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Waterbird and Wetland Monitoring at The Emiquon Preserve

Annual Report 2013

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INTRODUCTION

The Nature Conservancy (TNC) identified key ecological attributes (hereafter, KEAs) of specific biological characteristics or ecological processes that would guide and evaluate success of their restoration efforts 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 2013 to evaluate restoration success relative to desired conditions under the relevant KEAs. Our primary efforts included evaluating: 1) abundance, diversity, and behavior of waterfowl and other waterbirds through counts and observations; 2) productivity by waterfowl and other waterbirds through brood counts; 3) plant seed and invertebrate biomass to understand energetic carrying capacity for waterfowl during migration and breeding; and 4) composition and arrangement of wetland vegetation communities 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. Spring inventories 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 American coots, American white pelicans, bald eagles, double-crested cormorants, and waterfowl abundances 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 also expressed duck use estimates as UDs per ha of wetland (UDs/ha) to standardize for wetland size.

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 narrated 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 2013 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 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). Samples containing >200 individuals of a single invertebrate taxa were sub-sampled (up to ¼) using a Folsom plankton splitter. We converted invertebrate biomass estimates to per-unit-volume (mg/m^3) to account for different volumes of water sampled at various water depths.

Moist-soil Plant Seeds

During early fall 2013, 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 (≥2.5% by mass) of some 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 combined small and large seed masses to estimate total seed biomass per core (Stafford et al. 2011). We used biomass data from core samples to estimate overall moist-soil plant seed abundance (kg/ha; dry mass) using PROC MEANS in SAS v9.2 (SAS Institute, Inc., Cary, NC).

We used our overall estimates of seed abundance to estimate energetic carrying capacity for waterfowl, expressed as 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 a mallard of 292 kcal/day (Prince 1979, Reinecke et al. 1989) for EUD calculations.

Energetic Carrying Capacity

During fall 2013, we collected seeds, invertebrates, and plants at random locations within each of the 4 dominant vegetation communities 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 until processed. 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) in a ¼ 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 then identified seeds and tubers to Order or Family and dried them for ≥24 hours at 60° C. Seeds and tubers were weighed 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 x 45 x 65 cm) 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 collected box samples in ≤46 cm of water (approximate depth available to dabbling ducks) at random locations within each of the 4 dominant vegetation communities. We 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 ¼ 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 abundance 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, and vegetation communities during fall 2013. 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 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 or other physical features (e.g., vegetation islands, ditches) outside transects. We digitized wetland vegetation in ArcGIS 10.1 using field notes and GPS waypoints overlaid on high-resolution color infrared aerial photographs from 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 at Emiquon generally followed those defined by Cowardin et al. (1979) and Suloway and Hubbell (1994). Woody vegetation was classified as bottomland forest if trees were >6 m in height or scrub-shrub if trees were ≤6 m tall (Cowardin et al. 1979). Other wetland classifications included non-persistent emergent vegetation (e.g., moist-soil plants; Fredrickson and Taylor 1982), persistent emergent vegetation (e.g., cattails and bulrushes), mudflats, floating-leaved aquatic vegetation (e.g., American lotus and watershield), aquatic bed (e.g., coontail), hemi-marsh (open water interspersed with persistent emergent; Weller and Spatcher 1965), and open water (flooded habitat without vegetation; Cowardin et al. 1979, Suloway and Hubbell 1994, Stafford et al. 2010). We also included a category to account for areas of upland vegetation (e.g., goldenrod and foxtail) growing within the wetland basin that had been inundated or insular.

We attempted to be as descriptive as possible when categorizing wetland vegetation and, as such, it was possible for some plant species to occur in multiple categories. For instance, cattail was present in 2 vegetation classes: hemi-marsh and persistent emergent. We categorized cattail as hemi-marsh if there was approximately even interspersion of cattail and open water or aquatic bed (i.e., 30–70% cover of emergent vegetation by ocular estimate). We classified cattail as persistent emergent when accompanied by other persistent emergent species, such as bulrush and bur reed. Likewise, willows occurred in multiple categories (i.e., bottomland forest and scrub-shrub).

RESULTS

Waterfowl Abundance

Spring–Fall, 2013. We conducted 10 ground inventories from 13 February to 17 April (Table 3) and 5 aerial inventories from 8 March to 2 April 2013 (Table 4). Peak waterfowl abundance reached 80,785 during a ground inventory on 13 February and 151,010 on 8 March during an aerial inventory. We observed 24 species of waterfowl during spring (18 duck species, 3 goose species, and 3 swan species). Lesser snow geese were the most abundant species during ground inventories, accounting for 31.2% of total waterfowl abundance, followed by mallards (11.5%) and ruddy ducks (11.3%). Similar to 2012, dabbling ducks were more abundant than diving ducks, accounting for 40.5% and 20.7% of the total waterfowl abundance, respectively. Spring waterfowl UDs were 1,699,743 in 2013, representing a 25% decline from spring 2012 and the lowest spring UD estimate since 2010 (1,150,901 UDs; Table 5). Dabbling ducks (644,695 UDs; Fig.2) contributed 37.9% of the spring waterfowl use at Emiquon, while diving ducks (338,290 UDs; Fig.2) accounted for 19.9% of the use.

We conducted 16 aerial inventories at Emiquon from 3 September 2013 to 8 January 2014 (Table 6). We observed 18 species of waterfowl (15 duck species, 2 goose species, and unidentified swan species) with a peak abundance of 107,885 on 28 October. Gadwall (23.5%) were the most abundant species, followed by northern pintail (18.7%), mallard (13.3%), and northern shoveler (12.6%). Estimated waterfowl UDs at Emiquon totaled 3,548,098 during fall (Table 5). Dabbling ducks (3,195,675 UDs; Fig. 3) accounted for 90.1% of UDs, whereas only 9.4% of waterfowl UDs was attributable to diving ducks (332,068 UDs; Fig. 3). Waterfowl UDs at Emiquon in fall 2013 were similar to 2012 (3,557,086 UDs), and they were above the 2007–2012 average (3,151,559 UDs). Dabbling duck (+2%) and diving duck (+6%) UDs in fall 2013 exhibited modest increases over 2012 estimates (dabbling ducks – 3,137,278 UDs; diving ducks – 312,630 UDs), and remained 14% and 6% above the 6-year average, respectively.

Non-Waterfowl Abundance

Spring–Fall, 2013. We documented 12 waterbird and raptor species during ground counts in spring 2013 (Table 7). Peak abundance of non-waterfowl species observed during ground inventories was 10,838 individuals on 17 April, whereas aerial inventories revealed a peak of 13,937 individuals on 22 March (Table 8). American coots were the most common species observed and accounted for 93.6% and 96.7% of non-waterfowl abundance based on ground and aerial inventories, respectively. American coot abundance peaked at 10,118 (13,800 via aerial inventories), while their overall use of Emiquon totaled 202,128 UDs (Fig. 2). Other commonly observed species included American white pelicans (3.1%), double-crested cormorants (2.3%), and bald eagles (0.7%).

American coots were the most abundant species during 16 aerial inventories in fall 2013 (Table 9). The peak estimate of American coots was 113,400 on 23 October; constituting 99.1% of non-waterfowl abundance during fall. Likewise, American coots accounted for 98.9% (3,823,533 UDs; Fig. 3) of non-waterfowl use, followed by American white pelicans (0.5%) and double-crested cormorants (0.5%). American coot UDs in fall 2013 increased 50.5% from fall 2012 (2,540,330 UDs) and represented the highest UD estimate for this species since the peak in 2009 (4,249,563 UDs). Similarly, fall UDs of American coots in 2013 were 52.4% greater than the 2007–2012 average (2,509,319 UDs). Finally, American coots contributed 52% of all waterbird use (including waterfowl) during fall at Emiquon.

Duck Behavior

We conducted behavior observations (n = 5,624) between 13 February and 11 April 2013. Species observed included American green-winged teal, canvasback, gadwall, lesser scaup, mallard, northern pintail, northern shoveler, and ruddy duck. These species spent most of their time feeding (44.9%), followed by resting (25.5%; Table 10, Fig. 4). Dabbling ducks spent 61.8% of their time feeding, while diving ducks spent 33.5% of their time feeding. Diving ducks were observed feeding and resting (33.7%) equally. This is the second largest proportion of time allocated to feeding by diving ducks since 2009 (36.3%).

Brood Observations

We conducted fixed-point brood surveys (*n* = 8) from 15 May to 21 August 2013 and observed 53 waterbird broods comprised of 6 species, including the state-threatened common gallinule (Table 11). The most abundant broods recorded in 2013 were wood ducks (*n* = 22), American coots (*n* = 16) and Canada geese (*n* = 9). Brood observations peaked (*n* = 26) on 21 August, and this single survey accounted for nearly half of all broods observed in 2013. Average age classes of broods increased throughout the observation period.

Aquatic Invertebrates

We collected invertebrates via sweep net (*n* = 40 samples) on 13 August along the shores of Thompson and Flag lakes. Mean water volume sampled per sweep was 1.3 m^3, and invertebrate biomass averaged 158.1 mg/m^3 of water (Fig. 5). We identified 57 taxa with Cladocera, Copepoda, Oligochaeta, and Physidae occurring in all samples. Physidae (57.4 mg/m^3), Planorbidae (37.6 mg/m^3), and Aeshnidae (17.1 mg/m^3) accounted for the greatest biomass per volume (Table 12).

Moist-soil Plant Seeds

We collected soil cores (*n* = 30) at random locations along the east shore of Flag Lake and the west shore of Thompson Lake during 4–9 October to estimate seed abundance (kg/ha) and energetic carrying capacity of moist-soil plants for waterfowl. Average moist-soil plant seed biomass was 633.9 kg/ha (dry mass; Table 13, Fig. 6a). Large seeds contributed 489.2 kg/ha, whereas small seeds accounted for 139.7 kg/ha. The estimated energetic carrying capacity from moist-soil plant seeds in 2013 was 5,427.5 EUDs/ha (Fig. 6b).

Energetic Carrying Capacity

We collected benthic core (n = 15) and box samples (n = 15) from random locations within each of 4 dominant vegetation communities (n = 120 samples total): aquatic bed, hemi-marsh, persistent emergent, and open water during 4–9 October to estimate total energetic carrying capacity for waterfowl from invertebrates, seeds, and plant material produced at Emiquon. Hemi-marsh (2,177.8 kg/ha) produced the greatest amount of waterfowl forage per unit area, followed by aquatic bed (1,534.2 kg/ha), persistent emergent (656.3 kg/ha), moist-soil (633.9 kg/ha), and open water (608.4 kg/ha). The aquatic bed community provided the highest energetic carrying capacity per unit area with 9,198.3 EUDs/ha, followed by hemi-marsh (9,076.2 EUDs/ha), moist-soil (5,427.5 EUDs/ha), open water (3,123.7 EUDs/ha), and persistent emergent (2,909.6 EUDs/ha; Table14, Fig. 7). Overall energetic carrying capacity for waterfowl during fall 2013 totaled 13,485,015 EUDs at Emiquon. Aquatic bed (9,886,350.1 EUDs) contributed the most overall forage, followed by hemi-marsh (1,228,918.6 EUDs), open water (967,395.3 EUDs), persistent emergent (856,280.9 EUDs), and moist-soil plants (546,070.2 EUDs).

