 (2.1)
RUDU	0	0	0	313	6,104	5,116	8,764	3,385	1,144	24,826 (12.0)
SWAN	6	0	244	0	123	0	0	0	0	373 (0.2)
TRUS	0	0	30	0	0	13	10	8	0	61 (>0.1)
TUSW	13	0	0	0	0	0	0	0	0	13 (>0.1)
WODU	0	0	0	0	0	30	0	0	0	30 (>0.1)
Total	64	0	14,670	14,106	83,422	31,884	43,019	16,256	2,969	206,390

[a] See Table 1.

Table 4. Estimates of waterfowl abundance from aerial inventories at The Emiquon Preserve during spring 2014.

	Inventory Dates				
Species[a]	17 Mar	9 Apr	15 Apr	23 Apr	Total (%)
MALL	3,400	110	610	310	4,430 (3.4)
ABDU	0	0	0	0	0 (0.0)
NOPI	2,000	0	0	0	2,000 (1.5)
BWTE	0	275	255	550	1,080 (0.8)
AGWT	1,340	335	1,205	1,050	3,930 (3.0)
AMWI	0	0	0	0	0 (0.0)
GADW	4,400	580	615	200	5,795 (4.5)
NSHO	660	710	2,070	1,500	4,940 (3.8)
LESC	13,490	1,175	1,025	300	15,990 (12.3)
RNDU	7,700	765	410	50	8,925 (6.9)
CANV	14,450	225	410	5	15,090 (11.6)
REDH	210	225	205	0	640 (0.5)
RUDU	5,930	2,230	2,050	500	10,710 (8.2)
COGO	1,470	0	0	0	1,470 (1.1)
BUFF	800	225	205	50	1,280 (1.0)
COME	1,620	110	40	0	1,770 (1.4)
HOME	0	0	0	0	0 (0.0)
CAGO	10	10	25	20	65 (>0.1)
GWFG	600	500	525	50	1,675 (1.3)
LSGO	50,000	100	110	25	50,235 (38.6)
SWAN	70	102	10	8	190 (0.1)
Total	108,150	7,677	9,770	4,618	130,215

[a] See Table 1.

Table 5. Estimated waterfowl use days (UDs) and UDs per hectare (UDs/ha) at The Emiquon Preserve during spring and fall migrations.

	Spring		Fall	
Year	UDs[a]	UDs/ha	UDs[b]	UDs/ha
2007			1,416,082	5,617
2008	1,444,036	1,359	2,321,970	2,185
2009	2,373,627	1,317	3,439,975	1,908
2010	1,150,901	599	3,819,574	1,988
2011	2,239,686	1,230	4,354,668	2,392
2012	2,269,549	1,274	3,557,086	1,996
2013	1,699,743	954	3,548,098	1,825
2014	1,521,275	782	1,855,803	954

[a] Based on ground inventories.
[b]Based on aerial inventories. Fall ground inventories were discontinued after 2009.

Table 6. Estimates of waterfowl abundance from aerial inventories at The Emiquon Preserve during fall 2014.

