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Sedge/Grass Meadow Restoration on Former Agricultural Land: Analysis of Establishment Success

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by Alexander Joseph Healy

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Abstract

Sedge/grass meadow wetland restoration was conducted at three study sites located in about 4 ha of agricultural land recently acquired by New York State Department of Environmental Conservation (NYSDEC) adjacent to West Creek at its confluence with Braddock Bay in Hilton, Monroe County, New York. The restoration was conducted within a 75.35 to 75.60 m (IGLD1985) elevation range previously identified as capable of supporting sedge/grass meadow in Lake Ontario wetlands. This project consisted of an initial baseline survey during spring 2009, a seed-bank emergence study that began in September 2009 and terminated in early July 2010, restoration implementation during summer 2010, and follow-up after implementation during August 2010, 2011, and 2012. Data from other Lake Ontario drowned river-mouth wetlands and a study site at Kents Creek served as references.

Implementation at the three study sites began with disking in May 2010 to expose fresh soil and remove much of the old plant growth. Locally-sourced wetland seed mixes, plus seeds from Canada bluejoint grass (*Calamagrostis canadensis*) and tussock sedge (*Carex stricta*), were purchased, cold-stratified, and sown with shoulder-broadcast seed spreaders in June 2010 in the study site planted areas. Plugs of Canada bluejoint grass and tussock sedge were also hand-planted in the same areas. Sections of each disked site area were left unplanted and unseeded to serve as controls. At two of the sites, natural wetland remnants, near areas dominated

primarily by river bulrush (*Schoenoplectus fluviatilis*) in 2009, were not disked, planted, or seeded.

Plant surveys were conducted in the study site planted, control, and natural wetland areas, as well as in the 2009 baseline survey, by sampling in randomly-placed $1m^2$ quadrats. Plant data (frequency and percent cover of species in $1m^2$ quadrats) were used to calculate Importance Values; species were classified according to the National List of Vascular Plant Species that Occur in Wetlands; statistical tests were performed to determine important species and total percent cover and species count differences among study site areas; and data from all three sites across all four years were analyzed by ordination using non-metric multidimensional scaling (NMDS) in sample x Importance Value matrices.

Fifteen of the 42 seeded/planted species, 38 remnant sedge/grass meadow associates, and 36 potentially problematic (agricultural weed) species were identified in study site community samples across years, and additional species continue to be found. Following restoration, seeded species diversity increased in each subsequent year, and potentially problematic species generally decreased each subsequent year. Drought conditions during 2012 likely affected survival of some wetland species with greater water demand. Control treatments on high-canopy, annual agricultural weeds by mowing at a height of about 30 cm also affected plant community changes. The seed-bank emergence study did not successfully predict ultimate community composition following implementation, likely because survival of plants from seed is often dictated by post-recruitment processes. Instead, seeded species, remnant

vegetation, and nearby refuge populations seemed to contribute more to establishment in the planted areas than the original seed bank.

The NMDS ordination showed that the 2009 baseline plant communities had been displaced by 2010, likely as a result of implementation actions. The ordination also showed that overall communities in the planted areas at the three sites changed from year to year and largely converged with the unplanted controls by 2012, which suggests that remnant vegetation was highly influential and nearby refuge populations made contributions as seeded species spread throughout control and planted site areas.

Post-restoration sampling at the restoration sites identified 21 species that were found in the Lake Ontario drowned river-mouth wetland reference data base and six species sampled at the Kents Creek reference site. Reference data suggest that the restoration sites reflect sedge/grass meadow conditions but also contain many other species associated more commonly with disturbed sites.

The future plant community at these restoration sites will likely be dependent on survival and expansion of sedge/grass meadow species, as influenced by soil moisture and competition from remnant agricultural weed species. Prolonged drought could potentially extirpate many of the seeded/planted species, especially if those conditions occurred in successive years. Monitoring results showed that competition can be mitigated by repeated, well-timed mowing that cuts taller annual plants before seed set and opens the canopy for underlying sedges and sedge/grass meadow associates currently found beneath them.

Disking, mowing, and seeding/planting are all recommended in future restoration projects in this type of setting. However, hydrologic conditions (e.g., elevation, lake-level variability, and weather/climate variability) must be considered fully, as should changes in the seeding mixture. As in all restoration projects, invasive and other potentially problematic species must be identified and treated soon after detection. Monitoring is therefore critical and should be continued for at least ten years or until data show that the communities have stabilized.

Introduction

Natural lake-level fluctuations influence the distribution of plant communities along an elevation gradient, but quantitative studies that address the impact that lake-level regulation has upon vegetation are limited, especially with an emphasis on meadow marsh (sedges and grasses) restoration (Wilcox and Meeker 1991, Baldwin *et al*. 2001, Wilcox *et al*. 2008). This study evaluated an attempt to establish sedge/grass meadow vegetation and remove invasive species at three sites on about 4 ha of agricultural land (Figure 1) purchased by NYSDEC in the fall of 2008.

Meadow marsh vegetation requires occasional flooding to control invasive woody species and periodic low water levels to stop aggressive emergent plant expansion (Wilcox *et al*. 2005a). As shown by a recent study, sedge/grass meadow area decreased substantially at 16 Lake Ontario wetland sites following regulation of water levels that began in 1960 under Plan 1958D with deviations (1958DD), controlled at the Moses-Saunders hydroelectric dam between Cornwall, Ontario and Massena, New York (Hudon *et al*. 2006, Wilcox *et al*. 2008,Wilcox and Xie 2008).

The disruption of water-level changes that occur on seasonal and longer-term scales has reduced the total nearshore area along Lake Ontario that experiences regular periods of flooding and dewatering (Wilcox *et al*. 2005b). Altered hydrology has permitted the dominance of competitive emergent cattail (*Typha*) at the expense of meadow marsh species (Wilcox *et al*. 2008).

To evaluate the effectiveness of restoring characteristic native meadow marsh species, my field experiment consisted of four inter-related components: an initial baseline survey of established communities during the spring of 2009; a seed-bank emergence study from the fall of 2009 through the summer of 2010 to determine the potential presence of plant species in the seed bank, including those that might be aggressively invasive (Brown 1998); the experimental implementation of restorative procedures during the summer of 2010; and follow up investigations after implementation during the summers of 2010, 2011, and 2012, to determine what changes occurred. Few other studies have focused on the relationship between the presence of species in the seed bank and establishment after restoration (Bakker *et al*. 2005).

At least some persistence of remnant populations is expected due to their known contribution to resilience, which enhances species colonization and reduces variation, especially when refuge communities are present nearby (Eriksson 2000, Bakker *et al*. 2005). Remnants of prior communities sometimes have the capacity to recover and return to conditions that prevailed before disturbances such as disking and tilling (Eriksson 2000). However, clonal fragment interference may also suppress the colonization from seed, which would hinder the usefulness of seed-bank emergence study results (Angeler and Garcia 2005).

Specific wetland types develop through time in response to both geochemical and hydrologic variables that determine community development by influencing biogeochemical and biological properties (Bedford 1996). Theories regarding self-

design and self-organization of the study site communities were tested in this study using restorative experimental procedures to determine if introduced species were able to establish successfully along an elevation gradient deemed suitable for wet-meadow vegetation (Mitsch *et al*. 1998). Final floristic composition of plant communities was thus determined by how strongly species position along an elevation gradient influenced a natural linkage between differential germination, plant growth, and seedling establishment (Nicol *et al*. 2003). Restoration success in this study was evaluated by how plant communities responded to the methods used to encourage the growth of species associated with sedge meadows and reduce the threat of potentially problematic species.

Methods

Study Sites

Site visits were conducted in January 2009 at 4 ha of agricultural land (Figure 1) adjacent to West Creek at its confluence with Braddock Bay in Hilton, Monroe County, New York (lat 43.309 N, long 77.777 W), to determine the area with potential for sedge/grass meadow restoration and evaluate site conditions and limitations. Three sites (suitable restoration areas) (Figure 2) were identified that contained lower elevation remnant cropland and showed little sign of wetland invasive species (some purple loosestrife (*Lythrum salicaria*) occurred near the creek

at Site 2). Overall, the sites had adjacent narrow strips of wetland along the bank of West Creek that contained cattails mixed with other emergent vegetation. The upland side consisted of more than 81 ha of higher elevation cropland targeted by NYSDEC for grassland restoration – a buffer zone fringing the proposed meadow marsh areas. Site boundaries were established by surveying within the proposed elevation range (75.35 to 75.60 m IGLD85) where sedge/grass meadow has been shown to be resistant to cattail invasion (Wilcox and Xie 2007).

Site boundaries were staked and delineated in May 2009 using a Global Positioning System (GPS). Geographic Information System (GIS) software was used to display GPS waypoints and provided map boundaries in which established vegetation and Light Detection and Ranging (LIDAR) information could be viewed to identify existing relationships between elevation-gradients and plant communities. Elevation data were obtained in the North American Datum of 1983 [NAD 83] then converted to the International Great Lakes Datum of 1985 [IGLD 85] (NGS 2012). Although Digital Elevation Model (DEM) vertical resolution is often too coarse to use for characterizing floodplain gradients (Townsend 2001), LIDAR generates elevation data, like those incorporated into this study, with a typical accuracy between 0.15 m and 0.2 m (Sellars and Jolls 2007).

Sites 2 (St2) and 3 (St3) were fairly uniform across flatter elevation gradients, but Site 1 (St1) had a mixture of both dry and wet habitats; both mudflats and springs were found near the bottom of a hill in Site 1. Later inspection of the soils in conjunction with data downloaded from the Natural Resources Conservation Service

(NRCS) Soils Data Mart (USDA and NRCS 2010a) revealed that Site 1 had a mixture of clay/silt soils on the upland side, with more sandy soil closer to the creek. Site 2 had fairly uniform clay/silt soil, and Site 3 had a sandy loam soil close to the creek, which gradually became clay/silt further away.

Reference Sites

Appropriate reference conditions were needed to depict natural variability in emergent communities caused by short-term anthropogenic stress changes (Angeler and Garcia 2005). A reference site also provided insight into potential trajectories resulting from restoration. Wetlands classified as drowned river-mouth (situated at the mouth of a tributary flowing into Lake Ontario or the St. Lawrence River, and influenced by both the hydrology of the lake and the tributary) served as published regional wetland reference data (Wilcox *et al*. 2005). A study site located at Kents Creek (Figure 1) served as an immediate reference. Its broad basin provided extensive areas of un-flooded wetland conducive to the growth of sedges and grasses (Wilcox *et al*. 2008).

Kents Creek Reference Survey

Sedge/grass meadow vegetation was surveyed in an area of Kents Creek in July 2010 using randomly-placed quadrats to estimate species percent cover.

Randomization was accomplished by blindly tossing a 1-m^2 quadrat. Species were identified, and their percent cover was estimated inside each of ten quadrats.

Seed-Bank Emergence Study

A seed-bank emergence study in a greenhouse served as a useful indicator of both function and structure of the wetland habitat (Brown 1998, Baldwin *et al*. 2001, Norbert and Annette 2001, Angeler and Garcia 2005). Detection of any remnant native species that existed either as standing vegetation or in the seed bank was important, as they may have enhanced colonization and contribution to ecosystem stability by providing persistent habitat assemblages (Eriksson 2000).

Due to the chance of species germination failure when all conditions for germination and establishment were not met, including light, oxygen, and temperature, a seed-bank emergence study provided information regarding a specific subset of species that were able to emerge under the conditions provided (Leck 2003, Bakker *et al*. 2005). Some difficulties were expected when using this method to predict plant communities in the field due to the possibility of low similarity to environmental conditions (Brown 1998).

Near-surface soils, collected to about 5 cm depth (Baldwin *et al*. 2001) during May 2009, served as material for a seed-bank emergence study to determine potential vegetation (invasive and native) across the three sites. Sampling locations were chosen based upon relative area of the three sites and established communities within

them. Four soil samples were collected at Sites 1 and 3, while two soil samples were collected at Site 2. Following collection, soil samples were placed in cold storage for a few months to overcome seed dormancy and encourage germination.

Although some species may have failed to germinate under a particular treatment method (Brown 1998, Angeler and Garcia 2005), moist conditions (not flooded) (Nicol *et al*. 2003) and high-light conditions, similar to conditions during the early growing season or following the disturbance of adult plants (Baldwin *et al*. 2001), should have permitted the greatest number of species to germinate (Baldwin *et al*. 2001, Nicol *et al*. 2003), which is considered the primary concern when evaluating the vegetation restoration potential of a site (Wang *et al*. 2009). Attempts were made to maintain these conditions during the course of the study by checking moisture conditions regularly at 3- to 4-day intervals and setting the light to a consistent schedule – 0600 to 2100 daily.

Soil samples were spread evenly to a depth of 2.5 cm over 1.3 cm of sterile potting soil in 27.9 cm^2 (approximate) trays with perforations (Brown 1998, Baldwin *et al*. 2001), placed in continuously flooded 27.9 cm x 54.6 cm trays, and elevated sufficiently to create continuously moist but un-flooded conditions in sample soils (Leck 2003). A bucket and plastic tubing were used to deliver a constant drip to the trays.

Sample trays were monitored at 3- to 4-day intervals to ensure that no plants quickly emerged then died before being observed. All specimens (stems) were counted and identified to the lowest taxonomic level, which was generally species,

during the first true-leaf stage before being removed, unless unidentifiable. Seedlings deemed difficult to identify were replanted to allow further growth until the plants flowered, unless there was only one noticeable species representative, thus avoiding premature death due to disturbance. Some plants were not removed until study completion since they never flowered and uncertainty existed concerning their identification (e.g., *Carex,* which has failed to flower during other seed-bank emergence studies (Leck 2003)).

To determine the number of each species that germinated during the course of the emergence study, lists containing weekly observation counts and photos taken at 3- to 4-day intervals were compared against each other to determine changes in species abundance. The emergence study began in September 2009 and was terminated in early July 2010 to avoid potential negative temperature affects on growth during the hot summer months (Nicol *et al*. 2003, Bakker *et al*. 2005).

Restoration Site Preparation

The three restoration areas were disked in May 2010 to expose fresh soil and remove much of the old plant growth. Disking and shallow tilling, in conjunction with species-mix sowing, has had positive effects on restoration of degraded areas (Greenfield *et al*. 2003, Baoyin and Yonghong 2009).

Target Species

In addition to determining the relative importance of remnant vegetation and seed-bank composition for development of the recovering vegetation, the success of planting on the newly exposed soil was also evaluated (Brown 1998). By introducing native target species, it may be possible to encourage the re-development of characteristic communities (Vecrin *et al*. 2002). Unfortunately, planting and sowing attempts are only able to approximate historical communities, as knowledge of their plant species contribution and distribution is insufficient (Peach and Zedler 2006). Nevertheless, the unreliability of seed banks as a floodplain wetland seed source is the primary reason why van der Valk (2013) considers the planting and/or seeding of desired species a requirement for re-establishing pre-drainage (pre-disturbance) vegetation communities (van der Valk 2013).

Sowing Implementation

Southern Tier Consulting, West Clarksville, New York, prepared 3.9 kg of Northeast Wetland Diversity Mix and 12.7 kg of Northeast Wetland Hummock Mix (Table 1) for the planted areas that contained a variety of native, wet-meadow species (USDA and NRCS 2010b, webSURGE, LLC. 2012). Before sowing the mixtures, both were mixed together with about 200 g of *Calamagrostis canadensis* and 100 g of *Carex stricta* seeds and moist sand and then cold-stratified for one month to promote

germination. Since limited dispersal from nearby sources is an obstacle to restoring target sedge/grass meadow populations, success ultimately depended on these seeds germinating in the field (Norbert and Annette 2001).

A shoulder broadcast grass seed spreader was used to sow seeds in the planted areas during June 2010. Two problems arose that may have altered proper seed placement: wind was variable, causing the seeds to blow in different directions and at times drift away from the target-area; in addition, equipment problems occasionally caused some seeds to fall unevenly in clumps.

Planting Implementation

Calmagrostis canadensis and *Carex stricta* plugs were purchased from Southern Tier Consulting and placed directly into the ground during June 2010 within the flagged (planted) area at Sites 1 and 2 where seed sowing was performed. One-thousand *Calamagrostis canadensis* and 2,000 *Carex stricta* plugs were planted. At Site 3, planting was confined closer to the water edge, near denser vegetation, due to the potential threat of herbivory by Canada Geese (*Branta canadensis*). These two plant species are both considered prominent components of Great Lakes meadow marsh communities and have the ability to expand into open areas through tillering (Wilcox *et al*. 2008).

With the assistance of five students, the plugs were planted at approximate 1-m intervals. Spacing at all times was estimated but followed a generally consistent

pattern except where existing vegetation seemed too dense. Along the southwestern corner of Site 2, some plugs were placed above the flag line in an area that seemed too moist, and no plugs were planted in areas that seemed too dry. Planting in areas with standing water was avoided at all three sites. Un-tilled natural wetland areas (N, N11, and N12) near 2009 bulrush communities in Sites 1 and 2 and tilled control areas (C10, C11, and C12) were left un-planted and un-seeded (Table 2).

Pre-Restoration Sampling

Pre-restoration plant communities were characterized on 12-13 July 2009 by field sampling using randomly-placed quadrats, similar to what was done at Kents Creek, within the four dominant vegetation types – bulrush (BR), clover (CL), old field (OF), and sedge (SD) – across the three sites. All ten OF quadrats were sampled in Site 1, along with BR 5-10 and CL 7-10. BR 1-4 and CL 5-6 were sampled in Site 2. All ten SD quadrats were sampled in Site 3, in addition to CL 1-4. The pre-restoration sampling was conducted to determine the relative importance of current conditions and factors influencing vegetative community patterning in the three sites (Seabloom *et al*. 2001).

