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Illinois Waterfowl Surveys and Investigations W-43-R-63

Annual Progress Report FY2016

Period: 1 July 2015 – 30 June 2016

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Prepared for:
Illinois Department of Natural Resources, Division of Wildlife
&
U.S. Fish and Wildlife Service
Contract Number: RC09-13FWUIUC

INHS Technical Report 2016 (32)

Released 31 August 2016

Unrestricted – Release two years from issue date

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ANNUAL REPORT – FY2016
Illinois Waterfowl Surveys and Investigations
Federal Aid in Wildlife Restoration
W-43-R-63

EXECUTIVE SUMMARY

Objectives

1) Inventory abundance and distribution of waterfowl and other waterbirds (a minimum of 10 species and guilds) during autumn migration at a minimum of 30 sites along the Illinois and central Mississippi rivers of Illinois,
2) Estimate waterfowl and other waterbird population sizes (a minimum of 10 species and guilds) during autumn migration using an aerial quadrat survey along the central Illinois River for comparison with aerial inventories (Objective 1),
3) Investigate the ecology of up to 50 gadwall and 50 American green-winged teal during spring migration in and near the central Illinois River valley of Illinois,
4) Determine breeding bird use of and nest density in a minimum of 10 moist-soil wetlands managed for waterfowl during summer in central Illinois,
5) Investigate the breeding ecology of a minimum of 50 sandhill cranes during spring and summer in northeastern Illinois consistent with an ongoing research project,
6) Investigate movements and home range size of a minimum of 10 Canada geese during winter in and near the Greater Chicago Metropolitan Area of Illinois, and
7) Determine habitat quality of a minimum of 100 wetlands and deepwater habitats during spring, summer, and early autumn for migrating dabbling ducks, breeding wetland birds, and migrating shorebirds in Illinois.

Methods

We scheduled 17 flights of the Illinois and Mississippi rivers from early September 2015 to early January 2016 during which we inventoried 18–23 areas in each river valley. One observer conducted all inventories from a single-engine, fixed-wing aircraft flying at an altitude of <450 ft and 150–160 mph (Havera 1999). We computed waterfowl use-day (Stafford et al. 2007) and peak abundance estimates for the Illinois River valley (IRV) and central Mississippi River valley (CMRV) and made comparisons between the current waterfowl abundance and the most recent 5-year average. Concurrently from mid-October through early January, we surveyed 55 1-mi^2 quadrats within the La Grange and Peoria pools of the IRV to generate total population size for comparison with aerial inventories. We evaluated detection probabilities and count bias by comparing ground counts of fixed survey areas with aerial observer counts and evaluated a downward facing fuselage-mounted camera for future use in counting waterbirds.

We flew eight complete (50 1-mi^2 quadrats) and two partial (<50 1-mi^2 quadrats) quadrat surveys of the Illinois River valley from Hennepin, IL to Meredosia, IL. We flew quadrat surveys during weeks when traditional aerial waterfowl inventories were conducted (Objective 1). We collected photographs from an aircraft-fuselage mounted camera during quadrat surveys to estimate detection probability and estimate waterbird abundance. Additionally, we used ground observers to verify waterbird abundance, determine species composition, and monitor waterbird behavior and disturbance during quadrat flights.

We captured, using swim-in traps and rocket nets, and leg banded 1,262 ducks during spring 2016 in Mason, Fulton, and Tazewell counties along the Illinois River. We radiomarked 79 individuals with 6–7 g glue-on, backpack, radio transmitters. Specifically, we tagged 56 American green-winged teal (AGWT, scientific names presented in Table 1) and 23 gadwall (GADW) in February and March 2016. We used VHF radio telemetry and truck-mounted null-peak antennae systems to monitor AGWT and GADW both diurnally and nocturnally to determine movement distances, habitat use, home range size, survival, and stopover duration in central Illinois. Additionally, we lethally collected 44 foraging AGWT during March 3–April 14, 2016 to determine food use and selection in spring. We evaluated the abundance of waterfowl forage where AGWT were collected at 24 locations in the IRV.

We estimated breeding bird use of dewatered moist-soil wetlands during summers 2014–2015, including estimating bird density, nest density, and nest survival. We conducted point counts and searched known-size areas for nests every two–three weeks. Nests were revisited weekly until destroyed, abandoned, or hatched. Density and detection probability were estimated using distance methods.

During summer molt periods of 2014–2016, we captured and deployed neck collars and/or leg bands on 1,026 Canada geese in the Greater Chicago Metropolitan Area. During December 2014 – February 2015 and November 2015 – December 2015, we captured 207 geese with rocket nets and a handheld net gun and deployed cellular transmitters on 41 geese. We monitored survival, habitat use, and daily movements of marked geese in relation to several weather covariates during both winters.

We estimated wetland quantity and quality throughout Illinois during important time periods for several migratory bird guilds (spring – dabbling ducks, summer – marsh birds, autumn - shorebirds). We conducted aerial and ground counts for dabbling ducks and other waterbirds during spring, call-back surveys for marsh birds during late spring and early summer, and aerial and ground surveys for shorebirds during autumn; mapped wetland area and determined wetland quality during each time period; and conducted vegetation surveys during autumn (Conway 2011). We obtained habitat quality metrics within 100 meters surrounding the survey areas each time call-response surveys were conducted. We digitized spring and summer visited wetlands in ArcMap with corresponding inundation and vegetation cover data taken in the field.

Major Accomplishments and Findings

We completed all four scheduled flights of the IRV and three flights of the CMRV in September to document the distribution of early-migrating blue-winged and American green-winged teal (scientific names presented in Table 1). We completed 12 of 13 scheduled flights of the Illinois and Mississippi rivers from the second week of October to the first week of January. Peak duck abundance in the IRV was lower in 2015 than 2014, but higher in the CMRV in 2015 than 2014. Duck abundance peaked in the IRV on 2 November at 302,780 birds and ranked 56th out of 67 years of monitoring. Peak abundance of ducks in the CMRV occurred on December 3rd (649,895) and ranked 22nd out of 67 years. Despite a November 21st cold snap in central United States, total duck use-day estimates in 2015 exceeded those of 2014 along both river systems.

The total duck use-day estimate from the IRV ranked 47th and 22nd along the Mississippi River since the inception of surveys in 1948.

We posted aerial survey data weekly on the Forbes Biological Station web page (www.bellrose.org) for public outreach to the waterfowl hunting and bird watching communities. Additionally, we reported general observations of waterfowl and habitat conditions following each flight in a blog that was posted weekly on the Forbes Biological Station web page (www.bellrose.org) and on social media (http://www.facebook.com/forbesbiologicalstation) and reached 152,410 Facebook users in 2015 with an average viewership of 11,724 followers each week. Additionally, our blog was posted weekly at http://www.heartlandoutdoors.com/yetter, and http://www.straycasts.net, and it was printed in weekly newspaper columns in the Mason County Democrat and Fulton County Democrat. Aerial survey data was also used by the Mallard Migration Observation Network to generate the Mallard Migration Status map posted online by the Missouri Department of Conservation (http://huntfish.mdc.mo.gov/hunting-trapping/species/waterfowl/waterfowl-reports-prospects/mallard-migration).

We determined the detection probability of waterfowl was 100% and the proportion of waterfowl detected was 96.0% (SE = 7%) during traditional and quadrat surveys (range = 53.3–105.2% across guilds). Our data show that estimated waterfowl abundance derived from aerial photographs was not reliable. Error rates between aerial-observer and photograph-generated waterfowl abundance in the IRV was 2,760% (SE = 1,150%). On average, 12.2% (SE = 2%) of ducks were disturbed by aerial surveys and 2.0% (SE = 1%) of ducks abandoned the survey site completely. When we combined all locations in the IRV, error between the two survey types for population size within the entire study area ranged from -14,593% for northern pintails to 66.8% for American green-winged teal. Disparity in the northern pintail estimates was due to the mass departure of pintails from the IRV following the November 21st freeze up. In most cases, aerial quadrat surveys produced higher abundance estimates than traditional inventory surveys. We found quadrat surveys were more parsimonious during early time periods, with total ducks and waterbirds displaying errors of 11.6% and 6.0%, respectively. However, between-survey error increased during later time periods for both ducks (-45.7%) and total waterbirds (-42.5%) due to redistributions of birds as ice cover and/or inundated wetland availability increased due to precipitation.

We triangulated 951 locations (453 diurnal and 498 nocturnal) of AGWT and GADW during spring 2016. Movement distances between day and night roosts ranged from 5,000–5,650 m. Across age classes, spring survival was 0.810 for the entire 49-day period when the majority of AGWT were present in the IRV and marked individuals were tracked (CI^{95} = 0.478–0.952). All GADW survived during spring 2016 until departing the IRV or radio failure. Stopover duration during spring 2016 was 14.4 days and 26.5 days for AGWT and GADW, respectively. The combined estimate of stopover duration for both species was 17.3 days. The most frequently used habitat types of both species was emergent marsh (46.1%), wooded wetland (18.7%), and open water (18.2%). Our estimates of home range size (95% Minimum Convex Polygons) for AGWT and GADW averaged 2,413 ha (SE = 591) and 2,791 ha (SE = 703), respectively.

We lethally collected and processed gastrointestinal tracts of 44 foraging AGWT (32 male, 12 female) in the IRV during March 3–April 14, 2016. Generally, plant material was observed most frequently (100%) and with a greater aggregate mass (nearly 75%) than invertebrate items. The three most common food items were *Polygonum* seeds, *Cyperus* seeds, and aquatic worms (Class Oligochaeta). Food density was 309 kg/ha across collection locations during spring migration 2016. Waterfowl forage density was greatest at Chautauqua National Wildlife Refuge (631 kg/ha), Quiver Creek (560 kg/ha) and Sand Lake (467 kg/ha) in Mason County, IL.

We quantified avian use of dewatered moist-soil wetlands in the Illinois River valley compared to grasslands and used environmental variables to predict measures of avian density, avian conservation significance (ACS), nest density, and nest success. Nest densities were greater in grasslands (0.13 nests/ha, SE = 0.02) than in moist-soil wetlands (0.09 nests/ha, SE = 0.01), but habitat did not have a strong effect on avian density (grassland $\overline{x}$ = 13.5 birds/ha, SE = 3.5; moist-soil wetland $\overline{x}$ = 10.2 birds/ha, SE = 1.1) or ACS (grassland $\overline{x}$ = 218.6, SE = 27.8; moist-soil wetland $\overline{x}$ = 214.2, SE = 15.9). The percent cover of woody vegetation had a positive relationship with ACS, and the percent cover of forbs had a negative relationship with avian density. Sites that were disconnected from the river had greater avian conservation significance than partially connected sites. Wetland size and the proximity to the Illinois River were poor predictors of nest density. Many grassland birds used moist-soil wetlands, including nesting dickcissels (*Spiza americana*, a generalist-grassland nester) and grasshopper sparrows (*Ammodramus savannarum*, an obligate-grassland nester). We also observed the state endangered northern harrier (*Circus cyaneus*), common gallinule (*Gallinula galaeta*), and Forster's tern (*Sterna forsteri*) in moist-soil wetlands. Dewatered moist-soil wetlands provided useful breeding habitat for grassland birds, but wetlands that were partially connected to the Illinois River posed a risk to nesting birds if they flooded during the breeding season.

In 2015, we concluded monitoring of tagged adult and juvenile sandhill cranes (*Grus canadensis*) in northern Illinois. The primary activity during this fiscal year was analyzing the population dynamics of the cranes in the Midwest and providing data and analyses to the U.S. Fish and Wildlife Service (USFWS) to support a harvest model. In late 2015, graduate student Jeff Fox took a position with Operation Migration to continue his crane migration work and has continued to work with USFWS and project collaborators to manipulate and analyze data as needed.

During 2015, emergent polygon inundation rates of randomly-selected wetland plots across Illinois exceed 60% during spring and summer but were around 40% during autumn. Inundation rates were greatest during summer (42%) in forested polygons, but similar and low overall during spring and autumn (33%). Shallow inundation was <44% in all sampling periods and polygon types as was the proportion of inundated dense emergent vegetation (<16%) and non-persistent emergent vegetation (<36%). Mudflats comprised a small proportion of all habitat types during autumn (<4%). During 2016, 55 wetland plots were visited during mid-February – mid-March 2016 by INHS and 57 sites were visited by SIU. During spring 2016, 3,735 waterbirds were counted during aerial surveys, but no waterbirds were detected in 58% of plots. During mid-April through mid-June, 61 wetland plots were surveyed by INHS and 65 by SIU. We detected 98 sora (*Porzana Carolina*), 63 American coot (*Fulica Americana*), 13 Virginia rail (*Rallus limicola*), 7 pied-billed grebe (*Podilymbus podiceps),* and 2 American bittern (*Botaurus lentiginosus*) in survey plots. Additional analyses will be reported in future reports following completion of our 2016 field season.

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NARRATIVE

STUDY 123: AERIAL INVENTORIES OF WATERFOWL IN ILLINOS

Objectives:

1) Identify and enumerate waterfowl and American coots at a minimum of 30 locations along the Illinois and central Mississippi rivers of Illinois during autumn migration using light aircraft.

2) Compute annual use-days and peak abundances for observed species with long-term averages.

3) Provide general inference regarding the distribution of waterfowl in space and time relative to habitat conditions.

4) Compare these data to recent and long-term averages.

5) Summarize and distribute these data.

Introduction

The Illinois and Mississippi river valleys are major migration and wintering areas for nearly 30 species of waterfowl in the Mississippi Flyway. Additionally, these regions provide significant recreational opportunities (e.g., hunting and bird watching). Data from aerial inventories are used to direct waterfowl management, habitat acquisition, ecological research, and for public outreach. There are many important private, state, and federal waterfowl areas and refuges within these river floodplains, such as the Mark Twain National Wildlife Refuge (NWR), the Illinois River National Wildlife and Fish Refuges, and Keokuk Pool. The Illinois Natural History Survey (INHS), with support from the Illinois Department of Natural Resources (IDNR) and the Federal Aid in Wildlife Restoration Fund through the U.S. Fish and Wildlife Service (USFWS), has conducted aerial inventories of waterfowl along the Illinois and Mississippi rivers since 1948 (flown each year but 2001). This undertaking represents the longest known inventory of waterfowl, preceding even the USFWS breeding waterfowl counts and mid-winter inventories established in 1955. Therefore, 66 years of data exist on fall-migrating waterfowl for these critical ecoregions, collected by only 4 observers.

Aerial inventory data are frequently requested and used by federal and state agencies for regulatory decisions, evaluation of management or enhancement projects, and conservation prioritization. Specifically, the IDNR relies on these inventories to guide the establishment of hunting season dates, zones, and other regulations and to prioritize wetland habitat acquisitions.

Previously, this database has been used by the Mississippi Flyway Technical Section and Council to monitor abundance and distribution of migrating waterfowl, especially canvasbacks, mallards, and northern pintails. Requests for inventory information are received annually from state, federal, and private-sector employees to be used for projects such as Environmental Management Programs, scientific publications, theses and dissertations, formal presentations, and newspaper and magazine articles. Further, the long-term nature of this dataset makes it particularly unique and valuable; therefore, it was essential that the fall inventory database continue to be summarized and maintained for future analyses. We monitored waterfowl in Illinois to maintain this long-term dataset, evaluated spatial and temporal variation in abundance and distribution of waterfowl, and presented these data concisely to aid waterfowl and wetland management decisions in this region.

Methods

The INHS began aerial inventories of waterfowl during fall migration in the Illinois and Mississippi river floodplains in 1948. Initially, these flights were conducted weekly from 1–21 September to mid-December, and the winter inventory in early January was added in 1955. More recently, 4 flights were made in September and weekly flights from the second week of October through the first week of January to better overlap with important migration periods of waterbirds in our study region. We used fixed-wing aircraft to conduct aerial inventories of waterfowl and other waterbirds present at selected sites along the Illinois (Hennepin to Grafton, IL) and central Mississippi river valleys (Grafton to near New Boston, IL) during fall and early winter (Fig. 1; Havera 1999). One observer conducted all inventories from a single-engine, fixed-wing aircraft flying at an altitude of <450 ft and 150–160 mph (Havera 1999, Stafford et al. 2007).

We recorded the number and species composition of waterfowl at each site, and survey methods mirrored previous years to maintain consistency with past inventories (Table 1; Havera 1999). During each flight, we inventoried 18–23 areas in each river valley that typically host the majority of waterfowl in the region (Horath and Havera 2002). We computed waterfowl use-day (Stafford et al. 2007) and peak abundance estimates for the Illinois River valley (IRV) and central Mississippi River valley (CMRV) and made comparisons between the current waterfowl abundance and the most recent 5-year average. We also noted river water levels and resulting foraging habitat quality for waterfowl during September flights (Fig. 2).

Results and Discussion

Wetland Habitats and Fall Migration

We provided weekly summaries of waterbird abundance to the IDNR, USFWS, and other parties of interest (Appendix 1). We ranked wetland habitat conditions for migratory waterfowl and noted river stage readings during the growing season. Summer 2015 was characterized by frequent rains which caused extensive flooding along the Illinois River valley (IRV; Fig. 2; U.S. Army Corps of Engineers, unpublished data) and the confluence region of the Illinois and Mississippi rivers near Grafton, IL. The Illinois River stage at Havana on July 1st was the second highest (27.2 ft) crest on record; likewise, the Illinois River at Henry crest one day earlier (June 30th) and was the 11th highest stage of record. The Illinois River receded below flood stage in early August on both the Henry and Havana gages; however, rain events in mid-September caused another rise in river levels which destroyed much of the waterfowl foods at many locations along the Illinois River. Consequently, waterfowl food availability ranked below average for both the upper and lower reaches of the IRV. Notable exceptions included Hennepin & Hopper Lakes, Banner Marsh State Fish and Wildlife Area, and The Emiquon Preserve.

Similar to the Illinois River, the lower portion of the central Mississippi River valley (CMRV) experienced high water events during the growing season which compromised moist-soil vegetation at many of the refuges. Consequently, wetland conditions for migratory waterfowl were slightly below average along the CMRV. Beds of submersed aquatic vegetation (SAV) at Pool 19, a key migratory stopover habitat for diving ducks (Aythyini), of the Mississippi River were considered below average. Average amounts of SAV were noted near the dam at Pool 19 near Hamilton, IL; however, SAV was below average on other portions of the pool. Most noteworthy was the lack of vegetation at the American lotus (*Nelumbo lutea*) bed north of Montrose, IA along the western shore of Pool 19. This stand of floating-leaved vegetation (typically >800 acres) was virtually non-existent during fall inventories, and no SAV was noted at this location. We intend to monitor this lotus bed in subsequent years. Notable refuges with quality waterfowl forage along the CMRV included: Louisa and Keithsburg divisions of the Port Louisa National Wildlife Refuge (NWR), Clarence Cannon NWR, Delair Division of the Great River NWR, and Ted Shanks Conservation Area.

Abundances and Species Comparisons

We completed 16 of 17 (94%) scheduled weekly aerial inventories of the IRV and 15 of 17 (88%) flights of the CMRV during fall migration beginning 31 August 2015 and ending 5 January 2016. Fall 2015 was characterized by above average temperatures and late season flooding beginning in mid-November. Other than a temporary freeze-up at Thanksgiving, many wetlands remained ice-free until early January 2016. As a consequence of flooding and below average duck food availability, peak abundance estimates of ducks ranked 56th in the IRV (302,780 total ducks) and 22nd in the CMRV (649,895 total ducks) out of the 67 years we have been monitoring waterfowl along these rivers (Fig. 3).

Peak abundance of total ducks was lower in the IRV but greater in the CMRV in 2015 than 2014 (Table 2). In the IRV, peak abundance of total ducks for 2015 occurred on 2 November (Fig. 4; 302,780); this estimate was 46% below the 2014 peak (562,800) and 42% below the most recent 5-year average of 523,544 (2010–2014; hereafter, 5-year average). Peak counts of waterfowl in the IRV over the last 5 years have varied chronologically from 2 November (2015), 5 November (2014), 8 November (2013), 12 December (2012) to 15 November (2011).

Ducks persisted longer in the CMRV than the IRV despite late season flooding along both rivers (Figs. 4-5). Several rains passing through the lower portions of the CMRV in December shallowly inundated several refuges and provided extensive areas of high quality foraging habitat for dabbling ducks. For instance, 222,755 ducks were observed at Clarence Cannon NWR on December 15th as the moist-soil vegetation in the wetland complex was nearly 100% covered with shallow water and sheet water. Total duck numbers declined from mid-December through the end of December. However, temperatures across the Midwest dropped in early January forcing staging ducks in northerly locations to migrate south. As noted during the January 5th inventory, over 227,000 canvasbacks were estimated on Pool 19 in the CMRV. Total duck abundance peaked in the CMRV on 3 December (649,895) at levels 24% above 2014 (522,130) and 36% above the 5-year average (476,716) (Fig. 3, 5; Table 2). Peak abundance of total ducks has varied from 25 November to 12 December over the last 5 years: 2015 (3 December), 2014 (25 November), 2013 (29 November), 2012 (12 December), and 2011 (30 November). The peak abundance of total ducks for the two river systems combined (850,605) was 11% below the peak in 2014 (954,165) and 3% below the 5-year average (880,424).

Waterfowl Use-Days

Use-day estimates for total ducks were higher in the IRV and CMRV in 2015 than 2014 (16,858,035 [+7%] and 24,875,718 [+15%], respectively; Table 3; Fig. 6). In the IRV, estimated use days for dabbling ducks were slightly higher (+2%) in 2015 than 2014. And, dabbling duck use days were up 23% in the CMRV (19,618,448) in comparison to 2014 (15,995,595). Excepting mallards and American wigeon, estimated use days for all species of dabbling duck species were higher in 2015 than 2014 in the CMRV. Since the inception of the waterfowl inventory in 1948, total duck use days in the IRV ranked 47th in 2015. Conversely, total duck use days in the CMRV ranked 22nd out of 67 years.

Total diving duck use-day estimates in the IRV were 49% higher in 2015 than 2014 (2,671,003 and 1,790,905, respectively; Table 3). Use-day estimates for lesser scaup (-54%) and common goldeneye (-95%) were lower in the IRV in 2015 than 2014; however, ruddy duck use days (+175%) nearly tripled during fall 2015 in comparison to fall 2014. In the CMRV, scaup (+27%) had higher use days in 2015 than 2014; however, canvasbacks were down (-43%) from the previous fall. The lower numbers of canvasbacks in the CMRV was due to the late arrival of this species in early January from northerly staging areas. Overall, fall diving duck use days (5,254,993) were fairly similar in 2014 and 2015, but were 31% higher than the 2010-2014 average.

Outreach

We distributed waterbird abundance data weekly as fall aerial inventories were completed and summarized. INHS biologist Aaron Yetter also recorded his general observations of waterfowl distributions and wetland habitat conditions following flights (n = 13) in a blog that was posted weekly at www.bellrose.org, www.facebook.com/forbesbiologicalstation, http://www.heartlandoutdoors.com/yetter, and http://www.straycasts.net and printed in a weekly newspaper column in the Mason County Democrat and Fulton County Democrat. Our Facebook page received 152,410 views over the 13 weeks; for an average readership of 11,724 Facebook followers each week.

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Table 1. Avian species encountered during fall 2015 aerial inventories of the Illinois and central Mississippi rivers.

Common Name/Species Group	Scientific Name[a]	Abbreviation
Dabbling ducks		
Mallard	*Anas platyrhynchos*	MALL
American black duck	*Anas rubripes*	ABDU
Northern pintail	*Anas acuta*	NOPI
Blue-winged teal	*Anas discors*	BWTE
American green-winged teal	*Anas crecca*	AGWT
American wigeon	*Anas americana*	AMWI
Gadwall	*Anas strepera*	GADW
Northern shoveler	*Anas clypeata*	NSHO
Diving ducks		
Lesser scaup	*Aythya affinis*	LESC
Ring-necked duck	*Aythya collaris*	RNDU
Canvasback	*Aythya valisineria*	CANV
Redhead	*Aythya americana*	REDH
Ruddy duck	*Oxyura jamaicensis*	RUDU
Common goldeneye	*Bucephala clangula*	COGO
Bufflehead	*Bucephala albeola*	BUFF
Mergansers		
Common merganser	*Mergus merganser*	COME
Red-breasted merganser	*Mergus serrator*	RBME
Hooded merganser	*Lophodytes cucullatus*	HOME
Geese		
Greater white-fronted goose	*Anser albifrons*	GWFG
Canada goose	*Branta canadensis*	CAGO
Snow goose	*Chen caerulescens*	LSGO
American coot	*Fulica americana*	AMCO
American white pelican	*Pelecanus erythrorhynchos*	AWPE

[a] According to the American Ornithologists' Union Check-list, 2006.

Table 2. Peak abundance estimates of various species of waterfowl during falls 2014 and 2015, the average for 2010─2014 and the percent change (Δ) between 2015 and periods of interest.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Mallard					
Illinois River	157,850	130,350	246,371	-17	-47
Central Mississippi River	359,710	390,195	289,437	8	35
Illinois & Mississippi Rivers	503,760	510,740	535,463	1	-5
American black duck					
Illinois River	1,070	700	1,565	-35	-55
Central Mississippi River	100	600	797	500	-25
Illinois & Mississippi Rivers	1,120	1,300	1,915	16	-32
Northern pintail					
Illinois River	55,385	59,880	72,967	8	-18
Central Mississippi River	83,200	105,100	69,718	26	51
Illinois & Mississippi Rivers	138,585	144,080	130,595	4	10
Blue-winged teal					
Illinois River	17,750	49,405	30,230	178	63
Central Mississippi River	1,240	18,855	4,411	1421	327
Illinois & Mississippi Rivers	18,990	68,260	34,293	259	99
American green-winged teal					
Illinois River	76,375	78,720	82,164	3	-4
Central Mississippi River	54,960	73,535	49,897	34	47
Illinois & Mississippi Rivers	130,640	138,325	114,728	6	21
American wigeon					
Illinois River	7,280	4,205	7,255	-42	-42
Central Mississippi River	4,270	650	2,858	-85	-77
Illinois & Mississippi Rivers	11,550	4,855	8,850	-58	-45
Gadwall					
Illinois River	107,490	30,210	76,281	-72	-60
Central Mississippi River	58,705	36,000	47,307	-39	-24
Illinois & Mississippi Rivers	166,195	62,185	115,223	-63	-46
Northern shoveler					
Illinois River	35,900	32,210	29,088	-10	11
Central Mississippi River	12,535	23,570	12,199	88	93
Illinois & Mississippi Rivers	48,435	55,780	35,663	15	56
Dabbling ducks					
Illinois River	406,210	254,695	448,985	-37	-43
Central Mississippi River	444,170	517,930	375,047	17	38
Illinois & Mississippi Rivers	668,005	666,160	724,399	0	-8

Table 2. Continued.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Lesser scaup					
Illinois River	48,155	5,700	12,918	-88	-56
Central Mississippi River	71,650	35,710	37,254	-50	-4
Illinois & Mississippi Rivers	119,805	41,410	49,510	-65	-16
Ring-necked duck					
Illinois River	40,810	15,610	35,220	-62	-56
Central Mississippi River	35,400	33,125	25,237	-6	31
Illinois & Mississippi Rivers	76,210	46,810	52,039	-39	-10
Canvasback					
Illinois River	6,555	4,370	4,510	-33	-3
Central Mississippi River	153,775	120,000	130,013	-22	-8
Illinois & Mississippi Rivers	156,350	124,310	131,407	-20	-5
Redhead					
Illinois River	1,030	1,370	524	33	161
Central Mississippi River	3,400	875	979	-74	-11
Illinois & Mississippi Rivers	3,400	1,370	1,167	-60	17
Ruddy duck					
Illinois River	60,030	44,360	30,297	-26	46
Central Mississippi River	16,630	28,295	18,559	70	52
Illinois & Mississippi Rivers	76,660	66,660	45,998	-13	45
Common goldeneye					
Illinois River	5,045	210	2,477	-96	-92
Central Mississippi River	20,970	5,600	12,562	-73	-55
Illinois & Mississippi Rivers	26,015	5,810	14,089	-78	-59
Bufflehead					
Illinois River	1,360	560	1,316	-59	-57
Central Mississippi River	3,465	6,300	4,919	82	28
Illinois & Mississippi Rivers	4,825	6,860	6,023	42	14
Diving ducks					
Illinois River	156,580	66,635	77,343	-57	-14
Central Mississippi River	198,540	219,695	167,080	11	31
Illinois & Mississippi Rivers	286,615	269,270	197,421	-6	36
Total mergansers					
Illinois River	2,645	980	2,917	-63	-66
Central Mississippi River	12,665	200	10,441	-98	-98
Illinois & Mississippi Rivers	14,065	1,180	12,441	-92	-91

Table 2. Continued.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Total ducks					
Illinois River	562,800	302,780	523,544	-46	-42
Central Mississippi River	522,130	649,895	476,716	24	36
Illinois & Mississippi Rivers	954,165	850,605	880,424	-11	-3
Greater white-fronted goose					
Illinois River	2,855	10,115	4,346	254	133
Central Mississippi River	8,615	3,200	3,180	-63	1
Illinois & Mississippi Rivers	11,470	13,315	7,269	16	83
Canada goose					
Illinois River	7,160	7,430	17,002	4	-56
Central Mississippi River	8,335	13,890	9,375	67	48
Illinois & Mississippi Rivers	13,210	19,050	24,085	44	-21
Lesser snow goose					
Illinois River	3,505	8,405	4,349	140	93
Central Mississippi River	9,015	7,200	6,543	-20	10
Illinois & Mississippi Rivers	9,025	15,605	9,647	73	62
American coot					
Illinois River	163,680	208,870	150,453	28	39
Central Mississippi River	53,440	69,000	35,395	29	95
Illinois & Mississippi Rivers	195,375	270,685	177,617	39	52

Table 3. Use-day estimates of waterfowl during falls 2014 and 2015, the average for 2010─2014 and the percent change (Δ) between 2015 and periods of interest.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Mallard					
Illinois River	6,301,230	5,289,830	7,711,843	-16	-31
Central Mississippi River	11,722,595	9,331,268	7,445,504	-20	25
Illinois & Mississippi Rivers	18,023,825	14,621,098	15,157,347	-19	-4
American black duck					
Illinois River	29,260	26,240	42,339	-10	-38
Central Mississippi River	2,073	9,183	9,056	343	1
Illinois & Mississippi Rivers	31,333	35,423	51,394	13	-31
Northern pintail					
Illinois River	1,860,220	2,143,095	2,595,276	15	-17
Central Mississippi River	1,853,958	4,294,508	2,370,891	132	81
Illinois & Mississippi Rivers	3,714,178	6,437,603	4,966,167	73	30
Blue-winged teal					
Illinois River	340,633	760,438	766,350	123	-1
Central Mississippi River	33,943	315,360	114,779	829	175
Illinois & Mississippi Rivers	374,575	1,075,798	881,129	187	22
American green-winged teal					
Illinois River	2,903,393	3,369,768	3,210,400	16	5
Central Mississippi River	1,271,893	3,282,230	1,772,229	158	85
Illinois & Mississippi Rivers	4,175,285	6,651,998	4,982,628	59	34
American wigeon					
Illinois River	204,503	103,873	211,740	-49	-51
Central Mississippi River	47,320	16,388	51,483	-65	-68
Illinois & Mississippi Rivers	251,823	120,260	263,223	-52	-54
Gadwall					
Illinois River	1,396,795	1,181,795	2,131,948	-15	-45
Central Mississippi River	815,203	1,518,155	1,222,327	86	24
Illinois & Mississippi Rivers	2,211,998	2,699,950	3,354,275	22	-20
Northern shoveler					
Illinois River	837,693	1,295,323	1,067,712	55	21
Central Mississippi River	208,613	851,358	357,824	308	138
Illinois & Mississippi Rivers	1,046,305	2,146,680	1,425,535	105	51
Dabbling ducks					
Illinois River	13,873,725	14,170,360	17,737,607	2	-20
Central Mississippi River	15,955,595	19,618,448	13,743,741	23	43
Illinois & Mississippi Rivers	29,829,320	33,788,808	31,481,348	13	7

Table 3. Continued.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Lesser scaup					
Illinois River	409,373	186,280	151,849	-54	23
Central Mississippi River	810,795	1,027,090	688,456	27	49
Illinois & Mississippi Rivers	1,220,168	1,213,370	840,304	-1	44
Ring-necked duck					
Illinois River	552,785	559,143	706,943	1	-21
Central Mississippi River	798,060	1,126,125	652,169	41	73
Illinois & Mississippi Rivers	1,350,845	1,685,268	1,359,112	25	24
Canvasback					
Illinois River	96,160	165,005	84,398	72	96
Central Mississippi River	3,091,018	1,775,305	1,888,488	-43	-6
Illinois & Mississippi Rivers	3,187,178	1,940,310	1,972,886	-39	-2
Redhead					
Illinois River	7,855	33,610	6,075	328	453
Central Mississippi River	40,885	22,515	11,789	-45	91
Illinois & Mississippi Rivers	48,740	56,125	17,863	15	214
Ruddy duck					
Illinois River	620,045	1,706,003	637,883	175	167
Central Mississippi River	334,895	1,123,453	482,163	235	133
Illinois & Mississippi Rivers	954,940	2,829,455	1,120,046	196	153
Common goldeneye					
Illinois River	94,280	4,955	29,423	-95	-83
Central Mississippi River	510,523	109,340	202,274	-79	-46
Illinois & Mississippi Rivers	604,803	114,295	231,697	-81	-51
Bufflehead					
Illinois River	10,408	16,008	22,373	54	-28
Central Mississippi River	31,448	71,105	84,442	126	-16
Illinois & Mississippi Rivers	41,855	87,113	106,815	108	-18
Diving ducks					
Illinois River	1,790,905	2,671,003	1,638,942	49	63
Central Mississippi River	5,617,623	5,254,933	4,022,121	-6	31
Illinois & Mississippi Rivers	7,408,528	7,925,935	5,661,063	7	40
Total mergansers					
Illinois River	39,595	16,673	24,815	-58	-33
Central Mississippi River	135,598	2,338	54,506	-98	-96
Illinois & Mississippi Rivers	175,193	19,010	79,321	-89	-76

Table 3. Continued.

Species and Regions	2014	2015	2010─2014 Average	% Δ from 2014	% Δ from 2010─2014
Total ducks					
Illinois River	15,704,225	16,858,035	19,401,363	7	-13
Central Mississippi River	21,708,815	24,875,718	17,820,368	15	40
Illinois & Mississippi Rivers	37,413,040	41,733,753	37,221,731	12	12
Greater white-fronted goose					
Illinois River	26,230	99,155	31,373	278	216
Central Mississippi River	50,985	56,978	28,012	12	103
Illinois & Mississippi Rivers	77,215	156,133	59,385	102	163
Canada goose					
Illinois River	283,433	381,783	309,965	35	23
Central Mississippi River	324,570	734,235	328,128	126	124
Illinois & Mississippi Rivers	608,003	1,116,018	638,093	84	75
Lesser snow goose					
Illinois River	10,643	103,075	21,761	869	374
Central Mississippi River	57,270	67,478	68,245	18	-1
Illinois & Mississippi Rivers	67,913	170,553	90,006	151	89
American coot					
Illinois River	5,785,280	8,039,368	5,122,585	39	57
Central Mississippi River	1,083,860	2,547,065	1,025,861	135	148
Illinois & Mississippi Rivers	6,869,140	10,586,433	6,148,446	54	72

Figure 1. Locations in the Illinois and central Mississippi river valleys aerially inventoried for waterfowl by the Illinois Natural History Survey, fall 2015.

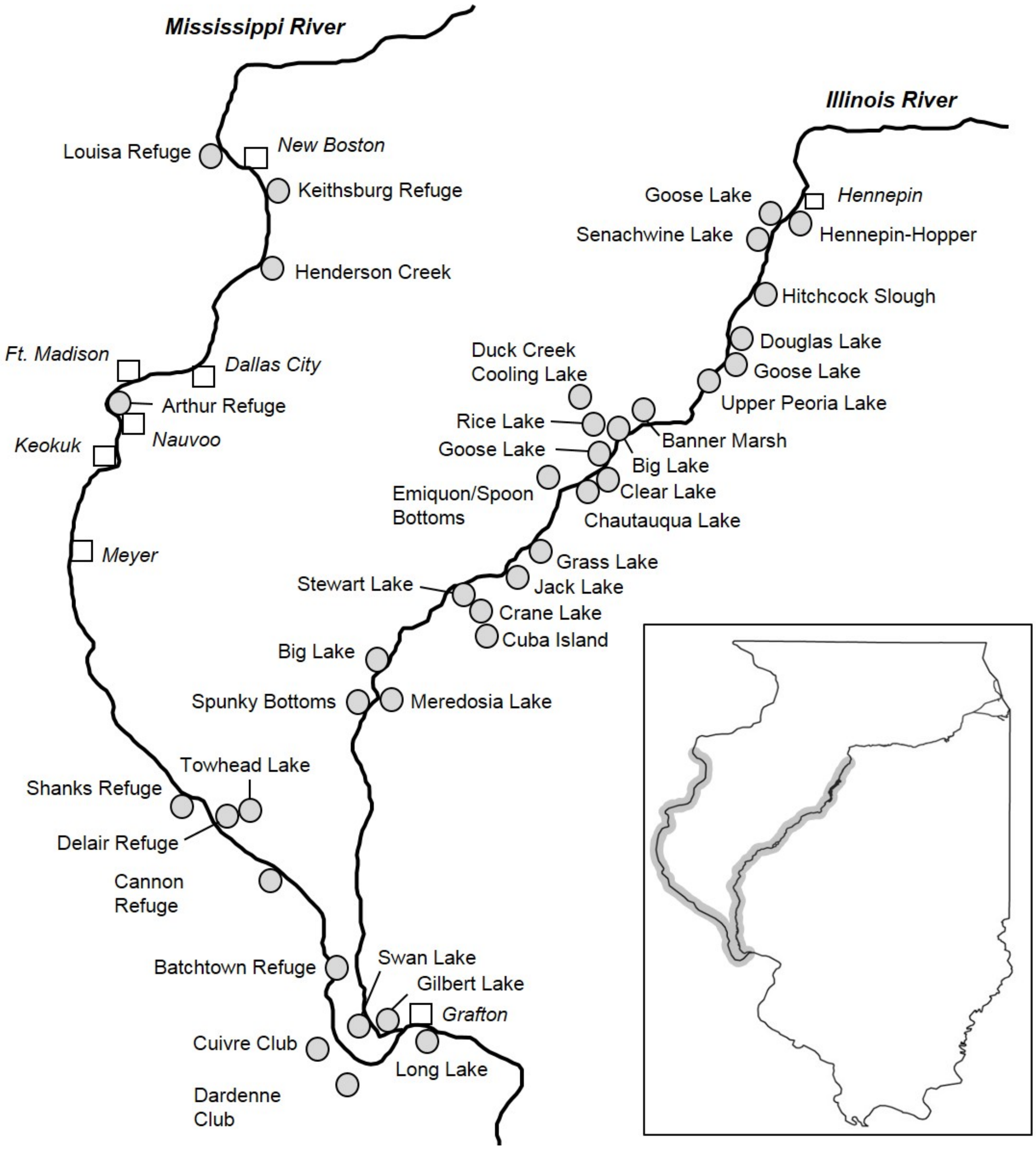


Figure 2. Water levels of the Illinois River during the 2015 growing season and fall waterfowl migration. (http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm)

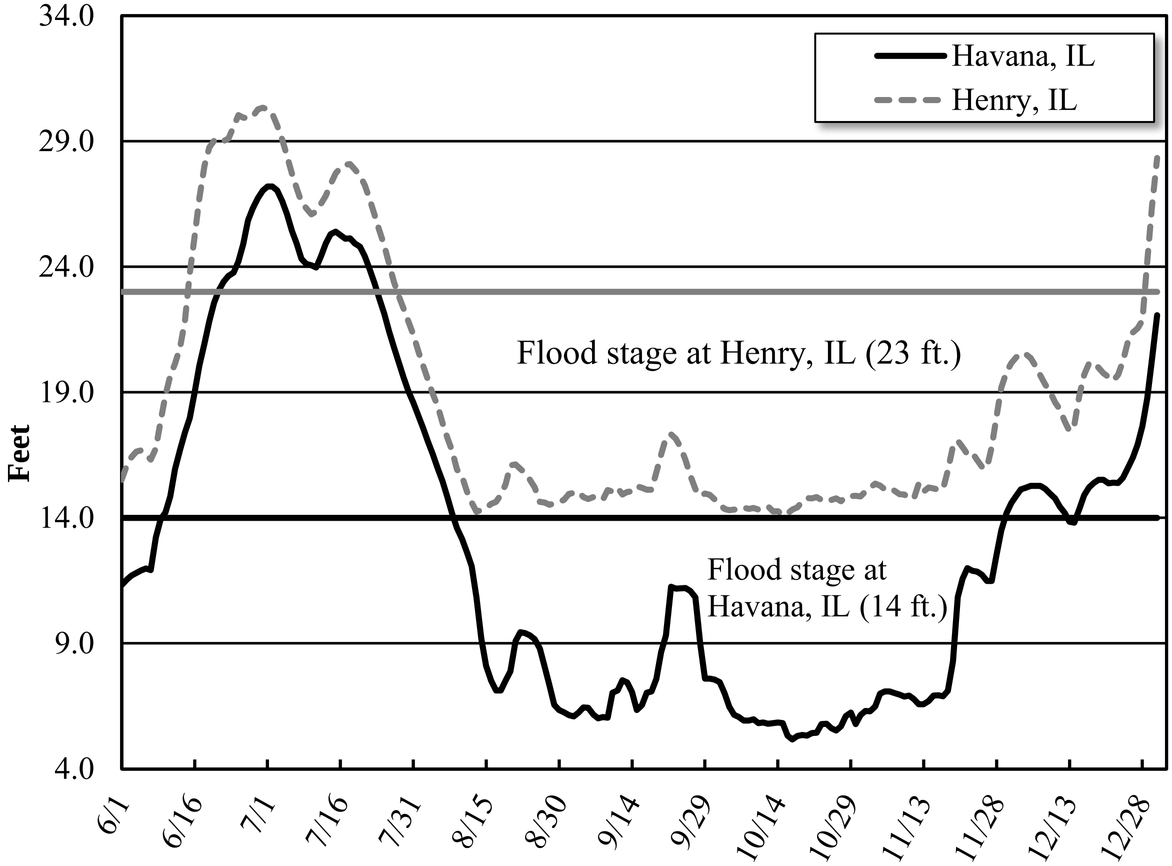


Figure 3. Peak abundance of total ducks observed during falls 1948–2015 in the Illinois River valley and central Mississippi River valley.

