U. S. FISH & WILDLIFE SERVICE - DEPARTMENT OF THE INTERIOR

Waterbird Migration Summary for the Fall of 2016 through Spring 2017 Season and Comparisons of Management Costs for Two Rivers National Wildlife Refuge, Illinois

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Cover Photo: Northern Pintail flock over moist-soil habitat. Credit: William R. Coatney.

Summary:

Two Rivers National Wildlife Refuge is comprised of three divisions that span 60 miles of the Mississippi River, and 9 miles of the lower Illinois River. The refuge provides managed wetland habitats for migratory birds that rest, feed, and winter along the Mississippi Flyway. Twelve of the refuge's fifteen managed wetland units and the majority of the waterbird use occur on the Calhoun Division. Most of the units can be described as small to medium sized moist-soil impoundments but two of the units are each over 1,000 acres in size and are subimpoundments of the largest backwater lake in the lower Illinois River valley. All of these units are actively managed as a complex to provide high quality waterbird habitats but refuge staff must assess the relative return in terms of a primary objective (bird-use days) in order to efficiently manage the complex in times of restricted budgets. Waterbird data collected under the Integrated Waterbird Management & Monitoring Initiative's protocol (IWMM) were used to compare unit specific contributions by adjusting bird-use days for impoundment size, flooded area, and management costs. Unit level waterbird use-days were adapted as a measure for evaluating returns on management costs.