Post-Implementation Sampling

Post-implementation sampling, conducted during August 2010, was similar to pre-restoration sampling and used randomly-placed quadrats to estimate species percent cover in the planted (1P10 – 20 quadrats and 2P10 and 3P10 – each ten quadrats), untreated natural wetland (1N10 and 2N10 – each ten quadrats), and control areas (C10St1 and C10St2 – each three quadrats and C10St3 – four quadrats). Changes that occurred after planting and sowing and the success of native wet-meadow community restoration attempts became evident by comparing the degree of estimated species percent cover similarity between the treated and untreated site areas to reference data, including quadrats sampled in 2009 (Brown 1998). Mowing by the former property owner at 30-cm height to control tall annual weeds in the Site 3 planted and seeded area in 2010 created a third variable (3PM10 – 20 quadrats), which was surveyed using the same method. August 2011 and August 2012 post-implementation sampling used 20 quadrats in the Site 3 planted area; all other samples were collected identically.

Data Analyses

Duration (DUR) and native status (NS) classification for plants at my study sites followed the USDA website (USDA and NRCS 2010b). Wetland indicator status (WI) was also noted (Table 3) using the National List of Vascular Plant Species that

Occur in Wetlands: 1996 National Summary (U.S. Fish and Wildlife Service 1996), since this has been used in previous studies to note similarities to restored vegetation (Brown 1998).

To determine the relative contribution of an individual species to surveyed community composition, Importance Values (IV) were calculated as the sum of relative frequency and relative mean percent cover (Handel *et al*. 2007). Mann-Whitney and Kruskal-Wallis tests were performed to determine group differences in important species and total percent cover and species count using Minitab Pro 16 and procedures outlined by Hampton and Havel (2005).

Community data from 2009 pre-restoration through 2012 post-restoration study site samples were analyzed in sample x Importance Value matrices using non-metric multidimensional scaling (NMDS; McCune and Grace 2002) with autopilot on, Sorensen distance, and no species weighting. Forty-three plant taxa with a frequency of at least two (quadrat occurrences) that were among the five most important taxa in at least one sample were included (Table 4). According to McCune and Grace (2002), NMDS is a non-parametric ordination method based on rank orders of plot similarity that works with any distance measure, and researchers should avoid stress results above 20 and strive for instabilities less than 0.0001 to ensure accurate interpretation. Axis 1, 2, and 3 scores for study site community samples were graphed in a three-dimensional plot to show the species composition and dominance dissimilarities or similarities among sampled communities (Wilcox and

Nichols 2008). Axis 1 and 2 scores for plant taxa were graphed in a two-dimensional plot that explained much of the variation shown in the study site community plot.

Results

Reference Site

Sampling of the reference site at Kents Creek (K) identified 13 taxa (Table 4), including five taxa not found in study site samples (Table 5). *Carex lacustris* was dominant (had the highest IV), while *Calamagrostis canadensis* and *Impatiens capensis* were prominent (among the highest IV). One species was annual and one biennial; all others were perennial. Two species were introduced; all others were native.

Seed-Bank Emergence Study

At Site 1, the seed-bank emergence study (GHSt1) identified 22 taxa (Table 6), including 10 species that did not occur in randomly placed quadrats in the field. *Cerastium glomeratum* was dominant, while *Festuca filiformis* and *Panicum flexile* were prominent. Ten species were annual and two biennial; all others were perennial. Eight species were introduced; all others were native.

At Site 2, the seed-bank emergence study (GHSt2) identified 21 taxa (Table 6), including 14 species that did not occur in randomly placed quadrats in the field. *Carex* sp. was dominant, while *Festuca filiformis* and *Lythrum alatum* were prominent. Eleven species were annual and one biennial; all others were perennial. Six species were introduced; all others were native.

At Site 3, the seed-bank emergence study (GHSt3) identified 24 taxa (Table 6), including 14 species that did not occur in randomly placed quadrats in the field. *Cerastium glomeratum* was dominant, while *Festuca filiformis* and *Panicum flexile* were prominent. Nine species were annual and three biennial; all others were perennial. Five species were introduced; all others were native.

Study Site 1

Pre-Restoration Vegetation (2009)

Bulrush Community (BRSt1) (Table 2)

Sampling of the Site 1 bulrush community prior to restoration (BRSt1) identified 12 taxa (Table 7). Five species occurred in BRSt1 but were not observed in other Site 1 samples. *Schoenoplectus fluviatilis* was dominant, while *Equisetum arvense* and *Eupatorium purpureum* were prominent. *Calamagrostis canadensis*, *Polygonum lapathifolium*, *Trifolium pretense*, and *Vernonia noveboracensis* also occurred in Site 1 seed-bank emergence study soil samples. Three species were annual and one biennial; all others were perennial. Three species were introduced; all others were native.

Clover Community (CLSt1)

Sampling of the Site 1 clover community prior to restoration (CLSt1) identified eight taxa (Table 8). *Trifolium pratense* was dominant, while *Hypericum perforatum* and *Rumex obtusifolius* were prominent. *Ambrosia artemisiifolia* also occurred in Site 1 seed-bank emergence study soil samples. Three species were annual and one biennial; all others were perennial. Four species were introduced; all others were native.

Old Field Community (OFSt1)

Sampling of the old field community prior to restoration (OFSt1) identified 30 taxa (Table 9). Eleven species occurred that were not observed in other Site 1 samples. *Juncus tenuis* was dominant, while *Alisma triviale* and *Ambrosia artemisiifolia* were prominent. *Ranunculus abortivus* and *Salsola tragus* were also observed in Site 1 seed-bank emergence study soil samples. Five species were annual and two biennial; all others were perennial. Ten species were introduced; all others were native.

Post-Restoration Vegetation (August 2010, 2011, and 2012)

Treated (Planted) Site 1 (1P10, 1P11, and 1P12)

Sampling of the Site 1 planted area in 2010, two months after planting and seeding (1P10), identified 27 taxa (Table 10). *Setaria faberi* occurred in 1P10 but was not observed in other Site 1 samples. *Trifolium pratense* was dominant, while

Ambrosia artemisiifolia and *Hordeum jubatum* were prominent. *Acalypha rhomboidea* and *Hordeum jubatum* also occurred in Site 1 seed-bank emergence study soil samples in 2010. Ten species were annual and one biennial; all others were perennial. Seven species were introduced; all others were native.

Sampling of the Site 1 planted area in 2011, one year after planting and seeding (1P11), identified 36 taxa (Table 11). Four species occurred in 1P11 but were not observed in other Site 1 samples. *Agrostis stolonifera* was dominant, while *Trifolium pratense* was prominent in 2011. *Bidens tripartita*, *Lactuca serriola*, *Plantago major*, and *Verbena hastata* were also observed in Site 1 seed-bank emergence study soil samples. Seven species were annual and three biennial; all others were perennial. Twelve species were introduced; all others were native.

Sampling of the Site 1 planted area in 2012, two years after planting and seeding (1P12), identified 29 taxa (Table 12). Eight species occurred in 1P12 but were not observed in other Site 1 samples. *Epilobium hirsutum* was dominant, while *Agrostis stolonifera* and *Lactuca serriola* were prominent in 2012. Four species were annual and two biennial; all others were perennial. Seven species were introduced; all others were native.

Treated (Planted) Site 1 Summary

Eight species occurred in the Site 1 planted area in all three years. Five species occurred only in 1P10 and 1P11, and nine species occurred only in 1P11 and 1P12. Nine species were unique to 1P10, and twelve species each were unique to

1P11 and 1P12. Total *Carex* sp. (not identifiable to species level) was among the most prominent species in the Site 1 planted area in all three years. *Trifolium pratense* was among the most prominent species in 1P10 and 1P11, while *Agrostis stolonifera* was among the most prominent species in 1P11 and 1P12.

Tilled, Unplanted Control Site 1 (C10St1, C11St1, and C12St1)

Ambrosia artemisiifolia, *Polygonum lapathifolium*, *Rumex obtusifolius*, and *Xanthium strumarium* occurred only in C10St1 and C11St1, while *Agrostis stolonifera* and *Epilobium hirsutum* occurred only in C11St1 and C12St1 (Tables 13 - 15). Eight species were unique to C10St1, five species were unique to C11St1, and *Daucus carota*, *Solidago canadensis*, and *Stachys tenuifolia* were unique to C12St1. None of the species that were prominent in C10St1 were prominent in subsequent years. *Agrostis stolonifera* was among the most prominent species in C11St1 and C12St1.

Untreated, Natural Wetland Site 1

Ambrosia artemisiifolia, *Schoenoplectus fluviatilis*, and *Xanthium strumarium* occurred in the Site 1 natural wetland area (1N) in all three years (Tables 16-18). *Lythrum salicaria* and *Trifolium pratense* occurred only in 1N10 and 1N11, six species occurred only in 1N10 and 1N12, and *Agrostis stolonifera*, *Carex vulpinoidea*, and *Typha* × *glauca* occurred only in 1N11 and 1N12. Thirteen species were unique to 1N10, seven species were unique to 1N11, and *Solidago canadensis*

and *Stachys tenuifolia* were unique to 1N12. *Epilobium hirsutum* was among the most prominent species in 1N10 and 1N12, while *Xanthium stromarium* was among the most prominent species in 1N10 and 1N11. *Agrostis stolonifera* was among the most prominent species in 1N11 and 1N12.

Site 1 Summary

In 2009, Site 1 was initially dominated by *Juncus tenuis, Schoenoplectus fluviatilis,* and *Trifolium pratense*. Following restoration, *J. tenuis* decreased in importance. *Schoenoplectus fluviatilis* remained dominant in the Site 1 natural wetland area samples across subsequent years. *Trifolium pratense* was also dominant in C10St1 and 1P10 then decreased in importance. Site 1 control and planted areas were dominated by *Agrostis stolonifera* in 2011 and *Epilobium hirsutum* in 2012.

Site 1 Statistical Results

Epilobium hirsutum increased significantly from 2010 to 2012, while three species decreased significantly in prominence across years. A Kruskal- Wallis test on *Epilobium hirsutum* (Table 19) revealed that 1P10, 1N10, 1P11, and 1P12 samples were not representative (H = 13.18, DF = 3, p = 0.004) of identical populations. A Mann-Whitney test on *E. hirsutum* percent cover (Table 20) indicated that 1P12 and 1P10 had the most highly significant difference (W = 20, U1 = 75, U2 = 5, p = 0.0043) in median percent cover. A Mann-Whitney test on *Ambrosia artemisiifolia* (Table 21) indicated that 1P10 had significantly more (W = 281.5, U1 = 3.5, U2 =

91.5, p = 0.0019) *A. artemisiifolia* percent cover than 1P11. A Kruskal- Wallis test on *Schoenoplectus fluviatilis* (Table 22) revealed that 1N10, 1P11, 1N11, and 1N12 samples were not representative (H = 22.51, DF = 3, p < 0.0001) of identical populations. A Mann-Whitney test on *S. fluviatilis* percent cover (Table 23) indicated that 1N11 had significantly more (W = 130.5, U1 = 14.5, U2 = 75.5, p = 0.0135) *S. fluviatilis* percent cover than 1N12. A Mann-Whitney Test on *Trifolium pratense* (Table 24) indicated that 1P10 had significantly more (W = 432, U1 = 98, U2 = 222, p = 0.0489) *T. pratense* percent cover than 1P11.

Study Site 2

Pre-Restoration Vegetation (2009)

Bulrush Community (BRSt2)

Sampling of the Site 2 bulrush community prior to restoration (BRSt2) identified 11 taxa (Table 7). Four species occurred in BRSt2 but were not observed in other Site 2 samples. *Schoenoplectus fluviatilis* was dominant, while *Calamagrostis canadensis* and *Monarda fistulosa* were prominent. Two species were annual and one biennial; all others were perennial. Three species were introduced; all others were native.

Clover Community (CLSt2)

Sampling of the Site 2 clover community prior to restoration (CLSt2) identified four taxa (Table 8). *Tanacetum vulgare* occurred in CLSt2 but was not

observed in other Site 2 samples. *Trifolium pratense* was dominant, while *Rumex obtusifolius* and *Tanacetum vulgare* were prominent. One species was annual and one biennial; all others were perennial. Three species were introduced, while one species was native.

Post-Restoration Vegetation (August 2010, 2011, and 2012)

Treated (Planted) Site 2 Area (2P10, 2P11, and 2P12)

Sampling of the Site 2 planted area in 2010, two months after planting and seeding (2P10), identified 23 taxa (Table 25). Four species occurred in 2P10 but were not observed in other Site 2 samples. Total *Carex* spp. was dominant, while *Ambrosia artemisiifolia* and *Trifolium pratense* were prominent. Eight species were annual and one biennial; all others were perennial. Four species were introduced; all others were native.

Sampling of the Site 2 planted area in 2011, one year after planting and seeding (2P11), identified 24 taxa (Table 26). Two species occurred in 2P11 but were not observed in other Site 2 samples. *Agrostis stolonifera* was dominant, while total *Carex* sp. and *Linum usitatissimum* were prominent in 2011. Five species were annual and three biennial; all others were perennial. Six species were introduced; all others were native.

Sampling of the Site 2 planted area in 2012, two years after planting and seeding (2P12), identified 23 taxa (Table 27). Six species occurred in 2P12 but were not observed in other Site 2 samples. *Epilobium hirsutum* was dominant, while

Agrostis stolonifera and total *Carex* sp. (not identifiable to species level) were prominent in 2012. Two species were annual and two biennial; all others were perennial. Six species were introduced; all others were native.

Treated (Planted) Site 2 Summary

Oxalis corniculata, Polygonum amphibium, and *Schoenoplectus fluviatilis* occurred in the Site 2 planted area in all three years. *Ambrosia artemisiifolia, Hordeum jubatum,* and *Xanthium stromarium* occurred only in 2P10 and 2P11; *Alisma triviale* and *Trifolium pratense* occurred only in 2P10 and 2P12; and ten species occurred only in 2P11 and 2P12. Eleven species were unique to 2P10; *Linum usitatissimum, Rumex obtusifolius, Salsola tragus,* and *Solidago rugosa* were unique to 2P11; and eight species were unique to 2P12. Total *Carex* sp. (not identifiable to species level)was among the most prominent species in the Site 2 planted area in all three years, *Xanthium stromarium* was among the most prominent species in 2P10 and 2P11, and *Agrostis stolonifera* was among the most prominent species in 2P11 and 2P12.

Tilled, Unplanted Control Site 2 (C10St2, C11St2, and C12St2)

Schoenoplectus fluviatilis occurred in the Site 2 control area in all three years (Tables 13 - 15). *Ambrosia artemisiifolia, Hordeum jubatum, Polygonum hydropiperoides,* and *Trifolium pratense* occurred only in C10St2 and C11St2, while *Agrostis stolonifera, Euthamia graminifolia, Solidago canadensis,* and *Solidago*

nemoralis occurred only in C11St2 and C12St2. Nine species were unique to C10St2, *Oxalis corniculata* and *Polygonum amphibium* were unique to C11St2, and six species were unique to C12St2. None of the species that were prominent in C10St2 were prominent in subsequent years. *Agrostis stolonifera*, total *Carex* sp., *Euthamia graminifolia*, and *Solidago canadensis* were among the most prominent species in C11St2 and C12St2.

Untreated, Natural Wetland Site 2 (2N10, 2N11, and 2N12)

Leersia oryzoides, *Polygonum amphibium*, *Schoenoplectus fluviatilis*, and *Xanthium strumarium* occurred in the Site 2 natural wetland area (2N) in all three years (Tables 28-30). *Lythrum salicaria* occurred only in 2N10 and 2N11, *Epilobium hirsutum* occurred only in 2N10 and 2N12, and *Agrostis stolonifera* and *Calystegia sepium* occurred only in 2N11 and 2N12. Seven species were unique to 2N10; *Chenopodium album*, *Equisetum sylvaticum*, *Euthamia graminifolia*, and *Solidago nemoralis* were unique to 2N11; and *Lysimachia ciliata*, *Polygonum lapathifolium*, and *Salix exigua* were unique to 2N12.

Site 2 Summary

In 2009, Site 2 was initially dominated by *Schoenoplectus fluviatilis* and *Trifolium pratense*. Following restoration, *Schoenoplectus fluviatilis* remained dominant in the Site 2 natural wetland area samples across subsequent years. *Trifolium pratense* was also dominant in C10St2 then decreased in importance. The

Site 2 planted area was dominated by total *Carex* sp. in 2010, *Agrostis stolonifera* in 2011, and *Epilobium hirsutum* in 2012. The Site 2 control area was dominated by *Euthamia graminifolia* in 2011 and *Agrostis stolonifera* in 2012.

Site 2 Statistical Results

Schoenoplectus fluviatilis decreased significantly in prominence in Site 2 natural wetland area across years, while *Glyceria striata* was sampled only in Site 2 in 2010. A Mann-Whitney test on *Glyceria striata* (Table 31) indicated that 2N10 had significantly more (W = 15, U1 = 45, U2 = 0, p = 0.0030) *G. striata* percent cover than 2P10. A Kruskal- Wallis test on *S. fluviatilis* (Table 32) revealed that 2N10, 2N11, and 2N12 samples were not representative (H = 6.85, DF = 2, p = 0.033) of identical populations. A Mann-Whitney test on *S. fluviatilis* percent cover (Table 23) indicated that 2N11 had significantly more (W = 140.5, U1 = 14.5, U2 = 85.5, p = 0.0078) *S. fluviatilis* percent cover than 2N12.

Study Site 3

Pre-Restoration Vegetation (2009)

Clover Community (CLSt3)

Sampling of the Site 3 clover community prior to restoration (CLSt3) identified 20 taxa (Table 8). Two species occurred in CLSt3 but were not observed in other Site 3 samples. *Trifolium pratense* was dominant, while *Agrostis stolonifera* and

Rumex obtusifolius were prominent. Five species were annual and one biennial; all others were perennial.

Sedge Community (SDSt3)

Sampling of the sedge community prior to restoration (SDSt3) identified 20 taxa (Table 33). *Capsella bursa-pastoris* occurred in SDSt3 but was not observed in other Site 3 samples. *Ambrosia artemisiifolia* and total *Carex* sp. were both dominant, while *Equisetum arvense* was prominent. Five species were annual and one biennial; all others were perennial. Five species were introduced; all others were native.

