St. Louis District

Environmental Pool Management 2017 Summary Report

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Cover photo: Vegetation supported by environmental pool management (Ben McGuire, U.S. Fish and Wildlife Service - USFWS, formerly U.S. Army Corps of Engineers – USACE)

SUSTAINABLE RIVER PROGRAM

ENVIRONMENTAL POOL MANAGEMENT 2017 SUMMARY REPORT

ST. LOUIS DISTRICT

Contents

CONTENTS 2

CHAPTER 1 INTRODUCTION 5

1.1 PROJECT AREA 5
1.2 INTRODUCTION 5
1.3 EPM OPERATIONS 7
1.4 ACREAGES 13

CHAPTER 2 VEGETATION SURVEYS 14

2.1 SITE SELECTION 14
2.2 INTEGRATED WATERBIRD MANAGEMENT AND MONITORING VEGETATION SURVEYS 18
2.2.1 Methods 18
2.2.2 Results 19
2.2.3 Discussion 24
2.3 LONG TERM RESOURCE MONITORING VEGETATION SURVEYS 26
2.3.1 Methods 26
2.3.2 Results 27
2.3.3 Discussion 29
2.4 SEED HEAD ANALYSIS 30
2.4.1 Methods 30
2.4.2 Results 31
2.4.3 Discussion 31
2.5 TRANSECT VEGETATION SURVEYS 31
2.5.1 Methods 31
2.5.2 Results 32
2.5.3 Discussion 34

CHAPTER 3 ADDITIONAL RESULTS 35

3.1 VEGETATION 35
3.2 LEAST TERN 36
3.3 WATERFOWL USE 38
3.4 SEDIMENT CONSOLIDATION 41

CHAPTER 4 OUTREACH 42

4.1 MEETINGS/ WORKSHOPS 42

CHAPTER 5 REFERENCES 44

APPENDIX A – ALTON LAKE (POOL 26) AND MIDDLETON ISLAND (POOL 24) SEED YIELD AND DUCK ENERGY-DAY ESTIMATES, SEPTEMBER 2017 46

APPENDIX B – JIM CROW ISLAND (POOL 25) SEED YIELD AND DUCK ENERGY-DAY ESTIMATES, SEPTEMBER 2017 49

FIGURES

Figure 1. Watershed map of St. Louis District displaying HUC 4 units. 5
Figure 2. Schematics depicting water levels with upper and lower dam point and upper and lower hinge point elevations at Mel Price Locks and Dam during low flow/flat pool (upper left), increasing/decreasing flow (upper right), maximum drawdown (lower left), and open river (lower right) 8
Figure 3. Schematic depicting water conveyance and USACE owned flowage easements during low flow/flat pool (upper left), increasing/decreasing flow (upper right), maximum drawdown (lower left), and open river (lower right) 9
Figure 4. Hydrograph of Pool 26 showing actual elevations (blue) and elevation driving vegetation growth (green) 10
Figure 5. Hydrograph of Pool 25 showing actual elevations (blue) and elevation driving vegetation growth (green) 11
Figure 6. Hydrograph of Pool 26 showing actual elevations (blue) and elevation driving vegetation growth (green) 12
Figure 7. Average size of vegetation survey sites (in acres) by Pool with standard error bars. 14
Figure 8. Pool 26 selected sites with acreages. Sites include: Dresser Island Conservation Area, Alton Lake, Ellis Bay, Mile 210, and Piasa Island. 15
Figure 9. Pool 25 selected sites with acreages. Sites include: Batchtown (exterior), Turner Island, Jim Crow Island, Hausgen Island, Stag Island. 16
Figure 10. Pool 24 selected sites with acreages. Sites include: Middleton Island, Pharrs Island, Crider Island, Gosline Island, and Ducher Island. 17
Figure 11. Pool 26, 25, and 24 average percent cover during IWMM surveys. 20
Figure 12. Pool 26 species percent frequency of occurrence for IWMM surveys. 20
Figure 13. Pool 26 average percent cover by during IWMM surveys. 20
Figure 14. Pool 26 average percent cover by species and site during IWMM surveys. 20
Figure 15. Pool 25 average percent cover by species and site during IWMM surveys. 21
Figure 16. Pool 25 species percent frequency of occurrence for IWMM surveys. 21
Figure 17. Pool 24 species percent frequency of occurrence for IWMM surveys. 21
Figure 18. Pool 25 average percent cover by site during IWMM surveys. 21
Figure 19. Pool 24 average percent cover by species and site during IWMM surveys. 22
Figure 20. Pool 24 average percent cover by site during IWMM surveys. 22
Figure 21. Count of seed head density by site. Average seed head density categorized as low, moderate, or high by species. 22
Figure 22. Count of species with seed heads by site. Average seed head size categorized as none, small, average, or large by species 22
Figure 23. Simpson's diversity index for Pools 26, 25, and 24 from IWMM surveys in 2017 and 2016. 23
Figure 24. Species richness by pool 23
Figure 26. Stag Island (Pool 25), August 15, 2017. 24
Figure 25. Piasa Island (Pool 26), August 17, 2017. 24
Figure 27. Middleton Island (Pool 25), August 25, 2017. 25
Figure 28. LTRM vegetation survey points in Pool 26, RM 201-221. 26

Figure 29. Pool 26 average percent cover from LTRM vegetation survey ... 28
Figure 30. Pool 26 species percent frequency of occurrence for LTRM surveys. ... 28
Figure 31. Shannon's diversity index, Simpson's diversity index, and Simpson's evenness Pool 26 LTRM vegetation surveys. ... 29
Figure 32. Photo of vegetation survey plot (1m^2) used for seed head surveys. Photo taken at Alton Lake in Pool 26. ... 30
Figure 33. Photo of *Echinochloa walteri* seed heads, Alton Lake, Pool 26 ... 31
Figure 34. Photo of transect vegetation survey plot (1/4 m^2), Piasa Island, Pool 26. ... 32
Figure 35. Average percent cover by site. ... 32
Figure 36. Species diversity by site. ... 33
Figure 37. Average species percent cover by site. ... 33
Figure 38. Simpson's diversity index by site. ... 34
Figure 39. Photo of American Lotus (*Nelumbo lutea*) growing at Alton Lake in Pool 26. ... 35
Figure 40. Photo of arrowhead (*Sagittaria latifolia*) growing at Alton Lake in Pool 26. ... 35
Figure 41. From Lott *et al* 2013. Map of Interior Least Tern populations ... 36
Figure 42. Least tern occurrence in Pool 24, August 2, 2017. ... 37
Figure 43. Least Tern occurrence in Pool 25, August 4, 2017 ... 37
Figure 44. Illinois Natural History Survey spring 2018 aerial waterfowl survey for "Batchtown Pool" are in Pool 25. MALL=Mallard; NOPI=Northern Pintail; BWTE=Blue-winged Teal; GWTE=Green-winged Teal; GADW=Gadwall; NSHO=Northern Shoveler; LESC=Lesser Scaup; RNDU=Ring-necked Duck; CANV=Canvasback; RUDU=Ruddy Duck; COGO=Common Goldeneye; BUFF=Bufflehead. ... 38
Figure 45. Illinois Natural History Survey spring 2018 aerial waterfowl survey on the Mississippi River in Pool 26 and Pool 25. ... 38
Figure 46. Illinois Natural History Survey spring 2018 aerial waterfowl survey for "Grafton-Alton" are in Pool 26. MALL=Mallard; NOPI=Northern Pintail; BWTE=Blue-winged Teal; GWTE=Green-winged Teal; GADW=Gadwall; NSHO=Northern Shoveler; LESC=Lesser Scaup; RNDU=Ring-necked Duck; CANV=Canvasback; RUDU=Ruddy Duck; COGO=Common Goldeneye; BUFF=Bufflehead. ... 39
Figure 47. Alton Lake, Pool 26. ... 39
Figure 48. Cropped upper right quarter of photo in Figure 47, Alton Lake area, Pool 26, showing approximately 1,800 ducks within a 10 acre area ... 40
Figure 49. Photo showing truck tire tracks at Alton Lake in Pool 26. ... 41
Figure 50. Photo with vehicle road occurring at Alton Lake in Pool 26. ... 41

TABLES

Table 1. Lock and dam operation limits in terms of pool elevations for L&D 26, 25, and 24 ... 7
Table 2. Summary of satellite image acreage delineations with image dates, elevations of the pools with headwater elevations, typical Environmental Pool Management elevations, and estimated elevation driving vegetation growth as shown in Figures 32, 33, and 34. ... 13
Table 3. Table showing total acreage by site. ... 14
Table 4. Table of all species encountered during vegetation surveys. ... 19
Table 5. Table of all species encountered during LTRM-type vegetation surveys. ... 27
Table 6. Table showing summary of fund expenditures in addition to SRP funding by MVS during the 2017 EPM season. ... 42

Chapter 1 Introduction

1.1 Project Area (Figure 1)

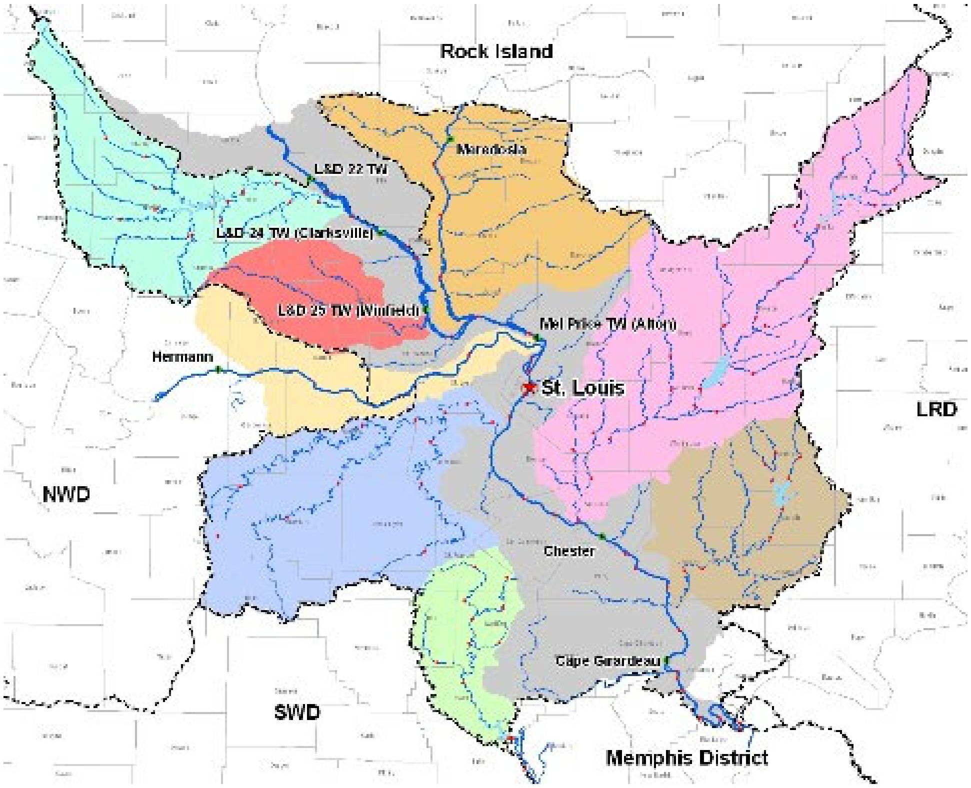


Figure 1. Watershed map of St. Louis District displaying HUC 4 units.

1.2 Introduction

Twenty years of managing Pools 24-26 below maximum regulated pool during the summer growing season for 30-40 days shows that ecological conditions could be significantly enhanced for annual emergent aquatic plants production (moist-soil plants). River shoreline, interior island wetlands and island fringe areas, which are exposed from the reduction are consistently revegetated with species such as smartweed (*Polygonum* spp.), millet (*Echinochloa* spp.), sedges (*Carex* spp.), Amazon sprangletop (*Leptochloa panicoides*), flatsedge (*Cyperus* spp.) etc. Seed production of these plants are valuable for resident and migratory waterbirds but also provide, bank stabilization, nutrient processing, sediment deposition, invertebrate habitat, egg-laying structure for fish and amphibians, food for aquatic reptiles, cover and nursery habitat for juvenile fish, etc. Long term fisheries monitoring indicate that native fish species are not negatively affected by this change. In fact, in Pool 25 it has been found that water level management for growing this type of plant community benefits riverine fish communities as a whole (Garvey *et al* 2003). Furthermore, nominal commercial and recreational issues have been reported as a result of the pool water level changes. Twenty years of demonstration indicates this is a beneficial practice to balance the needs of navigation with the needs of the ecosystem.

Prolonged high flow conditions upstream in 2014 necessitated an 86 day drawdown in lower Pool 26. River biologists observed this atypical condition produced not only annual aquatic vegetation but also perennial aquatic vegetation, such as arrowhead (*Sagittaria* spp.), American lotus (*Nelumbo lutea*), and spatterdock (*Nuphar lutea*). These observances demonstrated that it is still possible to grow perennial aquatic vegetation in this portion of the Upper Mississippi River (UMR). Prior to 1994, perennial aquatic vegetation was common in back waters of lower Pool 26. Currently however, perennial aquatic vegetation only exists within one backwater area in Pool 26. In the more northern pooled portion of the UMR, both annual and perennial plants have responded positively to reduced water level conditions when the reduction is targeted for 90 days of the growing season. Additionally, two consecutive years of water level reduction promotes perennial tubers, which can dramatically increase in size (up to 16 X first year growth) and persist for over six years after reflooding. The unique conditions of 2014 shows a restoration goal to regenerate a mix of annual and perennial aquatic vegetation is possible within the lower section of the UMR and would provide additional benefits to physical river function and biological resources.

In the fall 2014, river biologists again asked the Corps if the 30-40 day reduction could be extended to 90 or more days to improve conditions for annual and perennial aquatic plant response. The Corps said if hydrologic conditions provided an opportunity, they would attempt to manage pools 24-26 below full pool beginning as the spring flood waters receded. After coordinating with other state and federal natural resource managers it was decided to begin the reduction as the spring water levels receded in each of the three pools and depending on hydrologic conditions maintain that level for 90 or more days.

The St. Louis District of the Corps of Engineers attempted to maintain the water levels below maximum regulated pool in Pools 24-26 for most of the summer of 2015, beginning in April. An increase in flow around mid-June interrupted continuous reduction in all three pools but the Corps did return to reduced water levels after the flood waters receded. Due to the height of the flood and duration, all the plants were lost during inundation. However, the growth after the flood produced similar vegetative response and continued until water levels were brought back up to full pool by October 1, 2015.

The St. Louis District of the Corps of Engineers maintained the water levels below full pool in Pools 24-26 (Table 1, Figures 2 and 3) for the summer of 2016, beginning in April. Optimum river flows allowed pools levels to be maintained in Pool 26 for 110 days at 2' below full pool, in Pool 25 for 139 days at 1.5' below full pool and in Pool 24 for 97 days at 1' below full pool. These conditions produced large amounts of vegetation coverage and higher species diversity as the growing season continued. This is particularly important for the resiliency of the aquatic ecosystem, in that the longer growing season created favorable conditions for perennial species that have been lacking compared to historic conditions. Repeat conditions in 2017 should improve conditions for plant diversity and robustness, unfortunately hydrologic conditions did allow for a repeat and the chance to document those expected changes was not realized.

In 2017 we attempted another extended water level reduction in Pools 24-26 (Figures 4, 5, and 6) with the following Goals and Objectives:

Goals:

1) Increase aquatic vegetation diversity in the Upper Mississippi River: Pools 24, 25, and 26.
2) Increase emergent aquatic vegetation production by extending Environmental Pool Management (EPM) operations.
3) Quantify the response of aquatic vegetation to extended EPM operations.

Objectives:

1) Increase EPM operations to 90+ days for Pools 24, 25, and 26.
2) Quantify aquatic vegetation seed production using Integrated Waterbird Management and Monitoring's (IWMM) *Seed Head Assessment Guide* 2015.
3) Use established aquatic vegetation monitoring protocols (*Long Term Resource Monitoring Program Procedures: Aquatic Vegetation Monitoring* and *IWMM's Vegetation Survey* 2015*)* to quantify aquatic vegetation response to 90+ day EPM operations.

1.3 EPM Operations

Table 1. Lock and dam operation limits in terms of pool elevations for L&D 26, 25, and 24.