	Inventory Dates																
Species	3 Sep	11 Sep	16 Sep	23 Sep	16 Oct	20 Oct	29 Oct	5 Nov	12 Nov	20 Nov	25 Nov	3 Dec	9 Dec	17 Dec	29 Dec	8 Jan	Total (%)
MALL	200	50	125	120	100	3,335	2,665	12,980	2,300	12,315	6,275	210	50	100	660	0	41,485 (17.0)
ABDU	0	0	0	0	0	0	5	0	0	10	5	0	0	0	0	0	20 (>0.1)
NOPI	595	300	600	300	4,260	10,760	4,275	6,390	50	0	30	0	0	0	0	0	27,560 (11.3)
BWTE	5,950	4,330	3,800	2,340	0	0	0	0	0	0	0	0	0	0	0	0	16,420 (6.7)
AGWT	1,190	3,730	1,600	1,170	2,840	5,380	4,275	6,390	100	0	0	0	0	0	0	0	26,675 (10.9)
AMWI	0	0	0	50	4,260	1,075	1,710	2,555	50	0	0	0	0	0	0	0	9,700 (4.0)
GADW	0	0	0	50	7,100	5,380	4,275	19,170	3,800	10	100	0	0	70	0	0	39,955 (16.3)
NSHO	595	1,110	700	1,170	2,840	0	4,275	12,780	400	0	0	0	0	0	0	0	23,870 (9.8)
LESC	0	0	0	0	0	0	855	12,780	0	0	0	0	0	15	0	10	13,660 (5.6)
RNDU	0	0	0	0	1,420	1,075	2,565	3,835	1,500	0	10	10	0	0	0	0	10,415 (4.3)
CANV	0	0	0	0	0	0	0	3,835	770	50	5	0	0	10	20	0	4,690 (1.9)
REDH	0	0	0	0	0	0	0	640	0	10	0	0	0	0	0	0	650 (0.3)
RUDU	0	0	0	0	500	300	2,565	12,780	1,500	330	105	0	0	20	0	0	18,100 (7.4)
COGO	0	0	0	0	0	0	0	0	0	500	430	560	150	500	2,010	0	4,150 (1.7)
BUFF	0	0	0	0	0	0	0	0	600	0	0	25	0	0	0	0	625 (0.3)
COME	0	0	0	0	0	0	0	0	0	0	175	550	580	1,550	1,250	60	4,165 (1.7)
HOME	0	0	0	0	0	0	0	0	150	10	170	0	25	240	40	0	635 (0.3)
CAGO	50	25	30	15	40	315	60	0	15	0	0	0	10	15	60	15	650 (0.3)
GWFG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	20	1,020 (0.4)
LSGO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
SWN	4	8	15	10	10	5	0	2	10	4	0	0	0	0	161	41	270 (0.1)
Total	8,584	9,553	6,870	5,225	23,370	27,625	27,525	94,137	11,245	13,239	7,305	1,355	815	2,520	5,201	146	244,715

Table 7. Estimates of waterbird and raptor abundance from ground inventories at The Emiquon Preserve during spring 2014.

	Inventory Dates									
Species[a]	18 Feb	24 Feb	7 Mar	13 Mar	20 Mar	28 Mar	5 Apr	10 Apr	17 Apr	Total (%)
AMCO	0	0	10	1,200	11,405	30,843	32,510	26,063	12,881	114,912 (98.3)
AWPE	0	0	0	0	160	360	85	191	20	816 (0.7)
BAEA	3	3	2	61	12	9	4	3	2	99 (0.1)
BEKI	0	0	0	0	0	0	0	0	2	2 (>0.1)
DCCO	0	0	0	0	14	293	170	292	206	975 (0.8)
GBHE	1	0	0	0	1	2	0	5	0	9 (>0.1)
GREG	0	0	0	0	0	0	0	0	0	0 (0.0)
GRYE	0	0	0	0	0	0	0	0	2	2 (>0.1)
HOGR	0	0	0	0	2	2	2	1	1	8 (>0.1)
NOHA	1	2	2	5	3	3	2	2	1	21 (>0.1)
PBGR	0	0	0	0	2	6	7	6	5	26 (>0.1)
RTHA	0	1	2	1	1	3	0	2	0	10 (>0.1)
SORA	0	0	0	0	0	0	0	0	1	1 (>0.1)
UNGU	0	0	0	0	0	0	0	0	1	1 (>0.1)
Total	5	6	16	1,267	11,600	31,521	32,780	26,565	13,122	116,882

[a] See Table 1.

Table 8. Estimates of waterbird and raptor abundance from aerial inventories at The Emiquon Preserve during spring 2014.

	Inventory Dates				
Species[a]	17 Mar	9 Apr	15 Apr	23 Apr	Total (%)
AMCO	2,000	33,825	13,735	5,030	54,590 (98.4)
AWPE	55	105	50	35	245 (0.4)
BAEA	13	2	3	2	20 (>0.1)
DCCO	0	90	150	390	630 (1.1)
Total	2,068	34,022	13,938	5,457	55,485

[a] See Table 1.