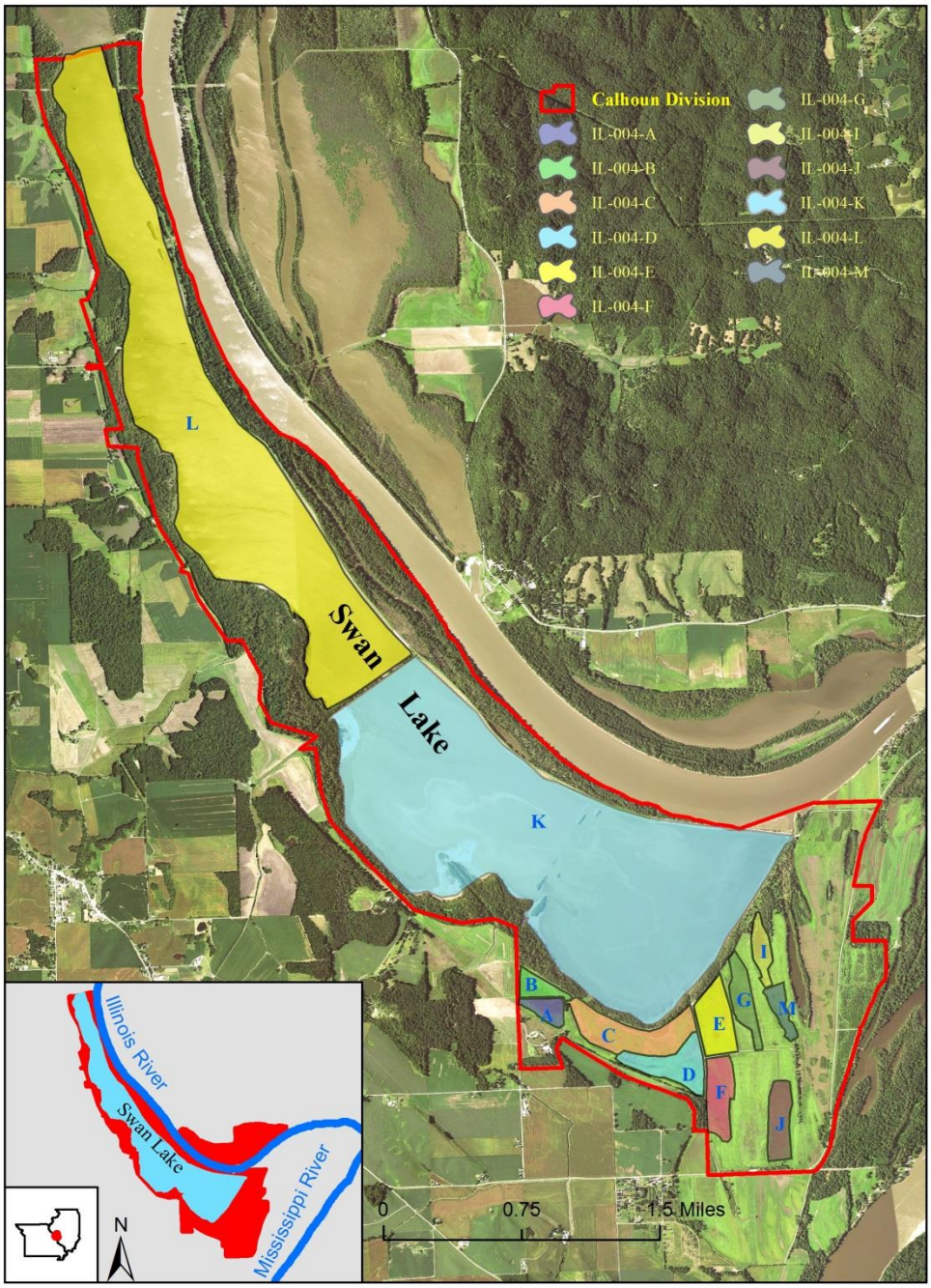

Figure 1 Managed wetland impoundments as Integrated Waterbird Management Monitoring survey units on the Calhoun Division of Two Rivers National Wildlife Refuge, Calhoun County, Illinois. The two large units, Il-004-K and Il-004-L, are sub-impoundments of Swan Lake**.**

Site Description:

The refuge was established in 1958 as part of the Mark Twain NWR complex to provide inviolate sanctuary for migratory birds. The 2011 Habitat Management plan identified American bittern, blue-winged teal, canvasback , lesser scaup, least tern ,short-billed dowitcher, pectoral sandpiper, and the mallard as focal species for the area's wetlands (USFWS 2011). The Refuge includes six divisions - Calhoun, Gilbert Lake, Batchtown, Portage Island, Apple Creek, and Clarksville Island totaling 9,360 acres. At 4656 acres, Calhoun Division is the largest and most intensively managed with numerous small moist-soil impoundments and two large units managed as sub-impoundments of Swan Lake (fig.1). When resources and river levels allow all of the units are intensively managed for moist-soil plant communities to provide forage for migrating and wintering waterfowl.

There is a large discrepancy in the area of the swan lake units and the moist-soil impoundments. At 2900 acres Swan Lake is a prominent but highly altered habitat feature for the lower Illinois Valley. Habitat degradation of this and similar floodplain lakes within the Illinois River system has progressed since the refuge was established. The prominent stressors to these backwater systems include sedimentation, increased river flows from the Chicago Sanitary and Ship Canal, increased stage and stability of low base flows due to the lock and dam system, and levee and drainage ditch construction (Bellrose et al 1979, 1983, Theiling and Nestler 2010). To counteract the multiple hydrological alterations, Swan Lake is managed by altering its water level relative to adjacent Illinois River. To produce desired plant communities the lake is disconnected from the Illinois River and pumped several feet below the pool elevation of the river during the summer and slowly flooded during the fall migration. The lake is approximately a meter deep at normal river pool. Dewatering efforts can take a few weeks or months depending on local precipitation patterns. The levee, pumps, and stop-log structures were designed and built as part of the Swan Lake Habitat Restoration and Enhancement Project sponsored by the US Army Corps of Engineers.

The ten moist-soil units (MSUs) range in size from 15 to 76 acres and average 32.9 acres. Beginning in the summer and fall of 2015 the units have been enrolled in an aggressive effort to set back plant community succession. All of the units are exposed to frequent inundation whenever the Illinois or Mississippi rivers reach moderate flood stages. In wet-periods the window for managing vegetation in the units may be closed for several months. Water smartweed (*Polygonum coccineum*) and calico aster (*Symphyotrichum lateriflorum*) are two perennial rhizomatous broadleaf plants that are flood tolerant and fast growing. These are the primary plants that displace early to mid-season mudflats in the MSUs. The species are controlled through mechanical means (primarily disking and mowing) in an effort to increase habitat heterogeneity, plant diversity, and waterfowl seed production. Water levels can fluctuate widely over the migration season due to groundwater losses, evaporation, and active water management.