Location	Upper Limit (ft)	Lower Limit (ft)	Hinge Point Limits (ft)
Lock & Dam 24	449.0	445.5	11.5-12.2
Lock & Dam 25	434.0	429.7	434.0-437.0
Lock & Dam 26 (Melvin Price)	419.0	412.5	14.2-16.2

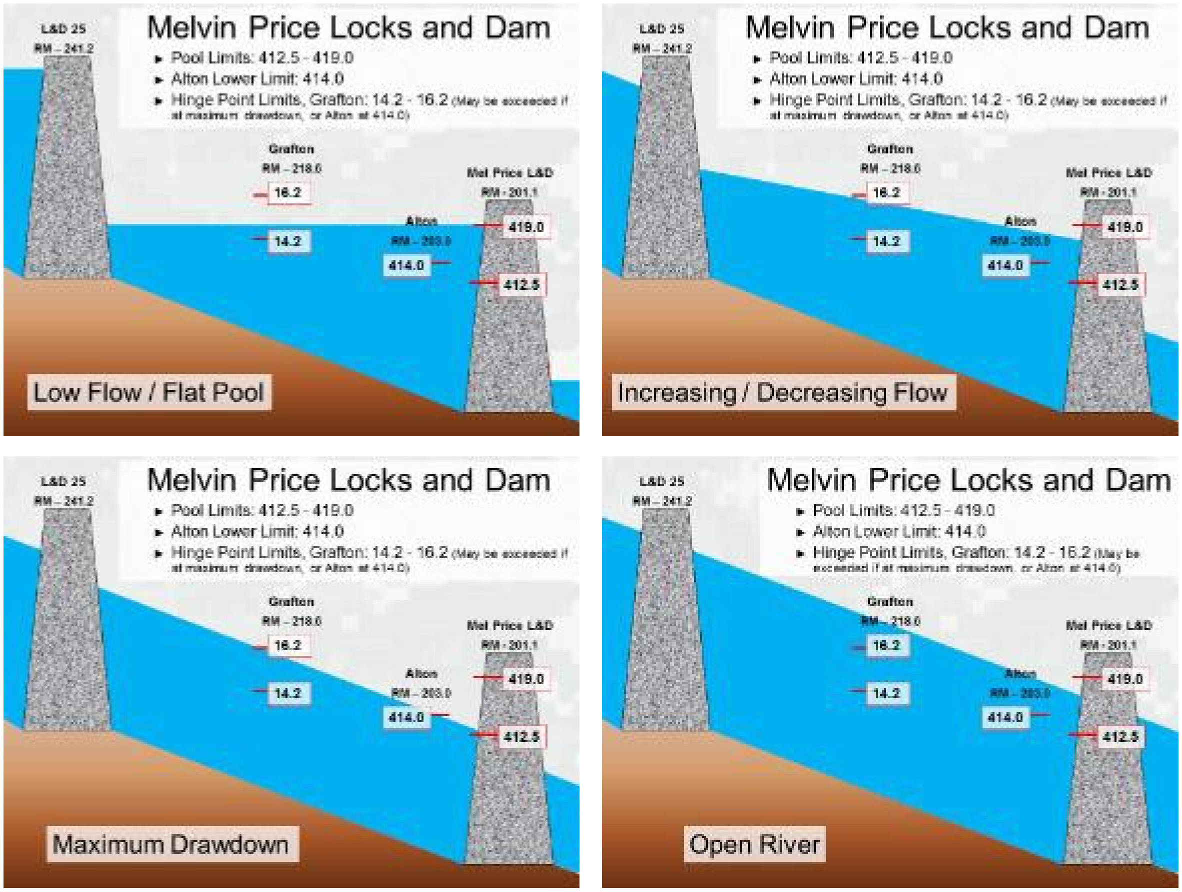


Figure 2. Schematics depicting water levels with upper and lower dam point and upper and lower hinge point elevations at Mel Price Locks and Dam during low flow/flat pool (upper left), increasing/decreasing flow (upper right), maximum drawdown (lower left), and open river (lower right).

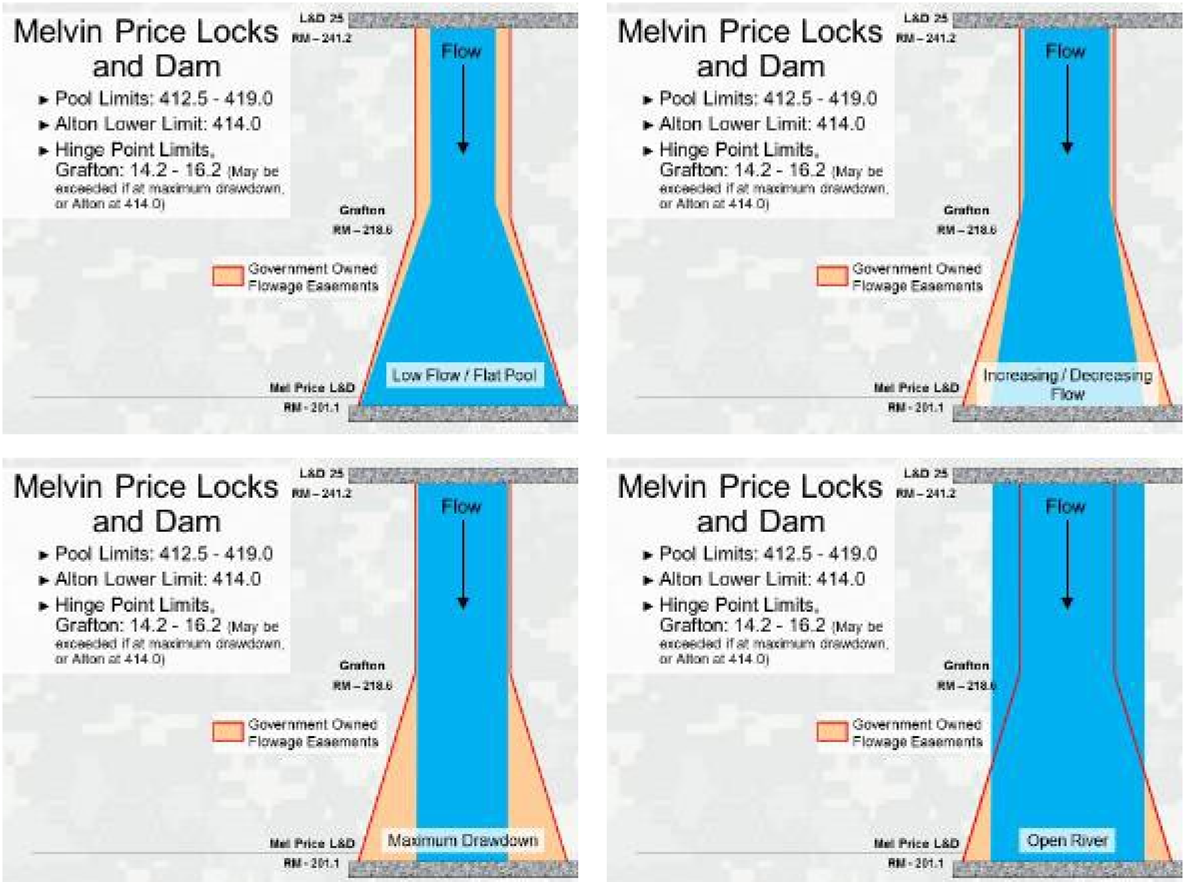


Figure 3. Schematic depicting water conveyance and USACE owned flowage easements during low flow/flat pool (upper left), increasing/decreasing flow (upper right), maximum drawdown (lower left), and open river (lower right).

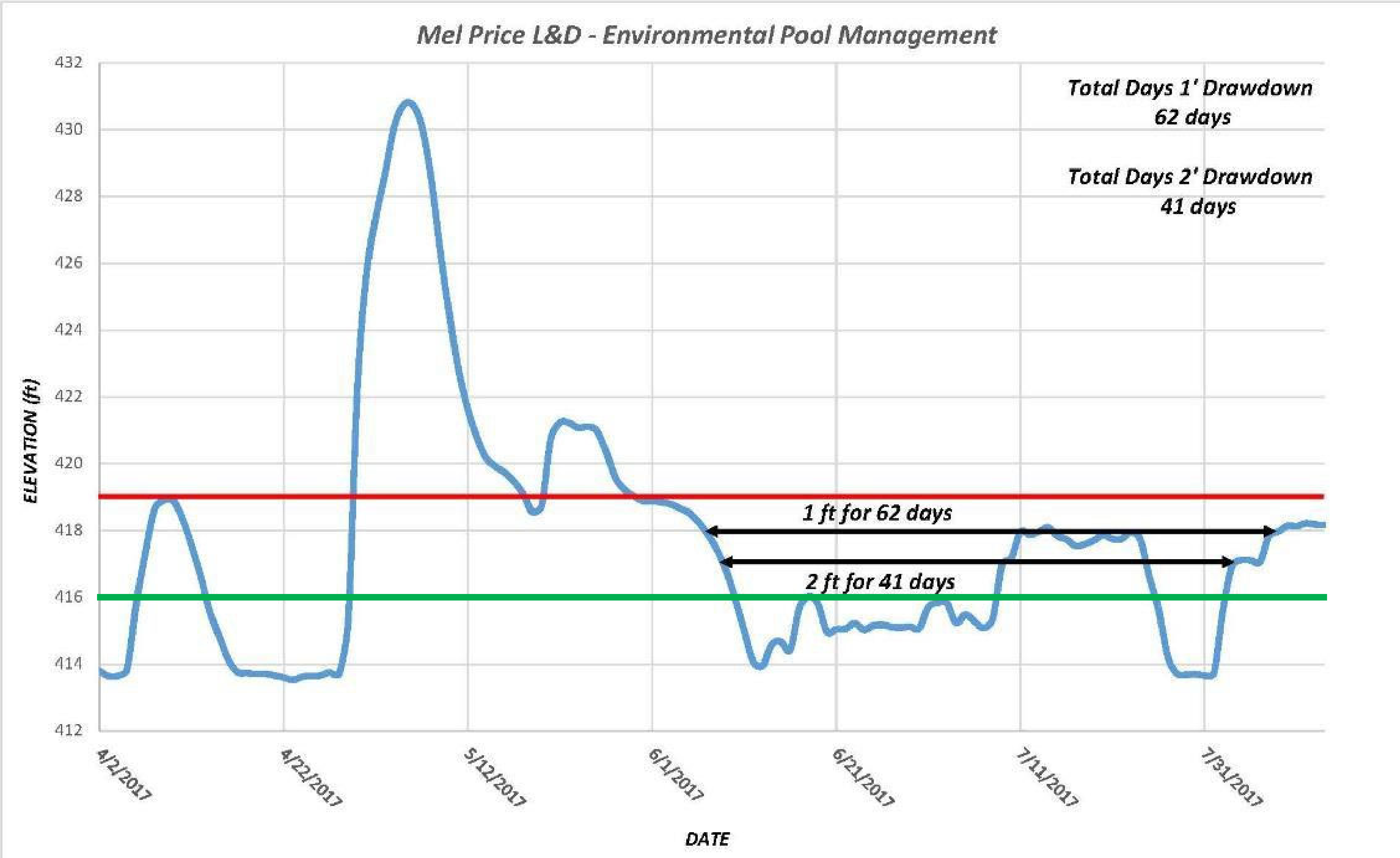


Figure 4. Hydrograph of Pool 26 showing actual elevations (blue) and elevation driving vegetation growth (green).

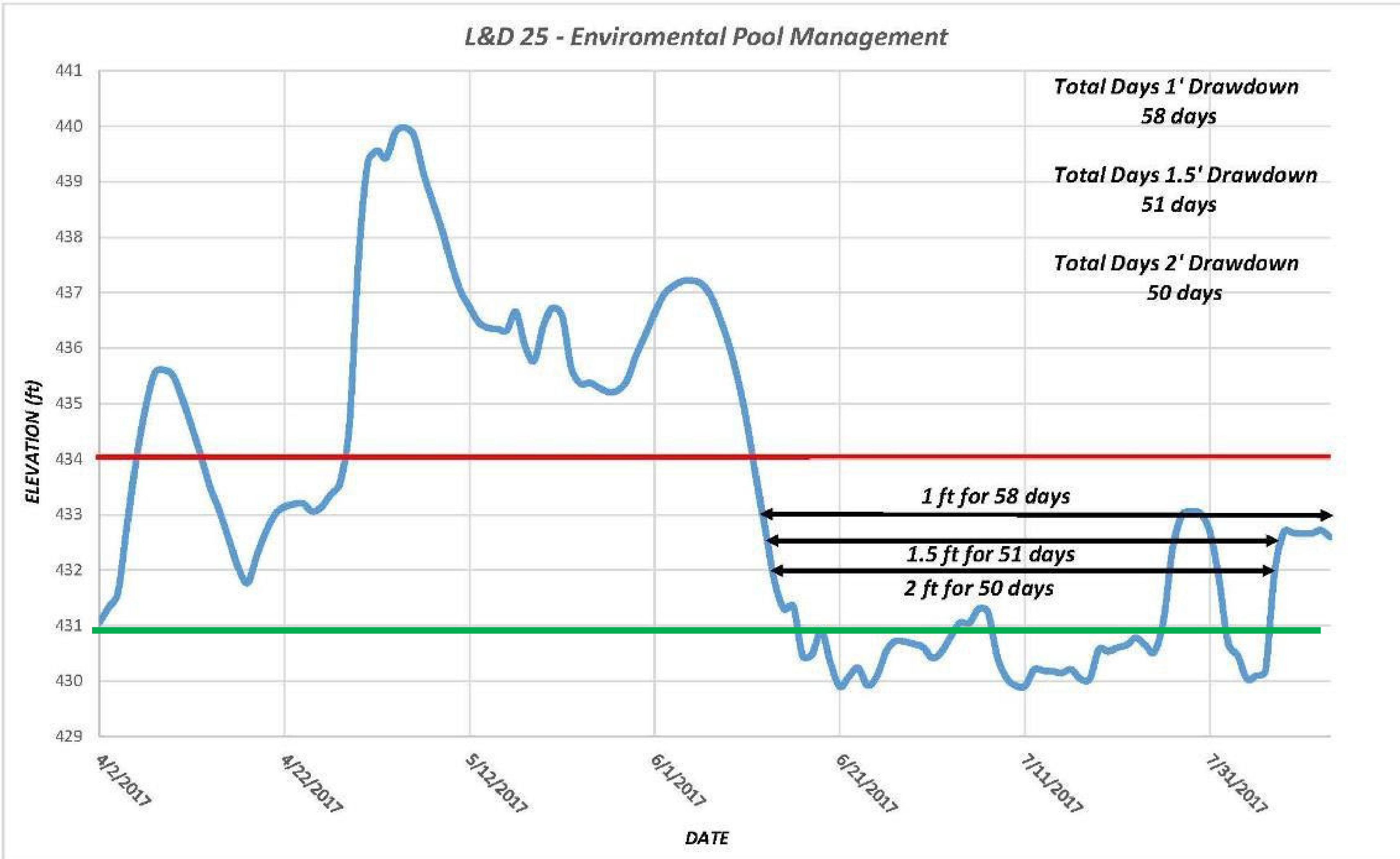


Figure 5. Hydrograph of Pool 25 showing actual elevations (blue) and elevation driving vegetation growth (green).