Post-Restoration (August 2010, 2011, and 2012)

Treated Site 3 (3P10, 3PM10, 3P11, and 3P12)

Sampling of the Site 3 planted area in 2010, two months after planting and seeding (3P10), identified 13 taxa (Table 34). *Echinochloa crus-galli* occurred in 3P10 but was not observed in other Site 3 samples. *Xanthium strumarium* was dominant, while *Ambrosia artemisiifolia* and *Hordeum jubatum* were prominent. Eight species were annual and one biennial; all others were perennial. Five species were introduced; all others were native.

Sampling of the Site 3 planted and mowed area in 2010, two months after planting and seeding (3PM10), identified 28 taxa (Table 35). Four species occurred in 3PM10 but were not observed in other Site 3 samples. Thatch occurred in C10St3 and 3PM10. *Hordeum jubatum* was dominant, while *Ambrosia artemisiifolia* and total

Carex sp. were prominent in 3PM10. Ten species were annual and one biennial; all others were perennial. Six species were introduced; all others were native.

Sampling of the Site 3 planted area in 2011, one year after planting and seeding (3P11), identified 43 taxa (Table 36). Five species occurred in 3P11 but were not observed in other Site 3 samples. *Xanthium strumarium* was dominant, while total *Carex* sp. and *Vicia tetrasperma* were prominent in 2011. Ten species were annual and two biennial; all others were perennial. Ten species were introduced; all others were native.

Sampling of the Site 3 planted area in 2012, two years after planting and seeding (3P12), identified 40 taxa (Table 37). Nine species occurred in 3P12 but were not observed in other Site 3 samples. *Epilobium hirsutum* was dominant, while *Agrostis stolonifera* and *Lathyrus palustris* were prominent in 2012. Eight species were annual and three biennial; all others were perennial. Ten species were introduced; all others were native.

Treated Site 3 Summary

Ambrosia artemisiifolia, *Trifolium pratense*, and *Xanthium stromarium* occurred in the Site 3 planted area in all three years and in 3PM10. *Epilobium hirsutum* occurred in all three Site 3 planted area samples but was unobserved in 3PM10. *Panicum capillare* occurred only in 3P10 and 3PM10. *Cyperus odoratus*, *Hordeum jubatum*, *Polygonum lapathifolium*, and *Vicia tetrasperma* occurred only in 3P10, 3PM10, and 3P11. *Abutilon theophrasti* occurred only in 3P10 and 3P11.

Convolvulus arvensis and *Polygonum punctatum* occurred only in 3PM10 and 3P11; and *Lysimachia ciliata, Solanum carolinense,* and *Taraxacum officinale* occurred only in 3PM10, 3P11, and 3P12. *Oxalis corniculata* and *Solidago nemoralis* occurred only in 3PM10 and 3P12. Fifteen species occurred only in 3P11 and 3P12. *Echinochloa crus-galli* was unique to 3P10, six species were unique to 3PM10, nine species were unique to 3P11, and 16 species were unique to 3P12. The same species were prominent in 3P10 and 3PM10. Total *Carex* sp., *Hordeum jubatum*, *Trifolium pratense,* and *Xanthium strumarium* were among the most prominent species in 3P10, 3PM10, and 3P11.

Control Site 3 (C10St3, C11St3, and C12St3)

Ambrosia artemisiifolia and *Symphyotrichum lanceolatum* occurred in the Site 3 control area in all three years (Tables 13 - 15). *Hordeum jubatum, Lysimachia ciliata,* and *Oxalis corniculata* occurred only in C10St3 and C11St3; *Trifolium pratense* and *Xanthium strumarium* occurred only in C10St3 and C12St3; and six species occurred only in C11St3 and C12St3. *Polygonum lapathifolium, Rumex crispus, Sonchus oleraceus,* and *Vicia tetrasperma* were unique to C10St3; 14 species were unique to C11St3; and *Epilobium hirsutum*, *Populus deltoides,* and *Solidago canadensis* were unique to C12St3. *Ambrosia artemisiifolia* and *Trifolium pratense* were among the most prominent species in C10St3 and C12St3, while *Plantago major* was among the most prominent species in C11St3 and C12St3.

Site 3 Summary

In 2009, Site 3 was dominated by *Ambrosia artemisiifolia,* total *Carex* sp., and *Trifolium pratense*. Following restoration, *Ambrosia artemisiifolia* was also dominant in C10St3 then decreased in importance. *Xanthium strumarium* was dominant in 3P10 and 3P11 then decreased in importance. *Hordeum jubatum* dominated 3PM10, while *Epilobium hirsutum* dominated 3P12. The Site 3 Control area was dominated by *Trifolium repens* in 2011 and *Agrostis stolonifera* in 2012.

Site 3 Statistical Results

Ambrosia artemisiifolia and *Trifolium pratense* decreased significantly, while total *Carex* sp., *Vicia tetrasperma,* and *Xanthium stromarium* increased significantly in prominence across years. A Kruskal- Wallis test on *A. artemisiifolia* percent cover (Table 38) revealed that 3P10, 3PM10, 3P11, and 3P12 samples were not representative ($H = 27.25$, $DF = 3$, $p < 0.0001$) of identical populations. A Mann-Whitney test on *A. artemisiifolia* percent cover (Table 21) indicated that 3P10 and 3P11 had the most highly significant difference ($W = 182$, $U1 = 3$, $U2 = 127$, $p = 0.0001$) in median percent cover. However, *A. artemisiifolia* did not occur at a percent cover value greater than 0.5 in 3P12. A Mann-Whitney test on *T. pratense* percent cover (Table 24) indicated that 3P10 and 3P12 had the most significant difference ($W = 99.5$, $U1 = 8.5$, $U2 = 54.5$, $p = 0.0167$) in median percent cover. A Kruskal-Wallis test on total *Carex* sp. percent cover (Table 39) revealed that 3P10, 3PM10, 3P11, and 3P12 samples were not representative ($H = 17.52$, $DF = 3$, $p =$

0.001) of identical populations. A Mann-Whitney test on total *Carex* sp. percent cover (Table 40) indicated that 3P11 and 3P10 had the most highly significant difference (W = 76, U1 =179, U2 = 21, p = 0.0005) in median total *Carex* sp. percent cover. A Kruskal-Wallis test on *V. tetrasperma* percent cover (Table 41) revealed that 3P10, 3PM10, and 3P11 samples were not representative (H = 7.48, DF = 2, p = 0.024) of identical populations. A Mann-Whitney test on *V. tetrasperma* percent cover (Table 42) indicated that 3P11 and 3P10 had the most highly significant difference (W = 21.5, U1 = 48.5, U2 = 6.5, p = 0.0195) in median percent cover. A Mann-Whitney test on *X. strumarium* (Table 43) indicated that 3P11 and 3PM10 had the most highly significant difference (W = 46, U1 = 87, U2 = 18, p = 0.0164) in median percent cover. Although 3P11 had a higher median *X. strumarium* percent cover than 3P10, it had a higher importance value in 3P10 than 3P11.

4-Year Ordination Results

The NMDS ordination procedure produced an ordination with final stress = 21.33047, final instability = 0, number of iterations = 108. Study site community sample and species scores are graphed separately. Sample scores were plotted in three dimensions, because all three axes showed differences among units. Axes 1 and 2 were sufficient to demonstrate differences among species scores, resulting in a two-dimensional plot.

CL, OF, and SD communities in 2009 plotted substantially away from those sampled following restoration (Figure 3). Taxa with major influence in these communities included *Trifolium pratense* and *Rumex obtusifolia* (CL); *Juncus tenuis* and *Salsola tragus* (OF); and total *Carex* sp. (not identifiable to species level), *Equisetum arvense*, and *Alisma triviale* (SD) (Figure 4, Tables 8, 9, 33). With the exception of *Trifolium pratense* and *Carex* sp., these taxa were greatly reduced in 2010 sampling (Tables 10, 13, 25, 34, 35), perhaps as a result of the disking treatment. Plotting of the BR community was influenced by *Schoenoplectus fluviatilis* and *Eupatorium purpureum*; sampling of the untreated, natural community (N) was also greatly influenced by *Schoenoplectus fluviatilis* in post-restoration years (Figures 3, 4, Tables 17, 18, 29, 30).

In 2010, the planted areas (P) at all three restoration sites plotted similarly; they were distinct from but adjacent to control areas (C) (Figure 3), likely because the lack of planted species growth yielded insubstantial cover. The mowing treatment 3PM (10-3M) was similar to the non-mowed planted areas. Influential taxa for the P and C communities in 2010 included *Ambrosia artemisiifolia*, *Carex* sp., *Hordeum jubatum*, *Trifolium pratense*, and *Xanthium strumarium* (Figure 4, Tables 10, 13, 25, 34, 35). Although the N communities in 2010 contained much *Schoenoplectus fluviatilis* percent cover, they were also influenced by *Glyceria striata* and *Lycopus virginicus*, which later declined (Figure 4, Tables 16, 17, 18, 28, 29, 30).

In 2011, both the P and C communities overlapped and plotted far from those in 2010 (Figure 3). Influential taxa in the 2011 P and C communities included

Agrostis stolonifera, *Carex* sp., *Euthamia graminifolia*, *Linum usitatissimum*, and *Xanthium strumarium* (Figure 4, Tables 11, 26). *Ambrosia artemisiifolia*, *Hordeum jubatum*, and *Trifolium pratense* that were prominent in 2010 had declined. The Site 3 planted area community 3P11 (11-3) was an outlier dominated by *Carex* sp. and *Xanthium strumarium* (Figure 4, Table 36), while the Site 3 unplanted, control area community 3C11 (11-3) was an outlier highly influenced by *Trifolium repens* (Figure 4, Table 14). The N communities in 2011 were overwhelmingly dominated by *Schoenoplectus fluviatilis* (Figure 4, Tables 17, 29), which greatly influenced their position in Figure 3 and was repeated, although less importantly, in 2012 (Figure 4, Tables 18, 30). *Agrostis stolonifera* and *Leersia oryzoides* importance also increased in subsequent post-restoration years in the N communities.

In 2012, the C communities plotted similarly to those in 2011; however, the planted P communities shifted further from those in 2011 (Figure 3), likely due to the nearly complete disappearance of *Xanthium strumarium*, which seemed to succumb to the mowing treatment, and increased prevalence of *Lathyrus palustris* and *Solidago canadensis* (Figure 4, Tables 12, 27, 37). Total *Carex* sp. (all species) importance decreased in CSt1, CSt3, 1P, and 2N and increased in CSt2, 1N, 2P, and 3P communities from 2011 to 2012, as more *Carex* sp. became identifiable in planted areas.

4-Year Site Total Percent Cover and Species Count Comparison

Site 1

Species richness was highest in 1P11, decreased in the Site 1 control and natural wetland areas, and increased in the Site 1 planted area across subsequent years (Table 8). A Kruskal-Wallis test on total percent cover revealed that 1P10, 1N10, 1P11, 1N11, 1P12, and 1N12 samples were not representative ($H = 17.01$, $DF = 5$, $p = 0.004$) of identical populations (Table 44). Mann-Whitney tests indicated that 1N10 and 1P12 had the most significantly different ($W = 239$, $U1 = 16$, $U2 = 184$, $p = 0.0002$) median total percent cover per quadrat (Table 45). It significantly decreased in the Site 1 planted and natural wetland areas across subsequent years.

A Kruskal-Wallis test on species count revealed that 1P10, 1N10, 1P11, 1N11, 1P12, and 1N12 samples were not representative ($H = 44.84$, $DF = 5$, $p < 0.0001$) of identical populations (Table 46). Mann-Whitney tests indicated that 1P10 and 1N12 had the most significantly different ($W = 410$, $U1 = 0$, $U2 = 200$, $p < 0.0001$) median species count per quadrat (Table 47). It significantly decreased in the Site 1 planted and natural wetland areas across subsequent years.

Site 2

Species richness was highest in 2P12, decreased in the Site 2 control and natural wetland areas, and increased in the Site 2 planted area across subsequent years (Table 27). Total percent cover decreased in the Site 2 planted and control areas and increased in the Site 2 natural wetland area across subsequent years. A Kruskal-

Wallis test on total percent cover revealed that 2P10, 2N10, 2P11, 2N11, 2P12, and 2N12 samples were not representative ($H = 17.45$, $DF = 5$, $p = 0.004$) of identical populations (Table 48). Mann-Whitney tests indicated that 2N12 and 2P12 had the most significantly different ($W = 65$, $U1 = 90$, $U2 = 10$, $p = 0.0028$) median total percent cover per quadrat (Table 45).

A Kruskal-Wallis test on species count revealed that 2P10, 2N10, 2P11, 2N11, 2P12, and 2N12 samples were not representative ($H = 39.77$, $DF = 5$, $p < 0.0001$) of identical populations (Table 49). Mann-Whitney tests indicated that 2P10 and 2N11 had the most significantly different ($W = 154.5$, $U1 = 0.5$, $U2 = 99.5$, $p = 0.0002$) median species count per quadrat (Table 47). It significantly decreased in the Site 2 planted and natural wetland areas across subsequent years.

Site 3

Species richness was highest in 3P11 and 3P12, decreased in the Site 3 control area, and increased in the Site 3 planted area across subsequent years (Tables 34 and 35). Total percent cover decreased in the Site 3 planted and control areas across subsequent years. A Kruskal-Wallis test on total percent cover revealed that 3P10, 3PM, 3P11, and 3P12 samples were not representative ($H = 24.96$, $DF = 3$, $p < 0.0001$) of identical populations (Table 50). Mann-Whitney tests indicated that 3P11 and 3PM had the most significantly different ($W = 248$, $U1 = 362$, $U2 = 38$, $p < 0.0001$) median total percent cover per quadrat (Table 45). As 3P10 had significantly

more percent cover than other planted Site 3 samples, mowing seemed to effectively reduce percent cover.

A Kruskal-Wallis test on species count revealed that 3P10, 3PM10, 3P11, and 3P12 samples were not representative ($H = 18.04$, $DF = 3$, $0.0001 < p < 0.001$) of identical populations (Table 51). Mann-Whitney tests indicated that 3P11 and 3PM10 had the most significantly different ($W = 278$, $U1 = 332$, $U2 = 68$, $p = 0.0003$) median species count per quadrat (Table 47). It significantly increased in the Site 3 planted area across subsequent years.

Discussion

Target (Planted/Seeded) Species

Fifteen of the 42 seeded and planted species were identified as established in post-restoration samples. Thirteen seeded species occurred in the Site 1 planted area samples, nine seeded species occurred in the Site 2 planted area samples, and twelve seeded species occurred in the Site 3 planted area samples. More seeded species were observed in each subsequent year in all sites following restoration efforts (Figure 5).

Management objectives that don't require immediate cover or survival of selected plants may encourage self-designed and sustainable landscape development by allowing natural processes to dictate the rate of establishment (Mitsch *et al*. 1998). Spatial relationships involving refugial species distributions, ruderal species

competition, seedling survivorship, suitable habitat locations, and viable seed availability may create a lag period before current environmental conditions determine community compositions (Seabloom *et al*. 2001). During lag periods, species distributions may reflect recruitment patterns observed prior to restoration more than ones influenced by current environmental conditions. Due to a lack of information regarding historic, regional sedge meadow communities, it is uncertain how much current treated communities resemble those once present. However, study-site communities are expected to continue development toward self-designed optimal assemblages through natural selection.

It is possible that some seeded species established but lacked identifiable characteristics or occurred in a non-sampled portion of planted areas. Perhaps, some seeds failed to germinate due to unfavorable conditions for growth. Post-recruitment processes may have also eliminated some species that did germinate. Continued monitoring is recommended to identify any seeded species that establish or have identifiable characteristics in future years. Invasive species monitoring and removal is also recommended to permit additional species establishment opportunities and reduce competitive species dominance.

Seeded and planted *Calamagrostis canadensis* did not occur in randomly placed quadrats in post-implementation years in Site 1 and 2. However, it was observed in BRSt1 and BRSt2. *Calamagrostis canadensis* is a high-affinity (the most frequently observed grass species), non-invasive associate of sedge meadows (Eggers and Reed 2006, Johnston and Zedler 2011). It was also observed in 3P11 and 3P12

communities. Although some seeded *Carex* species have been identified in planted areas, identifiable *Carex stricta* has not occurred in study site samples.

Site 1

Total *Carex* sp. (not identifiable to species level) had its highest importance in 1P11 (Table 8). Its importance decreased from C10St1 to C11St1 and increased in the Site 1 native wetland area across subsequent years. Since total *Carex* sp. also occurred in seed-bank emergence study soil samples, I don't know how much seeding effort contributed to establishment.

Two seeded species occurred in both pre-restoration and post-restoration samples. *Juncus effusus* had the highest importance in CLSt1. It is a sedge meadow associate (The Pennsystone Project 2011). *Juncus effusus* increased in importance from 1P11 to 1P12. *Leersia oryzoides* had the highest importance in 1N12. It is an associate graminoid of sedge meadows that is valuable in restoring wetlands since it helps to stabilize sediment, is highly palatable (to species including Canada Goose (*Branta canadensis*), muskrat (*Ondatra zibethicus*), and skipper caterpillars **(**Hesperiidae), and provides dense cover habitat (Dorris and Bartow 2008, The Pennsystone Project 2011, Hiltry 2012). *Leersia oryzoides* also occurred in 1P12. *Juncus effusus* decreased and *Leersia oryzoides* increased in importance following restoration, but both species now seem to be increasing in importance, especially *Leersia oryzoides*.

Three other seeded species occurred only in post-restoration Site 1 samples. *Carex vulpinoidea* and *Solidago rugosa* had the highest importance in 1N12. *Carex vulpinoidea* is a sedge meadow associate and sometimes the dominant sedge (The Pennystone Project 2011, Hiltry 2012). *Solidago rugosa* borders spring branches and streams (Bracken 2012). *Carex vulpinoidea* and *S. rugosa* also occurred in 1P11. *Plantago major* had the highest importance in C11St1. The United States Department of Agriculture (USDA) lists it as an invasive species that may alter successional regimes (Klein 2011, Uva *et al*. 2012). *Plantago major* had a lower importance in 1P12 than 1P11 and C11St1. Since *C. vulpinoidea* and *S. rugosa* did not occur in randomly placed quadrats in pre-restoration communities or Site 1 seed-bank emergence study soil samples, seeding effort seems most responsible for their establishment. *Plantago major* was also observed in Site 1 seed-bank emergence study soil samples, so it is not clear how much seeding effort contributed to its establishment.