Monitoring Approach:

Waterbird surveys were conducted throughout the non-breeding period following the Integrated Waterbird Management and Monitoring (IWMM) protocol (Loges et al 2015). For the purposes of this study each management unit was treated as an individual survey unit. Bird abundance and habitat covariates on water depth, dry ground, and habitat cover were collected weekly or biweekly. Gaps in surveys longer than two weeks reflect periods outside the migration/wintering portion of the annual life cycle or "iced-up" conditions when few birds were present. Management actions were tracked by unit and summarized at the end of the Calendar year. Vegetation surveys were completed late in the growing season to assess the vegetation communities of the units.

Analysis:

Bird Use

Bird observation and management actions data were downloaded from the IWMM database for the surveys conducted between Sept 1, 2016 and March 31, 2017. Bird observations were converted to raw use-days by species and unit and filtered for dabbling ducks to produce a dabbler-use-day (dud) measure following the area under the curve approach (Farmer & Durbian 2006). The bird survey covariates of % dry and % mud were used to document the proportion of the unit flooded over the migration season to account for the influence of fluctuating water levels on the availability of dabbling duck habitat at the unit scale. The total DUDs were then adjusted by flood frequency for comparisons across units. As a primary focal guild for the refuge, only dabbling duck use-days (DUDs) were used for unit scale abundance and cost efficiency comparisons.

$$duds = \int_{t=1}^{f} d_t$$

$$duds\ per\ water\ acre = \frac{\int_{t1}^{f} d_t}{\frac{1}{n}\sum[100 - (q_t + m_t)]}$$

Where d= the estimate of dabbling ducks on survey date t, f=the last survey for the season, q= proportion of unit that was dry on survey date t, m= proportion of unit that was mud on survey date t, n= number of survey dates.

Management Actions

Costs by unit were derived from actions downloaded from the IWMM database and cost estimates from IWMM's national protocol framework. It should be noted that costs are static for a defined set of actions and are derived from general sources. The estimates do not include major repairs or capital improvements. The costs are useful as constants for relative comparisons across units but they do not

reflect actual expenditures at the refuge. To measure the management cost for a unit, the acre-based cost for each implemented action in a unit was summed for the period of interest.

To convert the area estimate of drawdown in Swan Lake to an acre foot value a regression of the area of the lake exposed at various elevations between 420 and 417 feet was used for lower Swan (af =.2833 ax -86.431) and middle Swan (af=.2825 ax -71.581) where af = acre feet and ax = acres exposed. The MSUs are all managed for shallow water, we assumed an average depth of 1 foot for the MSUs which allowed for a 1:1 ratio of flooded surface acres to acre feet in the cost calculations.

Seed Production Index

For a general assessment of the waterfowl food quantity in each unit a seed production index (SPI) (Naylor et al. 2005) for each unit was produced as a report from the IWMM database using vegetation survey observations from early September 2016. The SPI is derived from the proportion of a survey unit's area covered by a plant (PlantPct*EmergentCover) /100) and a seed head size and density score for each species by unit.

Plant taxa included in the seed head index are:

- Barnyardgrass or wild millet (*Echinochloa crus-galli*)
- Coast cockspur grass or Walter's millet (*Echinchloa walteri*)
- Rice Cutgrass (*Leersia oryzoides*)
- Fall panicgrass (*Panicum dichotomiflorum*)
- Curlytop knotweed (*Polygonum lapathifolium*)
- Pennsylvania smartweed or pinkweed or big seeded smartweed (*Polygonum pensylvanicum*)
- Foxtail (*Setaria*)
- Beggarticks (*Bidens*)
- Yellow Nutsedge (*Cyperus esculentus*)
- Amazon sprangletop (*Leptochloa panicoides*)
- Redroot flatsedge (*Cyperus erythrorhizos*)

Results:

Bird Use

Total waterbird use-days on the Calhoun Division was 8.3 million for the period of September 1st 2016 through March 31st 2017. Thirty-six waterbird species were observed with dabbling ducks dominant; species in this guild represented 80 % of the total waterbird use (6.7 million use-days). Northern pintails were the most abundant (3.0 million use-days), contributing 45% of all DUDs for the division and 36% of all waterbird use-days. Mallard (16%) and gadwall (14%) were the only other species exceeding 10% of all waterbird use-days. Use-day totals by species and unit are presented in appendix A.

Combined, the two Swan Lake survey units (Il-004-l and IL-004-K) provided 96% of the overall WUDs and DUDs for the Division. The "Office" MSU had the highest density of bird use when raw DUDs were adjusted for surface water acres while the middle Swan Lake unit had the second highest density (table 1).