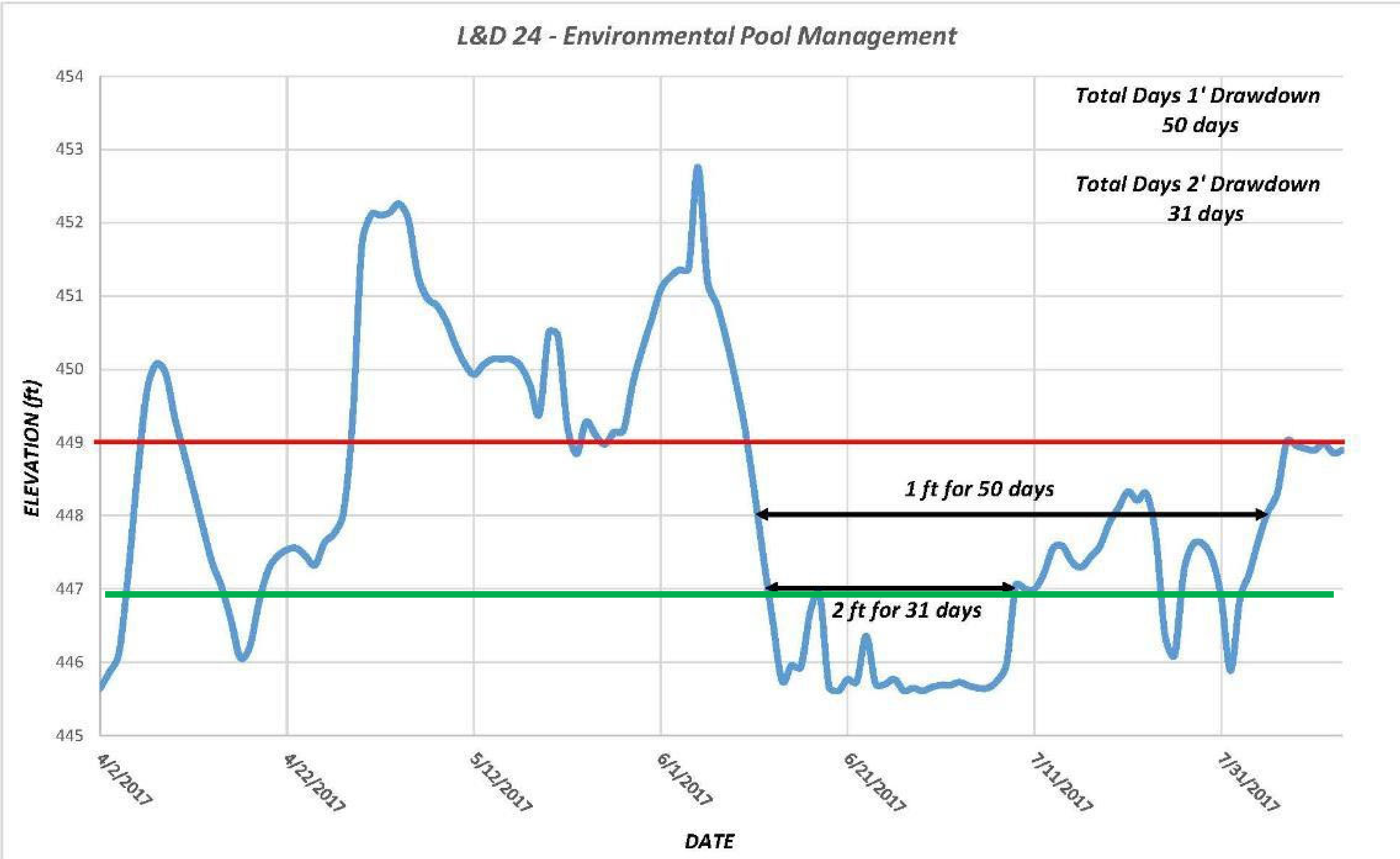


Figure 6. Hydrograph of Pool 26 showing actual elevations (blue) and elevation driving vegetation growth (green).

1.4 Acreages

Summary of acreages of vegetation growth supported by EPM. Acreages estimated based on Light Detection and Ranging (LiDAR) land surface elevation data acquired in winter 2016/2017. LiDAR data used to compute acreages by elevation. Total pooled acreage in the lower half of each pool were then broken down as EPM acreages based on differences between acreages associated with typical low "Pool Elevation" values and the "2017 Elevation Driving Vegetation Growth" values (Table 2).

Pool	Image Date	Pool Elevation	Typical EPM Elevations	2017 Elevation Driving Vegetation Growth	Acreage
Pool 24	23-Apr-15	447.71	448.0-448.5	447.80	315.61
Pool 24	3-Feb-17	446.95	448.0-448.5	447.80	338.77
Pool 25	3-Feb-17	429.80	432.00	430.51	518.97
Pool 25	29-Jun-16	430.03	432.00	430.51	448.33
Pool 26	26-Apr-16	413.56	418.00	416.70	1348.08
Pool 26	3-Feb-17	416.90	418.00	416.70	753.57

Table 2. Summary of satellite image acreage delineations with image dates, elevations of the pools with headwater elevations, typical Environmental Pool Management elevations, and estimated elevation driving vegetation growth as shown in Figures 32, 33, and 34.

Chapter 2 Vegetation Surveys

2.1 Site Selection

Pool 26		Pool 25		Pool 24	
Site	Acres	Site	Acres	Site	Acres
Alton Lake	210	Turner Island	4.3	Middleton Island	9.2
Dresser	45.4	Jim Crow Island	2.3	Crider Island	14.0
Mile 210	28.3	Hausgen Island	2.5	Gosline Island	10.4
Ellis Bay	39.1	Stag Island	1.3	Ducher Island	6.2
Piasa Island	40.7	Batchtown (exterior)	3.0	Pharrs Island	5.0

Table 3. Table showing total acreage by site.

An aerial imagery analysis was conducted to locate areas with exposed mudflat during the growing season in previous EPM implemented years. Potential sites were identified and a target of five sites per pool was set to have a large enough data set and attain measurable results. Site selection preference was given to sites with larger overall area as well as connection with the river. Sites disconnected from the river or that contained a water control structure of some sort were not included due to a difference in hydrology compared to the river. In addition, professional judgment and knowledge from field personnel was taken into account for known locations where emergent vegetation occurred in previous years. However, due to the structure and variance of geomorphology between pools, average site sizes and locations varied between pools. For example, Pool 26 contains more connected backwater locations with larger overall areas compared to Pools 25 and 24 (Table 3 and Figure 7). Site selection was as follows for each pool: Pool 26 Dresser Island Conservation Area, Alton Lake, Ellis Bay, Mile 210 Area, Piasa Island (Figure 8); Pool 25, Batchtown (exterior), Turner Island, Jim Crow Island, Hausgen Island, Stag Island (Figure 9); Pool 24, Middleton Island, Pharrs Island, Crider Island, Gosline Island, Ducher Island (Figure 10).

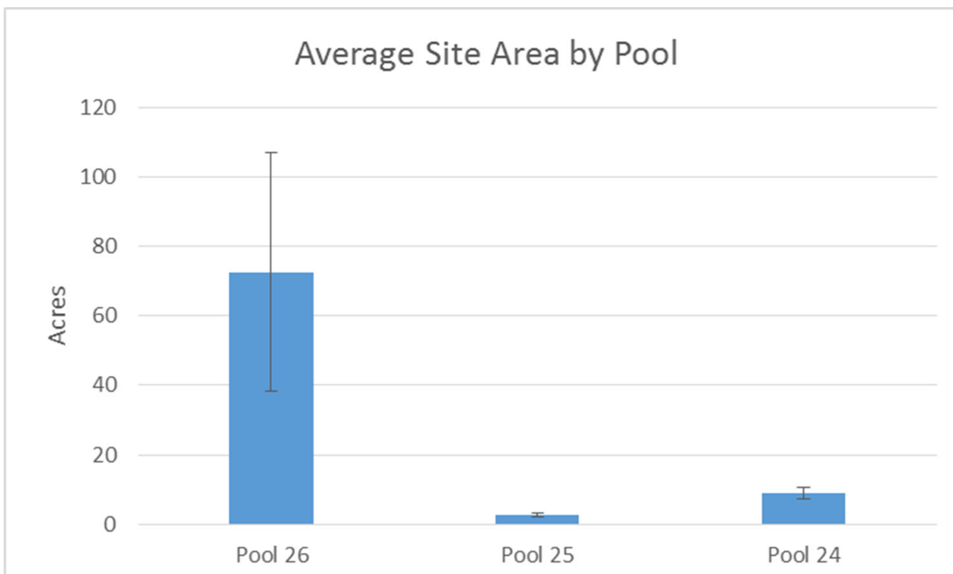


Figure 7. Average size of vegetation survey sites (in acres) by Pool with standard error bars.

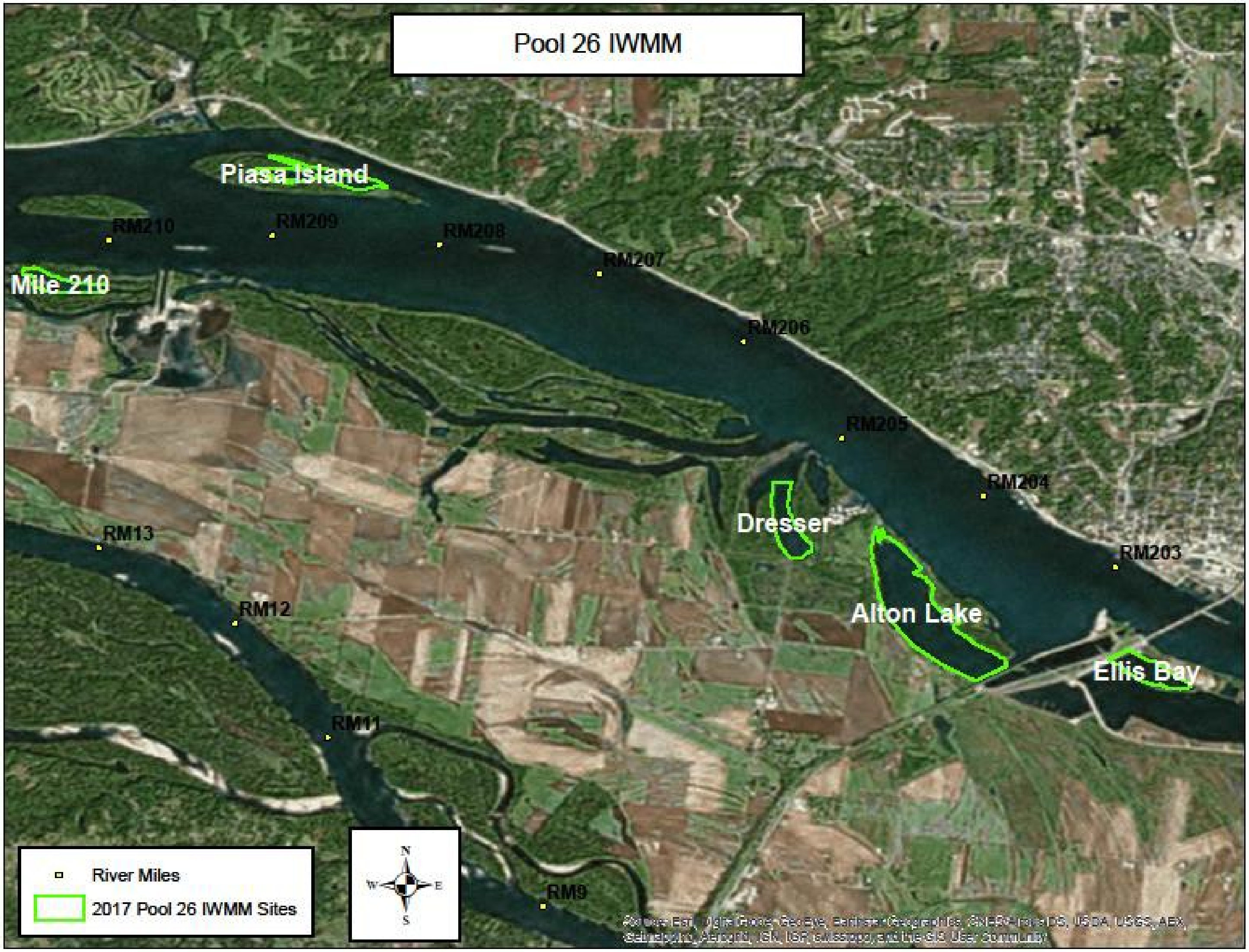


Figure 8. Pool 26 selected sites with acreages. Sites include: Dresser Island Conservation Area, Alton Lake, Ellis Bay, Mile 210, and Piasa Island.

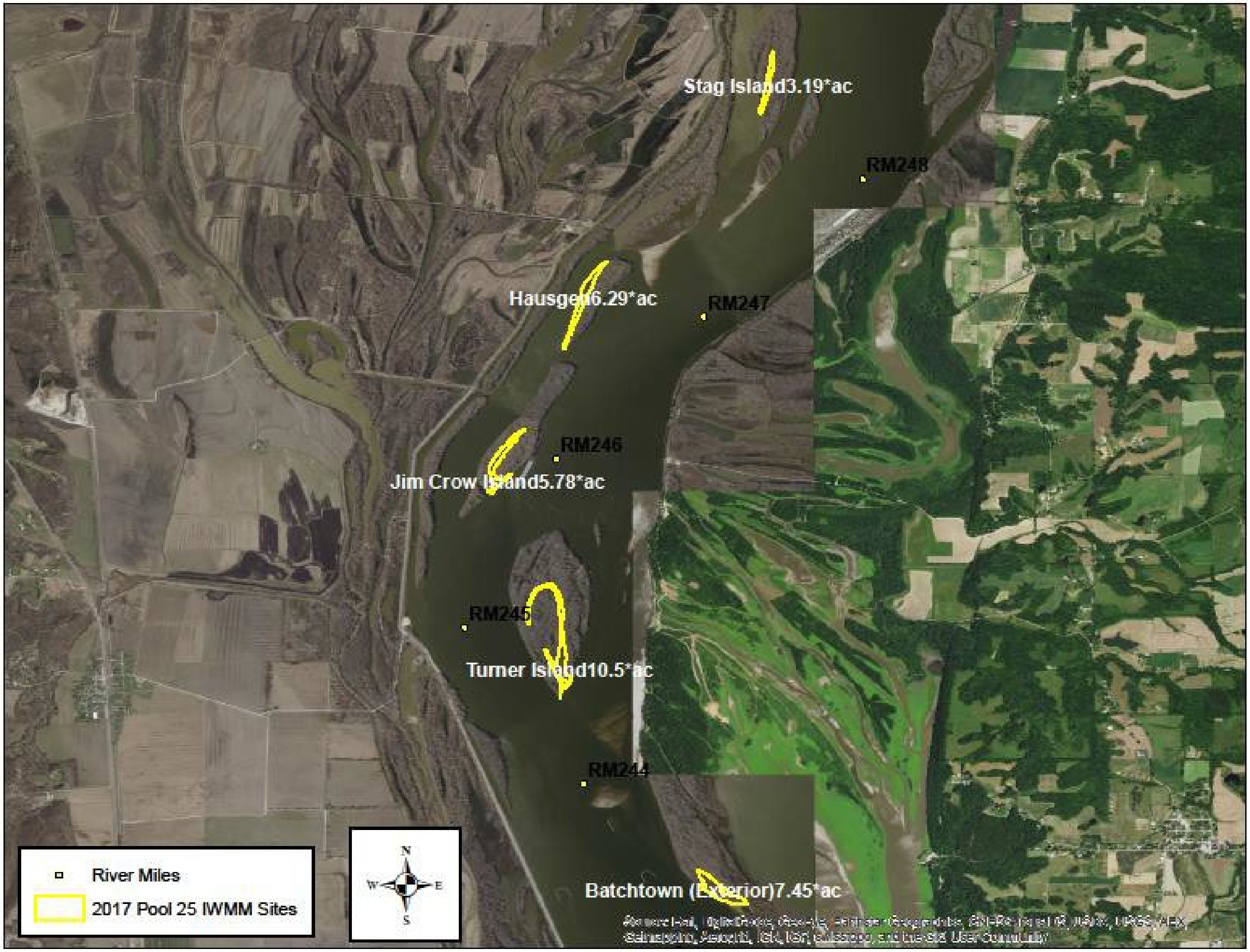


Figure 9. Pool 25 selected sites with acreages. Sites include: Batchtown (exterior), Turner Island, Jim Crow Island, Hausgen Island, Stag Island.