Seven seeded species occurred in the Site 1 planted area but were not observed in other Site 1 samples. *Asclepias incarnata* and *Verbena hastata* occurred only in 1P11. *Asclepias incarnata* is associated with sedge meadows (Eggers and Reed 2006, The Pennystone Project 2011). *Verbena hastata* habitat includes river borders and sedge meadows (on tussocks) (Eggers and Reed 2006, Peach and Zedler 2006, Hiltry 2012). *Carex lupulina*, *Elymus canadensis*, *Euthamia graminifolia*, and *Symphyotrichum novae-angliae* occurred only in 1P12. *Carex lupulina* occurs in floodplain woodlands, degraded marshes, and soggy meadows along streams (Hiltry

2012). *Elymus canadensis* is a prairie species and commonly seeded during restoration (Blumenthal *et al*. 2003). *Euthamia graminifolia* inhabits sedge meadows (PRI 2012). *Symphyotrichum novae-angliae* is an open lands plant and sedge meadow associate (Eggers and Reed 2006, U.S. Forest Service 2012). *Eupatorium perfoliatum* increased in importance from 1P11 to 1P12. *Eupatorium perfoliatum* is a sedge meadow associate and pioneer species (Eggers and Reed 2006, The Pennystone Project 2011). Continued monitoring of these species is recommended to determine if they remain established.

Site 2

Leersia oryzoides is the only seeded species that was observed in both pre-restoration and post-restoration communities in Site 2. It had the highest importance in 2N12 and increased in importance across subsequent years. Continued monitoring is recommended to determine if it continues to increase in importance and establishes in the Site 2 planted area.

Carex sp. was observed only in post-restoration communities. Total *Carex* sp. increased in importance in the Site 2 control area across subsequent years. While total *Carex* sp. (not identifiable to species level) decreased in the Site 2 natural wetland and planted areas across subsequent years, *Carex lupulina* and *Carex vulpinoidea* were identified in Site 2 for the first time in 2P12. Since total *Carex* sp. also occurred in the Site 2 seed-bank emergence study soil samples, the effect of seeding on establishment is not clear.

Euthamia graminifolia had the highest importance in C11St2. It had a higher importance in C11St2 and 2N11 than 2P12 and C12St2. Since *Euthamia graminifolia* occurred in the Site 2 planted area for the first time in 2P12, continued monitoring is recommended to determine if it remains established.

Six other seeded species occurred only in the Site 2 planted area samples. *Solidago rugosa* occurred in 2P11. *Elymus canadensis*, *Juncus effusus*, *Plantago major*, and *Verbena hastata* occurred in 2P12. *Eupatorium perfoliatum* increased in importance from 2P11 to 2P12. I cannot determine how much seeding effort contributed to *P. major* establishment, as it also occurred in the Site 2 seed-bank emergence study soil samples. Continued monitoring is recommended to determine if *S. rugosa* becomes re-established and those that were observed in 2012 increase in importance.

Site 3

Total *Carex* sp. had the highest importance in SD. While total *Carex* sp. (not identifiable to species level) decreased in importance from 3P11 to 3P12, *Carex lurida*, *Carex lupulina*, and *Carex vulpinoidea* were identified in Site 3 for the first time in 3P12. *Carex lurida* inhabits ditches, marsh edges, and sedge meadows (Hiltry 2012). Since total *Carex* sp. had a higher importance in 3PM10 than 3P10, mowing may have discouraged more competitive species and/or helped to encourage *Carex* growth. It is not clear how much seeding effort contributed to establishment due to total *Carex* sp. also occurring in the Site 3 seed-bank emergence study soil samples.

Juncus effusus and *Solidago rugosa* also occurred in pre-restoration samples. *Juncus effusus* had the highest importance in CLSt3 and did not occur in randomly placed quadrats in post-restoration areas. *Solidago rugosa* had the highest importance in 3P11. Continued monitoring is recommended to determine if *J. effusus* re-establishes and *S. rugosa* further increases in importance.

Four seeded species occurred only in post-restoration communities. *Eupatorium perfoliatum* had the highest importance in 3P12. It had a higher importance in 3P12 and C12St3 than 3P11 and C11St3. *Euthamia graminifolia* and *Verbena hastata* had the highest importance in C11St3. *Euthamia graminifolia* increased, while *V. hastata* decreased in importance from 3P11 to 3P12. *Plantago major* had the highest importance in C12St3 and increased in importance from 3P11 to 3P12. Since *P. major* and *V. hastata* occurred in the Site 3 seed-bank emergence study soil samples, I am unable to determine how much seeding effort contributed to their establishment. Monitoring is recommended to assess whether *E. perfoliatum*, *E. graminifolia*, and *P. major* continue to increase as *V. hastata* decreases in importance.

Four seeded species were observed only in the Site 3 planted area. While *Elymus canadensis* only occurred in 3P11, *Bidens frondosa* only occurred in 3P12. *Bidens frondosa* occupies moist to saturated soils, including wet-meadows (VWPS 2012). *Asclepias incarnata* and *Calamagrostis canadensis* increased in importance from 3P11 to 3P12. I don't know how much the seeding effort contributed to *C. canadensis* establishment, as it also occurred in the seed-bank emergence study soil sample – 3D. Continued monitoring is recommended to determine if *A. incarnata*, *B.*

frondosa, and *C. canadensis* further increase in importance and *E. canadensis* re-establishes.

Remnant Sedge/Grass Meadow Associates

Study site sampling identified 38 remnant sedge/grass meadow associates (Table 52). Seventeen species occurred in pre-restoration samples, and 34 species occurred in post-restoration samples. *Agrostis stolonifera* and *Schoenoplectus fluviatilis* were dominant, and nine species were prominent.

Site 1

Twenty-seven remnant sedge/grass meadow associates occurred within Site 1 (Table 52). Seven species each occurred in 1P10 and 1P11, while six species occurred in 1P12. Fifteen species occurred in only one Site 1 sample.

Five important remnant sedge/grass meadow associates occurred in both pre-restoration and post-restoration samples. *Agrostis stolonifera* had the highest importance in 1P12. It has sediment-stabilizing rhizomes and roots and occupies a wide variety of habitats including meadows (U.S. Fish and Wildlife Service 1996). *Agrostis stolonifera* increased in importance from 1P11 to 1P12, C11St1 to C12St1, and 1N11 to 1N12. *Alisma triviale* had the highest importance in OF. It is a native, typical emergent marsh species (Miklovic and Galatowitsch 2005, Chayka and Dziuk 2012). *Alisma triviale* increased in importance from 1N10 to 1N12, and it also

occurred in 1P10. *Equisetum arvense* and *Schoenoplectus fluviatilis* had the highest prominence in BRSt1. *Equisetum arvense* is listed by USDA as a weedy species, although it may be found between tussocks in sedge meadows (Hiltry 2012, Uva *et al*. 2012). *Schoenoplectus fluviatilis* is typical of emergent marshes and shallow water habitats where it provides food, especially for muskrats, and cover (Miklovic and Galatowitsch 2005, Fabula 2009). Since *S. fluviatilis* had significantly more percent cover in 1N11, it is possible that randomly placed quadrats failed to land where more *S. fluviatilis* was growing in 1N12 community or drier conditions during the 2012 season were not as conducive to the growth of *S. fluviatilis*. *Lycopus americanus* had the highest importance in C11St1 and also occurred in 1P11. It inhabits poorly drained fields and sedge meadows (Eggers and Reed 2006, Hiltry 2012). Monitoring is recommended to determine if *A. stolonifera* continues to increase as *A. triviale, E. arvense, L. americanus,* and *S. fluviatilis* establish in the Site 1 planted area.

Two important remnant sedge/grass meadow associates occurred only in post-restoration samples. *Glyceria striata* and *Lycopus virginicus* had the highest importance in 1N10 and also occurred in 1P10. *Glyceria striata* is a fairly common sedge meadow associate (The Pennystone Project 2011, NRCS 2007). *Lycopus virginicus* inhabits soggy meadows and stream-borders and tolerates many wetland conditions (Hiltry 2012). Continued monitoring is recommended to determine if these species re-establish.

Site 2

Fifteen remnant sedge/grass meadow associates occurred within Site 2 (Table 52). Seven species occurred in 2P10, four species occurred in 2P11, and five species occurred in 2P12. Eight species occurred in only one Site 2 sample.

Glyceria striata occurred only in 2010 samples, while two important remnant sedge/grass meadow associates occurred in both pre-restoration and post-restoration samples. As 2N10 had significantly more *G. striata* percent cover than 2P10, conditions for growth may have been more suitable for *G. striata* growth in the Site 2 natural wetland area. *Agrostis stolonifera* had the highest importance in C12St2. It decreased in importance from 2P11 to 2P12 and 2N11 to 2N12 and increased in importance from C11St2 to C12St2. *Schoenoplectus fluviatilis* had the highest importance in 2N11. It decreased in importance from 2P11 to 2P12, C11St2 to C12St2, and 2N11 to 2N12. Since *S. fluviatilis* had significantly more percent cover in 2N11, it is possible that randomly placed quadrats failed to land where more *S. fluviatilis* was growing in 2N12 community or drier conditions during the 2012 season were not as conducive to its growth. Continued monitoring is recommended to determine if these two species continue to decrease in importance as *G. striata* re-establishes.

Site 3

Twenty-four remnant sedge/grass meadow associates occurred within Site 3 (Table 52). Two species occurred in 3P10, six species occurred in 3PM, 15 species

occurred in 3P11, and 11 species occurred in 3P12. Eleven species occurred in only one Site 3 sample.

Three important remnant sedge/grass meadow associates occurred in both pre-restoration and post-restoration samples. *Agrostis stolonifera* had the highest importance in C12St3. It had a higher importance in C12St3 and 3P12 than C11St3 and 3P11. *Equisetum arvense* was most prominent in SD and also occurred in 3P11. *Lathyrus palustris* had the highest importance in 3P12. It is a high affinity associate of sedge meadows that occurs on tussocks and contributes nitrogen through fixation (Peach and Zedler 2006, Johnston and Zedler 2011). Continued monitoring is recommended to determine if *A. stolonifera* and *L. palustris* increase further in importance and *E. arvense* re-establishes.

Polygonum amphibium occurred only in post-restoration samples. It had the highest importance in C11St3. *Polygonum amphibium* grows in water or on shorelines (Novak 2011). It had the same importance in 3P11 and 3P12. Continued monitoring is recommended to determine if *P. amphibium* increases in importance.

Potentially Problematic Species

Study site sampling identified 36 potentially problematic species (many agricultural weeds) that may interfere with restoration success, as described below (Table 53). Sixteen species occurred in pre-restoration samples, while 28 species occurred in post-restoration samples. Six species were dominant, while 11 species

were prominent. Continued monitoring and removal of these species is recommended to prevent their increase.

Site 1

Twenty-nine potentially problematic species occurred within Site 1 (Table 53). Ten species occurred in 1P10, 14 species occurred in 1P11, and 12 species occurred in 1P12. Ten species occurred in only one Site 1 sample.

Hypericum perforatum occurred only in 2009 samples and had the highest importance in CLSt1, while three other important potentially problematic species occurred both in pre-restoration and post-restoration samples. *Hypericum perforatum* is an introduced, invasive species of disturbed soil and roadside locations that crowds out native species (Bolton 2011, Chayka and Dziuk 2012). *Ambrosia artemisiifolia* had the highest importance in C10St1. It is listed by the USDA as a native species that has allelopathic properties that inhibit neighboring plant development and growth and invades developed areas (Chayka and Dziuk 2012, Hiltry 2012, Uva *et al*. 2012). *Ambrosia artemisiifolia* decreased in importance from 1N11 to 1N12 and increased in importance from 1P11 to 1P12. *Juncus tenuis* had the highest importance in OF. It is listed by the USDA as a weed that invades disturbed locations where it may affect other native species through competition and habitat alteration (ISSG 2010, Uva *et al*. 2012). *Juncus tenuis* increased in importance from 1P11 to 1P12. *Trifolium pratense* had the highest importance in CLSt1. It is an introduced species that fixes nitrogen

and inhabits fields and weedy meadows where it is slightly-moderately aggressive (Hiltry 2012). *Trifolium pratense* decreased in importance from 1P11 to 1P12.

Four important potentially problematic species occurred only in post-restoration samples. *Epilobium hirsutum* had the highest importance in C12St1. It inhabits a wide range of moist soils including wetlands and is capable of escaping cultivation to form dense monotypic stands (Hamel 2011). *Epilobium hirsutum* had a higher importance in 1P12, C12St1, and 1N12 than 1P11 and C11St1. *Lactuca serriola* was more prominent in 1P12 than 1P11. The USDA lists it as an invasive species that most commonly inhabits disturbed soils, fields, and roadsides (Hagood 2011, Chayka and Dziuk 2012, Uva *et al*. 2012). *Typha* × *glauca* was more prominent in 1N12 than 1N11. It is an invasive sedge meadow associate (Angeloni *et al.* 2006, Johnston and Zedler 2011). *Xanthium strumarium* had the highest importance in C11St1. It is listed by the USDA as a native species that has nearly worldwide distribution, invades and forms dominant ground cover in agricultural fields, is a nuisance to livestock, and often occurs scattered in natural habitats along shorelines (U.S. Forest Service 2002, Uva *et al*. 2012). *Xanthium strumarium* decreased in importance from 1N11 to 1N12, and it increased in importance from 1P to 1P11 but was not observed in 1P12, likely as a result of the mowing treatment.

Site 2

Twenty potentially problematic species occurred within Site 2 (Table 53). Nine species each occurred in 2P10, 2P11, and 2P12. Five species occurred in only one Site 2 sample.

Tanacetum vulgare occurred only in CLSt2, while two important potentially problematic species occurred both in pre-restoration and post-restoration samples. *Tanacetum vulgare* is an introduced potential weed that can form thick clumps that crowd out forbs and grasses, resulting in habitat loss, and usually inhabits moist soils (Jacobs 2008, Chayka and Dziuk 2012). *Ambrosia artemisiifolia* had the highest importance in 2P10. *Trifolium pratense* had the highest importance in CLSt2. It had a higher importance in C11St2 than 2P12.

Three important potentially problematic species occurred only in post-restoration samples. *Calystegia sepium* had the highest importance in 2N12. The USDA lists it as an invasive species that inhabits disturbed, moist soils, where it entwines neighbors, as do other Convolvulaceae family members (Tenaglia 2007, Uva *et al*. 2012). *Calystegia sepium* increased in importance from 2P11 to 2P12. *Epilobium hirsutum* had the highest importance in 2P12. *Solidago canadensis* had the highest importance in C12St2. It inhabits fields and open woods where it forms large crowded colonies (Chayka and Dziuk 2012). *Solidago canadensis* increased in importance from 2P11 to 2P12.

Site 3

Twenty-five potentially problematic species occurred within Site 3 (Table 53). Seven species occurred in 3P10, nine species occurred in 3PM10, 13 species occurred in 3P11, and 14 species occurred in 3P12. Eight species occurred in only one Site 3 sample.

Two important, potentially problematic species occurred both in pre-restoration and post-restoration samples. *Ambrosia artemisiifolia* had the highest importance in 3P10. It decreased in importance in the Site 3 planted area across subsequent years, while it increased in importance from C11St3 to C12St3. *Trifolium pratense* had the highest importance in CLSt3. It decreased in importance from 3P11 to 3P12.

Four important potentially problematic species occurred only in post-restoration samples. *Epilobium hirsutum* had the highest importance in C12St3. *Trifolium repens* had the highest importance in C11St3. The USDA lists it as an invasive species that inhabits fields, open woods, and wetlands, although it serves as a forage source (for species including white-tailed deer (*Odocoileus virginianus*)) (U.S. Forest Service 2002, ISSG 2010, Chayka and Dziuk 2012, Uva *et al*. 2012). *Trifolium repens* had a higher importance in 3P11 and C11St3 than 3P12. *Vicia tetrasperma* had the highest importance in C10St3. The USDA lists it as an introduced species that invades degraded soils and meadows (Novak 2011, Uva *et al*. 2012). It is uncertain whether mowing was at least partly responsible for 3PM10 and 3P11 having significantly, higher *V. tetrasperma* percent cover than 3P10. *Xanthium stromarium*

had the highest importance in 3P10 but decreased greatly by 2012, likely as a result of mowing.

Mowing seems responsible for the observed decline in cover of five potentially problematic species. *Abutilon theophrasti* had a higher importance in 3P10 than 3P11 and did not occur in randomly placed quadrats in 3P12. *Ambrosia artemisiifolia* and *Trifolium pratense* had a higher importance in 3P10 than 3PM10 and decreased in importance across subsequent years. *Echinochloa crus-galli* only occurred in 3P10. The USDA lists *E. crus-galli* as an invasive species which does not seem to improve sedge meadow development but suppresses *Phalaris arundinacea* growth; it may interfere with establishment by establishing dense stands and persistent thatch layers but serves as an important waterfowl forage (U.S. Forest Service 2002, Perry and Galatowitsch 2003, Uva et al. 2012). *Xanthium stromarium* had the highest importance in 3P10 and decreased in importance from 3P11 to 3P12. Continued mowing in the future is recommended to further encourage the decrease in importance of *A. artemisiifolia*, *T. pratense*, and *X. stromarium*.

Seed-Bank Emergence Study Comparison

Twelve species that occurred in seed-bank emergence study soil were also observed in study site samples (Table 54). Seven species occurred in pre-restoration samples, while ten species occurred in post-restoration samples. Three species were dominant, while four species were prominent. Site-by-site comparisons consider only

the appearance of species, not changes across years, since survival is mostly influenced by post-recruitment processes.