Wetland Covermapping

We mapped all wetland vegetation associated with Thompson and Flag lakes during 23 August–6 September and documented 8 vegetation communities (Fig. 8). Aquatic bed (1,074.8 ha) was most abundant, followed by open water (298.2 ha), persistent emergent (294.3 ha), hemi-marsh (135.4 ha), and non-persistent emergent (101.3 ha; Table 15). We covermapped 1,943.6 ha and documented 73 plant taxa in 2013.

Species composition data from randomly-selected 1 m^2 plots indicated nearly half (49.7%) of the aquatic bed community contained longleaf pondweed, followed by Eurasian water milfoil (27.0%), coontail (16.7%), and sago pondweed (6.7%). The hemi-marsh community contained mostly Eurasian water milfoil (51.7%) and coontail (25%), with lesser proportions of longleaf pondweed (12.3%) and cattail (5.7%). Non-persistent emergent vegetation at Emiquon was mostly comprised of rice cutgrass (43.0%), creeping water primrose (9.5%), barnyardgrass (8.3%), ferruginous flatsedge (6.7%), and reed canarygrass (6.3%). Lastly, the persistent emergent vegetation community was dominated by cattail (94.9%), while duckweed (1.3%), watermeal (1.3%), and coontail (1.0%) were much less important.

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 2013 brought below normal temperatures during February (-0.1° C), March (-3.6° C), and April (-1.1° C) and above normal precipitation in February (+1.8 cm) and April (+8.4 cm; Angel 2013). March went from the warmest on record in 2012 to ranking as one of the coldest (11^{th}) in 2013. Accordingly, duck use (982,985 UDs) of Emiquon in spring 2013 declined 25% from 2012 and was the lowest observed during all seasons and years. Dabbling ducks (644,695 UDs) and non-mallard dabbling ducks (44,659 UDs) declined 17% and 24%, respectively from spring 2012. Despite this decline, dabbling (66%) and non-mallard dabbling ducks (45%) in 2013 still represented the highest proportions of spring duck use during 2008–2013 (Fig. 2). Emiquon still supported more than 17,000 waterfowl during the last inventory on 17 April, giving further evidence of the late spring migration in 2013 (Table 3).

Goals for spring diving duck abundance at Emiquon are not specified under current KEAs. Consequently, we proposed to use the simple mean diving duck UDs/ha during 2008–

2013 to assess spring diving duck use at Emiquon (App. A). Diving duck use in 2013 (190 UDs/ha) was the lowest observed at Emiquon, representing a 76% decline from the peak (785 UDs/ha) in 2008 and 53% below the average (405 UDs/ha) during spring. Likewise, diving duck UDs have exhibited a significant decline (-64%) since 2009 and dropped 47% below the average in spring 2013. Furthermore, diving ducks contributed only 34% of the duck use in spring 2013 compared to 58% in 2008 and 2010, whereas diving ducks contributed 50% of the spring duck UDs during the entire 6 years of monitoring (Fig. 2). The timing of the diving duck decline corresponded with apparent downward trends in hemi-marsh, aquatic invertebrate biomass, and to a lesser degree, area of aquatic bed during fall.

Fall

Total duck UDs/ha in fall 2013 (n = 1,816) ranked fair according to current KEA goals, but they've declined for a second consecutive year (App. A). Overall duck use was largely comprised of non-mallard dabbling ducks (78%), particularly gadwall (22%), northern pintail (20%), and northern shoveler (14%). The desired range for non-mallard dabbling duck use at Emiquon is 33–51% of the non-mallard dabbling duck use in the IRV, the proportions observed during 2007–2010. The proportion of IRV non-mallard dabbling ducks at Emiquon was only 16.6% in 2013, which is the lowest observed to date and the second consecutive year it has dropped below the desired range. This proportion has been declining since the high in 2009 (51.3%), while non-mallard dabbling duck UDs in the IRV have increased during the same period. Non-mallard dabbling duck use (1,420 UDs/ha) of Emiquon in 2013 was similar to that of 2012 (1,470 UDs/ha) and was rated as good under proposed KEAs based on average long-term use at CNWR, but fell 9% below the mean of the top 5 non-mallard dabbling duck locations in the IRV (App. A). Disturbance associated with increased waterfowl hunting activity, the enlarged wetland area at Emiquon, and relatively good forage quality in other IRV wetlands (A.P. Yetter, unpublished data), may have contributed to the observed changes in duck UDs during fall 2013. For instance, CNWR achieved successful drawdowns in the north and south pools during summer 2013 resulting in fall non-mallard dabbling duck use (2,863.3 UDs/ha) that was nearly 12 times greater than the 2007–2012 average (226.7 UDs/ha). Moreover, peak duck abundance at Emiquon occurred early (28 October) in 2013, shortly after (2 days) the start of waterfowl hunting season, followed by a precipitous decline. Duck abundance in the IRV also experienced a relatively early peak on 8 November compared to 12 December in 2012 (Yetter et al. 2014). The KEA related to fall diving duck UDs states that Emiquon should support 29–42% (2008–2010 observed range) of the diving duck use in the IRV. Emiquon fell short of this goal, as it contributed only 14% of the diving duck use in 2013. Likewise, diving duck use (172 UDs/ha) increased slightly from 2012 (161 UDs/ha) but remained well below proposed goals (App. A). The expanded hunting activity since 2012 may have influenced use by diving ducks more than other guilds, as diving ducks have been documented to be especially susceptible to disturbance (Thornburg 1973, Korschgen et al. 1985, Havera et al. 1992, Knapton et al. 2000). Declines in fall diving duck abundance in the IRV began in the 1950s and have yet to recover (Havera 1999). Correspondingly, important forage resources, such as aquatic plants and benthic invertebrates also declined in the IRV during that time. Their declines were attributed to a combination of sedimentation and chemical pollution, especially ammonia (Havera 1999).

We used standardized fall duck use estimates to compare Emiquon with other backwater lakes in the IRV (App. A). We calculated the mean duck UDs/ha for 5 IRV lakes with the greatest duck use during fall 2013 relative to duck use at Emiquon. Emiquon ranked fourth in total duck UDs/ha and dropped 28% below the average. This was the first year Emiquon dropped below the mean, and in most other years it had readily exceeded it. Conversely, Emiquon supported the second highest non-mallard dabbling duck UDs/ha in the IRV but fell short of the mean by 9%. Similar to total ducks, diving duck UDs/ha ranked fourth in the IRV with an estimate that was 47% below the average (App. A). This was the second consecutive year diving duck UDs/ha at Emiquon fell below the average.

Non-waterfowl Abundance

Spring

The late spring conditions also were reflected in abundances of non-waterfowl avifauna observed at Emiquon. Similar to waterfowl, we witnessed dramatic reductions in waterbird use in spring 2013. The peak ground count of non-waterfowl avifauna occurred 3 weeks later than the 2012 peak (23 March), and it was 62% lower than that of 2012 (28,741). Similarly, aerial inventories indicated a later non-waterfowl peak abundance that was 46% less than the peak in spring 2012. Non-waterfowl abundance fell 71% from spring 2012, and it was the lowest observed at Emiquon in either season (Tables 7 and 8). American coot use (202,128 UDs) of Emiquon also was the lowest observed in either season during 2007–2013. Coot UDs in 2013 represented a 75% decline from spring 2012 and an 85% drop from the peak in spring 2009. American coot abundance did not peak at Emiquon until the last ground inventory on 17 April 2013 (Table 7). Similarly, double-crested cormorants (4,798 UDs) exhibited a 70% reduction in use from spring 2012 and an 85% fall from peak UDs in 2010 (Fig. 5b). Furthermore, American white pelicans did not use Emiquon (-66%) during the monitoring period in spring 2013 (6,271 UDs) as much as they did in 2012. American white pelican UDs in spring 2013 were 81% less than their peak in 2010. Despite these astounding reductions in waterbird abundance, bald eagles continued to increase their use of Emiquon in spring 2013. Bald eagle use (1,921 UDs) increased 26% from 2012, representing the most UDs documented in either season for eagles at Emiquon during 2007–2013.

Fall

Use days of American coots in fall 2013 recovered from a 15% decline between 2011 and 2012. However, the proportion of American coots in the IRV using Emiquon (51%) in fall 2013 was the lowest since 2007 (50%; Fig. 3). The proportion of IRV coots at Emiquon has exhibited a downward trend since 2008. Furthermore, some of the decline in proportional use during 2013 may be attributed to restoration efforts at Hennepin and Hopper lakes, which contributed 22% (1,657,945 UDs) of the American coot UDs in the IRV. Bald eagle use of Emiquon in fall 2013 (411 UDs) increased 16% from 2012 and represented the 2nd highest UD estimate since monitoring began. Double-crested cormorant UDs in 2013 (n = 18,290) more than doubled the 2012 estimate (8,860 UDs) but remained 25% below the peak in 2011 (24,523 UDs). Conversely, American white pelicans UDs plummeted 75% in 2013 (20,870 UDs) from a high of 82,083 UDs in fall 2012. Similar to coots, numbers of American white pelicans fell rapidly following their peak in mid-October. Furthermore, we experienced below normal temperatures during the second half of October and the month of November which may have contributed to the observed decline in UDs (Angel and Atkins 2013, Angel 2014).

Duck Behavior

The conditions stipulated under the KEA addressing spring waterfowl foraging include the presence of shallowly flooded areas over residual vegetation and invertebrates. Although we did not specifically evaluate spring foraging habitat, these areas do exist along the wetland periphery and in shallow areas in the center of the wetland along ridges and spoil piles. Such areas were more appropriate for foraging dabbling ducks than diving ducks, which prefer slightly deeper areas. Like 2012, our behavioral observations revealed that dabbling ducks indeed spent about 62% of their time foraging during spring 2013 (Tables; Fig 4). These estimates varied by month and ranged from 56–89%, declining as spring progressed. 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 34% of their time during spring 2013 (Table 10; Fig. 4), which was similar to published estimates (Paulus 1988, Bergan et al. 1989). Similar to dabbling ducks, estimates varied by month (18–63%) but exhibited a downward trend throughout spring. 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. Furthermore, some research suggests that diving ducks, like dabbling ducks, will readily consume seeds during spring migration (Smith 2007, Strand et al. 2008, Hitchcock 2008). Thus, residual moist-soil plant seeds can provide an additional food source for diving ducks during spring. Although we lack food habits data of waterfowl utilizing Emiquon, our observations were generally consistent with those from other time-activity studies of Anatids (Driver et al. 1974, Paulus 1984, 1988, Bergan et al. 1989, Crook et al. 2009). Moreover, we attempted to prevent underestimation of diving duck foraging behavior by modifying our scan sampling methodology; thus, we contend that it should better represent the foraging behavior of diving ducks than if we had used unmodified scan sampling.