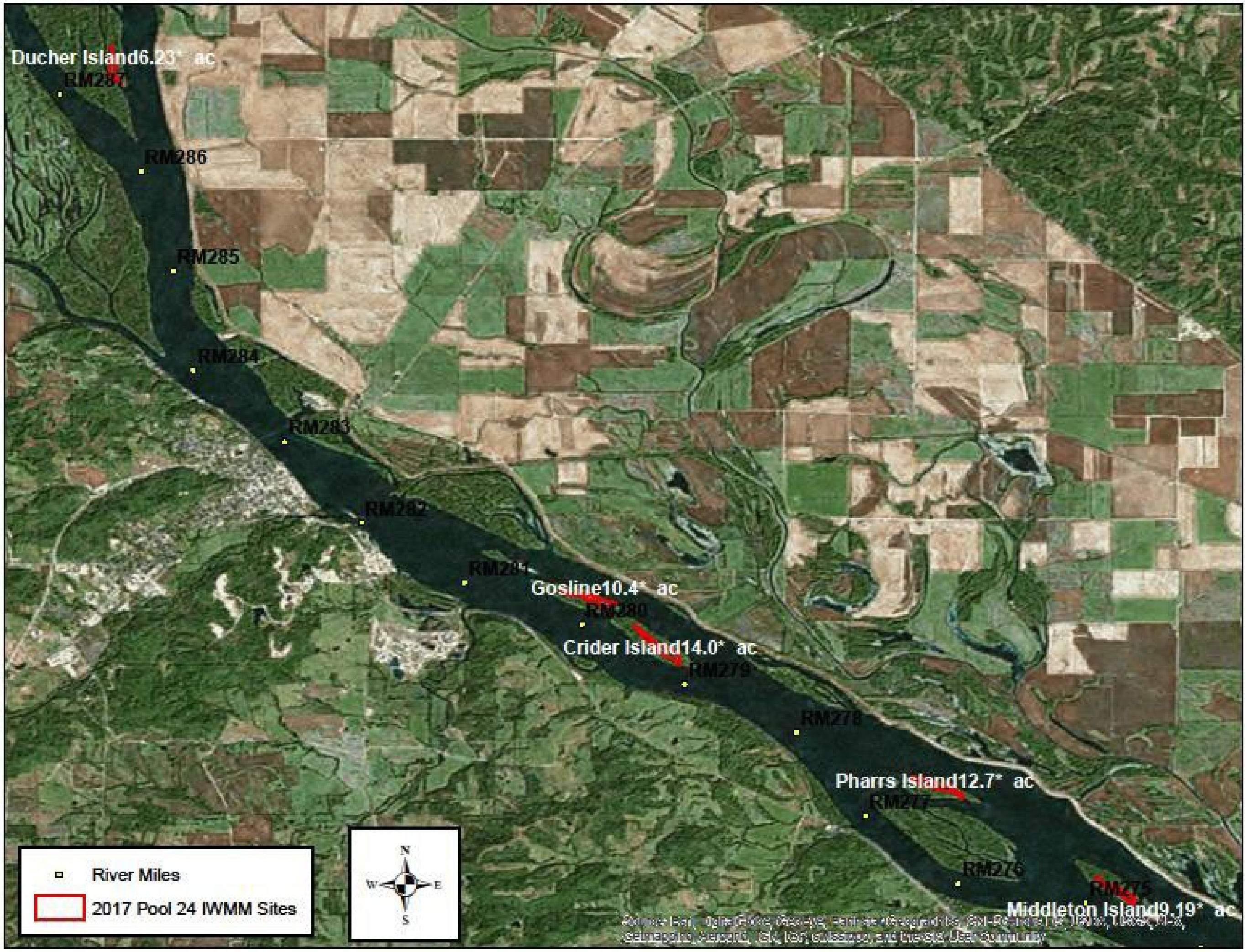


Figure 10. Pool 24 selected sites with acreages. Sites include: Middleton Island, Pharrs Island, Crider Island, Gosline Island, and Ducher Island.

2.2 Integrated Waterbird Management and Monitoring Vegetation Surveys

2.2.1 Methods

A total of 15 sites as described in Section 2.1 were surveyed in August 2017 to assess individual emergent plant species cover in Pools 26, 25, and 24. The Integrated Waterbird Management and Monitoring protocol was utilized to assess species abundance and percent cover (USFWS 2015). Only emergent vegetation from the current growing season was assessed. To complete the vegetation surveys while adhering to the protocol, two major steps were completed: 1) an assessment of percent cover of emergent vegetation within the survey unit was completed and 2) a species inventory and species-specific percent cover assessment within the areas of emergent vegetation were completed.

To complete the first step, the location of all emergent vegetation areas within each survey unit were determined. This was done by a visual assessment throughout each survey unit. Once all areas of emergent vegetation were identified, an estimate of the percent cover of the survey unit by emergent vegetation was completed. Percent cover is defined as the percentage of the survey unit covered by vertical projections from the outermost perimeter of the plants' foliage (Anderson 1986).

To complete the second step, a list of all common emergent vegetation species was compiled and an estimate of each species' percent cover was completed. For this estimate, percent cover is defined as above except that it is estimated as a percentage of emergent vegetation area, not as a percentage of the total survey unit area. For example, a survey unit could only contain a single species, Species X across 50% of the total survey unit area, but as an individual plant species it could cover 100% of the emergent vegetation area within the survey unit. So, 100% would be recorded for this measurement. Total cover across species can exceed 100% due to the stratification of plant species with varying heights and growth forms.

In addition to the two above measurements taken at each site, a qualitative estimate of seed head size and density was completed for each common emergent plant species. Seed head sizes were assigned a size of average, smaller, or larger than the average size for each species as compared to diagrams provided by this protocol. For seed head densities, the density of stems for a species and proportion of as species' stems with seed heads were assessed. Densities were assigned as low, moderate, or high. Low densities were characterized by large areas of bare ground and low proportion of seed heads to plant stems. High seed head densities were characterized by areas with little bare ground and a high proportion of seed heads to stems. Moderate seed head densities fall between the two aforementioned categories.

Mean percent cover was calculated by pool to compare species composition and densities between pools. Mean percent cover during IWMM surveys was calculated by site. Species percent frequency of occurrence for was calculated by pool. Species richness was calculated by pool. Simpson's diversity indices were calculated for Pools 26, 25, and 24. Simpson's evenness was calculated for Pools 26, 25, and 24. All species encountered throughout the IWMM and LTRM surveys were recorded and are displayed in Table 4.

2.2.2 Results

Table 4. Table of all species encountered during vegetation surveys.

Species Code	Latin Name	Common Name
AMCO	*Ammonia coccinea*	Valley redstem
AMSP	*Amaranthus spp.*	Pigweed spp.
ASSP	*Aster spp.*	Daisy spp.
ARAN	*Artemisia annua*	Annual wormwood
BISP	*Bidens spp.*	Beggarticks
BOFL	*Bolboschoenus fluviatilis*	River bulrush
CASP	*Carex spp.*	Sedge spp.
CYES	*Cyperus esculenta*	Yellow nutsedge
CYSP	*Cyperus spp.*	Flatsedge spp.
ECCR	*Echinochloa crusgalli*	Barnyard grass
ECES	*Echinochloa esculenta*	Japanese millet
ECPR	*Eclipta prostrata*	False daisy
ECWA	*Echinochloa walteri*	Walter's millet
ELSP	*Eleocharis spp.*	Spikerush spp.
ERHY	*Eragrostis hypnoides*	Teal lovegrass
EUPE	*Eupatorium spp.*	Thoroughwort spp.
HUJA	*Humulus japonicus*	Japanese hops
LEOR	*Leersia oryzoides*	Rice cutgrass
LEPA	*Leptochloa panicoides*	Amazon sprangletop
LIDU	*Lindernia dubia*	Yellowseed false pimpernel
LIMI	*Limna minor*	Duckweed
LUSP	*Ludwigia spp.*	Water primrose spp.
LYER	*Lycopus americana*	American bugleweed
MIRI	*Mimulus ringens*	Monkeyflower
NELU	*Nelumbo lutea*	American lotus
PADI	*Panicum dichotomiflorum*	Fall panicum
PASP	*Panicum spp.*	Panicum spp.
PEDI	*Pentharum sedoites*	Ditch stonecrop
PHLA	*Phyla lanceolata*	Lanceleaf frogfruit
POLA	*Polygonum lapathifolium*	Curlytop smartweed
POPE	*Polygonum pensylvanicum*	Pennsylvania smartweed
RUSP	*Rumex spp.*	Dock spp.
SALA	*Sagittaria latifolia*	Broadleaf arrowhead
SANI	*Salix nigra*	Black willow
SASP	*Sagittaria spp.*	Arrowhead spp.
SYLA	*Symphyotrichum lanceolatum*	White panicle aster
SYPR	*Symphyotrichum praealtum*	Willowleaf aster
VEHA	*Verbena hastata*	Swamp verbena
XASP	*Xanthium spp.*	Cocklebur spp.

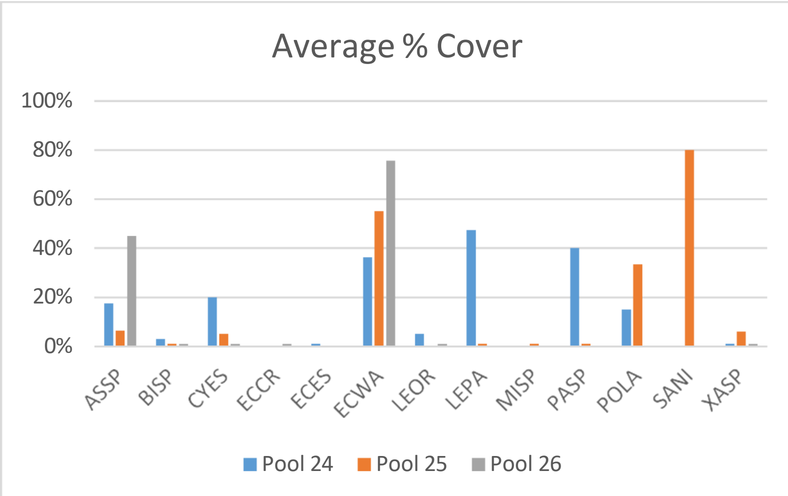


Figure 11. Pool 26, 25, and 24 average percent cover during IWMM surveys.

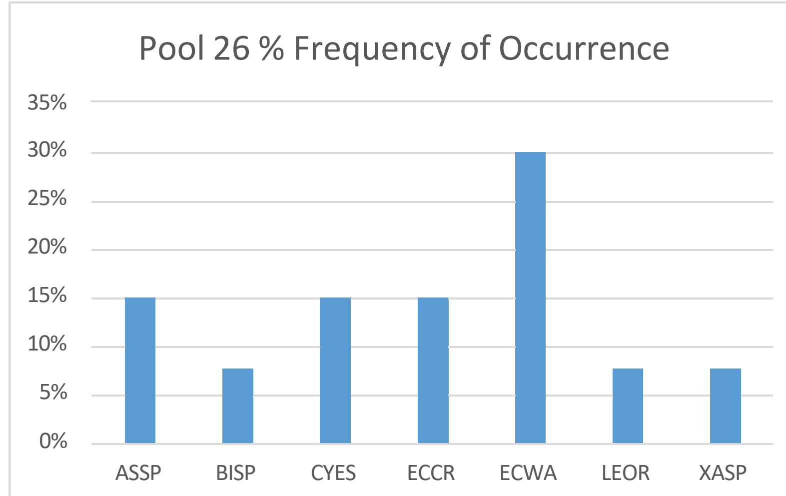


Figure 12. Pool 26 species percent frequency of occurrence for IWMM surveys.

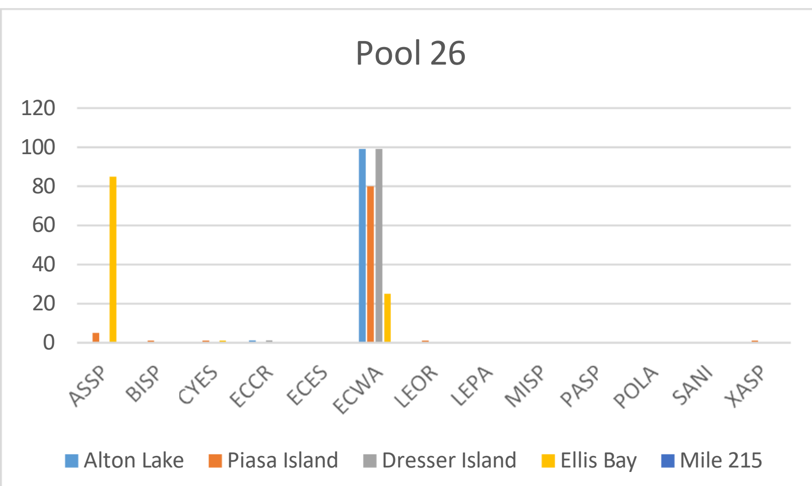


Figure 14. Pool 26 average percent cover by species and site during IWMM surveys.

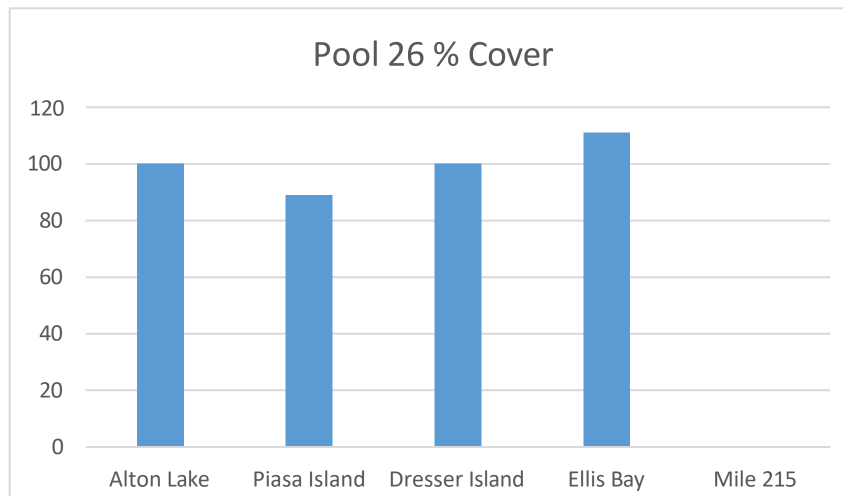


Figure 13. Pool 26 average percent cover by during IWMM surveys.

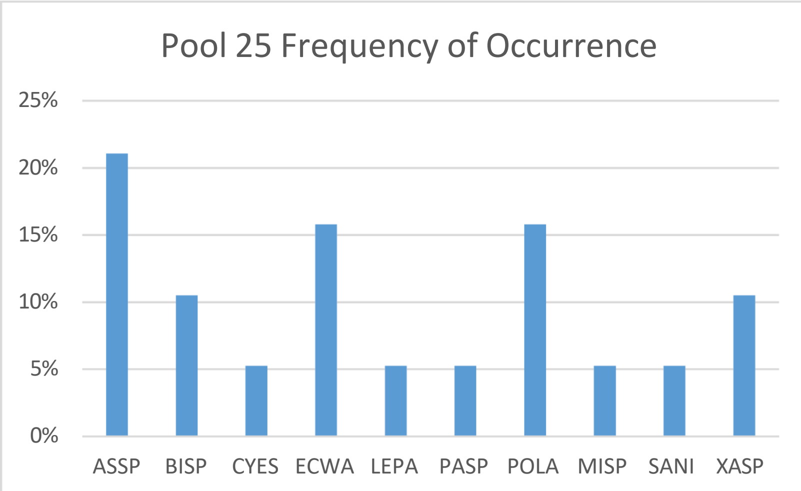


Figure 16. Pool 25 species percent frequency of occurrence for IWMM surveys.

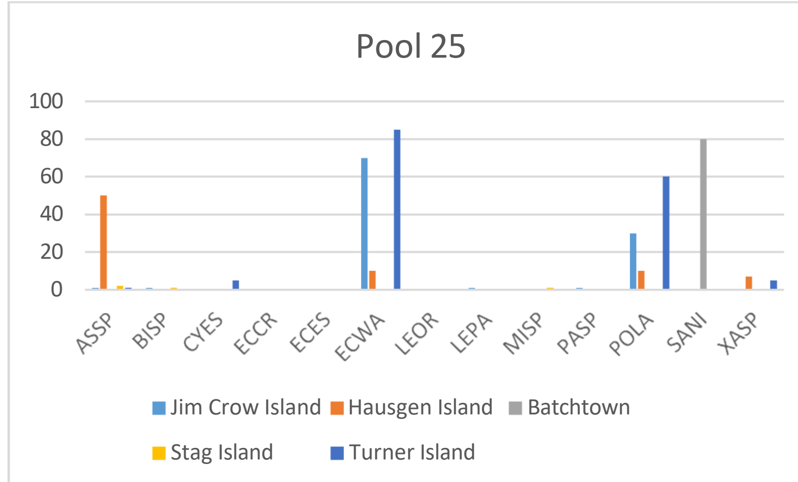


Figure 15. Pool 25 average percent cover by species and site during IWMM surveys.