Table 9. Estimates of waterbird and raptor abundance from aerial inventories at The Emiquon Preserve during fall 2014.

	Inventory Dates																
Species[a]	3 Sep	11 Sep	16 Sep	23 Sep	16 Oct	20 Oct	29 Oct	5 Nov	12 Nov	20 Nov	25 Nov	3 Dec	9 Dec	17 Dec	29 Dec	8 Jan	Total (%)
AMCO	20	1,120	3,800	21,500	119,280	75,320	58,140	33,870	5,400	15	10	0	0	5	20	0	318,500 (98.5)
AWPE	380	730	235	280	130	80	115	60	30	0	0	0	0	0	0	0	2,040 (0.6)
BAEA	0	0	0	0	0	4	0	2	1	31	24	11	35	10	16	7	141 (>0.1)
DCCO	800	335	400	600	220	185	55	20	5	0	0	0	0	0	0	0	2,620 (0.8)
Total	1,200	2,185	4,435	22,380	119,630	75,589	58,310	33,952	5,436	46	34	11	35	15	36	7	323,301

[a] See Table 1.

Table 10. Duck behavior (%) by month and guild at The Emiquon Preserve during spring 2014.

		Activity				
Guild	Month	Feed	Rest	Other	Social	Locomotion
Dabbling Ducks	April	26.7	17.5	15.0	4.9	35.8
Diving Ducks	March	33.3	32.1	5.3	0.7	28.6
	April	66.0	23.6	7.4	0.0	2.9
	Average	39.8	30.4	5.7	0.5	23.5
All Ducks		36.1	26.7	8.3	1.8	27.0

Table 11. Waterbird brood observations by species at The Emiquon Preserve, 2014.

	Observation Dates								
Species[a]	15 May	29 May	12 Jun	26 Jun	9 Jul	23 Jul	12 Aug	Total Broods	%
AMCO	0	0	0	0	0	1	0	1	1.8
CAGO	9	9	6	0	1	0	0	25	45.5
COGA	0	0	0	0	0	0	4	4	7.3
MALL	0	0	1	0	0	1	0	2	3.6
PBGR	0	0	0	0	0	0	1	1	1.8
WODU	0	0	2	3	5	8	4	22	40.0
Total	9	9	9	3	6	10	9	55	
Mean Age[b]	1B	1C	2B	1C	2C	2B	2B		

[a] See Table 1.

[b] Gollop and Marshall 1954

Table 12. Abundance (mg/m^3, dry mass) and percent occurrence of aquatic invertebrates collected in net sweeps at The Emiquon Preserve, August 2014.

Taxa	Biomass (mg/m^3)[a]	Percent Occurrence
Bivalvia		
Sphaeriidae	0.5	7.7
Gastropoda		
Planorbidae	14.6	61.5
Physidae	4.9	51.3
Ostracoda	0.1	43.6
Cladocera	0.4	92.3
Copepoda	0.5	89.7
Amphipoda	5.1	79.5
Arachnida		
Araneae	0.2	25.6
Acari	0.3	56.4
Collembola	0.1	35.9
Coleoptera		
Curculionidae	0.6	28.2
Dytiscidae	0.4	41.0
Elmidae	0.2	12.8
Haliplidae	0.3	7.7
Hydrophilidae	0.2	23.1
Noteridae	0.7	23.1
Ptiliidae	0.0	2.6
Scirtidae	0.0	2.6
Diptera		
Ceratapogonidae	1.2	74.4
Chaoboridae	0.0	5.1
Chironomidae	1.7	100.0
Culicidae	0.1	17.9
Psychodidae	0.0	2.6
Sciomyzidae	0.0	5.1
Stratiomyidae	0.2	30.8
Tipulidae	0.1	7.7
Unknown	0.0	7.7
Ephemeroptera		
Baetidae	0.3	30.8
Caenidae	1.1	71.8
Ephemeridae	0.0	2.6