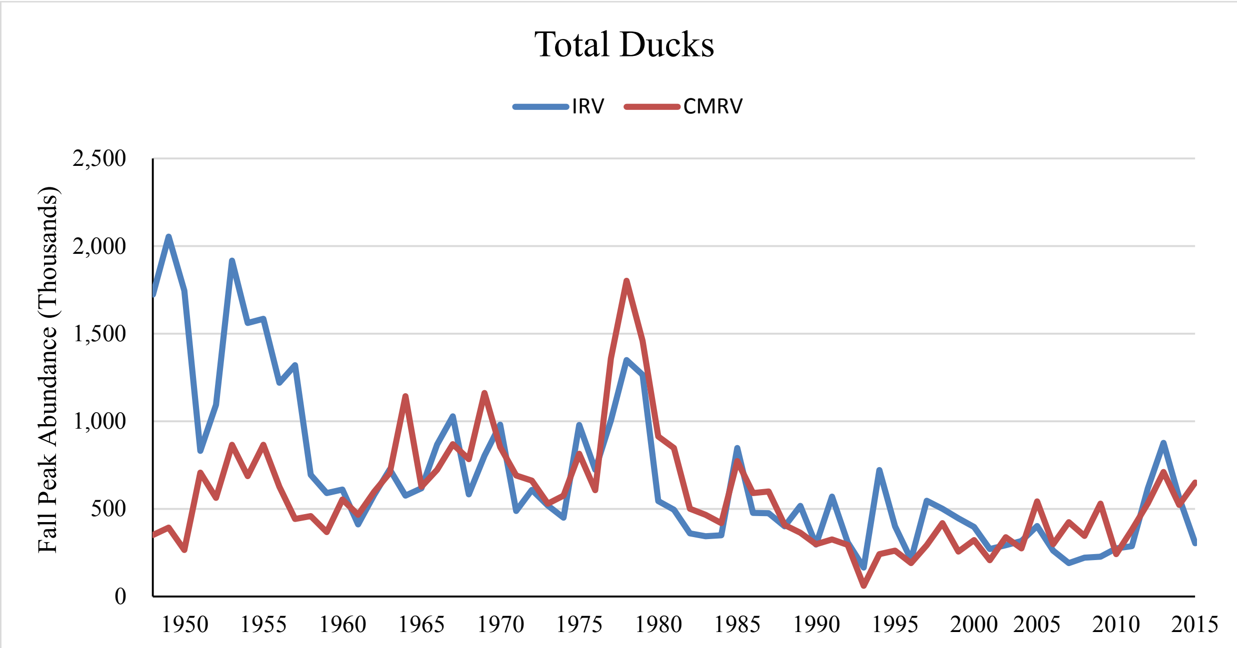


Figure 4. Estimated abundance of dabbling ducks, diving ducks, and total ducks observed during fall 2015 in the Illinois River valley.

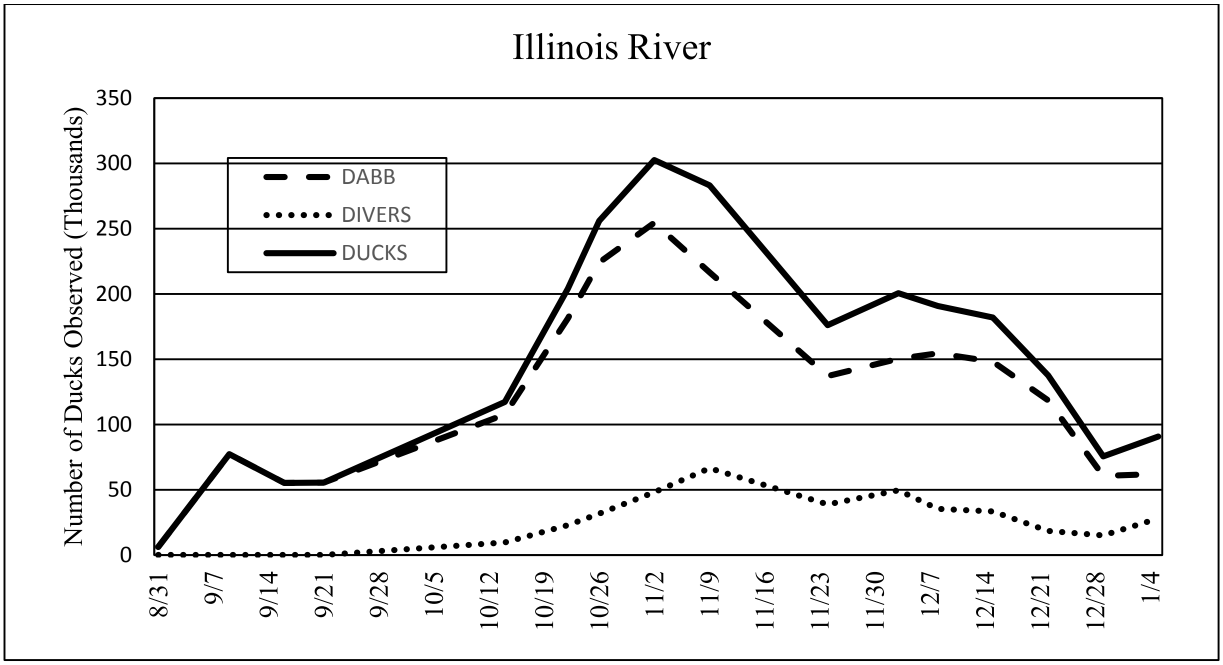


Figure 5. Estimated abundance of dabbling ducks, diving ducks, and total ducks observed during fall 2015 in the central Mississippi River valley.

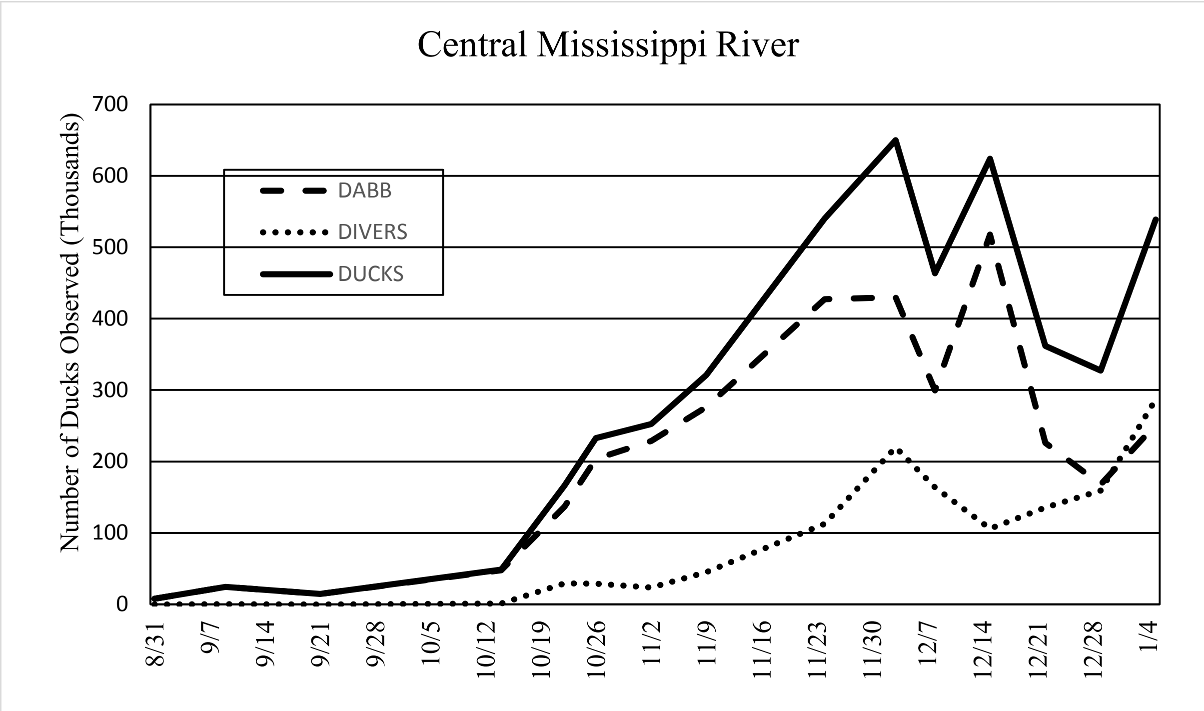
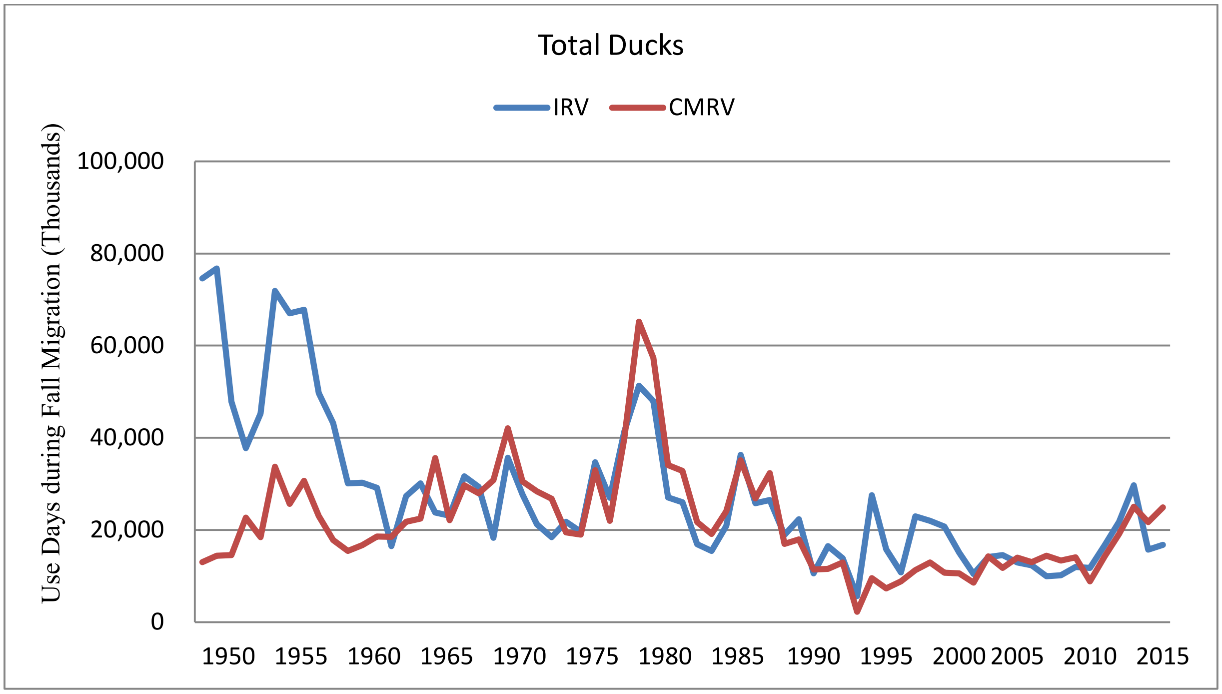


Figure 6. Total duck use-day estimates observed during falls 1948–2015 in the Illinois River valley and central Mississippi River valley.



STUDY 124: EVALUATION OF AN AERIAL QUADRAT WATERFOWL SURVEY ALONG THE ILLINOIS RIVER

Objectives:

1) Use an aerial quadrat survey design to identify and enumerate waterfowl and American coot at a minimum of 50 sites during a minimum of 12 weeks in and nearby the IRV during autumn migration.

2) Evaluate feasibility and cost of an aerial quadrat waterfowl survey along the Illinois River compared to traditional aerial inventories (Study 123).

3) Estimate bias in traditional aerial waterfowl inventories.

4) Determine sample size necessary to yield target level of precision (<20%) and factors affecting precision.

Introduction

Aerial counts of waterfowl have been conducted along the Illinois River of Illinois since 1948. Methodologies have remained the same since initiation of the survey, making the survey a reliable index of waterfowl abundances over time (Havera 1999). A myriad of stakeholders use aerial survey data of waterfowl for recreation, research, conservation planning, and administrative purposes (see Study 124). However, there is increasing need to estimate actual population size by using a randomized survey design and incorporating methods which allow determination of detection probability (Pearse et al. 2008*a,b*). In fact, conservation planners seek population estimates of waterfowl in order to prioritize wetland habitat conservation and management activities across the state and the region (Soulliere et al. 2007, Schultheis and Eichholz 2013).

An evaluation of long-term aerial surveys conducted by the INHS and IDNR are needed to determine bias in relation to actual population sizes. Two projects have recently been completed to evaluate aerial survey designs for rivers with an associated floodplain. Hennig et al. (2013) used a quadrat survey design consisting of 2.6 km2 (1-mi^2) sections (i.e., sample units) to enumerate waterfowl along the Wabash River in southeastern Illinois and recommended this approach for riverine areas. Shirkey (2012) recommended transect surveys with distance methods for estimating population sizes of diving ducks, but Hagy et al. (2013) used transect surveys perpendicular to the river course on Pool 19 of the Mississippi River and concluded that distance methods produced highly variable and unrealistic population sizes. Unlike transect surveys, quadrat surveys allow observers to use natural reference points on the landscape (e.g., mile sections) and are logistically compatible with currently available low-winged aircraft.

Moreover, transect surveys in river systems require frequent turns and may be less economical and taxing on personnel than a quadrat design.

Given consistent methodology for more than 60 years and uniqueness of the long-term data set (see Study 123), a concurrent evaluation of a new survey design with existing traditional aerial inventory methods is needed. Evaluating and refining a new survey design concurrent with an existing inventory design will allow comparisons between counts and estimates. Understanding this relationship will provide a linkage between estimates produced by new aerial surveys and counts produced using traditional methods.

Methods

Abundance

We defined our study area as the 100-year floodplain of the Illinois River as determined by the Illinois State Water Survey from Hennepin to Meredosia, IL. Using ArcMap 10.2, we generated a grid of 1-mi^2 quadrats (n = 432) and layered the boundary shapefile on a second shapefile outlining the typical concentration areas of waterbirds within core survey locations inventoried under Study 123. We excluded Upper Peoria Lake, Goose Lake (Fulton County), and Spunky Bottoms from core areas because of their lack of ducks during waterfowl hunting season. During early flights, we determined that we could survey approximately 55 quadrats per day within our study area. We designated two sample strata for quadrat surveys, a high-density stratum and a low-density stratum. The high-density strata contained quadrats which were within the 100-year floodplain of the Illinois River and overlapped an area where waterfowl concentrations during fall were typically high at one of our traditional inventory locations (n = 73; Pearse et al. [2008*a*]). We randomly selected at least one quadrat overlapping each traditional aerial survey location each week until 25 were selected. Larger sites which typically hosted large concentrations of waterfowl, such as Chautauqua National Wildlife Refuge and Emiquon Preserve, had more than one quadrat from the high-density stratum each week. Additionally, we randomly selected 25 quadrats that did not overlap high-density locations but were within the 100-year floodplain of the Illinois River (n = 359; low density stratum). Following waterfowl enumeration and identification within each of the 50 quadrats, we re-surveyed five randomly-selected quadrats from within the high-density stratum to determine if time-of day influenced counts.

We flew aerial quadrat surveys from a single-engine, fixed-wing aircraft flying approximately 241 kph (150 mph) and 91 m (300 ft) above ground level. We flew quadrat surveys the day following traditional waterfowl aerial inventories (Study 123) unless prevented by weather, but for comparison both inventory and quadrat surveys were always flown within the same week. A pilot plus two observers flew a diagonal from the NE to SW corner and around the outside of each 1-mi^2 quadrat. The front seat observer estimated waterbird abundances by species while the rear seat observer recorded habitat information from within the 1-m^2 quadrat (e.g., inundated, woody vegetation, open water, herbaceous vegetation, ice coverage).

We compared abundance estimates between the traditional survey methods (Study 123) and the aerial quadrat design. Quadrat observations that included fewer than 50 individuals were excluded from analyses due to their disproportionate impact on the final results. Differences between aerial survey methods were calculated using the equation:

$$\% \, Difference = \frac{I - G}{I} * 100$$

where I = the estimate from the aerial inventory and G = the estimate from the aerial quadrat survey. Results are presented in relation to the traditional aerial inventory. Counts from locations where individuals did not occur in both survey types were excluded. Means and standard errors were calculated by species and location.

Detection Probability and Count Bias

We attempted to determine waterbird abundance estimates during aerial quadrat surveys from photographs collected from a camera mounted to the fuselage of the aircraft. While flying a diagonal across the quadrat, photographs were taken from a camera mounted to the bottom of the fuselage. Once activated by the observer at the edge of the quadrat, the camera captured a series of photographs that covered the entire diagonal of the quadrat. Photos were taken at a rate that each photograph lined up to the edge of the next photograph, creating a sequence that covered the entire diagonal of the quadrat. Photographs were georeferenced with GPS coordinates and altitude. We collected digital images only from the high density stratum to increase the chances of capturing waterbirds on images. If this method produces reasonable abundance estimates, it may be used to determine detection probability in the future.

Our ability to collect digital images at a constant elevation above ground level proved difficult. Therefore, we had to determine the area of individual images in order to calculate the density of waterbirds in photographs. To this end, a series of aerial photographs was taken over markers placed on the ground at known altitudes. We used the analysis tool in Adobe Photoshop to count the number of pixels that represented a known area on the ground. The photograph area was then calculated by determining the proportion of pixels of the object of known size to the number of pixels contained in the entire photograph. We created an algebraic equation to determine the area of each photograph from its altitude by plotting the series of altitudes and their corresponding areas and calculating a trend line.

We successfully collected photos on 16 surveys during autumns 2014 and 2015 on a total of 486 quadrats. Due to the impracticalities of maintaining a constant speed, elevation, and heading while flying the quadrat, not every photograph was analyzed. We determined duck abundance in every other photograph to eliminate the possibility of double counting birds in overlapping photographs. The georeferenced aerial photographs were added to a geographic information system containing the boundaries of all quadrats. Photographs that did not reside inside the corresponding quadrat were removed from analysis. Each photograph was visually searched for waterbirds and each individual was counted and identified to species. Birds that could not be identified to species were identified to the lowest possible taxonomic group (e.g., dabbler, diver, duck, goose, swan). Both the geographic area and the numbers of waterbirds in each photograph were summed for all photographs in a quadrat. The proportion of the total photograph area to the entire area of the quadrat (260 ha) was calculated for each quadrat. This value was used to extrapolate the total number of counted waterbirds to represent the entire quadrat. Extrapolated waterbird numbers were compared to the adjusted aerial estimate for each corresponding quadrat and an error rate was calculated. An overall error rate was calculated for all waterbird species along with individual error rates for each major guild (e.g., ducks, geese, swans).

We conducted ground surveys concurrent with traditional aerial inventories and quadrat surveys to determine detection probability and count bias. Immediately before an aerial survey, a ground observer enumerated all waterbirds within a discrete area by species from an elevated location where visibility was unobstructed by vegetation or infrastructure. Due to the large size of the quadrats (1 mi^2) and inability of ground observers to view entire quadrats, most ground survey locations were comparably small (<25 ha) and well defined areas that could be counted effectively. When possible, we used natural landmarks as boundaries (e.g., shorelines, levees, vegetation) to define a survey location. When natural landmarks were not present, we used buoys (e.g., brightly painted duck decoys) to define plot boundaries. Before surveys, we provided both aerial and ground observers a map of the survey location. When possible, discrete ground locations were nested within quadrats or traditional census locations. We used optics (e.g., spotting scope, binoculars) to tally all waterbirds present in the survey location. All individuals were identified to species or smallest possible taxonomic group (e.g., dabbling duck, diving duck, goose, grebe, gull).

Disturbance

While conducting ground surveys, we documented disturbance to waterbirds presumably attributable to the aerial survey. Ground observers counted and recorded the number of each species within each count area that 1) exhibited a noticeable response to the airplane (e.g., flew but settled back in the survey area, dove under water, ran across the water but remained in the survey area) and 2) abandoned the plot completely and did not return during or immediately following aerial surveys. We also estimated the distance abandoning birds traveled when they abandoned the survey area. We determined disturbance rates for all waterfowl species and American coot.

Results and Discussion

Detection Probability and Count Bias

Our data show that photograph-estimated numbers for all waterfowl were drastically greater than that of aerial estimates with an average percent error of 2,760% (SE = 1,150). Total ducks had an average percent error of 3,339% (SE = 1,207%), geese had an average percent error of 1,735% (SE = 516%), and swans had an average percent error of 919% (SE = 222%). Our photograph-based estimates of American coot abundance were also greater than that of aerial estimates with and average percent error of 684% (SE = 148%).

We compared aerial estimates to ground counts to determine count bias (Table 4). The aerial observer detected 96.0% (SE = 7%) of all waterfowl resulting in a count bias correction factor of 1.04. On average, ducks were underestimated by 6% (average proportion detected = 94.4%, SE = 8%) resulting in a correction factor of 1.06. Dabbling ducks were overestimated by 5% (average proportion detected = 105.2%, SE = 11%) resulting in a correction factor of 0.95. Diving ducks were underestimated by 25% (average proportion detected = 74.8%, SE = 11%) resulting in a correction factor of 1.34. Mergansers were underestimated by 46% (average proportion detected = 53.3%, SE = 8%) resulting in a correction factor of 1.87. Geese were underestimated by 8% (average proportion detected = 92.4%, SE = 9%) resulting in a correction factor of 1.08. Swans were underestimated by 8% (average proportion detected = 91.5%, SE = 9%) resulting in a correction factor of 1.09. American coots were underestimated by 42% (average proportion detected = 58.0%, SE = 8%) resulting in a correction factor of 1.72.

Disturbance

We determined that 18.4% (SE = 3%) of waterfowl were disturbed by aerial surveys and 5.5% (SE = 2%) of waterfowl abandoned the survey site completely (Table 5). We estimated 12.2% (SE = 2%) of ducks were disturbed (dabbling ducks = 11.5% [SE = 2%], diving ducks =

4.5% [SE = 1%], mergansers = 13.0% [SE = 3%]) and 2.0% (SE = 1%) abandoned the survey site (dabbling ducks = 1.2% [SE = 1%], diving ducks = 0.7% [SE = 0.4%], mergansers = 4.3% [SE = 1%]). For geese, 28.6% (SE = 4%) were disturbed and 15.1% (SE = 3%) abandoned the survey site. For swans, 3.2% (SE = 0.4% were disturbed, but none abandoned the survey site. For American coot, 2.9% (SE = 1%) were disturbed, but none abandoned the survey site.

We identified differences in disturbance rates of quadrat surveys and traditional inventory-style surveys (Table 5). For all waterfowl, aerial quadrat surveys had a disturbance rate of 11.1% (SE = 2%) and an abandonment rate of 2.5% (SE = 1%) while traditional area surveys had a disturbance rate of 20.8% (SE = 3%) and an abandonment rate of 6.6% (SE = 2%) for total ducks.

Overall Abundance

Differences between the quadrat and traditional inventory surveys, with the exception of northern pintails, ranged from -182.3% for gadwall to 66.8% for American green-winged teal (Table 6). Aerial inventory counts often yielded lower estimates than the quadrat survey. Quadrat estimates were greater for mallards (-26.9%), total ducks (-22.8%), and total waterbirds (-23.1%). Conversely, American coots (-10.3%) and canvasbacks (-17.6%) had the lowest error rates. We found surveys were more parsimonious during early time period, with total ducks and waterbirds displaying errors of 11.6% and 6.0%, respectively; however, between-survey error increased during later time periods for both ducks (-45.7%) and total waterbirds (-42.5%). Most wetlands in the IRV froze on November 21, 2015 and results from the aerial inventory indicated that many ducks, including most of the northern pintails, departed the IRV with that cold weather event (Table 6, Fig. 7). Estimated duck abundance from quadrat surveys was elevated relative to aerial inventories for the remainder of the waterfowl surveys during autumn 2015. Aerial quadrat surveys lacked precision with CV values ranging from 91–235% during autumn 2015 (Fig. 7).

We calculated the contribution of quadrats from the low-density stratum in areas outside of the traditional inventory locations to the estimated abundance of birds in the weekly aerial quadrat survey (Table 7). The percentage of ducks from these quadrats was 6% in 2014. Interestingly, the proportion of total duck abundance in the quadrat survey from low-density quadrats outside of traditional inventory locations increased to 24% during autumn 2015. Late-autumn rainfall inundated many agricultural fields with shallow water which were readily used by waterfowl during 2015. Agricultural drainage ditches within drainage and levee districts also held notable numbers of ducks, especially gadwall, during quadrat surveys.

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Table 4. Average detection rates of waterbirds during aerial quadrat surveys during autumn 2014–2015 along the Illinois River floodplain.

Species/Guild	% Detected	Correction Factor
Waterfowl	96.0%	1.04
Ducks	94.4%	1.06
Dabbling Ducks	105.2%	0.95
Diving Ducks	74.8%	1.34
Mergansers	53.3%	1.87
Geese	92.4%	1.08
Swans	91.5%	1.09
American Coot	58.0%	1.72

Table 5. Percentage of waterbird guilds exhibiting a response to (disturbed) or abandoning quadrats and selected survey areas during aerial surveys along the Illinois River in autumn 2014–2015.

Species/Guild	% Disturbed			% Abandoned		
	Overall	Quadrat	Area	Overall	Quadrat	Area
Waterfowl	18.4%	11.1%	20.8%	5.6%	2.5%	6.6%
Ducks	12.2%	7.2%	14.1%	2.0%	1.1%	2.4%
Dabbling Ducks	11.5%	6.6%	13.3%	1.2%	0.4%	1.5%
Diving Ducks	4.5%	3.1%	5.5%	0.7%	1.4%	0.0%
Mergansers	13.0%	22.6%	7.5%	4.3%	0.7%	6.3%
Geese	28.6%	20.0%	31.7%	15.1%	13.4%	15.7%
Swans	1.2%	0.0%	1.4%	0.0%	0.0%	0.0%
American coot	2.9%	0.0%	5.1%	0.0%	0.0%	0.0%

Table 6. Error between aerial inventory counts and aerial quadrat survey population estimates across all survey periods and locations within the Illinois River valley during autumn 2015 for select waterbird species/guilds with associated standard errors and sample sizes. Differences represented in relation to the aerial inventory (e.g., aerial inventory estimate is x% greater or less than the quadrat survey estimate). "Early" data included the first 4 survey periods, "late" data were survey periods 5-10, and "overall" includes all survey periods. SWAN = Total Swans, DABB = Total Dabbling Ducks, DUCKS = Total Ducks, WTRB = Total Waterbirds.

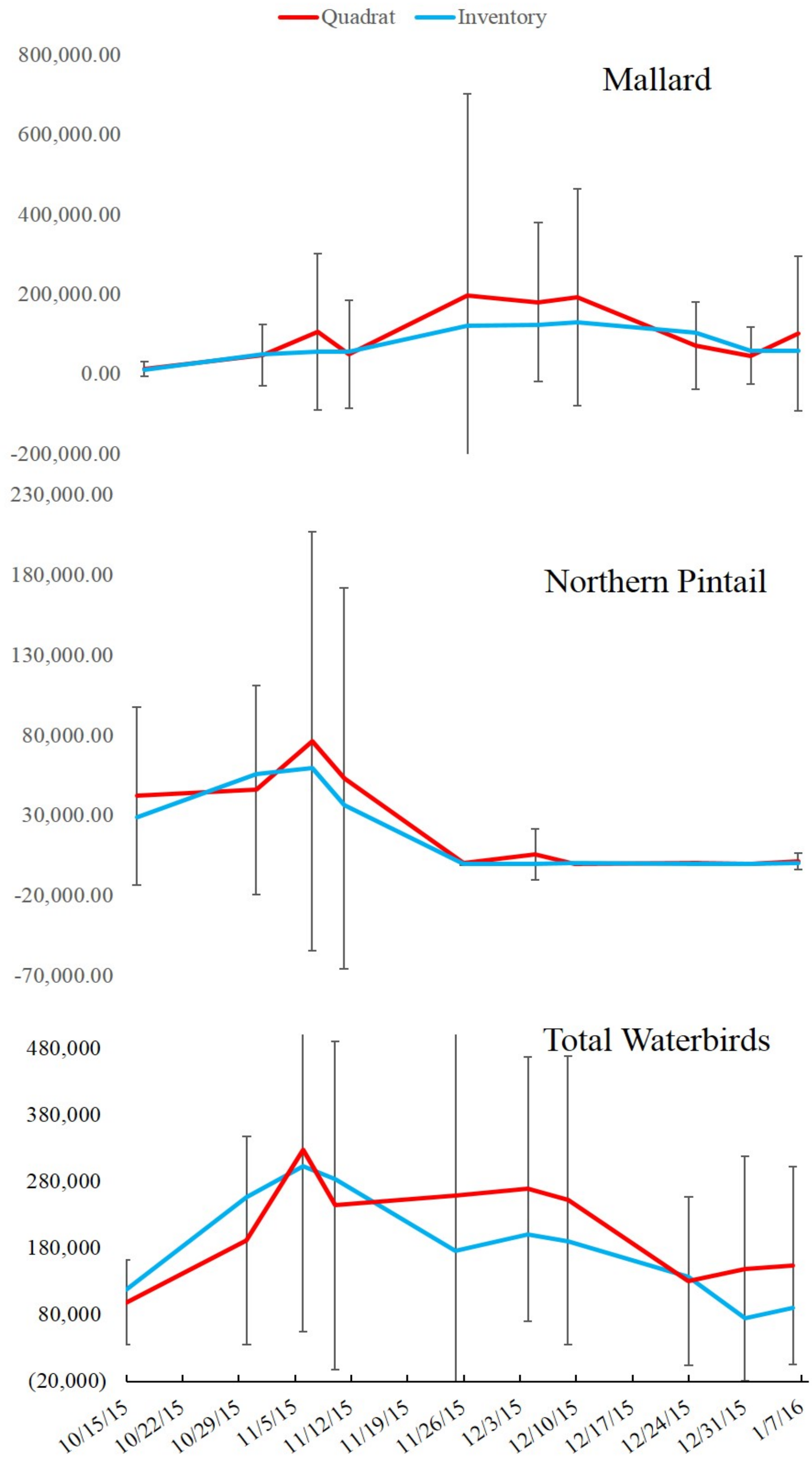
Species/Guild	Early			Late			Overall		
	Mean	SE	N	Mean	SE	N	Mean	SE	N
MALL	-23.1%	23.4%	4	-29.5%	18.0%	6	-26.9%	13.5%	10
ABDU	-121.0%	130.4%	3	-203.0%	139.8%	6	-175.7%	98.7%	9
NOPI	-25.7%	15.1%	4	-29,160.4%	29,179.9%	4	-14,593.1%	14,586.7%	8
AGWT	34.7%	10.7%	4	92.5%	4.3%	5	66.8%	11.3%	9
GADW	33.3%	18.8%	4	-326.1%	360.3%	6	-182.3%	216.3%	10
NOSH	47.9%	12.4%	4	75.6%	21.3%	5	63.3%	13.2%	9
LESC	79.6%	8.8%	3	-188.3%	98.5%	6	-99.0%	77.7%	9
RNDU	-21.0%	11.3%	4	-75.6%	46.2%	6	-53.7%	28.4%	10
CANV	69.2%	6.8%	4	-75.4%	72.9%	6	-17.6%	48.3%	10
RUDU	5.8%	26.6%	4	-152.0%	82.5%	6	-88.9%	55.0%	10
CAGO	-16.2%	30.3%	4	-35.5%	22.7%	6	-27.8%	17.4%	10
SWAN	-139.6%	142.2%	4	14.9%	20.2%	6	-46.9%	58.9%	10
AMCO	9.3%	16.0%	4	-23.4%	37.8%	6	-10.3%	23.2%	10
DABB	11.8%	9.9%	4	-30.9%	14.4%	6	-13.9%	11.4%	10
DIVE	14.4%	19.1%	4	-112.5%	41.8%	6	-61.7%	32.5%	10
DUCKS	11.6%	7.0%	4	-45.7%	14.3%	6	-22.8%	12.7%	10
WTRB	6.0%	8.5%	4	-42.5%	11.9%	6	-23.1%	10.9%	10

Table 7. Proportion of population estimates from quadrats within the low-density stratum and outside of traditional aerial inventory locations in the Illinois River valley during autumn 2014–2015.

Species[a]/Guild	2014	2015
MALL	3%	24%
ABDU	0%	11%
NOPI	5%	47%
BWTE	147%	0%
AGWT	49%	13%
AMWI	1%	0%
GADW	27%	30%
NSHO	7%	3%
LESC	18%	26%
RNDU	1%	21%
CANV	0%	9%
REDH	0%	14%
RUDU	15%	3%
COGO	7%	45%
BUFF	4%	9%
COME	30%	44%
HOME	0%	37%
CAGO	45%	46%
GWFG	49%	9%
LSGO	42%	33%
WHPE	38%	83%
CORM	14%	43%
SWAN	23%	27%
AMCO	17%	11%
Dabbling Ducks	5%	29%
Diving Ducks	6%	15%
Total Ducks	6%	24%
Total Waterbirds	13%	23%

[a] According to the American Ornithologists' Union Check-list, 2006.

Figure 7. Weekly waterbird abundance estimates from the traditional aerial inventory and aerial quadrat surveys (with standard error bars) during autumn 2015 in the Illinois River valley.



<u>STUDY 125</u>: ECOLOGY OF SPRING-MIGRATING DUCKS IN THE ILLINOIS RIVER VALLEY

Objectives:

1) Determine home range size, estimate survival, and describe daily movements of a minimum of 50 American green-winged teal during spring migration in Illinois.

2) Determine diet composition and food selection of a minimum of 50 experimentally-collected American green-winged teal during spring in and near the Illinois River valley.

3) Estimate energy density at foraging locations of a minimum of 50 American green-winged teal during spring in and near the Illinois River valley.

4) Leg-band a minimum of 1,000 lesser scaup along the Illinois River.

Introduction

Millions of waterbirds rely on Illinois wetlands during autumn and spring migration, despite these landscape-scale modifications (Havera 1999). In particular, the IRV is a focus area of the Upper Mississippi River and Great Lakes Region (UMRGLR) Joint Venture of the North American Waterfowl Management Plan (Soulliere et al. 2007). Peak abundance of ducks in the IRV currently averages 388,000 during autumn (range 210,000–545,000; based on 1995–2005 INHS aerial inventories). Additionally, the UMRGLR Joint Venture specifically relies on the IRV and other migratory focal areas in Illinois to protect, maintain, enhance or restore more than 800,000 ha of wetland habitats for waterfowl (Soulliere et al. 2007). Migratory waterfowl common to this region are ecologically important as predators and prey and economically important to Illinois communities by providing hunting and viewing opportunities (see Study 123). Thus, investigations of migrating and wintering waterfowl in Illinois are critical to guide conservation planning and harvest management that provide recreational and economic benefits to Illinois.

According to U.S. Fish and Wildlife Service parts collection survey data from 2010–2012, gadwall (*Anas strepera*) and American green-winged teal (*A. crecca*) comprised approximately 15% of the duck harvest in Illinois and were commonly in the top five duck species harvested in the state; however, little information exists to describe spring migration ecology of these important species, which is related to autumn population size (Hoekman et al. 2002). Detailed information on spring distribution, habitat associations, food selection, and stopover duration for these species are lacking or antiquated. An investigation documenting these factors would provide data critical to effectively allocating conservation efforts and help guide wetland habitat restoration and conservation planning at state and regional levels. Extensive declines of natural wetlands within habitats that these species typically frequent (e.g., aquatic bed, moist-soil, exposed mudflats) may necessitate restoration of these and other important habitats. Currently, energetic carrying capacity models used for prioritization of habitat restoration and protection objectives require accurate estimates of stopover duration, habitat use and selection, energetics of foods used by these species, and possibly other useful aspects of their migration ecology. Previous studies have indicated generally low food densities in most spring habitats used by diving and dabbling ducks, but some data indicates that birds respond positively to spring-flooding of seasonal wetlands; however, little information exists to help managers understand food use and availability in spring-flooded wetlands, especially in agricultural fields (Straub et al. 2012).

Additionally, recent research has indicated a need for increased banding data during multiple seasons of the year to improve the reliability of current survival estimates, especially during non-breeding periods (Koons et al. 2006). Band returns establish linkages between migration stopover locations and other critical areas used during the annual cycle; however, lesser scaup (*Aythya affinis*) have been typically underrepresented in banding efforts and additional banding data is critically needed (Austin et al. 2000). As the Illinois River is a major autumn and spring migration stopover location for ducks traveling to the Great Lakes and the Prairie Pothole Region, additional banding data is needed to assess the relative importance of this region and compare with the Mississippi River using banding data from concurrent studies.

Methods

Our study area encompassed the La Grange Pool and part of Peoria Pool of the Illinois River extending from Spring Valley (River Mile 218.5), IL, to the La Grange Lock and Dam (River Mile 80) near Meredosia, IL. This segment of the Illinois River floodplain included portions of Putnam, Bureau, Marshall, Woodford, Peoria, Tazewell, Fulton, Mason, Schuyler, Brown, and Cass counties. Additionally, we monitored telemetered birds in tributary streams, wetlands, and strip-mined lands outside of the Illinois River floodplain in these counties as necessary.

We used rocket nets and swim-in traps baited with corn to capture American green-winged teal and gadwall during spring migration (Sykes et al. 1990, Johnson et al. 1991, Anich et al. 2009). We attached a standard aluminum leg band and a glue-on, VHF transmitter (6-7 gram; <3% of body mass s) equipped with a mortality switch to individual birds. We staggered capture and radio-marking of individuals throughout the spring migration period.

We used standard radio-telemetry techniques to track American green-winged teal and gadwall to determine diurnal (½ hr after sunrise to ½ hr before sunset) and nocturnal (½ hr after sunset to ½ hr before sunrise) habitat use. Birds were located by ground crews using triangulation techniques with vehicle-mounted null-array antenna systems and hand-held antennas (Davis et al. 2009). We determined locations of ducks using Program LOAS 4.0.3.8, which partially automated telemetry locations using a global positioning system and digital compass. Tracking crews practiced triangulations until azimuth standard deviation was <3°. We recorded habitat use of radio-marked individuals triangulated to wetland and upland habitat types as depicted on aerial images and National Wetlands Inventory base layer shapefiles in LOAS. We aerially searched for birds not found via ground tracking approximately weekly. When birds were located from the air, ground crews were dispatched to that area for location and triangulation. We rotated tracking schedules so that a minimum of half of our telemetered birds were triangulated during each diurnal and nocturnal tracking period. For example, a transmittered duck found during the diurnal period of Day 1 would subsequently be located during the nocturnal period of Day 2, and then this bird would again be triangulated diurnally on Day 3 and so on. We determined habitat use of GADW and AGWT by overlaying daily waypoints of triangulated birds on the 2010 Illinois Landcover database in ArcMAP 10.3. During each triangulation, we verified status (i.e., alive or dead). We calculated consecutive day roost to night roost (Day-Night) and night roost to day roost (Night-Day) movement distances from daily location data using the Pythagorean Theorem. We calculated home range size (95% Minimum Convex Polygons [MCP]) for birds that remained in the study area ≥ 3 days using the Minimum Bounding Geometry Tool in ArcToolBox ArcMAP 10.3.1. We used separate general linear models in SAS (Proc GLM) to compare home range sizes between age groups and sexes of marked ducks. For stopover estimation, we assumed an individual had emigrated from the study area if we failed to locate them via ground or aerial searches. We estimated total stopover duration using encounter sampling through Program DISTANCE (Otis et al. 1993, Lehnen and Krementz 2005). We estimated survival of spring migrating AGWT and GADW using the known fate model in Program MARK (White and Burnham 1999, White et al. 2006). We used Akaike's Information Criterion to evaluate models containing effects of age, sex, and capture date on daily survival rates.