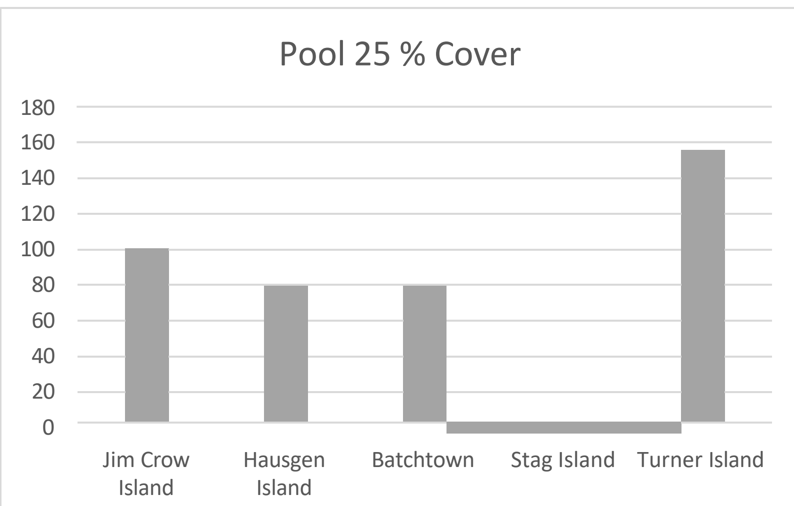
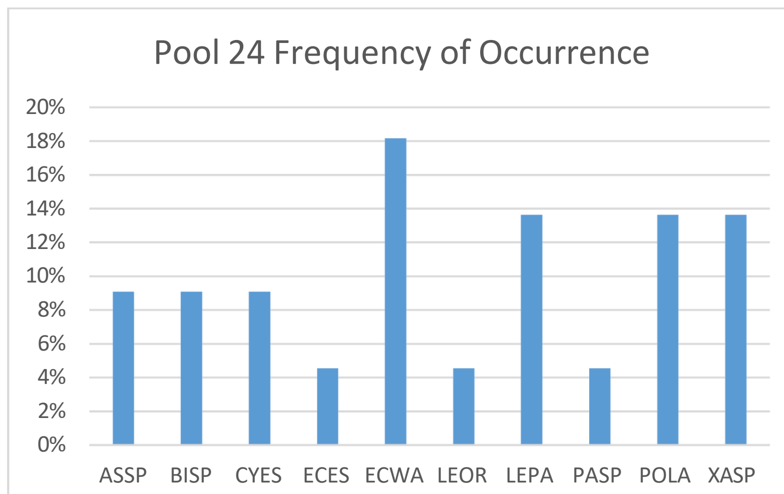


Figure 18. Pool 25 average percent cover by site during IWMM



surveys.

Figure 17. Pool 24 species percent frequency of occurrence for IWMM surveys.

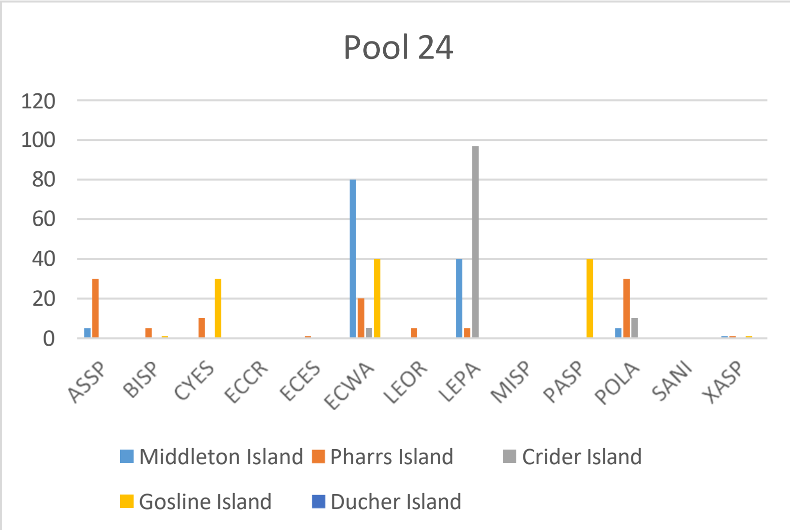


Figure 19. Pool 24 average percent cover by species and site during IWMM surveys.

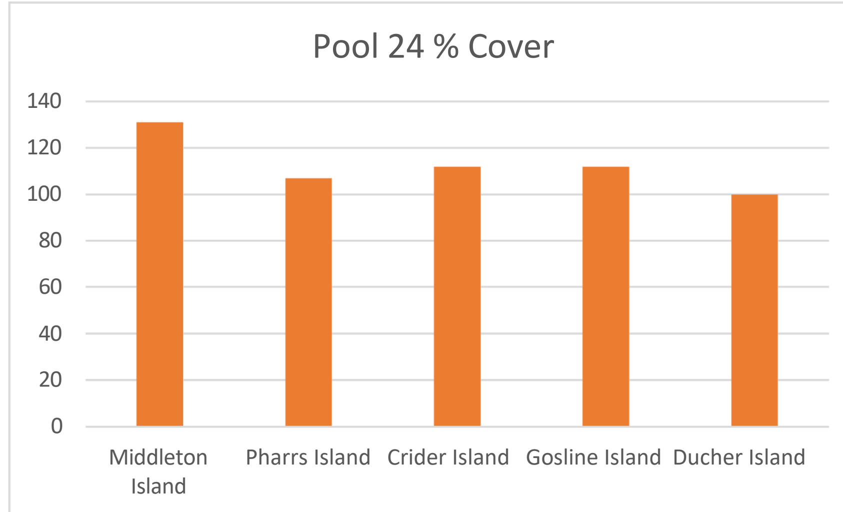


Figure 20. Pool 24 average percent cover by site during IWMM surveys.

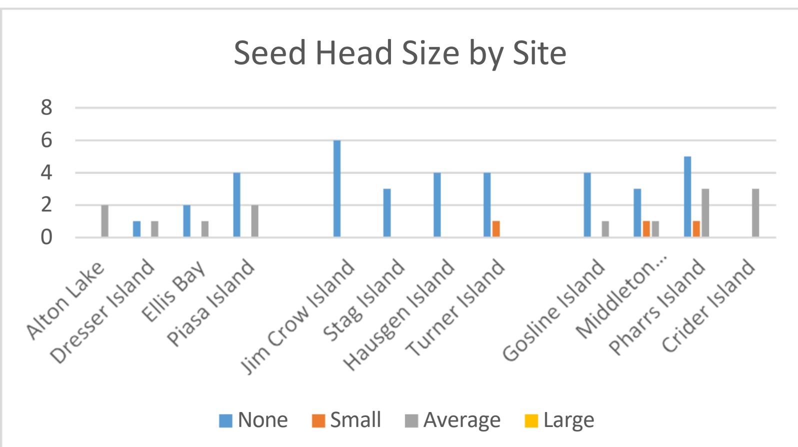


Figure 22. Count of species with seed heads by site. Average seed head size categorized as none, small, average, or large by species.

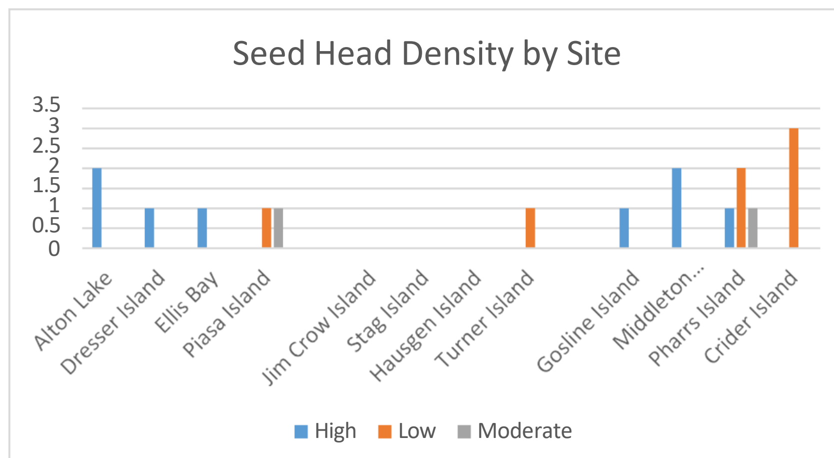


Figure 21. Count of seed head density by site. Average seed head density categorized as low, moderate, or high by species.

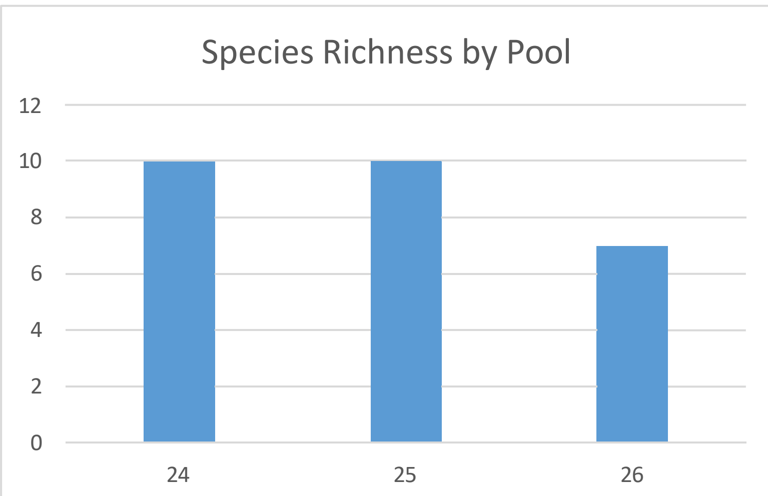


Figure 24. Species richness by pool.

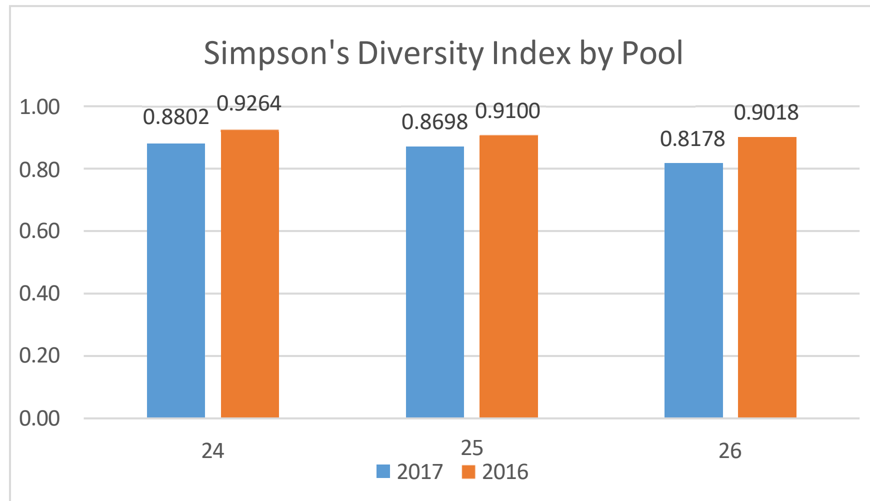


Figure 23. Simpson's diversity index for Pools 26, 25, and 24 from IWMM surveys in 2017 and 2016.

2.2.3 Discussion

Average percent species cover varied by site and by pool (Figure 11). In Pool 26, *Echinochloa walteri* had the highest percent frequency of occurrence (30.77%), followed by *Aster* sp. (15.38%), *Cyperus esculenta* (15.38%), and *Echinochloa crusgalli* (15.38%) (Figure 12). Average percent cover varied by site, with Ellis Bay having the highest percent cover (Figure 13). Average percent cover at each site was primarily dominated by *Echinochloa walterii,* other than Ellis Bay, which was dominated by *Aster* sp. (Figure 14). As noted in Section 2.2.1, percent cover is determined for areas with emergent vegetation present (Figures 25, 26, and 27). At each site, areas were present without vegetation, which is dependent on ground elevations and water level fluctuations.

Figure 26. Piasa Island (Pool 26), August 17, 2017. Photo by Ben McGuire, USFWS, formerly USACE.

Figure 25. Stag Island (Pool 25), August 15, 2017. Photo by Ben McGuire, USFWS, formerly USACE.

In Pool 25, species percent cover varied by site. *Aster* sp., *Echinochloa walteri*, and *Polygonum lapathifolium* were dominant at particular sites (Figure 15). *Aster* sp. had the highest frequency of occurrence (21.05%) followed by *Echinochloa walterii* (15.79%) and *Polygonum lapathifolium* (15.79%) (Figure 16). Turner Island had the largest percent cover of the Pool 25 sites with 156%, followed by Jim Crow Island with 104% (Figure 18).

In Pool 24, *Echinochloa walteri* had the highest percent frequency of occurrence of 18.18%, followed by *Leptochloa panicoides, Polygonum lapathifolium,* and *Xanthium* spp. with 13.64% each (Figure 17). Average percent cover at each site was primarily dominated by *Echinochloa walteri* and *Leptochloa panicoides* (Figure 19). Middleton Island had the highest percent cover by site with 131%, followed by Crider Island and Gosline with 112% each (Figure 20).

Species diversity varied by pool (Figure 24). Both Pool 24 and Pool 25 had higher species diversity than Pool 26, which is likely due to the geomorphological difference between pools and backwater areas connected to the river. This is likely due to the average size of sites within each pool (Figure 7). Smaller sites that exist within Pool 24 and Pool 25 contain a larger transition edge between the forested area


Figure 27. Middleton Island (Pool 25), August 25, 2017. Photo by Ben McGuire, USFWS, formerly USACE.

and the areas with emergent vegetation. Similar results were observed in 2016 (USACE 2017). Calculated Simpson's diversity indices demonstrate similar results, which varied by pool from 2016 calculated Simpson's diversity indices (Figure 23). This is likely due to the difference in hydrology between the two years in which 2016 had a longer growing season and earlier initial growing time.

Seed producing emergent plant species densities varied by site and pool (Figure 21). For example Pool 25 only had one site (Turner Island) with seed head densities at the time of the survey. This can likely be attributed to the hydrology in 2017, where each of the pools was in flood stage until the end of May, as well as ground elevations within each site. Although each of the sites would likely have been exposed by early June, each site requires a different lengths of time to dry, depending on ground elevations and choke points. In Pool 26 seed head sizes were mostly small or average at the time of the survey. Similar results can be seen with average seed head size by site (Figure 22). In Pool 25, Turner Island was again the only site that had recordable seed head sizes at the time of the survey. This again can likely be attributed to the later start of germination compared to 2016 (USACE 2017).

The above results demonstrate that the sites sampled had high diversity, percent cover, and potential for seed production, but that these values have been documented to improve over time as well. This is particularly important when considering the length in which Environmental Pool Management is implemented. Past practices had an average of 30 to 45 days in which Pools 26, 25, and 24 attempted to maintain lower water elevations when flows allowed. This is particularly important for the resiliency of the aquatic ecosystem, in that the longer growing season creates favorable conditions for perennial species that have been lacking compared to historic conditions.

2.3 Long Term Resource Monitoring Vegetation Surveys

2.3.1 Methods

The lower half (RM 201-221) of Pool 26 was sampled using the Long Term Resource Monitoring Vegetation Survey Protocol, Yin *et al* 2000. Within each site, plot locations were determined using the LTRM Stratified Random Sampling design, where a 50 x 50 meter grid is generated and overlaid into a GIS map. Nodes of the grid are geo-spatially registered with coordinates generated. Nodes that fall within the sites and 2.5 meters or greater in water depth were selected as vegetation survey plot locations. This was done for the lower half of Pool 26, RM 201-221. In total, 203 plots were generated (Figure 28). At each plot location, sampling is normally done via a boat and a total of six subplots are located off each corner of the boat and off the port and starboard sides of the boat. Each subplot is assigned a percent cover estimate using a rating of 0 to 5. The cover rating relating to species percent cover is as follows: 0 = None; 1 = 1-20%; 2 = 21-40%; 3 = 41-60%; 4 = 61-8-%; 5 = 81-100%. A cover rating was assigned to each species within each subplot.