Table 12. Continued

Taxa	Biomass (mg/m^3)[a]	Percent Occurrence
Hemiptera		
Aphididae	0.9	35.9
Belostomatidae	0.2	2.6
Corixidae	0.0	5.1
Gerridae	0.0	2.6
Mesoveliidae	0.1	30.8
Notonectidae	0.3	2.6
Pleidae	0.7	48.7
Veliidae	0.0	30.8
Lepidoptera		
Pyralidae	0.6	35.9
Odonata		
Coenagrionidae	1.6	76.9
Corduliidae	0.0	2.6
Libellulidae	2.0	61.5
Trichoptera		
Leptoceridae	0.0	5.1
Hydroptilidae	0.0	2.6
Unknown	0.0	2.6
Turbellaria		
Unknown	0.3	51.3
Rotifera	0.0	25.6
Nematoda	0.0	46.2
Oligochaeta	7.2	100.0
Hirudinea		
Glossiphonidae	0.3	12.8
Unknown	0.0	2.6
Hydra	0.2	56.4
Bryozoa	2.2	17.9

Table 13. Moist-soil plant seed abundance (kg/ha, dry mass) and energetic use days (EUD) per hectare at The Emiquon Preserve, 2007−2014.

Year	Seed Size[a]	n	Abundance $\bar{x}$	Abundance SE	Abundance CV (%)	EUDs $\bar{x}$	EUDs 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
2010	Large	20	421.9	112.3	26.6	3,612	962
	Small	20	207.6	64.5	31.1	1,778	552
	Total	20	629.5	114.5	18.2	5,389	1,237
2011	Large	20	937.2	184.8	19.7	8,024.2	1,582.3
	Small	20	179.0	39.8	22.2	1,532.6	340.6
	Total	20	1,116.2	193.3	17.3	9,556.8	1,654.6
2012	Large	20	411.6	93.7	22.8	3,524.2	802.1
	Small	20	111.1	38.2	34.4	951.3	327.3
	Total	20	522.7	96.2	18.4	4,475.4	823.6
2013	Large	30	489.2	77.4	15.8	4,188.3	663.0
	Small	30	139.7	30.4	21.8	1,196.1	260.7
	Total	30	633.9	76.4	12.1	5,427.5	654.1
2014	Large	30	754.5	133.5	17.7	5,596.9	990.7
	Small	30	361.0	185.8	51.5	2,678.5	1,378.1
	Total	30	1,115.5	211.3	18.9	8,275.4	1,567.8
IDNR[b]	Large	735	383.6	89.7	23.4	2,846	665
	Small	735	308.6	66.4	21.5	2,289	493
	Total	735	691.3	56.4	8.2	5,128	418

[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. 2011).

Table 14. Energetic carrying capacity expressed as energetic use days (EUDs) for diving ducks and dabbling ducks at Emiquon during fall 2014.

		Diving Ducks		Dabbling Ducks	
Vegetation Community	ha	EUDs/ha	Total EUDs	EUDs/ha	Total EUDs
Aquatic Bed	1,089.9	23,348.0	25,447,002	10,689.3	11,650,284
Hemi-Marsh	178.6	34,140.7	6,097,529	6,207.4	1,108,645
Open Water	332.9	1,543.1	513,700	6.6	2,209
Persistent Emergent	297.7	6,097.1	1,815,099	931.8	277,385
Moist-Soil	33.7	8,275.4	278,882	8,275.4	278,882
Total	1,932.8	17,669.8	34,152,212	6,890.2	13,317,405

Table 15. Area and proportions of vegetation communities at The Emiquon Preserve during fall, 2007−2014.