We used radio-telemetry locations to identify potentially important foraging habitats (e.g., temporary wetlands in agricultural fields, spring-flooded moist-soil wetlands) and experimentally collected foraging green-winged teal with a shotgun to determine food use. Prior to collection, birds were observed foraging for ≥5 minutes to increase the likelihood of ingesta upon dissection. Immediately after harvest, we removed the upper digestive tracts (i.e., proventriculus and esophagus) from birds, placed zip ties at the anterior of the esophagus and at the junction of the proventriculus and gizzard, preserved food items by injecting a 10% formalin solution stained with rose Bengal at several locations within the digestive tract, and refrigerated the entire digestive tracts in a bath of the aforementioned preservative until processing occurred at the Forbes Biological Station in Havana, IL (approximately 90–160 days). In the laboratory, the proventriculus and esophagus were thawed and all food items identified, enumerated, and weighed to the nearest 0.1 mg. We followed approved protocols and necessary approvals prior to collections (i.e., University of Illinois Institutional Animal Care and Use Committee Permit #15032, U.S. Fish and Wildlife Service Scientific Collection Permit #MB145466-4, Illinois Department of Natural Resources Scientific Collecting W16.4071 and Scientific Research permits SS16-030, U.S. Fish and Wildlife Service Central Illinois River Refuges Permit #33653E-16-001, U.S. Fish and Wildlife Service Salvage Permit #MB121922-0, and The Nature Conservancy Research Permit #2016-7).

We collected benthic core samples (hereafter, food samples) from within experimental collection locations to quantify density (kg/ha) of plant seeds, invertebrates, and other potential waterfowl foods. We collected 3 benthic cores (5 cm diameter × 10 cm depth) in each collection location. We combined core samples for each location in the field, preserved each amalgamation with 10% formalin solution stained with rose bengal, and refrigerated the mixture in polyethylene bags until processing (approximately 60–120 days). We rinsed (500-µm mesh sieve) samples through sieves to remove preservatives and soil, removed invertebrates and dried to constant mass separately by lowest taxonomical level practical, dried samples at room temperature for >24 hr, removed seeds by hand, and enumerated and weighed by species or genus using published protocols (Hagy et al. 2011, Hagy and Kaminski 2012). At each food sample location, we also recorded water depth and secchi depth for use in later analysis.

We captured and leg band lesser scaup along the Illinois River using baited swim-in traps from March through April (Anteau and Afton 2008*a,b*, Yetter et al. 2012, Hagy et al. 2015). We aged, sexed, and obtain morphological measurements from captured scaup.

Results and Discussion

We radiomarked 56 American green-winged teal (AGWT) and 23 gadwall (GADW) during spring 2016. A total of 951 locations (453 diurnal and 498 nocturnal) were triangulated during spring 2016. Mean movement distances of AGWT from day to night was and 5,000.5 m

(SE = 290.1, n = 136) and from night to day locations was 5,160.8 m (SE = 223.7, n = 189), respectively. Similarly, day–night and night–day movement distances for GADW were 5,649.6 m (SE = 374.1, n = 133) and 5,463.3 m (SE = 356.2, n = 159), respectively. Stopover duration during spring 2016 was 14.4 days (CI^{95} = 11.0–18.9 days) for AGWT and 26.5 days (CI^{95} = 12.1–58.3 days) for GADW. Estimated of stopover duration for both AGWT and GADW combined was 17.3 days (CI^{95} = 13.7–21.8 days).

Three AGWT and one GADW perished following radio transmitter attachment during spring 2016 in the Illinois River valley. We censored from survival analysis one AGWT due to mortality within 1 day of transmitter attachment and one GADW due to a possible broken leg at time of release. Daily survival varied by age, but other models were not competitive ($\Delta AIC_c > 2$). Daily survival was less for second-year birds ($\bar{x}$ = 0.988, CI^{95} = 0.954–0.997) than after second-year birds ($\bar{x}$ = 1.000, CI^{95} = 0.999–1.000). Across age classes, spring survival was 0.810 for the entire 49-day period when the majority of AGWT were present in the IRV and marked individuals were tracked (CI^{95} = 0.478–0.952). Overall survival during the mean 14-day stopover period for AGWT in the IRV was 0.941 (CI^{95} = 0.787–0.985).

We found AGWT utilized emergent marsh (59.7%) most often, followed by wooded wetlands (13.9%), agriculture (10.4%), and open water (10.0%; Table 8). AGWT were found in emergent wetlands (e.g., Emiquon Preserve) during most nocturnal periods (81.5%). GADW utilized wooded wetlands (44.7%) most often during the day; however, a mix of emergent marsh (47.1%) and open water (32.2%) were used during nocturnal periods. Our estimates of home range size (95% MCP) for AGWT and GADW averaged 2,412.7 ha (SE = 590.9) and 2,790.6 ha (SE = 703.1), respectively. Home range size was similar (P = 0.701, $F_{1,66}$ = 0.15) between species. Males typically had larger home ranges in both species; however, the differences were not significant (AGWT - ♂ 2,900.9 ± 934.8; ♀ 1,680.4 ± 449.1 ha; $F_{1,44}$ = 1.02, P = 0.317: GADW - ♂ 2,982.8 ± 843.9; ♀ 1,925.5 ± 753.4 ha; $F_{1,21}$ = 0.33, P = 0.575).

We lethally collected and processed gastrointestinal tracts of 44 foraging AGWT (32 male, 12 female) in the IRV during 3 March–14 April 2016. We removed from analysis diets of 5 AGWT, all of which were male, that contained insufficient food in the esophagus for inference (<0.1g / bird and/or >5 items). Generally, plant material was observed more frequently (100.0%) and at a greater percent aggregate mass (74.6%) than invertebrates (59.0% and 25.4%, respectively; Table 9). Notable food items occurring in AGWT included seeds of sedges, rice cutgrass, and smartweeds as well as chironomidae larvae and aquatic worms (Class oligochaeta).

We collected and processed core samples (n = 72) from 24 collection locations throughout the IRV. Across all locations, seeds, tubers, and invertebrates totaled 308.9 kg/ha (275.5 lbs/ac; Table 10), with seeds and tubers comprising 78.8% of available food during 2016. Whereas AGWT showed strong selection tendencies for plant foods, we did not observe apparent selection of specific taxa in either plant or animal foods. Our preliminary results support previous studies which reported AGWT frequently consuming seeds of sedges, smartweeds, grasses (e.g., panicgrass and rice cutgrass), and other foods that can be procured from exposed mudflats or shallow-water environments. While traditional food items were present in diets, a wide variety of plant and animal material was present suggesting omnivorous tendencies of AGWT in the IRV.

During spring 2016, we leg-banded 1,011 lesser scaup, 143 American green-winged teal, 40 mallard, 23 gadwall, 19 blue-winged teal, 9 American wigeon, 8 northern shoveler, 8 wood duck, and 1 ring-necked duck.

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Table 8. Proportion of diurnal and nocturnal locations of American green-winged teal (*Anas crecca*), gadwall (*Anas strepera*), and their combination among 6 habitat types during February–April 2016 in the Illinois River valley.

		Habitat Type					
Species	Period	Wooded wetlands	Strip mine lakes	Mudflats	Emergent marsh	Open water	Agriculture
AGWT	Day	26.5%	4.3%	2.4%	35.2%	15.0%	16.6%
	Night	2.8%	3.1%	2.1%	81.5%	5.6%	4.9%
	Overall	13.9%	3.7%	2.2%	59.7%	10.0%	10.4%
GADW	Day	44.7%	2.4%	1.0%	9.2%	25.2%	17.5%
	Night	5.3%	1.0%	9.6%	47.1%	32.2%	4.8%
	Overall	24.9%	1.7%	5.3%	28.3%	28.7%	11.1%
Combined	Day	34.6%	3.5%	1.7%	23.5%	19.6%	17.0%
	Night	3.8%	2.2%	5.3%	67.0%	16.8%	4.9%
	Overall	18.7%	2.8%	3.6%	46.1%	18.2%	10.7%

Table 9. Proportion of spring-migrating American green-winged teal (*Anas crecca*) consuming individual food items (percent occurrence) and mean biomass per individual (aggregate percent) of common food items with mean food availability (kg/ha) and rankings of dominant items in the Illinois River valley during spring 2016.

Taxa	Percent Occurrence	Aggregate Percent	Diet Rank	Food Availability	Availability Rank
Polygonum spp.	71.8%	29.9%	1	94.6	1
Oligochaeta	56.4%	13.8%	2	31.8	3
Cyperus spp.	64.1%	10.5%	3	8.5	11
Leersia oryzoides	20.5%	8.6%	4	9.1	9
Eleocharis spp.	33.3%	5.3%	5	7.2	12
Amaranthus spp.	25.6%	5.3%	6	23.7	4
Sphaeriidae	7.7%	5.2%	7	1.8	18
Panicum spp.	17.9%	3.4%	8	5.7	13
Chrionomidae	38.5%	3.0%	9	2.2	17
Lemna spp.	28.2%	2.8%	10	34.2	2
Nematoda	5.1%	1.9%			
Wolffia spp.	12.8%	1.3%			
Stellaria spp.	2.6%	1.3%			
Suaeda depressa	25.6%	1.2%			
Leptochloa spp.	2.6%	1.0%			
Chenopodium spp.	28.2%	0.9%			
Melilotus officinalis	12.8%	0.8%			
Sinapis arvensis	5.1%	0.7%			
Scirpus spp.	10.3%	0.6%			
Viviparidae	7.7%	0.5%			
Physiidae	5.1%	0.3%			
Carex spp.	5.1%	0.3%			
Ceratopogonidae	7.7%	0.2%			
Cephalanthus occidentalis	10.3%	0.2%			
Ludwigia peploides	7.7%	0.2%			
Potamogeton spp.	12.8%	0.2%			
Total animal	59.0.%	25.4%			
Total plant	100.0%	74.6%			

Table 10. Sampling locations of American green-winged teal (*Anas crecca*) during spring 2016 in the Illinois River valley along with number of birds collected (*n*), and densities (kg/ha) of seeds and tubers (Seeds), benthic invertebrates (Benthos), and combined (Overall) that are typically consumed by dabbling ducks.

Location	*n*	Benthos	Seeds	Overall
Big Lake SFWA	5	43.1	160.2	203.3
Chautauqua NWR	3	7.1	624.1	631.2
Emiquon NWR - Horseshoe	3	92.6	117.6	210.2
Emiquon NWR - South Globe	4	32.3	186.1	218.5
Emiquon NWR - Wilder Tract	9	43.1	382.9	426.0
Lacy Ditch	3	27.4	19.2	46.5
MS River SFWA	3	41.4	64.1	105.5
Quiver Creek	7	330.6	228.9	559.5
Rice Lake SFWA	3	25.4	237.5	262.8
Sand Lake	1	26.1	441.0	467.1
Wightman Lake	3	51.3	215.3	266.6
Illinois River Valley	**44**	**65.5**	**243.4**	**308.9**

<u>STUDY 126</u>: BREEDING BIRD USE OF WETLANDS MANAGED FOR WATERFOWL IN ILLINOIS

Objectives:

1) Estimate general use, including density, diversity, and richness of breeding birds using managed moist-soil vegetation in a minimum of 10 dewatered, seasonal wetlands in and nearby the IRV.

2) Estimate nest density and success of breeding birds using managed moist-soil vegetation in a minimum of 10 dewatered, seasonal wetlands in and nearby the IRV.

3) Identify factors influencing nest success of breeding birds using managed moist-soil vegetation in a minimum of 10 dewatered, seasonal wetlands in and nearby the IRV.

Introduction

Breeding bird populations have undergone widespread declines in the midwestern United States since the 1800s (Brennan and Kuvelsky 2005). In particular, grassland bird populations have declined due to the near complete loss of native prairie in this region. Illinois has lost > 99% of the prairie present in the 1800s (Fischer and Lindenmayer 2007, Walk et al. 2011). Most original prairie has been converted to row-crop agriculture, urban development, and other land types that are largely unsuitable for most avian use, especially during the breeding season (Herkert 1995). The remainder has been converted into other types of grasslands (e.g., pastures, hayfields), accounting for approximately 19% of current Illinois land cover. The remaining grasslands tend to be highly fragmented, disturbed, or otherwise not considered to be of high-quality although they may still provide useful habitat for breeding (Vickery et al. 1994, Best et al. 1995, Herkert et al. 1996). Grasslands that are dominated by exotic plants or are frequently disturbed tend to have lower levels of avian use than less-disturbed areas with native grasses (Warner 1994, Scheiman et al. 2003).

Grassland birds (e.g., grasshopper sparrows [*Ammodramus savannarum*] and dickcissels [*Spiza americana*]) used to be relatively common species in Illinois but are now identified as species in greatest need of conservation by the Illinois Comprehensive Wildlife Conservation Plan and Strategy due to the loss of breeding habitat (Illinois Department of Natural Resources 2005, U.S. Fish and Wildlife Service 2008). For example, the grasshopper sparrow has declined to an estimated 8.3% of their original Illinois breeding population since 1966 (Coppedge et al. 2008, Sauer et al. 2014). Furthermore, many of the birds listed as state threatened or endangered in Illinois such as the loggerhead shrike (*Lanius ludovicianus*), barn owl (*Tyto alba*), short-eared owl (*Asio flammeus*), upland sandpiper (*Bartramia longicauda*), Swainson's hawk (*Buteo swainsoni*), northern harrier (*Circus cyaneus*), and greater prairie-chicken (*Tympanuchus cupido*) all use grasslands for nesting or foraging during the breeding season (Illinois Endangered Species Protection Board 2015).

Alternate habitats with a similar vegetation structure to grasslands, such as dewatered moist-soil wetlands, can potentially support breeding birds during the breeding season. Moist-soil wetlands are often located in areas connected to a water source (e.g., the floodplain of rivers) and are inundated from autumn to spring during waterfowl migration and wintering periods. Moist-soil management is usually characterized by the use of water control structures (e.g., gas-fueled pumps, drop-board structures) to manipulate water levels (Strader and Stinson 2005). The goal of moist-soil management is to provide foraging habitat for migrating and wintering waterfowl by producing an abundance of seed-producing plants (Laubhan 1992, Kross et al. 2008). Typically, a moist-soil wetland is dewatered in late spring or summer to allow annual vegetation to grow and reach peak seed production by early autumn. The length of the growing season varies mainly based on latitude and elevation, but a growing season length suitable for most desirable moist-soil plants in the Midwest is 60 to 90 days (Bellrose et al. 1983, Fredrickson 1991). Examples of desirable moist-soil plants include barnyard grasses (*Echinochloa* spp.), smartweeds (*Polygonum* spp.), rice cutgrass (*Leersia oryzoides*), and sedges (e.g., *Cyperus* spp.; Kaminski et al. 2003, Bowyer et al. 2005). In autumn and winter, moist-soil wetlands are shallowly flooded, which creates a nutrient-rich environment that is attractive as foraging habitat to migrating waterfowl (Low and Bellrose 1944, Stafford et al. 2011).

Moist-soil wetlands are assumed to provide useful habitat for other wildlife outside of the flooded period (Schultheis and Eichholz 2013). For example, mud-flats and shallow water often exist during drawdowns, providing foraging habitat for shorebirds, wading birds, and marsh birds (Galat et al. 1998, Smith et al. 2012, Russell et al. 2016, Wilson 2016). Evidence exists to suggest that seasonally dewatered wetlands may support species like songbirds during the growing season (Fleming 2010, Benson et al. 2011, Benson et al. 2013). Natural resource agencies and wetlands managers need information regarding the importance of moist-soil wetlands to wildlife other than waterfowl outside of the flooded period in order to maximize conservation efforts for a diverse suite of species (Illinois Department of Natural Resources 2005).

The nesting season of most grassland birds is similar to the date of drawdown and length of the growing season in dewatered moist-soil wetlands, and the desirable vegetation in dewatered seasonal wetlands may be able to provide suitable breeding habitat for grassland birds (Wittenberger 1980, Winter 1999, Fleming 2010). Vegetation composition (e.g., woody vegetation cover, total vegetation cover) has been shown to have an effect on nest densities and success rates of grassland birds, but more data are needed, especially in alternate habitat types (Winter et al. 2005). Understanding the relationship between the vegetation in moist-soil wetlands and breeding birds that use them is critical, especially for the acutely threatened grassland birds in this region.

We quantified avian use in moist-soil wetlands and upland grasslands during late spring and summer of 2014 and 2015 and identified factors that influenced avian density, avian conservation significance, nest density, and nest success. We predicted that moist-soil wetlands would yield similar values of all measured avian variables to grasslands and provide comparable habitat function. We also predicted that moist-soil wetlands with management capabilities and those closer to a water source (e.g., the Illinois River) would yield greater avian densities and conservation scores. We expected some vegetative characteristics (e.g., percent cover of forbs, woody vegetation, ground litter) to be among top supported predictors for nest density and success in moist-soil wetlands and grasslands.

Methods

Study Area

In 2014 and 2015, we collected data from sites located near or within the 100-year floodplain of the Illinois River valley (IRV) within DeWitt, Fulton, Mason, Woodford, and Tazewell counties which contain approximately 3.4% of the state's seasonal wetlands (Illinois Department of Natural Resources 1996). We collected data from land managed by private landowners, the Illinois Department of Natural Resources, Ducks Unlimited, and the U.S. Fish and Wildlife Service. The sites were located north to south from Woodford to Fulton County, and as far west as DeWitt County (Fig. 8). Survey sites ranged from 2 to 170 ha ($\bar{x}$ = 38.7 ha, SE = 5.4). The average site area exceeds the minimum area requirement for most nesting grassland birds (5 – 55 ha; Herkert 1994), and individual sites less than the minimum required area were located within a larger matrix of similar habitat and could have likely supported nesting birds. We collected data from late June to September in 2014 and from May to August in 2015. We only surveyed wetlands that had been dewatered and where desirable moist-soil vegetation (e.g., a diverse community of annual grasses and forbs) was growing (Hagy and Kaminski 2012). We also surveyed grasslands in the same region but located outside of the 100-year floodplain of the river because none were available within the floodplain in the study area. Moist-soil wetlands (*n* = 25) ranged from 2 to 99 ha ($\bar{x}$ = 42.6, ha SE = 6.1) and grasslands (*n* = 5) ranged from 2 to 34 ha ($\bar{x}$ = 19 ha, SE = 5.9). We selected grasslands within the study area based on their lack of flooding and the vegetation composition being primarily grasses with the allowance of smaller portions of woody (< 10%) and forb (< 50%) cover.

The average precipitation for the central portion of the IRV is approximately 89 – 114 cm per year. The main channel of the Illinois River generally occupies only 3 – 6% of the total width of the river's floodplain, which spans 2.5 – 5 km along the middle Illinois River (Sparks 1995). During periods of high rainfall that results in flooding, the river expands its reach to fill more of the floodplain and begins to fill partially-connected wetlands that are protected by low-elevation levees during normal flow and mild flood events but that are overtopped during moderate and severe floods (Fredrickson and Taylor 1982). Flooding can inundate shallow backwater lakes that, as flooding recedes, produce moist-soil vegetation (Bellrose et al. 1983). Changes in the hydrology in this region of Illinois have resulted in the elimination of most obligate emergent aquatic plants but a 162% increase in cover of moist-soil vegetation since the 1930s (Stafford et al. 2010). Thus, moist-soil wetlands are very important for migrating waterfowl in the IRV (Havera 1999).

Experimental Design

Within each site, we conducted point counts at 2–10 randomly-generated locations, with the number of points relative to the size of the site. We generated random points using ArcMap 10.3 and then randomly selected final points based on the following criteria: points were 1) at least 100 m away from any other surrounding habitat (e.g., forests) and 2) at least 250 m away from one another to avoid overlapping of observations. We collected data in three survey periods that began when sites became dry enough to survey, and whose durations were influenced by the number of days with acceptable weather conditions: late-May through mid-July (period 1), mid-July through mid-August (period 2), and mid-August to September (period 3). We surveyed between 30 minutes before and approximately 3 hours after sunrise, but did not survey in instances of dense fog, moderate to heavy precipitation, or winds exceeding 28 kilometers per hour (Gutzwiller 1991). The duration of point counts were 10 minutes with no preceding waiting period (Ralph et al. 1995, Lee and Marsden 2008). We identified and recorded birds within a

100-m radius, and for each individual or cluster of birds, we recorded the time of detection, sex, age (if possible), distance from the observer, habitat (e.g., moist-soil wetland, grassland, edge), behavior (e.g., flying, perched, territorial behavior), and number of individuals. We also recorded birds outside of the 100-m radius in this manner, but excluded them from subsequent analyses. At each point, we recorded a standardized description of the vegetation within the 100-m radius, the timing of the survey (time of day and date), and standardized measures of weather conditions and ambient noise level (Gutzwiller 1991, Alldredge et al. 2007).

Following each point count, we measured vegetation structure and composition within 3 randomly-placed 2-m^2 plots nearby each point count location. These plots were placed at the end of three random azimuths of three random distances between 0 and 25 m using the point count location as a radial anchor. Within each vegetation survey plot, we visually estimated the percent cover of each vegetation type (e.g., woody, forb, grass, sedge [e.g., *Carex* spp., *Cyperus* spp.], and rush [e.g., *Juncaceae* spp.]) as well as each plant species present. We estimated vegetation height as the average of the tallest and shortest plants present. In 2015, we also recorded the total percent cover of vegetation in each plot, the percent ground cover of litter, and litter depth in cm. Additional site-wide characteristics included management intensity (recorded as 1 if actively managed, e.g., protected by levees with the presence of a water control structure, or if planting had occurred in the past year, 0 if not managed or passively managed), connectivity to the Illinois River (1: sites partially connected to the river were often protected by levees that would prevent inundation under mild flooding of the river [> 4.3 m], but may become inundated at higher flood levels; 0: sites that were disconnected from the river were not at risk for becoming inundated even during extreme flooding of the river), proximity to the Illinois River in meters, and the nearest proximity to any source of water in meters (e.g., rivers, lakes, ditches > 4 m wide with persistent water throughout the growing season. Bordering water was considered a proximity of 0; Table 11).

We searched for nests at each point count location after the bird survey was complete. We systematically searched an 800-m^2 area to the east of each point using a transect approach (Fig. 9). When we found a nest, we recorded the location, date, species (if possible), adult presence, nest contents, stage of development of eggs/nestlings, nest bowl composition (e.g., fine grasses, reeds and sticks), vegetation height, water depth, and a full vegetation survey as described above. We estimated embryo development using a field candler made of foam pipe insulation, and then revisited each nest at 3- to 4-day intervals until nestlings fledged or fate could be determined

(Johnson and Temple 1990, Lokemoen and Koford 1996). We considered a nest to be successful if at least one bird fledged. We also searched 1 m on each side of my path between points to augment systematic surveys and recorded those as ancillary observations. We used nests discovered incidentally outside of the search areas (e.g., during vegetation surveys or outside of a site) in the calculation of success but not density, and otherwise treated them in the same manner as nests found during searches. Additionally, we used behavioral cues of birds to find additional nests for use in nest survival estimates. The behavioral cues included displaying male birds, agitated adults, and birds holding food or nest material (Vickery et al. 1992, Davis and Sealy 2000, Kosciuch et al. 2006). We did not estimate detection probability, but used similar nest searching methods in grasslands and wetlands and assumed my technique provided a reliable index of nest density.

Statistical Analyses

We generated estimates of avian density using program DISTANCE 6.2 (Thomas et al. 2010, Research Unit for Wildlife Population Assessment, St. Andrews, UK). We truncated observations at a radial distance of 100 m, and applied a filter to exclude observations classified as flyovers (i.e., birds not actively using the habitat within the 100-m radius of the point count). We ran each model with a conventional distance sampling (CDS) engine (Fig. 10). We ran five models within each analysis using different key function and series expansions (i.e., uniform/cosine, uniform/simple polynomial, half-normal/cosine, half-normal/hermite polynomial, and hazard-rate/cosine) and selected the model with the lowest Akaike's Information Criterion corrected for small sample size (AIC_c; Burnham and Anderson 2002). We selected the number of intervals based on goodness of fit tests, appearance of the detection function, and biological plausibility of density estimates. To test for differences between grassland and moist-soil wetland densities, we post-stratified results by habitat type. For an index of avian density by habitat type and species, we separated avian observations by habitat type, summed observations for each species, and then divided that by the total number of points we surveyed for that habitat type.

We generated site level conservation scores using concern values as described by Twedt (2005). For land birds, we used Partners in Flight concern scores specific to area 22 (breeding regional concern score for Eastern Tallgrass Prairie), and for non-landbirds, we used preliminary scores from the Bird Conservancy of the Rockies for waterbirds (Partners in Flight Science Committee 2012; Bird Conservancy of the Rockies, unpublished data). The end result was a value for each site reflecting the site's conservation value, henceforth referred to as avian conservation significance (ACS). To compare the degree of influence on ACS that grassland birds had between habitat types, we calculated an ACS for grasslands and moist-soil wetlands separately only using birds considered obligate (entirely dependent on grasslands) or facultative grassland (commonly use grasslands) birds (Vickery et al. 1999). We calculated nest densities for each site by dividing total nests found during systematic searches by the total area searched at each site.

We used an information theoretic approach based on AIC_c to evaluate vegetation and site-specific characteristics as predictors of avian density, ACS, and nest density using a general linear mixed model in software SAS™ 9.4 (PROC MIXED; SAS Institute Inc., Cary, NC, Littell et al. 1996). We examined residual plots for each dependent variable to ensure that the assumptions for normality and homogeneity of variances were met. We applied a square root transformation to the values of nest density to meet the assumptions for the homogenous distribution of residuals. Site-specific characteristics included management intensity, connectivity to the Illinois River, average vegetation height, percent cover of forb, woody, grass, cocklebur (*Xanthium* spp., a common plant whose growth is generally discouraged by moist-soil managers), and smartweed (*Polygonum* spp.; a desirable moist-soil plant), the site's proximity to the Illinois River and to any source of water, habitat type (grassland or moist-soil wetland), the site's area, the total percent cover of vegetation, and the percent cover and depth of ground litter (Strader and Stinson 2005). Prior to data analysis, we developed biologically meaningful combinations of variables for inclusion in model sets. Using PROC CORR in SAS, we examined correlations among explanatory variables prior to analyses to avoid problems with multicollinearity, and considered variables with the absolute value of the Pearson correlation coefficient <0.5 to be uncorrelated (Rodgers and Nicewander 1988). We included site and year as random effects. We ranked models in each set by the lowest AIC_c, retained those within 4 ΔAIC_c units of the top model, and then assigned model weights (w_i) to determine the relative support for each model (Burnham and Anderson 2002). If there was model uncertainty and variables occurred in more than one supported model, we model-averaged parameter estimates or predicted values and generated unconditional 85% confidence intervals (Burnham and Anderson 2002). We considered model-averaged variables whose confidence intervals did not include zero and predicted variables whose standard errors did not overlap to be strongly supported. Several predictors (i.e., total percent cover of vegetation, percent litter cover, and litter depth) were only measured during 2015 and could not be included in multi-year models, but post-hoc analyses using only data from 2015 revealed that none of those variables were important predictors for any dependent variables, and we omitted them from pooled analyses.

We calculated daily survival rates (DSR) for nests using the Mayfield method, and calculating nest success rates by raising the DSR to the power of the number of days in the nesting cycle (Mayfield 1975). Since most nests were red-winged blackbirds and sample sizes were low across species, we used a 25-day nesting cycle to calculate overall success rates for all species, but those probabilities should be viewed with caution since they include multiple species (Dolbeer 1976, Johnson and Shaffer 1990, Confer and Pascoe 2003, Knutson et al. 2004, Novak et al. 2016). We used logistic exposure models (SAS PROC GENMOD) to identify site-wide, temporal, and environmental factors that influenced daily nest survival (Shaffer 2004). Using this approach, we examined the effects of the percent cover of woody vegetation, forbs, grass, cocklebur, smartweed, site area, habitat type, vegetation height, percent cover of total vegetation, litter cover and depth, and temporal characteristics including the year, date, and survey period in which the nest was checked. We selected the best-supported models using AIC_c, and we inferred significant differences between continuous variables based on the overlap of model-averaged coefficients with 85% confidence intervals, and model-averaged predicted means with standard errors for categorical variables when variables appeared in multiple top models.

Results

In 2014, we surveyed 12 moist-soil wetlands totaling 561 ha during the 3 sample periods. We recorded a total of 2,498 bird observations within the 100-m radius of point counts. In 2015, we surveyed 18 sites at least once, however, due to flooding at 6 moist-soil wetlands as a result of record high levels of the Illinois River, we were only able to survey those in period 1. We surveyed the remaining 12 sites (7 moist-soil wetlands and 5 grasslands) in all 3 survey periods for a total area of 600 ha. Birds recorded within 100 m of point counts in 2015 totaled 1,005. Combining both years, we surveyed approximately 1,161 ha and recorded 3,503 individual bird observations.

We observed 78 species within the 100-m radius of survey points from both years. The most common species of birds recorded were tree swallows (*Tachycineta bicolor*; 1.1 birds/point in grasslands, 3.2 birds/point in moist-soil wetlands), red-winged blackbirds (*Agelaius phoeniceus*; 4.1 birds/point in grasslands, 3.2 birds/point in moist-soil wetlands), and dickcissels (0.7 birds/point in grasslands, 1.4 birds/point in moist-soil wetlands). These three species composed 67% of all observations for the 2014 and 2015 field seasons. We observed several state threatened or endangered birds during within the 100-m radius of counts, including the common gallinule (*Gallinula galaeta*) and Forster's tern (*Sterna forsteri*), and the northern harrier and peregrine falcon outside of the 100 m. The northern harrier and peregrine falcon were both observed using moist-soil wetlands for foraging in late summer. Other species of conservation concern observed during surveys included the Bell's vireo (*Vireo bellii*), bobolink (*Dolichonyx oryzivorous*), dickcissel, grasshopper sparrow, pied-billed grebe (*Podilymbus podiceps*), prothonotary warbler (*Protonotaria citrea*), red-headed woodpecker (*Melanerpes erythrocephalus*), sedge wren (*Cistothorus platensis*), and willow flycatcher (*Empidonax traillii*).

Avian Density

In 2014, density estimates ranged from 4.3 to 16.8 birds/ha ($\bar{x}$ = 10.0, SE = 1.2). In 2015, density estimates ranged from 4.6 to 18.3 birds/ha ($\bar{x}$ = 12.6, SE = 1.1). Avian density varied as a function of average forb cover, habitat type, and average vegetation height across top models. Avian density declined 0.7 birds/ha (SE = 0.3) for every 10% increase in forb cover, but confidence intervals for average vegetation height included zero indicating no true effect. Avian density was similar in grasslands ($\bar{x}$ = 13.5, SE = 3.5) and moist-soil wetlands ($\bar{x}$ = 10.2, SE = 1.1).

Avian Conservation Significance

Avian conservation significance for all sites ranged from 62.5 to 384.1 with a mean score of 214.9 (SE = 13.8). Mean ACS in grasslands ($\bar{x}$ = 218.6, SE = 27.8) and moist-soil wetlands ($\bar{x}$ = 214.2, SE = 15.9) was similar. Considering only the obligate and facultative grassland birds, ACS was 260.1 (*n* = 16 species) in grasslands and 179.2 (*n* = 24 species) in moist-soil wetlands, and in those sets, the mean species-level conservation scores were similar between grasslands ($\bar{x}$ = 13.8, SE = 0.7) and moist-soil wetlands ($\bar{x}$ = 13.0, SE = 0.6). ACS varied as a function of the connectivity to the Illinois River, management intensity, and percent cover of woody vegetation among top models. ACS increased 7.5 (SE = 3.8) for every 1% increase in cover of woody vegetation. ACS was less in sites partially connected to the Illinois River ($\bar{x}$ = 171.0, SE = 17.9) than those disconnected from the river ($\bar{x}$ = 247.6, SE = 16.6). Actively managed sites ($\bar{x}$ = 218.6, SE = 14.6) had similar ACS to unmanaged and passively managed sites ($\bar{x}$ = 198.1, SE = 20.1).

Nest Density and Abundances

We observed 17 nests in 2014. Of those nests, 3 (18%) successfully hatched chicks, and 2 (18%) were determined to have failed. One of these failures was believed to be due to predation, and the other due to flooding. The remaining 12 nests (70%) were either empty for each visit, or of an undetermined fate due to insufficient evidence for success or failure.

In 2015, we observed 26 nests of which 4 (15%) successfully fledged chicks, 16 (62%) failed, and 6 (23%) were empty for every visit. Sources of nest failure in 2015 were due to predation of 5 nests (31%), flooding of 4 (25%), and the cause of the remaining 7 failures could not be determined (44%). Eighteen of the nests from 2015 (69%) were found in moist-soil wetlands, and 8 (31%) were found in grasslands. In grasslands, 2 (25%) nests were successful, 5 (63%) failed, and 1 (13%) was empty for each visit. DSR in grasslands was 0.894 for an overall nest success of 6%. Three (60%) of nest failures in grasslands were due to predation, and 2 (40%) failed due to unknown causes.

Across habitats and years, nest failures with known causes were due to predation (35%) and flooding (29%). DSR across both years and habitats was 0.912 for a 10% overall nest success. In moist-soil wetlands across years, 5 (14%) nests were successful, 13 (37%) failed, the fates of 5 (14%) were unknown, and the remaining 12 (34%) were empty for each visit. Three nest failures in moist-soil wetlands were due to predation (23%), 5 to flooding (38%), and the remaining 5 (38%) failed due to unknown causes. DSR in moist-soil wetlands was 0.924 for an overall nest success of 14%. Apparent nest success was 11.1% and 25.0% in moist-soil wetlands and grasslands respectively, and apparent failure rates were 61.1% and 62.5%. The remaining nests were empty for each visit. Daily survival rates of nests varied by year with a greater DSR in 2014 than 2015. All other models had an AIC_c greater than the constant survival model, thus, we detected no environmental variables that explained variation in nest DSR.

Grasslands tended to have a greater number of species nesting than moist-soil wetlands. Of eight nests found in grasslands, we confirmed five nesting species including red-winged blackbirds, grasshopper sparrows, brown thrashers (*Toxostoma rufum*; a species of concern in Illinois), indigo buntings (*Passerina cyanea*), and dickcissels. From the 29 nests observed in moist-soil wetlands, 27 were red-winged blackbirds, one dickcissel, and one grasshopper sparrow.

Nest densities were greater in grasslands (0.13 nests/ha, SE = 0.02) than in moist-soil wetlands (0.09 nests/ha, SE = 0.01). Proximity to the Illinois River appeared in all 4 top models for nest density, but the model-averaged predicted values for sites 220 m (lower quartile) and

1,600 m (median distances) from the river were 0.06 nests/ha (SE = 0.02) and 0.07 nests/ha (SE = 0.02), respectively. The average proximity to the river of sites with nests (*n* = 17) was 8,378 m, and the average proximity to the river from sites with no nests (*n* = 13) was 3,197 m. Site area did not have a strong effect on nest density, with model-averaged predicted values for sites 20 ha (lower quartile; 0.03 nests/ha, SE = 0.01) similar to sites 26.85 ha (median; 0.04 nests/ha, SE = 0.00).

Discussion

Moist-soil wetlands can provide nesting and foraging habitat for birds during the breeding season, including some grassland species. Moist-soil wetlands and grasslands had similar values of ACS and avian densities, indicating the conservation value of moist-soil wetlands to be comparable to that of grasslands in this system. However, grasslands tended to have slightly greater nest densities and a greater number of nesting species than moist-soil wetlands and were used by a greater number of obligate and facultative grassland birds. Moist-soil wetlands have the potential to become ecological traps for nesting birds due to an increased risk of flooding during early portions of the breeding season, but they still have the potential to provide important habitat for breeding birds when dewatered and in areas with adequate flood protection.

We recorded only one species exclusively in grassland sites, the northern mockingbird (*Mimus polyglottos*), which is not considered a grassland species or species of conservation concern in Illinois (Table 12). Grasslands had a greater number of grassland birds of conservation concern than moist-soil wetlands, but the greater diversity of birds from different guilds that used moist-soil wetlands compensated for the difference in ACS. Some of the birds that I observed only in moist-soil sites were waterbirds and non-grassland songbirds with high regional concern scores (e.g., American goldfinch [*Spinus tristis*], American white pelican [*Pelecanus erythrorhynchos*], chimney swift [*Chaetura pelagica*], red-headed woodpecker), and those species contributed significantly to the greatest proportion of the difference in ACS between moist-soil wetlands and grasslands.

The two species most commonly observed in both habitat types were the red-winged blackbird and tree swallow. Red-winged blackbirds were most abundant in grasslands, whereas tree swallows were most abundant in moist-soil wetlands. Tree swallows eat primarily flying insects that may be emerging from recently dewatered wetlands or nearby water (Quinney and Smith 1985, Anderson and Smith 2000). Although locally abundant, tree swallow populations are declining across North America along with other aerial insectivores (Nebel et al. 2010). Other aerial insectivores including cliff swallows, barn swallows, and chimney swifts, were relatively common in moist-soil wetlands (> 0.1 birds/point). Barn and cliff swallows were also relatively common in grasslands, but chimney swifts were not. Moist-soil management has been shown to increase aquatic invertebrate density, biomass, and diversity, and the production of invertebrates is a goal of moist-soil management for waterfowl (Anderson and Smith 2000). The positive relationship with moist-soil management and invertebrate communities may help explain why actively managed sites tended to have greater ACS, and why we observed more aerial insectivores foraging at those sites.

We observed grassland birds nesting in both grasslands and moist-soil wetlands, but the only important predictor for nest density was habitat type. Nest densities were likely greater than estimated here because of their extremely cryptic nature. In a study comparing nest search methods for grassland birds, Winter et al. (2003) reported that for the savannah sparrow that builds nests similar to grasshopper sparrow, systematic walking and behavioral observations resulted in detection probabilities of 16–52%. Although my estimates of nest density are likely conservative based on previous estimates of detection probability, we assume that detection probabilities were similar across habitats and provided a reliable index for comparing nesting between habitats. Although moist-soil wetlands provide slightly lower nest densities than grasslands, they still provide useful nesting habitat for grassland birds.

We found two grassland bird species nesting in moist-soil wetlands, dickcissels and grasshopper sparrows. The dickcissel is typically a grassland nesting species, but they are also known for being generalists that will nest in a variety of habitat that contain herbaceous vegetation (Winter 1999). In contrast, the grasshopper sparrow is generally described as an obligate-grassland species (Coppedge et al. 2008, Hovick et al. 2012). The fact that grasshopper sparrows were found nesting in a moist-soil wetland suggests that the vegetation structure, including the ground litter in which they nest, may mimic grasslands enough to provide suitable habitat for a variety of grassland bird species. Several of the nests we observed in moist-soil wetlands, including the grasshopper sparrow, failed due to flooding. The increase in frequency and magnitude of flooding in the floodplain of the IRV raises the concern that moist-soil wetlands may act as ecological traps for nesting birds, especially early in the breeding season (Sparks 1995, Sparks et al. 1998).

During 2013–2015, there have been 3 major floods that drove the Illinois River to record-high peaks. Three out of the four highest peaks in recorded history (since the 1800s) in Havana, Illinois have occurred since 2013 (National Weather Service, unpublished data). Human disturbance has resulted in drastic changes in hydrology, therefore making areas like moist-soil wetlands in river floodplains a risky area for nesting birds. The risk is greatest in sites that are partially connected to the Illinois River and flood at moderate flood stages. Moist-soil wetlands that are hydrologically disconnected from the river (e.g., outside of the 100-year floodplain of the river or isolated by a drainage and levee districts) provide more dependable habitat for breeding birds because they do not easily flood as a result of higher river levels. For example, the three sites with the greatest ACS were from a complex of managed moist-soil wetlands within the floodplain of the Illinois River that were protected by a large river levee and therefore protected from flooding due to high river levels. Conversely, some of the sites with the lowest ACS were from a managed moist-soil complex in the floodplain of the Illinois River that were likely to flood under moderate river levels. Sites with the greatest ACS scores tended to be actively managed and hydrologically disconnected from the Illinois River, and some of those sites also had the greatest nest densities (e.g., 3.5 and 0.5 nests/ha).

Interestingly, the sites with the least amount of forb cover and greatest amount of grass cover tended to have the greatest ACS scores. Across habitat types, forb cover had a negative relationship with avian density. The effect of forb cover on grassland bird densities has been shown to vary across species, and also that the relationship is not linear in that forb cover has a positive effect on avian density when cover is sparse but a negative effect if forbs predominate (Skinner 1975). In one study, a mean forb cover of 22% (range 3–53%) had a positive relationship with the abundance of two grassland bird species, but a negative relationship with a third grassland species (Patterson and Best 1996). Mean forb cover in both moist-soil wetlands and grasslands in this study exceeded 30% and may have been greater in many wetlands than preferred by grassland birds. It should also be noted that moist-soil wetlands had a greater percent cover of forbs than most grasslands but also a greater range in forb cover (Table 11). There may be an upper threshold in which forb cover begins to have a negative impact on avian density, and the sites from this study may have exceeded that since there is a linear decline in avian density as forb cover increases.