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 species observed during brood surveys at Emiquon in 2013. Despite increased survey effort, total brood observations in 2013 declined 66% from 2012 and represented the fewest broods observed since monitoring began. Furthermore, the 2013 peak in brood observations was the latest recorded at Emiquon and nearly 2 months later than the peak in 2012 (27 June). Cold and wet conditions in early spring combined with a record-setting flood in April likely caused delayed nesting and nest loss of some waterbirds, contributing to low brood observations and the late peak. 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 2013 (n = 3) rated fair and included the Illinois threatened common gallinule for the third consecutive year. Furthermore, we also proposed an American coot brood density of >1 brood/km^2 as an indicator of waterbird nesting at Emiquon (App. A).

Densities of American coots crashed in 2010 (0 broods) and 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. Reasons for this increase are unclear, but brood surveys in 2013 extended to 21 August, the latest since 2009 (25 Aug.). Peak observations of coot broods usually occur in early August, but the apparent late nesting season in 2013 delayed the peak hatch date. The 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 2013 (5/km^2 for all broods), resulting 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. Similarly, Wheeler and March (1979) reported 1.0 brood/km^2 in southern Wisconsin. In contrast, 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 declined 75% from 2012, 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 = 57 taxa) increased 24% in 2013, representing the highest number of taxa observed at Emiquon (Table 12). Invertebrate biomass per volume increased 54.4% from 2012 but remained 6.4% below the 5-year average (169.0 mg/m^3) of samples taken in August. Total invertebrate biomass in 2013 (6,560.4 mg) was 141% greater than that collected in 2012 (2,720.9 mg) and the highest observed since the peak in 2009 (14,476.6 mg). Moreover, we reduced the number of samples taken in 2013 (*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 in 2013 to include Flag Lake, whereas invertebrate collection had been confined to Thompson Lake in previous years. We wanted to investigate whether Flag Lake was experiencing low invertebrate abundances similar to that observed in Thompson Lake. We collected nearly twice the invertebrate biomass in Flag Lake (4,316 mg) as Thompson Lake (2,244 mg) from an equal number of samples (*n* = 20) at each location. Correspondingly, standardized estimates of invertebrate abundance (mg/m^3) indicated Flag Lake (176.7 mg/m^3) supported 27% more invertebrate biomass than Thompson Lake (139.5 mg/m^3). Snails contributed the most invertebrate biomass 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. Snail abundance at Emiquon in 2013 was the highest observed since the peak in 2009. Dragonfly (Aeshnidae – 34.2 mg/m^3) larvae and aquatic worms (Oligochaeta – 8.1 mg/m^3) also were important invertebrate taxa in Flag Lake, whereas beetle larvae (Hydrophilidae – 13.3 mg/m^3) and worms (Oligochaeta – 10.1 mg/m^3) were important in Thompson Lake. The drought of 2012 followed by abundant rainfall and flooding in 2013 may have provided the perturbations needed to bolster invertebrate populations, providing important forage for breeding and brood-rearing waterbirds at Emiquon.

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 2013 (633.9 kg/ha) exceeded the minimum goal and represented a 21% increase from the 2012 seed estimate (522.7 kg/ha; Table 13, App A). While seed abundance increased in 2013, it remained slightly below the 6-year average (665.2 kg/ha). 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. Although on a more local scale, 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 2013 was comparable to but slightly below the averages of these published estimates. 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 at Emiquon in 2013 (5,427 EUDs/ha) fell within these published estimates for this region. Like moist-soil plant seed abundance, EUDs increased from the 2012 estimate (4,475.4 EUDs/ha) but remained about 5% below the 6-year average. Although there were no mudflats in 2013 due to high water levels, the abundant spring rainfall increased soil moisture and likely promoted growth of moist-soil plants in wet-prairie and upland vegetation communities.

We expanded our moist-soil plant seed sampling to include portions of Flag Lake for the first time in 2013. Flag Lake samples (713.3 kg/ha) averaged 26.4% more seed than Thompson Lake samples (564.5 kg/ha). Furthermore, the Flag Lake seed abundance estimate was slightly above (+7%) the 6-year average for Thompson Lake (665.2 kg/ha). Likewise, energetic carrying capacity generated from Flag Lake moist-soil plants averaged 6,107.2 EUDs/ha, whereas Thompson Lake moist-soil plants produced 4832.8 EUDs/ha. These data support anecdotal observations of greater moist-soil plant abundance along the east shore of Flag Lake during covermapping operations in preceding years, and greater duck densities in Flag Lake, especially north of the pump ditch (Hine et al. 2013: App. B).

Community composition goals for moist-soil vegetation specified forbs comprise $\geq$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 well within these KEA goals. The most invasive species observed was reed canarygrass, which comprised only 6.3% of the moist-soil area in our sample plots; however, 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

Estimating energetic carrying capacity of the dominant vegetation communities at Emiquon for fall-migrating waterfowl was a new objective 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 (Table 14).

We found invertebrate abundances to be highest from benthic cores taken in open water (420.1 kg/ha) and from samples taken in persistent emergent (330.3 kg/ha) vegetation, which represented 81% of the invertebrate biomass collected in all vegetation communities. Consequently, energetic carrying capacity generated from invertebrates was highest in open water (1,528.8 EUDs/ha) and in persistent emergent vegetation (1,202.3 EUDs/ha). Overall invertebrate abundance averaged 231.5 kg/ha, providing 842.7 EUDs/ha. Invertebrates contributed 1,528,768.9 EUDs, or 11.2% of the total energetic carrying capacity at Emiquon.

Hemi-marsh (1,666.0 kg/ha) and aquatic bed (1,160.3 kg/ha) communities produced the most submersed aquatic vegetation, and accounted for 94% of this vegetation type in all communities sampled. Submersed aquatic vegetation provided 7,083.4 EUDs/ha and 4,933.1 EUDs/ha in hemi-marsh and aquatic bed, respectively. Abundance of submersed aquatic vegetation averaged 749.5 kg/ha across all vegetation communities, representing 3,186.8 EUDs/ha. Submersed aquatic vegetation accounted for 42.5% (5,781,565.1 EUDs) of the total energetic carrying capacity in fall 2013.

Seed and tuber abundances were highest in moist-soil plant (633.9 kg/ha) and hemi-marsh (458.8 kg/ha) communities, representing nearly 65% of the biomass from seeds and tubers in all communities. Furthermore, moist-soil plants produced 5,427.5 EUDs/ha and the hemi-marsh community provided 3,901.6 EUDs/ha from seeds and tubers. Abundance of seeds and tubers averaged 386.7 kg/ha for all vegetation communities and contributed 3,288.5 EUDs/ha.

Finally, seeds and tubers contributed a total of 6,299,217.5 EUDs, or 46.3% of the energetic carrying capacity for waterfowl.

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 (13,485,015.1 EUDs) was twice that of dabbling ducks (6,621,164.7 EUDs) at Emiquon in fall 2013 (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.

Wetland Covermapping

In contrast to the drought of 2012, abundant rainfall and record flooding in the IRV occurred in spring 2013. Consequently, the spatial coverage of wetland vegetation (1,944 ha) at Emiquon increased 9% from 2012 (1,782 ha) and represented the largest area mapped since monitoring began (Table 15). The area of aquatic bed in 2013 increased 28% from 2012 and was 47% above the 2007–2012 average. Open water was similar to 2012 but 22% above the 6-year average. The spatial extent of persistent emergent vegetation in 2013 was the greatest observed at Emiquon, representing nearly 2.5 times the 2007–2012 average (118.7 ha). Hemi-marsh increased substantially (68%) from 2012 estimates but remained 5% below the average. Finally, the area of non-persistent emergent vegetation in 2013 declined 42% from 2012 and was 6% below the 6-year average (108.1 ha).

The criteria for KEAs related to habitat composition stipulate <10% invasive species coverage and 100% exclusion of purple loosestrife. The expansion of common reed appeared to have equalized as our encounters in 2013 (n = 24) were similar to those in 2012 (n = 28), likely a result of herbicide application by TNC staff the last 2 years. This was the first year since 2009 that encounters with common reed had not increased. We documented only 2 individual plants of purple loosestrife during our monitoring work in 2013; however, TNC staff removed numerous plants from the preserve throughout the year, mainly from the northeast corner of the property (T. Hobson, pers. commun.). Furthermore, our encounters with reed canarygrass (n = 62) increased substantially (158%) in 2013 from observations made in 2012 (n = 24). Lastly, we documented plant species composition data at random locations across Emiquon for the first time in 2013. Eurasian water milfoil was the most dominant species in the hemi-marsh vegetation community (52%) and the second most prominent species (27%) in the aquatic bed community behind longleaf pondweed. We've documented the rapid expansion of Eurasian water milfoil at Emiquon since 2008, and it continued to be a large component of the aquatic vegetation communities at Emiquon in 2013.

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, 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 documented that large areas with these characteristics were present on the preserve (Table 15; Figs. 8 and 9).

The KEA indicator 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. Abundant rainfall in early spring lead to the south levee being overtopped by the Illinois River and nearly filled Emiquon to its highest level to date. Water levels remained high throughout the summer and fall, thereby eliminating most of the desired shorebird foraging habitat (i.e. mudflat). However, shorebirds could find suitable foraging areas along the outer perimeter of the wetland, which provided some shallowly flooded habitat. Overall, shorebird foraging habitat was limited by high water levels at Emiquon in 2013.

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 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 2013 was dominated by aquatic bed (55.3%), open water (15.3%), and persistent emergent (15.1%;

Fig. 9). Persistent emergent and scrub-shrub (1.3%) were the only vegetation communities in 2013 that were comparable to historical conditions in the IRV (persistent emergent – 12.3%, scrub-shrub – 1.3%). Although, high water eliminated all mudflats at Emiquon in 2013. Floating-leaved aquatic vegetation (i.e. longleaf pondweed) 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.