	2007		2008		2009		2010	
Vegetation Community	Ha	%	Ha	%	Ha	%	Ha	%
American Lotus	0.0	0.0	0.1	0.0	0.6	0.0	1.0	0.1
Aquatic Bed	2.6	1.0	238.1	22.1	1,185.7	65.7	1,036.3	52.5
Bottomland Forest	0.0	0.0	0.2	0.0	0.8	0.0	1.0	0.0
Brasenia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cattail	25.5	10.0	33.1	3.1	38.1	2.1	N/A[b]	N/A
Coontail	0.4	0.2	2.6	0.2	N/A[a]	N/A	N/A[a]	N/A
Ditch	18.7	7.3	15.4	1.4	12.2	0.7	14.0	0.7
Hemi-marsh	29.9	11.7	220.5	20.5	290.4	16.1	119.8	6.1
Mudflat	3.5	1.4	0.0	0.0	0.0	0.0	83.2	4.2
Non-persistent Emergent	50.7	19.9	127.3	11.8	23.6	1.3	217.7	11.0
Open Water	106.4	41.8	275.1	25.5	221.3	12.3	248.7	12.6
Persistent Emergent	7.4	2.9	0.2	0.0	6.2	0.3	199.0	10.1
Scrub Shrub	6.9	2.7	1.4	0.1	1.7	0.1	0.3	0.0
Upland	2.7	1.0	14.7	1.4	1.1	0.1	53.1	2.7
Upland - Wet	0.0	0.0	147.9	13.7	16.1	0.9	N/A	N/A
Willow	0.2	0.1	0.7	0.1	0.1	0.0	N/A[c]	N/A
Total Area	254.7		1,077.2		1,803.9		1,974.1	

Table 15 Continued.

	2011		2012		2013		2014	
Vegetation Community	Ha	%	Ha	%	Ha	%	Ha	%
American Lotus	4.1	0.2	8.8	0.5	16.9	0.9	35.0	1.8
Aquatic Bed	1,071.7	58.9	839.5	47.1	1,074.8	55.3	1,054.8	54.3
Bottomland Forest	1.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Brasenia	0.1	0.0	0.2	0.0	0.2	0.0	N/A[d]	N/A
Cattail	N/A[b]	N/A	N/A[b]	N/A	N/A[b]	N/A	N/A[b]	N/A
Coontail	N/A[a]	N/A	N/A[a]	N/A	N/A[a]	N/A	N/A[a]	N/A
Ditch	11.6	0.6	13.6	0.8	11.5	0.6	N/A[e]	N/A
Hemi-marsh	109.3	6.0	80.7	4.5	135.4	7.0	178.7	9.2
Mudflat	11.8	0.6	93.4	5.2	0.0	0.0	0.0	0.0
Non-persistent Emergent	61.5	3.4	174.4	9.8	101.3	5.2	33.7	1.7
Open Water	323.5	17.8	292.4	16.4	298.2	15.3	332.9	17.1
Persistent Emergent	223.3	12.3	276.2	15.5	294.3	15.1	297.7	15.3
Scrub Shrub	2.3	0.1	2.7	0.2	10.9	0.6	11.3	0.6
Upland	0.2	0.0	0.2	0.0	N/A	N/A	N/A	N/A
Upland - Wet	N/A	N/A	N/A	N/A	0.1	0.0	0.0	0.0
Willow	N/A[c]	N/A	N/A[c]	N/A	N/A[c]	N/A	N/A[c]	N/A
Total Area	1,820.6		1,782.3		1,943.6		1,944.2	

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

[b] Cattail was included with persistent emergent or hemi-marsh in 2010.

[c] Willow was included with scrub-shrub or bottomland forest in 2010.

[d] Included with American lotus.

[e] Ditch category was eliminated in 2014.

Appendix A. Conservation targets and Key Ecological Attributes (KEAs) of The Nature Conservancy at The Emiquon Preserve during 2007−2014 for waterbird and wetland monitoring objectives with observed values good (green), fair (yellow), or poor (red) relative to desired ranges. Red text indicates proposed modifications to facilitate quantification of target ranges using data collected by Forbes Biological Station.