Although flooding during the growing season is typically avoided when possible, higher river levels do not necessarily have a negative impact on the environment. Brief, shallow floods can stimulate the growth of moist-soil vegetation, kill undesirable vegetation, and benefit other species. Some waterbirds may actually benefit from flooding during the breeding season as more habitat becomes inundated for them to use for foraging and possibly even nesting (Fredrickson and Taylor 1982). During a mild flood in 2014, we observed the state endangered Forster's tern foraging in a moist-soil wetland. Grassland birds are not the only guild of birds in need of conservation in this region. Illinois has experienced an extensive loss of wetlands since the 1800s, and the majority of the birds listed as state threatened or endangered in Illinois or as species of conservation concern by the U.S. Fish and Wildlife Service rely on wetlands in some capacity (U.S. Fish and Wildlife Service 2008, Illinois Endangered Species Protection Board 2015). So despite the detrimental effects of flooding for some wildlife, it may also benefit others as long as it is not prolonged or deep enough to kill moist-soil vegetation.

Across years and habitats, the success rate for nests observed in this study assuming a 25-day nesting cycle was 10%, which is lower than most values reported in other studies for grassland birds (Jehle et al. 2004, Winter et al. 2005, Morgan et al. 2010, Walk et al. 2010). Overall nest success was lower in grasslands (6%) than in moist-soil wetlands (13.7%) across years, but these results should be viewed with caution due to the relatively low sample sizes. In a review of 87 DSR estimates from 21 grassland nest studies in the Midwest, Benson et al. (2013) reported a mean DSR of approximately 0.935 which, assuming a 25-day nesting cycle like my data, results in a success rate of 18.6%. Others have reported difficulties in identifying environmental characteristics that impact nest success in grasslands and similar habitats (e.g., Winter et al. 2005, Benson et al. 2013). Our results mirror those findings, in that no environmental explanatory variables explained significant variation in nest success. Nest predation is relatively high in grasslands and often the main source of nest failure, as was the case in grasslands in this study with 60% of grassland nest failures attributed to predation compared to the 23% in moist-soil wetlands, although it should be noted that nests in moist-soil wetlands are subjected to the additional risk of flooding. The high predation rate could mean that vegetative characteristics are less important as predictors of nest success than other variables, like those influencing predator abundance or activity (Nolan 1963, Vickery et al. 1992).

Woody vegetation cover had a positive effect on ACS; however, the growth of woody vegetation is typically discouraged in managed moist-soil wetlands (Strader and Stinson 2005). The presence of woody vegetation in an area with desirable moist-soil vegetation increases the diversity of the overall vegetation composition and structure, and it is a reasonable assumption that this would result in a greater diversity of avian species with different habitat preferences. We did not consider the distribution within the wetland or species composition of the woody vegetation in this project. A better understanding of those factors may help guide moist-soil management to provide breeding habitat for a broader range of conservation priority species during drawdown without having a detrimental effect on the productivity of the wetland for waterfowl (Stauffer and Best 1980).

Management recommendations for moist-soil wetlands involve drawing down water in spring or early summer and then maintaining soil moisture throughout the growing season before shallowly inundating vegetation in the fall (Fredrickson and Taylor 1982, Bowyer et al. 2005). The timing and speed of drawdown has an impact on the vegetation community in moist-soil wetlands. Slow, early-season drawdowns (before May 15th) usually encourage a greater production of seeds than fast and mid-season (May 15th–July 1st) or late (after July 1st) drawdowns. Fast and late drawdowns increase the chance that undesirable vegetation will grow due to the lower moisture retention of the soil. Early drawdowns usually produce the most productive vegetation, but there is a risk of the moist-soil wetland becoming too dry later in the season if the area does not get enough precipitation. In the case of an early drawdown and a dry season, wetland managers may induce a short mid-season flood to stimulate the growth of desirable plants (Fredrickson and Taylor 1982). If a flood does occur after drawdown and during the breeding season, as it did in 2015 in my study area, it is likely to cause nest failures. Nest attempts among grassland birds in this region have been reported to peak during June, but have also been shown to begin as early as mid-April and conclude in early July (Basore et al. 1986, Giocomo et al. 2008). The timing of typical drawdowns tends to occur after some birds have begun breeding, but most moist-soil wetlands are dewatered by peak breeding season (Strader and Stinson 2005). Additionally, re-nesting is common for grassland birds with such consistently high rates of nest failure, so even if moist-soil wetlands are not dry until later in the breeding season, they will likely still provide habitat for late-nesting and re-nesting birds.

In conclusion, we have shown that moist-soil wetlands can provide habitat for breeding birds, including grassland species, during the breeding season. However, the susceptibility of moist-soil wetlands in river floodplains to water-level fluctuations make them a potentially risky place for nesting, particularly for the grassland species that nest on or near the ground. This risk is exacerbated by the increase in occurrence and severity of floods due to the highly altered landscape in the midwestern United States. We found that vegetation structure and composition play a role in the dynamics of moist-soil avian communities, so to augment future moist-soil management recommendations for breeding birds, it would be beneficial to further explore the role of specific environmental variables. We recommend examining the distribution, species composition, and vegetation structure of woody plants on avian conservation significance, the role of invasive plants on measures of avian use, invertebrate communities as foraging opportunities for birds during the breeding season, and the timing and speed of drawdown in the beginning of the growing season and its impact on nest survival and success.

In order to manage moist-soil wetlands to provide productive habitat for grassland birds, wetland managers should consider the characteristics of each wetland when making management decisions. Moist-soil wetlands that will inundate under mild flood conditions and sites that are hydrologically connected to the Illinois River pose the greatest risk to nesting grassland birds. To minimize the risk of creating an ecological trap for breeding birds, we recommend that moist-soil managers conduct a mid-season or late drawdown (e.g., late-June through July) in connected and partially-connected wetlands within the IRV to discourage birds from nesting until the greatest risk of flooding has passed (Sparks et al. 1998). If nesting does occur after drawdown, we recommend keeping the site completely dewatered, if possible, until the end of the breeding season. In moist-soil wetlands that are disconnected from the Illinois River and where flooding is less likely, we recommend conducting an early drawdown (e.g., mid-May through mid-June) to allow moist-soil vegetation to grow and provide habitat for grassland birds during peak breeding season.

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Table 11. Mean, standard error, and ranges for environmental variables and characteristics recorded at grasslands (n = 5) and moist-soil wetlands (n = 25) in and near the Illinois River valley from May – September in 2014 and 2015.

	Grasslands			Moist-soil Wetlands		
Variables	Mean	SE	Range	Mean	SE	Range
Site Area (ha)	19	5.9	2.1 – 34	42.6	6.1	2.1 – 98.7
Proximity to River (km)	12.4	3.8	5.5 – 22.0	4.9	3.6	100 – 90.0
Proximity to Water (km)	2.7	1.7	0 – 7.8	0.2	0.2	0 – 4.0
Management Intensity[a]	0.2	0.2	0 – 1	0.8	0.1	0 – 1
Connectivity to River[b]	0	0	0 – 1	0.6	0.1	0 – 1
Average Veg Height (m)	73.3	14.3	46.5 – 125.9	72.8	7.2	17 – 143.5
% Woody	0.2	0.1	0 – 0.6	2.7	0.7	0 – 14.9
% Forb	35.6	2.1	32.1 – 43.2	50.3	4.9	6.8 – 87.8
% Grass	69.5	4.1	54 – 76.3	30.5	4.4	0 – 77.3
% Sedge	1.7	1.0	0 – 5.3	4.8	1.1	0 – 25.8
% Rush	2.6	2.3	0 – 11.9	2.6	1.2	0 – 21.4
% Total Cover	88.4	5.3	71.8 – 98.4	67.7	6.4	30.4 – 99
% Smartweed	0.1	0.1	0 – 0.3	15.7	4.4	0 – 72.0
% Cocklebur	0.2	0.2	0 – 1.1	9.8	2.7	0 – 49.9
% Litter Cover	45.2	21.8	0 – 100	47.5	8.9	4.8 – 99.4
Litter Depth (cm)	6.4	3.4	0 – 18.3	3.9	1.0	0.5 – 11.4

[a] Sites that were actively managed (e.g., water control, planting) were recorded as 1, and sites that were not managed were recorded as 0. The mean reflects the proportion of actively managed sites.

[b] Sites that were partially connected to the Illinois River were recorded as 1, and sites that were completely disconnected from the Illinois River were recorded as 0. The mean represents the proportion of partially connected sites.

Table 12. A list of all avian species observed during the study period presented in this thesis separated by grassland and moist-soil wetland including common name, number of birds observed, an index of avian abundance, and regional concern score (breeding; RCS-b). The regional concern scores for species marked with a (*) were obtained from Bird Conservancy of the Rockies as preliminary data, species marked with a (†) were only observed in grasslands, and species marked with a (‡) were considered obligate or facultative grassland birds.

Moist-soil wetlands			
Species	No. Observed	No./point	RCS-b
Tree swallow	1156	4.78	8
Red-winged blackbird‡	762	3.15	13
Dickcissel‡	342	1.41	17
American white pelican*	186	0.77	11
Indigo bunting	133	0.55	10
Common yellowthroat‡	89	0.37	13
American goldfinch	77	0.32	13
Cliff swallow‡	63	0.26	9
Song sparrow	59	0.24	10
Killdeer*‡	56	0.23	12
Barn swallow‡	50	0.21	13
Chimney swift	32	0.13	15
Lesser yellowlegs*‡	32	0.13	13
Red-headed woodpecker	29	0.12	18
Field sparrow‡	28	0.12	17
Gray catbird	28	0.12	10
American robin	27	0.11	9
Eastern meadowlark‡	27	0.11	17
Common grackle	26	0.11	10
Mourning dove‡	21	0.09	10
Northern cardinal	20	0.08	9
House wren	19	0.08	9
Warbling vireo	19	0.08	9
Yellow-billed cuckoo	19	0.08	15
Cedar waxwing	18	0.07	9
Northern flicker	14	0.06	16
Northern bobwhite‡	13	0.05	16
Bell's vireo	12	0.05	14
Grasshopper sparrow‡	12	0.05	16
Ruby-throated hummingbird	10	0.04	11

Table 12 (cont.) Moist-soil wetlands

Species	No. Observed	No./point	RCS-b
Mallard*‡	9	0.04	8
Sedge wren‡	9	0.04	12
Canada goose*‡	8	0.03	9
Eastern wood-pewee	8	0.03	14
Green heron*	8	0.03	11
Great crested flycatcher	7	0.03	10
White-breasted nuthatch	7	0.03	10
Bald eagle	6	0.02	12
Eastern kingbird‡	6	0.02	15
Great blue heron*	6	0.02	11
Brown-headed cowbird‡	5	0.02	10
Chipping sparrow	5	0.02	9
Great egret*	5	0.02	9
Red-tailed hawk	5	0.02	10
Rose-breasted grosbeak	5	0.02	12
Sora*	5	0.02	11
Willow flycatcher	5	0.02	13
Black-capped chickadee	4	0.02	11
Blue jay	4	0.02	12
Caspian tern	4	0.02	8
Short-billed dowitcher*‡	4	0.02	14
American crow	3	0.01	10
Baltimore oriole	3	0.01	12
Eastern bluebird‡	3	0.01	11
Red-bellied woodpecker	3	0.01	11
Scarlet tanager	3	0.01	10
American kestrel‡	2	0.01	13
Belted kingfisher	2	0.01	14
Brown thrasher	2	0.01	16
Downy woodpecker	2	0.01	11
Hairy woodpecker	2	0.01	12
Pied-billed grebe*	2	0.01	10
Prothonotary warbler	2	0.01	13
Black-billed cuckoo	1	0.00	15
Blue-gray gnatcatcher	1	0.00	10
Bobolink‡	1	0.00	16
Carolina wren	1	0.00	9

Table 12 (cont.) Moist-soil wetlands			
Species	No. Observed	No./point	RCS-b
Common gallinule*	1	0.00	10
Eastern towhee	1	0.00	11
Horned lark‡	1	0.00	12
House finch	1	0.00	7
Least flycatcher	1	0.00	9
Pileated woodpecker	1	0.00	9
Ring-necked pheasant‡	1	0.00	13
Spotted sandpiper*	1	0.00	12
Tree sparrow	1	0.00	11
Tufted titmouse	1	0.00	12
Turkey vulture‡	1	0.00	8
Winter wren	1	0.00	10
Wood duck*	1	0.00	12
Yellow warbler	1	0.00	9
Yellow-rumped warbler	1	0.00	7

Table 12 (cont.) Grasslands

Species	No. Observed	No./point	RCS-b
Red-winged blackbird‡	143	4.09	13
Tree swallow	39	1.11	8
Cliff swallow	27	0.77	9
Common yellowthroat‡	25	0.71	13
Dickcissel‡	25	0.71	17
Field sparrow‡	18	0.51	17
Grasshopper sparrow‡	17	0.49	16
Indigo bunting	17	0.49	10
American goldfinch	15	0.43	13
Bobolink‡	14	0.40	16
Barn swallow‡	12	0.34	13
Sedge wren‡	12	0.34	12
Northern cardinal	10	0.29	9
Eastern towhee	9	0.26	11
Mourning dove‡	7	0.20	10
Song sparrow	7	0.20	10
House wren	6	0.17	9
Mallard*‡	6	0.17	8
American robin	5	0.14	9
Blue jay	5	0.14	12
Eastern meadowlark‡	5	0.14	17
Northern bobwhite‡	5	0.14	16
Northern mockingbird†	5	0.14	10
Willow flycatcher	4	0.11	13
American crow	2	0.06	10
Bell's vireo	2	0.06	14
Chipping sparrow	2	0.06	9
Eastern kingbird‡	2	0.06	15
Gray catbird	2	0.06	10
Killdeer*‡	2	0.06	12
Ring-necked pheasant‡	2	0.06	13
Black-capped chickadee	1	0.03	11
Cedar waxwing	1	0.03	9
Chimney swift	1	0.03	15
Common gallinule*	1	0.03	10
Downy woodpecker	1	0.03	11
Eastern wood-pewee	1	0.03	14

Table 12 (cont.) Grasslands			
Species	No. Observed	No./point	RCS-b
European starling†	1	0.03	10
House finch	1	0.03	7
Horned lark‡	1	0.03	12
Pileated woodpecker	1	0.03	9
Warbling vireo	1	0.03	9
Wood duck*	1	0.03	12

Figure 8. Locations of moist-soil wetlands and grasslands located in or near the floodplain of the Illinois River Valley near Havana, Illinois and studied for breeding bird use from May – September of 2014 and 2015.

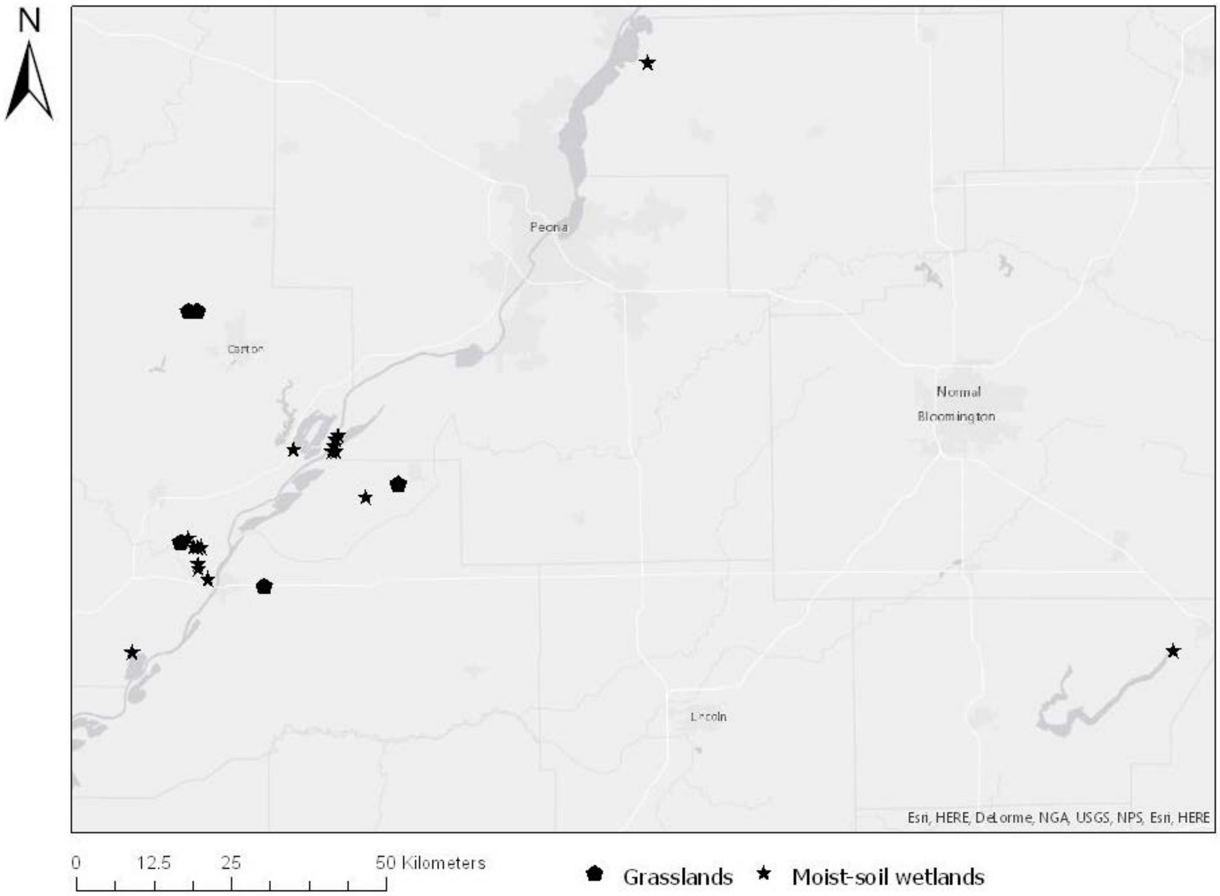


Figure 9. Systematic nest search pattern for obtaining estimates of nest density in moist-soil wetlands and grasslands in and near the floodplain of the Illinois River Valley from May – September in 2014 and 2015. The star represents the starting point of the search, which is also a point count location. We traveled a total of 400 m during a single nest search, checking one meter each side of the path.

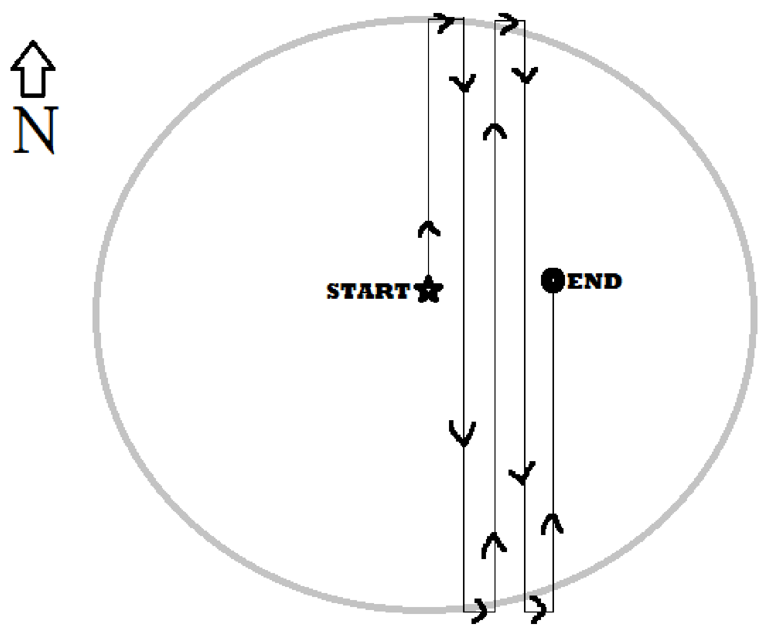
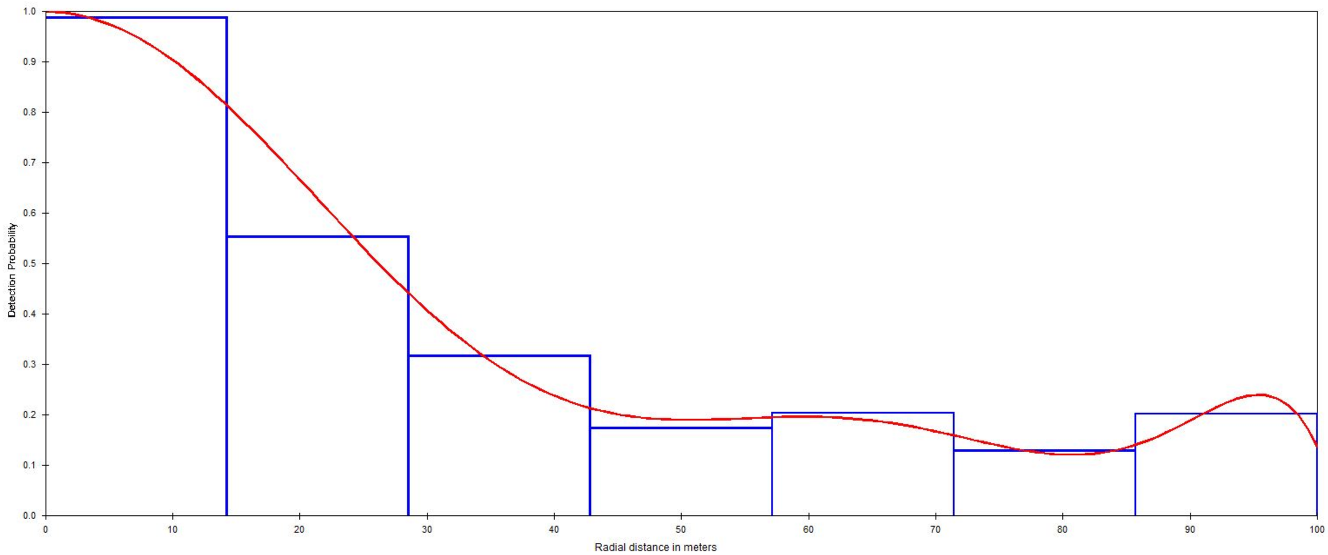


Figure 10. Example of a conventional distance sampling (CDS) detection probability curve for avian point count data (blue) and with a uniform key function simple polynomial series expansion in Program DISTANCE 6.2.



<u>STUDY 127</u>: REPRODUCTIVE SUCCESS AND SURVIVAL OF THE EASTERN POPULATION OF SANDHILL CRANES

Objectives: 1) Estimate the reproductive success (average # of young produced per pair) of a minimum of 50 sandhill cranes in urban and rural landscapes of northeastern Illinois.

2) Estimate the survival of a minimum of 50 juvenile (individuals that no longer rely on parents but are not breeding) sandhill cranes in urban and rural landscapes of northeastern Illinois.

3) Estimate the survival of a minimum of 50 adult breeding sandhill cranes in urban and rural landscapes of northeastern Illinois.

Introduction

The Eastern Population (EP) of Greater Sandhill Cranes (*Grus canadensis tabida*) has demonstrated an impressive recovery since the population's historic low in the 1930s (e.g. ~25 breeding pairs documented in Wisconsin; Henika 1936, Meine and Archibald 1996). At present, the EP numbers more than 70,000 birds (Kruse and Dubovsky 2015) and interest in harvest for recreation and to mitigate crop depredation has come to the forefront of discussions on the population's management. The Management Plan for the Eastern Population of Sandhill Cranes (2010) has proposed a harvest-management strategy based on fall surveys to monitor the population and maintain running three-year average indices above 30,000 cranes (Ad Hoc Eastern Population Sandhill Crane Committee 2010). While precedents set by the harvest of the Mid-Continent Population (MCP) and Rocky Mountain Population (RMP) of Sandhill Cranes support this approach, the landscape within the EP's range is far more varied than the landscapes in the MCP and RMP ranges and continues to be rapidly urbanized (Fig. 1, Appendix 3). If cranes are able to thrive in these urbanizing landscapes it is likely that the EP will continue to increase, perhaps mirroring the population trajectory of the Giant Canada Goose throughout the Midwest in the last 33 years (17.5% per year; Sauer et al. 2011). However, there remain several knowledge gaps in the demographics of the EP including landscape-dependent reproductive success and juvenile and adult survival (e.g. two studies published on reproductive success in or near urban environments; Dwyer and Tanner 1992, Toland 1999). Evaluating these vital rates in different landscapes of the EP's range and at different population densities is essential to refining models of population growth and abundance under different land-use and management scenarios (e.g. urban sprawl and EP harvest).

Methods

In order to investigate the reproductive success of sandhill cranes, we estimated the survival of nests and fledglings in northeastern Illinois and southeast and south-central Wisconsin. Nests were located via aerial surveys and monitored until the eggs hatched. Young were radio-tagged and subsequently monitored to determine the fate of these individuals. We radio-tagged both juveniles and adults and monitored them during the breeding season every 2–3 days using vehicle-mounted radio receivers. After the breeding season, automated telemetry receiving units (a.k.a. automated receiving units or "ARUs"; JDJC Corporation) positioned in the EP migration route at Chain O'Lakes State Park in Illinois and at a primary migratory stopover site at Jasper-Pulaski State Fish and Wildlife Area in Indiana (JP) were used to record the movements of radio-marked juvenile and adult cranes. ARUs increase the probability of detecting marked birds during migration by increasing search time which can inadvertently increase precision of survival analyses through increased detections. Moreover, these units are expected to provide insight into potential status-dependent (e.g. breeding vs. non-breeding) migratory timing and behavior as well as generating data on birds from geographically distinct regions of the EP breeding range. Data were used to construct known fate models in Program MARK (v.7.0) to estimate nest productivity and fledging success. In addition, simple multi-state models were also constructed in Program MARK (v.7.0) to evaluate age- and status-dependent survival.

Results

During the 2012 and 2013 breeding seasons, we monitored crane nests, radio-marked hatchings and pre-fledged young, and captured and permanently banded hatch-year and adult cranes. We have continued to collect data from these marked birds via automated telemetry units deployed at Jasper-Pulaski Fish and Wildlife Area in Indiana and Chain-O-Lakes State Park in Illinois. The probability of a nest producing fledged young was 19% (1.9% SE), and the mean size of a fledged broods was 1.2 young. Juvenile survival post-fledging to 11 months of age (i.e., latest age of independence) was 65% (5.1% SE). Through 2015, annual survival for adult birds was 94% (2.7% SE) and did not appear to vary significantly relative to breeding status. These data suggest 9% survivorship from nest to earliest breeding at 3 yrs of age, but the USFWS and other collaborators will continue to compile available ARU data.

In 2015, we concluded monitoring of tagged adults and juveniles. The primary activity during this fiscal year was analyzing the population dynamics of the cranes in the Midwest and providing data and analyses to the USFWS to support a harvest model. We purchased the software package Ramas to model the dynamics of the crane population and then to change the variables as may be expected if the species was harvested to determine how the long-term population of cranes may be impacted. Graduate student Jeff Fox also worked with the USFWS to advise them on how to capture and monitor cranes in Minnesota. Survival estimates and other data were included in a final report to the IDNR and USFWS. ARU data manipulation, processing, and archiving was completed in 2015. In late 2015, Jeff Fox took a position with Operation Migration to continue his crane migration work and continued to work with USFWS and project collaborators to manipulate and analyze data as needed.

Discussion

The Eastern Population (EP) of Greater Sandhill Cranes has recovered from a historic low of approximately 25 breeding pairs in the 1930s to over 70,000 individuals today (Henika 1936, Meine and Archibald 1996, Kruse and Dubovsky 2015). While the EP has increased dramatically, the data generated from this study are necessary to help shape future management decisions to provide a sustainable population of sandhill cranes, while allowing potential harvest opportunities for hunters. Adult survival for birds in this study averaged 94%, which is consistent with a 95% adult survival rate observed for birds in the Rocky Mountain Population (RMP; Subcommittee on Rocky Mountain Greater Sandhill Cranes 2007). Annual recruitment of juveniles to adults in the RMP averaged 8% during 1972–1992, and Mid-Continent Population (MCP) recruitment averaged 11% during 1987-1992. Our data show a 9% recruitment rate of juveniles to the breeding population (3 years of age), indicating a higher annual recruitment than other populations (RMP and MCP) of greater sandhill cranes.

While sandhill cranes in the Rocky Mountain Population (RMP) have been documented abandoning nests or territories in response to human disturbance, EP individuals showed a positive relationship between fledgling success and urbanization (Drewien 1973, Walkinshaw 1973, Boise 1976). As the percentage of urban development within 1,500 m of sandhill crane nests increased, fledging success also increased. While this contradicts data from the RMP, it appears individuals in the EP are adapting to successfully nest in close proximity to people. Though the mechanism for this is unclear, urbanization may be creating small refuges that minimize nest and juvenile depredation. It is possible that this relationship between urbanization and fledging success may continue to increase to a point, at which urbanization may come at the cost of reduced availability of nesting habitat. At this point, the breeding range of EP individuals may need to expand if the population continues to increase.

While the data do not represent the entire Eastern Population of greater sandhill cranes, survival and recruitment values meet or exceed those from other populations of cranes (RMP and MCP), which currently offer ample opportunities for management through harvest. Data from the overall EP are necessary to successfully manage this particular population, and these data will be used to generate population models to estimate the future trajectory of EP sandhill crane numbers, inform management decisions, and regulate a sustainable harvest of sandhill cranes.

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STUDY 128: MOVEMENT ECOLOGY OF CANADA GEESE WINTERING IN THE GREATER CHICAGO METROPOLITAN AREA

Objectives:

1) Determine daily flight distance, winter home range size, and proportional habitat use of a minimum of 10 Canada geese in the GCMA during winter.

2) Determine factors affecting daily movements and habitat use of a minimum of 10 Canada geese in the GCMA during winter.

3) Identify movement patterns of a minimum of 10 Canada geese that pose risks from conflict with humans in target areas of the GCMA during winter.

Introduction

Canada geese (*Branta canadensis*) are important ecologically and economically throughout Illinois and the midwestern United States. Canada goose population ecology is well studied in the U.S. and Canada, and this species is intensively managed to regulate sport harvest within and among goose subpopulations (Klimstra and Padding 2012). In the past several decades, the Mississippi Valley population of subarctic-breeding Canada geese, which breeds in the lowlands of Hudson Bay, Canada, has remained relatively stable in abundance but appears to have changed its wintering range and migration timing (Gates et al. 2001, AGJV 2013). Anecdotal information suggests that subarctic-breeding geese winter farther north than historically and many previous assumptions regarding factors affecting their movements may be incorrect due to changing food and habitat availability on the landscape. Concurrently, temperate-breeding (i.e., “resident”) Canada goose populations have increased drastically across much of the Midwest (Nelson and Oetting 1998, Dolbeer et al. 2014). During winter, these populations’ ranges overlap creating large abundances of geese in some areas (Paine et al. 2003).

One such mixed congregation area is the Greater Chicago Metropolitan Area (GCMA) in northeastern Illinois which includes the city of Chicago and surrounding suburbs with a human population of greater than 9.4 million and a breeding goose population of >30,000 (Paine et al. 2003, U.S. Census Bureau 2013). In northern wintering regions, geese may congregate in mixed, high-density flocks near electric generation cooling lakes, open river channels, navigation waterways, and other isolated areas of open water (Havera 1999). During mild winters, the GCMA may be the terminal wintering latitude for many migrating subarctic-breeding geese, and many temperate breeding geese may remain throughout winter creating mixed high-density aggregations. Geese are likely attracted to the GCMA because of reduced risk from natural predators and little to no hunting; open water throughout winter at aerated ponds, warm-water out-flows into waterways, and electrical generation cooling lakes; and presumably ample food sources due to extensive agriculture and waste grain within the region. The total GCMA goose population may reach significant numbers during winter offering opportunities for wildlife recreation (e.g., viewing, hunting), but may also create challenges and conflicts that range from inconvenient (e.g., noise, droppings) to extremely dangerous (e.g., aircraft strikes).

Understanding how to manage Canada geese in the GCMA will require a better understanding of the genetic composition of the population and how the two populations may differ behaviorally. Temperate-breeding Canada geese are considered over abundant by most administrative authorities. Administrative approval to reduce the population will not likely be acquired without a better understanding of how these activities will potentially impact the subarctic-breeding component of the winter population within and nearby the GCMA. The subarctic-breeding component of the population most likely consists of those Canada geese traditionally considered the Mississippi Valley Population. These geese historically nested in the Hudson Bay Lowlands and migrated to regions south of the GCMA. Recently and most likely due to increase water availability, warming climate, and a modification in farming practices, these geese have thrived in landscapes such as the GCMA, farther north than traditional wintering sites. Because of the important recreational opportunity these geese provide for regions north of the GCMA in Minnesota, Wisconsin, and Michigan, there is a strong political desire to maintain population abundance. Thus, a reduction of the temperate-breeding Canada goose populations can only take place if populations are temporally or spatially segregated adequately to influence the temperate-breeding population without influencing the migrant population.

We will investigate wintering Canada goose ecology in the GCMA, including characterizing daily movements, characteristics of desirable and undesirable habitats, and the influences of weather and other factors on habitat use. Results of this research will provide a better understanding of factors influencing how geese use the GCMA, source populations of geese using areas of interest, and how wildlife and habitat managers can manage geese to increase wildlife related recreation or dissuade geese from using areas to avoid dangerous conflicts.

Methods

Study Area

Canada geese were captured in the Greater Chicago Metropolitan Area (GCMA; 915 km^2) located in northeastern Illinois, USA (Fig. 11) during late autumn and winter. The GCMA included portions of three counties (Cook, Du Page, and Will). The GCMA is heavily urbanized, but did have agricultural fields present within the GCMA boundaries (United States Department of Agriculture 2015). The GCMA averages 43 days annually below freezing, with 7 days below -18 °C. November has an average high of 9 °C and a low of 0 °C, December has an average high temperature is 2 °C with a low of -6 °C, January has an average is a high of 0 °C and a low of -9 °C, and February has an average high of 2 °C and low of -7 °C (NOAA 2015*a*). Chicago averages approximately 93 cm of snowfall annually (NOAA 2015*a*). The GCMA has an estimated temperate-breeding Canada goose population exceeding 30,000 individuals (Paine et al. 2003) and a human population of 9.4 million, including the city of Chicago and surrounding suburbs (United States Census Bureau 2013).

Field Methods

During 13 November 2014 through 28 February 2015 and 14 November 2015 through 29 February 2016, we captured and attached transmitters to 41 Canada geese within the GCMA. We focused capture efforts at sites nearby Midway International Airport (41º47'6.5"N, 87º45'6"W) such as large parks, cemeteries, and the Stickney Water Reclamation Plant because of their available habitat and increased risk of goose-aircraft collisions when Canada geese concentrated at these locations throughout the fall and winter months (Fig. 12). Standard waterfowl capture techniques (e.g., rocket nets and cannon nets) could not be used in most urban areas, so cast nets and small animal net guns (Wildlife Capture Services, Flagstaff, Arizona, USA) were used for most capture attempts. After a Canada goose was captured, we determined sex and age using cloacal inversion and feather characteristics and then obtained morphological measurements (i.e., mass, skull length, culmen length, tarsus length; Moser and Rolley 1990, Moser et al. 1991) as potential indicators of body condition. All length measurements were taken using a caliper (nearest 0.1 mm) and mass was obtained using a Rapala mini digital scale (nearest 0.01 km). An aluminum tarsal band and a GPS transmitter affixed to a white plastic waterfowl neck collar with black alphanumeric codes was then placed on each goose prior to release (Castelli and Trost 1996, Coluccy et al. 2002, Caswell et al. 2012).

Transmitters (n = 10 in 2014–2015 and n = 31 in 2015–2016) were deployed during four times periods each year (mid November, early December and mid December, and early January) to account for temporal variation and across seven different capture locations to account for spatial variation (Table 13). Transmitters recovered from hunters (n = 3) were redeployed during the late February. Transmitters included solar-powered GPS units from Cellular Tracking

Technologies in Somerset, Pennsylvania, USA, and operated on the Global System for Mobile communications network and were configured to acquire a GPS location once per hour. Generation 2 models were used during 2014–2015 ($\bar{x}$ = 69.7 grams, SE = 0.2) and Generation 3 transmitters were used during 2015–2016 ($\bar{x}$ = 62.2 grams, SE = 0.2). Transmitters were < 2% of the body mass of Canada geese ($\bar{x}$ = 4,713 grams, SE =10.6) and all Canada geese were captured and handled using the approved methods detailed by the University of Illinois Institutional Animal Care and Use Committee (Protocol # 14155).

Data Analysis

We removed locations from the day of capture from analysis, except for survival analysis, to minimize potential influences on movements and habitat use. Transmitters required a once-weekly cellular connection to program their duty cycle to the standardized rate of 1 location/hour for the entire day and upload locations to an accessible database. Depending on deployment, some transmitters did not link properly so data from transmitters with less than 10 days of data collection were removed from analysis (*n* = 1 in 2014–2015 and *n* = 4 in 2015–2016). Locations with only one satellite fix or with a horizontal dilution of precision value above 5 were removed because GPS coordinates were either not obtained or they had extremely low accuracy (Cellular Tracking Technologies 2015). All analyses were performed using R Version 3.1.3 (R Core Team 2015).

To determine spatial habitat use, we used a dynamic Brownian Bridge Movement Model (dBBMM) to estimate the 50% and 95% utilization distribution (UD; km^2) using the adehabitatHR, rgdall, and move packages (Calenge 2006, Bivand et al. 2015, Kranstauber and Smolla 2015). Weestimated 50% utilization distributions (hereafter, core use areas) to target specific areas used by Canada geese during winter where management actions may need to focus and the 95% UD to represent total spatial use of Canada geese during winter. A dBBMM is a more appropriate method to estimate spatial habitat use than home range or kernel density estimates because it incorporates the temporal structure of the locations to estimate potential trajectories of the segments between those locations using a maximum likelihood function (Horne et al. 2007, Kranstauber et al. 2012). The dBBMM also provides a more accurate estimate than home range analysis for systematically collected data because the locations are not independent (Burt 1943, Worton 1989, Fieberg et al. 2010). If a Canada goose emigrated (i.e., did not return during the remainder of the year) from the GCMA, all locations from migration date forward were removed from 50% core use area and 95% UD analysis. Data collected from winter 2014–2015 were limited due to transmitter battery recharging issues with Generation 2 models (*n* = 9 transmitters, $\bar{x}$ = 10.5 locations/transmitter/day, SE = 2.9, range 2.0–26.4) compared to winter 2015–2016 when Generation 3 models provided increased battery life and efficiency (*n* = 27 transmitters, $\bar{x}$ = 20.8 locations/transmitter/day, SE = 0.4, range 15.4–23.3). Time between locations was greater for Generation 2 models in 2014–2015 ($\bar{x}$ = 274.1 min, SE = 75.2) than Generation 3 models in 2015–2016 ($\bar{x}$ = 70.1 min, SE = 1.3). All locations obtained from 15 November–28 February of both years (*n* = 3,496 in 2014–2015 and *n* = 35,896 in 2015–2016) were used to calculate 50% core use areas and 95% UD estimates.

We also classified the autumn and winter period into three distinct periods using feeding flight and activity data from Raveling et al. (1972); early winter (15 November–31 December), mid winter (1 January–31 January), and late winter (1 February–28 February). We used mean imputation to fill in missing data for time period analysis, which simultaneously retained important 50% core use area and 95% UD information (Zar 2010). Transmitters (*n* = 6) from 2014–2015 that were present in the GCMA during 2015–2016 were not used for analysis during the second year because of limited locations with poor temporal spacing (i.e., weeks between locations) and low accuracy. We removed one location from analysis (Museum of Science and Industry) due to a limited sample size of Canada geese (*n* = 2). In separate linear mixed models using the lme function in the nlme package (Pinheiro et al. 2016), we analyzed the response variables of 50% core use areas and 95% UD against the predictor variable of time period (i.e., early, mid-, and late winter) with location of capture and year as random effects. Statistical significance for all analyses was inferred if $P \leq 0.05$. Mean 95% UD were plotted by location for visual representation of variation across locations.

To identify habitat use and selection, we plotted all locations of Canada geese (*n* = 39,392) on Google Earth Pro using the rgdall and adehabitatLT packages (Calenge 2006, Bivand 2015). Habitats were classified as green space, riverine, deep-water, industrial urban, or residential using available aerial imagery and ancillary information. Green spaces were typically large parks, cemeteries, and other large grass areas that contained a mixture of ponds, trees and shrubs, large sports fields, and golf courses within their boundaries. We also included small grass lawns and areas between buildings in the green space habitat. Riverine habitat consisted of the Des Plaines and Calumet Rivers. Deep-water habitats were defined as the Chicago Sanitary and Ship Canal, which had steep concrete walls and warm water discharges along the canal corridor, and the Stickney Water Reclamation Plant, which was a mixture of gravel embankments and grass near deep-water settling ponds ($n = 96$). Deep-water habitat remained ice-free throughout the entire winter due to constant moving water within the settling ponds and warm-water discharge and barge traffic within the canal. Industrial urban habitats were defined as rooftops, which were typically large flat industrial buildings and retail stores, and adjacent rail yards composed of large complex series of railroad tracks where railcars were loaded, unloaded, and stored. Residential habitats were typically houses and developments, parking lots, and miscellaneous other land uses occurring in residential areas.