Site 1

Ten species occurred in Site 1 seed-bank emergence study soil and Site 1 samples (Table 54). *Ambrosia artemisiifolia*, *Polygonum lapathifolium*, and *Salsola tragus* were most prominent in Site 1 emergence study soil samples (Table 4). Four species occurred in 1P10, seven species occurred in 1P11, and four species occurred in 1P12. Four species occurred in only one Site 1 sample. Three species occurred only in pre-restoration samples, three species occurred in both pre-restoration and post-restoration samples, and four species occurred only in post-restoration samples. *Bidens tripartita* occurred only in 1P11.

Site 2

Four species occurred in Site 2 seed-bank emergence study soil and Site 2 samples (Table 54). *Ambrosia artemisiifolia*, *Polygonum lapathifolium*, and *Salsola tragus* were most prominent in Site 2 seed-bank emergence study soil samples (Table 4). Three species occurred in 2P10, three species occurred in 2P11, and none occurred in 2P12. *Salsola tragus* occurred only in 2P11. *Ambrosia artemisiifolia* and *Polygonum lapathifolium* occurred in pre-restoration and post-restoration samples, while *Hordeum jubatum* occurred only in post-restoration samples. *Polygonum lapathifolium* occurred in the Site 2 natural wetland area for the first time in 2N12.

Site 3

Eight species occurred in Site 3 seed-bank emergence study soil and Site 3 samples (Table 54). *Trifolium pratense*, *Polygonum lapathifolium*, and *Hordeum jubatum* were most prominent in Site 3 seed-bank emergence study soil samples (Table 4). Four species occurred in 3P10, four species occurred in 3PM10, seven species occurred in 3P11, and six species occurred in 3P12. *Bidens tripartita* occurred only in 3P12. Three species occurred in pre-restoration and post-restoration samples, while five species occurred only in post-restoration samples.

Kents Creek Reference Site Comparison

Six species occurred in both Kents Creek and study site samples (Table 54). *Calamagrostis canadensis*, *Impatiens capensis*, and *Lathyrus palustris* were most prominent in Kents Creek sample (Table 4). Four species occurred in pre-restoration samples, while all six species occurred in post-restoration samples.

Regional Drowned River-Mouth Reference Comparison

Published U. S. drowned river-mouth regional wetland reference data included a Kents Creek study site and seven other sites (Wilcox *et al*. 2005a, Wilcox *et al*. 2005b). Plant community data were collected in late July through early August, 2003 in 0.5 x 1.0 m quadrats. Meadow marsh vegetation area was sampled in

transects A (75.60 m), B (75.45 m), and C (75.35 m) that were parallel to shoreline. Similar to this study, percent cover estimates were made by visual inspection and plant species were identified in each quadrat.

Twenty-six species occurred in my study site samples and had the highest mean cover in A, B, and C regional drowned river-mouth wetland transects (Table 54). *Calamagrostis canadensis*, *Cornus sericea*, *Equisetum arvense*, and *Impatiens capensis* were the most prominent species by mean percent cover among A, B, and C regional drowned river-mouth wetland transects (Wilcox et al. 2005a). Twelve species occurred in my pre-restoration samples, while 21 species occurred in my post-restoration samples. Three species were dominant, while ten species were prominent in at least one of my study site samples.

Restored Ecosystem Attribute Analysis

Over the course of my study, planted/seeded species count increased in all experimental study sites as the number of remnant sedge meadow species decreased. The total number of potentially problematic species decreased in Site 1 and 3 and remained the same in Site 2. Therefore, restoration attempts appeared successful in establishing seeded species, although potentially problematic species remain a threat.

Restoration to a former, historic condition currently is prevented by water-level regulation on Lake Ontario. Anthropogenic interference therefore prevents naturally occurring periodic stress events from maintaining Lake Ontario watershed

integrity as a whole. Despite regulation, restoration of former sedge meadow communities is limited by insufficient knowledge of historical, regional biodiversity (Peach and Zedler 2006).

Therefore, restoration efforts attempted to substitute a replacement ecosystem for the sedge/grass meadow expected to have existed before human interference. A goal of this study was to help the NYSDEC restore sedge meadow community in an elevation range that was suitable for planted and seeded species establishment. Although reference data were broad, limited information about regional pre-disturbance conditions prevented direct comparison.

All ecological restoration projects share several goals; these are related to the recovery of ecosystem health, integrity, and potential for long-term sustainability (SER 2004). Scheduled monitoring and other inventories judge the degree to which each goal has been achieved or is expected to develop passively without intervention. If these attributes are satisfied, it is more likely that the restored ecosystem will be able to continue its development through persistence and sustain itself.

Planted areas in all sites contained native sedge meadow associates that occur in the reference ecosystems, although none of the species prominent in reference locations were prominent in post-restoration communities. Continued development toward the desired ecosystem is expected in all sites since seeded species annually increased in richness following implementation (Figure 5). More seeded species may have established if sown in greater amounts, but it seems better to increase diversity through over-introduction rather than overplanting fewer species.

Sedge meadow associate survival was likely affected in 2012 by below average precipitation that has contributed to the water-level on Lake Ontario remaining below the long-term average (Lawrence 2012, USACE 2012a). The water level peaked above the long-term average in 2009 and 2011, and was about 1 cm below the long-term average in 2010 (USACE 2010, USACE 2011, USACE 2012b). While infrequent high water-level events may help promote ecosystem health, continued monitoring is recommended to determine how the prolonged low water-level affects study sites.

Plantago major and seven remnant sedge meadow associate species occurred in both the Site 1 planted and control area communities, while three seeded and ten remnant sedge meadow associate species occurred in both the Site 1 planted and natural wetland area communities. *Euthamia graminifolia* occurred in the Site 2 planted, control, and natural wetland area communities; seven remnant sedge meadow associate species occurred in both the Site 2 planted and control area communities; and five remnant sedge meadow associate species occurred in both the Site 2 planted and natural wetland area communities. Four seeded and seven remnant sedge meadow associate species occurred in both the Site 3 planted and control area communities. The planted site area communities therefore integrated into the landscape and interacted with the surrounding area through biotic exchanges.

Although *Lycopus americanus* did not occur in randomly placed quadrats in 1P12, three sedge meadow associates that occurred in pre-restoration communities, but did not occur in randomly placed quadrats in 1P10, seemingly re-established in

the Site 1 planted area in subsequent years (Tables 8, 10, and 31). *Agrostis stolonifera* occurred in BRSt2 but did not occur in randomly placed quadrats in 2P10 and seemingly re-established in 2P11, while *Alisma triviale* occurred in 2P10, but did not occur in randomly placed quadrats in 2P11, and seemingly re-established in 2P12 (Tables 5, 17, 18, and 19). Six sedge meadow associates that occurred in pre-restoration communities, but did not occur in randomly placed quadrats in 3P10 or 3PM, seemingly re-established in the Site 3 planted area in subsequent years (Tables 24, 25, and 31). As sedge meadow associates re-established in the planted site areas after apparently being removed, restored ecosystems appear sufficiently resilient to endure normal periodic stress events.

Due to water-level regulation, it is uncertain if the restored communities will prove capable of indefinite existence. However, monitoring the persistence of sedge meadow associate populations will determine if the restored communities continue to develop along the desired trajectory. Continued mowing and other methods deemed necessary to control potentially problematic species are recommended to help prevent their increase in importance.

Conclusions

In accordance with the Great Lakes Restoration Initiative, our restoration project focused on restoring wetland habitat near the confluence of West Creek with Braddock Bay (EPA 2012). Only about one-third of the species seeded in 2010 have

appeared in sampling through 2012, although additional species continue to be found. Some of the increases through time may be the result of chance occurrence in randomly-placed quadrats; however, some are the result of sedges previously unidentifiable to species level reaching maturity and being identified. Reviewing the attribute analysis, it is apparent that the planted areas contain seeded/planted and remnant sedge meadow associates found in reference ecosystems and exchanged sedge meadow associates with the surrounding area, as some species re-established themselves following implementation. At this time, it seems that some seeded species failed to germinate or establish, although some of those species might have established under wetter hydrologic conditions. Therefore, altering seeding mixtures and multi-year plantings should be considered for similar projects undertaken elsewhere.

Fifteen of the 42 seeded/planted species, 38 remnant sedge/grass meadow associates, and 36 potentially problematic species were identified in study site samples across years. Although seeded species diversity increased in each subsequent year following restoration efforts (Figure 5), sampling identified more potentially problematic species (agricultural weeds) than remnant sedge meadow species. The mowing treatment and any other adaptive management actions deemed necessary should both potentially control problematic species and permit more sedge meadow species to establish or survive.

The seed-bank emergence study did not successfully predict ultimate community composition following implementation, which was not unexpected since

survival of plants from seed is often dictated by post-recruitment processes. Instead, seeded species, remnant vegetation, and nearby refuge populations seemed to contribute more to establishment in planted areas than the original seed bank. Most species that occurred in the seed-bank emergence study soil samples have seemingly disappeared – although randomly tossed quadrats may have failed to sample them at Sites 1-3.

The NMDS ordination showed that the 2009 baseline plant communities had been displaced by 2010, likely as a result of implementation actions. The ordination also showed that overall communities in the planted areas at the three sites changed from year to year and largely converged with unplanted controls by 2012. This again suggests that, in addition to seeded species, remnant vegetation was highly influential and nearby refuge populations made contributions as seeded species spread throughout the control and planted site areas.

Species prominent in 2009 samples, except *Agrostis stolonifera*, *Lathyrus palustris*, and *Schoenoplectus fluviatilis*, either decreased substantially across subsequent year samples or were absent in the 2012 samples. Total *Carex* sp., *Hordeum jubatum*, and *Xanthium strumarium* were first observed following implementation in 2010 samples, while *Ambrosia artemisiifolia* increased as *Trifolium pratense* decreased in importance from 2009 to 2010 in all three sites. These species, except total *Carex* sp., became less dominant across subsequent year samples. *Agrostis stolonifera* was absent in 2010 samples then increased in importance in all communities except 2P and 2N, while *Trifolium repens* was first

observed in 2011 samples and then became less prominent in all three sites in 2012. *Euthamia graminifolia* was first observed, after being seeded, in 1P12 in Site 1, while it occurred in 2011 samples in Sites 2 and 3 and had a higher importance in 2P12 and 3P12 than 2P11 and 3P11.

It is uncertain how much seeding effort promoted *Calamagrostis canadensis* establishment in Site 3, *Plantago major* establishment in Sites 1 and 3, and *Verbena hastata* establishment in Site 3, as they also occurred in the seed-bank emergence study soil samples from each site. *Juncus effusus* had a higher importance in CLSt1 than post-restoration samples, and it did not occur in randomly placed quadrats in Site 3 post-restoration samples. *Leersia oryzoides* occurred in Site 1 and 2, while *Solidago rugosa* occurred in Site 3 pre-restoration and post-restoration samples. Since *Solidago rugosa* occurred only in post-restoration samples in Sites 1 and 2, seeding effort seems to have contributed most to its establishment.

A sustained decrease in water level from January 2012 to the August 2012 sampling date likely affected survival of some wetland species with greater water requirements (USACE 2013). However, four seeded species in the Site 1 planted area, seven seeded species in the Site 2 planted area, and four seeded species in the Site 3 planted area were sampled for the first time in 2012. First appearance in 2012 could be a ramification of random sampling; however, it may have been influenced by control treatments on problematic species, many of which were high-canopy annual plants. Mowing at a height of about 30 cm was initiated experimentally in late August 2010 before seed-set and was repeated across much of the three sites in 2011

and 2012. The 2011 treatment resulted in nearly complete eradication of the most prominent problematic species (*Xanthium strumarium;* rough cocklebur) by 2012.

Post-restoration sampling at the restoration sites identified 21 species that were found in the Lake Ontario drowned river-mouth wetland reference data base. Six species were sampled at both the Kents Creek reference site and the restoration sites. More co-occurring species between the wetland data base and the restoration sites reflects greater numbers of potentially problematic species appearing in the wetland data base. The Kents Creek reference site is among the most pristine in Lake Ontario, and sampling there during this project found only 11 species total, nearly all of which were native sedge/grass meadow plants. Reference data thus suggest that the restoration sites reflect sedge/grass meadow conditions but also contain many other species associated more commonly with disturbed sites.

The future plant community at this restoration site will likely be dependent on survival and expansion of sedge/grass meadow species, as influenced by soil moisture and competition from remnant agricultural weed species. Prolonged drought similar to 2012 could potentially extirpate many of the seeded/planted species, especially if those conditions occurred in successive years. Irrigation is not possible at this location, so climate/weather conditions cannot be mitigated. Monitoring results showed that competition can be mitigated by repeated, well-timed mowing that cuts taller annual plants before seed set and opens the canopy for underlying sedges and sedge/grass meadow associates currently found beneath them. Further maturation of the target species, coupled with decline of the problematic species may reduce the

need for mowing at some time in the future. However, mowing will remain as a component of adaptive management until such time as monitoring results indicate that it is not necessary. Although not funded, annual monitoring using the sampling protocols already established for this project will also continue until such time that few changes are occurring from year to year.

Under the hydrologic conditions found at this project site, a future seed mixture might focus on the species of *Bidens* (beggarticks), *Carex* and *Cyperus* (sedges), *Juncus* (rushes), *Eupatorium* (boneset), *Solidago* and *Euthamia* (goldenrods), and *Symphyotrichum* (asters), as well as *Asclepias* (jewelweed), *Verbena* (blue vervain), and *Leersia* (rice cut-grass). Under wetter conditions or at elevations closer to lake level, *Schoenoplectus* (bulrushes), *Iris* (iris), *Cicuta* (water hemlock), and *Sium* (water parsnip) might be successful also. Seeded/planted *Calamagrostis canadensis* (Canada bluejoint grass) and *Carex stricta* (tussock sedge) have not yet fared well in this restoration effort (or have not matured enough to be identifiable), especially in Sites 1 and 2. If they are to be included in future restoration efforts, careful consideration should be given to planting methodologies and environmental conditions that will result in successful establishment of these species. For example, phased plantings selected to link preferential associate species with establishment opportunities, created by natural processes including canopy and gap formation, may increase restoration success (Johnston and Zedler 2011).

Based on the continued success of some of the species seeded in this project, these study sites might serve as an immediate reference for larger-scale sedge/grass

meadow restoration elsewhere along the shore of Lake Ontario. Although previously collected data from 32 Lake Ontario wetlands suggested that the elevation range of 75.35 to 75.60 m IGLD85 was most suitable for restoration of sedge/grass meadow, climate change or potential adoption of Plan Bv7 for more natural future regulation of Lake Ontario water levels could change the desired elevation range. Wetlands with an area greater than 100 ha may provide native taxa with more adequate local connectivity and resources in less fragmented landscapes than the approximate 4 ha of agricultural land used in this study (Mateos *et al*. 2012). Other sedge/grass meadow restoration efforts might therefore prove more successful if the methods used in this study are applied in more extensive un-flooded wetland areas in the elevation range more conducive to sedge/grass meadow growth.

Disking, mowing, and seeding/planting are all recommended in future restoration projects in this type of setting. However, hydrologic conditions (e.g., elevation, lake-level variability, and weather/climate variability) must be considered fully. As in all restoration projects, invasive and other problematic species must be identified and treated soon after detection. Monitoring is therefore critical and should be continued for at least ten years or until data show that the communities have stabilized. Long-term monitoring is also necessary to document the success of a restoration project, as noted in the axiom, “Give it time.”

Literature Cited:

Angeler, D. G. and G. Garcia. 2005. Using emergence from soil propagule banks as indicators of ecological integrity in wetlands: advantages and limitations. Journal of the North American Benthological Society 24: 740-752.

Angeloni, N. L., K. J. Jankowski, N. C. Tuchman, and J. J. Kelly. 2006. Effects of an invasive cattail species (*Typha* x *glauca*) on sediment nitrogen and microbial community composition in a freshwater wetland. Federation of European Microbiological Societies 263: 86-92.

Bakker, C., H. F. de Graaf, W. H. O. Ernst, and P. M. van Bodegom. 2005. Does the seed bank contribute to the restoration of species-rich vegetation in wet dune slacks. Applied Vegetation Science 8: 39-48.

Baldwin, A. H., M. S. Egnotovich, and E. Clarke. 2001. Hydrologic change and vegetation of tidal freshwater marshes: field, greenhouse, and seed-bank experiments. Wetlands 21: 519-531.

Baoyin, T. and F. Yonghong. 2009. Can shallow plowing and harrowing facilitate restoration of *Leymus chinensis* grassland? Results from a 24-year monitoring program. Rangeland Ecology & Management 62: 314-320.

Bedford, B. L. 1996. The need to define hydrologic equivalence at the landscape scale for freshwater wetland mitigation. Ecological Applications 6: 57-68.

Blumenthal, D. M., N. R. Jordan, and E. L. Svenson. 2003. Weed control as a rationale for restoration: the example of tallgrass prairie. [Online.] Conservation Ecology 7: 6. Available at http://www.consecol.org. Accessed 12 January 2012.

Bolton, J. 2011. Species profiles. [Online.] National Invasive Species Information Center, National Agricultural Library, Beltsville, Maryland.
Available at http://www.invasivespeciesinfo.gov. Accessed 12 January 2012.

Bracken. 2012. The Great Basin and invasive weeds: Russian thistle. [Online.] Utah State University, Logan, Utah. Available at http://www.usu.edu. Accessed 12 January 2012.

Brown, S. C. 1998. Remnant seed banks and vegetation as predictors of restored marsh vegetation. Canadian Journal of Botany 76: 620-629.

Chayka, K. and P. M. Dziuk. 2012. Minnesota wildlfowers: a project for justice. [Online.] info@MinnesotaWildflowers.info. Available at MinnesotaWildflowers.info. Accessed 12 January 2012.

Davis, T. 2010. Noxious weeds in Montana. [Online.] Whiehall Schools, Whitehall, Montana. Available at http://mtwow.org. Accessed 12 January 2012.