#	Conservation Target	KEA	Indicator	Desired range	2007	2008	2009	2010	2011	2012	2013	2014	Notes
1	Emergent / Floating-leaved vegetation	Community Composition	Cattail, river bulrush, bur reed dominance	Hemi-marsh conditions, 25-75% emergent vegetation, Poor = <10% of wetland area, Fair = 10–15% of wetland area, Good = >15% of wetland area	11.7	20.5	16.1	6	6	4.5	7	9.2	Revised: Split
2			Cattail, river bulrush, bur reed dominance	Any one species (e.g., cattails) should represent <50% of the emergent plant community.	No	No	No	No	No	No	No	No	Revised: Split
3	Moist-soil Vegetation	Community Composition	Native versus exotic species	<10% cumulative composition of exotic species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
4			Non-woody invasives	<50% goldenrod, cocklebur, and other undesirable species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	New/Proposed
5			Woody encroachment	<25% coverage woody invasive species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	New/Proposed
6			Forb and grass coverage	forbs ≥10% coverage	-	-	-	-	-	-	Yes	Yes	
7	Other Wetland Birds	Nesting	Brood Species Richness	GOOD = >5 species; FAIR = 3-4 species; POOR = <3 species	-	3	2	1	3	3	3	3	Revised
8			AMCO Brood density	>1 brood/km2	-	1.2	1.4	0	0.1	0.1	1.0	.04	New/Proposed

Appendix A. Continued.

#	Conservation Target	KEA	Indicator	Desired range	2007	2008	2009	2010	2011	2012	2013	2014	Notes
9	Waterfowl	Disturbance	Disturbance from human activity	≥50% of Emiquon should be classified as "refuge" (KEA 2010 document)	-	-	-	-	-	Yes	-	-	Revised
10		Foraging Habitat	Moist-soil Seed Production	Desired range: at least 578 kg/ha with seed available in moist soil wetlands. EXCELLENT = >800 kg/ha	992 kg/ha	495 kg/ha	235 kg/ha	630 kg/ha	1,116 kg/ha	523 kg/ha	634 kg/ha	1,115 kg/ha	
11			Total Dabbler+Diver use days (Fall)	GOOD = >2,000 UDs/ha; FAIR = 1,500-2,000 UDs/ha; POOR = <1,500 UDs/ha	4,834	2,104	1,857	1,951	2,338	1,893	1,780	933	
12			Relative Dabbler+Diver use days (Fall)	>Top 5 IRV Lakes average UD/ha	151%	45%	17%	74%	45%	-10%	-38%	-50%	New/Proposed
13			Total Non-Mallard Dabbling Duck use days (Fall)	EXCELLENT = >1,477 UDs/ha; GOOD = 903-1,477 UDs/ha; FAIR = 783-902 UDs/ha; POOR = <782 UDs/ha	3,821	1,261	1,082	1,507	1,680	1,437	1,391	598	New/Proposed
14			Relative Non-Mallard Dabbling Duck use days (Fall)	>Top 5 IRV Lakes average UD/ha	250%	132%	105%	108%	88%	45%	-25%	-37%	New/Proposed
15			Total Diving Duck use days (Fall)	EXCELLENT = >375 UDs/ha; GOOD = 288-374 UDs/ha; FAIR = 189-287 UD/ha; POOR = <188 UDs/ha	21	69	438	158	190	157	167	194	New/Proposed
16			Relative Diving Duck use days (Fall)	>Top 5 IRV Lakes average UD/ha	-80%	112%	32%	36%	27%	-43%	-51%	5%	New/Proposed
17			Total Diving Duck use days (Spring)	>405 UDs/ha	-	757	516	300	316	292	170	270	New/proposed
18		Nesting	Brood counts	>0.15 broods/ha peak survey (15 b/km2)	-	10	14	18	15	16	5	4	Revised

Submitted by:

Heath M. Hagy, Ph.D., AWB
Principal Investigator
Director – Forbes Biological Station
Illinois Natural History Survey

Date: 3 September 2015