Table 1 Unit summaries for the 2016/17 migration season of raw dabbler-use-day totals, proportion of total duds as a %, duds adjusted for area of surface water at the time of each survey and rank of adjusted DUDs**.**

Unit Name	Unit Code	Raw DUDs	% of total raw DUDs	DUDs/water acre	Rank by DUDs/water acre
Office MSU	IL-004-A	47610	0.7	3881	1
Duck Club MSU	IL-004-B	13063	0.2	1452	8
Lower Calhoun MSU	IL-004-C	65781	1.0	1101	9
Upper Calhoun MSU	IL-004-D	8993	0.1	255	11
Pump Station MSU	IL-004-E	49550	0.7	3205	3
Schoolhouse MARSH	IL-004-F	11311	0.2	729	10
Lower Headquarters MSU	IL-004-G	2250	0.0	152	12
Little Swan MSU	IL-004-I	32093	0.5	1716	6
County Road MSU	IL-004-J	31875	0.5	1843	5
Lower Swan Lake	IL-004-K	2936733	44.2	2149	4
Middle Swan Lake	IL-004-L	3429783	51.6	3443	2
Brushpile	IL-004-M	22640	0.3	1676	7

Management Actions

The total costs of managing each unit was derived as the product of the total acres or acre-feet (for water level actions) treated in a unit for all management actions and the respective action specific costs, as a constant, for each action. Detailed descriptions of the action specific costs can be found in the IWMM monitoring framework. In moist-soil systems the benefit derived from management actions may persist for only a few years before plant succession shifts back to woody or perennial herbaceous vegetation (Fredrickson and Taylor 1982). For this reason we reviewed management actions for the 18 month period leading up to Nov 1 2016.

The total estimated cost for the 18 month period across all management actions across all units was $85412 or roughly $57,000 per year (table 2). Pumping cost for both swan lake units was estimated at $58,662. Swan lake costs are limited to pumping water using a diesel powered pumps, no disturbance management is needed on this unit. The cost in diesel alone in 2016 for both Swan Lake units exceeded $27,000. IWMM protocol costs were derived using a diesel price of $3.50 per gallon while the September 2016 actual cost reflected diesel prices averaging $2.39 per gallon nationally.

Table 2 Estimated management costs for the 2016/17 migration season with and costs per dabbler use-day (DUD) as adjusted for area of surface water with effciciency ratios to the most efficient unit.

Unit	Unit Code	Total Cost	Unit cost/acre	DUDs per water-acre	Cost per water acre-use-day	ratio to most efficient
Office MSU	IL-004-A	$1,753	$112	3881	$0.029	7
Duck Club MSU	IL-004-B	$1,794	$108	1452	$0.074	17
Lower Calhoun MSU	IL-004-C	$6,537	$86	1101	$0.078	18
Upper Calhoun MSU	IL-004-D	$3,894	$82	255	$0.322	76
Pump Station MSU	IL-004-E	$3,705	$87	3205	$0.027	6
Schoolhouse MARSH	IL-004-F	$2,499	$73	729	$0.100	23
Lower Headquarters MSU	IL-004-G	$1,889	$65	152	$0.428	101
Little Swan MSU	IL-004-I	$944	$47	1716	$0.027	6
County Road MSU	IL-004-J	$2,496	$78	1843	$0.042	10
Lower Swan lake	IL-004-K	$43,637	$31	2149	$0.015	3
Middle Swan lake	IL-004-L	$15,025	$15	3443	$0.004	1
Brushpile	IL-004-M	$1,239	$80	1676	$0.048	11