Dorris, D. and A. Bartow. 2008. Plant guide for rice cutgrass (*Leersia oryzoides*). [Online.] USDA-Natural Resources Conservation Service, Plant Materials Center, Bismarck, North Dakota. Available at http://plants.usda.gov. Accessed 12 January 2012.

Eggers, S. D. and D. M. Reed. 2006. Wetland plants and plant communities of Minnesota and Wisconsin: III.A. sedge meadows. [Online.] U.S. Department of the Interior and U.S. Geological Survey, Menlo Park, California. Available at http://www.npwrc.usgs.gov. Accessed 12 January 2012.

EPA (U.S. Environmental Protection Agency). 2012. Great Lakes restoration. [Online.] Great Lakes National Program Office, Chicago, Illinois. Available at http://greatlakesrestoration.us. Accessed 26 November 2012.

Eriksson, O. 2000. Functional roles of remnant plant populations in communities and ecosystems. Global Ecology & Biogeography 9: 443-449.

Fabula, K. T. 2009. Native herbaceous plants. [Online.] Signature Horticultural Services, Freeland, Maryland. Available at http://www.signaturehort.com. Accessed 12 January 2012.

Greenfield, K. C., M. J. Chamberlain, L. W. Burger, Jr., and E. W. Kurzejeski. 2003. Effects of burning and disking conservation reserve program fields to improve habitat quality for Northern Bobwhite (*Colinus virginianus*). American Midland Naturalist 149: 344-353.

Hagood, S. 2011.Weed identification guide. [Online.] Department of Plant Pathology, Physiology, and Weed Science, College of Agriculture and Life Science, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. Available at http://www.ppws.vt.edu. Accessed 12 January 2012.

Hamel, K. 2011. Non-native invasive freshwater plants. [Online.] Washington State Department of Ecology, Olympia, Washington. Available at http://www.ecy.wa.gov. Accessed 12 January 2012.

Hampton, R. E. and J. E. Havel. 2005. Introductory biological statistics. Second Edition. Waveland Printing Inc., Long Grove, Illinois, USA.

Handel, W. C., L. Phillippe, and J. Ebinger. 2007. An ecological study of the prairie and sedge meadow communities of Richardson Wildlife Foundation. [Online.] University of Illinois, Urbana-Champaign, Illinois.
Available at https://www.ideals.illinois.edu. Accessed 12 January 2012.

Hiltry, J. 2012. Illinois wildflowers. [Online.] john@illinoiswildflowers.info.
Available at http://www.illinoiswildflowers.info. Accessed 12 January 2012.

Hudon, C., D. Wilcox, and J. Ingram. 2006. Modeling wetland plant community response to assess water-level regulation scenarios in the Lake Ontario-St. Lawrence River Basin. Environmental Modeling and Assessment 113: 303-328.

ISSG. 2010. Global invasive species database. [Online.] IUCN Species Survival Commission. Available at http://www.issg.org. Accessed 12 January 2012.

Jacobs, J. 2008. Ecology and management of common tansy (*Tanacetum vulgare* L.) [Online.] USDA and NRCS, Bozeman, Montana.
Available at www.mt.nrcs.usda.gov. Accessed 12 January 2012.

Johnston, C. A. and J. B. Zedler. 2011. Identifying preferential associates to initiate restoration plantings. [Online.] Society for Ecological Restoration International. Available at http://onlinelibrary.wiley.com. Accessed 12 January 2012.

Klein, H. 2011. Common plantain (*Plantago major* L.). [Online.] Alaska Natural Heritage Program, Anchorage, Alaska. Available at http://aknhp.uaa.alaska.edu. Accessed 12 January 2012.

Lawrence, E. D. 2012. Report: Great Lakes water levels may flirt with record lows. [Online.] Detroit Free Press, Detroit, Michigan. Available at http://www.freep.com. Accessed 26 November 2012.

Leck, M. A. 2003. Seed-bank and vegetation development in a created tidal freshwater wetland on the Delaware River, Trenton, New Jersey, USA. Wetlands 23: 310-343.

Mateos, D. M., M. E. Power, F. A. Comin, and R. Yockteng. 2012. Structural and functional loss in restored wetland ecosystems. [Online.] PLoS Biology 10: e1001247. Available at http://www.plosbiology.org. Accessed 12 January 2012.

McCune, B. and J. Grace. 2002. Analysis of ecological communities. Mjm Software Design, Gleneden Beach, Oregon, USA.

Miklovic, S. and S. M. Galatowitsch. 2005. Effect of NaCl and *Typha angustifolia* L. on marsh community establishment: a greenhouse study. Wetlands 25: 420-429.

Mitsch, W. J., X. Wu, R. W. Nairn, P. E. Weihe, N. Wang, R. Deal, and C. E. Boucher. 1998. Creating and restoring wetlands. BioScience 48: 1019-1030.

NGS (National Geodetic Survey). 2012. IGLD 85 height conversion. [Online.] Communications and Outreach Branch, NOAA, Silver Spring, Maryland. Available at http://www.ngs.noaa.gov. Accessed 2013.

Nicol, J. M., G. G. Ganf, and G. A. Pelton. 2003. Seed banks of a southern Australian wetland: the influence of water regime on the final floristic composition. Plant Ecology 168: 191-205.

Norbert, H. and O. Annette. 2001. The impact of flooding regime on the soil seed bank of flood-meadows. Journal of Vegetation Science 12: 209-218.

Novak, J. 2011. Gallery of Connecticut wildflowers. [Online.] Connecticut Botanical Society, New Haven, Connecticut. Available at http://www.ct-botanical-society.org. Accessed 12 January 2012.

NRCS (Natural Resources Conservation Service). 2007. Mannagrass – *Glyceria striata*. [Online.] Montana NRCS State Office, Bozeman, Montana. Available at http://www.mt.nrcs.usda.gov. Accessed 12 January 2012.

Peach, M. and J. B. Zedler. 2006. How tussocks structure sedge meadow restoration. Wetlands 26: 322-335.

PRI (Prairie Restorations, Inc.). 2012. Grass-leaved goldenrod (*Euthamia graminifolia*). [Online.] Princeton Headquarters, Princeton, Minnesota. Available at http://www.prairieresto.com. Accessed 12 January 2012.

Seabloom, E. W., K. A. Moloney, and A. G. van der Valk. 2001. Constraints on the establishment of plants along a fluctuating water-depth gradient. Ecology 82: 2216-2232.

Sellers, J. D. and C. L. Jolls. 2007. Habitats for *Amaranthus pumilus*: an application of light detection and ranging (LIDAR) data. Journal of Coastal Research 23: 1193-1202.

SER (Society for Ecological Restoration International Science & Policy Working Group). 2004. The SER International Primer on Ecological Restoration. [Online.] www.ser.org & Tucson: Society for Ecological Restoration International. Available at www.ser.org. Accessed 12 January 2012.

Tenaglia, D. 2007. Missouriplants.com. [Online.] Auburn, Alabama. Available at Missouriplants.com. Accessed 12 January 2012.

The Pennystone Project. 2011. Tussock sedge meadow. [Online.] Pennsylvania Native Plant Landscaping. Available at http://www.pennystone.com. Accessed 12 January 2012.

Townsend, P. A. 2001. Relationships between vegetation patterns and hydroperiod on the Roanoke River floodplain, North Carolina. Plant Ecology 156: 43-58.

USDA and NRCS. 2010a. Soil data mart. [Online.] New York State Office, Syracuse, New York. Available at http://soildatamart.nrcs.usda.gov. Accessed 20 May 2010.

USDA and NRCS. 2010b. The plants database, version 3.5. [Online.] National Plant Data Center, Baton Rouge, Louisiana. Available at http://plants.usda.gov. Accessed 12 January 2012.

USACE (U.S. Army Corps of Engineers). 2010. Great Lakes update: 2009 annual summary. [Online.] U.S. Army Corps of Engineers, Detroit District. Available at http://www.lre.usace.army.mil. Accessed 26 November 2012.

USACE (U.S. Army Corps of Engineers). 2011. Great Lakes update: 2010 annual summary. [Online.] U.S. Army Corps of Engineers, Detroit District. Available at http://www.lre.usace.army.mil. Accessed 26 November 2012.

USACE (U.S. Army Corps of Engineers). 2012a. Great Lakes basin hydrology August 2012. [Online.] U.S. Army Corps of Engineers, Detroit District. Available at http://www.lre.usace.army.mil. Accessed 26 November 2012.

USACE (U.S. Army Corps of Engineers). 2012b. Great Lakes update: 2011 annual summary. [Online.] U.S. Army Corps of Engineers, Detroit District. Available at http://www.lre.usace.army.mil. Accessed 26 November 2012.

USACE (U.S. Army Corps of Engineers). 2013. Great Lakes update: 2012 annual summary. [Online.] U.S. Army Corps of Engineers, Detroit District. Available at http://www.lre.usace.army.mil. Accessed 12 February 2013.

U.S. Fish and Wildlife Service. 1996. National list of vascular plant species that occur in wetlands: 1996 national summary. [Online.] Washington, D.C. Available at http://wetlands.fws.gov. Accessed 12 January 2012.

U.S. Forest Service. 2002. Index of species Information. [Online.] Washington, DC. Available at http://www.fs.fed.us. Accessed 12 January 2012.

U.S. Forest Service. 2012. Celebrating wildflowers. [Online.] Washington, D.C. Available at http://www.fs.fed.us. Accessed 12 January 2012.

Uva, R. H., J. C. Neal, and J. M. DiTomaso. 2012. Weeds of the northeast. [Online.] National Plant Data Center, Baton Rouge, Louisiana. Available at plants.usda.gov. Accessed 12 January 2012.

van der Valk, A. G. 2013. Seed banks of drained floodplain, drained plaustrine, and undrained wetlands in Iowa, USA. Wetlands 33: 183-190.

Vecrin, M. P., R. van Diggelen, F. Grevilliot, and S. Muller. 2002. Restoration of species-rich flood-plain meadows from abandoned arable fields in NE France. Applied Vegetation Science 5: 263-270.

Vermont Wetland Plant Supply (VWPS). 2012. Plants for ecological restoration. [Online.] Vermont Wetland Plant Supply, LLC., Orwell, Vermont. Available at http://www.vermontwetlandplants.com. Accessed 12 January 2012.

Wang, Z, H. Xu, L. Yin, J. Li, Z. Zhang, and Y. Li. 2009. Effects of water treatments on the activation of soil seed banks – A case study on the lower reaches of the Tarim River. Progress in Natural Science 19: 733-740.

webSURGE, LLC. 2012. Catalog – seed mixes. [Online.] Southern Tier Consulting, Inc., West Clarksville, New York. Available at http://www.southerntierconsulting.com. Accessed 09 March 2010.

Wilcox, D. A., J. W. Ingram, K. P. Kowalski, J. E. Meeker, M. L. Carlson, Y. Xie, G. P. Grabas, K. L. Holmes, and N. J. Patterson. 2005b. Evaluation of water level regulation influences on Lake Ontario and Upper St. Lawrence River coastal wetland plant communities: final project report. International Joint Commission, Ottawa, Ontario and Washington, DC.

Wilcox, D. A., K. P. Kowalski, and M. L. Carlson. 2005a. Year 3 report for the wetland habitat quantity performance indicator study: relationships between Lake Ontario water levels and wetlands. [Online.] State University of New York at Buffalo, Buffalo, NY. Available at http://www.eng.buffalo.edu. Accessed 12 January 2012.

Wilcox, D. A. K. P. Kowalski, H. L. Hoare, M. L. Carlson, and H. N. Morgan. 2008. Cattail invasion of sedge/grass meadows in Lake Ontario: photointerpretation analysis of sixteen wetlands over five decades. Journal of Great Lakes Research 34: 301-323.

Wilcox, D. A and J. E. Meeker. 1991. Disturbance effects on aquatic vegetation in regulated and unregulated lakes in northern Minnesota. Canadian Journal of Botany 69: 1542-1551.

Wilcox, D. A. and S. J. Nichols. 2008. The effects of water-level fluctuations on vegetation in a Lake Huron wetland. Wetlands 28: 487-501.

Wilcox, D. A. and Y. Xie. 2007. Predicting wetland plant community responses to proposed water-level regulation plans for Lake Ontario: GIS-based modeling. Journal of Great Lakes Research 33: 751-773.

Wilcox, D. A. and Y. Xie. 2008. Predicted effects of proposed new regulation plans on sedge/grass meadows of Lake Ontario. Journal of Great Lakes Research 34: 745-754.

Figure 1. Study Sites (St1, St2, and St3) are located at the south-east corner of Bennett Road and Curtis Road, Hilton, Monroe County, New York (lat 43.309 N, long 77.777 W), adjacent to the confluence of West Creek and Braddock Bay. The three sites are located in about 4 ha of former agricultural land. Kents Creek is a broad basin with extensive un-flooded wetland areas conducive to sedge and grass growth, which is located along Lake Ontario north-east of Braddock Bay near Cape Vincent, Jefferson County, New York (lat 44.07228 N, long 76.33161.W).

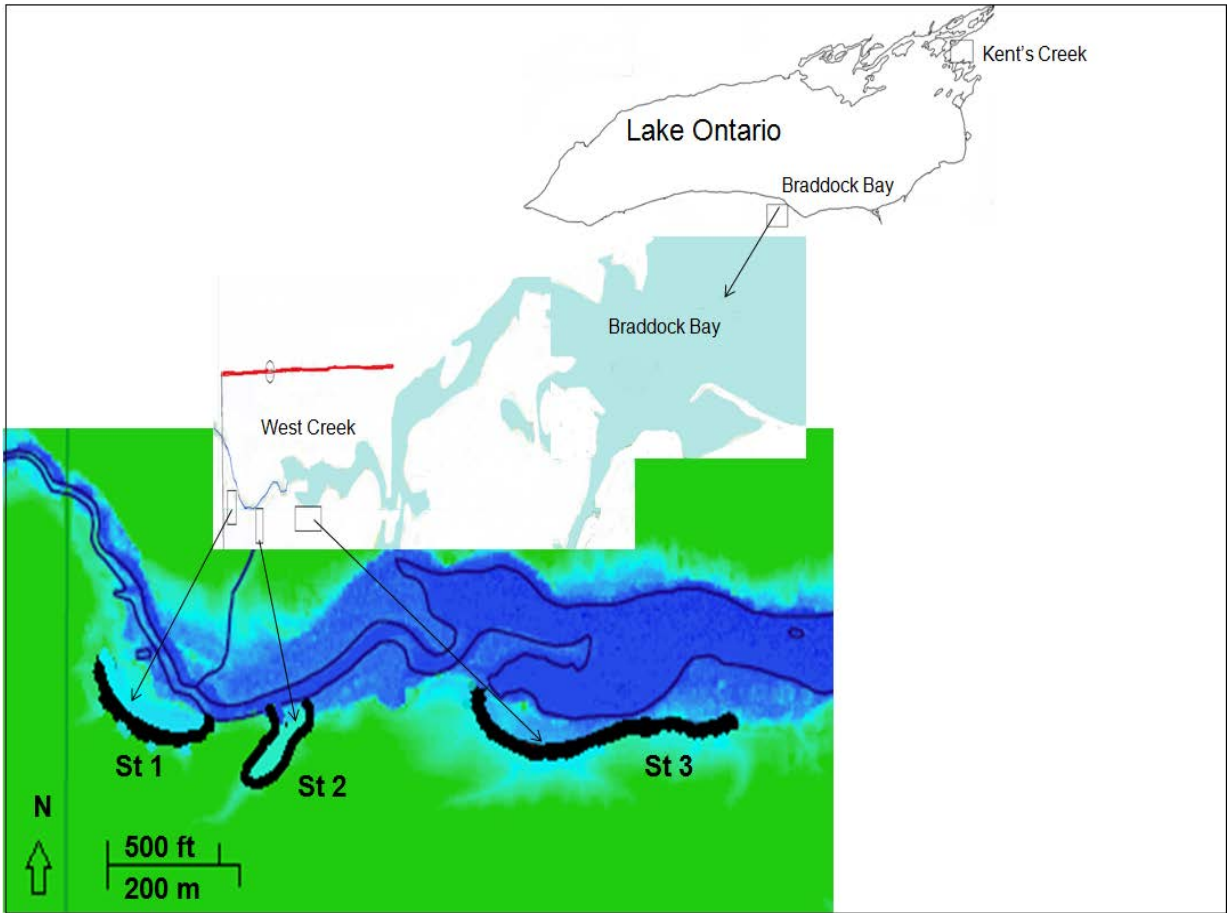


Figure 2. Flags were used to denote post-implementation sampled control (C), planted-mowed (PM), planted (P), and natural wetland (N) areas located in Sites 1 (a), 2 (b), and 3 (c). Control areas were disked similarly to planted areas in May 2010, but plug planting and seed mixture sowing occurred only in planted areas. Mowing at 30-cm height by the former property owner to control tall annual weeds created a third variable in 2010 – 3PM10. Natural wetland areas were near 2009 bulrush community quadrats in Sites 1 and 2.