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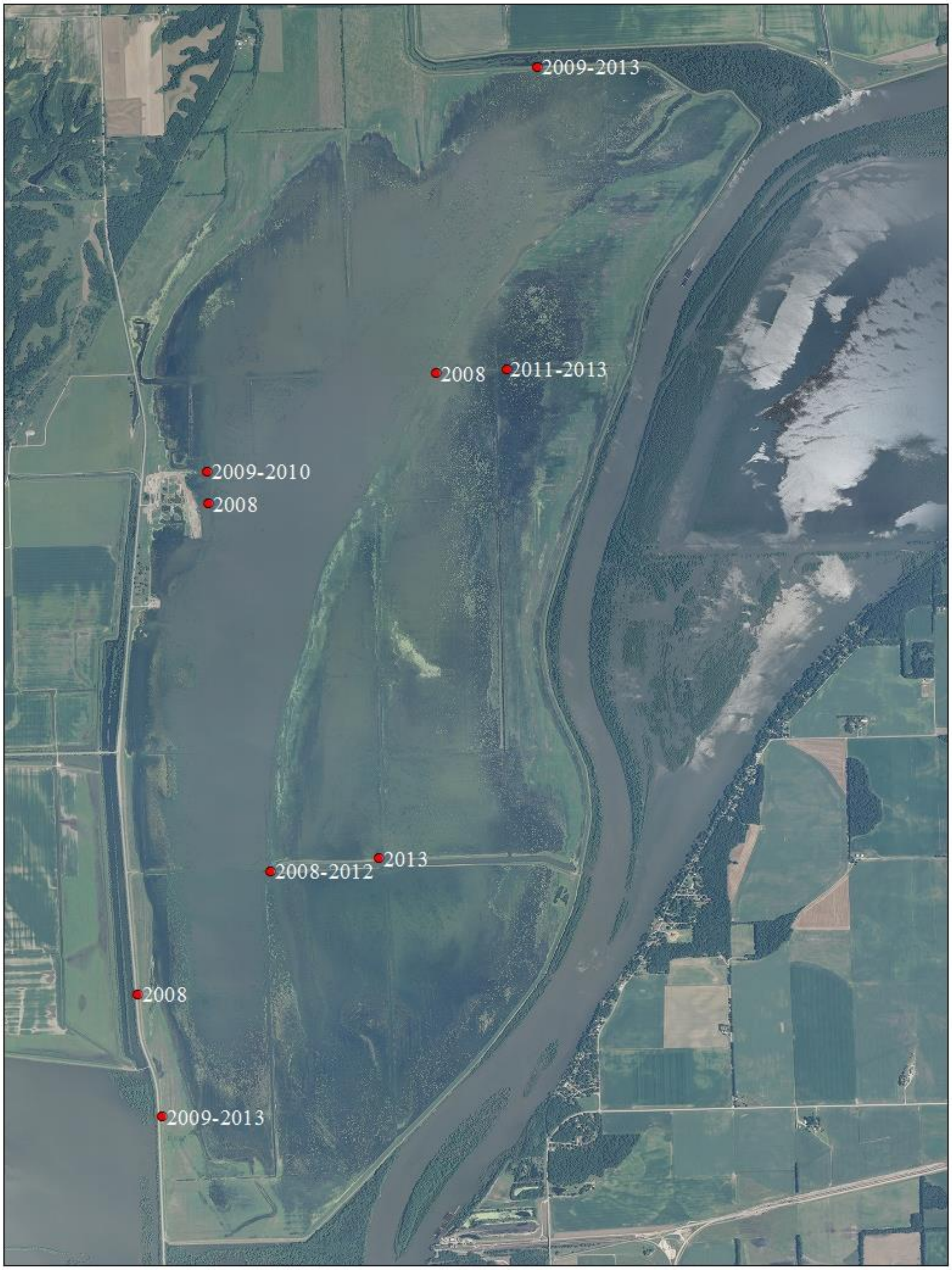


Figure 1. Brood observation locations by year at The Emiquon Preserve, summers 2008–2013. Observation points varied by year due to expanding water levels on the Preserve.

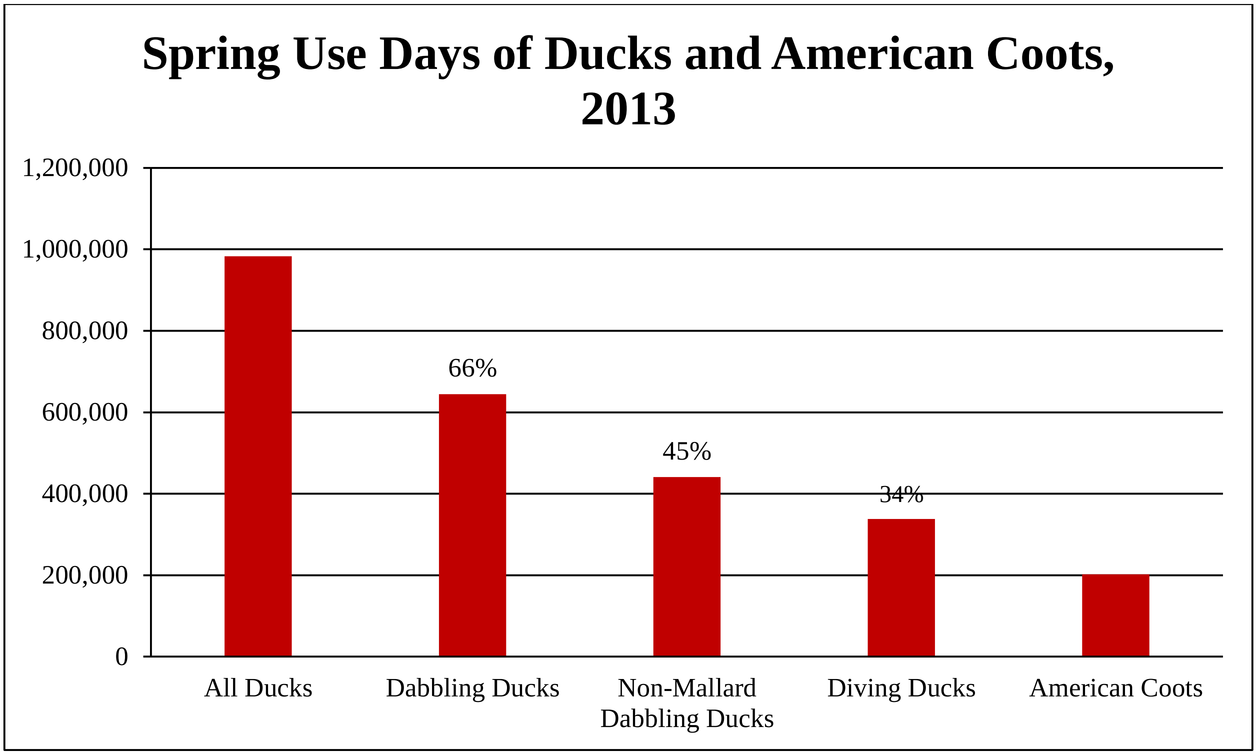


Figure 2. Use days of ducks and American coots at the Emiquon Preserve from ground inventories during spring 2013. Percentages represent proportions of total duck use days.

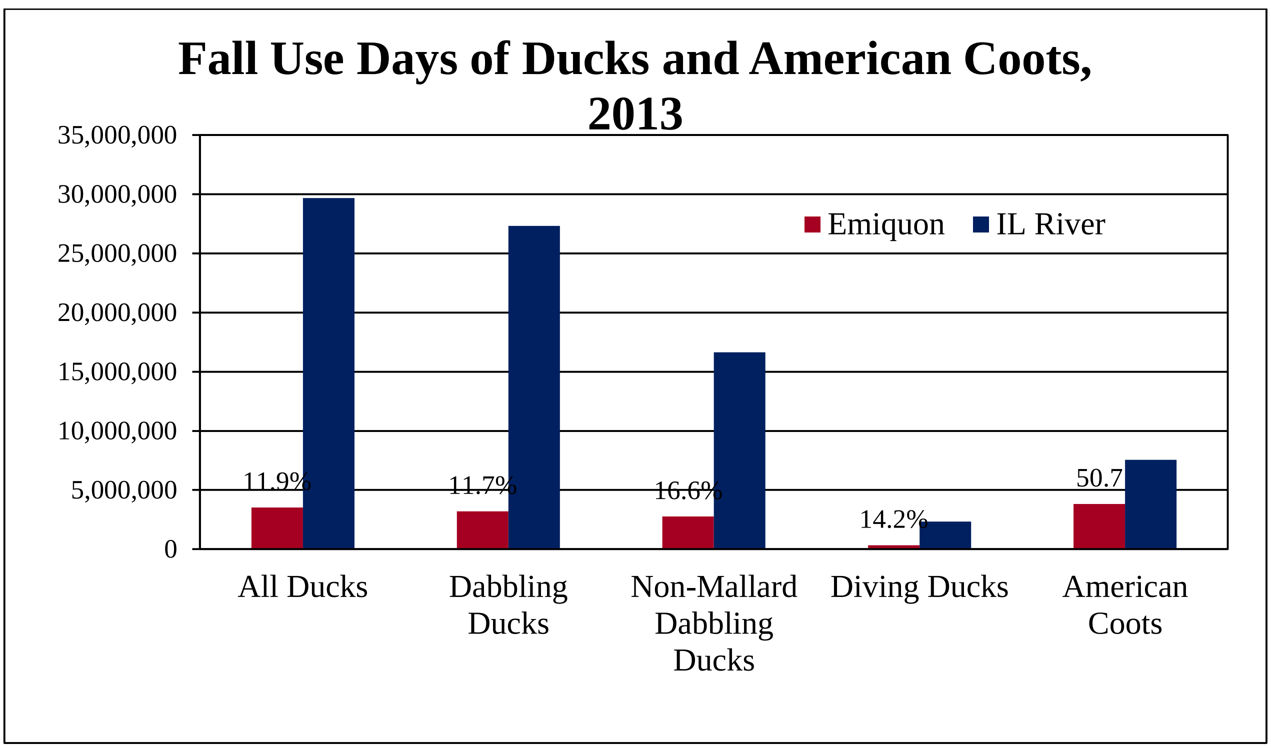


Figure 3. Use days of ducks and American coot at the Emiquon Preserve from aerial inventories during fall 2013. Percentages represent proportions of Illinois River use days.