To determine availability of the aforementioned use areas within the GCMA, we used a random number generator to create 500 locations within the study area and then classified each location using the same methods as was used for habitat use locations. We compared habitat use and availability across the entire autumn and winter period for both years and when the temperature dropped below the theoretical lower critical temperature (LCT) for Canada geese (Batt et al. 1992). The LCT is estimated using the resting metabolic rate and is the point where the ambient temperature is below the thermoneutral zone and heat is required to maintain body temperature, typically through metabolizing endogenous reserves. We used the theoretical LCT of -6 ^{0}C for Canada geese as my threshold with knowledge that this is not a discrete threshold and that the LCT varies by individual through a complex interplay of physiological and behavioral adaptations. Additionally, we compared use across the 3 time periods (early, mid-, late winter). We conducted a Chi-squared test to compare proportional habitat use against proportion of availability for years (including all locations and below LCT) and across the time periods setting statistical significance for all analyses at $P < 0.05$ (Campbell 2007, Richardson 2011). Phenology of spring and fall migration dates was determined once a goose either left or entered the GCMA.

To address habitat use and selection, we used the resource selection function (RSF) with an exponential link to estimate w(x), which is the proportion of used locations with characteristics x, divided by the proportion of available locations with characteristics x (McDonlad 2013). When $w(\mathrm{x}) > 1$, the habitat type is selected and Canada geese are not in that location by random chance. When $w(\mathrm{x}) = 1$, presence in a habitat is random, and when $w(\mathrm{x}) < 1$ Canada geese are avoiding these habitat types. We determined habitat use by taking all locations ($n = 39{,}392$) and creating a table of counts of Canada geese in habitat types and we then generated available habitat points (1 per used location) as a random draw, with replacement, from the sample of 500 random habitat locations used to generate habitat availability. This action doubled the dataset providing 78,784 locations used to estimate the RSF *w*(x). We then classified used locations and available locations belonging to the aforementioned 5 different habitat types and assumed that there was no change in urban habitat across years. We expected the relationship between habitat use and snow depth and minimum daily temperature to be curvilinear. Using the RSF, we analyzed habitat use as a function of habitat type (i.e., green space, riverine, deep-water, industrial urban, and residential), time of day (i.e., diurnal or nocturnal), and snow depth (cm). In a separate RSF analysis, we analyzed habitat use as a function of habitat type, time of day, and minimum daily temperature (°C) (Manly et al. 2007, McDonald 2013, Nielson and Sawyer 2013). The diurnal time period was set at 0500–1900 to account for crepuscular movements and the nocturnal time period was 1901–0459. We expected that there would be a threshold in both snow depth and minimum daily temperature so we used a quadratic term. We also expected the effect of snow depth and time of day (i.e., nocturnal or diurnal) to vary in habitat types and that is why we used an interaction term. Covariates of daily snow depth and daily minimum temperature were used because of their correlation with Canada goose activity patterns and weather data were obtained from the weather station at Midway International Airport (Raveling et al. 1972, Weather Underground 2016). We plotted the parameter estimates to make predictions of RSF *w*(x) (relative probability of a Canada goose using a particular habitat) within the range of minimum daily temperatures and snow depth data (Neter et al. 1996). We ran a smoothing factor for the plots to interpolate the predicted RSF *w*(x) between large gaps in snow depth data.

We defined a movement as the distance (m) between subsequent hourly GPS locations. Transmitters used for movement analysis were Generation 3 models that operated with high efficiency (n =27 transmitters, $\bar{x}$ = 20.8 locations/transmitter/day, SE = 0.4, range 15.4–23.3) and obtained locations on average close to the hourly setting ($\bar{x}$ = 70.1 min, SE = 1.3). To analyze movements and classify habitat types, we plotted all locations of Canada geese (n = 35,896) on Google Earth Pro and measured distance moved between hourly locations using the rgdall and adehabitatLT packages (Calenge 2006, Bivand 2015). We removed distance measurements that were not from subsequent hourly locations (i.e., more than two hours between locations). Transitional movements (n = 3,264) between habitat types were also removed to provide data consisting of only movements within habitats for analysis. We conducted a Fisher's exact test to determine if transitional movements were greater between habitat types, both above and below the lower critical temperature (LCT), than by random chance. The LCT is estimated using the resting metabolic rate and is the point where the ambient temperature is below the thermoneutral zone and heat is required to maintain body temperature, typically through metabolizing endogenous reserves. We used the theoretical LCT of -6 ^{0}C for Canada geese, but we acknowledge that this is not a discrete threshold and that the LCT varies by individual through a complex interplay of physiological and behavioral adaptations (Batt et al. 1992). We calculated maximum daily movement distance (m) as the longest distance between subsequent hourly GPS locations for each day. We used a generalized linear model to test for the effects of snow depth, minimum daily temperature, and their interactions on maximum daily movement distance using the glm function in the nlme package (Pinheiro et al. 2016). In a separate generalized linear model, we modeled movement distances as a function of independent variables habitat, snow depth (cm), time of day (i.e., diurnal or nocturnal), LCT (i.e., above or below the LCT), and their interaction. Transformations ($\log_{10}$ [x+1]) were used to normalize movement distance parameters. The diurnal time period was set at 0500–1900 to account for crepuscular movements and the nocturnal time period was 1901–0459. Covariates of daily snow depth and daily minimum temperature were used because of their correlation with Canada goose activity patterns (Raveling et al. 1972). We analyzed movements within habitats and transitional movements to understand possible energy expenditure since increased movements distances require increased energy expenditure (Bowlin et al. 2005, Couturier et al. 2010, Jachowski and Singh 2015). Mean movements above and below the LCT were plotted by hour for visual representation of variation across the day. The non-significant predictor variables and interactions were removed from models by using partial sums of squares until only significant associations remained (Crawley 2005).

To compare daily temperatures among habitat types, we used a general linear model with the lme function in package nlme package (Pinheiro et al. 2016) with mean daily temperature (^{0}C) as my dependent variable and habitat type as an independent variable and ID (data logger) as a random effect. We conducted similar linear mixed effects models for minimum and maximum daily temperature. We used a similar linear model to determine if mean and maximum wind speed (km/h) varied by habitat type with ID (data logger) as a random effect. We removed one location from my wind analysis due to constantly being knocked over and blown off the rooftop (last recorded wind speed that day was 78.9 km/h), which resulted in large gaps (i.e., months) of missing entries in the dataset. We conducted a post hoc Tukey's HSD test for significant results ($\alpha = 0.05$) to simultaneously test for differences in the means (Zar 2010).

Winter survival (*S*) with 95% confidence intervals (CI) was calculated using the Known-Fate model in Program MARK because transmitters provided fine-scale data and status (i.e., alive or dead) of all Canada geese (n = 41) was known (Cooch and White 2016). We assumed that all transmittered Canada geese were mutually exclusive and because of spatial variation in transmitter deployment, I used a staggered entry design with paired entries with "0" in the first position to indicate a Canada goose was not transmittered yet and "1" in the first position for individuals that were transmittered. The second position in the pair was "0" if the Canada goose survived to the end of the interval or "1" if it died sometime during the interval. I broke down time intervals into weeks (n = 15) and then grouped them into the 3 time periods (i.e., early, mid-, late winter). A body condition index (BCI) was developed by regressing the residuals from an ordinary least-squares regression of mass against an index of body size (Devries et al. 2008). The body size index was calculated by running a principal component analysis of all structural morphological measurements (skull, culmen, and tarsus) obtained at capture with the prcomp function in Program R and the first principal component (PC1) was used as the index of body size (Arsnoe et al. 2011). We created 6 models to evaluate the effects of BCI, group (remained in GCMA or migrated from GCMA), and time period on survival and ranked models using Akaike's information criterion adjusted for a small sample size (AIC_c; Burnham and Anderson 2002). I summed model weights (w_i) of top models to determine relative variable importance.

Results

We banded and neck-collared 459 temperate-breeding Canada geese at Marquette Park, Sherman Park, McKinley Park, Brookfield Zoo, and Resurrection Cemetery within the GCMA during July 2014 (Figs. 11–12). Geese were captured by slowly driving flightless birds into holding areas until banding could commence. During winter of 2014–2015, we captured 116 geese using net guns, rocket nets, and cast nets and obtained DNA samples and morphological measurements from each bird. Based on morphological measurements, 78 were temperate- and 38 were subarctic-breeding geese. Of those 116 winter-captured geese, 9 were fitted with transmitters, including 7 temperate- and 2 subarctic-breeding geese. Three transmitters were deployed on 13 November 2015, 1 was deployed on each of 8 and 14 December 2014, and 4 were deployed during 26–28 January 2015. Due to delays in funding appropriations and lead time needed for the manufacturer to produce GSM transmitters, only 9 transmitters were available for deployment during our first field season.

During mid-June and early July 2015, we banded and neck-collared 232 temperate-breeding Canada geese throughout the GCMA. From mid-November–February of 2015–2016 we captured 91 Canada geese within the GCMA using net guns and rocket nets. We placed transmitters on 31 of the Canada geese captured during late autumn and winter. During July 2016, we banded and collared 330 temperate-breeding Canada geese throughout the GCMA. In total, we banded and neck-collared 1,021 Canada geese within the GCMA during summer molt, banded and neck-collared 208 Canada geese during the late autumn and winter, and deployed 41 transmitters (Table 13).

Neither the 50% core use areas ($\bar{x}$ = 0.7 km^2, SE = 0.3) nor the 95% UD ($\bar{x}$ = 24.5 km^2, SE = 5.2) of Canada geese (n = 36) varied by time period. Canada geese selected green space (59.8%), deep-water (15.2%), industrial urban (11.3%), and riverine (8.1%) habitats in greater proportion than their availability. When temperatures were below the LCT, Canada geese increased use of deep-water (+245.6%) and riverine habitats (+158.0%) while decreasing their use of green space (-60.2%). Green space was selected more than any other habitat and used in disproportion to available green space during the early winter time period (80.4%), but selection of green space declined during mid winter (52.2%) and late winter (52.8%). Canada geese increased use of deep-water habitat throughout the time periods from 0.7% in early winter to 41.7% during mid winter and 37.5% in late winter. Similarly, increased use of industrial urban habitats was observed from early winter (6.8%) to mid winter (11.3%) and late winter (14.2%).

Snow depth, minimum daily temperature, time of day, and all interactions ($P < 0.01$) affected habitat use. The resource selection function (RSF) w(x) was above 1 for every habitat type except residential indicating that Canada geese selected green space, industrial urban, riverine, and deep-water habitats, but avoided residential habitats. As snow depth increased the RSF w(x) increased for industrial urban, riverine, and deep-water habitats, while use of green space decreased. Residential habitat had the lowest RSF w(x) that was near "0" across almost all snow depths and minimum daily temperature (^{0}C) ranges. Canada geese selected riverine and deep-water habitats more often during nocturnal than diurnal periods. As minimum daily temperature (^{0}C) decreased, the RSF w(x) increased for riverine and deep-water habitats. Industrial urban habitats had an increase in RSF w(x) as temperature decreased, but then selection peaked and started to decrease towards "1" at -5 ^{0}C. Green space use declined as temperature decreased and approached w(x) = 1 near -20 ^{0}C indicating that use was almost by chance.

Habitats did not differ in daily minimum temperature, but they did have different daily maximum temperature. The maximum daily temperatures were 3.15 ^{0}C (SE = 1.1) and 3.54 ^{0}C (SE = 1.4) warmer at rooftops and deep-water locations respectively than green space. Both rooftop and deep-water habitats had higher maximum daily temperatures for every month when compared to green space, although the difference was greater later in the winter. Both mean daily wind speeds and maximum daily wind speeds varied by habitat. The mean daily wind speeds were 13.6 km/h (SE = 1.1) greater on rooftops than green space and deep-water habitat had mean wind speeds 6.5 km/h (SE = 1.3) greater than green space. Rooftops had mean daily wind speeds of 7.1 km/h (SE = 1.3) greater than deep-water habitats. Maximum daily wind speeds were 22.9 km/h (SE = 2.0) greater at rooftops than green space habitats and deep-water habitats had maximum wind speeds 12.1 km/h (SE = 2.4) greater than green space. The wind speeds on rooftops were 10.7 km/h (SE = 2.4) greater than at deep-water habitats.

Movement distance differed by habitat type, temperature, snow depth, and time of day. Movement distances for Canada geese were shorter when temperature was below the LCT, as snow depth increased geese made shorter movements, and geese made shorter movements during the nocturnal period. Movements by Canada geese within rail yard ($\bar{x}$ = 224.0 m, SE = 13.0) and green space habitats ($\bar{x}$ = 145.6 m, SE = 3.4) were the longest for any habitat type, while movements by geese in deep-water habitats ($\bar{x}$ = 85.7 m, SE = 3) and rooftop habitats ($\bar{x}$ = 52.9 m, SE = 5.5) were the shortest. In general, Canada geese moved 2 to 4 times farther in rail yards and green space than in deep-water and rooftop habitats.

Canada geese were more likely to move between certain habitats and these habitats changed when temperatures were above and below the LCT. When the temperature was below the LCT, the only habitat transition that occurred more often than random was to green spaces from deep-water and vice versa. When the temperature was above the LCT, there were more movements between green space and rail yards than would be expected by chance. The mean movements for all transition flights between habitats was 1554.4 m (SE = 30.4).

The proportion of locations in green space was highest during diurnal hours (i.e., 0500–1900) and overall Canada geese used green space most. Both deep-water and riverine habitats had a spike in proportional use during early morning, but use decreased throughout the day. Proportional use of rail yards increased during early afternoon while use of residential habitat was consistent throughout the day. There were two peaks in movement distances during crepuscular periods (i.e., early morning and late evening), and the timing of these movements also varied depending if the temperature was above or below the LCT. The mean maximum daily movement of individuals across all habitats was 2,009.3 m (SE = 74.6) with the longest movement within the GCMA being 19,998 m.

Winter survival was 100% for Canada geese using the GCMA (*n* = 35) and 48% (95% CI range = 16% to 82%; *n* = 6) for geese that emigrated from the GCMA. Weekly survival for emigrating Canada geese was 95% (95% CI range = 86% to 98%). Time period affected survival for Canada geese that left the GCMA with an estimated weekly survival of 100% for early winter, 85% (95% CI range = 62% to 95%) during the mid winter, and 100% for late winter. We documented three direct mortalities, all from hunting during the mid-winter time period. Mortalities occurred 8 days (range 2–16) after the Canada geese emigrated from the GCMA. Hunting mortalities occurred in northwest Indiana, southwest Illinois, and northwest Tennessee. BCI was related negatively to survival, but confidence intervals overlapped zero indicating no true effect. The top two models for survival analysis ($\sum w_i = 0.9$) included time period. All Canada geese that migrated from the GCMA died during the mid winter time period, a time period that corresponds to the hunting season in the region.

The majority of Canada geese (85%) fitted with transmitters never migrated south from the GCMA. During 2014–2015, only 3 Canada geese left the GCMA. One Canada goose left on 30 November 2014 and 2 left on 4 January 2015. During 2015–2016, only 3 of the 31 Canada geese emigrated from the GCMA to more southern latitudes, 1 left on 30 December 2015 and 2 left on 13 January 2016.

In 2015, Canada geese (*n* = 7) initiated spring migration on 11 March through 16 March 2015, while 2 geese remained in the GCMA for the breeding season. Spring migration initiated earlier in 2016 when Canada geese (*n* = 15) started northward from 20 February through 1 April 2016. Fourteen Canada geese remained within the GCMA during the breeding portion of the annual cycle in 2016. Canada geese showed high site fidelity to the GCMA. All Canada geese with active transmitters from 2014–2015 (*n* = 7) were present within the GCMA during the autumn of 2015. Return flights to the GCMA ranged from May through November in 2015.

Discussion

Canada geese in the GCMA had relatively small core use areas (Rutledge et al. 2015), remained within urban areas and did not make flights to agricultural fields within or outside of the GCMA where they might have been subjected to hunting mortality, high survival and made use of novel habitats within highly urbanized areas such as rooftops, rail yards, water treatment facilities, and warm-water discharges along rivers and the canal. Canada geese in the GCMA tended to have relatively small 50% core use areas, which predominately included green spaces, and 95% UD were similar to the home range estimate of 25 km^2 produced by Groepper et al. (2008). Although agricultural fields were present within and nearby the GCMA Canada geese did not make foraging flights and apparently did not require waste grain in agricultural fields for survival. Possibly Canada geese entered the winter at with abundant fat reserves to minimize the need for feeding flights and instead choose to minimized energy expenditure by remaining within the GCMA throughout winter. For example, male Canada geese were approximately 500 g heavier and females were 700 g heavier than geese captured during winter near Rochester, Minnesota (McLandress and Raveling 1981). Additionally, Canada geese in the GCMA were larger than wintering geese from southern Illinois and east-central Wisconsin (Gates e al. 2001). Moreover, Canada geese increased use of these industrial urban habitats as snow depth increased and temperature decreased suggesting there may be thermal or survival benefits from selecting these areas. While I know of no other published accounts of Canada geese extensively using rooftops and rail yards in winter, I expect they are taking advantage of the relative safety of the urban landscape.

Canada geese used a mix of habitats in the GCMA, including many areas not previously reported as primary habitats (e.g., rooftops, rail yards, wastewater treatment facilities). Large green spaces were selected across all time periods, even when temperatures were below the LCT for Canada geese, and likely provide necessary food and water resources needed by geese even during winter. Although the LCT may have been affected by a complex interplay of physiological and behavioral mechanisms resulting in variation between individuals and habitats, I believe the LCT I selected represented an approximate temperature threshold which could have influenced thermoregulatory costs of Canada geese in the GCMA during winter. During winter weather events when snow depth increased and temperatures decreased, Canada geese reduced their use of green spaces and increased use of industrial urban habitats (i.e., rooftops, rail yards, and the canal). This change may be in response to availability of roost areas and forage within green spaces becoming limited due to ice coverage and increased snow depth. Canada geese may change to novel urban habitats for thermal benefits, sanctuary, food resources. For example during these cold periods, spilled grain may have been available in rail yards. Industrial rooftops may have provided thermoregulatory benefits and sanctuary from disturbances and predators, and deep-water habitat may have provided open water for roost locations. Once temperature increased and snow depth decreased, Canada geese increased proportional use of green spaces. The difference in use of green space between the 2 years may be due to the weather extremes. The winter during 2014–2015 was 2 °C colder and had 32 cm more snow accumulation than an average winter for the GCMA compared to 2015–2016 that was 3 °C warmer with 30 cm less snow than average (NOAA 2015*b*, 2016). Harsh winter conditions during 2014–2015 may have affected the ability of Canada geese to roost on water sources in green spaces and reduced the availability of grass for foraging making geese utilize novel urban habitats at a higher frequency.

High survival of Canada geese in the GCMA relative to other published estimates during autumn and winter suggests that urban habitats provide sanctuary and other resources needed for survival north of historic wintering ranges (Balkcom 2010). Typically, survival rates for Canada geese are lower during winter months at more northern latitudes than I observed within the GCMA (72–98%; Hestbeck and Malecki 1989). Unlike Groepper et al. (2008), a study conducted in another urban landscape, Canada geese that wintered in the GCMA never occupied locations that permitted hunting and all geese had their entire 95% UD within city limits.

The majority of transmittered Canada geese (85%) never migrated south of the GCMA during winter and no geese made daily feeding flights to agricultural fields unlike results reported by Groepper et al. (2008). Canada geese could be shifting their foraging efforts and exploiting different types of available food resources within urban areas, similar in shifts seen by Atlantic brant (*Branta bernicla hrota*; Ladin et al. 2011). The most compelling reason for Canada geese not leaving the GCMA may be the lack of predation risk. Similarly, Balkcom (2010) indicated high seasonal survival (95.8%) in urban areas of Georgia, USA. I suspect that Canada geese are continually adapting to changing climate and landscapes in North America by shifting wintering ranges northward and utilizing nontraditional habitats within urban areas, which provide sanctuary conditions.

Autumn migration of Canada geese returning to the GCMA occurred earlier than other studies in the Midwest (Wege and Raveling 1983). Approximately 50% of Canada geese returned to the GCMA prior to open hunting seasons. Arriving during times when hunting pressure is limited allowed Canada geese to reach urban areas and remain within the city limits during autumn and winter when hunting seasons were open. Canada geese that did migrate from the GCMA during the winter did so during portions of the year when Canada goose hunting seasons were open in Illinois and surrounding states making geese susceptible to predation via hunting, ultimately lowering their survival estimates. Increased hunting pressure outside of urban environments likely creates a strong selection pressure for Canada geese to remain in urban environments, especially when novel urban habitat types may provide necessary resources for survival (Lima and Dill 1990).

Wintering ranges of Canada geese in the Mississippi Flyway have shifted northward and use of urban areas in northern latitudes appears to be a strategy for increasing survival. There might be a strong selection pressure on migratory Canada geese to winter at more northerly latitudes to minimize spring migration flight distances resulting in minimized energy expenditure and arrival to nesting grounds at a more opportune time to secure preferred nest sites (Alerstam and Lindstrom 1990). Canada geese appear to be utilizing a new strategy to winter at these northern clines through the use of nontraditional habitats occurring within urban areas (Chapter 1). During the autumn and winter 2014–2016, 66.7% of transmittered geese used novel urban habitats (rooftops and rail yards) and the ability of Canada geese to use these nontraditional habitats in urban areas likely allows them to maintain a positive energy balance and may even increase survival. The ability of Canada geese to survive in these urban landscapes appears due to the ability to find potentially warmer habitats where costs of thermoregulation are within tolerable ranges, locate food sources (e.g., grass in green spaces, spilled grain in rail yards), and use disturbance free areas for loafing (e.g., rooftops).

There appear to be limited thermal benefits for selected habitats; we found no difference in daily low temperatures between habitats used by Canada geese, but data are limited to only sites that are being used by Canada geese. The maximum daily temperature was greater on rooftops and at deep-water habitats, but these habitats also had the greatest amount of wind. Green space had the lowest wind speed for all habitat types due to trees and buildings acting as wind blocks. Canada geese moved to deep-water habitats when temperatures were below the LCT, but given how the low temperatures in the green spaces were nearly the same as the deep-water habitats the thermal benefits of rooftops and deep-water habitats is likely limited. Shifts in habitat use may also be link to decreased open water in green spaces as ice coverage forces Canada geese to find alternative roost locations. The warmer temperatures on rooftops are likely the result of solar radiation as nearly all the rooftops used by Canada geese were black. Black rooftops and deep-water habitats absorbing solar radiation during the day would account for the warmer maximum temperatures, but no difference in the low temperatures at night.

Management of Canada geese in urban areas should focus on harassment during extreme winter weather conditions to reduce the risk of goose-aircraft collisions. Canada geese can mitigate the extreme weather events by taking advantage of novel urban habitats at the northern edge of their wintering range and increase survival. We suspect that Canada geese wintering in northern locations, such as the GCMA, are pushing their thermoregulatory limits, especially during harsh winter conditions. While no transmittered Canada geese died during the study within the GCMA, we found several goose carcasses on rooftops after extreme weather conditions. Harassment of Canada geese at these nontraditional habitats during cold periods may "push" geese to the point where they have to choose to either migrate out of the area, to locations where hunting is permissible, or potentially risk death due to increased energy demands and exposure to the elements. Currently much of the harassment and management of Canada geese within the GCMA is focused on the breeding season (Smith et al. 1999, Scribner et al. 2003), and we suggest there is an opportunity to effectively manage geese in urban areas in winter. Additional research is needed to better understand response of Canada geese to harassment in urban areas and understand thermoregulatory balance in these areas.

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Table 13. Morphological measurements and subspecies classification using culmen length classification method provided by Moser et al. (1991) of Canada geese (*Branta canadensis; n* = 41) captured and fitted with transmitters in the Greater Chicago Metropolitan, Illinois, USA, during autumn and winter 2014–2016. Female *B.c. interior* culmen < 53 mm, Female *B.c. maxima* culmen < 56.8 mm, male *B.c. interior* > 53 mm, male *B.c. maxima* > 56.8 mm.

ID	Sex	Skull (mm)	Culmen(mm)	Tarsus(mm)	Mass (kg)	Classification
00D	M	136.0	61.5	112.1	6.0	*B.c. maxima*
01D	F	121.2	54.9	108.4	4.2	*B.c. maxima*
02D	F	121.2	50.7	98.7	4.0	*B.c. interior*
03D	M	130.0	57.4	110.8	4.5	*B.c. maxima*
57R	F	129.4	59.3	105.9	4.8	*B.c. maxima*
58R	M	135.2	57.7	125.9	5.9	*B.c. maxima*
59R	F	125.9	54.0	112.9	5.1	*B.c. maxima*
60R	M	125.8	53.2	120.9	5.1	*B.c. interior*
61R	F	130.2	57.7	117.8	4.3	*B.c. maxima*
62R	F	119.8	53.4	103.9	3.3	*B.c. maxima*
63R	F	128.4	57.4	109.8	4.2	*B.c. maxima*
64R	F	126.0	56.6	110.7	4.2	*B.c. maxima*
65R	M	109.9	43.4	101.2	3.7	*B.c. interior*
66R	M	131.9	59.8	110.2	5.0	*B.c. maxima*
67R	F	125.3	55.5	108.8	3.9	*B.c. maxima*
68R	F	117.3	51.1	107.8	3.7	*B.c. interior*
69R	M	127.5	55.6	112.8	3.9	*B.c. interior*
70R	M	129.1	60.4	108.9	4.6	*B.c. maxima*
71R	M	136.9	65.2	122.2	5.1	*B.c. maxima*
72C	F	115.8	51.9	100.2	4.1	*B.c. interior*
72R	M	131.1	60.3	111.8	5.0	*B.c. maxima*
73C	M	130.9	58.1	110.5	5.3	*B.c. maxima*
73R	M	137.4	63	122.1	4.7	*B.c. maxima*
74C	F	121.5	55.5	106.8	4.3	*B.c. maxima*
76C	M	130.9	59.8	105.1	5.3	*B.c. maxima*
76R	F	134.2	64.4	120.8	5.7	*B.c. maxima*
78C	F	108.3	43.4	99.4	3.8	*B.c. interior*
83C	F	129.1	56.5	110.9	4.5	*B.c. maxima*
84C	M	127.2	54.6	107.8	5.0	*B.c. maxima*

Table 13. Continued.

ID	Sex	Skull (mm)	Culmen(mm)	Tarsus(mm)	Mass (kg)	Classification
85C	M	132.8	58.3	118.5	5.5	*B.c. maxima*
86C	M	139.5	66.2	120.8	5.1	*B.c. maxima*
87C	M	121.9	53.8	109.0	4.7	*B.c. interior*
88C	F	117.8	50.9	99.2	4.2	*B.c. interior*
89C	M	132.7	59.8	117.4	5.2	*B.c. maxima*
90C	M	135.0	63.8	121.1	5.0	*B.c. maxima*
91C	F	122.7	54.7	105.8	5.1	*B.c. maxima*
95C	M	133.7	57.2	118.8	5.5	*B.c. maxima*
96C	F	129.2	58.2	116.5	5.6	*B.c. maxima*
97C	F	122.0	54.7	106.0	4.2	*B.c. maxima*
98C	M	139.7	62.5	120.0	5.0	*B.c. maxima*
99C	F	131.5	59.9	117.1	5.0	*B.c. maxima*

Figure 11. The Greater Chicago Metropolitan Area located in northeast Illinois, USA.

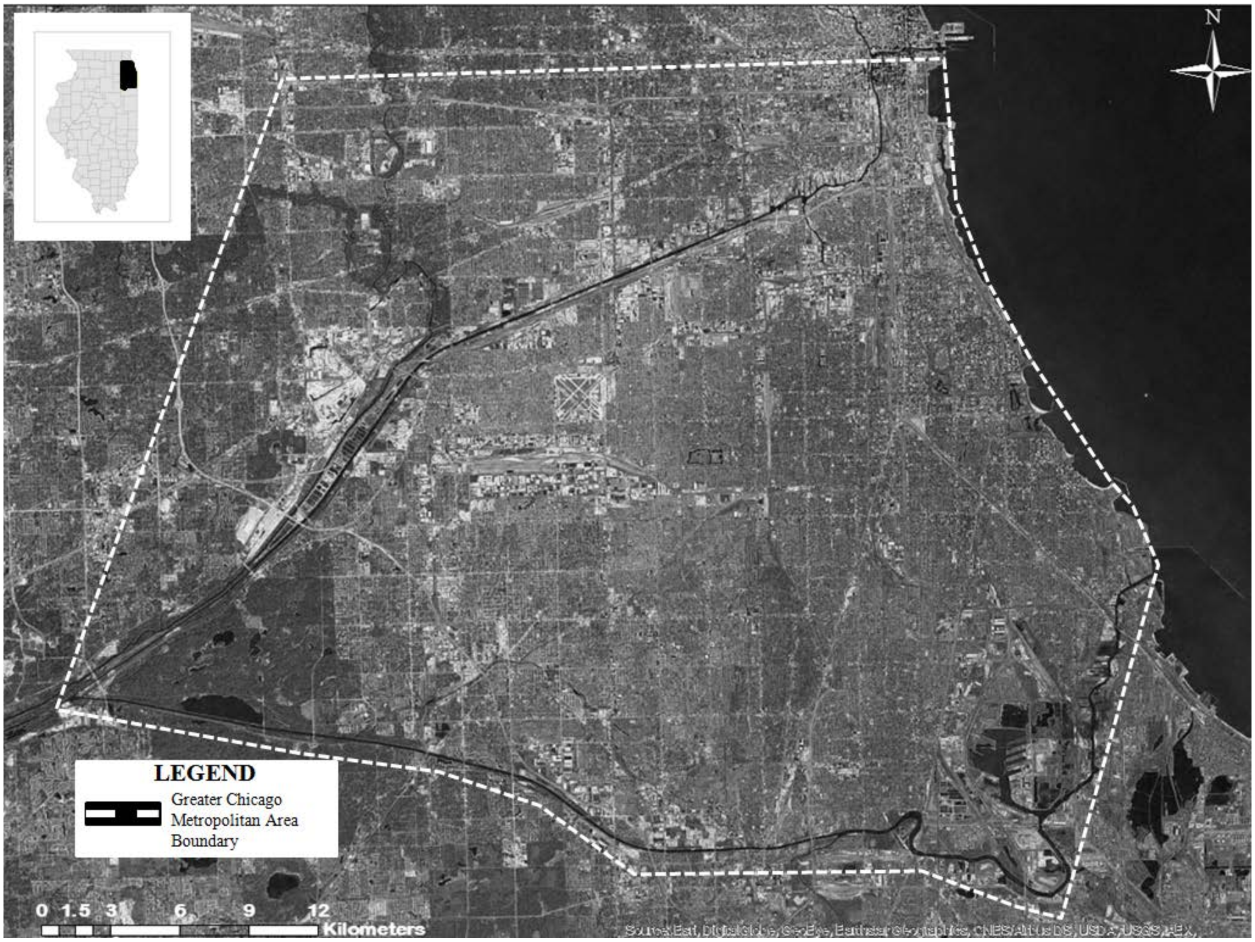

Figure 12. Main capture locations (n = 7) for Canada geese (*Branta canadensis*) in relation to Midway International Airport in the Greater Chicago Metropolitan Area, Illinois, USA.

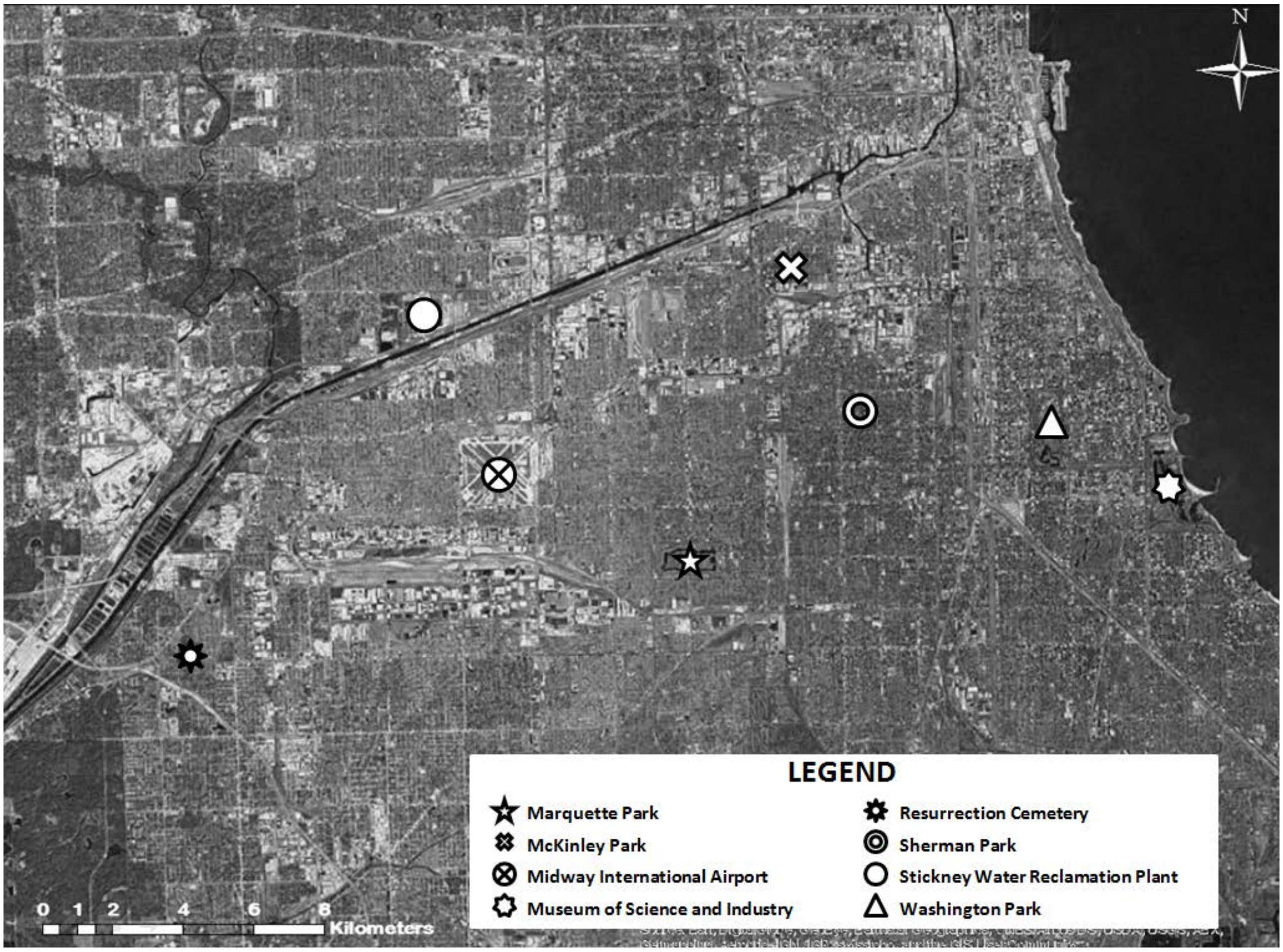

Figure 13. Canada geese foraging on agricultural waste at a rail yard in the Greater Chicago Metropolitan Area, Illinois, USA during the winter of 2014–2015.

Figure 14. Canada geese loafing on a rooftop in the Greater Chicago Metropolitan Area, Illinois, USA during the winter of 2014–2015.

STUDY 129: HABITAT QUALITY FOR WETLAND BIRDS IN ILLINOIS

Objectives: 1) Estimate habitat quality of a minimum of 100 wetland and deepwater polygons during spring, summer, and autumn for focal wetland wildlife guilds of the Illinois Wetlands Campaign.

2) Develop a model to predict wetland quality for focal species of the Illinois Wetlands Campaign relative to wetland and landscape characteristics.

Introduction

Although wetland quality has declined over the last 200 years due to a variety of anthropogenic influences, the rate and extent of that decline is unknown (Mitsch and Gosselink 2000). Data are needed to both better describe the current level of function of extant wetlands as well as establish baseline data for estimating rate of wetland degradation in the state of Illinois relative to habitat needs for wetland-dependent wildlife. Currently, National Wetland Inventory (NWI) data provide the most comprehensive source of information that can be used to quantify wetland availability and habitat suitability for wetland wildlife. However, wildlife often require surface hydrology within specific depth ranges and at specific times of the year for wetlands to provide functional habitat. Unfortunately, NWI data does not include descriptions of water depth or seasonality of surface hydrology. Thus, NWI wetland estimates likely overestimate and amount of wetland and deepwater habitat available to wetland wildlife, especially during spring and autumn migrations.

Moreover, current wetland availability estimates in Illinois are not corrected for wetlands which have suitable hydrology and may not provide habitat of sufficient quality to be useful to many species of wetland wildlife (e.g., power plant cooling lakes, borrow pits along interstates, ponds in urban developments, etc.). A major assumption of many habitat conservation plans is that foraging habitat is most limiting during spring and autumn migration in non-breeding regions such as Illinois (e.g., Soulliere et al. 2007). Aquatic habitats with extensive disturbance or those lacking aquatic vegetation likely provide little value as foraging habitats (Stafford et al. 2010, Hagy et al. 2015) and information to describe the actual availability of wetland habitat or suitable quality for migrating wetland bird species in Illinois is lacking.

We assessed the functional quantity (i.e., relative value to focal species of the wetland area actually inundated by water to the appropriate depths) of wetlands currently assumed to be available to waterbirds and other wetland-dependent organisms during spring, summer, and autumn in Illinois. This information can then be used to develop fine-scale wetland conservation objectives for wetland-dependent organisms at different times of the year. Moreover, an index of wetland quality can be used to estimate values (e.g., foraging habitat quality, breeding habitat quality, etc.), risk of conversion to other types or drainage, and habitat availability relative to specific taxa. Understanding the current status of average wetland quality and the rate of change in wetland quality is critical for appropriate planning objectives. This study will provide estimates of current functional quality of wetlands allowing a more precise development of wetland enhancement and restoration implementation objectives.

Methods

We stratified Illinois by natural division and allocated survey effort in proportion to wetland density within natural divisions. We consolidated NWI polygons into 6 classes (Freshwater Pond, Lake, Freshwater Emergent [herbaceous only], Freshwater Scrub-Shrub/Forested, Riverine, and Other; Table 13) based on our focal species guilds in 3 different seasons (spring [1 March – 15 April] – migrating waterfowl, summer [15 May – 30 June] – breeding marsh birds, and autumn [25 July – 10 September] – migrating shorebirds). We determined our maximum sampling effort (i.e., ~50 sites/season ground) given temporal and monetary constraints and used total wetland area to determine the number of sample plots in each in each natural division with Neyman allocation. We then used the Reversed Randomized Quadrant-Recursive Raster tool in ArcMap to assign plot locations within wetland area inside each natural division, which created a more spatially-balanced sample population than simple random allocation. We also generated a second set of 80 plots using the same methodology which served as a backup sample population if a primary plot could not be sampled. We established 1/4-km^2 plots as sample units and obtained aerial photographs of each during the three seasons concurrent with ground surveys. We selected approximately 50 1/4-km^2 plots and conducted intensive ground surveys on a random ¼ of each plot (i.e., subplot; Fig. 15,16). Conducting ground surveys on all 1/4-km^2 plots was not feasible due to temporal limitations and issues obtaining landowner permission. During 2015, aerial photographs were obtained from 2,000–4,500 ft above ground level for later digitizing of inundation boundaries and habitat classification for comparison with ground surveys to see if blind-digitizing methods could be used to increase sample sizes of plots.

Our ground surveys included the Grand Prairie, Northeastern Morainal, and Middle Mississippi River Borders natural divisions; the Rock River Hill Country and the Wisconsin Driftless divisions; the Illinois / Mississippi River Sand Areas; Major Water Bodies; and the Upper Mississippi / Illinois River Bottomlands natural division (Fig. 15, 16). During aerial surveys in spring, an observer identified and enumerated waterfowl and other waterbirds as possible by making one or more low-altitude passes over each wetland within each plot in a low-winged aircraft at speeds of approximately 240 kph (Havera 1999). We also recorded bird abundances through flush counts during ground surveys for comparison with aerial surveys. During ground surveys of subplots, observers traveled along surface inundation boundaries within or around each polygon, marked water boundaries using GPS units, and recorded surface water coverage as a percentage of each polygon using visual estimation (Fig. 15). For each NWI polygon within each subplot, observers also recorded proportion of inundated area <45 cm deep, cover of dense emergent vegetation, cover of herbaceous vegetation (e.g., moist-soil vegetation), cover of submersed and floating-leaved aquatic vegetation, and other habitat characteristics. Observers estimated the proportion of each polygon containing mudflats and under various management practices (e.g., mowing, burned, planted in food plots). Within each subplot and for each polygon, observers noted hydrological characteristics, evidence of wetland management activities, and possible wetland stressors (e.g., levees, invasive species, drainage ditches, etc.). We assessed wetland vegetation community composition and condition using a modified version of the Environmental Protection Agency's National Wetland Condition Assessment rapid assessment method (USA-RAM; Gray et al. 2012). The USA-RAM procedure uses potential stressors as indicators of wetland condition that are consistent with current EPA methods, yet inclusive of metrics indicative of wetland quality for focal wildlife species under a wide variety of modified conditions (e.g., impoundment management of hydrology).