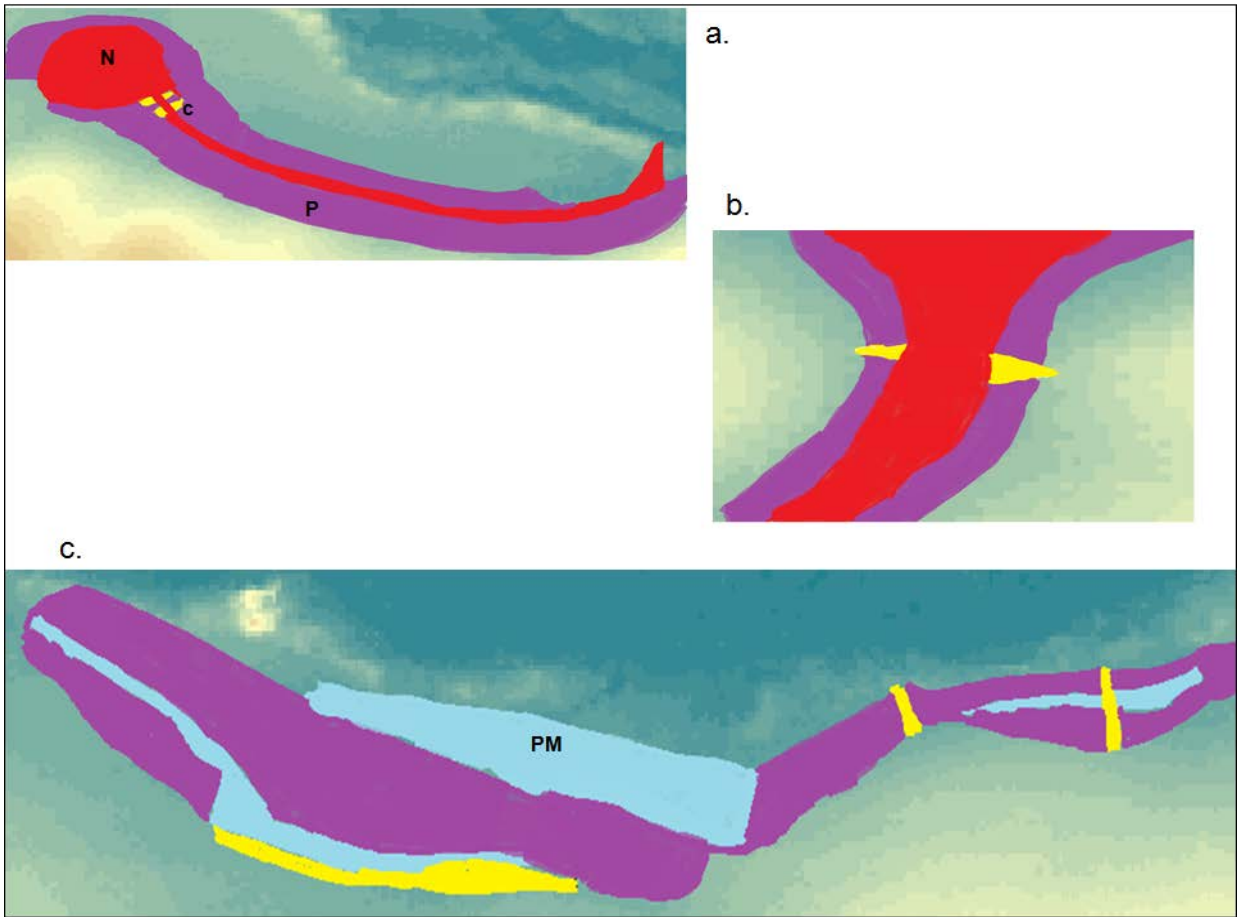
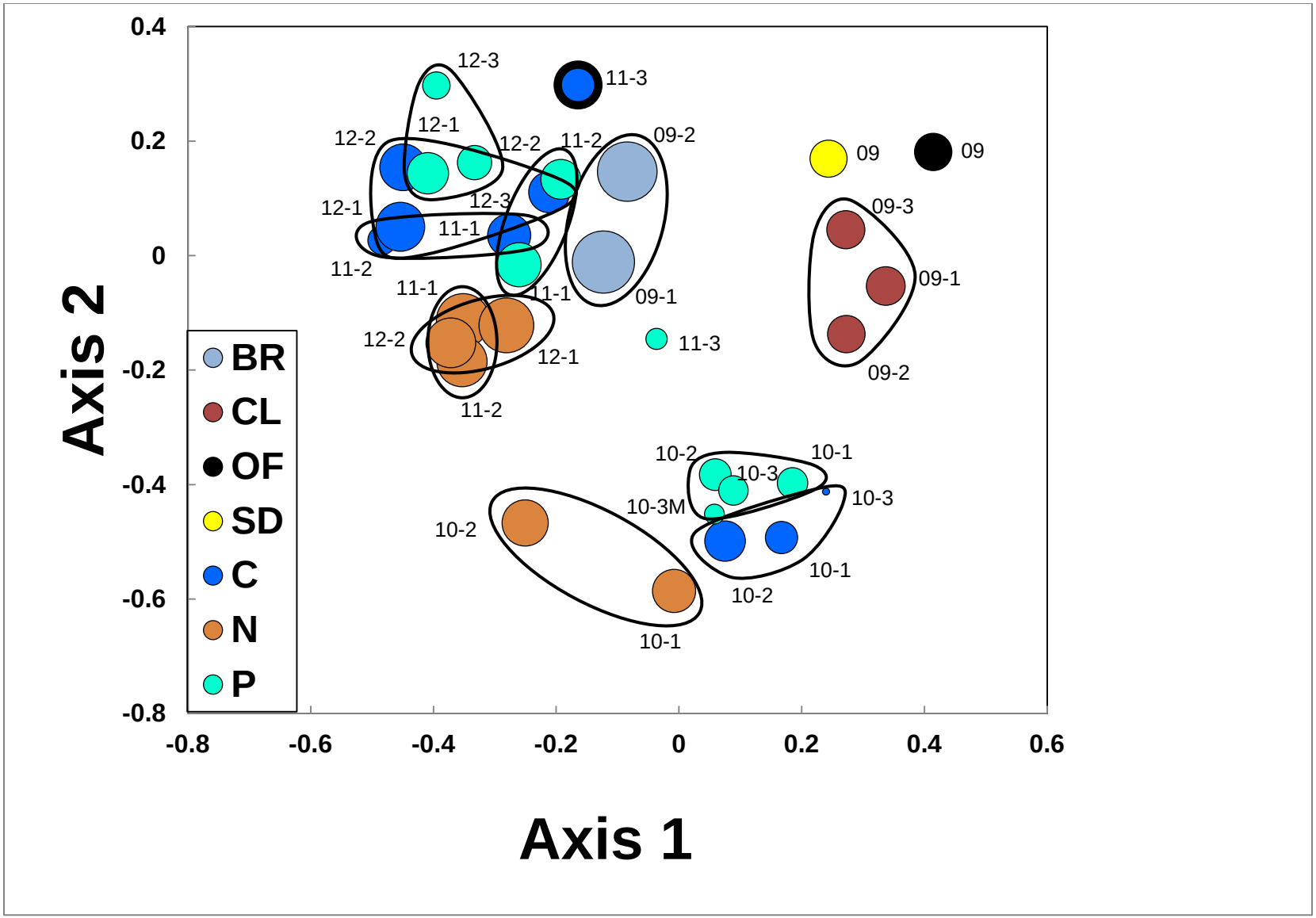


Figure 3. Three-dimensional plot of axis 1, 2, and 3 study site community sample scores with axis 3 indicated by circle size. Importance Value for samples, from 2009 pre-restoration through 2012 post-restoration (See Table 2), were analyzed in study site community sample x Importance Value matrices by ordination, using non-metric multidimensional scaling (NMDS, McCune and Grace 2002) with autopilot on, Sorensen distance, no species weighting, final stress = 21.33047, final instability = 0, number of iterations = 108.
* C11St3 had a negative value on Axis 3


0.4
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-0.2
-0.4
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Axis 2
Axis 1
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Figure 4. Two-dimensional plot of axis 1 and 2 species scores from ordination analysis. Importance Values for sampling units, from 2009 pre-restoration through 2012 post-restoration, were analyzed in sampling unit x Importance Value matrices by ordination, using non-metric multidimensional scaling (NMDS, McCune and Grace 2002) with autopilot on, Sorensen distance, no species weighting, final stress = 21.33047, final instability = 0, number of iterations = 108. Abbreviations for forty-three plant taxa that were among the most important in study site community samples and occurred in at least two quadrats in a sample are shown (See Table 4).

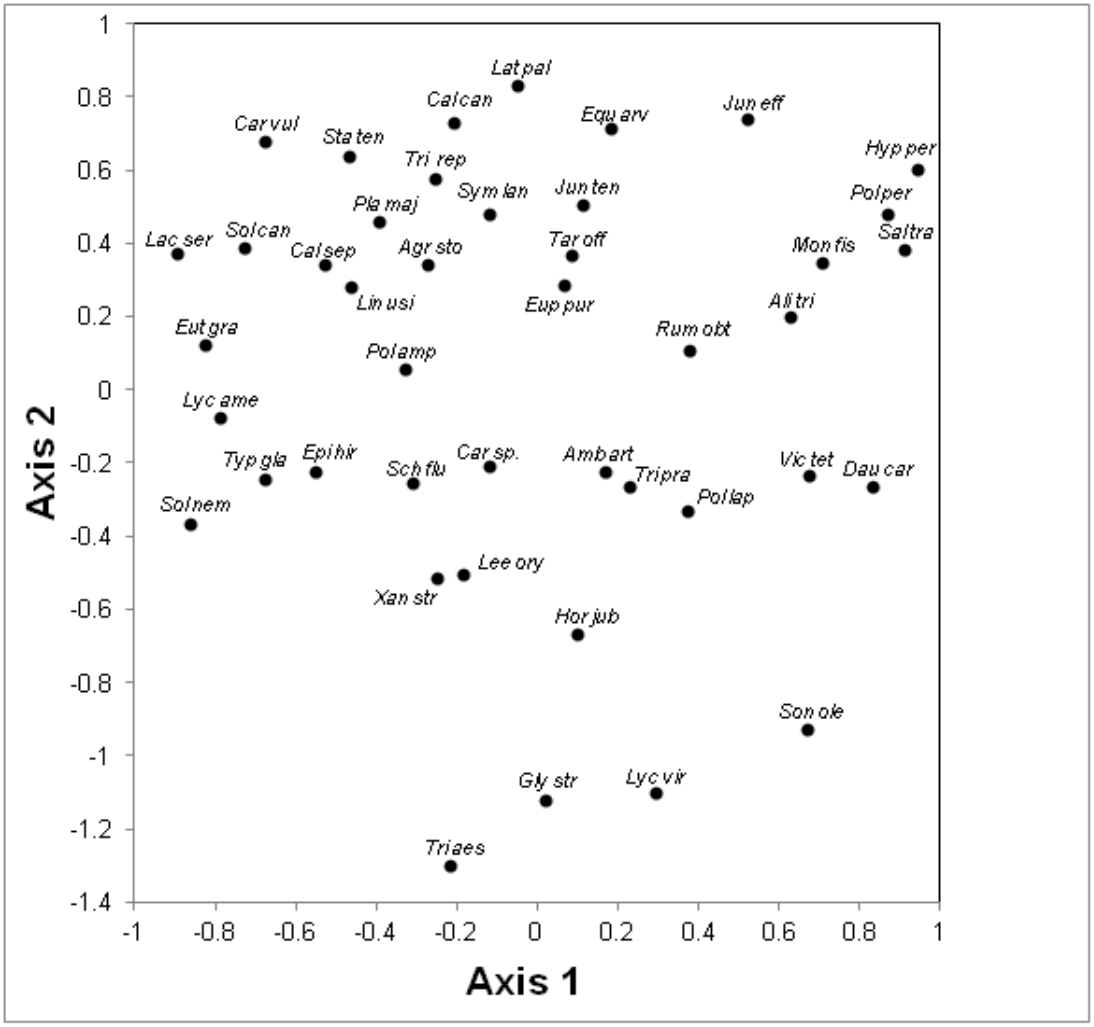

Figure 5. Total number of seeded species observed per year in each study site.

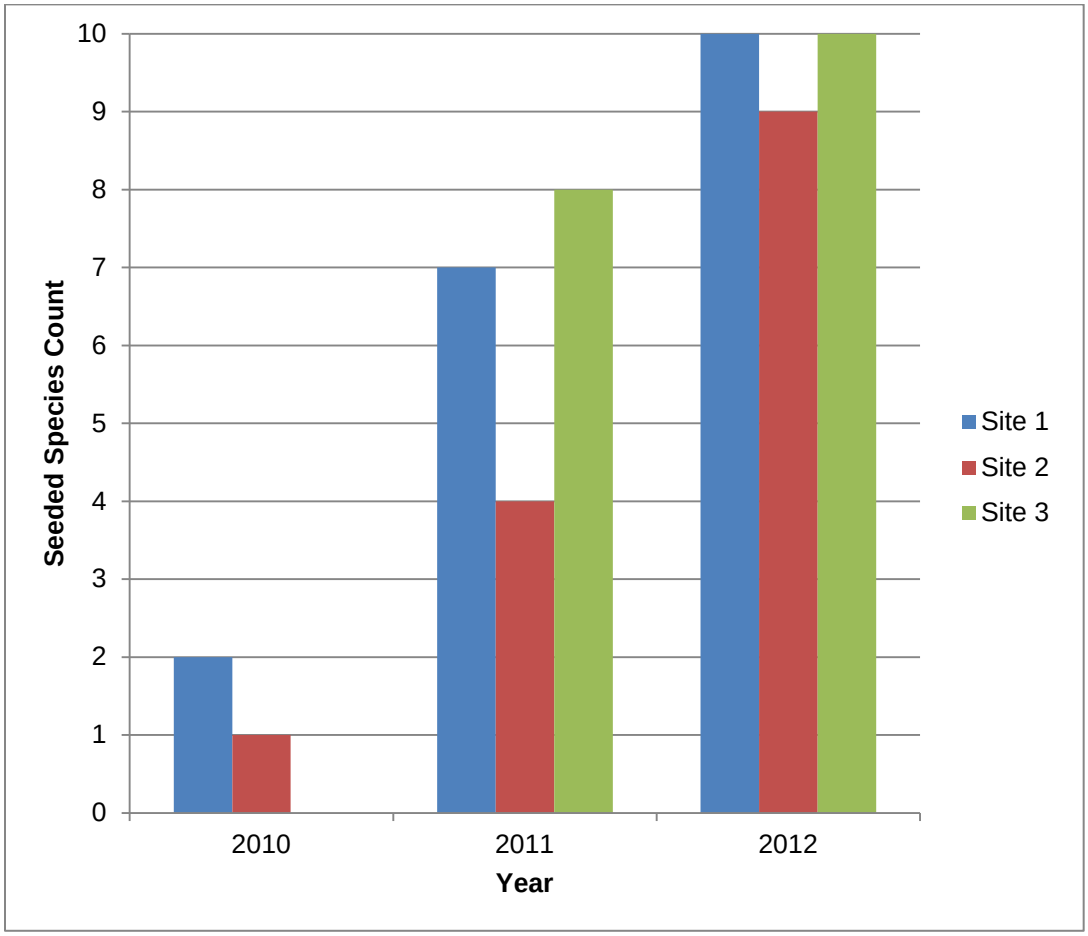

Table 1. Seed percentage (not weight) of species included in Northeast Wetland Diversity Mix and Northeast Wetland Hummock Mix purchased from Southern Tier Consulting, Inc., West Clarksville, NY and sown in June 2010 within study site planted areas. *Species occurred in planted area(s).

Northeast Wetland Diversity Mix	Percent (%)
Angelica atropurpurea	0.06
*Asclepias incarnata**	0.04
Bidens cernua	0.22
*Bidens frondosa**	0.08
Carex comosa	0.31
Carex crinita	0.26
*Carex lupulina**	0.02
*Carex lurida**	0.05
*Carex vulpinoidea**	8.35
Cephalanthus occidentalis	0.38
Cicuta maculate	0.16
Cyperus strigosus	0.47
Dichanthelium clandestinum	0.24
Doellingeria umbellata	0.35
*Elymus canadensis**	0.10
Elymus riparius	0.03
*Eupatorium perfoliatum**	2.09
*Euthamia graminifolia**	0.47
Eutrochium maculatum	0.89
Glyceria Canadensis	1.36
Glyceria grandis	6.68
Helenium autumnale	1.48
Iris versicolor	0.01
*Juncus effusus**	13.05
*Leersia oryzoides**	1.57
Mimulus ringens	12.01
Penthorum sedoides	7.83
*Plantago major**	0.52
Polygonum pensylvanicum	0.04
Rumex verticillatus	0.05
Scirpus atrovirens	28.82
Scirpus cyperinus	5.22
Scirpus microcarpus	0.18
Schoenoplectus tabernaemontani	0.36
Sium suave	0.21
Solidago gigantean	0.24
*Solidago rugosa**	0.47
*Symphyotrichum novae-angliae **	0.73
Symphyotrichum puniceum	0.42
*Verbena hastata**	4.18
Northeast Wetland Hummock Mix	
Carex comosa	1.3
Carex crinita	0.9

*Carex lupulina**	0.2
*Carex lurida**	0.2
*Carex vulpinoidea**	33.5
*Juncus effusus**	19.0
*Leersia oryzoides**	1.3
Scirpus atrovirens	43.6

Table 2. Study site community sample abbreviation descriptions.

Reference	
GHSt1, GHSt2, GHSt3	Seed-bank emergence study (inside greenhouse)
K	Kent's Creek reference site sample
Pre-Restoration	
BRSt1, BRSt2	Bulrush Community Site 1 (BR 5-10), Site 2 (BR 1-4)
CLSt1, CLSt2, CLSt3	Clover Community Site 1 (CL 7-10), Site 2 (CL 5-6), Site 3 (CL 1-4)
OF(St1)	Old Field Community
SD(St3)	Sedge Community
Post-Restoration	
C10, C11, C12	Control Area – tilled but un-planted Site 1 (C 8-10), Site 2 (C 5-7), Site 3 (C 1-4)
1P10, 1P11, 1P12	Site 1 Planted Area
1N10, 1N11, 1N12	Site 1 Natural Wetland Area - near BR 5-10
2P10, 2P11, 2P12	Site 2 Planted Area
2N10, 2N11, 2N12	Site 2 Natural Wetland Area - near BR 1-4
3P10, 3P11, 3P12	Site 3 Planted Area
3PM10	Site 3 Planted and Mowed Area

Table 3. Wetland indicator abbreviation descriptions (USDA and NRCS 2010b).

OBL	Obligate Wetland – most often occurs in wetlands (99% probability)
FACW	Facultative Wetland – usually occurs in wetlands (67-99% probability)
FAC	Faculative – equally likely to occur in wetlands or non-wetlands (34-66% probability)
FACU	Facultative Upland – usually occurs in non-wetlands (67-99% probability)
UPL	Obligate Upland – normally occurs in non-wetlands (99% probability)
NI	No Indicator – insufficient information

Table 4. Abbreviations for forty-three taxa that had a frequency of at least two (quadrats) and were among the five most important taxa in at least one study site community sample.