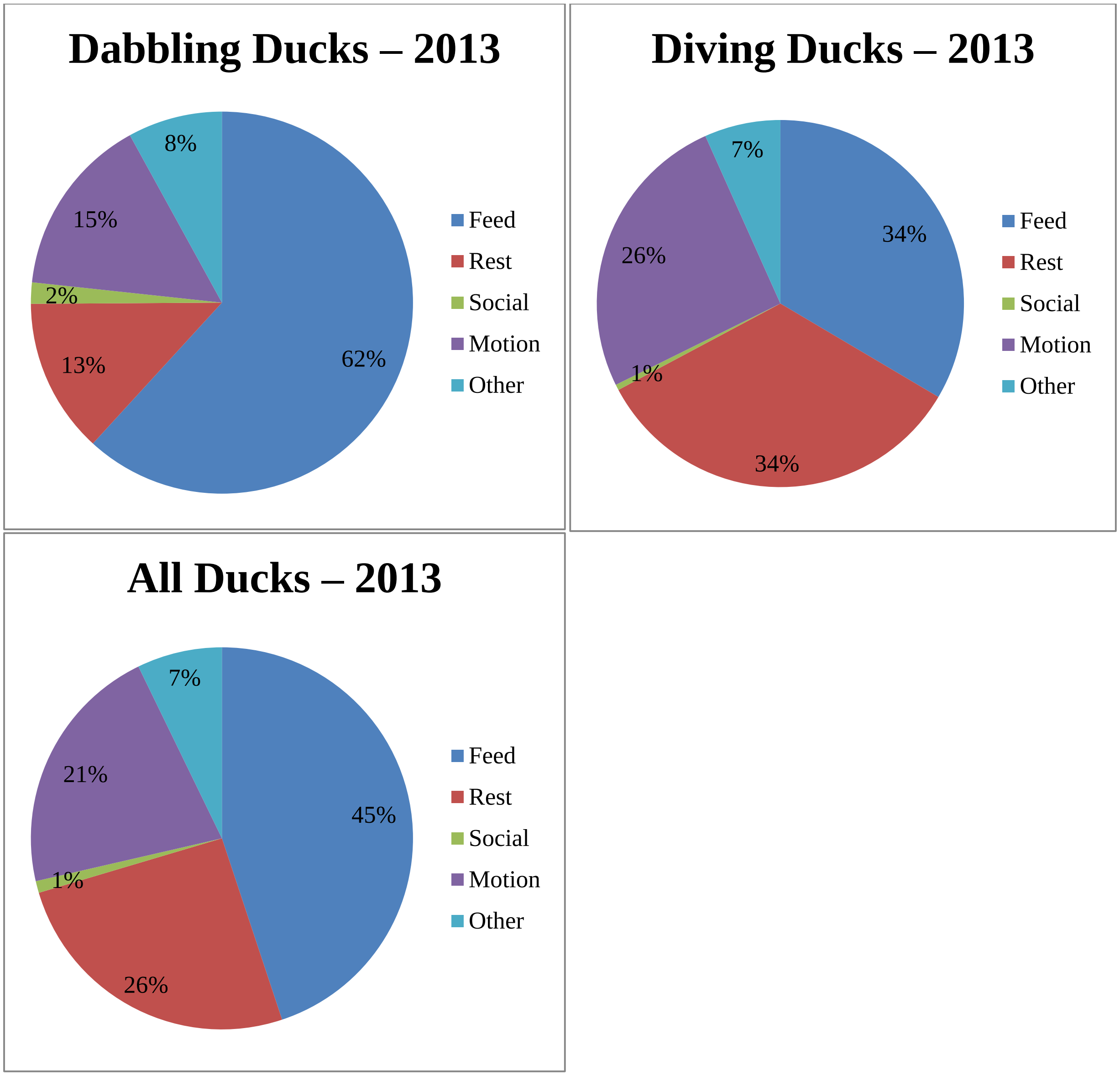


Figure 4. Time activity budgets of ducks at Emiquon Preserve during spring 2013.

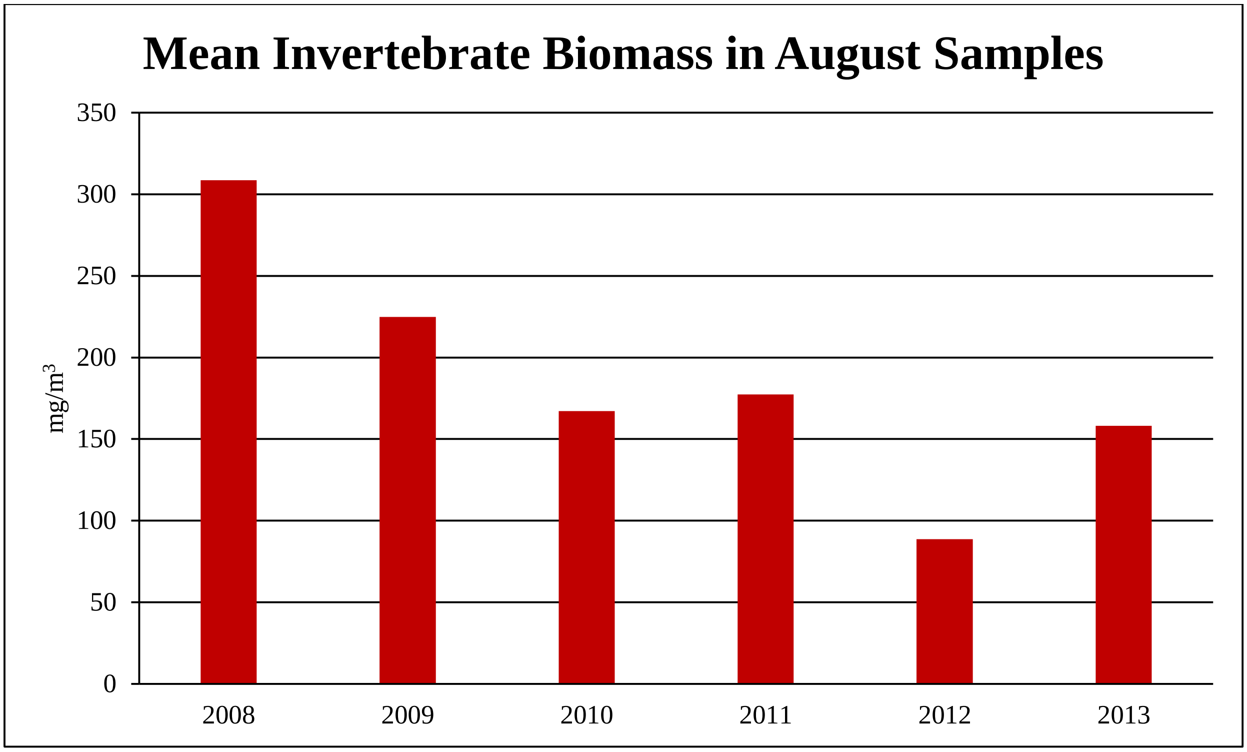
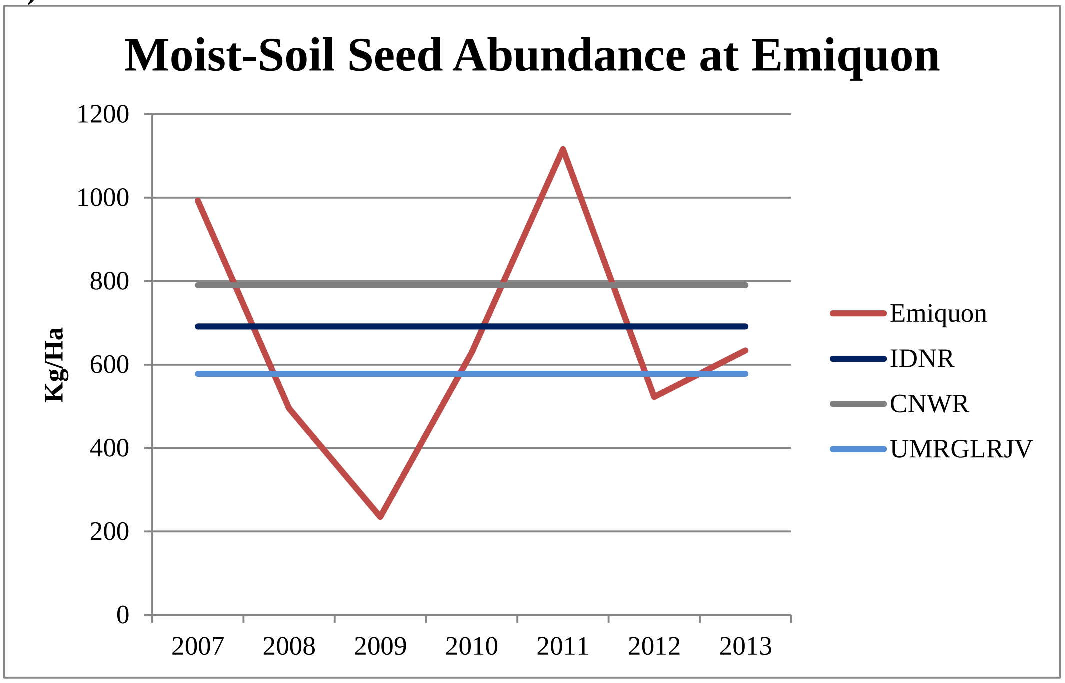


Figure 5. Mean mass of invertebrates collected in sweep nets during August at The Emiquon Preserve, 2008–2013.

A)



B)

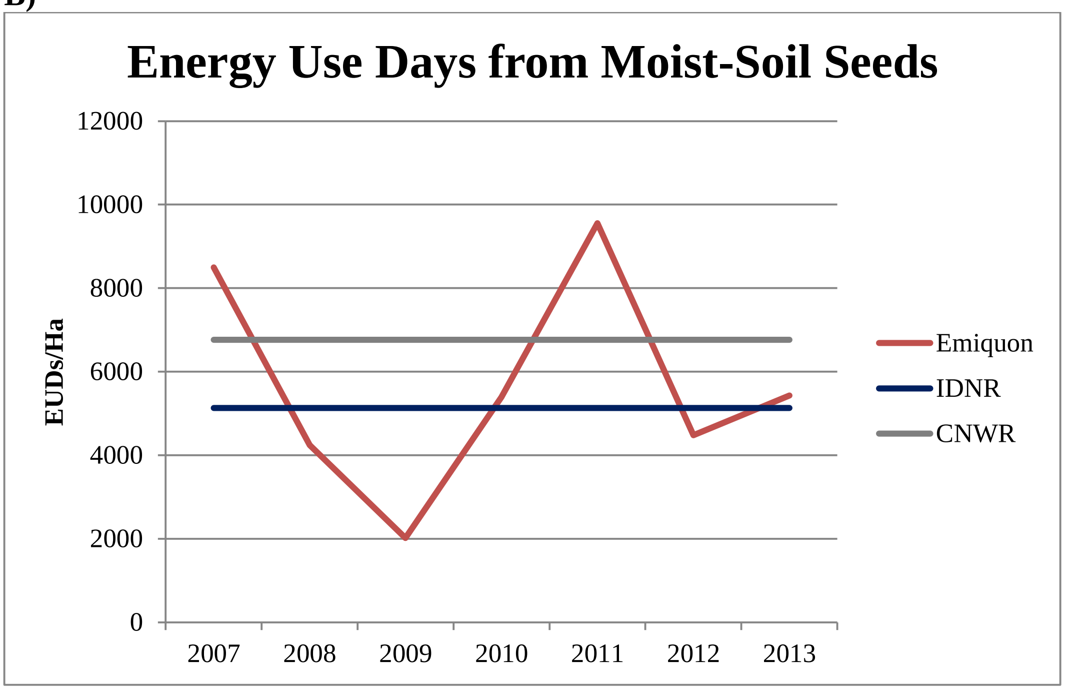


Figure 6. Moist-soil plant seed abundance (A) and energy use days (EUDs; B) from moist-soil plants at the Emiquon Preserve compared to estimates (constants) from wetlands at Illinois Department of Natural Resources (IDNR) sites, Chautauqua National Wildlife Refuge (CNWR), and carrying capacity goals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