Wetland characteristics, such as emergent vegetation type and height, can influence animal occupancy rates of wetland complexes, but associations with intrinsic and extrinsic factors are highly variable in the Midwest, perhaps because habitat is limited (Bolenbaugh et al. 2011). Thus, we considered both intrinsic and extrinsic wetland characteristics as influencing wetland quality and bird use. As intrinsic vegetation characteristics may be less important than wetland surroundings (DeLuca et al. 2004) and size (Brown and Dinsmore 1986) in site occupancy of some species (e.g., waterbirds), we used ArcMap and available imagery and land use shapefiles (e.g., Landsat 8) to characterize the landscape around each wetland. We will evaluate parameters such as wetland isolation, surrounding buffer, proximity to developed areas, and other factors using available spatial data (e.g., Landsat) or head's-up digitizing. After multiple years of data are collected and analyzed, we will model factors affecting wetland quality and occupancy by focal species.

Results and Discussion

2015

During 2015, we counted 3,709 waterbirds during the spring survey season, 747 during the summer survey season, and 1,783 in the fall survey season. During spring aerial surveys, mallards (*Anas platyrhynchos*) were the most common duck encountered and were present at 40% of plots. Canada geese (*Branta canadensis*) were the most frequently observed goose species and occurred at 28% of plots. In total, 21 species of waterbirds and waterfowl were observed during spring aerial surveys, but 35% of sites had no birds present during aerial counts. The abundance of waterfowl was highest in the spring survey season (3,194 individuals). Marsh birds were recorded in relatively high numbers in spring (181 individuals), but only 5 marsh birds were recorded in the summer survey season. We rarely observed or heard marsh birds at plots during our summer sampling, likely because few plots contained significant areas of emergent vegetation and surveys occurred after most species migrated through Illinois. This result prompted us to shift the summer sampling season, aimed at marsh birds, towards the migration and early breeding period during 2016, a more biologically important time for the marsh birds (e.g., April and May) and when vocalizations may be more likely. In the future, waterbird occupancy will be modeled as a function of habitat quality and other wetland metrics important to marsh birds.

During 2015, emergent polygon inundation rates exceed 60% during spring and summer but were around 40% during autumn. Inundation rates were greatest during summer (42%) in forested polygons, but similar and low overall during spring and autumn (33%). Shallow inundation was <44% of polygons in all sampling periods and polygon types as was the proportion of inundated dense emergent vegetation (<16%) and non-persistent emergent vegetation (<36%). Mudflats comprised a small proportion of all habitat types during autumn (<4%; Table 14).

We conducted a digitization experiment in which field personnel blindly digitized habitat boundaries which were surveyed by a different individual on the ground. We found our aerial digitizing accuracy was less than acceptable rates (4–11% mean error) and that assignment of incorrect cover types occurred frequently. We do not plan on utilizing aerial imagery without ground truthing to increase samples sizes in the future.

2016

Fifty-five wetland plots were visited during mid-February – mid-March 2016 by INHS and 57 sites were visited by SIU (Table 15). Data were collected in the field using Juniper System Archer Units (Version 1 and 2) with GPS capabilities rather than the GPS's that were used in the first year of the project. The Archer Units offered enhanced data collection capabilities (e.g., collecting electronic data, taking photographs) and they increased the ease and decreased the time needed for later wetland site digitization.

During spring 2016, 3,735 waterbirds were counted during aerial surveys, including 1,355 dabbling ducks, 930 diving ducks, 394 geese, 394 herons and egrets, and 662 American coots and other waterbirds. No waterbirds were detected in 58% of plots. Once waterbirds were detected, they were placed accordingly into one of the NWI-classes (Emergent, Forested, etc.) based upon what sort of habitat they were located in (e.g., in a river, or in a forested wetland). However, further data quality assurance is needed before data will be analyzed further (e.g., must be checked against actual NWI class at each site) and additional results will be presented in subsequent reports.

During the summer season, we replaced approximately 50% of plots dominated by forested polygons randomly with plots containing predominately emergent wetland polygons, as classified by NWI, to better encompass potential habitat for migrating and breeding marsh birds, our focal guild during this sampling season. Wetland surveys were completed during mid-April through mid-June. A total of 61 wetland sites were surveyed by INHS and 65 by SIU (Table 15). Marsh bird call-back surveys were conducted at sites at 30 sites with flooded dense persistent emergent vegetation (e.g., *Typha* spp.). We detected 98 sora (*Porzana Carolina*), 63 American coot (*Fulica Americana*), 13 Virginia rail (*Rallus limicola*), 7 pied-billed grebe (*Podilymbus podiceps),* and 2 American bittern (*Botaurus lentiginosus*) in survey plots. Additional analyses will be reported in future reports following completion of our 2016 field season.

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Table 13. Wetland types used in analyses. For more information, see the National Wetland Inventory Wetland Mapper (http://www.fws.gov/wetlands/data/Mapper-Wetlands-Legend.html).

Wetland Type[1]	NWI Map Code	Cowardin System and Class	General Description
Freshwater Forested and Shrub-shrub	PFO, PSS	Palustrine forested and/or Palustrine shrub	Forested swamp or wetland shrub bog or other wetland with 30% woody vegetation cover > 1 m in height
Freshwater Emergent	PEM	Palustrine emergent	Herbaceous march, fen, swale and wet meadow, non-woody
Freshwater Pond	PUB, PAB	Palustrine unconsolidated bottom, Palustrine aquatic bed	Pond, small wetland with open water or aquatic bed vegetation only
Riverine	R	Riverine wetland and deepwater	River or stream channel
Lake	L	Lacustrine wetland and deepwater	Lake or reservoir basin
Other Freshwater Wetland	Misc. types	Palustrine wetland	Farmed wetland, ditches, saline seep and other miscellaneous wetland

[1] Estuarine and marine wetlands omitted

Table 14. Mean percent (± standard deviation) of polygons (n) during each sampling season inundated by surface water, inundated by surface water to a depth of less than 45 cm which is the maximum foraging depth for dabbling ducks, inundated by surface water to a depth less than 8 cm which is the maximum foraging depth for most shorebirds, emergent vegetation within standing water, submersed- and floating leaf aquatic vegetation, and other characteristics of polygons occurring in 1/4-km^2 plots throughout central and western Illinois during 2015.

Season	NWI Polygon Type	n	Inundated	Inundated <45cm	Inundated <8cm	Dense Emergent Vegetation	Non-persistent Emergent Vegetation	Mudflats
Spring	Emergent (herbaceous)	36	62.08±42	36.83±38		7.27±16	35.67±37	
	Forested/Scrub-shrub	68	33.51±36	12.18±20		0.66±3	1.34±4	
	Lake	27	99.07±3	24.04±33		1.15±3	1.11±3	
	Pond	19	96.68±9	25.38±33		0.74±2	1.93±3	
	Riverine	35	99.54±2	29.46±32		0	0.29±1	
	Other	4	47.00±37	87.50±40		0	0	
	Total	189	67.19	23.61		1.86	7.67	
Summer	Emergent (herbaceous)	38	68.71±36	44.48±36		16.01±29	21.78±37	
	Forested/Scrub-shrub	74	41.96±37	27.35±28		0.45±2	3.92±19	
	Lake	29	89.48±26	22.45±25		2.95±7	6.04±12	
	Pond	26	85.96±27	27.23±29		4.81±17	8.90±24	
	Riverine	30	87.83±24	21.95±28		0.19±1	5.04±7	
	Total	197	67.08	29.18		4.33	8.47	
Autumn	Emergent (herbaceous)	53	43.62±36		12.90±16			2.49±6
	Forested/Scrub-shrub	101	33.12±30		9.78±14			3.26±6
	Lake	45	88.89±15		8.19±15			1.03±3
	Pond	28	83.75±23		9.34±11			0.79±2
	Riverine	30	76.97±31		7.27±10			2.51±6
	Total	257	55.68		9.81			2.35

Table 15. Number and type of polygons and total number of plots sampled by personnel from the Illinois Natural History Survey (INHS), Southern Illinois University (SIU), and overall occurring 1/4-km^2 plots throughout Illinois during spring, summer, and autumn (results not yet available) 2016.

Season	NWI (Class)	Overall	INHS	SIU
Spring	Emergent	56	27	29
	Forested	100	49	51
	Lake	41	28	13
	Riverine	33	22	11
	Pond	23	12	11
	New	20	10	10
	Other	0	0	0
	Total Plots	112	55	57
Summer	Emergent	75	27	29
	Forested	109	51	68
	Lake	39	26	13
	Riverine	28	20	8
	Pond	33	13	20
	New	21	10	11
	Other	1	1	0
	Total Plots	126	61	65
Autumn	Emergent	--	--	--
	Forested	--	--	--
	Lake	--	--	--
	Riverine	--	--	--
	Pond	--	--	--
	New	--	--	--
	Other	--	--	--
	Total Plots	--	--	--

Figure 15. 1-km^2 plot with the sampled ¼-km^2 subplot during ground surveys in 2015 (blue outline) with wetland polygons as determined by the National Wetland Inventory.

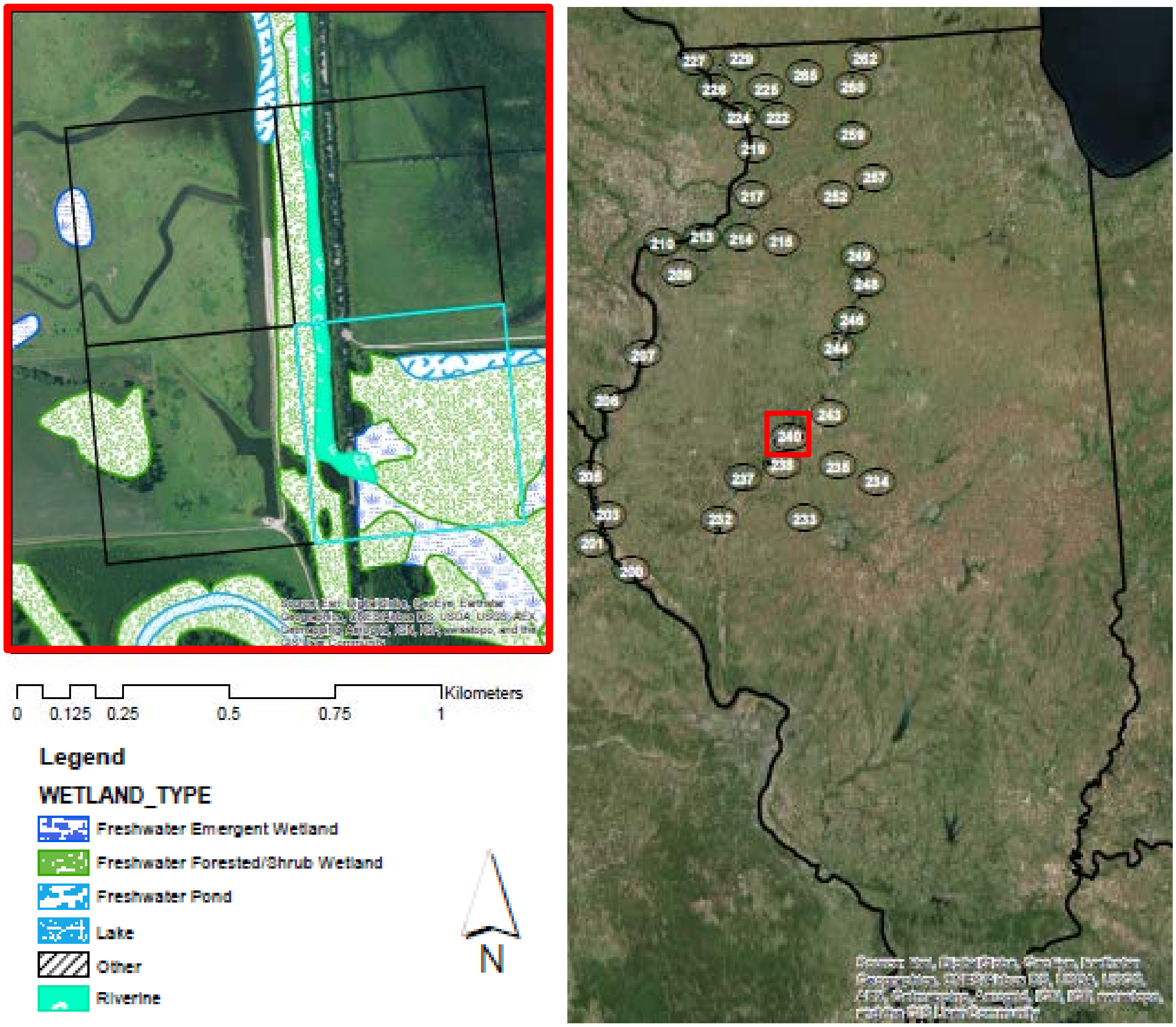
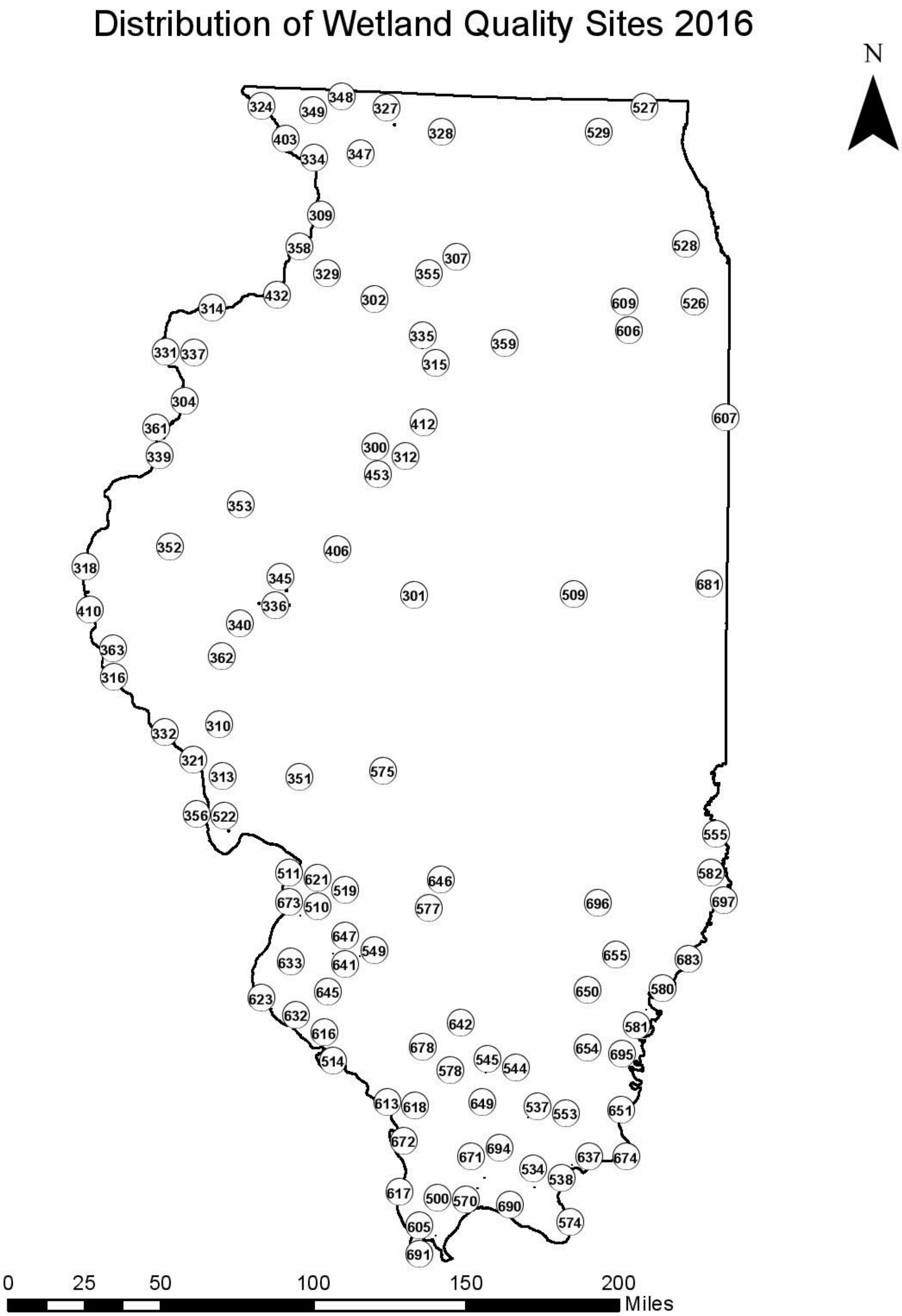


Figure 16. Sample plot locations during 2016 throughout Illinois.



Acknowledgements

Project W-43-R-63 was supported by the Federal Aid in Wildlife Restoration Act (Pittman-Robertson), with funds administered by the U.S. Fish and Wildlife Service (USFWS) and the Illinois Department of Natural Resources (IDNR). Mike Cruce of Cruce Aviation provided aerial survey support for this project. The Nature Conservancy (TNC), USFWS, IDNR, and many private landowners allowed access to their properties. Randy Smith, Mark Alessi, Dan Holm, and Roy Domazlicky (IDNR) advised the project.

Disclaimer

Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of TNC, USFWS, Illinois DNR, or other organizations that supported this research.

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Appendix 1. 2015 Fall Waterfowl Inventories of the Upper and Lower Divisions of the Illinois and Central Mississippi Rivers by Date and Location

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 08/31/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Hennepin/Hopper	95	0	0	0	0	250	0	0	0	185	0	0	0	0	0	0	0	0	0	435	0	0	0	0	500
Goose Lake	70	0	105	0	100	500	50	0	0	0	0	0	0	0	0	0	0	0	0	755	0	0	0	1,450	0
Senachwine Lake	95	0	200	0	0	500	200	0	0	50	0	0	0	0	0	0	0	0	0	950	20	0	0	1,800	0
Hitchcock Slough	70	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Douglas Lake	30	0	30	0	0	400	1,300	0	0	200	0	0	0	0	0	0	0	0	0	1,930	125	0	0	0	0
Goose Lake	95	0	70	0	10	100	10	0	0	60	0	0	0	0	0	0	0	0	0	250	300	0	0	500	0
Upper Peoria	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0
TOTAL UPPER			405	0	110	1,770	1,560	0	0	495	0	0	0	0	0	0	0	0	0	4,340	455	0	0	3,750	500
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0
Rice Lake	90	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0
Big Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0
Banner Marsh	90	0	20	0	5	30	0	0	0	5	0	0	0	0	0	0	0	0	0	60	15	0	0	0	0
Duck Creek	100	0	5	0	0	10	0	0	0	5	0	0	0	0	0	0	0	0	0	20	5	0	0	0	0
Clear Lake	80	0	50	0	10	3,000	0	0	0	10	0	0	0	0	0	0	0	0	0	3,070	0	0	0	4,850	0
Chautauqua	80	0	165	0	620	8,800	1,250	0	0	800	0	0	0	0	0	0	0	0	0	11,635	225	0	0	500	0
Emiquon/Spoon Btm	80	0	1,160	0	2,100	4,435	1,325	0	0	1,700	0	0	0	0	0	0	0	0	0	10,720	150	0	0	120	3,660
Grass Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stewart Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0
Crane Lake	90	0	25	0	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0	425	0	0	0	0	0
Cuba Island	60	0	25	0	10	600	200	0	0	150	0	0	0	0	0	0	0	0	0	985	300	0	0	0	0
Big Lake	25	0	10	0	0	265	0	0	0	100	0	0	0	0	0	0	0	0	0	375	50	0	0	4,000	0
Spunky Bottoms	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meredosia Lake	60	0	15	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	265	0	0	0	0	0
TOTAL LOWER			1,480	0	2,745	17,790	2,775	0	0	2,770	0	0	0	0	0	0	0	0	0	27,560	835	0	0	9,520	3,660
TOTAL ILLINOIS			1,885	0	2,855	19,560	4,335	0	0	3,265	0	0	0	0	0	0	0	0	0	31,900	1,290	0	0	13,270	4,160
10-Year Average 2005-2014			2,168	0	1,906	17,546	4,737	0	6	1,991	0	0	0	0	0	0	0	0	0	28,354	820	0	0	10,612	626

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 08/31/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	50	0
Arthur Refuge	90	0	100	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	200	120	0	0	110	0
Nauvoo-Ft. Madison	90	0	10	0	0	3,500	200	0	0	100	0	0	0	0	0	0	0	0	0	3,810	300	0	0	170	0
Ft. Madison-Dallas	90	0	0	0	0	25	0	0	0	5	0	0	0	0	0	0	0	0	0	30	10	0	0	60	0
Henderson Creek	75	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0	0	0
Keithsburg Refuge	80	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	100	0	0	1,440	0
Louisa Refuge	40	0	10	0	0	650	0	0	0	100	0	0	0	0	0	0	0	0	0	760	100	0	0	1,400	0
TOTAL UPPER			280	0	0	4,275	200	0	0	205	0	0	0	0	0	0	0	0	0	4,960	705	0	0	3,230	0

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Swan Lake	70	0	0	0	0	2,130	300	0	0	100	0	0	0	0	0	0	0	0	0	2,530	500	0	0	3,660	0
Gilbert Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Long Lake	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Dardenne Club	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuivre Club	10	0	0	0	0	100	0	0	0	10	0	0	0	0	0	0	0	0	0	110	0	0	0	0	0
Batchtown Refuge	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cannon Refuge	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Towhead Lake	60	0	0	0	0	400	0	0	0	50	0	0	0	0	0	0	0	0	0	450	0	0	0	0	0
Delair Refuge	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shanks Refuge	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Meyer-Keokuk	100	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	120	0	0	0	0
TOTAL LOWER			5	0	0	2,630	300	0	0	160	0	0	0	0	0	0	0	0	0	3,095	625	0	0	3,665	0
TOTAL MISSISSIPPI			285	0	0	6,905	500	0	0	365	0	0	0	0	0	0	0	0	0	8,055	1,330	0	0	6,895	0
10-Year Average 2005-2014			442	0	97	3,848	763	0	0	121	0	0	0	0	0	0	0	0	0	5,272	609	0	0	3,590	11

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 09/09/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Hennepin/Hopper	100	0	10	0	100	450	50	0	0	300	0	0	0	0	0	0	0	0	0	910	140	0	0	10	1,100
Goose Lake	70	0	0	0	1,000	4,010	1,000	0	0	130	0	0	0	0	0	0	0	0	0	6,140	100	0	0	50	0
Senachwine Lake	95	0	0	0	0	115	0	0	0	100	0	0	0	0	0	0	0	0	0	215	0	0	0	3,600	0
Hitchcock Slough	70	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0
Douglas Lake	30	0	200	0	300	3,900	600	50	0	300	0	0	0	0	0	0	0	0	0	5,350	250	0	0	650	0
Goose Lake	95	0	110	0	300	100	0	0	0	80	0	0	0	0	0	0	0	0	0	590	200	0	0	2,700	0
Upper Peoria	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0
TOTAL UPPER			320	0	1,700	8,675	1,650	50	0	910	0	0	0	0	0	0	0	0	0	13,305	725	0	0	7,010	1,100
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	325	0
Rice Lake	90	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	2,000	0
Big Lake	90	0	0	0	0	55	0	0	0	0	0	0	0	0	0	0	0	0	0	55	20	0	0	400	0
Banner Marsh	90	0	15	0	0	275	0	0	200	0	0	0	0	0	0	0	0	0	0	490	310	0	0	0	0
Duck Creek	100	0	10	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0
Clear Lake	80	0	115	0	300	3,230	500	0	0	250	0	0	0	0	0	0	0	0	0	4,395	100	0	0	1,300	0
Chautauqua	50	0	200	0	1,100	18,000	5,000	0	0	2,000	0	0	0	0	0	0	0	0	0	26,300	25	0	0	1,600	0
Emiquon/Spoon Btm	80	0	2,285	0	2,210	11,080	4,360	20	235	1,680	0	0	0	0	0	0	0	0	0	21,870	235	0	5	400	5,900
Grass Lake	100	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stewart Lake	90	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	50	0	0	0	3,750	0
Crane Lake	80	0	50	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0	850	120	0	0	100	0
Cuba Island	60	0	50	0	0	5,400	900	0	0	200	0	0	0	0	0	0	0	0	0	6,550	325	0	0	0	0
Big Lake	25	0	50	0	100	1,150	250	0	0	400	0	0	0	0	0	0	0	0	0	1,950	0	0	0	2,105	0
Spunky Bottoms	10	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	500	0
Meredosia Lake	60	0	30	0	100	710	200	0	0	300	0	0	0	0	0	0	0	0	0	1,340	5	0	0	500	10
TOTAL LOWER			2,805	0	3,810	40,730	11,210	20	455	4,880	0	0	0	0	0	0	0	0	0	63,910	1,140	0	5	12,980	5,910
TOTAL ILLINOIS			3,125	0	5,510	49,405	12,860	70	455	5,790	0	0	0	0	0	0	0	0	0	77,215	1,865	0	5	19,990	7,010
10-Year Average 2005-2014			3,192	0	2,699	17,859	7,744	11	506	2,277	0	0	0	0	0	0	0	0	0	34,287	871	0	0	13,176	2,869

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 09/09/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	30	20	0	0	30	50
Arthur Refuge	80	0	30	0	50	800	200	0	0	50	0	0	0	0	0	0	0	0	0	1,130	290	0	0	275	0
Nauvoo-Ft. Madison	100	0	0	0	0	2,000	0	0	0	305	0	0	0	0	0	0	0	0	0	2,305	355	0	0	375	0
Ft. Madison-Dallas	100	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	25	80	0	0	20	0
Henderson Creek	80	0	120	0	0	100	0	0	0	25	0	0	0	0	0	0	0	0	0	245	415	0	0	215	0
Keithsburg Refuge	80	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	50	75	0	0	560	0
Louisa Refuge	40	0	65	0	0	1,850	200	0	0	20	0	0	0	0	0	0	0	0	0	2,135	200	0	0	125	0
TOTAL UPPER			215	0	50	4,825	400	0	0	400	0	0	0	0	30	0	0	0	0	5,920	1,435	0	0	1,600	50
LOWER MISSISSIPPI RIVER VALLEY																									
Swan Lake	80	0	500	0	500	9,000	1,000	0	0	1,500	0	0	0	0	0	0	0	0	0	12,500	325	0	0	605	0
Gilbert Lake	90	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0
Long Lake	Not surveyed due to rain																								
Dardenne Club	Not surveyed due to rain																								
Cuivre Club	Not surveyed due to rain																								
Batchtown Refuge	40	0	0	0	0	120	0	0	0	0	0	0	0	0	0	0	0	0	0	120	0	0	0	0	0
Cannon Refuge	10	0	25	0	100	610	100	0	0	70	0	0	0	0	0	0	0	0	0	905	0	0	0	0	0
Towhead Lake	60	0	50	0	400	4,000	100	0	0	330	0	0	0	0	0	0	0	0	0	4,880	300	0	0	0	0
Delair Refuge	70	0	0	0	0	150	0	0	0	10	0	0	0	0	0	0	0	0	0	160	0	0	0	0	0
Shanks Refuge	10	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	50	0
Meyer-Keokuk	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	0	0	0	0
TOTAL LOWER			575	0	1,000	14,030	1,200	0	0	1,910	0	0	0	0	0	0	0	0	0	18,715	750	0	0	655	0
TOTAL MISSISSIPPI			790	0	1,050	18,855	1,600	0	0	2,310	0	0	0	0	30	0	0	0	0	24,635	2,185	0	0	2,255	50
10-Year Average 2005-2014			615	0	407	3,776	1,654	8	39	389	0	0	0	0	0	0	0	0	0	6,889	838	0	0	3,726	67

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 09/16/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Hennepin/Hopper	100	0	395	0	590	1,970	2,955	0	0	985	0	0	0	0	0	0	0	0	0	6,895	0	0	0	0	14,050
Goose Lake	70	0	200	0	500	2,000	2,500	0	0	450	0	0	0	0	0	0	0	0	0	5,650	70	0	0	1,400	0
Senachwine Lake	95	0	10	0	250	100	100	0	0	200	0	0	0	0	0	0	0	0	0	660	0	0	0	700	0
Hitchcock Slough	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Douglas Lake	30	0	50	0	200	1,500	1,400	0	0	350	0	0	0	0	0	0	0	0	0	3,500	0	0	0	2,500	0
Goose Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	875	0
Upper Peoria	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	320	0
TOTAL UPPER			655	0	1,540	5,570	6,955	0	0	1,985	0	0	0	0	0	0	0	0	0	16,705	70	0	0	5,795	14,050

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Goose Lake	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300	0
Rice Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,460	0
Big Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	3,000	0
Banner Marsh	90	0	5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	15	75	0	0	30	50
Duck Creek	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0
Clear Lake	80	0	100	0	1,010	2,000	1,100	0	0	1,300	0	0	0	0	0	0	0	0	0	5,510	210	0	0	350	0
Chautauqua	40	0	150	0	400	2,500	6,000	0	0	1,300	0	0	0	0	0	0	0	0	0	10,350	450	0	0	510	0
Emiquon/Spoon Btm	80	0	5,755	0	6,120	2,355	2,855	100	270	3,365	0	0	0	0	0	0	0	0	0	20,820	100	0	0	1,340	23,745
Grass Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stewart Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	450	0
Crane Lake	80	0	50	0	0	200	200	0	0	150	0	0	0	0	0	0	0	0	0	600	30	0	0	1,750	0
Cuba Island	60	0	50	0	0	250	0	0	0	30	0	0	0	0	0	0	0	0	0	330	590	0	0	400	0
Big Lake	30	0	100	0	20	310	120	0	0	50	0	0	0	0	0	0	0	0	0	600	50	0	0	805	0
Spunky Bottoms	10	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100	30	0	0	2,200	0
Meredosia Lake	60	0	5	0	50	20	50	0	0	0	0	0	0	0	0	0	0	0	0	125	90	0	0	820	0
TOTAL LOWER			6,215	0	7,600	7,645	10,325	100	270	6,295	0	0	0	0	0	0	0	0	0	38,450	1,660	0	0	13,435	23,795
TOTAL ILLINOIS			6,870	0	9,140	13,215	17,280	100	270	8,280	0	0	0	0	0	0	0	0	0	55,155	1,730	0	0	19,230	37,845
10-Year Average 2005-2014			3,206	0	6,015	12,861	10,721	93	788	2,780	0	0	0	0	0	0	0	0	0	36,464	1,058	0	0	7,258	7,108

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 09/21/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Hennepin/Hopper	100	0	370	0	555	740	555	185	185	975	0	0	0	0	0	0	0	0	0	3,565	110	0	0	35	14,430
Goose Lake	90	0	110	0	1,030	100	800	0	0	0	0	0	0	0	0	0	0	0	0	2,040	80	0	0	600	0
Senachwine Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	260	0
Hitchcock Slough	90	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0
Douglas Lake	30	0	25	0	300	50	250	0	0	30	0	0	0	0	0	0	0	0	0	655	150	0	0	30	0
Goose Lake	100	0	0	0	0	50	0	0	0	20	0	0	0	0	0	0	0	0	0	70	0	0	0	165	0
Upper Peoria	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
TOTAL UPPER			535	0	1,885	940	1,605	185	185	1,025	0	0	0	0	0	0	0	0	0	6,360	540	0	0	1,095	14,430

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Goose Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	430	0
Rice Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1,520	0
Big Lake	90	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	1,030	0
Banner Marsh	90	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5	40	0	0	460	0
Duck Creek	100	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5	35	0	0	35	0
Clear Lake	80	0	30	0	2,000	2,000	1,200	0	0	500	0	0	0	0	0	0	0	0	0	5,730	180	0	0	2,200	0
Chautauqua	50	0	625	0	1,850	4,550	8,400	0	0	3,275	0	0	0	0	0	0	0	0	0	18,700	720	0	0	1,130	0
Emiquon/Spoon Btm	90	0	2,490	0	5,990	4,900	5,400	200	300	2,270	0	0	0	0	0	0	0	0	0	21,550	25	0	0	1,000	32,820
Grass Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
Stewart Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	215	0
Crane Lake	80	0	10	0	10	200	100	0	0	10	0	0	0	0	0	0	0	0	0	330	5	0	0	1,210	0
Cuba Island	60	0	50	0	100	200	600	0	0	30	0	0	0	0	0	0	0	0	0	980	410	0	0	610	0
Big Lake	30	0	160	0	250	10	150	0	0	50	0	0	0	0	0	0	0	0	0	620	5	0	0	350	0
Spunky Bottoms	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	10	0
Meredosia Lake	60	0	90	0	160	350	500	0	0	150	0	0	0	0	0	0	0	0	0	1,250	200	0	0	1,600	40
TOTAL LOWER			3,455	0	10,360	12,215	16,360	200	300	6,290	0	0	0	0	0	0	0	0	0	49,180	1,670	0	0	11,805	32,860
TOTAL ILLINOIS			3,990	0	12,245	13,155	17,965	385	485	7,315	0	0	0	0	0	0	0	0	0	55,540	2,210	0	0	12,900	47,290
10-Year Average 2005-2014			5,629	0	15,373	12,640	20,219	161	369	7,179	0	0	0	0	0	0	0	0	0	61,570	1,446	0	0	7,598	24,939

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 09/21/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	5	0	0	5	0	0	0	0	0	0	0	0	0	10	150	0	0	25	0
Arthur Refuge	60	0	35	0	0	5	150	0	0	5	0	0	0	0	0	0	0	0	0	195	260	0	0	15	20
Nauvoo-Ft. Madison	90	0	10	0	0	30	30	0	0	15	0	0	0	0	0	0	0	0	0	85	300	0	0	670	1,000
Ft. Madison-Dallas	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	0	65	0
Henderson Creek	80	0	0	0	300	50	50	0	0	50	0	0	0	0	0	0	0	0	0	450	230	0	0	860	1,300
Keithsburg Refuge	80	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	30	390	0	0	5	0
Louisa Refuge	40	0	10	0	0	50	470	0	0	0	0	0	0	0	0	0	0	0	0	530	345	0	0	0	0
TOTAL UPPER			55	0	300	135	735	0	0	75	0	0	0	0	0	0	0	0	0	1,300	1,755	0	0	1,640	2,320

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Swan Lake	80	0	590	0	2,360	4,130	2,950	0	0	1,770	0	0	0	0	0	0	0	0	0	11,800	1,000	0	0	4,600	0
Gilbert Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long Lake	100	0	0	0	10	0	50	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0
Dardenne Club	30	0	10	0	10	0	50	0	0	25	0	0	0	0	0	0	0	0	0	95	0	0	0	0	0
Cuivre Club	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0
Batchtown Refuge	30	0	20	0	0	35	80	0	0	0	0	0	0	0	0	0	0	0	0	135	70	0	0	0	0
Cannon Refuge	10	0	0	0	10	50	35	0	0	20	0	0	0	0	0	0	0	0	0	115	0	0	0	0	0
Towhead Lake	60	0	30	0	300	200	410	0	0	50	0	0	0	0	0	0	0	0	0	990	150	0	0	0	0
Delair Refuge	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shanks Refuge	10	0	0	0	0	10	25	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0
Meyer-Keokuk	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	5	0
TOTAL LOWER			650	0	2,690	4,425	3,600	0	0	1,865	0	0	0	0	0	0	0	0	0	13,230	1,300	0	0	4,605	0
TOTAL MISSISSIPPI			705	0	2,990	4,560	4,335	0	0	1,940	0	0	0	0	0	0	0	0	0	14,530	3,055	0	0	6,245	2,320
10-Year Average 2005-2014			1,326	0	2,903	1,668	3,438	70	423	507	0	0	0	0	0	0	0	0	0	10,334	1,579	0	1	2,104	1,343

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 10/14/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	1,105	0	5,520	0	1,655	275	2,760	5,520	0	200	50	0	3,865	0	0	0	0	20,950	830	0	0	10	34,775
Goose Lake	70	0	400	0	2,100	0	5,700	0	0	1,600	0	0	0	0	0	0	0	0	0	9,800	255	0	0	10	0
Senachwine Lake	90	0	950	0	4,800	0	1,100	0	0	700	0	0	0	0	200	0	0	0	0	7,750	0	0	0	30	0
Hitchcock Slough	50	0	0	0	0	0	800	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0	40	0
Douglas Lake	80	0	200	0	1,550	0	2,400	0	0	0	0	0	0	0	0	0	0	0	0	4,150	0	0	0	10	100
Goose Lake	80	0	3,050	0	1,000	50	1,500	0	0	400	0	0	0	0	0	0	0	0	0	6,000	0	0	0	500	700
Upper Peoria	100	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	10	0	0	520	20
TOTAL UPPER			5,725	0	14,970	50	13,155	275	2,760	8,220	0	200	50	0	4,065	0	0	0	0	49,470	1,095	0	0	1,120	35,595
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	90	0	0	0	0	0	610	0	0	0	0	0	0	0	0	0	0	0	0	610	0	0	0	0	0
Rice Lake	90	0	215	0	30	0	410	0	0	30	0	0	0	0	10	0	0	0	0	695	60	0	0	310	25
Big Lake	90	0	0	0	0	0	100	0	0	0	0	0	0	0	60	0	0	0	0	160	175	0	0	10	0
Banner Marsh	95	0	100	0	50	0	60	0	5	0	0	0	0	0	0	0	0	0	0	215	70	0	0	330	0
Duck Creek	100	0	10	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	30	130	0	0	0	0
Clear Lake	90	0	50	0	600	0	2,700	0	0	30	0	0	0	0	500	0	0	0	0	3,880	0	0	0	20	100
Chautauqua	60	0	980	0	3,920	185	11,995	0	550	1,410	0	0	0	0	550	0	0	0	0	19,590	10	0	0	10	1,500
Emiquon/Spoon Btm	90	0	3,930	0	7,850	650	6,520	2,605	6,510	5,365	0	0	0	0	3,905	0	0	0	0	37,335	40	0	0	170	93,095
Grass Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	15	20
Jack Lake	100	0	10	0	0	0	0	0	0	10	0	0	0	0	200	0	0	0	0	220	0	0	0	30	5
Stewart Lake	80	0	100	0	675	0	800	0	0	300	0	0	0	0	0	0	0	0	0	1,875	0	0	0	400	0
Crane Lake	80	0	0	0	0	0	200	0	0	0	0	0	0	0	0	0	0	0	0	200	40	0	0	310	400
Cuba Island	70	0	125	0	500	0	1,500	0	0	0	0	0	0	0	0	0	0	0	0	2,125	330	0	0	0	0
Big Lake	30	0	10	0	60	0	25	0	0	20	0	0	0	0	20	0	0	0	0	135	15	0	0	0	50
Spunky Bottoms	10	0	0	0	10	0	0	0	0	20	0	0	0	0	0	0	0	0	0	30	40	0	0	0	0
Meredosia Lake	60	0	20	0	255	0	410	0	0	0	0	0	0	0	0	0	0	0	0	685	190	0	0	0	1,400
TOTAL LOWER			5,550	0	13,950	835	25,330	2,605	7,085	7,185	0	0	0	0	5,245	0	0	0	0	67,785	1,110	0	0	1,605	96,595
TOTAL ILLINOIS			11,275	0	28,920	885	38,485	2,880	9,845	15,405	0	200	50	0	9,310	0	0	0	0	117,255	2,205	0	0	2,725	132,190
10-Year Average 2005-2014			22,042	154	23,676	1,941	27,029	3,906	10,842	9,588	2	1,137	32	11	2,641	0	0	0	0	103,002	2,147	19	0	3,090	77,847