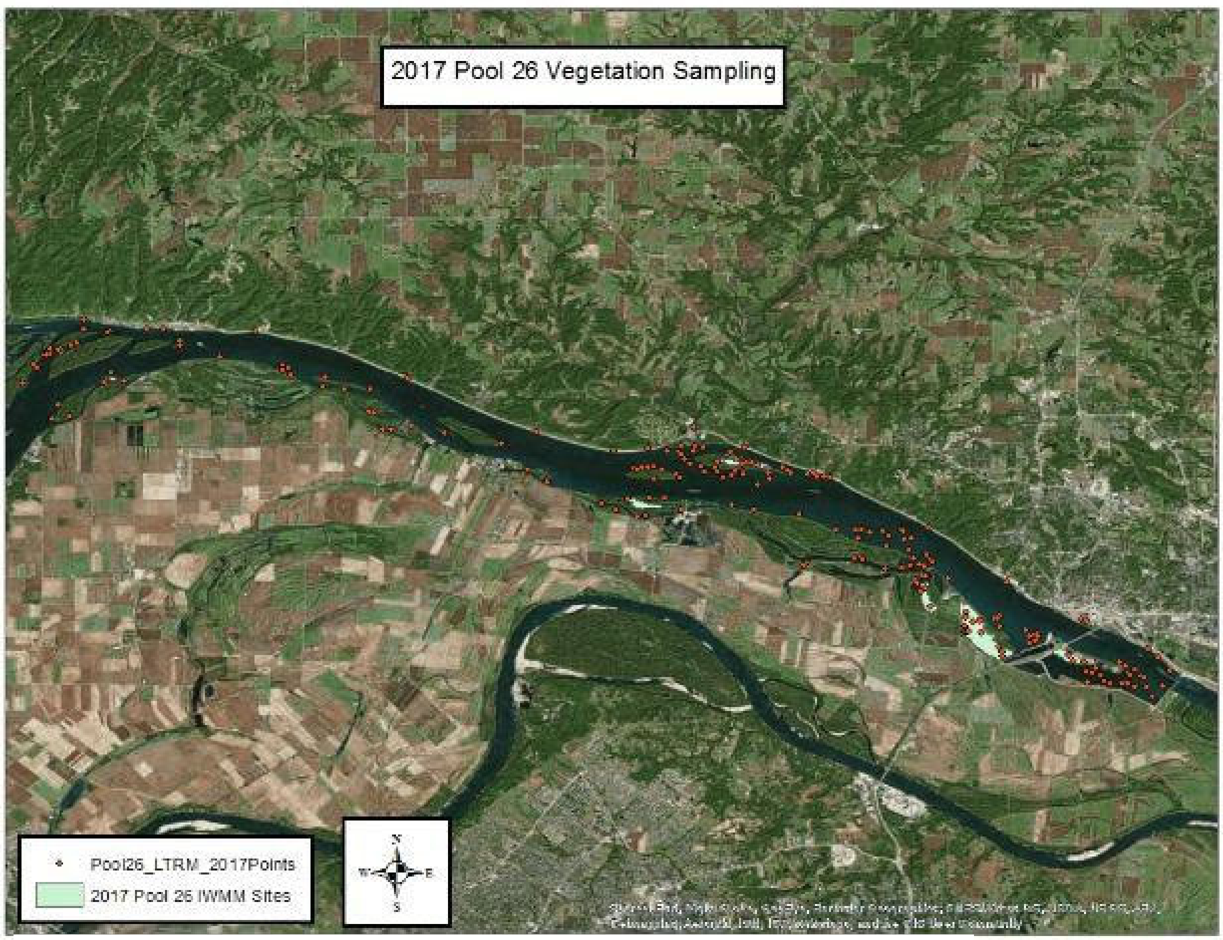


Figure 28. LTRM vegetation survey points in Pool 26, RM 201-221.

Although this vegetation survey protocol is primarily designed for sampling submersed aquatic vegetation via a boat, in Section 1.4.3 of the LTRM vegetation sampling protocol, *Unusual Situations* describes circumstances in which emergent aquatic vegetation sampling can be done on the ground. When utilizing this approach, the subplots are estimated visually as to their approximate location as if sampling was done from a boat.

Average species percent cover, percent frequency of occurrence, and species richness were calculated. Simpson's diversity index, Shannon's diversity index, and Simpson's evenness were calculated.

2.3.2 Results

Table 5. Table of all species encountered during LTRM-type vegetation surveys.

Code	Common Name
ACSA	Silver Maple
AMSP	Ameranthus sp.
ASSP	Aster sp.
BISP	Bidens Sp.
CASP	Sedge Sp.
CYES	Yellow nut sedge
ECCR	Barnyard grass (millet)
ECMU	Rough barnyard grass
ECWA	Walter's Millet
IPSP	Morning glory
LEPA	Amazon sprangletop
LIDU	Yellowseed false pimpernel
LINO	Frog fruit
PASP	Panicum species
POCO	Water smartweed
POLA	Curlytop smartweed
POPE	Pennsylvania smartweed
SANI2	Black willow
UNKN	Unknown

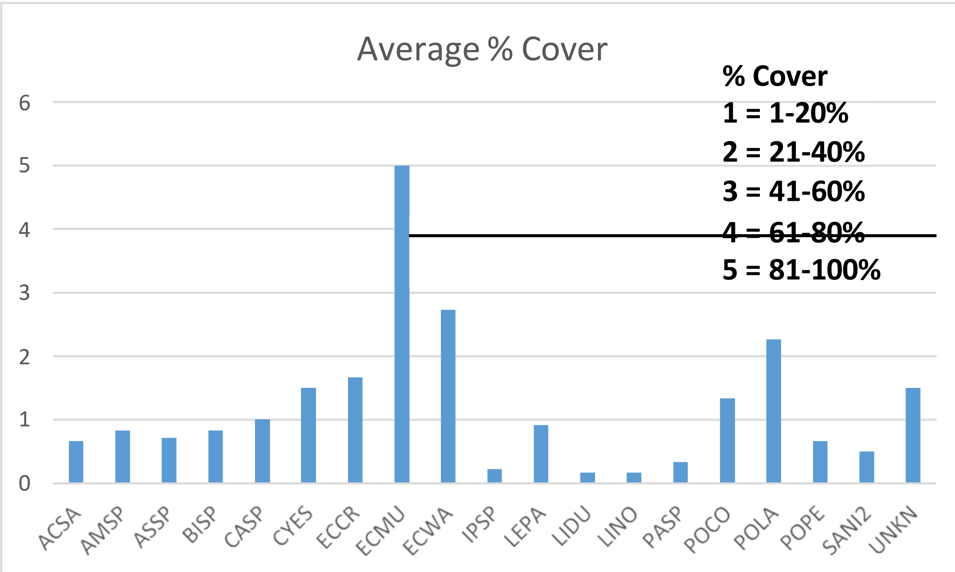


Figure 29. Pool 26 average percent cover from LTRM vegetation survey.

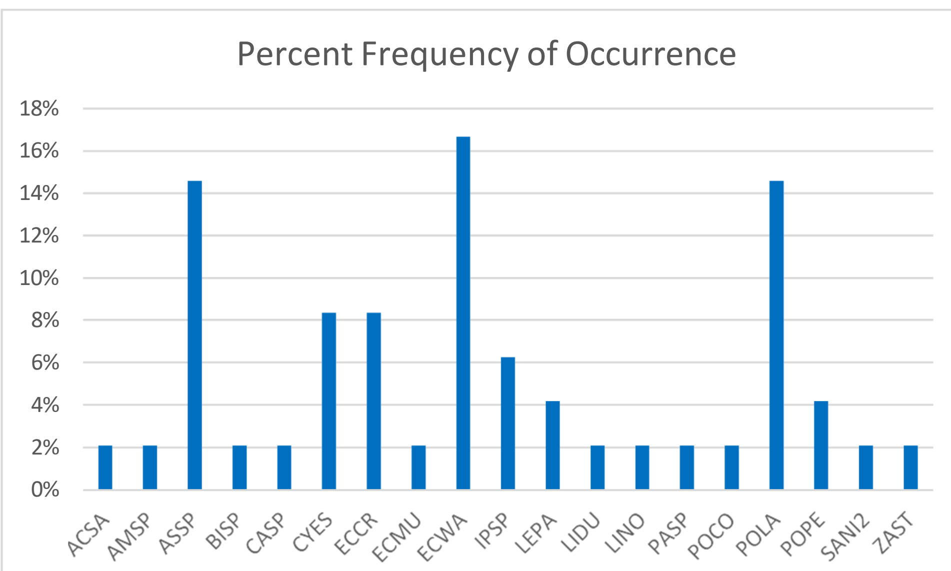


Figure 30. Pool 26 species percent frequency of occurrence for LTRM surveys.

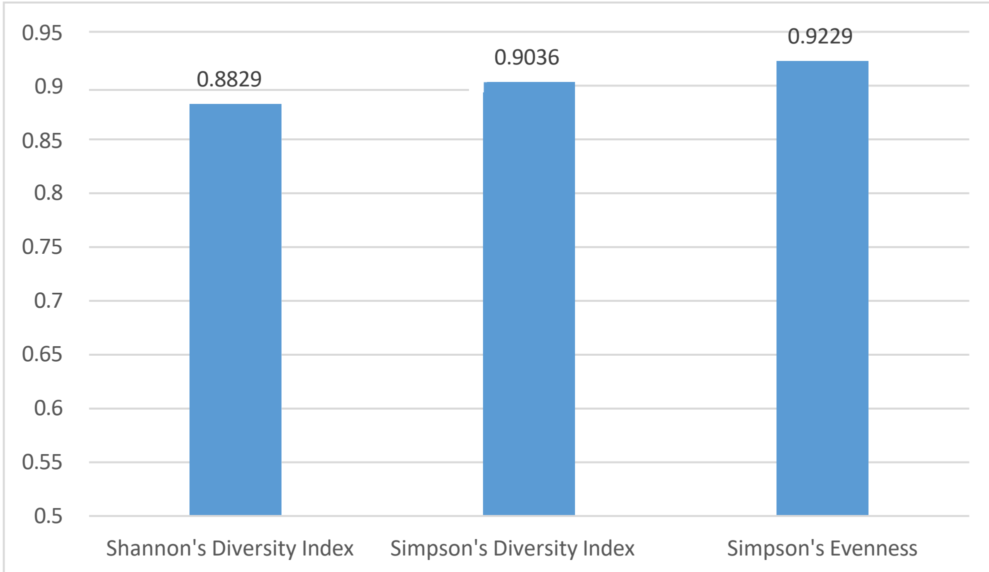


Figure 31. Shannon's diversity index, Simpson's diversity index, and Simpson's evenness Pool 26 LTRM vegetation surveys.

2.3.3 Discussion

In total, 18 species and one unknown species were documented during the surveys (Table 5). Average percent cover varied by species, the most dominant species were millets (*E. walteri* and *E. muricata*) and smartweed (*Polygonum lapathifolium*) (Figure 29). Percent frequency of occurrence was highest for *Echinochloa walteri* (16.7%), followed by *Polygonum lapathifolium* (14.6%) and *Aster* sp. (14.6%) (Figure 30). Overall, the sampled portion of Pool 26, contained a relatively high species diversity (Figure 31). Of the 203 sites sampled, only 46 contained vegetation. When setting parameters for plot location a maximum depth of 8.2 feet (2.5 meters) below full pool (419 ft) was selected. This was done to capture anything that would be within the area exposed at max drawdown elevation (412.5). However, since Pool 26 was in flood until the end of May and EPM levels were not achieved until early June, many of the areas within the area between 416 ft and 410.8 ft would have been underwater at the time of the surveys (Figure 4).

2.4 Seed Head Analysis

2.4.1 Methods

In order to quantify the amount of seed produced from emergent aquatic plant species, a seed analysis was conducted. Three sites were chosen, Middleton Island in Pool 24, Jim Crow Island in Pool 25, and Alton Lake in Pool 26, with high emergent vegetation plant growth and qualitatively observed high rates of seed production. Sampling occurred when the majority of the plants had produced seed heads and before shattering. To accomplish the seed head analysis, randomly placed 1 m^2 plots were established at each site. Within each plot, the number of seed-producing plant stems were counted. Only the seven species that currently have a model built for seed production were counted, following Gray *et al* 2009. These species include: flatsedge (*Cyperus erythrorhizos*), barnyard grass (*Echinochloa crusgalli*), Walter's millet (*E. walteri*), Amazon sprangletop (*Leptochloa panicoides*), rice cutgrass (*Leersia oryzoides*), fall panicum (*Panicum dichotomiflorum*), and curlytop smartweed (*Polygonum lapathifolium*). One randomly selected plant stem specimen from each species was collected from each plant. In cases with multiple seed heads per stem, all seed heads were collected. Once seed heads were collected, they were placed into plastic bags while in the field. Upon returning from the field, the bags were opened and a fan was placed on them for drying. Drying was necessary to prevent mold from growing on the collected seed heads between sampling and during shipping of the specimens. Samples were sent to University of Tennessee, Knoxville for analysis utilizing Gray *et al* 2009 approach to quantify kilograms of dry seed produced per hectare, duck-energy-days (Kaminski *et al* 2003), total kilograms of seed produced per site, and total duck energy days (DEDs) per site.

Figure 32. Photo of vegetation survey plot (1m^2) used for seed head surveys. Photo taken at Alton Lake in Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

2.4.2 Results

Duck energy-day estimates are provided in Appendix A and B. Seed production per acre improved from 2016. Seed production rates higher than 1,322.8 lbs/ac are considered highly productive for moist soil units (Dugger & Feddersen 2009). The three sites surveyed this year were close to or exceeded this value. Middleton Island produced on average 1,252.1 lbs/ac, Jim Crow Island produced on average 1,644.3 lbs/ac, and Alton Lake (Figures 32 and 33) produced on average 1,167.0 lbs/ac.

2.4.3 Discussion

The results in section 2.4.2 show a high seed production yield as compared to other wetlands which used the same quantification approach (Dugger & Feddersen 2009). The mean seed production rates of 1,252.1 lbs/acre, 1,644.3 and 1,167.0 lbs/acre for Pool 24, Pool 25, and Pool 26 respectively are higher than average sampled moist-soil unit sites (Dugger & Feddersen 2009). Since the plots shown in Figure 32 were randomly placed within each of the sampled sites, areas which did not have vegetation, i.e., bare earth were sampled. Therefore, these calculations are conservative and do not represent the seed per acre produced within vegetated areas. Further, since the random plots within these sites captured a diversity of conditions within each site, these results can be extrapolated and applied to the area of influence for EPM for each pool in which each of the sites were located. Using this method, in Pool 24, 338.77 acres of vegetation produced 424,173.92 pounds of seed. In Pool 25, 518.97 acres of vegetation produced 853,342.37 pounds of seed. In Pool 26, 753.57 acres of vegetation produced 879,416.19 pounds of seed. The three pools combined produced a total of 2,156,982 pounds of seed. When translated to Duck Energy Days (DEDs), the three pools can sustain the metabolic requirements of 8,125,440 ducks for one day or 135,424 ducks for 60 days.

Figure 33. Photo of *Echinochloa walteri* seed heads, Alton Lake, Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

2.5 Transect Vegetation Surveys

2.5.1 Methods

Following the Illinois Natural History Survey, Critical Trends Assessment Protocol for Wetland sites (INHS 2002), a transect is placed perpendicular to the long length of the wetland. A random a distance along the transect is selected. This baseline is placed along the edge of the wetland vegetation and parallel to the long dimension of the wetland. When lying the transect, the tape measure is pulled taut, but laid upon the ground at all points along its length (Figure 34). Herbaceous vegetation is sampled in ¼ m^2 quadrats at an interval of every 2m along the transect, starting 2m from the baseline. A total of 20 quadrats are sampled per site. Quadrats are placed 1m from the transect on alternate sides, starting on

Figure 34. Photo of transect vegetation survey plot (1/4 m^2), Piasa Island, Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

the left at the 2m point (e.g. the first quadrat covers the area from 2-2.5m along the transect, at a distance covering 1-1.5m left of the transect).

Average percent cover by site, average species percent cover by site, species richness, and Simpson's diversity index were calculated (Figures 35-38).

2.5.2 Results

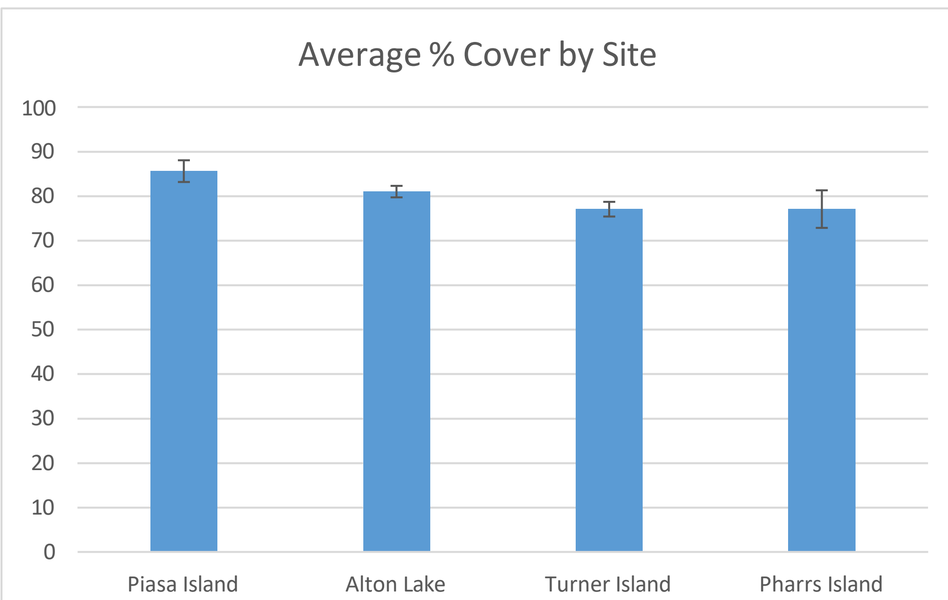


Figure 35. Average percent cover by site.