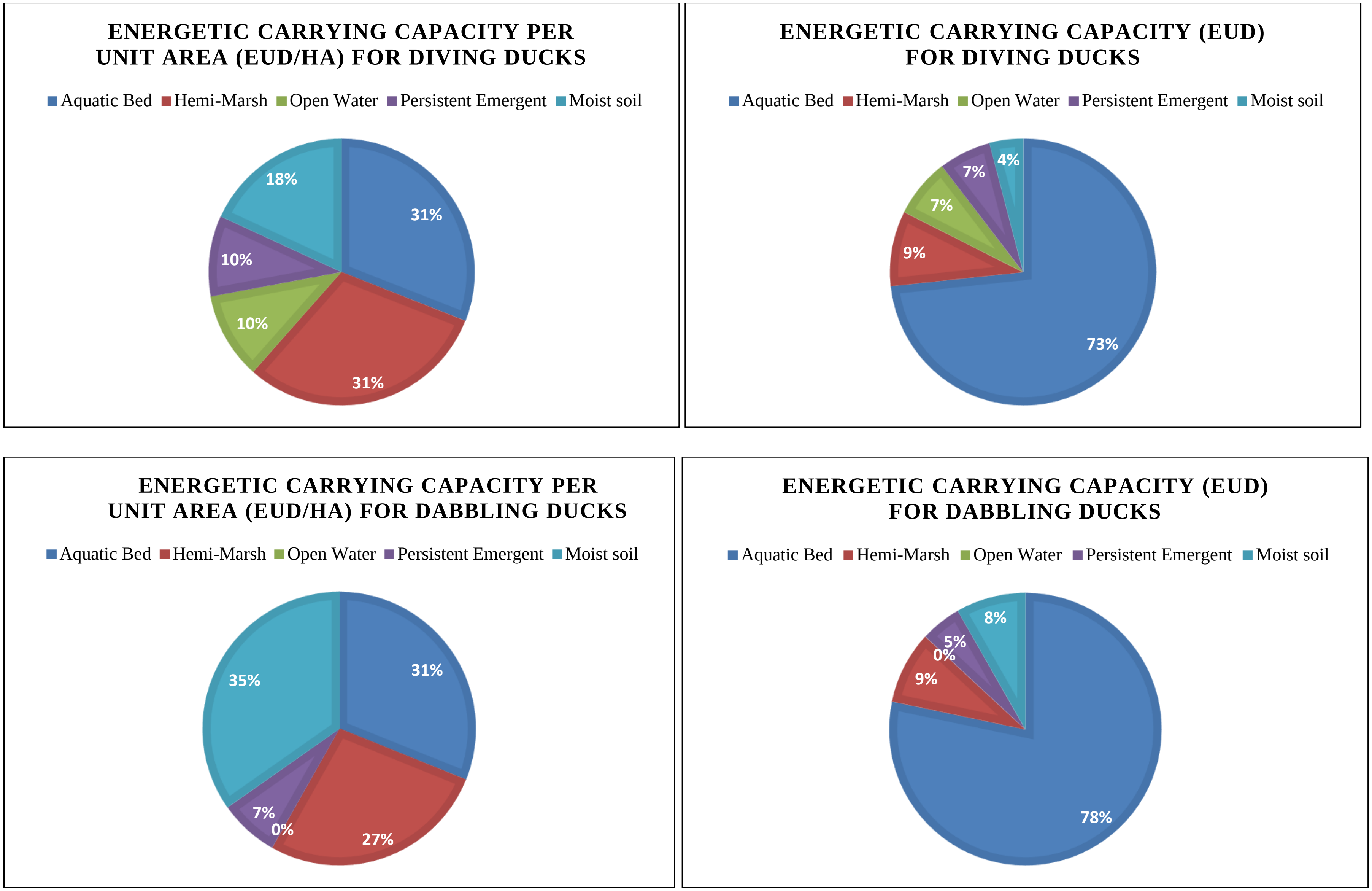


Figure 7. Energetic carrying capacity for diving ducks and dabbling ducks by vegetation community at Emiquon during fall 2013.

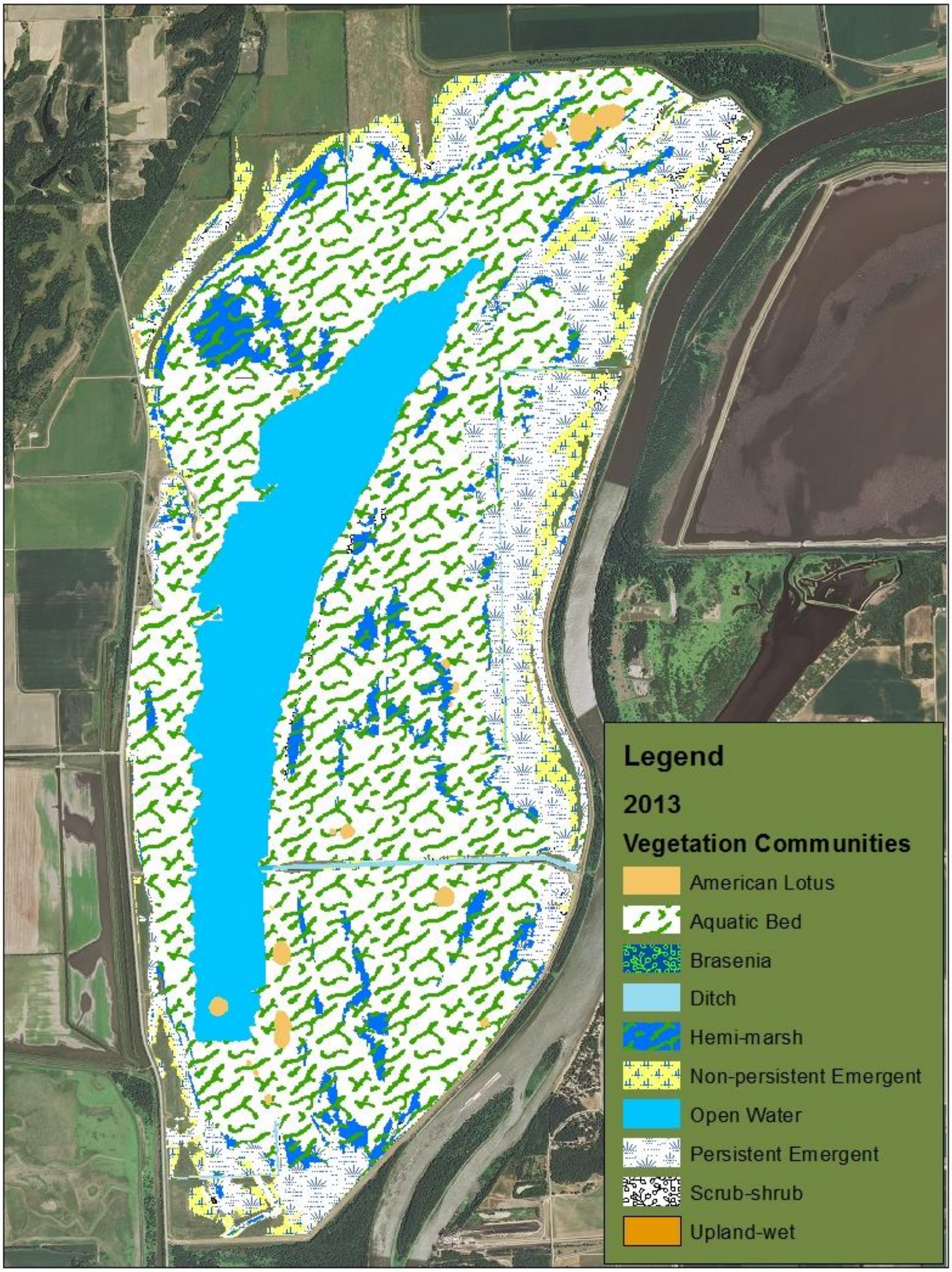


Figure 8. Wetland vegetation map of The Emiquon Preserve (1,943.6 ha), 23 August–6 September, 2013.

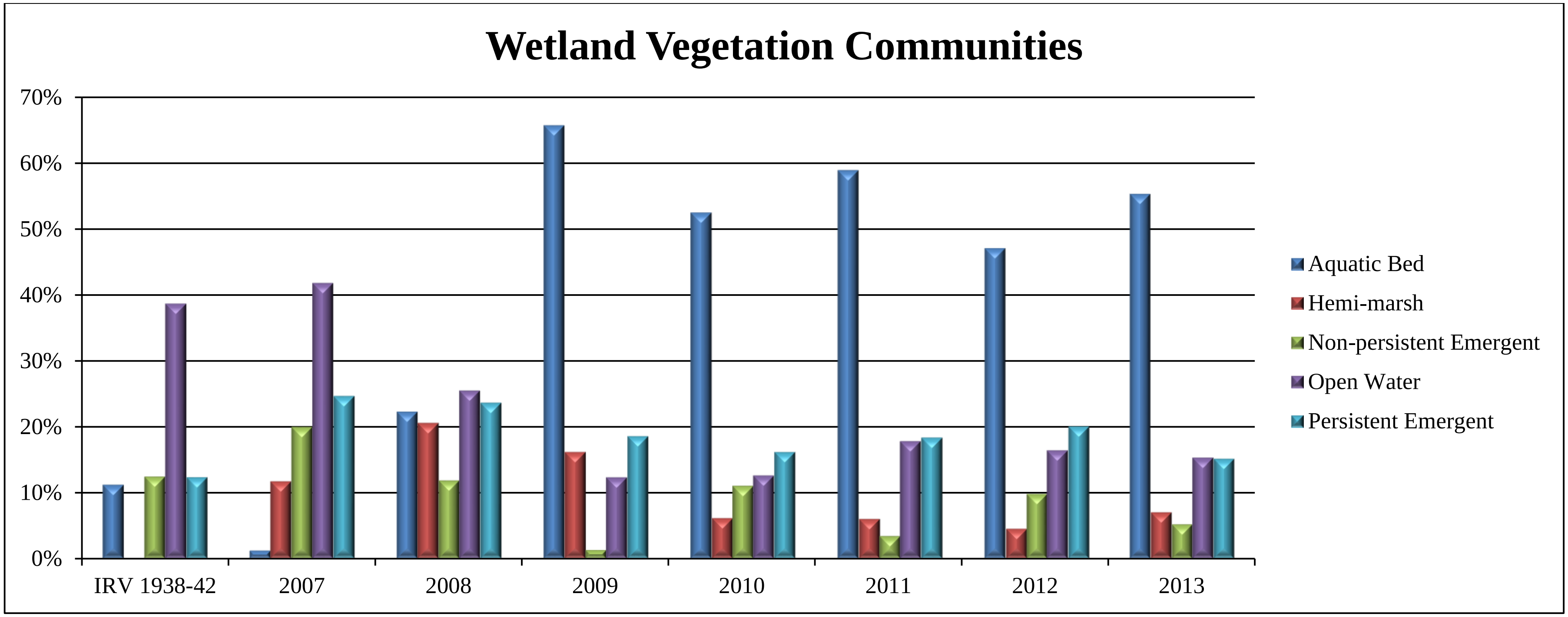


Figure 9. Proportional coverage of wetland vegetation communities at the Emiquon Preserve during early fall 2007–2013 and those historically present in IRV wetlands (1938–1942).