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 10/14/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	WHPE	AMCO
Keokuk-Nauvoo	100	0	20	0	100	0	0	0	0	5	0	30	0	0	850	0	0	0	0	1,005	50	0	0	5	6,000
Arthur Refuge	80	0	100	0	250	0	1,700	0	0	75	0	0	0	0	0	0	0	0	0	2,125	420	0	0	15	500
Nauvoo-Ft. Madison	100	0	10	0	1,000	50	500	0	125	50	0	0	0	0	0	0	0	0	0	1,735	345	0	0	70	13,800
Ft. Madison-Dallas	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	520	0	0	210	0
Henderson Creek	70	0	50	0	900	0	200	0	150	200	0	0	0	0	0	0	0	0	0	1,500	100	0	0	130	2,500
Keithsburg Refuge	90	0	80	0	160	0	25	0	50	0	0	0	0	0	0	0	0	0	0	315	520	0	0	10	700
Louisa Refuge	40	0	150	0	700	10	820	0	50	100	0	0	0	0	0	0	0	0	0	1,830	1,210	0	0	0	400
TOTAL UPPER			410	0	3,110	60	3,245	0	375	430	0	30	0	0	850	0	0	0	0	8,510	3,165	0	0	440	23,900
LOWER MISSISSIPPI RIVER VALLEY																									
Swan Lake	90	0	1,900	0	4,500	360	8,850	180	360	1,800	0	50	0	0	0	0	0	0	0	18,000	420	0	0	2,160	400
Gilbert Lake	100	0	35	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	135	0	0	0	0	0
Long Lake	90	0	0	0	10	0	100	0	0	10	0	0	0	0	0	0	0	0	0	120	0	0	0	0	0
Dardenne Club	70	0	200	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	300	0	0	0	0	0
Cuivre Club	60	0	25	0	10	0	10	0	0	10	0	0	0	0	0	0	0	0	0	55	0	0	0	100	0
Batchtown Refuge	50	0	100	0	4,500	0	6,200	0	0	100	0	0	0	0	0	0	0	0	0	10,900	370	0	0	0	0
Cannon Refuge	10	0	100	0	4,500	0	1,500	0	0	0	0	0	0	0	0	0	0	0	0	6,100	0	0	0	100	0
Towhead Lake	70	0	100	0	1,400	0	500	25	100	100	0	0	0	0	0	0	0	0	0	2,225	380	0	0	0	3,000
Delair Refuge	80	0	25	0	200	0	600	0	0	0	0	0	0	0	0	0	0	0	0	825	70	0	0	0	0
Shanks Refuge	20	0	10	0	500	0	1,000	0	0	0	0	0	0	0	0	0	0	0	0	1,510	0	0	0	0	350
Meyer-Keokuk	100	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	70	0	0	40	20
TOTAL LOWER			2,535	0	15,720	360	18,860	205	460	2,020	0	50	0	0	0	0	0	0	0	40,210	1,310	0	0	2,400	3,770
TOTAL MISSISSIPPI			2,945	0	18,830	420	22,105	205	835	2,450	0	80	0	0	850	0	0	0	0	48,720	4,475	0	0	2,840	27,670
10-Year Average 2005-2014			10,877	3	18,357	469	15,705	1,487	5,592	2,701	0	1,670	1	0	1,704	0	0	0	0	58,566	2,656	67	0	1,718	15,588

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 10/22/2015 Observer: Aaron Yetter

LOCATION	%WET	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	1,720	0	1,720	0	1,720	0	2,680	4,300	250	1,720	430	430	2,580	0	0	0	0	17,550	790	0	0	120	68,800
Goose Lake	80	1,100	0	2,100	0	16,000	0	0	2,710	0	0	0	0	0	0	0	0	0	21,910	5	0	0	20	0
Senachwine Lake	100	3,000	0	4,600	0	5,000	0	0	2,500	0	0	0	0	1,000	0	0	0	0	16,100	0	0	0	200	200
Hitchcock Slough	70	0	0	0	0	3,000	0	0	0	0	0	0	0	0	0	0	0	0	3,000	0	0	0	0	0
Douglas Lake	90	410	25	6,200	0	1,000	0	0	0	0	0	0	0	500	0	0	0	0	8,135	0	0	0	5	500
Goose Lake	90	6,100	200	6,000	0	1,000	0	0	0	0	500	0	0	6,000	0	0	0	0	19,800	10	0	0	750	2,000
Upper Peoria	100	500	0	0	0	100	0	0	0	0	0	0	0	620	0	0	0	0	1,220	50	0	0	5	300
TOTAL UPPER		12,830	225	20,620	0	27,820	0	2,680	9,510	250	2,220	430	430	10,700	0	0	0	0	87,715	855	0	0	1,100	71,800
LOWER ILLINOIS RIVER VALLEY																								
Goose Lake	95	10	0	50	0	200	0	25	0	0	0	0	0	0	0	0	0	0	285	0	0	0	0	100
Rice Lake	95	360	5	400	0	100	0	0	200	0	0	0	0	115	0	0	0	0	1,180	0	0	0	150	0
Big Lake	95	1,330	0	500	0	3,300	0	50	50	0	0	0	0	200	0	0	0	0	5,430	0	0	0	280	300
Banner Marsh	95	330	0	20	0	120	0	305	0	0	0	0	0	0	0	0	0	0	775	395	0	0	160	10
Duck Creek	100	50	0	0	0	0	0	180	0	0	0	0	0	0	0	0	0	0	230	335	0	0	20	0
Clear Lake	90	1,540	0	2,695	0	1,540	0	0	1,540	0	0	0	0	0	0	0	0	0	7,315	325	0	0	0	385
Chautauqua	70	2,050	0	8,250	0	12,200	0	2,300	6,200	0	0	0	0	0	0	0	0	0	31,000	50	0	0	300	1,500
Emiquon/Spoon Btm	90	3,805	0	9,465	0	5,775	1,885	18,850	9,695	940	0	940	940	3,770	0	0	0	0	56,065	270	40	0	440	132,900
Grass Lake	90	50	0	0	0	0	0	0	0	0	25	0	0	200	0	0	0	0	275	0	0	0	15	0
Jack Lake	100	0	0	0	0	0	0	50	0	0	0	0	0	800	0	0	0	0	850	10	0	0	0	0
Stewart Lake	90	1,000	0	500	0	1,460	0	10	420	0	0	0	0	210	0	0	0	0	3,600	0	0	0	200	100
Crane Lake	90	50	0	0	0	100	0	0	0	0	0	5	0	400	0	0	0	0	555	10	0	0	435	0
Cuba Island	90	200	0	3,200	0	1,900	0	0	50	0	0	0	0	0	0	0	0	0	5,350	685	50	0	0	0
Big Lake	20	200	0	0	0	50	0	0	0	0	0	0	0	0	0	0	0	0	250	0	0	0	0	50
Spunky Bottoms	10	0	0	0	0	50	0	0	400	0	0	0	0	0	0	0	0	0	450	5	0	0	0	0
Meredosia Lake	60	585	0	1,025	0	700	0	100	100	0	0	0	0	200	0	0	0	0	2,710	0	0	0	60	1,725
TOTAL LOWER		11,560	5	26,105	0	27,495	1,885	21,870	18,655	940	25	945	940	5,895	0	0	0	0	116,320	2,085	90	0	2,060	137,070
TOTAL ILLINOIS		24,390	230	46,725	0	55,315	1,885	24,550	28,165	1,190	2,245	1,375	1,370	16,595	0	0	0	0	204,035	2,940	90	0	3,160	208,870
10-Year Average 2005-2014		42,414	262	35,146	1,521	30,794	4,184	20,337	13,239	266	2,224	82	52	4,408	0	0	0	9	154,938	2,092	17	0	1,683	87,301

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 10/22/2015 Observer: Aaron Yetter

LOCATION	%WET	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	10	0	0	0	0	0	25	0	50	500	0	0	22,010	0	10	0	0	22,605	0	0	0	20	14,050
Arthur Refuge	80	100	0	800	0	3,000	0	200	400	0	0	0	0	0	0	0	0	0	4,500	1,150	0	0	210	1,000
Nauvoo-Ft. Madison	100	525	0	2,100	0	5,200	0	0	1,000	0	0	0	0	100	0	0	0	0	8,925	200	0	0	200	15,900
Ft. Madison-Dallas	100	50	0	50	0	100	0	0	25	0	0	0	0	0	0	0	0	0	225	600	0	0	10	100
Henderson Creek	70	300	200	0	0	400	0	2,500	500	0	0	0	0	3,000	0	0	0	0	6,900	0	0	0	570	6,600
Keithsburg Refuge	90	300	0	200	0	500	0	800	200	0	0	0	0	0	0	0	0	0	2,000	1,500	0	0	10	2,500
Louisa Refuge	40	1,100	0	2,010	0	3,000	100	2,000	1,000	0	0	0	0	0	0	0	0	0	9,210	1,740	30	0	205	500
TOTAL UPPER		2,385	200	5,160	0	12,200	100	5,525	3,125	50	500	0	0	25,110	0	10	0	0	54,365	5,190	30	0	1,225	40,650
LOWER MISSISSIPPI RIVER VALLEY																								
Swan Lake	90	2,285	0	10,030	0	13,110	220	10,925	6,555	0	300	0	0	3,175	0	0	0	0	46,600	1,805	200	0	15	2,800
Gilbert Lake	90	50	0	0	0	10	0	30	100	0	0	0	0	0	0	0	0	0	190	50	0	0	0	0
Long Lake	90	300	0	1,000	0	300	0	0	0	0	100	0	0	0	0	0	0	0	1,700	0	0	0	0	0
Dardenne Club	80	2,000	0	9,000	0	100	0	0	0	0	0	0	0	0	0	0	0	0	11,100	0	0	0	0	100
Cuivre Club	60	600	0	2,600	0	500	0	400	50	0	0	0	0	0	0	0	0	0	4,150	0	0	0	0	0
Batchtown Refuge	50	1,700	0	12,000	0	4,300	0	200	200	0	0	0	0	0	0	0	0	0	18,400	580	0	0	0	0
Cannon Refuge	30	1,500	0	15,000	0	500	0	500	100	0	0	0	0	0	0	0	0	0	17,600	130	0	0	0	0
Towhead Lake	50	100	0	1,500	0	4,500	0	0	0	0	0	0	0	0	0	0	0	0	6,100	0	0	0	0	5,700
Delair Refuge	80	100	0	0	0	1,000	0	50	100	0	0	0	0	0	0	0	0	0	1,250	450	0	0	0	0
Shanks Refuge	10	125	0	4,500	0	0	10	100	100	0	0	0	0	0	0	0	0	0	4,835	0	0	0	0	3,000
Meyer-Keokuk	100	50	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	60	50	0	0	70	0
TOTAL LOWER		8,810	0	55,630	0	24,320	230	12,205	7,205	0	400	0	0	3,185	0	0	0	0	111,985	3,065	200	0	85	11,600
TOTAL MISSISSIPPI		11,195	200	60,790	0	36,520	330	17,730	10,330	50	900	0	0	28,295	0	10	0	0	166,350	8,255	230	0	1,310	52,250
10-Year Average 2005-2014		25,964	1	27,830	272	18,641	2,048	13,069	2,152	550	3,160	150	19	3,814	0	6	0	1	97,677	2,841	88	4	1,158	19,753

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 10/26/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	420	0	840	0	840	840	3,360	840	1,680	1,680	1,680	420	3,360	0	0	0	0	15,960	1,010	0	0	110	68,040
Goose Lake	80	0	12,500	0	5,500	0	15,300	0	200	800	0	0	0	0	0	0	0	0	0	34,300	0	0	0	0	1,080
Senachwine Lake	100	0	3,900	100	10,600	0	3,200	0	0	200	0	0	0	0	500	0	0	0	0	18,500	0	0	0	0	0
Hitchcock Slough	90	0	300	0	0	0	7,000	0	0	100	0	0	0	0	0	0	0	0	0	7,400	0	0	0	0	0
Douglas Lake	90	0	2,000	100	7,000	0	2,000	0	1,000	500	0	1,000	0	0	0	0	0	0	0	13,600	0	0	0	0	200
Goose Lake	90	0	20,200	200	10,000	0	5,000	0	0	1,000	0	0	10	0	8,100	0	0	0	0	44,510	0	0	0	0	200
Upper Peoria	100	0	400	0	0	0	0	0	0	0	0	100	0	0	500	0	0	0	0	1,000	0	0	0	5	50
TOTAL UPPER			39,720	400	33,940	0	33,340	840	4,560	3,440	1,680	2,780	1,690	420	12,460	0	0	0	0	135,270	1,010	0	0	115	69,570

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice Lake	95	0	50	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	55	5	0	0	10	0
Big Lake	95	0	350	0	0	0	250	0	0	5	0	0	0	0	0	0	0	0	0	605	5	0	0	20	500
Banner Marsh	95	0	600	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	850	165	0	0	190	100
Duck Creek	100	0	380	0	0	0	0	0	430	0	0	0	0	0	0	0	0	0	0	810	355	0	0	40	0
Clear Lake	90	0	600	0	500	0	2,055	0	0	1,030	0	0	0	0	2,000	0	0	0	0	6,185	0	0	0	0	0
Chautauqua	70	0	2,500	0	7,800	0	21,000	0	6,000	7,000	0	0	0	0	0	0	0	0	0	44,300	650	0	0	10	1,000
Emiquon/Spoon Btm	90	0	3,500	0	6,725	0	3,625	3,365	8,410	5,310	840	840	840	840	6,725	0	0	0	0	41,020	200	0	0	775	127,840
Grass Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	300	0	0	0	0	300	5	0	0	5	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105
Stewart Lake	90	0	400	0	3,300	0	10,000	0	0	2,000	0	0	0	0	0	0	0	0	0	15,700	0	0	0	200	30
Crane Lake	90	0	5	0	0	0	0	0	200	100	0	100	0	0	200	0	0	0	0	605	100	0	0	100	300
Cuba Island	90	0	1,100	0	3,500	0	3,025	0	0	0	0	0	0	0	0	0	0	0	0	7,625	305	0	0	0	300
Big Lake	20	0	500	0	100	0	500	0	0	100	0	0	0	0	0	0	0	0	0	1,200	0	0	0	10	0
Spunky Bottoms	10	0	0	0	0	0	50	0	0	500	0	0	0	0	0	0	0	0	0	550	0	0	0	0	0
Meredosia Lake	60	0	230	0	100	0	400	0	100	100	0	20	0	0	0	0	0	0	0	950	5	0	0	0	550
TOTAL LOWER			10,215	0	22,025	0	40,905	3,365	15,390	16,145	840	960	840	840	9,230	0	0	0	0	120,755	1,795	0	0	1,360	130,725
TOTAL ILLINOIS			49,935	400	55,965	0	74,245	4,205	19,950	19,585	2,520	3,740	2,530	1,260	21,690	0	0	0	0	256,025	2,805	0	0	1,475	200,295
10-Year Average 2005-2014			77,927	524	40,387	457	39,155	3,990	33,126	10,334	362	7,402	841	144	10,596	0	10	0	2	225,253	2,567	73	1	1,300	88,596

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 10/26/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	50	0	0	0	0	0	1,000	0	1,000	500	0	0	23,500	0	0	0	0	26,050	0	0	0	5	12,000
Arthur Refuge	80	0	1,300	0	6,000	0	9,000	0	500	1,800	0	0	0	0	0	0	0	0	0	18,600	1,250	0	0	0	100
Nauvoo-Ft. Madison	100	0	300	0	100	0	7,000	0	400	300	0	0	0	0	0	0	0	0	0	8,100	100	0	0	0	31,000
Ft. Madison-Dallas	100	0	210	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	210	320	0	0	15	0
Henderson Creek	70	0	1,090	0	100	0	100	0	3,400	0	0	0	0	0	0	0	0	0	0	4,690	400	0	0	90	100
Keithsburg Refuge	90	0	800	0	700	0	300	200	3,500	500	0	0	0	0	0	0	0	0	0	6,000	2,050	0	0	200	5,000
Louisa Refuge	50	0	4,000	0	2,000	0	3,000	0	4,100	500	0	500	0	0	0	0	0	0	0	14,100	1,650	0	0	200	4,600
TOTAL UPPER			7,750	0	8,900	0	19,400	200	12,900	3,100	1,000	1,000	0	0	23,500	0	0	0	0	77,750	5,770	0	0	510	52,800

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	90	0	5,075	0	14,160	0	13,220	0	1,860	7,440	0	2,000	0	0	700	0	0	0	0	44,455	610	100	0	0	500
Gilbert Lake	90	0	100	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	160	310	0	0	510	0
Long Lake	90	0	2,000	0	3,000	0	500	100	200	100	0	0	0	0	0	0	0	0	0	5,900	0	0	0	0	0
Dardenne Club	90	0	5,000	0	23,000	0	3,000	300	1,000	0	0	0	0	0	0	0	0	0	0	32,300	0	0	0	0	0
Cuivre Club	80	0	2,500	0	4,000	0	2,000	0	200	0	0	0	0	0	0	0	0	0	0	8,700	0	0	0	0	0
Batchtown Refuge	50	0	1,000	0	3,100	0	5,600	0	500	500	0	0	0	0	0	0	0	0	0	10,700	900	0	0	0	0
Cannon Refuge	20	0	5,300	0	20,500	0	2,000	0	500	500	0	0	0	0	0	0	0	0	0	28,800	0	0	0	0	0
Towhead Lake	50	0	2,000	0	3,000	0	3,500	0	2,000	500	0	500	0	0	0	0	0	0	0	11,500	0	0	0	0	4,000
Delair Refuge	80	0	1,000	0	200	0	5,100	0	1,000	500	0	100	0	0	0	0	0	0	0	7,900	2,000	0	0	0	300
Shanks Refuge	20	0	500	0	3,000	0	300	50	100	500	0	0	0	0	0	0	0	0	0	4,450	0	0	0	0	3,200
Meyer-Keokuk	100	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	30	0	0	60	0
TOTAL LOWER			24,485	0	73,960	0	35,280	450	7,360	10,040	0	2,600	0	0	700	0	0	0	0	154,875	3,850	100	0	570	8,000
TOTAL MISSISSIPPI			32,235	0	82,860	0	54,680	650	20,260	13,140	1,000	3,600	0	0	24,200	0	0	0	0	232,625	9,620	100	0	1,080	60,800
10-Year Average 2005-2014			42,411	20	30,815	3	24,469	1,025	18,033	2,326	5,360	8,904	3,415	36	7,183	19	120	0	0	144,136	3,399	88	441	1,166	26,262

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 11/02/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	1,470	0	980	0	490	245	2,450	4,900	0	490	980	0	4,900	0	0	0	0	16,905	900	250	0	45	32,095
Goose Lake	90	0	5,400		1,800	0	6,200	0	525	6,550	0	100	0	0	1,000	0	0	0	0	21,575	0	0	0	10	2,200
Senachwine Lake	100	0	6,500	0	12,300	0	15,000	0	300	2,000	200	0	0	0	500	0	0	0	0	36,800	0	0	0	0	300
Hitchcock Slough	90	0	100	0	0	0	7,000	0	0	1,000	0	0	0	0	0	0	0	0	0	8,100	0	0	0	0	0
Douglas Lake	90	0	5,000	0	10,000	0	1,000	0	2,000	500	0	0	0	0	0	0	0	0	0	18,500	0	0	0	0	2,000
Goose Lake	90	0	22,500	0	10,500	0	8,000	0	200	1,700	300	0	0	0	5,000	0	0	0	0	48,200	0	0	0	400	0
Upper Peoria	100	0	3,025	0	1,000	0	1,000	0	0	0	0	300	0	0	4,800	0	0	0	0	10,125	0	0	0	0	500
TOTAL UPPER			43,995	0	36,580	0	38,690	245	5,475	16,650	500	890	980	0	16,200	0	0	0	0	160,205	900	250	0	455	37,095

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	95	0	0	0	0	0	0	0	50	0	75	0	0	0	100	0	0	0	0	225	0	50	5	30	2,500
Rice Lake	95	0	250	0	0	0	10	0	0	20	0	0	0	0	100	0	0	0	0	380	0	0	0	5	0
Big Lake	95	0	50	0	0	0	350	0	200	100	200	0	0	0	200	0	0	0	0	1,100	105	0	0	35	4,800
Banner Marsh	95	0	1,200	0	600	0	500	200	1,350	100	0	0	0	0	0	0	0	0	0	3,950	270	0	0	225	350
Duck Creek	100	0	150	0	0	0	50	0	1,150	50	0	0	0	0	0	0	0	0	0	1,400	170	0	0	10	20
Clear Lake	95	0	1,300	0	2,500	0	2,400	0	1,200	1,100	0	0	0	0	3,000	0	0	0	0	11,500	450	0	0	0	1,100
Chautauqua	80	0	4,000	100	15,000	0	20,700	200	3,100	8,000	50	0	0	0	6,000	0	0	0	0	57,150	350	50	0	225	900
Emiquon/Spoon Btm	90	0	3,700	0	2,200	0	4,000	930	9,400	2,450	930	2,000	930	930	10,400	0	0	0	0	37,870	35	0	0	350	151,920
Grass Lake	90	0	0	0	0	0	0	0	0	0	0	100	0	0	300	0	0	0	0	400	0	0	0	0	100
Jack Lake	100	0	10	0	0	0	0	0	610	0	0	250	0	0	850	0	0	0	0	1,720	0	0	0	0	700
Stewart Lake	90	0	200	0	500	0	10,000	0	100	1,400	0	0	0	0	0	0	0	0	0	12,200	0	0	0	250	400
Crane Lake	90	0	0	0	0	0	0	0	3,500	510	0	300	0	0	1,000	0	0	0	0	5,310	70	0	0	10	200
Cuba Island	90	0	200	0	2,400	0	1,500	0	0	500	0	0	0	0	0	0	0	0	0	4,600	1,200	150	5	0	0
Big Lake	20	0	750	10	0	0	100	0	0	1,000	0	0	0	0	0	0	0	0	0	1,860	0	0	0	0	0
Spunky Bottoms	10	0	0	0	0	0	20	0	0	200	0	0	0	0	0	0	0	0	0	220	0	0	0	0	0
Meredosia Lake	60	0	200	0	100	0	400	10	50	130	300	0	0	0	1,500	0	0	0	0	2,690	0	0	0	150	1,600
TOTAL LOWER			12,010	110	23,300	0	40,030	1,340	20,710	15,560	1,555	2,650	930	930	23,450	0	0	0	0	142,575	2,650	250	10	1,290	164,590
TOTAL ILLINOIS			56,005	110	59,880	0	78,720	1,585	26,185	32,210	2,055	3,540	1,910	930	39,650	0	0	0	0	302,780	3,550	500	10	1,745	201,685
10-Year Average 2005-2014			130,609	889	38,067	0	53,336	3,995	52,839	14,341	7,715	23,744	2,551	209	16,743	7	84	0	40	345,168	3,216	239	18	518	57,359

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 11/02/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	5	0	0	0	0	0	0	0	500	500	0	0	11,100	0	0	0	0	12,105	0	0	0	0	33,300
Arthur Refuge	80	0	400	0	500	0	3,500	0	300	900	0	0	0	0	0	0	0	0	0	5,600	1,600	0	0	0	1,500
Nauvoo-Ft. Madison	100	0	100	0	0	0	1,000	0	300	300	0	0	0	20	100	0	0	0	0	1,820	100	0	0	80	18,700
Ft. Madison-Dallas	100	0	60	0	0	0	50	0	0	70	0	0	0	0	0	0	0	0	0	180	520	50	0	10	0
Henderson Creek	70	0	3,300	0	800	0	800	300	7,200	2,600	2,600	0	100	0	0	0	0	0	0	17,700	50	200	10	255	2,500
Keithsburg Refuge	90	0	1,200	0	400	0	100	0	500	2,500	0	0	0	0	0	0	0	0	0	4,700	1,250	0	0	275	4,100
Louisa Refuge	80	0	2,600	0	4,500	0	2,000	0	7,400	3,000	0	1,500	0	0	0	0	0	0	0	21,000	1,500	0	0	0	1,200
TOTAL UPPER			7,665	0	6,200	0	7,450	300	15,700	9,370	3,100	2,000	100	20	11,200	0	0	0	0	63,105	5,020	250	10	620	61,300

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	95	0	1,700	0	13,500	0	15,600	200	8,900	8,000	0	5,800	0	0	750	0	0	0	0	54,450	1,475	150	0	10	1,000
Gilbert Lake	90	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100	50	0	0	150	0
Long Lake	90	0	1,500	0	4,000	0	3,000	0	500	500	0	0	0	0	0	0	0	0	0	9,500	0	0	0	0	0
Dardenne Club	90	0	8,000	0	40,000	0	3,000	100	5,000	3,000	0	0	0	0	0	0	0	0	0	59,100	0	0	0	0	600
Cuivre Club	80	0	2,500	0	500	0	2,000	0	1,200	500	0	0	0	0	0	0	0	0	0	6,700	0	0	0	0	0
Batchtown Refuge	60	0	3,600	0	1,600	0	11,500	0	1,000	1,000	0	0	0	0	0	0	0	0	0	18,700	600	0	0	0	0
Cannon Refuge	60	0	3,800	0	17,000	0	7,100	0	1,400	600	0	0	0	0	0	0	0	0	0	29,900	40	0	0	0	2,100
Towhead Lake	80	0	800	0	500	0	1,200	0	800	100	0	700	0	0	0	0	0	0	0	4,100	0	0	0	0	1,800
Delair Refuge	80	0	500	0	500	0	3,000	0	1,200	400	0	0	0	0	0	0	0	0	0	5,600	520	100	0	0	100
Shanks Refuge	40	0	100	0	400	0	200	0	300	0	0	0	0	0	0	0	0	0	0	1,000	0	0	0	0	2,100
Meyer-Keokuk	100	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40	70	0	0	70	0
TOTAL LOWER			22,540	0	78,000	0	46,600	300	20,300	14,200	0	6,500	0	0	750	0	0	0	0	189,190	2,755	250	0	230	7,700
TOTAL MISSISSIPPI			30,205	0	84,200	0	54,050	600	36,000	23,570	3,100	8,500	100	20	11,950	0	0	0	0	252,295	7,775	500	10	850	69,000
10-Year Average 2005-2014			58,021	58	43,369	0	28,903	2,113	27,673	3,943	22,093	19,042	8,733	222	8,693	83	59	0	0	223,003	3,687	110	1,004	696	23,855

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 11/09/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	2,400	0	960	0	1,440	240	4,800	2,400	480	2,400	1,440	240	4,800	0	0	0	0	21,600	1,500	0	0	60	26,400
Goose Lake	90	0	5,700		500	0	3,100	0	800	700	0	2,500	0	0	0	0	0	0	0	13,300	0	0	0	0	0
Senachwine Lake	100	0	11,000	100	7,500	0	11,000	0	500	2,000	200	300	0	0	1,500	0	0	0	0	34,100	0	0	0	0	200
Hitchcock Slough	90	0	300	0	0	0	6,000	0	0	500	0	0	0	0	0	0	0	0	0	6,800	0	0	0	50	0
Douglas Lake	90	0	3,500	0	6,000	0	3,800	0	2,000	500	0	6,000	0	0	0	0	0	0	0	21,800	0	0	0	0	300
Goose Lake	90	0	15,000	300	12,000	0	2,000	0	0	500	0	1,000	0	0	13,500	0	0	0	0	44,300	0	0	0	0	2,500
Upper Peoria	100	0	4,100	0	1,000	0	1,000	0	0	200	400	0	0	0	12,000	0	50	0	0	18,750	75	0	0	0	550
TOTAL UPPER			42,000	400	27,960	0	28,340	240	8,100	6,800	1,080	12,200	1,440	240	31,800	0	50	0	0	160,650	1,575	0	0	110	29,950
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30
Rice Lake	95	0	1,505	0	100	0	0	0	300	10	0	0	0	0	0	0	0	0	0	1,915	10	0	0	45	0
Big Lake	95	0	0	0	0	0	0	0	0	50	40	0	0	0	0	0	0	0	0	90	0	0	0	0	1,500
Banner Marsh	95	0	510	0	0	0	0	5	510	0	0	0	0	0	0	0	0	0	0	1,025	865	0	0	50	5
Duck Creek	100	0	1,285	0	0	0	0	0	5,305	0	0	0	0	0	0	0	0	0	0	6,590	520	0	0	25	0
Clear Lake	95	0	3,800	30	600	0	1,000	0	410	1,620	250	0	0	0	4,500	0	0	0	0	12,210	20	0	0	0	0
Chautauqua	70	0	3,000	50	3,700	0	22,600	0	1,500	10,500	100	200	0	0	2,000	0	0	0	50	43,700	150	0	0	50	1,000
Emiquon/Spoon Btm	90	0	3,130	0	2,075	0	3,145	405	12,180	4,725	810	810	1,620	405	4,660	0	405	0	100	34,470	10	0	0	335	54,050
Grass Lake	90	0	0	0	0	0	0	0	0	0	0	0	0	0	600	0	0	0	0	600	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	200	0	100	500	0	0	500	0	0	0	0	1,300	0	0	0	0	0
Stewart Lake	90	0	0	0	0	0	200	0	0	1,300	0	0	0	0	0	0	0	0	0	1,500	0	0	0	10	0
Crane Lake	90	0	220	0	0	0	55	0	105	0	100	1,500	0	0	200	0	0	0	0	2,180	200	0	0	0	900
Cuba Island	90	0	1,300	0	2,000	0	5,300	0	100	500	0	100	0	0	0	0	0	0	0	9,300	1,600	150	0	0	0
Big Lake	20	0	700	0	0	0	3,000	0	1,000	400	0	150	0	0	50	0	0	0	0	5,300	0	0	0	0	0
Spunky Bottoms	10	0	50	0	0	0	50	0	0	150	0	0	0	0	0	0	0	0	0	250	0	0	0	0	0
Meredosia Lake	60	0	110	0	100	0	1,100	0	500	200	25	150	0	0	50	0	0	0	0	2,235	0	0	0	0	1,600
TOTAL LOWER			15,610	80	8,575	0	36,450	410	22,110	19,455	1,425	3,410	1,620	405	12,560	0	405	0	150	122,665	3,375	150	0	515	59,085
TOTAL ILLINOIS			57,610	480	36,535	0	64,790	650	30,210	26,255	2,505	15,610	3,060	645	44,360	0	455	0	150	283,315	4,950	150	0	625	89,035
10-Year Average 2005-2014			142,735	952	24,028	0	40,082	2,373	40,197	8,189	2,618	16,855	1,358	39	9,257	28	289	0	131	289,131	2,909	257	56	535	39,284

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 11/09/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	110	0	0	0	0	0	200	0	3,600	1,500	0	0	20,100	0	0	0	0	25,510	0	0	0	0	29,500
Arthur Refuge	80	0	200	0	400	0	800	0	100	1,200	0	0	0	0	0	0	0	0	0	2,700	1,150	0	0	0	0
Nauvoo-Ft. Madison	100	0	105	0	300	0	1,025	0	0	0	4,000	0	0	200	600	0	0	0	0	6,230	0	0	0	10	13,100
Ft. Madison-Dallas	100	0	50	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	150	860	0	0	0	0
Henderson Creek	70	0	5,010	10	500	0	1,100	0	1,600	1,500	0	0	0	0	0	0	0	0	0	9,720	100	0	0	50	300
Keithsburg Refuge	90	0	1,470	0	100	0	250	0	400	2,755	0	0	0	0	0	0	0	0	0	4,975	1,650	0	0	0	500
Louisa Refuge	80	0	9,100	0	3,600	0	500	0	4,500	600	0	4,500	0	0	0	0	0	0	0	22,800	1,200	0	0	0	1,000
TOTAL UPPER			16,045	10	4,900	0	3,775	0	6,800	6,055	7,600	6,000	0	200	20,700	0	0	0	0	72,085	4,960	0	0	60	44,400

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	95	0	12,540	0	4,080	0	23,160	205	8,160	8,160	0	5,500	0	0	1,600	0	0	0	0	63,405	665	120	0	30	200
Gilbert Lake	90	0	200	0	0	0	0	0	0	50	0	0	0	0	0	0	0	0	0	250	60	0	0	0	0
Long Lake	90	0	7,000	0	1,500	0	4,000	0	1,000	300	0	0	0	0	0	0	0	0	0	13,800	0	0	0	5	0
Dardenne Club	90	0	15,000	0	38,400	0	3,000	0	3,000	600	0	0	0	0	0	0	0	0	0	60,000	0	0	0	0	400
Cuivre Club	80	0	1,500	0	2,000	0	2,000	0	500	0	0	0	0	0	0	0	0	0	0	6,000	0	0	0	0	600
Batchtown Refuge	70	0	4,000	0	500	0	10,600	0	600	400	100	1,200	0	0	0	0	0	0	0	17,400	1,600	0	0	0	0
Cannon Refuge	70	0	17,000	0	18,500	0	22,000	0	5,000	5,500	0	0	0	0	0	0	0	0	0	68,000	250	0	0	0	700
Towhead Lake	75	0	600	0	2,600	0	4,000	0	200	500	100	1,800	50	0	0	0	0	0	0	9,850	0	0	0	0	0
Delair Refuge	90	0	2,500	0	1,500	0	1,000	0	1,000	500	0	0	0	0	0	0	0	0	0	6,500	1,700	125	0	0	0
Shanks Refuge	40	0	3,500	0	0	0	0	0	300	0	0	0	0	0	0	0	0	0	0	3,800	0	0	0	0	1,500
Meyer-Keokuk	100	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	150	0	0	60	0
TOTAL LOWER			63,890	0	69,080	0	69,760	205	19,760	16,010	200	8,500	50	0	1,600	0	0	0	0	249,055	4,425	245	0	95	3,400
TOTAL MISSISSIPPI			79,935	10	73,980	0	73,535	205	26,560	22,065	7,800	14,500	50	200	22,300	0	0	0	0	321,140	9,385	245	0	155	47,800
10-Year Average 2005-2014			146,439	411	37,989	0	29,748	2,438	33,980	6,023	19,355	25,616	11,804	233	13,619	126	1,272	3	61	329,121	3,561	184	764	313	16,179

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 11/24/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	20	4,375	0	0	0	0	0	875	0	875	1,750	3,500	0	4,375	0	0	0	0	15,750	210	0	0	0	1,750
Goose Lake	100	60	19,000	200	0	0	500	0	0	0	0	0	0	0	100	0	30	0	0	19,830	1,310	0	0	5	0
Senachwine Lake	100	10	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	0	0	0	0	0
Hitchcock Slough	100	10	1,600	0	0	0	0	0	0	0	0	0	0	0	400	50	0	0	0	2,050	50	0	0	0	0
Douglas Lake	100	90	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0
Goose Lake	100	10	40,000	300	0	0	0	0	0	0	300	5,000	0	0	0	0	0	0	0	45,600	0	0	0	0	0
Upper Peoria	100	0	10,300	0	0	0	0	0	0	0	1,100	0	0	0	1,100	125	0	0	0	12,625	270	0	0	0	0
TOTAL UPPER			76,475	500	0	0	500	0	875	0	2,275	6,750	3,500	0	5,975	175	30	0	0	97,055	1,840	0	0	5	1,750
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	100	50	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0
Rice Lake	95	25	430	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	430	150	0	0	0	0
Big Lake	100	50	3,400	50	0	0	1,500	0	0	0	0	500	0	0	0	0	0	0	0	5,450	0	0	0	0	0
Banner Marsh	95	10	1,070	0	0	0	100	0	1,200	0	0	0	0	0	0	0	0	0	0	2,370	550	0	0	0	105
Duck Creek	100	0	10,500	0	0	0	0	0	800	20	0	0	0	0	0	0	0	0	0	11,320	285	0	0	0	0
Clear Lake	100	10	2,500	0	0	0	300	0	100	0	300	100	0	0	3,000	0	0	0	0	6,300	400	0	0	0	0
Chautauqua	80	50	7,500	0	0	0	1,000	0	850	2,200	0	0	0	0	400	0	50	0	0	12,000	340	0	0	55	50
Emiquon/Spoon Btm	90	20	5,605	0	0	0	690	0	1,115	445	445	1,115	870	115	5,685	0	115	0	250	16,450	10	0	0	40	6,155
Grass Lake	100	10	310	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	320	0	0	0	0	0
Jack Lake	100	10	200	0	0	0	0	0	0	0	0	100	0	0	500	0	0	0	0	800	0	0	0	0	0
Stewart Lake	100	30	0	0	0	0	0	0	0	0	400	0	0	0	1,100	0	200	0	0	1,700	0	0	0	0	0
Crane Lake	100	10	310	0	0	0	0	0	320	0	0	3,500	0	0	0	0	0	0	0	4,130	50	0	0	0	200
Cuba Island	100	10	6,000	0	0	0	150	0	700	150	0	1,000	0	0	0	0	0	0	0	8,000	1,300	150	0	0	0
Big Lake	30	10	1,600	0	0	0	150	0	0	0	0	0	0	0	0	10	0	0	0	1,760	0	0	0	160	50
Spunky Bottoms	40	10	2,250	0	0	0	1,000	0	0	0	0	0	0	0	0	0	0	0	0	3,250	35	0	0	0	0
Meredosia Lake	75	10	4,005	0	0	0	0	0	300	0	200	0	0	0	400	0	10	0	0	4,915	200	0	0	0	100
TOTAL LOWER			45,690	50	0	0	4,890	0	5,385	2,815	1,345	6,315	870	115	11,095	10	375	0	250	79,205	3,320	150	0	255	6,660
TOTAL ILLINOIS			122,165	550	0	0	5,390	0	6,260	2,815	3,620	13,065	4,370	115	17,070	185	405	0	250	176,260	5,160	150	0	260	8,410
10-Year Average 2005-2014			189,900	1,039	9,530	0	10,744	552	12,169	3,820	526	10,509	1,176	0	3,176	466	272	40	138	244,058	3,244	962	57	89	6,570

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 11/24/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	24,200	3,000	8,000	500	7,000	1,000	500	0	0	44,200	0	0	0	0	6,200
Arthur Refuge	80	0	2,050	0	0	0	200	0	0	100	0	0	0	0	0	0	0	0	0	2,350	1,220	20	0	0	1,000
Nauvoo-Ft. Madison	100	0	0	0	0	0	0	0	0	100	6,000	0	22,000	300	2,000	2,100	1,200	0	0	33,700	0	0	0	0	8,700
Ft. Madison-Dallas	100	0	500	0	0	0	0	0	0	0	0	0	0	0	300	20	0	0	0	820	400	0	0	0	50
Henderson Creek	80	10	21,000	100	0	0	1,000	0	250	0	0	0	200	0	0	0	0	0	0	22,550	250	0	0	0	610
Keithsburg Refuge	90	50	3,550	0	0	0	0	100	3,800	0	10	0	0	0	0	0	0	0	0	7,460	800	0	0	0	0
Louisa Refuge	90	50	44,000	0	0	0	0	0	0	0	0	500	0	0	0	0	0	0	0	44,500	4,700	0	0	0	0
TOTAL UPPER			71,100	100	0	0	1,200	100	4,050	200	30,210	3,500	30,200	800	9,300	3,120	1,700	0	0	155,580	7,370	20	0	0	16,560

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	95	0	14,250	0	500	0	8,000	0	5,300	3,500	500	23,000	120	0	3,700	100	0	0	0	58,970	1,050	100	50	70	400
Gilbert Lake	100	0	100	0	0	0	0	0	0	200	0	0	0	0	0	0	0	0	0	300	750	150	0	0	0
Long Lake	100	0	36,000	0	3,000	0	5,000	0	4,000	500	0	1,000	0	0	0	0	0	0	0	49,500	0	0	0	0	0
Dardenne Club	100	0	45,100	0	15,000	0	2,000	0	5,000	0	0	0	0	0	0	0	0	0	0	67,100	0	0	0	0	400
Cuivre Club	100	0	20,000	0	10,000	0	5,000	0	4,000	1,300	0	0	0	0	0	0	0	0	0	40,300	0	0	0	0	100
Batchtown Refuge	90	0	7,000	0	250	0	4,000	0	2,000	1,000	0	0	0	0	0	0	0	0	0	14,250	1,500	0	0	0	0
Cannon Refuge	80	0	40,650	100	24,390	0	16,260	0	4,065	2,440	0	1,625	0	0	0	0	0	0	0	89,530	320	0	0	0	100
Towhead Lake	80	0	2,700	0	0	0	1,500	0	500	0	0	4,000	0	0	0	0	0	0	0	8,700	0	0	0	0	0
Delair Refuge	100	0	20,200	0	250	0	6,000	0	3,000	250	0	0	0	0	0	0	0	0	0	29,700	2,700	400	0	0	0
Shanks Refuge	80	0	20,600	0	0	0	3,000	0	2,500	0	0	0	0	0	0	0	0	0	0	26,100	0	0	0	0	4,100
Meyer-Keokuk	100	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	200	0	0	0	10
TOTAL LOWER			206,630	100	53,390	0	50,760	0	30,365	9,190	500	29,625	120	0	3,700	100	0	0	0	384,480	6,520	650	50	70	5,110
TOTAL MISSISSIPPI			277,730	200	53,390	0	51,960	100	34,415	9,390	30,710	33,125	30,320	800	13,000	3,220	1,700	0	0	540,060	13,890	670	50	70	21,670
10-Year Average 2005-2014			219,373	155	23,176	0	17,229	505	17,354	2,155	13,131	13,793	94,748	726	5,448	6,179	2,253	311	36	416,741	4,367	572	2,508	121	6,182

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 12/03/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	2,000	0	0	0	500	0	500	0	1,700	900	3,300	0	5,000	0	0	0	0	13,900	2,030	0	0	0	2,000
Goose Lake	100	0	3,800	35	0	0	700	0	100	100	0	0	0	0	0	0	0	0	0	4,735	10	0	0	0	100
Senachwine Lake	100	0	8,000	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,100	200	0	0	0	0
Hitchcock Slough	100	0	1,730	10	0	0	0	0	0	0	0	0	0	0	150	0	0	5	0	1,895	20	0	0	0	0
Douglas Lake	100	0	10,000	0	0	0	4,000	0	0	0	0	3,000	0	0	600	0	0	0	0	17,600	0	0	0	0	0
Goose Lake	100	0	5,100	50	0	0	0	0	300	0	1,000	7,000	100	0	4,100	0	0	0	0	17,650	0	0	0	0	0
Upper Peoria	100	0	20,000	200	0	0	0	0	0	0	2,700	0	150	0	4,225	100	0	0	0	27,375	0	0	0	0	0
TOTAL UPPER			50,630	395	0	0	5,200	0	900	100	5,400	10,900	3,550	0	14,075	100	0	5	0	91,255	2,260	0	0	0	2,100