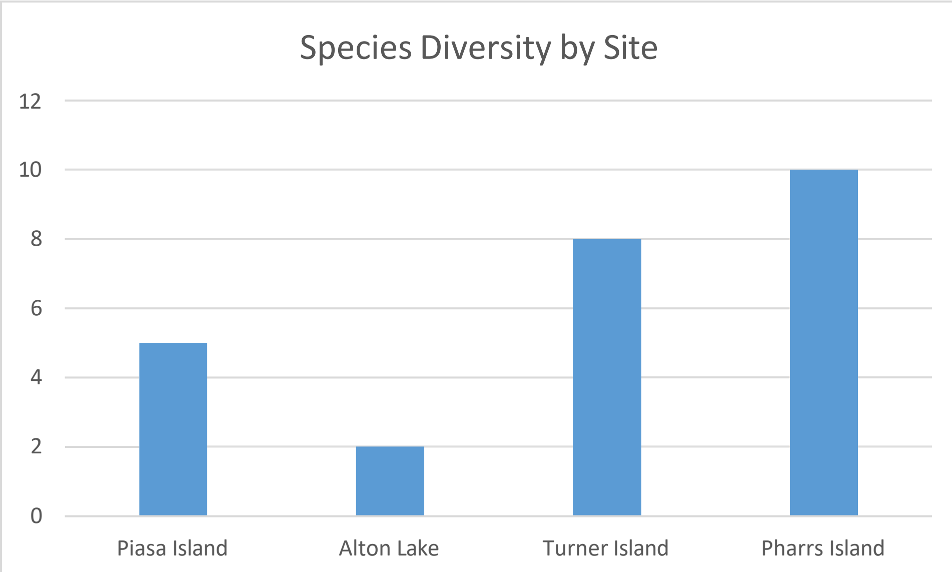


Figure 36. Species diversity by site.

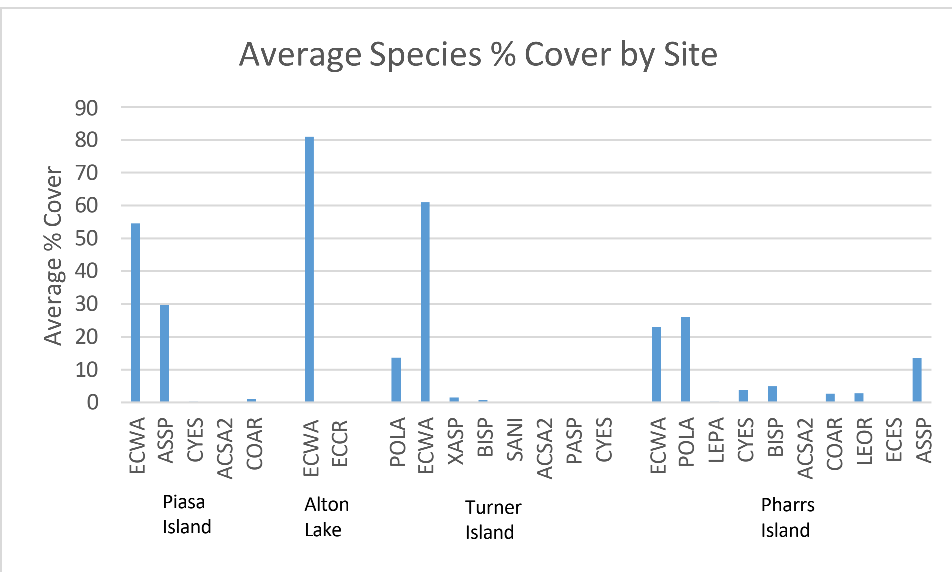


Figure 37. Average species percent cover by site.

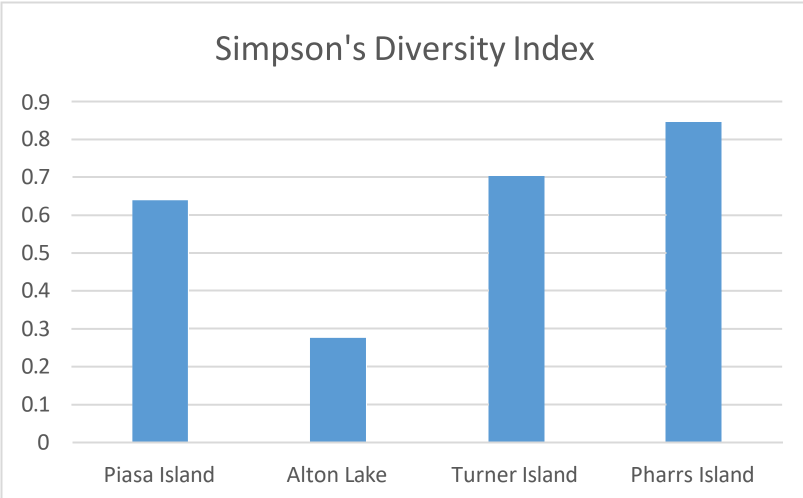


Figure 38. Simpson’s diversity index by site.

2.5.3 Discussion

Results for the transect surveys were similar to that of the IWMM surveys (Section 2.2) in that sites sampled in Pool 26 (Piasa Island and Alton Lake) had lower species diversity than compared to Pool 25 (Turner Island) and Pool 24 (Pharrs Island) (Figure 36) Alton Lake was dominated solely by millet species and a slightly more dense percent cover than Turner Island and Pharrs Island, but slightly less than Piasa Island (Figure 37). The higher presence of millet throughout the sites within each pool can likely be attributed to the later time in which these sites were dried and maintained suitable soil temperatures for the germination of emergent aquatic plants (Yoshioka *et al* 1998). Overall, Pharrs Island in Pool 24 had the highest Simpson’s diversity index and Alton Lake in Pool 26 had the lowest (Figure 38). These results are similar to the Integrated Waterbird Management and Monitoring surveys discussed in Section 2.2.3.

Chapter 3 Additional Results

3.1 Vegetation

In Pool 26 at Alton Lake, seeds of American lotus (*Nelumbo lutea*) were observed throughout the site in the substrate in 2016. Some seeds germinated in 2016 and 2017 at the same site (Figure 39). Arrowhead (*Sagittaria latifolia*) was also observed in several locations throughout Alton Lake (Figure 40). These species were documented within this area of Pool 26 historically (Reese and Lubinski 1983) but more recently have not been observed. The longer water level reduction time during 2016 likely restored conditions in which American lotus and arrowhead could germinate and continue their growth in 2017. These species have seeds that are viable for long periods of time. With continued longer duration water level reductions, these species would likely continue to germinate, build below-ground resources, and possibly persist if given multiple seasons to do so. In addition, the consolidated sediment observed in this site and others would improve establishment conditions for these plants as well as submersed aquatic plants.

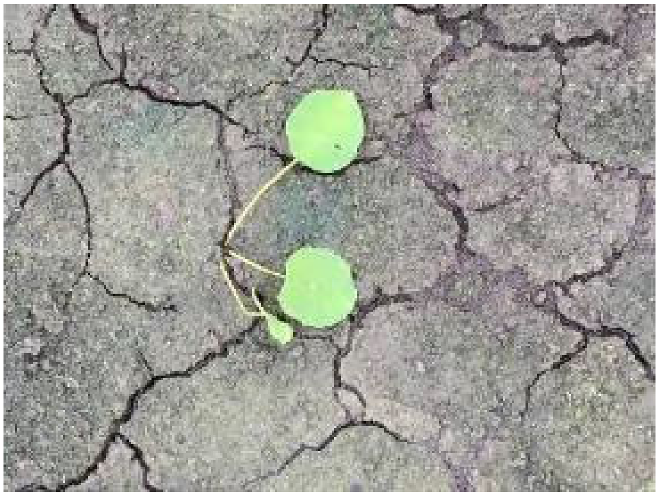


Figure 39. Photo of American Lotus (*Nelumbo lutea*) growing at Alton Lake in Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

Figure 40. Photo of arrowhead (*Sagittaria latifolia*) growing at Alton Lake, Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

3.2 Least Tern

The interior least tern (ILT) was listed as endangered in 1985. It is estimated that about 2,000 ILT existed at the time of listing. More recent studies estimate that the ILT population is greater than 17,500 (Lott 2006). This estimate greatly exceeds the rangewide numerical recovery criteria (7,000 adult birds) identified in the 1990 recovery plan for at least 18 years (USFWS 1990). Although the rangewide population has rebounded and USFWS's 5-year review of ILT recommends delisting due to recovery (USFWS 2013), their range is still limited compared to historical distribution, especially in the Upper Mississippi River (Figure 41).

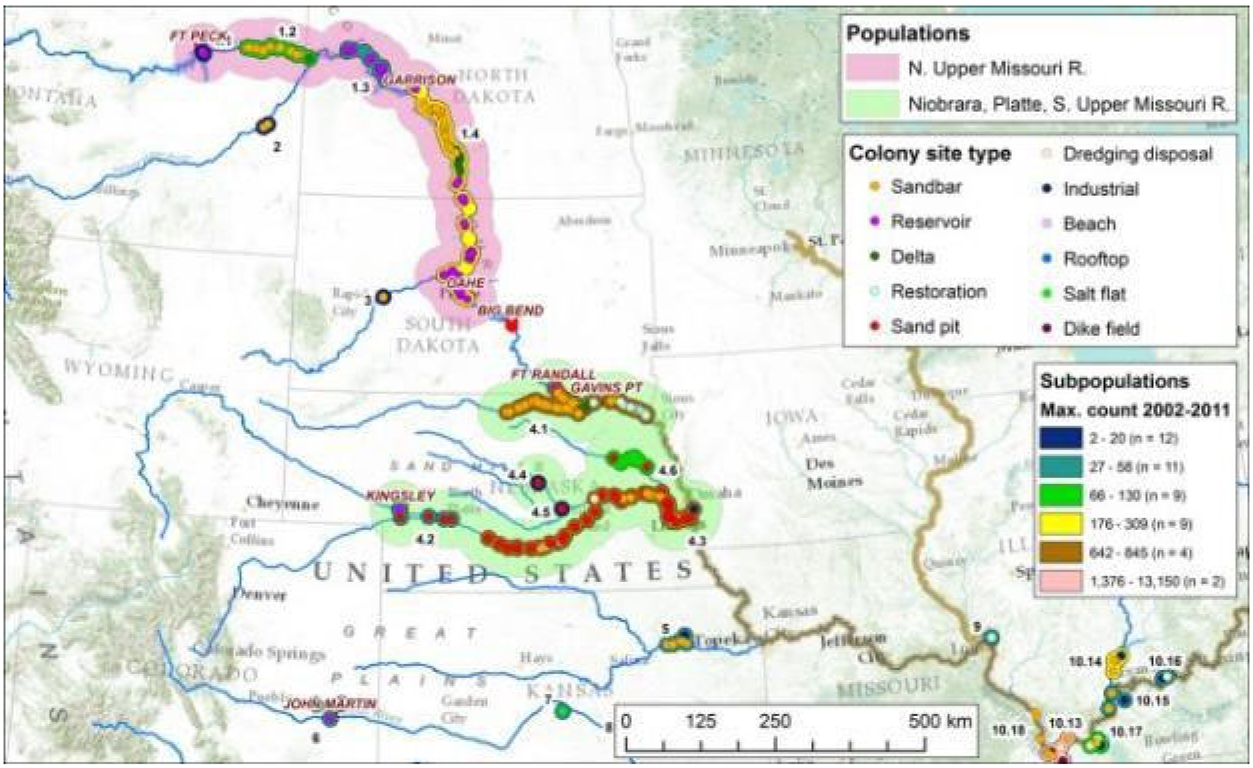


Figure 41. From Lott *et al* 2013. Map of Interior Least Tern populations

Observations of ILT in Pool 25 in June 2016 led to the discovery of successful nesting of ILT in August that same year (USACE 2016). Three ILTs were observed in Pool 24 on August 2, 2017 (Figure 42). Due to the distance away from the birds, it was unclear whether or not they were adults or juveniles. One adult ILT was observed on August 4, 2017 in Pool 25 (Figure 43). Due to the late observation of these species, it is likely that they attempted to nest or were successful in nesting in this general area or upstream in the Mississippi River. It is also interesting to note that the 2017 observation occurred approximately 700 yards from the successful ILT fledglings in 2016. Least terns have been documented to have high site fidelity to where they nested the previous year (Atwood and Massey 1988).

Although EPM operations are currently utilized in Pools 26, 25, and 24, operations do not normally occur upstream in the Rock Island and St. Paul Districts. Regularly implementing water level reductions throughout the entire UMR would likely benefit the range restoration of the interior least tern.

Figure 42. Least tern occurrence in Pool 24, August 2, 2017.

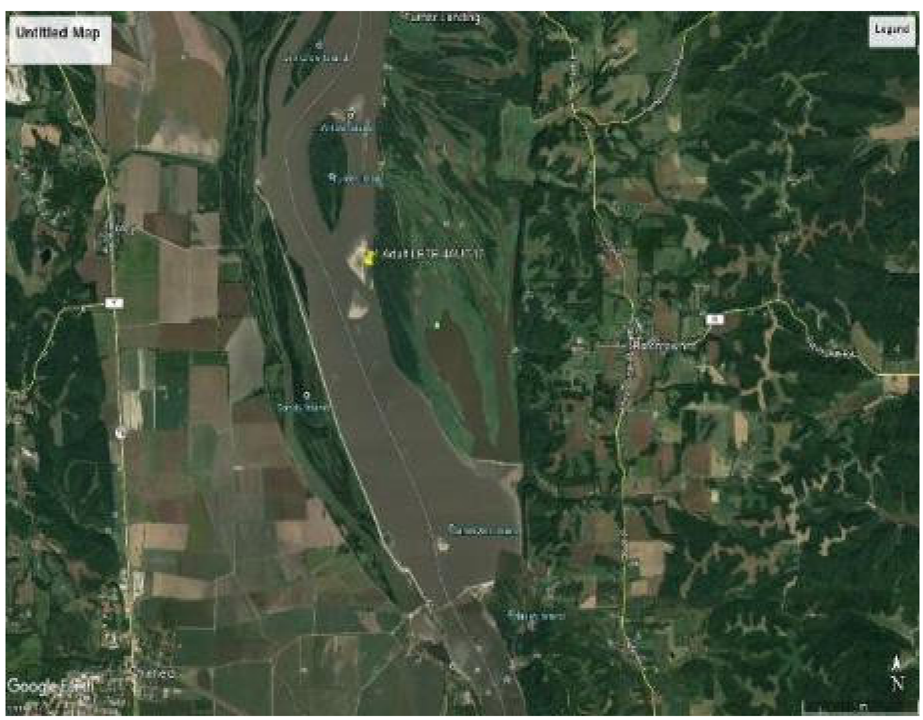


Figure 43. Least Tern occurrence in Pool 25, August 4, 2017

3.3 Waterfowl Use

The results from Section 2.4.2 demonstrate that there is a high availability for food for waterfowl. Since many of the areas influenced by EPM are located within waterfowl hunting areas, it is likely that waterfowl use for these areas peaks during the spring migration. The Illinois Natural History Survey began spring waterfowl aerial flights in spring 2018 for areas along the Mississippi and Illinois Rivers. The surveys primarily capture large impounded waterfowl refuges but areas connected to the Mississippi River where EPM affects water levels is also captured. Within Pool 26, the area between Grafton (RM 218) and Alton (RM 203) was surveyed and within Pool 25, the area between Lock and Dam 25 (RM 242) and the upstream portion of Red's Landing (RM 256) was surveyed. Seven flights between February 26 and April 26 were completed (Figure 45). The peak number of total waterfowl observed during the flights in Pool 25 was 5,420 on April 9, 2018. Of the total waterfowl observed that day, 2,700 were ring-necked ducks (Figure 44). The peak number of total waterfowl

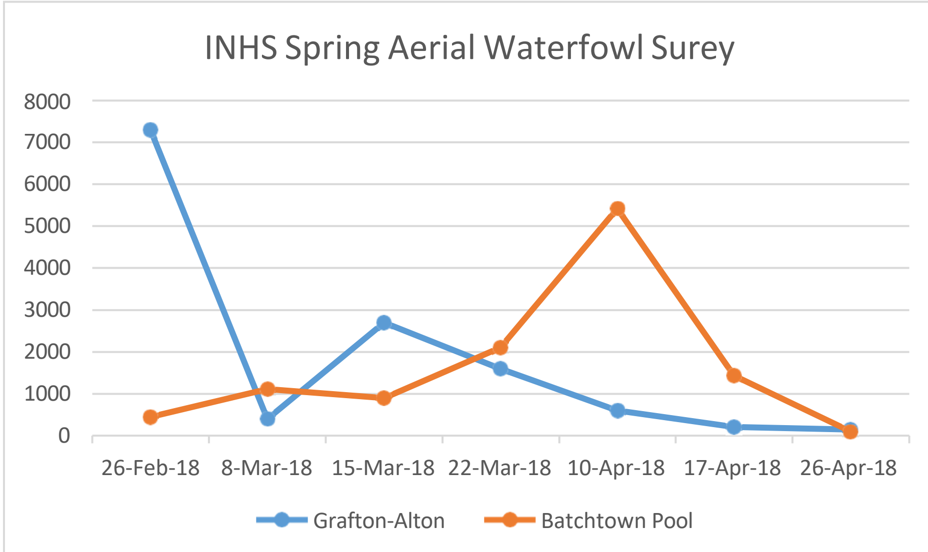


Figure 45. Illinois Natural History Survey spring 2018 aerial waterfowl survey on the Mississippi River in Pool 26 and Pool 25.