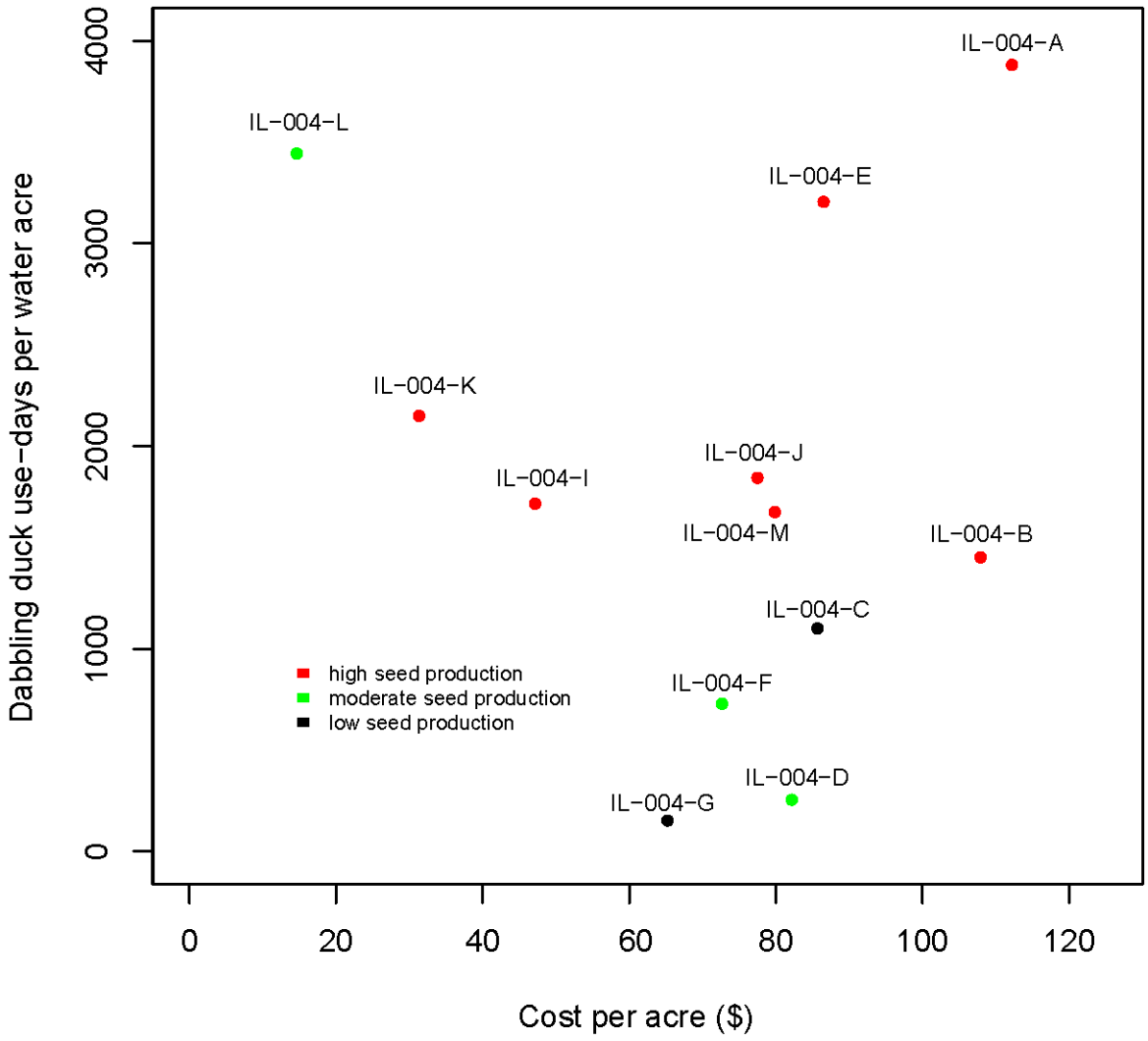

Figure 2 Scatterplot of adjusted dabbler use-day totals to management cost by unit and color coded to reflect seed production quality derived from unit scale seed production index values.

2016 Seed Production

SPI values in table 3 ranged from 8 to 49. SPI values in similar Illinois river valley wetlands were found to be significantly related to seed abundances from core samples and ranged from a low of 10 to high of 67 (Stafford et al 2011). Moist-soil seed production could be described as high or moderate in all but two units (IL-004-G & IL-004-C). A hypothetical unit saturated with a single species at maximum seed size, density, and coverage would have an SPI value of 20, this value established the qualitative thresholds.

We used an SPI of 20 as the high production threshold while SPI's including and ranging between 12 and 19 are considered moderate seed production. Values below 12 are considered low seed production. In 2016, the mean SPI values for the two Swan Lake units and the MSUs were similar (24.5 and 22.2 respectively).