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	100	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Rice Lake	95	0	6,100	10	0	0	2,600	0	0	0	0	0	0	0	0	0	0	0	0	8,710	100	0	0	0	5
Big Lake	100	0	5,210	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	5,310	0	0	0	0	0
Banner Marsh	95	0	45	0	0	0	1,500	0	605	0	0	0	0	0	0	0	0	0	0	2,150	245	0	0	0	805
Duck Creek	100	0	1,520	0	0	0	0	0	50	0	0	5	0	0	0	0	0	0	20	1,595	15	0	0	0	0
Clear Lake	100	0	1,000	0	0	0	105	0	0	0	200	0	0	0	4,400	0	0	0	0	5,705	650	0	0	0	0
Chautauqua	90	0	26,330	150	0	0	1,470	0	5,100	390	0	5	10	0	750	0	0	0	0	34,205	1,220	300	4,000	5	0
Emiquon/Spoon Btm	90	0	4,900	0	0	0	500	0	1,100	270	100	200	700	200	3,000	100	100	20	590	11,780	575	0	0	10	11,000
Grass Lake	100	0	3,010	0	0	0	600	0	0	0	0	0	0	0	200	0	0	0	0	3,810	20	0	0	0	0
Jack Lake	100	0	100	0	5	0	0	0	0	0	0	0	0	0	100	0	0	0	0	205	100	0	0	0	0
Stewart Lake	100	0	0	0	0	0	0	0	0	0	0	0	50	0	900	0	220	20	0	1,190	0	0	0	0	0
Crane Lake	100	0	0	0	0	0	0	0	60	0	0	0	0	0	0	0	0	0	0	60	50	0	0	0	10
Cuba Island	100	0	2,405	0	0	0	0	0	0	0	0	4,000	0	0	100	0	0	0	0	6,505	1,100	310	5	0	10
Big Lake	30	0	7,500	0	0	0	1,500	0	0	0	0	0	0	0	0	0	0	0	0	9,000	0	0	0	0	0
Spunky Bottoms	90	0	14,200	0	0	0	3,500	0	300	0	0	0	0	0	0	0	0	0	0	18,000	610	0	0	0	100
Meredosia Lake	100	0	1,000	0	0	0	0	0	100	0	0	0	0	0	100	0	10	0	0	1,210	100	0	0	0	350
TOTAL LOWER			73,340	160	5	0	11,775	0	7,315	660	300	4,210	760	200	9,650	100	330	40	610	109,455	4,785	610	4,005	15	12,280
TOTAL ILLINOIS			123,970	555	5	0	16,975	0	8,215	760	5,700	15,110	4,310	200	23,725	200	330	45	610	200,710	7,045	610	4,005	15	14,380
10-Year Average 2005-2014			171,744	1,113	6,449	0	13,356	0	10,971	4,587	1,393	10,191	1,076	16	6,862	813	458	393	264	229,684	5,093	1,199	561	60	9,253

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 12/03/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	23,000	2,000	52,000	350	16,300	500	500	0	0	94,650	0	0	0	0	3,000
Arthur Refuge	80	0	6,000	0	0	0	300	0	0	100	0	0	0	0	0	0	200	0	0	6,600	1,300	150	0	5	200
Nauvoo-Ft. Madison	100	0	50	0	0	0	0	0	100	0	11,000	0	65,000	325	1,500	4,000	1,100	0	0	83,075	200	0	0	10	300
Ft. Madison-Dallas	100	0	300	0	0	0	0	0	0	0	100	0	0	0	0	0	10	0	0	410	0	0	0	190	0
Henderson Creek	80	0	13,410	0	0	0	500	0	0	0	200	0	2,500	0	800	0	0	0	0	17,410	1,100	0	0	0	200
Keithsburg Refuge	90	0	8,500	0	0	0	0	0	3,600	0	0	0	50	0	0	0	0	0	10	12,160	2,500	0	0	0	0
Louisa Refuge	90	0	36,300	0	0	0	0	0	500	0	110	2,500	100	0	0	0	0	0	0	39,510	1,600	0	0	0	300
TOTAL UPPER			64,560	0	0	0	800	0	4,200	100	34,410	4,500	119,650	675	18,600	4,500	1,810	0	10	253,815	6,700	150	0	205	4,000

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	100	0	32,230	0	100	0	5,600	0	3,000	1,200	1,200	17,000	350	200	5,500	1,000	0	150	0	67,530	1,210	300	1,500	5	0
Gilbert Lake	100	0	100	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	200	300	200	0	0	0
Long Lake	100	0	11,200	0	3,000	0	1,000	0	0	0	0	4,000	0	0	0	0	0	0	0	19,200	0	0	0	0	0
Dardenne Club	100	0	20,000	0	30,000	0	2,000	0	2,000	0	0	0	0	0	0	0	0	0	0	54,000	0	0	0	0	120
Cuivre Club	100	0	15,000	0	8,000	0	2,000	0	3,000	3,000	0	0	0	0	0	0	0	0	0	31,000	0	0	0	0	600
Batchtown Refuge	100	0	12,000	0	0	0	1,500	0	0	100	0	3,000	0	0	0	0	0	0	0	16,600	400	0	0	0	0
Cannon Refuge	90	0	65,000	0	59,000	0	15,000	0	1,000	5,100	0	0	0	0	0	0	0	0	0	145,100	100	0	0	0	200
Towhead Lake	90	0	500	0	0	0	0	0	0	0	0	3,100	0	0	0	0	0	0	0	3,600	0	0	0	0	0
Delair Refuge	100	0	10,100	0	0	0	2,000	0	0	500	0	0	0	0	0	0	0	0	0	12,600	1,915	1,400	10	0	0
Shanks Refuge	90	0	37,500	0	5,000	0	2,500	0	1,100	0	0	100	0	0	0	0	0	0	0	46,200	100	0	0	0	4,700
Meyer-Keokuk	100	0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	530	0	0	10	0
TOTAL LOWER			203,680	0	105,100	0	31,600	0	10,100	9,900	1,300	27,200	350	200	5,500	1,000	0	150	0	396,080	4,555	1,900	1,510	15	5,620
TOTAL MISSISSIPPI			268,240	0	105,100	0	32,400	0	14,300	10,000	35,710	31,700	120,000	875	24,100	5,500	1,810	150	10	649,895	11,255	2,050	1,510	220	9,620
10-Year Average 2005-2014			252,640	666	23,490	0	11,943	1,066	12,290	2,694	14,671	19,342	53,329	441	3,866	6,951	2,968	4,025	24	410,405	6,874	1,135	3,121	101	2,961

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 12/08/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	4,000	0	0	0	0	0	1,000	0	800	500	1,000	0	4,000	0	0	0	0	11,300	950	0	0	0	1,000
Goose Lake	100	0	8,700	100	0	0	0	0	0	0	0	200	0	0	200	0	0	0	0	9,200	0	0	0	0	0
Senachwine Lake	100	0	10,800	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,000	300	0	0	0	0
Hitchcock Slough	100	0	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	400	500	0	0	0	0
Douglas Lake	100	0	8,100	200	400	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8,700	0	0	0	0	0
Goose Lake	100	0	2,000	100	0	0	0	0	0	0	2,500	3,000	0	0	4,000	0	0	0	0	11,600	0	0	0	0	0
Upper Peoria	100	0	16,000	100	0	0	0	0	0	0	100	0	0	0	1,300	100	100	0	0	17,700	0	0	0	0	0
TOTAL UPPER			50,000	700	400	0	0	0	1,000	0	3,400	3,700	1,000	0	9,500	100	100	0	0	69,900	1,750	0	0	0	1,000
LOWER ILLINOIS RIVER VALLEY																									
Goose Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice Lake	95	0	6,300	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	6,400	200	0	0	0	0
Big Lake	100	0	7,100	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	7,200	0	0	0	0	0
Banner Marsh	95	0	2,700	0	0	0	0	0	700	0	0	0	0	0	10	0	10	0	0	3,420	375	0	0	0	160
Duck Creek	100	0	2,700	0	0	0	0	0	400	0	0	0	0	0	0	0	0	0	0	3,100	60	0	0	0	0
Clear Lake	100	0	1,210	0	0	0	0	0	0	0	300	0	0	0	5,200	0	0	0	10	6,720	100	0	0	0	0
Chautauqua	95	0	20,680	0	0	0	0	0	8,500	1,630	0	500	250	0	300	0	0	0	0	31,860	1,575	4,800	8,100	0	5
Emiquon/Spoon Btm	90	0	5,850	0	0	0	0	0	2,650	200	350	150	450	200	4,600	0	250	0	940	15,640	1,010	3,215	5	0	8,600
Grass Lake	100	0	1,100	0	0	0	6,000	0	0	0	0	0	0	0	0	0	0	0	0	7,100	0	0	0	0	0
Jack Lake	100	0	210	0	0	0	0	0	0	0	0	0	0	0	230	0	0	0	0	440	170	0	0	0	0
Stewart Lake	100	0	40	0	0	0	0	0	0	0	0	0	0	0	500	0	100	0	0	640	0	0	0	0	0
Crane Lake	100	0	960	0	0	0	100	0	50	0	0	0	0	0	0	0	100	0	0	1,210	710	150	0	0	0
Cuba Island	100	0	5,700	0	0	0	0	0	100	0	0	4,000	0	0	0	0	0	0	0	9,800	770	300	0	0	0
Big Lake	50	0	8,200	0	0	0	250	0	0	0	0	0	0	0	0	0	0	0	0	8,450	0	1,500	300	0	0
Spunky Bottoms	90	0	17,400	0	0	0	1,200	0	0	0	0	0	0	0	0	0	0	0	0	18,600	710	150	0	0	0
Meredosia Lake	100	0	200	0	0	0	0	0	100	0	50	0	50	0	0	0	0	0	30	430	0	0	0	0	0
TOTAL LOWER			80,350	0	0	0	7,650	0	12,600	1,830	700	4,650	750	200	10,840	0	460	0	980	121,010	5,680	10,115	8,405	0	8,765
TOTAL ILLINOIS			130,350	700	400	0	7,650	0	13,600	1,830	4,100	8,350	1,750	200	20,340	100	560	0	980	190,910	7,430	10,115	8,405	0	9,765
10-Year Average 2005-2014			155,286	911	8,395	0	2,781	0	2,977	491	249	2,954	342	0	2,200	1,096	215	838	257	178,991	11,206	808	1,161	9	1,858

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 12/08/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	100	500	1,500	1,000	0	8,000	0	0	0	0	11,100	5	0	0	5	1,200
Arthur Refuge	90	0	1,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,600	1,000	0	0	50	0
Nauvoo-Ft. Madison	100	0	0	0	0	0	0	0	0	0	31,000	5,500	71,500	550	11,500	2,000	3,000	0	200	125,250	0	0	0	0	3,300
Ft. Madison-Dallas	100	0	100	0	0	0	0	0	0	0	0	0	0	0	0	100	700	0	0	900	600	0	0	5	0
Henderson Creek	90	0	11,500	50	0	0	0	0	300	200	0	10	100	0	0	0	2,500	0	0	14,660	750	0	0	0	200
Keithsburg Refuge	100	0	5,000	0	0	0	0	0	3,700	100	25	0	0	5	0	0	0	0	0	8,830	1,000	0	0	0	0
Louisa Refuge	90	0	27,000	50	500	0	0	0	1,000	500	0	4,100	100	0	0	0	0	0	0	33,250	850	0	0	0	400
TOTAL UPPER			45,200	100	500	0	0	0	5,000	900	31,525	11,110	72,700	555	19,500	2,100	6,200	0	200	195,590	4,205	0	0	60	5,100

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	95	0	12,000	0	0	0	18,100	0	6,100	500	600	12,000	350	0	1,200	0	100	0	0	50,950	2,050	1,000	7,000	0	0
Gilbert Lake	100	0	100	0	0	0	0	0	600	0	0	0	0	0	0	0	0	0	0	700	340	0	0	0	0
Long Lake	100	0	7,200	200	1,000	0	0	0	0	0	0	3,000	0	0	0	0	0	0	0	11,400	0	0	0	0	0
Dardenne Club	100	0	20,000	0	8,000	0	0	0	2,000	0	0	0	0	0	0	0	0	0	0	30,000	0	0	0	0	100
Cuivre Club	100	0	20,000	0	5,000	0	500	0	3,400	500	0	0	0	0	0	0	0	0	0	29,400	0	0	0	0	500
Batchtown Refuge	100	0	8,000	0	0	0	0	0	1,000	0	0	1,000	0	0	0	0	0	0	0	10,000	400	0	0	0	0
Cannon Refuge	90	0	58,600	100	12,000	0	2,000	0	2,600	700	0	0	0	0	0	0	0	0	0	76,000	400	600	100	0	0
Towhead Lake	70	0	5,600	0	0	0	500	0	0	0	0	2,000	0	0	0	0	0	0	0	8,100	0	1,500	100	0	0
Delair Refuge	100	0	8,000	0	0	0	500	0	0	0	0	0	0	0	0	0	0	0	0	8,500	1,350	100	0	0	0
Shanks Refuge	80	0	40,600	200	2,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	42,800	0	0	0	0	5,100
Meyer-Keokuk	100	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	350	0	0	0	0
TOTAL LOWER			180,200	500	28,000	0	21,600	0	15,700	1,700	600	18,000	350	0	1,200	0	100	0	0	267,950	4,890	3,200	7,200	0	5,700
TOTAL MISSISSIPPI			225,400	600	28,500	0	21,600	0	20,700	2,600	32,125	29,110	73,050	555	20,700	2,100	6,300	0	200	463,540	9,095	3,200	7,200	60	10,800
10-Year Average 2005-2014			161,703	72	10,276	0	8,141	0	4,930	751	6,304	6,821	32,589	71	2,902	7,366	2,741	3,252	8	248,380	6,463	706	2,052	9	1,964

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 12/15/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	900	0	0	0	500	0	100	0	50	200	20	0	3,300	0	25	0	5	5,100	1,145	0	0	0	500
Goose Lake	100	0	200	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	205	0	0	0	0	0
Senachwine Lake	100	0	2,800	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	2,900	200	0	0	0	0
Hitchcock Slough	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Douglas Lake	100	0	6,200	100	0	0	4,000	0	0	0	0	0	0	0	0	0	0	0	0	10,300	0	0	0	0	0
Goose Lake	100	0	700	0	0	0	0	0	0	0	0	1,000	0	0	7,600	0	0	0	0	9,300	0	0	0	0	0
Upper Peoria	100	0	9,000	100	0	0	0	0	0	0	3,500	0	200	0	2,200	200	0	0	0	15,200	0	0	0	0	0
TOTAL UPPER			19,800	200	0	0	4,500	0	105	0	3,550	1,200	220	0	13,200	200	25	0	5	43,005	1,345	0	0	0	500

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice Lake	95	0	4,500	30	0	0	500	0	250	0	0	100	0	0	0	0	0	0	0	5,380	300	0	0	0	0
Big Lake	100	0	430	0	0	0	5,400	0	0	0	0	200	0	0	5	0	0	0	0	6,035	0	5	0	0	0
Banner Marsh	95	0	410	0	0	0	500	0	465	0	0	0	0	0	0	0	0	0	0	1,375	40	0	0	0	200
Duck Creek	100	0	230	0	0	0	0	0	5	0	0	0	0	0	0	5	0	0	0	240	65	0	0	0	0
Clear Lake	100	0	405	10	0	0	0	0	0	0	400	20	0	0	4,150	0	0	0	20	5,005	120	0	0	0	0
Chautauqua	100	0	24,960	130	0	0	2,000	0	4,600	200	50	0	10	0	1,150	5	5	0	0	33,110	530	4,000	7,000	0	0
Emiquon/Spoon Btm	95	0	9,300	80	0	0	400	0	2,320	470	100	855	310	250	5,000	0	105	0	420	19,610	630	510	0	10	5,000
Grass Lake	100	0	410	0	0	0	3,500	0	0	0	50	250	0	0	200	0	0	0	0	4,410	0	0	0	0	0
Jack Lake	100	0	10	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	60	100	0	0	0	0
Stewart Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	400	0	0	0	0	400	0	0	0	0	0
Crane Lake	100	0	140	0	0	0	0	0	0	0	250	0	0	0	0	0	0	0	0	390	270	0	0	0	0
Cuba Island	100	0	10,250	0	0	0	0	0	700	10	0	500	0	0	0	0	0	0	0	11,460	600	1,500	0	0	0
Big Lake	70	0	25,000	100	0	0	0	0	0	0	0	500	0	0	0	0	0	0	0	25,600	100	1,500	0	0	0
Spunky Bottoms	100	0	23,500	0	0	0	1,000	0	100	0	0	0	10	0	0	0	0	0	0	24,610	850	110	0	0	0
Meredosia Lake	80	0	1,200	0	0	0	0	0	110	0	0	0	0	0	0	0	0	0	0	1,310	15	5	0	0	100
TOTAL LOWER			100,745	350	0	0	13,300	0	8,550	680	850	2,475	330	250	10,905	10	110	0	440	138,995	3,620	7,630	7,000	10	5,300
TOTAL ILLINOIS			120,545	550	0	0	17,800	0	8,655	680	4,400	3,675	550	250	24,105	210	135	0	445	182,000	4,965	7,630	7,000	10	5,800
10-Year Average 2005-2014			122,746	709	2,959	0	5,421	7	2,997	1,951	266	4,280	130	0	580	1,544	59	1,078	286	145,014	13,376	3,488	3,144	3	1,969

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 12/15/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	105	0	0	0	0	0	0	0	100	2,100	2,200	0	6,000	0	0	0	0	10,505	0	0	0	5	550
Arthur Refuge	90	0	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250	1,250	200	0	0	0
Nauvoo-Ft. Madison	100	0	300	0	0	0	0	0	0	100	29,000	0	35,000	320	5	5,200	50	0	0	69,975	300	0	0	0	800
Ft. Madison-Dallas	100	0	110	0	0	0	0	0	0	0	0	0	50	0	0	400	0	0	0	560	300	0	0	10	0
Henderson Creek	90	0	19,500	50	0	0	0	0	0	0	0	0	300	0	0	0	0	0	5	19,855	300	0	0	0	0
Keithsburg Refuge	100	0	3,100	0	0	0	0	0	950	100	0	0	0	0	0	0	0	0	0	4,150	680	0	0	0	0
Louisa Refuge	90	0	20,000	50	1,000	0	0	0	0	0	100	2,600	30	0	0	0	0	0	0	23,780	1,150	500	0	0	200
TOTAL UPPER			43,365	100	1,000	0	0	0	950	200	29,200	4,700	37,580	320	6,005	5,600	50	0	5	129,075	3,980	700	0	15	1,550

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	100	0	5,200	25	0	0	16,000	0	3,500	500	100	8,600	100	0	2,350	0	0	0	0	36,375	410	600	3,500	0	0
Gilbert Lake	100	0	800	10	0	0	0	0	50	0	0	0	0	0	0	0	0	0	0	860	250	100	0	0	0
Long Lake	100	0	16,000	50	500	0	0	0	0	0	0	1,000	0	0	0	0	0	0	0	17,550	0	0	0	0	0
Dardenne Club	100	0	50,000	0	5,000	0	0	0	4,000	1,000	0	0	0	0	0	0	0	0	0	60,000	0	0	0	0	200
Cuivre Club	100	0	40,000	0	5,000	0	0	0	6,000	1,000	0	0	0	0	0	0	0	0	0	52,000	0	0	0	0	0
Batchtown Refuge	100	0	15,700	0	0	0	0	0	1,000	0	0	4,000	0	0	0	0	0	0	0	20,700	700	0	0	0	0
Cannon Refuge	100	0	152,145	250	33,075	0	22,050	0	11,025	1,100	0	3,100	10	0	0	0	0	0	0	222,755	400	0	0	0	0
Towhead Lake	50	0	800	0	0	0	500	0	50	0	0	3,000	0	0	0	0	0	0	0	4,350	0	600	225	0	0
Delair Refuge	100	0	7,000	0	0	0	3,000	0	200	0	0	0	0	0	0	0	0	0	0	10,200	525	75	0	0	0
Shanks Refuge	90	0	59,150	100	3,500	0	3,500	0	3,500	0	0	350	0	0	0	0	0	0	0	70,100	0	0	0	0	6,300
Meyer-Keokuk	100	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	120	0	0	0	0
TOTAL LOWER			346,830	435	47,075	0	45,050	0	29,325	3,600	100	20,050	110	0	2,350	0	0	0	0	494,925	2,405	1,375	3,725	0	6,500
TOTAL MISSISSIPPI			390,195	535	48,075	0	45,050	0	30,275	3,800	29,300	24,750	37,690	320	8,355	5,600	50	0	5	624,000	6,385	2,075	3,725	15	8,050
10-Year Average 2005-2014			167,513	469	4,092	0	5,145	17	2,948	855	7,705	8,333	35,313	227	2,292	11,417	3,573	6,778	9	256,684	10,284	1,886	1,930	28	1,398

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 12/22/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	2,100	0	0	0	0	0	0	0	0	0	0	0	500	50	0	0	0	2,650	1,400	25	0	0	300
Goose Lake	100	0	2,500	0	0	0	0	0	0	0	0	0	0	0	50	50	0	0	0	2,600	165	0	0	0	0
Senachwine Lake	100	0	1,500	0	0	0	0	0	0	0	50	0	0	0	0	50	0	0	0	1,600	300	0	0	0	0
Hitchcock Slough	100	0	450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	450	0	0	0	0	0
Douglas Lake	100	0	800	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0	0	0
Goose Lake	100	0	21,000	100	0	0	0	0	0	0	1,000	0	0	0	500	0	0	0	0	22,600	0	0	0	0	0
Upper Peoria	100	0	1,050	0	0	0	0	0	0	0	1,700	0	150	0	700	1,350	0	0	0	4,950	0	0	0	0	0
TOTAL UPPER			29,400	100	0	0	0	0	0	0	2,750	0	150	0	1,750	1,500	0	0	0	35,650	1,865	25	0	0	300

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice Lake	95	0	1,925	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,925	835	0	0	0	0
Big Lake	100	0	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	0	0	0	0	0
Banner Marsh	95	0	255	0	0	0	0	0	565	0	0	0	0	0	0	0	0	0	5	825	250	0	0	0	100
Duck Creek	100	0	1,160	0	0	0	0	0	530	0	0	0	0	0	0	0	0	0	5	1,695	25	300	500	0	0
Clear Lake	100	0	0	0	0	0	5	0	10	0	50	0	0	0	2,520	50	0	0	10	2,645	0	0	0	0	0
Chautauqua	100	0	21,345	50	0	0	4,200	0	3,250	660	100	0	0	0	365	20	0	0	10	30,000	1,610	600	15,000	0	0
Emiquon/Spoon Btm	95	0	5,880	5	0	0	0	0	2,000	60	360	1,250	160	200	3,450	25	0	0	750	14,140	810	3,300	700	0	6,900
Grass Lake	100	0	120	0	0	0	300	0	0	0	10	0	0	0	100	0	0	0	0	530	0	0	0	0	0
Jack Lake	100	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Stewart Lake	100	0	150	0	0	0	0	0	0	0	220	0	0	0	300	110	0	0	0	780	0	0	0	0	0
Crane Lake	100	0	130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	130	430	0	1,000	0	50
Cuba Island	100	0	1,000	0	0	0	0	0	200	200	0	400	0	0	0	0	0	0	5	1,805	700	500	0	0	0
Big Lake	70	0	24,000	50	0	0	0	0	0	0	0	2,500	0	0	0	0	0	0	0	26,550	0	100	0	0	0
Spunky Bottoms	100	0	18,500	0	0	0	700	0	350	0	0	10	0	0	0	0	0	0	0	19,560	200	0	0	0	0
Meredosia Lake	80	0	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	150	0	0	0	10
TOTAL LOWER			75,985	105	0	0	5,205	0	6,905	920	740	4,160	160	200	6,735	205	0	0	785	102,105	5,010	4,800	17,200	0	7,060
TOTAL ILLINOIS			105,385	205	0	0	5,205	0	6,905	920	3,490	4,160	310	200	8,485	1,705	0	0	785	137,755	6,875	4,825	17,200	0	7,360
10-Year Average 2005-2014			83,055	674	70	0	900	0	1,610	102	342	1,003	127	0	1,195	1,390	25	2,425	85	93,219	23,649	5,382	3,917	1	549

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 12/22/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	0	500	450	0	4,500	0	0	0	0	5,450	0	0	0	0	400
Arthur Refuge	90	0	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200	1,100	300	0	5	0
Nauvoo-Ft. Madison	100	0	0	0	0	0	0	0	0	0	25,000	0	75,000	500	4,000	5,000	2,500	0	0	112,000	0	0	0	0	200
Ft. Madison-Dallas	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	20	0	0	0	30	0
Henderson Creek	90	0	21,300	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	21,305	900	0	0	0	0
Keithsburg Refuge	100	0	50	0	0	0	0	0	250	0	0	10	0	0	0	0	0	0	0	310	580	0	0	0	100
Louisa Refuge	90	0	900	0	0	0	0	0	100	0	100	2,000	0	0	0	0	0	0	0	3,100	1,100	3,000	5	0	300
TOTAL UPPER			22,450	0	0	0	0	0	350	0	25,100	2,510	75,455	500	8,500	5,020	2,500	0	0	142,385	3,680	3,300	5	35	1,000

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	100	0	8,000	0	50	0	1,100	0	2,200	100	150	9,400	200	0	2,000	200	150	0	0	23,550	1,000	500	8,000	5	0
Gilbert Lake	100	0	2,000	0	0	0	0	0	300	0	0	0	0	0	0	0	0	0	0	2,300	600	750	0	0	0
Long Lake	100	0	8,500	0	500	0	0	0	0	0	0	700	0	0	0	0	0	0	0	9,700	0	0	0	0	0
Dardenne Club	100	0	22,800	0	8,000	0	0	0	500	500	0	0	0	0	0	0	0	0	0	31,800	0	0	0	0	0
Cuivre Club	100	0	30,000	0	20,000	0	0	0	1,000	1,000	0	0	0	0	0	0	0	0	0	52,000	0	0	0	0	300
Batchtown Refuge	100	0	10,200	0	0	0	0	0	900	0	0	2,500	0	0	0	0	0	0	0	13,600	450	0	0	0	0
Cannon Refuge	100	0	29,250	0	6,750	0	4,500	0	2,250	2,250	100	0	0	0	0	0	0	0	0	45,100	770	1,000	0	0	0
Towhead Lake	50	0	400	0	0	0	100	0	0	0	0	500	0	0	0	0	0	0	0	1,000	100	0	0	0	0
Delair Refuge	100	0	1,500	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,600	450	4,000	500	0	0
Shanks Refuge	90	0	31,920	50	3,800	0	1,140	0	760	380	0	0	0	0	0	0	0	0	0	38,050	0	0	0	0	1,850
Meyer-Keokuk	100	0	600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	600	770	0	0	0	0
TOTAL LOWER			145,170	50	39,200	0	6,840	0	7,910	4,230	250	13,100	200	0	2,000	200	150	0	0	219,300	4,140	6,250	8,500	5	2,150
TOTAL MISSISSIPPI			167,620	50	39,200	0	6,840	0	8,260	4,230	25,350	15,610	75,655	500	10,500	5,220	2,650	0	0	361,685	7,820	9,550	8,505	40	3,150
10-Year Average 2005-2014			153,205	404	3,939	0	1,880	2	1,664	140	5,122	6,608	40,273	56	841	7,781	1,561	9,234	0	234,669	12,326	3,438	3,809	42	365

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 12/29/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	0	200	0	0	0	0	0	0	0	0	0	130	0	450	150	0	0	0	930	670	200	0	0	0
Goose Lake	100	0	2,130	10	0	0	0	0	0	0	0	75	0	0	0	0	0	0	0	2,215	50	0	0	0	0
Senachwine Lake	100	0	200	0	0	0	0	0	0	0	100	100	0	0	20	0	0	0	0	420	600	50	0	0	0
Hitchcock Slough	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0
Douglas Lake	100	0	1,305	5	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	1,325	0	0	0	0	0
Goose Lake	100	0	1,000	0	0	0	0	0	0	0	110	1,000	0	0	700	0	0	0	0	2,810	5	0	0	0	0
Upper Peoria	100	0	1,310	0	0	0	0	0	0	0	1,710	225	125	0	200	300	0	0	0	3,870	230	0	0	0	100
TOTAL UPPER			6,145	15	0	0	0	0	0	0	1,920	1,415	255	0	1,370	450	0	0	0	11,570	1,615	250	0	0	100

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice Lake	100	0	3,050	15	0	0	200	0	0	0	0	20	0	0	0	0	0	0	0	3,285	350	400	0	0	0
Big Lake	100	0	3,000	0	0	0	0	0	0	0	100	50	0	0	10	0	0	0	0	3,160	0	30	0	0	0
Banner Marsh	100	0	105	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	5	135	35	0	0	0	330
Duck Creek	100	0	210	0	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	235	5	100	0	0	0
Clear Lake	100	0	105	0	0	0	0	0	0	0	0	0	0	20	2,230	0	0	0	0	2,355	0	100	0	0	0
Chautauqua	100	0	18,505	100	0	0	0	0	0	0	10	0	0	0	220	100	0	0	0	18,935	250	4,300	26,000	0	0
Emiquon/Spoon Btm	95	0	9,085	0	15	0	0	0	700	0	165	1,150	160	200	1,260	20	0	0	30	12,785	550	2,100	0	5	6,400
Grass Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jack Lake	100	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	30	0	0	0	0	0
Stewart Lake	100	0	0	0	0	0	0	0	0	0	250	0	0	0	0	120	0	0	0	370	0	0	0	0	0
Crane Lake	100	0	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	300	250	0	0	0
Cuba Island	100	0	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	1,005	300	250	5	0	0
Big Lake	100	0	3,300	0	0	0	0	0	0	0	0	3,200	0	0	0	0	0	0	0	6,500	450	0	0	0	0
Spunky Bottoms	100	0	12,600	0	0	0	0	0	1,000	0	0	150	0	0	0	0	0	0	0	13,750	310	4,000	0	0	0
Meredosia Lake	100	0	930	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	1,030	105	0	0	0	0
TOTAL LOWER			52,390	115	15	0	200	0	1,750	0	525	4,670	160	220	3,750	240	5	0	35	64,075	2,655	11,530	26,005	5	6,730
TOTAL ILLINOIS			58,535	130	15	0	200	0	1,750	0	2,445	6,085	415	220	5,120	690	5	0	35	75,645	4,270	11,780	26,005	5	6,830
10-Year Average 2005-2014			83,055	674	70	0	900	0	1,610	102	342	1,003	127	0	1,195	1,390	25	2,425	85	93,219	23,649	5,382	3,917	1	549

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 12/29/2015 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	0	0	0	0	0	0	0	0	0	400	2,500	500	0	7,000	0	500	0	0	10,900	0	0	0	0	1,000
Arthur Refuge	100	0	300	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	400	300	400	0	5	0
Nauvoo-Ft. Madison	100	0	0	0	0	0	0	0	0	0	19,000	2,300	90,600	825	4,600	6,600	500	0	0	124,425	80	0	0	0	4,400
Ft. Madison-Dallas	100	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	220	0	0	0	0
Henderson Creek	100	0	9,500	0	10	0	0	0	0	0	0	300	0	0	0	0	0	0	0	9,810	630	3,700	10	0	0
Keithsburg Refuge	100	10	710	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	810	800	0	0	0	200
Louisa Refuge	100	70	10,000	0	0	0	0	0	400	0	0	1,100	50	0	0	0	0	0	0	11,550	400	6,500	0	0	0
TOTAL UPPER			20,515	0	10	0	0	0	400	0	19,400	6,300	91,150	825	11,600	6,700	1,000	0	0	157,900	2,430	10,600	10	5	5,600

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	100	0	4,500	0	100	0	100	0	200	0	430	7,900	500	0	3,600	100	100	0	0	17,530	0	200	4,500	0	0
Gilbert Lake	100	0	7,000	0	0	0	0	0	500	0	100	4,000	0	0	0	0	0	0	0	11,600	0	0	0	0	500
Long Lake	100	0	7,600	0	0	0	0	0	500	0	100	4,000	0	0	0	0	0	0	0	12,200	0	0	0	0	500
Dardenne Club	100	0	18,000	0	500	0	0	0	200	0	0	0	0	0	0	0	0	0	0	18,700	0	0	0	0	0
Cuivre Club	100	0	21,100	0	2,000	0	0	0	7,800	0	0	0	0	0	0	0	0	0	0	30,900	0	0	0	0	1,300
Batchtown Refuge	100	0	3,800	0	0	0	0	0	0	0	0	200	0	0	0	0	0	0	0	4,000	0	0	0	0	1,000
Cannon Refuge	100	0	44,500	0	2,400	0	100	25	2,400	1,000	0	1,000	0	0	0	0	0	0	0	51,425	320	0	0	0	500
Towhead Lake	100	0	150	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	10
Delair Refuge	100	0	3,600	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,600	350	0	0	0	0
Shanks Refuge	100	0	17,000	0	500	0	0	0	1,100	0	0	150	0	0	0	0	0	0	0	18,750	0	0	0	0	6,050
Meyer-Keokuk	100	0	350	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0	0	400	300	0	0	0	0
TOTAL LOWER			127,600	0	5,500	0	200	25	12,700	1,000	630	17,300	500	0	3,600	100	100	0	0	169,255	970	200	4,500	0	9,860
TOTAL MISSISSIPPI			148,115	0	5,510	0	200	25	13,100	1,000	20,030	23,600	91,650	825	15,200	6,800	1,100	0	0	327,155	3,400	10,800	4,510	5	15,460
10-Year Average 2005-2014			153,205	404	3,939	0	1,880	2	1,664	140	5,122	6,608	40,273	56	841	7,781	1,561	9,234	0	234,669	12,326	3,438	3,809	42	365

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER ILLINOIS RIVER VALLEY Date: 01/05/2016 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Hennepin/Hopper	100	90	0	0	0	0	0	0	0	0	0	0	50	0	0	10	0	10	0	70	1,330	400	0	0	200
Goose Lake	100	10	600	0	0	0	0	0	100	0	10	200	0	0	0	10	0	0	0	920	250	0	0	0	0
Senachwine Lake	100	10	250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	255	105	0	0	0	0
Hitchcock Slough	100	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0	0	0	0	0
Douglas Lake	100	20	7,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7,000	200	0	0	0	0
Goose Lake	100	10	5,000	0	0	0	0	0	0	0	0	500	0	0	600	0	0	0	0	6,100	800	20	0	0	0
Upper Peoria	100	10	600	0	0	0	0	0	0	0	400	0	25	10	0	9,000	0	0	0	10,035	710	300	0	0	0
TOTAL UPPER			13,475	0	0	0	0	0	100	0	410	700	75	10	600	9,020	0	15	0	24,405	3,395	720	0	0	200

LOWER ILLINOIS RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Goose Lake	100	10	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0
Rice Lake	100	10	2,650	0	0	0	0	0	0	0	0	0	0	0	40	0	0	0	0	2,690	280	0	0	0	0
Big Lake	100	10	23,050	0	0	0	0	0	0	0	0	0	100	0	0	5	0	0	0	23,155	800	4,500	0	0	0
Banner Marsh	100	99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	0	0	0	0
Duck Creek	100	10	500	0	0	0	0	0	175	0	0	0	0	0	0	0	0	10	25	710	2,000	1,500	0	0	0
Clear Lake	100	10	0	0	0	0	0	0	0	0	50	100	10	0	1,840	0	0	0	0	2,000	380	0	0	0	50
Chautauqua	100	0	120	0	0	0	0	0	0	0	0	0	0	0	115	0	0	0	0	235	610	0	0	0	0
Emiquon/Spoon Btm	100	40	7,340	5	600	0	0	0	955	50	200	4,000	550	0	1,215	2,150	50	230	510	17,855	620	380	0	0	3,500
Grass Lake	100	10	450	0	0	0	0	0	0	0	0	0	0	0	0	50	0	0	0	500	55	0	0	0	0
Jack Lake	100	10	15	5	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	50	0	0	0	0	0
Stewart Lake	100	10	0	0	0	0	0	0	0	0	40	0	0	0	30	70	0	0	0	140	0	0	50	0	0
Crane Lake	100	30	610	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	610	500	1,000	0	0	0
Cuba Island	100	20	200	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	205	370	30	0	0	0
Big Lake	100	10	5,000	10	0	0	0	0	0	0	0	5,000	700	0	0	0	0	0	0	10,710	400	0	0	0	0
Spunky Bottoms	100	10	3,500	0	0	0	0	0	1,000	0	0	500	200	0	0	0	0	0	0	5,200	55	0	0	0	0
Meredosia Lake	100	10	2,210	0	0	0	0	0	0	0	205	0	0	0	0	0	0	0	0	2,415	200	1,700	0	0	0
TOTAL LOWER			45,675	20	600	0	0	0	2,130	50	495	9,600	1,590	0	3,240	2,280	50	240	535	66,505	6,770	9,110	50	0	3,550
TOTAL ILLINOIS			59,150	20	600	0	0	0	2,230	50	905	10,300	1,665	10	3,840	11,300	50	255	535	90,910	10,165	9,830	50	0	3,750
10-Year Average 2005-2014			43,083	252	25	0	0	0	588	33	48	314	518	0	164	1,938	1	2,369	3	49,333	15,811	7,101	3,926	13	204

ILLINOIS NATURAL HISTORY SURVEY WATERFOWL AERIAL INVENTORY DATA

UPPER MISSISSIPPI RIVER VALLEY Date: 01/05/2016 Observer: Aaron Yetter

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Keokuk-Nauvoo	100	10	0	0	0	0	0	0	0	0	500	1,500	40,150	0	4,000	1,000	0	0	0	47,150	250	0	0	0	600
Arthur Refuge	100	90	1,100	0	0	0	0	0	0	0	0	0	0	0	0	500	0	10	0	1,610	4,050	400	0	0	0
Nauvoo-Ft. Madison	100	10	0	0	0	0	0	0	0	0	21,000	0	187,000	0	0	15,000	2,100	100	0	225,200	230	0	0	0	0
Ft. Madison-Dallas	100	10	50	0	0	0	0	0	0	0	0	0	0	0	0	450	0	260	0	760	1,150	0	0	0	0
Henderson Creek	100	80	40,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40,000	5,350	5,700	5	0	0
Keithsburg Refuge	100	99	2,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,000	1,535	0	0	0	50
Louisa Refuge	100	99	3,600	0	0	0	0	0	0	0	0	2,000	0	0	0	0	0	0	0	5,600	1,800	0	0	0	0
TOTAL UPPER			46,750	0	0	0	0	0	0	0	21,500	3,500	227,150	0	4,000	16,950	2,100	370	0	322,320	14,365	6,100	5	0	650

LOWER MISSISSIPPI RIVER VALLEY

LOCATION	%WET	%ICE	MALL	ABDU	NOPI	BWTE	AGWT	AMWI	GADW	NSHO	LESC	RNDU	CANV	REDH	RUDU	COGO	BUFF	COME	HOME	TOTAL DUCKS	CAGO	GWFG	LSGO	AWPE	AMCO
Swan Lake	100	10	2,200	0	0	0	0	0	2,100	0	0	10,000	20	0	300	0	0	0	0	14,620	600	0	7,000	0	0
Gilbert Lake	100	20	13,200	50	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,250	900	1,200	0	0	0
Long Lake	100	10	200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0	0	0
Dardenne Club	100	20	97,000	0	5,000	0	0	0	2,000	600	0	1,000	0	0	300	0	0	0	0	105,900	1,000	0	0	0	0
Cuivre Club	100	90	25,000	0	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,500	0	0	0	0	100
Batchtown Refuge	100	90	16,000	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16,300	650	0	0	0	0
Cannon Refuge	100	90	12,100	0	8,000	0	7,000	0	1,500	1,000	0	0	0	0	0	5	0	0	0	29,605	470	2,700	5	5	0
Towhead Lake	100	90	0	0	0	0	0	0	0	0	0	75	0	0	0	0	0	0	0	75	200	0	0	0	0
Delair Refuge	100	90	3,100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,100	800	4,000	0	0	0
Shanks Refuge	100	90	4,005	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4,105	0	0	0	0	100
Meyer-Keokuk	100	10	3,050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,050	2,345	4,000	0	0	0
TOTAL LOWER			175,855	50	14,900	0	7,000	0	5,600	1,600	0	11,075	20	0	600	5	0	0	0	216,705	6,965	11,900	7,005	5	200
TOTAL MISSISSIPPI			222,605	50	14,900	0	7,000	0	5,600	1,600	21,500	14,575	227,170	0	4,600	16,955	2,100	370	0	539,025	21,330	18,000	7,010	5	850
10-Year Average 2005-2014			116,126	139	1,588	0	375	0	754	0	3,700	1,063	35,876	6	66	2,338	579	4,823	0	167,431	8,458	3,484	2,266	6	101