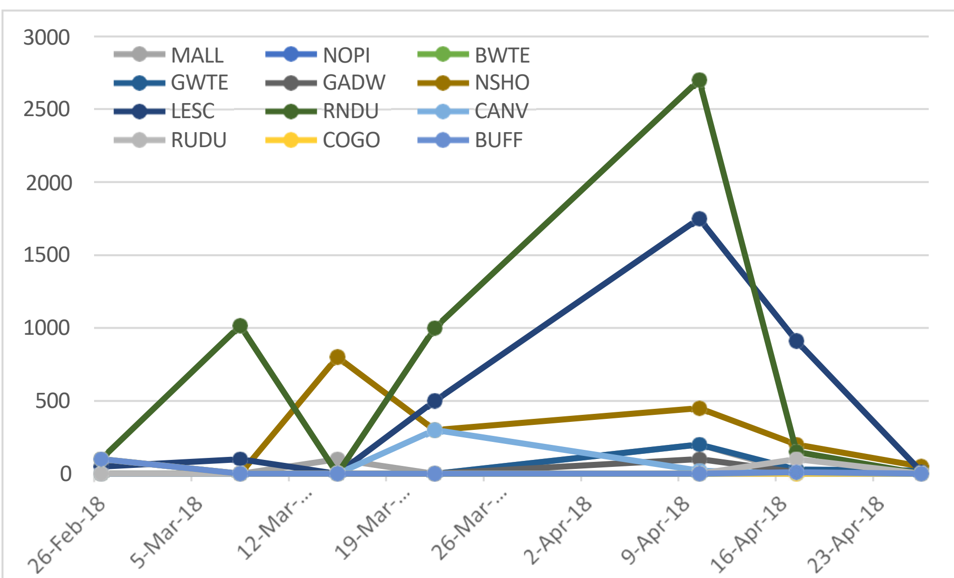


Figure 44. Illinois Natural History Survey spring 2018 aerial waterfowl survey for "Batchtown Pool" are in Pool 25. MALL=Mallard; NOPI=Northern Pintail; BWTE=Blue-winged Teal; GWTE=Green-winged Teal; GADW=Gadwall; NSHO=Northern Shoveler; LESC=Lesser Scaup; RNDU=Ring-necked Duck; CANV=Canvasback; RUDU=Ruddy Duck; COGO=Common Goldeneye; BUFF=Bufflehead.

observed during the flights in Pool 26 was 7,300 on February 26, 2018. Of the total waterfowl observed that day, 5,500 were northern pintails (Figure 46). This corresponds to other observations within the area of Alton Lake in Pool 26 on February 26, when approximately 5,000 Northern Pintails were observed (Figure 46). Figure 48 shows a cropped and enlarged area of the upper right quarter of Figure 47 in which

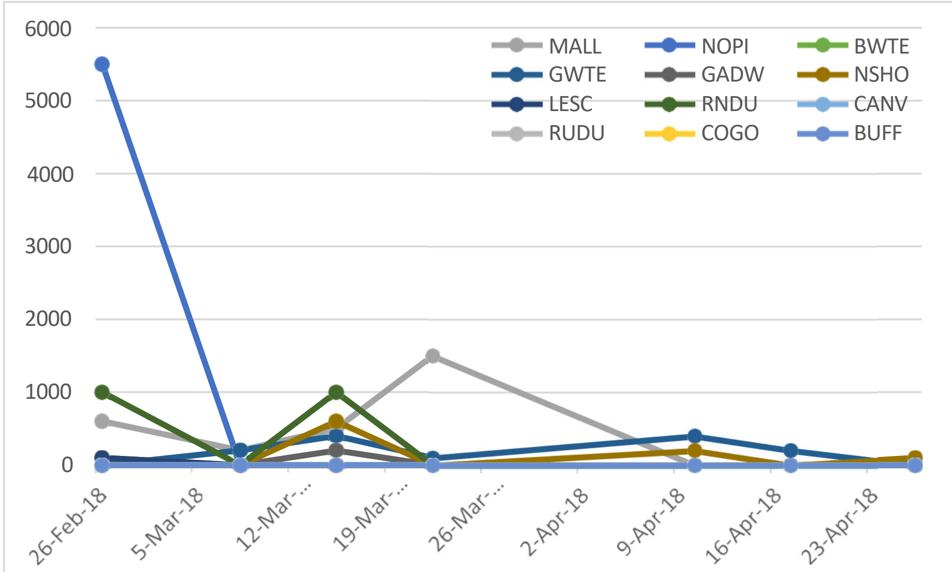


Figure 46. Illinois Natural History Survey spring 2018 aerial waterfowl survey for "Grafton-Alton" are in Pool 26. MALL=Mallard; NOPI=Northern Pintail; BWTE=Blue-winged Teal; GWTE=Green-winged Teal; GADW=Gadwall; NSHO=Northern Shoveler; LESC=Lesser Scaup; RNDU=Ring-necked Duck; CANV=Canvasback; RUDU=Ruddy Duck; COGO=Common Goldeneye; BUFF=Bufflehead.

approximately 1,800 ducks can be seen within the approximately 10 acre sized area. These results are consistent with previous studies in Pool 25 that documented waterfowl use along the Mississippi River following a successful EPM year (Dugger and Feddersen 2009). Areas like this are critical for waterfowl populations in North America to use during their spring migration to breeding grounds.

Figure 47. Alton Lake, Pool 26 (see Fig. 48 for credit)

Figure 48. Cropped upper right quarter of Figure 47, Alton Lake area, Pool 26, showing approximately 1,800 ducks within a 10 acre area. Photo by Ben McGuire, USFWS, formerly USACE.

3.4 Sediment Consolidation

Sediment consolidation and drying was observed to some degree at every site again during 2017. However, the instance at Alton Lake was again extraordinary. Figure 49 and Figure 50 show bare earth in which pickup trucks drove to the duck blinds located in this site. In previous years, prior to the extended EPM operations, flocculent sediment was observed to be approximately 1.5 feet deep in that same area. The prolonged water level reduction created conditions where the sediment was exposed and able to dry. Further sediment consolidation would benefit rooted floating leaf and submersed aquatic plants.

Figure 49. Photo showing truck tire tracks at Alton Lake in Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

Figure 50. Photo with vehicle road occurring at Alton Lake in Pool 26. Photo by Ben McGuire, USFWS, formerly USACE.

Chapter 4 Outreach

4.1 Meetings/ Workshops

Meeting Attended	**Approximate USACE additional dollar expenditure**
RRAT Tech Meeting	1k
EPM End of Season Meeting	3k
RRAT Boat Trip	2k
Water Control Open House Meetings	10k
Misc. MVS Meetings and Coordination	2k
Upper Mississippi River Basin Association workshops	5k
Total	**23k**

Table 6. Table showing summary of fund expenditures in addition to SRP funding by MVS during the 2017 EPM season.

Presentations demonstrating the results from the 2017 season (Table 6) were given at the River Resource Action Team annual boat trip meeting and the Upper Mississippi River Basin Association water level management workshop (MVP, MVR, and MVS districts) in January 2018. In addition, an oral presentation was done at The World Association for Waterborne Transport Infrastructure (PIANC) in September 2017. Public informational meetings were held at Mel Price Lock and Dam and at Cabelas in Hazelwood, MO on April 8, 2017. A Dredge Operations Environmental Research technical report and presentation has also been compiled for WLM activities in MVS, MVR, and MVP.

During the 2016 post-season meeting, new operation guidelines were established to reflect the longer duration of EPM operations. They are as follows:

1) Provide safe and dependable navigation channel
2) Begin pool drawdowns around 1st of April before majority of *Centrachid* fish spawn begins
3) Continue drawdowns from the 1st of May to the 30th of July for most suitable period of vegetation growth and seed production
4) Minimum of 0.5 feet drawdown for 30 days
5) After initial drawdowns, allow the pools to rise at a rate of < 0.3 ft/day, which allows some vegetation to survive and continue to grow

In addition to operating with the above 2016 guidelines in MVS, WLM implementation was continued upstream in MVR and MVP with workshops to discuss operations and implementation. The following is a summary of the January 30, 2018 outcomes:

Vision and mission for WLM system team developed by the 33 participants:

- Vision – Improve ecological health and resilience through optimal water level variation
- Mission – To promote systemic, routine, and coordinated water level variation, address policies and funding needs, advance interdisciplinary monitoring and research, and inform and engage the public.

2018 priorities and tasks - Participants identified recommended action tasks for 2018:

1. Implement pool-scale drawdowns in Pools 13 and 18 (beyond the operating band)
    - Facilitate conversations with IL DNR
    - IA DNR make a formal request
2. Perform opportunistic drawdown in Pool 10
3. Explore solutions to issues affecting feasibility of routine WLM (e.g., outlined in Pool 8 White Paper)
    - Determine mechanisms and seek funding for implementation (e.g., UMRR)
    - Establish monitoring protocols (utilizing existing protocols where possible) and perform monitoring on an opportunistic basis
4. UMRBA – UMRBA will organize and convene a system-wide WLM team, working with COE on team composition.
5. UMRBA will sign cost share agreement with Corps for PAS funds
    - Partners will sign agreement with UMRBA to provide WIK funds to help match UMRBA funds for PAS

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Appendix A – Alton Lake (Pool 26) and Middleton Island (Pool 24) Seed Yield and Duck Energy-day Estimates, September 2017

Summary

Benjamin McGuire submitted un-pressed seed heads to the University of Tennessee Wetlands Program for seed production and duck energy-day (DED) estimates that were collected randomly from 17 1-m^2 plots in moist-soil wetlands at two sites located along the Mississippi River in Missouri. Seed heads were pressed for one week, seed-head area for each plant was scanned, and seed-head 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 yellow nutsedge (*Cyperus esculentus*), sprangeltop (*Leptochloa panicoides*), wild millet (*Echinochloa crus-galli*), Walter's millet (*E. walterii*), and nodding smartweed (*Polygonum 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.

At the Alton Lake site, seed production among plots ranged from 830 - 1948 kg/ha (741 - 1738 lbs/ac, Table A1). Average seed production among plots was 1308 kg/ha (1167 lbs/ac; Table A1) and could be classified as high yield (see reference values below). Plots with the greatest seed production were #5 and #8. The lowest seed production was in plot #3 (Table A1).

At the Middleton Island site, seed production among plots ranged from 1024 – 1818 kg/ha (914 – 1622 lbs/ac, Table A2). Average seed production among wetlands was 1403 kg/ha (1252 lbs/ac; Table A2) and could be classified as high yield (see reference values below). Plots with the greatest seed production were #6 and #7. The lowest seed production was in plot #5 (Table A2).

<u>Seed Production Reference Values</u>[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).

Based on the plant species present and high seed production, the moist-soil wetlands surveyed 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 1.5X more variable at Alton Lake compared to Middleton Island (SDs in Tables A1 and A2). Thus, spot treatment of mechanical manipulations or herbicides, or supplemental planting of an agricultural variety of a moist-soil plant species (e.g., Japanese millet, *E. esculenta*) might improve seed production in areas near plots with less seed production. Moderate application of fertilizer also can improve seed production in moist-soil wetlands (Gray et al. 2013).

Duck energy-day estimates are provided (Tables A1 and A2). Total estimated DEDs for the Middleton Island site (2.94 ha, 7.27 ac) was 37,935 DEDs, which is equivalent to having the energetic potential to support **345 ducks per day for 110 days**. Total estimated DEDs for the Alton Lake site (38.6 ha, 95.5 ac) was 441,267 DEDs, which is equivalent to having the energetic potential to support **4,012 ducks per day for 110 days**.

Table A1. Seed production and duck energy-days (DED) estimated from 9 plots in moist-soil wetlands at Alton Lake, September 2017.

Plot	kg/ha	DED/ha	lbs/ac	DED/ac
1	904.7	8730.3	807.2	21563.8
2	1046.8	10183.1	933.9	25152.2
3	830.2	7277.0	740.7	17974.1
4	875.4	8516.2	781.1	21035.0
5	1947.8	8186.8	1737.8	20221.4
7	1630.0	15856.9	1454.3	39166.5
8	1672.6	16270.7	1492.2	40188.6
9	1467.1	14272.2	1309.0	35252.4
10	1397.3	13592.9	1246.7	33574.4
Mean	1308.0	11431.8	1167.0	28236.5
Median	1397.3	10183.1	1246.7	25152.2
Lower 95% CI	1042.1	9111.7	929.7	22505.9
Upper 95% CI	1574.0	13751.9	1404.3	33967.1
SD	407.1	3551.2	363.2	8771.4

Table A2. Seed production and duck energy-days (DED) estimated from 8 plots in moist-soil wetlands at Middleton Island, September 2017.

Plot	kg/ha	DED/ha	lbs/ac	DED/ac
1	1391.9	12925.4	1241.8	31925.7
2	1384.1	12799.1	1234.8	31613.8
3	1267.6	11657.9	1131.0	28795.0
4	1321.3	11884.8	1178.9	29355.4
5	1024.2	9424.1	913.8	23277.6
6	1748.4	15562.6	1559.9	38439.6
7	1818.3	16924.8	1622.2	41804.3
8	1271.9	12044.6	1134.8	29750.1
Mean	1403.5	12902.9	1252.1	31870.2
Median	1352.7	12421.8	1206.8	30682.0
Lower 95% CI	1222.4	11273.8	1090.6	27846.4
Upper 95% CI	1584.5	14532.0	1413.7	35894.0
SD	261.3	2350.9	233.1	5806.7

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Appendix B – Jim Crow Island (Pool 25) Seed Yield and Duck Energy-day Estimates, September 2017

Summary

Benjamin McGuire submitted un-pressed seed heads to the University of Tennessee Wetlands Program for seed production and duck energy-day (DED) estimates that were collected randomly from five 1-m^2 plots in moist-soil wetlands at Jim Crow Island. Seed heads were pressed for one week, seed-head area for each plant was scanned, and seed-head 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 yellow nutsedge (*Cyperus esculentus*), sprangeltop (*Leptochloa panicoides*), wild millet (*Echinochloa crus-galli*), Walter's millet (*E. walterii*), nodding smartweed (*Polygonum lapathifolium*), and Pennsylvania smartweed (*P. pensylvanicum*). 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 at Jim Crow Island ranged from 443 - 3801 kg/ha (395 - 3392 lbs/ac, Table B1). Average seed production among plots was 1843 kg/ha (1644 lbs/ac; Table B1) and could be classified as high seed yield (see reference values below). The plot with the greatest seed production was #3. The lowest seed production was in plot #5 (Table B1).

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).

Based on the plant species present and high seed production, the moist-soil wetlands surveyed 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 in plot 5 was moderate; hence, spot treatment of mechanical manipulations or herbicides, or supplemental planting of an agricultural variety of a moist-soil plant species (e.g., Japanese millet, *E. esculenta*) might improve seed production in that area. Moderate application of fertilizer also can improve seed production in moist-soil wetlands (Gray et al. 2013).

Duck energy-day estimates are provided (Table B1). Total estimated DEDs for Jim Crow Island wetlands (1.62 ha, 4 ac) was 22,164 DEDs, which is equivalent to having the energetic potential to support **201 ducks per day for 110 days**.

Table B1. Seed production and duck energy-days (DED) estimated from 5 plots in moist-soil wetlands at Jim Crow Island, September 2017.

Plot	kg/ha	DED/ha	lbs/ac	DED/ac
1	1864.7705	11533.75645	1663.710945	28488.37842
2	1799.155	12443.04	1605.17	30734.3
3	3801.7247	32245.28	3391.823	79645.85
4	1306.6264	10427.55	1165.746	25756.04
5	442.703	1762.242	394.9708	4352.738
Mean	1843.0	13682.4	1644.3	33795.5
Median	1799.2	11533.8	1605.2	28488.4
Lower 95% CI	761.7	3848.9	679.5	9506.9
Upper 95% CI	2924.3	23515.8	2609.0	58084.0
SD	1233.6	11218.5	1100.6	27709.7

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