Refuge staff successfully implemented partial drawdowns on 823 acres (333Ha) across both Swan lake units. A quantitative seed production report for the exposed portion of the Swan Lake estimated seed production of 1391 kg/ha (1241 lbs/ac) and an estimated carrying capacity was 3,892,423 Duck energy-days (DEDs) with a 95% CI ranging between 1,367,864 and 6,416,977 use-days (Gray 2016, included as appendix B). The observed use-day total was slightly above the upper limit of the CI and nearly twice that of the mean. The difference in the mean derived estimate of DEDs and observed DUDs for Swan Lake indicated a DED deficit of 38.9% for the 2016/2017 season.

Table 3 Seed production index values by management unit.

Unit	Unit Code	Seed Production Index	Seed Production Category	% annual vegetation*
Office MSU	IL-004-A	49	high	100
Duck Club MSU	IL-004-B	25	high	100
Lower Calhoun MSU	IL-004-C	10	low	56
Upper Calhoun MSU	IL-004-D	17	moderate	91
Pump Station MSU	IL-004-E	21	high	88
Schoolhouse MARSH	IL-004-F	12	moderate	78
Lower Headquarters MSU	IL-004-G	8	low	90
Little Swan MSU	IL-004-I	21	high	89
County Road MSU	IL-004-J	24	high	78
Lower Swan lake	IL-004-K	35	high	87
Middle Swan lake	IL-004-L	17	moderate	100
Brushpile	IL-004-M	32	high	100

* Proportion as a percent of all herbaceous vegetation with an annual life cycle.

Discussion

While wetland units on national wildlife refuges are typically managed for multiple objectives, selecting a primary objective and evaluating the performance of a complex of management units towards

meeting that objective can help refine management efforts by identifying efficient approaches. Unit specific waterbird abundance, water level data, and management costs collected under the IWMM protocol facilitated relative comparisons across units for the 2016/17 migration season.

Bird-use across all units was dominated by dabbling ducks and reflects the implementation of moist-soil management strategies targeting this guild. The two Swan Lake units represented an overwhelming majority (96%) of the Calhoun Division's bird-use in the 2016/17 migration season. Swan Lake is expected to contribute high use-day numbers due to its large size but when use-days were adjusted for water area, the two units still outperformed all but two of the moist-soil units. This contribution is not just due to the units' large size but can also be attributed to favorable habitat conditions induced by a summer drawdown. The favorable conditions are reflected in the bird-use adjusted for unit area figure (2). Observed bird use in Swan Lake also exceeded the estimated carrying capacity (Appendix B).

Cost per waterbird use-day estimates are scant in the literature but a 1981 study in SE Missouri, when inflation adjusted, had a per waterbird use-day cost of $.05, based $. 015 in 1979 adjusted to the consumer price index (Rundle and Fredrickson 1981). Seven of the twelve units examined here were less expensive than that estimate while the average cost of a use-day for the two Swan Lake units was $.008. For another perspective, the management cost for Swan Lake could increase six fold to over $300,000 a year and still be below this published cost estimate. Despite the large size and high management costs, the effort to manage Swan Lake was clearly the most efficient allocation across the entire division.

The relative benefit of the MSUs is expected to be low in a year when Swan Lake has ample seed production however river flooding and local precipitation events often prevent annual drawdowns in Swan Lake. Additional monitoring is needed to observe a wider range of habitat conditions for both the MSUs complex and Swan Lake. In 2016 all 12 units had vegetation communities that were dominated by annual vegetation and most were in good condition. Only two of the MSUs had low seed production; high cover values for cocklebur (*Xanthium strumarium*) and marsh smartweed (*Polygonum coccineum*) interfered with moist-soil seed production in these units. The importance of the MSUs relative to Swan Lake can be better evaluated after observing waterbird use in years when Swan Lake is in poor condition and the MSUs are in good condition.

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Appendix A. Total waterbird use-days by species and unit for the Calhoun Division of Two Rivers NWR, Calhoun Co IL for the 2016/17 nonbreeding season.