Table 1. Avian species observed during monitoring activities at The Emiquon Preserve, 2007–2013.

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, 2007−2013.

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.*
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.*
Prairie Cordgrass	*Spartina pectinata*

Table 2. Continued

Common Name	Scientific Name
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 2013.

	Inventory Dates										
Species[a]	13 Feb	22 Feb	28 Feb	7 Mar	15 Mar	21 Mar	27 Mar	3 Apr	11 Apr	17 Apr	Total (%)
ABDU	4	0	4	4	14	2	1	0	0	0	29 (0.0)
AGWT	0	0	0	134	2,114	1,477	3,658	2,173	2,836	3,091	15,483 (6.0)
AMWI	10	0	6	150	313	14	935	193	12	8	1,641 (0.6)
BUFF	0	0	36	159	140	1,170	590	566	214	298	3,173 (1.2)
BWTE	0	0	0	0	0	0	0	10	2,996	3,067	6,073 (2.4)
CAGO	2,072	237	621	900	261	943	348	71	76	76	5,605 (2.2)
CANV	115	0	48	84	560	240	725	222	8	4	2,006 (0.8)
COGO	1,232	0	94	624	0	0	0	2	0	0	1,952 (0.8)
COME	1,745	132	106	1,461	202	555	343	0	0	0	4,544 (1.8)
GADW	387	12	103	1,327	1,556	1,992	3,845	2,075	834	2,654	14,785 (5.7)
GWFG	5,575	0	72	4,913	1,148	150	380	20	0	20	12,278 (4.8)
HOME	18	5	16	75	93	480	50	4	0	0	741 (0.3)
LESC	283	50	255	869	2,564	991	2,188	797	116	95	8,208 (3.2)
LSGO	60,650	1	0	0	10,002	5,000	4,500	16	10	120	80,299 (31.2)
MALL	6,182	117	804	5,855	4,396	2,634	6,829	1,466	739	631	29,653 (11.5)
MUSW	11	2	19	16	10	0	12	6	15	21	112 (0.0)
NOPI	1,378	151	256	2,336	676	2,783	8,460	58	0	0	16,098 (6.3)
NSHO	0	4	16	325	1,720	2,187	4,629	4,347	4,338	2,852	20,418 (7.9)
REDH	63	0	0	0	0	10	150	0	0	4	227 (0.1)
RNDU	10	0	10	0	968	545	781	375	410	180	3,279 (1.3)
RUDU	918	11	0	485	3,489	5,109	5,400	4,705	4,777	4,117	29,011 (11.3)
SWAN	0	12	18	148	0	270	335	148	0	0	931 (0.4)
TRUS	132	0	28	40	31	10	2	4	2	3	252 (0.1)
TUSW	0	31	6	37	250	81	44	12	0	0	461 (0.2)
WODU	0	0	0	0	18	0	2	2	10	2	34 (0.0)
Total	80,785	765	2,518	19,942	30,525	26,643	44,207	17,272	17,393	17,243	257,293

[a] See Table 1.

Table 4. Estimates of waterfowl abundance from aerial inventories at The Emiquon Preserve during spring 2013.

	Inventory Dates					
Species[a]	8 Mar	14 Mar	22 Mar	27 Mar	2 Apr	Total (%)
MALL	25,730	7,260	10,350	7,545	1,190	52,075 (18.4)
NOPI	4,150	1,270	2,070	1,355	720	9,565 (3.4)
ABDU	210	125	100	50	0	485 (0.2)
BWTE	0	0	0	0	240	240 (0.1)
AGWT	830	7,620	6,900	8,130	2,380	25,860 (9.1)
AMWI	415	255	1,380	270	240	2,560 (0.9)
GADW	2,075	2,540	3,450	1,405	1,190	10,660 (3.8)
NSHO	1,245	1,270	3,450	2,710	3,570	12,245 (4.3)
LESC	2,075	760	2,070	540	1,190	6,635 (2.3)
RNDU	415	760	3,450	1,085	240	5,950 (2.1)
CANV	415	510	1,380	135	240	2,680 (0.9)
REDH	210	255	345	135	120	1,065 (0.4)
RUDU	830	1,570	17,250	1,355	3,925	24,930 (8.8)
COGO	220	510	690	270	240	1,930 (0.7)
BUFF	210	255	690	270	1,190	2,615 (0.9)
COME	2,085	535	1,430	320	240	4,610 (1.6)
HOME	220	255	365	320	250	1,410 (0.5)
CAGO	510	325	80	270	20	1,205 (0.4)
GWFG	38,000	800	100	375	0	39,275 (13.9)
LSGO	71,000	5	3,000	1,500	10	75,515 (26.7)
SWAN	165	423	345	460	225	1,618 (0.6)
Total	151,010	27,303	58,895	28,500	17,420	283,128

[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

[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 2013.

	Inventory Dates															
Species[a]	3 Sep	13 Sep	25 Sep	14 Oct	23 Oct	28 Oct	8 Nov	14 Nov	19 Nov	27 Nov	6 Dec	12 Dec	19 Dec	23 Dec	30 Dec	8 Jan	Total (%)
MALL	630	860	1,610	3,265	3,600	12,180	12,210	825	550	6,535	8,050	0	425	10	0	0	50,750 (13.3)
ABDU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
NOPI	1,890	1,720	8,055	11,410	18,000	26,390	4,000	0	0	0	0	0	0	0	0	0	50,750 (13.3)
BWTE	3,155	3,460	8,055	3,260	3,600	2,030	0	0	0	0	0	0	0	0	0	0	23,560 (6.2)
AGWT	630	1,720	5,570	8,150	12,600	10,150	200	0	500	0	0	0	0	0	0	0	39,520 (10.3)
AMWI	0	0	270	4,890	3,600	4,060	800	50	100	0	0	0	0	0	0	0	13,770 (3.6)
GADW	0	0	1,075	11,410	14,400	36,540	19,200	2,800	4,100	235	30	0	0	0	0	0	89,790 (23.5)
NSHO	1,260	1,725	4,025	11,410	9,000	10,150	9,100	1,260	150	0	0	0	0	0	0	0	48,080 (12.6)
LESC	0	0	0	0	0	150	0	100	0	0	0	0	0	0	0	0	250 (0.1)
RNDU	0	0	0	0	500	2,500	17,100	500	6,500	200	0	0	0	0	0	0	27,300 (7.1)
CANV	0	0	0	0	0	700	2,000	755	960	1,650	400	0	10	0	0	0	6,475 (1.7)
REDH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
RUDU	0	0	0	825	1,000	2,500	750	390	1,050	100	200	0	0	0	0	0	6,815 (1.8)
COGO	0	0	0	0	0	0	0	0	0	100	200	100	0	25	25	0	450 (0.1)
BUFF	0	0	0	0	0	0	100	150	110	300	100	0	0	0	0	0	760 (0.2)
COME	0	0	0	0	0	0	0	0	0	0	150	5	35	100	460	810	1,560 (0.4)
HOME	0	0	0	0	10	10	0	110	50	0	15	0	20	0	10	10	235 (0.1)
CAGO	35	110	185	150	200	500	5	0	80	60	150	5	15	0	0	10	1,505 (0.4)
GWFG	0	0	0	0	0	25	0	10	0	0	0	0	0	0	0	0	35 (0.0)
LSGO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 (0.0)
SWAN	0	7	3	2	2	0	42	0	125	150	123	10	0	0	0	5	469 (0.1)
Total	7,600	9,602	28,848	54,772	66,512	107,885	65,507	6,950	14,275	9,330	9,418	120	505	135	495	835	382,789

Table 7. Estimates of waterbird and raptor abundance from ground inventories at The Emiquon Preserve during spring 2013.

	Inventory Dates										
Species[a]	13 Feb	22 Feb	28 Feb	7 Mar	15 Mar	21 Mar	27 Mar	3 Apr	11 Apr	17 Apr	Total (%)[b]
AMCO	0	14	27	350	2,636	1,623	6,855	7,438	8,409	10,118	37,470 (93.6)
AMKE	0	0	0	0	0	0	1	0	0	0	1 (0.0)
AWPE	18	0	0	0	261	115	66	233	95	436	1,224 (3.1)
BAEA	49	12	42	81	35	33	14	3	3	4	276 (0.7)
BNST	0	0	0	0	0	0	0	0	3	0	3 (0.0)
COSN	0	0	0	0	0	0	0	0	1	0	1 (0.0)
DCCO	0	0	0	2	107	1	70	207	247	269	903 (2.3)
GBHE	3	4	9	25	7	27	14	2	1	0	92 (0.2)
GREG	0	0	0	0	0	0	0	0	0	6	6 (0.0)
NOHA	2	3	5	5	3	2	5	3	3	2	33 (0.1)
PBGR	0	0	0	0	0	0	0	1	1	3	5 (0.0)
RTHA	0	0	1	0	0	0	4	0	0	0	5 (0.0)
Total	72	33	84	463	3,049	1,081	7,029	7,887	8,763	10,838	40,019

[a] See Table 1.

[b] Percent of total for spring 2013

Table 8. Estimates of waterbird and raptor abundance from aerial inventories at The Emiquon Preserve during spring 2013.

	Inventory Dates					
Species[a]	8 Mar	14 Mar	22 Mar	27 Mar	2 Apr	Total (%)[b]
AMCO	500	500	13,800	1,355	6,660	22,815 (96.7)
AWPE	0	15	120	150	155	440 (1.9)
BAEA	23	25	7	2	2	59 (0.2)
DCCO	0	10	10	10	260	290 (1.2)
Total	523	550	13,937	1,517	7,077	23,604

[a] See Table 1.

Table 9. Estimates of waterbird and raptor abundance from aerial inventories at The Emiquon Preserve during fall 2013.

	Inventory Dates																
Species[a]	3 Sep	13 Sep	25 Sep	14 Oct	23 Oct	28 Oct	8 Nov	14 Nov	19 Nov	27 Nov	6 Dec	12 Dec	19 Dec	23 Dec	30 Dec	8 Jan	Total (%)[b]
AMCO	1,285	4,315	25,240	108,395	113,400	101,500	28,000	1,200	800	125	50	0	0	0	0	0	384,310 (99.1)
AWPE	290	190	325	470	350	155	80	20	50	0	5	0	0	0	0	0	1,935 (0.5)
BAEA	0	0	1	1	1	0	3	0	6	11	27	3	0	0	2	4	59 (0.0)
DCCO	300	440	245	405	90	100	0	10	15	0	0	0	0	0	0	0	1,605 (0.4)
Total	1,875	4,945	25,811	109,271	113,841	101,755	28,083	1,230	871	136	82	3	0	0	2	4	387,909

[a] See Table 1.

[b] Percent of total for fall 2013

Table 10. Duck behavior (%) by month and guild at The Emiquon Preserve during spring 2013.

		Activity				
Guild	Month	Feed	Rest	Other	Social	Locomotion
Dabbling Ducks	February	86.9	0.0	2.8	0.8	9.6
	March	59.4	11.6	9.5	2.1	17.4
	April	55.7	29.1	4.6	1.1	9.5
	Average	61.8	13.1	8.0	1.8	15.3
Diving Ducks	February	62.8	15.3	4.1	0.0	17.8
	March	18.2	31.4	7.5	0.9	41.9
	April	25.0	64.2	8.8	0.3	1.7
	Average	33.5	33.7	6.7	0.5	25.6
All Ducks		44.9	25.5	7.2	1.0	21.4

Table 11. Waterbird brood observations by species at The Emiquon Preserve, 2013.

	Observation Dates									
Species[a]	15 May	30 May	11 Jun	27 Jun	11 Jul	24 Jul	7 Aug	21 Aug	Total Broods	%
AMCO	0	0	0	0	0	1	3	12	16	30.2
CAGO	5	0	0	0	2	0	2	0	9	17.0
COGA	0	0	0	0	0	0	0	3	3	5.7
MALL	0	0	0	0	0	0	1	0	1	1.9
PBGR	0	0	0	0	1	0	0	0	1	1.9
WODU	0	0	0	1	2	5	3	11	22	41.5
Unknown	0	0	0	0	0	1	0	0	1	1.9
Total	5	0	0	1	5	7	9	26	53	
Avg. age[b]	1B	N/A	N/A	2B	2C	2B	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 2013.

Taxa	Biomass (mg/m^3)[a]	Percent Occurrence
Bivalvia		
Sphaeriidae	0.0	2.5
Gastropoda		
Physidae	57.4	100.0
Planorbidae	37.6	77.5
Lymnaeidae	0.5	5.0
Viviparidae	0.0	2.5
Ostracoda	0.0	12.5
Cladocera	0.5	100.0
Copepoda	0.7	100.0
Amphipoda	2.0	65.0
Arachnida	0.3	7.5
Araneae	0.2	30.0
Tetragnathidae	0.7	10.0
Acari	0.1	40.0
Collembola	0.1	72.5
Coleoptera		
Curculionidae	0.0	5.0
Dytiscidae	2.5	52.5
Elmidae	0.0	7.5
Haliplidae	0.9	25.0
Heteroceridae	0.1	5.0
Hydrophilidae	10.0	47.5
Noteridae	0.1	15.0
Diptera		
Ceratopogonidae	0.4	52.5
Chironomidae	1.7	95.0
Culicidae	0.2	42.5
Dolichopodidae	0.0	17.5
Empididae	0.0	2.5
Ephydridae	0.0	5.0
Psychodidae	0.0	2.5
Sciomyzidae	0.0	2.5
Stratiomyidae	2.3	30.0
Tipulidae	0.0	2.5
Unknown	0.0	5.0

Table 12. Continued

Taxa	Biomass (mg/m^3)[a]	Percent Occurrence
Ephemeroptera		
Baetidae	0.3	27.5
Caenidae	1.8	65.0
Hemiptera		
Aphididae	0.2	25.0
Corixidae	0.1	10.0
Mesoveliidae	0.1	5.0
Notonectidae	0.3	5.0
Pleidae	0.6	40.0
Veliidae	0.0	17.5
Hymenoptera		
Formicidae	0.0	5.0
Heloridae	0.0	15.0
Lepidoptera		
Pyralidae	0.2	30.0
Unknown	0.0	2.5
Odonata		
Aeshnidae	17.1	12.5
Coenagrionidae	4.0	85.0
Libellulidae	4.7	75.0
Trichoptera		
Leptoceridae	0.0	10.0
Hydroptilidae	0.0	5.0
Unknown	0.0	2.5
Turbellaria		
Planariidae	0.0	5.0
Unknown	0.0	20.0
Rotifera	0.1	35.0
Nematoda	0.1	57.5
Oligochaeta	9.2	100.0
Hirudinea		
Glossiphoniidae	0.3	12.5
Hydra	0.4	75.0

[a] Some taxa were not abundant enough to weigh after drying.

Table 13. Moist-soil plant seed abundance (kg/ha, dry mass) and energetic use days (EUD) per hectare at The Emiquon Preserve, 2007−2013.

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
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 2013.

		Diving Ducks		Dabbling Ducks	
Vegetation Community	ha	EUDs/ha	Total EUDs	EUDs/ha	Total EUDs
Aquatic Bed	1,074.8	9,198.3	9,886,350.1	4,822.2	5,182,946.2
Hemi-Marsh	135.4	9,076.2	1,228,918.6	4,197.3	568,316.7
Open Water	309.7	3,123.7	967,395.3	8.2	2,535.9
Persistent Emergent	294.3	2,909.6	856,280.9	1,091.7	321,295.8
Moist-Soil	101.3	5,427.5	546,070.2	5,427.5	546,070.2
Total	1915.5	7,039.9	13,485,015.1	3,456.6	6,621,164.7

Table 15. Area and proportions of vegetation communities at The Emiquon Preserve during fall, 2007−2013.

	2007		2008		2009		2010		2011		2012		2013	
Vegetation Community	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%
American Lotus	0.0	0.0	0.1	0.0	0.6	0.0	1.0	0.1	4.1	0.2	8.8	0.5	16.9	0.9
Aquatic Bed	2.6	1.0	238.1	22.1	1,185.7	65.7	1,036.3	52.5	1,071.7	58.9	839.5	47.1	1,074.8	55.3
Bottomland Forest	0.0	0.0	0.2	0.0	0.8	0.0	1.0	0.0	1.0	0.1	0.2	0.0	0.0	0.0
Brasenia	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.1	0.0	0.2	0.0	0.2	0.0
Cattail	25.5	10.0	33.1	3.1	38.1	2.1	N/A[b]	N/A	N/A[b]	N/A	N/A[b]	N/A	N/A	N/A
Coontail	0.4	0.2	2.6	0.2	N/A[a]	N/A	N/A[a]	N/A	N/A[a]	N/A	N/A[a]	N/A	N/A	N/A
Ditch	18.7	7.3	15.4	1.4	12.2	0.7	14.0	0.7	11.6	0.6	13.6	0.8	11.5	0.6
Hemi-marsh	29.9	11.7	220.5	20.5	290.4	16.1	119.8	6.1	109.3	6.0	80.7	4.5	135.4	7.0
Mudflat	3.5	1.4	0.0	0.0	0.0	0.0	83.2	4.2	11.8	0.6	93.4	5.2	0.0	0.0
Non-persistent Emergent	50.7	19.9	127.3	11.8	23.6	1.3	217.7	11.0	61.5	3.4	174.4	9.8	101.3	5.2
Open Water	106.4	41.8	275.1	25.5	221.3	12.3	248.7	12.6	323.5	17.8	292.4	16.4	298.2	15.3
Persistent Emergent	7.4	2.9	0.2	0.0	6.2	0.3	199.0	10.1	223.3	12.3	276.2	15.5	294.3	15.1
Scrub Shrub	6.9	2.7	1.4	0.1	1.7	0.1	0.3	0.0	2.3	0.1	2.7	0.2	10.9	0.6
Upland	2.7	1.0	14.7	1.4	1.1	0.1	53.1	2.7	0.2	0.0	0.2	0.0	N/A	N/A
Upland - Wet	0.0	0.0	147.9	13.7	16.1	0.9	N/A	N/A	N/A	N/A	N/A	N/A	0.1	0.0
Willow	0.2	0.1	0.7	0.1	0.1	0.0	N/A[c]	N/A	N/A[c]	N/A	N/A[c]	N/A	N/A	N/A
Total Area	254.7		1,077.2		1,803.9		1,974.1		1,820.6		1,782.3		1,943.6	

[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.

Appendix A. Conservation targets and Key Ecological Attributes (KEAs) of The Nature Conservancy at The Emiquon Preserve during 2007−2013 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	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	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	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	
4			Non-woody invasives	<50% goldenrod, cocklebur, and other undesirable species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	New/Proposed
5			Woody encroachment	<25% coverage woody invasive species	Yes	Yes	Yes	Yes	Yes	Yes	Yes	New/Proposed
6			Forb and grass coverage	forbs $\geq$10% coverage	-	-	-	-	-	-	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	Revised
8			AMCO Brood density	>1 brood/km2	-	1.2	1.4	0	0.1	0.1	1.0	New/Proposed

Appendix A. Continued.

#	Conservation Target	KEA	Indicator	Desired range	2007	2008	2009	2010	2011	2012	2013	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	
11			Total Dabbler+Diver use days (Fall)	GOOD = >2,000 UDs/ha; FAIR = 1,500-2,000 UDs/ha; POOR = <1,500 UDs/ha	5,601	2,183	1,898	1,972	2,390	1,936	1,816	
12			Relative Dabbler+Diver use days (Fall)	>Top 5 IRV Lakes average UD/ha	200%	49%	15%	93%	81%	3%	-28%	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	4,427	1,308	1,107	1,539	1,728	1,470	1,420	New/Proposed
14			Relative Non-Mallard Dabbling Duck use days (Fall)	>Top 5 IRV Lakes average UD/ha	260%	130%	99%	124%	94%	66%	-9%	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	24	70	447	157	194	161	172	New/Proposed
16			Relative Diving Duck use days (Fall)	>Top 5 IRV Lakes average UD/ha	-79%	105%	22%	27%	25%	-40%	-47%	New/Proposed
17			Total Diving Duck use days (Spring)	>405 UDs/ha	-	785	528	306	325	299	190	New/proposed
18		Nesting	Brood counts	>0.15 broods/ha peak survey (15 b/km2)	-	10	14	18	15	16	5	Revised

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