species		Middle Swan lake	Lower Swan lake	UPPER CALHOUN MSU	LOWER CALHOUN MSU	PUMP STATION MSU	Brushpile	LITTLE SWAN MSU	SCHOOL HOUSE MARSH	COUNTY ROAD MSU	LOWER HEADQUATERS MSU	DUCK CLUB MSU	OFFICE MSU	total across all units	relative use
		IL-004-L	IL-004-K	IL-004-D	IL-004-C	IL-004-E	IL-004-M	IL-004-I	IL-004-F	IL-004-J	IL-004-G	IL-004-A	IL-004-B		
American Black Duck	ABDU	29	0	0	0	0	0	0	0	0	0	0	0	29	0.00
American Coot	AMCO	200064	165703	0	2431	0	0	635	302	0	0	0	0	369135	4.48
American Golden-Plover	AMGP	0	0	0	4	0	0	0	0	0	0	0	0	4	0.00
American Wigeon	AMWI	22824	67483	0	0	0	0	0	0	0	0	0	0	90307	1.09
American White Pelican	AWPE	522	4345	0	0	0	0	0	0	0	0	0	0	4867	0.06
Bufflehead	BUFF	6913	8450	0	0	0	0	0	0	0	0	0	0	15363	0.19
Blue-winged Teal	BWTE	1016	9180	0	38	0	0	0	0	0	0	0	0	10234	0.12
Cattle Egret	CAEG	234	0	0	15	0	0	0	0	0	0	0	0	249	0.00
Canada goose	CANG	23005	27988	990	605	0	14	197	0	0	0	1475	0	54274	0.66
Canvasback	CANV	2373	5355	0	0	0	0	0	0	0	0	0	0	7728	0.09
Common Goldeneye	COGO	19189	9821	0	0	0	0	0	0	0	0	0	0	29010	0.35
Common Merganser	COME	0	1100	0	0	0	0	0	0	0	0	0	0	1100	0.01
Double-crested Cormorant	DCCO	0	14	0	0	0	0	0	0	0	0	0	0	14	0.00
Gadwall	GADW	882480	279590	2240	7841	0	0	3197	1101	0	0	1747	1757	1179952	14.31
Great Blue Heron	GBHE	99	230	0	0	0	0	0	1	0	0	0	0	329	0.00
Great Egret	GREG	3089	1882	0	0	0	0	0	0	0	0	0	0	4971	0.06
Greater Yellowlegs	GRYE	0	0	18	51	30	27	4	0	0	0	0	0	130	0.00
Greater White-fronted Goose	GWFG	24073	54225	14	525	0	0	0	0	0	0	980	0	79816	0.97
Green-winged Teal	GWTE	262248	394818	1503	6960	12600	0	2442	980	0	0	4490	1546	687587	8.34
Horned Grebe	HOGR	14	0	0	6	0	0	0	0	0	0	0	0	20	0.00
Killdeer	KILL	12	53	84	552	308	0	47	0	0	0	10	0	1066	0.01
Mallard	MALL	359761	861713	0	13754	23900	18890	7096	6172	24875	0	21732	4718	1342611	16.28
Northern Pintail	NOPI	1768827	1139150	1500	26786	7800	3750	13333	280	7000	0	19215	4830	2992471	36.28
Northern Shoveler	NSHO	132598	184800	3750	10403	5250	0	6025	2778	0	2250	427	213	348493	4.23
Pied-billed Grebe	PBGR	187	56	0	0	0	0	0	0	0	0	0	0	242	0.00
Pectoral Sandpiper	PESA	0	0	0	55	0	0	25	0	0	0	12	0	92	0.00
Ring-billed Gull	RBGU	1837	510	0	0	0	0	0	0	0	0	0	0	2347	0.03
Redhead	REDH	2000	4042	0	0	0	0	0	0	0	0	0	0	6042	0.07
Ring-necked Duck	RNDU	233959	268583	0	0	0	0	0	0	0	0	0	0	502542	6.09
Ruddy Duck	RUDU	59809	95325	0	0	0	0	0	0	0	0	0	0	155134	1.88
Snow Goose	SNGO	0	292250	0	0	0	0	0	0	0	0	0	0	292250	3.54
Spotted Sandpiper	SPSA	6	0	0	0	0	0	0	0	0	0	0	0	6	0.00
Trumpeter Swan	TRUS	84	740	0	5	0	0	0	0	0	0	0	0	828	0.01
Unknown Scaup	UNSC	25166	42900	0	0	0	0	0	0	0	0	0	0	68066	0.83
Wilson's Snipe	WISN	0	0	0	1	18	0	0	0	0	0	155	1	174	0.00
Wood Duck	WODU	198	478	0	73	0	0	0	0	0	0	0	0	749	0.01

Appendix B. 2016 Seed production and duck energy-day report provided by the University of Tennessee Wetland Program for Swan Lake, Two Rivers National Wildlife Refuge, Calhoun County IL.

TWO RIVERS NATIONAL WILDLIFE REFUGE
Seed Yield and Duck Energy-day Estimates
October 2016

Summary

Brian Loges submitted pressed seed heads to the University of Tennessee Wetlands Program that were collected randomly from ten 1-m^2 plots in moist-soil wetlands at the Lower Swan Unit for seed production and duck energy-day (DED) estimates. Seed-head area for each sample was scanned, and area (cm^2) estimates used to predict dry seed mass (g) per plant using models in Gray et al. (2009). Plant species that were collected included redroot flatsedge (*Cyperus erythrorhizos*), pinkweed (*Polygonum pensylvanicum*), rice cutgrass (*Leersia oryzoides*), sprangeltop (*Leptochloa filiformis*), wild millet (*Echinochloa crus-galli*), Walter's millet (*E. walterii*), and nodding smartweed (*P. lapathifolium*). Seed production/plant was multiplied by plant density/m^2 for each species, seed production was summed across species within a plot, and estimates were converted to kg/ha and lbs/ac. Duck energy-day estimates were calculated using seed production, true metabolizable energy of seed, and the daily energy requirement of mallards (Gray et al. 2013). Details on methods are available at http://fwf.ag.utk.edu/mgray/DED/DED.htm. Seed production and DED estimates were averaged among plots, and the standard deviation and 95% confidence intervals were calculated.

Seed production among plots ranged from 209 – 3840 kg/ha (186 – 3426 lbs/ac, Table 1). Average seed production among wetlands was 1391 kg/ha (1241 lbs/ac), and could be classified as high seed yield (see reference values below). Plots with highest seed production were #9 and #14, and the lowest seed production was in plot #12 (Table 1).

Based on the plant species present and high seed production, the moist-soil wetland surveyed in this study could be classified as early successional, and disturbance to set back succession (e.g., disking) probably isn't currently necessary. It should be noted that seed production was variable among plots, resulting in a large standard deviation (Table 1). Thus, spot treatment of mechanical manipulations or herbicides might be useful to improve seed production in those areas. Moderate application of fertilizer also can improve seed production in moist-soil wetlands (Gray et al. 2013). Duck energy-day estimates are provided (Table 1). Total estimated DEDs for the survey area (333 ha) was 3,892,423 DEDs, which is equivalent to having the energetic potential to support **35,386 ducks per day for 110 days**.

Seed Production Reference Values[1]

- <200 kg/ha = low production
- 200-600 kg/ha = moderate production
- >600 kg/ha = high production

[1]Based on moist-soil production estimates provided in Gray et al. (1999) and Kross et al. (2008).

Table 1. Seed production and duck energy-days (DED) estimated from 10 plots in moist-soil wetlands located in the Lower Swan Unit of Two Rivers National Wildlife Refuge, Illinois, USA, October 2016.

Plot	kg/ha	DED/ha	lbs/ac	DED/ac
1	693.1	5822.8	618.4	14382.3
2	419.5	3524.7	374.3	8706.1
3	1376.4	11563.6	1228.0	28562.2
4	464.4	3901.8	414.3	9637.4
9	3840.7	32267.2	3426.6	79700.0
10	1152.6	9683.6	1028.3	23918.4
11	1038.1	8721.6	926.2	21542.4
12	208.9	1755.2	186.4	4335.3
13	1224.9	10291.0	1092.9	25418.9
14	3494.4	29358.0	3117.7	72514.3
Mean	1391.3	11689.0	1241.3	28871.7
Median	1095.4	9202.6	977.3	22730.4
Lower 95% CI	488.9	4107.7	436.2	10145.9
Upper 95% CI	2293.7	19270.2	2046.4	47597.5
SD	1261.5	10597.9	1125.4	26176.8

[1]Estimates predicted from scanned seed-head area of moist-soil plants using models in Gray et al. (2009).

[2]Duck energy-days quantified by multiplying seed production by true metabolizable energy of seed and dividing by the daily energy requirement of mallards (Gray et al. 2013).

[3]n = 10 plots (1-m^2).

[4]Total estimated DEDs for the wetlands surveyed (333 ha) = 3,892,423 DEDs, which is equivalent to having the energetic potential to support 35,386 ducks/day for 110 days.

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