Taxa	Abbreviation
Agrostis stolonifera	*Agr sto*
Alisma triviale	*Ali tri*
Ambrosia artemisiifolia	*Amb art*
Calamagrostis canadensis	*Cal can*
Calystegia sepium	*Cal sep*
Carex sp.	*Car sp.*
Carex vulpinoidea	*Car vul*
Daucus carota	*Dau car*
Epilobium hirsutum	*Epi hir*
Equisetum arvense	*Equ arv*
Eupatorium purpureum	*Eup pur*
Euthamia graminifolia	*Eut gra*
Glyceria striata	*Gly str*
Hordeum jubatum	*Hor jub*
Hypericum perforatum	*Hyp per*
Juncus effusus	*Jun eff*
Juncus tenuis	*Jun ten*
Lactuca serriola	*Lac ser*
Lathyrus palustris	*Lat pal*
Leersia oryzoides	*Lee ory*
Linum usitatissimum	*Lin usi*
Lycopus americanus	*Lyc ame*
Lycopus virginicus	*Lyc vir*
Monarda fistulosa	*Mon fis*
Plantago major	*Pla maj*
Polygonum amphibium	*Pol amp*
Polygonum lapathifolium	*Pol lap*
Polygonum persicaria	*Pol per*
Rumex obtusifolius	*Rum obt*
Salsola tragus	*Sal tra*
Schoenoplectus fluviatilis	*Sch flu*
Solidago canadensis	*Sol can*
Solidago nemoralis	*Sol nem*
Sonchus oleraceus	*Son ole*
Stachys tenuifolia	*Sta ten*
Symphyotrichum lanceolatum	*Sym lan*
Taraxacum officinale	*Tar off*

Trifolium pratense	*Tri pra*
Trifolium repens	*Tri rep*
Triticum aestivum	*Tri aes*
Typha ×glauca	*Typ gla*
Vicia tetrasperma	*Vic tet*
Xanthium strumarium	*Xan str*

Table 5. Kents Creek (K) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (K1-K10). Analysis also included species richness and total percent cover and species count.

K % Cover	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	AV	FQ	IV
Agrostis stolonifera								1			0.10	1	2.1
Calamagrostis canadensis	5	30	35	15	25	5	10	40	40	60	26.50	10	58.2
Carex lacustris	50	40	40	25	25	60	45	25	15	5	33.00	10	67.6
Cirsium arvense										1	0.10	1	2.1
Impatiens capensis	5		1		5	1	2	1	3	5	2.30	8	19.0
Lathyrus palustris	2	1	1	2		1		2	5		1.40	7	15.8
Lysimachia thyrsiflora	2	2	2								0.60	3	6.8
Onoclea sensibilis		15									1.50	1	4.1
Polygonum amphibium			1								0.10	1	2.1
Pteridophyta	2										0.20	1	2.3
Solidago sp.				2							0.20	1	2.3
Verbena hastata				5	6			2	2		1.50	4	10.0
Vine sp.			1		1					10	1.20	3	7.6
TOTAL	66	88	81	49	62	67	57	71	65	81	68.70		
Species Count	6	5	7	5	5	4	3	6	5	5	5.10		
Species Richness	6	7	9	11	11	11	11	12	12	13			

Table 6. Scientific names, taxonomic authorities, and common names of species that occurred in Kents Creek and study site 1-m^2 quadrat samples and seed-bank emergence study soil samples. Duration (DUR) and native status (NS) classification follows the USDA website (USDA and NRCS 2010b). Wetland indicator status follows the National List of Vascular Plant Species that Occur in Wetlands: 1996 National Summary (U.S. Fish and Wildlife Service 1996). *Unique to Kents Creek or a seed-bank emergence study or study site sample.

Authority	Common Name	DUR	NS	WI
Abutilon theophrasti Medik.	Velvetleaf	ANN	INT	UPL
Acalypha rhomboidea Raf.	Common Threeseed Mercury	ANN	NAT	FACU
Agrostis stolonifera (L.)	Creeping Bentgrass	PER	INT	FACW
Alisma triviale Pursh	Northern Water Plantain	PER	NAT	NI
Amaranthus blitum L.*	Purple Amaranth	ANN	INT	NI
Ambrosia artemisiifolia (L.)	Annual Ragweed	ANN	NAT	FACU
Anthemis cotula (L.)*	Stinking Chamomile	ANN	INT	FACU
Argentina anserina (L.) Rydb.*	Silverweed Cinquefoil	PER	NAT	OBL
Asclepias incarnata L.	Swamp Milkweed	PER	NAT	OBL
Aureolaria virginica (L.) Pennell*	Downy Yellow False Foxglove	PER	NAT	NI
Barbarea vulgaris W.T. Aiton*	Garden Yellowrocket	BIE	INT	FACU
Bidens sp.				
Bidens frondosa L.*	Devil's Beggartick	ANN	NAT	FACW
Bidens tripartita (L.)	Threelobe Beggarticks	ANN	NAT	FACW
Bromus ciliatus (L.)*	Fringed Brome	PER	NAT	FACW
Bromus hordeaceus L.*	Soft Brome	ANN	INT	UPL
Calamagrostis canadensis (Michx.) P. Beauv.	Bluejoint	PER	NAT	FACW
Calystegia sepium (L.) R. Br.	Hedge False Bindweed	PER	NAT	FAC
Capsella bursa-pastoris (L.) Medik.*	Shepherd's Purse	ANN	INT	FACU
Carex sp.				
Carex lacustris Willd.*	Hairy Sedge	PER	NAT	OBL
Carex lupulina Muhl. ex Willd.	Hop Sedge	PER	NAT	OBL
Carex lurida Wahlenb.*	Shallow Sedge	PER	NAT	OBL
Carex vulpinoidea Michx	Fox Sedge	PER	NAT	OBL
Centaurea americana Nutt.*	American Star-Thistle	ANN	NAT	NI
Cerastium glomeratum Thuill.*	Sticky Chickweed	ANN	INT	UPL
Chenopodium album (L.)	Lambsquarters	ANN	NAT	FACU
Cicuta bulbifera L.	Bulblet-Bearing Water Hemlock	PER	NAT	OBL
Cirsium sp.				
Cirsium arvense (L.) Scop.*	Canada Thistle	PER	INT	FACU
Cirsium vulgare (Savi) Ten.	Bull Thistle	BIE	INT	FACU
Convolvulus arvensis (L.)	Field Bindweed	PER	INT	NI
Cornus sericea (L.)	Redosier Dogwood	PER	NAT	FACW
Cyperus odoratus (L.)	Fragrant Flatsedge	ANN	NAT	FACW

Daucus carota (L.)	Queen Anne's Lace	BIE	INT	NI
Echinochloa crus-galli (L.) P. Beauv.*	Barnyardgrass	ANN	INT	FACU
Echinochloa muricata (P. Beauv.) Fernald*	Rough Barnyardgrass	ANN	NAT	FACW
Echium vulgare L.*	Common Viper's Bugloss	ANN	INT	NI
Eleocharis intermedia Schult.*	Matted Spikerush	PER	NAT	FACW
Eleocharis ovata (Roth) Roem. & Schult.	Ovate Spikerush	ANN	NAT	OBL
Eleocharis parvula (Roem. & Schult.) Link ex Bluff, Nees & Schauer*	Dwarf Spikerush	ANN	NAT	OBL
Elymus canadensis L.	Canada Wildrye	PER	NAT	FACU
Epilobium hirsutum (L.)	Codlins and Cream	PER	INT	FACW
Equisetum arvense (L.)	Field Horsetail	PER	NAT	FAC
Equisetum sylvaticum (L.)	Woodland Horsetail	PER	NAT	FACW
Eupatorium perfoliatum L.	Common Boneset	PER	NAT	FACW
Eupatorium purpureum (L.)*	Sweet-Scented Joe Pye Weed	PER	NAT	FAC
Euthamia graminifolia (L.) Nutt.	Flat-Top Goldentop	PER	NAT	FAC
Festuca filiformis Pourr.*	Fineleaf Sheep Fescue	PER	INT	NI
Fraxinus pennsylvanica Marsh.*	Geen Ash	PER	NAT	FACW
Galium sp.				
Geum rivale (L.)*	Purple Avens	PER	NAT	OBL
Glyceria striata (Lam.) Hitchc.	Fowl Mannagrass	PER	NAT	OBL
Helianthus pauciflorus Nutt.	Stiff Sunflower	PER	NAT	NI
Hordeum jubatum (L.)	Foxtail Barley	PER	NAT	FAC
Hypericum perforatum (L.)	Common St. Johnswort	PER	INT	NI
Impatiens capensis Meerb.	Jewelweed	ANN	NAT	FACW
Juncus articulatus (L.)*	Jointleaf Rush	PER	NAT	OBL
Juncus canadensis J. Gay ex Laharpe*	Canadian rush	PER	NAT	OBL
Juncus effusus (L.)	Common Rush	PER	NAT	FACW
Juncus tenuis (Willd.)	Poverty Rush	PER	NAT	FAC
Lactuca serriola (L.)	Prickly Lettuce	ANN	INT	FAC
Lathyrus palustris (L.)	Marsh Pea	PER	NAT	FACW
Leersia oryzoides (L.) Sw.	Rice Cutgrass	PER	NAT	OBL
Linum usitatissimum (L.)	Common Flax	ANN	INT	NI
Lobelia inflata L.*	Indian-tobacco	ANN	NAT	FACU
Lycopus americanus Muhl. ex W. Bartram	American Water Horehound	PER	NAT	OBL
Lycopus asper Greene*	Rough Bugleweed	PER	NAT	OBL
Lycopus uniflorus Michx.*	Northern Bugleweed	PER	NAT	OBL
Lycopus virginicus (L.)	Virginia Water Horehound	PER	NAT	OBL
Lysimachia ciliata (L)	Fringed Loosestrife	PER	NAT	FACW
Lysimachia thyrsiflora L.*	Tufted Loosestrife	PER	NAT	OBL
Lythrum alatum Pursh*	Winged Lythrum	PER	NAT	FACW
Lythrum salicaria (L.)	Purple Loosestrife	PER	INT	FACW
Melissa officinalis L.	Common Balm	PER	INT	NI
Monarda fistulosa (L.)	Wild Bergamot	PER	NAT	UPL
Muhlenbergia frondosa (Poir.) Fernald*	Wirestem Muhly	PER	NAT	FAC
Muhlenbergia tenuiflora (Willd.) Britton, Sterns & Poggenb.*	Slimflower Muhly	PER	NAT	NI

Onoclea sensibilis L.*	Sensitive Fern	PER	NAT	FACW
Oxalis corniculata (L.)	Creeping Woodsorrel	ANN	NAT	FACU
Panicum sp.				
Panicum capillare (L.)	Witchgrass	ANN	NAT	FAC
Panicum flexile (Gattinger) Scribn.*	Wiry Panicgrass	ANN	NAT	FACU
Phalaris arundinacea (L.)	Reed Canarygrass	PER	NAT	FACW
Plantago major (L.)	Common Plantain	PER	INT	FACU
Polygonum sp.				
Polygonum amphibium (L.)	Water Knotweed	PER	NAT	OBL
Polygonum hydropiperoides Michx.	Swamp Smartweed	PER	NAT	OBL
Polygonum lapathifolium (L.)	Curlytop Knotweed	ANN	NAT	FACW
Polygonum persicaria (L.)	Spotted Ladysthumb	ANN	INT	FACW
Polygonum punctatum Elliot	Dotted Smartweed	ANN	NAT	OBL
Populus deltoides Bartram ex Marsh.	Eastern Cottonwood	PER	NAT	FAC
Potentilla norvegica (L.)	Norwegian Cinquefoil	ANN	NAT	FACU
Primula mistassinica Michx.*	Mistassini Primrose	PER	NAT	FACW
Pyrola asarifolia Michx.*	Liverleaf Wintergreen	PER	NAT	FACW
Ranunculus abortivus (L.)	Littleleaf Buttercup	BIE	NAT	FACW
Ranunculus pensylvanicus L. f.*	Pennsylvania buttercup	ANN	NAT	OBL
Rhynchospora sp.				
Ribes americanum (Mill.)	American Black Currant	PER	NAT	FACW
Rorippa sp.				
Rorippa palustris (L.) Besser*	Bog Yellowcress	ANN	NAT	OBL
Rudbeckia hirta L.*	Blackeyed Susan	ANN	NAT	FACU
Rumex acetosella (L.)*	Common Sheep Sorrel	PER	INT	UPL
Rumex crispus (L.)	Curly Dock	PER	INT	FACU
Rumex obtusifolius (L.)	Bitter Dock	PER	INT	FACU
Salix sp.				
Salix exigua Nutt.*	Narrowleaf Willow	PER	NAT	OBL
Salix pedicellaris Pursh*	Bog Willow	PER	NAT	OBL
Salsola tragus L.	Prickly Russian Thistle	ANN	INT	FACU
Schoenoplectus fluviatilis (Torr.) M.T. Strong	River Bulrush	PER	NAT	OBL
Schoenoplectus pungens (Vahl) Palla	Common Threesquare	PER	NAT	FACW
Schoenoplectus tabernaemontani (C.C. Gmel.) Palla.*	Soft-Stem Bulrush	PER	NAT	OBL
Setaria faberi Herrm.	Japanese Bristlegrass	ANN	INT	FACU
Solanum carolinense (L.)	Carolina Horsenettle	PER	NAT	UPL
Solidago sp.				
Solidago canadensis L.	Canada Goldenrod	PER	NAT	FACU
Solidago caesia (L.)*	Wreath Goldenrod	PER	NAT	FACU
Solidago hispida Muhl. ex Willd.	Hairy Goldenrod	PER	NAT	NI
Solidago nemoralis Aiton	Gray Goldenrod	PER	NAT	NI
Solidago odora Aiton*	Anisescented Goldenrod	PER	NAT	NI
Solidago rugosa Mill.	Wrinkleleaf Goldenrod	PER	NAT	FAC
Sonchus asper (L.) Hill*	Spiny Sowthistle	ANN	INT	FAC

Sonchus oleraceus (L)	Common Sowthistle	ANN	INT	UPL
Sphenopholis obtusata (Michx.) Scribn.*	Slender Wedgescale	PER	NAT	FAC
Sporobolus compositus (Poir.) Merr.*	Composite Dropseed	PER	NAT	UPL
Stachys tenuifolia Willd.	Smooth Hedge-Nettle	PER	NAT	FACW
Symphyotrichum sp.				
Symphyotrichum lanceolatum (Willd.) G.L. Nesom	White Panicle Aster	PER	NAT	NI
Symphyotrichum novae-angliae (L.) G.L. Nesom*	New England Aster	PER	NAT	FAC
Tanacetum vulgare (L.)*	Common Tansy	PER	INT	NI
Taraxacum officinale F.H. Wigg.	Common Dandelion	PER	NAT	FACU
Teucrium canadense (L.)*	Canada Germander	PER	NAT	FACW
Toxicodendron radicans (L.) Kuntze*	Eastern Poison Ivy	PER	NAT	FAC
Trifolium arvense (L.)*	Rabbitfoot Clover	ANN	INT	NI
Trifolium dubium Sibth.*	Suckling Clover	ANN	INT	UPL
Trifolium pratense (L.)	Red Clover	BIE	INT	FACU
Trifolium repens L.	White Clover	PER	INT	NI
Triticum aestivum (L.)*	Common Wheat	ANN	INT	NI
Typha latifolia (L.)*	Broadleaf Cattail	PER	NAT	OBL
Typha ×glauca Godr. (pro sp.)		PER	NAT	OBL
Verbena hastata (L.)	Swamp Verbena	BIE	NAT	FACW
Vernonia noveboracensis (L.) Michx.	New York Ironweed	PER	NAT	FACW
Vicia tetrasperma (L.) Schreb.	Lentil Vetch	ANN	INT	NI
Xanthium strumarium L.	Rough Cocklebur	ANN	NAT	FAC

Table 7. Seed-bank emergence study, conducted in the greenhouse (GH), average stem count (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in the soil samples (1A-3D) from each study site (St1, St2, and St3). Analysis also included species richness and total stem count and species count.

GH % Cover	1A	1B	1C	1D	2A	2B	3A	3B	3C	3D	St1AV	St1FQ	St1IV	St2AV	St2FQ	St2IV	St3AV	St3FQ	St3IV
Acalypha rhomboidea						1								0.50	1	5.9			
Amaranthus blitum	1			1	1	1					0.50	2	7.5	1.00	2	11.7			
Ambrosia artemisiifolia	1	4	3	6	2	1	5	1			3.50	4	19.1	1.50	2	12.4	1.50	2	7.3
Anthemis cotula					2									1.00	1	6.5			
Bidens tripartita	7		1	5	14					5	3.25	3	15.4	7.00	1	13.8	1.25	1	4.4
Bromus hordeaceus					3	1								2.00	2	13			
Calmagrostis canadensis										1							0.25	1	3
Carex sp.	1		26		56	94		8	4	14	6.75	2	17.9	75.00	2	102	6.50	3	16.9
Centaurea americana							1										0.25	1	3
Cerastium glomeratum	100	30	1	6			60	20	29	95	34.25	4	70.2				51.00	4	80.9
Echinochloa muricata				2	2						0.50	1	4.2	1.00	1	6.5			
Echium vulgare				6							1.50	1	5.8						
Eleocharis parvula									1	3							1.00	2	6.6
Festuca filiformis	5	31	3	8	7	23	16	26	10	10	11.75	4	32.8	15.00	2	28.8	15.50	4	31.9
Hordeum jubatum	2				1			1	1	1	0.50	1	4.2	0.50	1	5.9	0.75	3	8.9
Juncus articulatus							1										0.25	1	3
Lactuca serriola				1							0.25	1	3.7						
Lycopus asper							11										2.75	1	6.4
Lythrum alatum	4			6	58	22		2			2.50	2	10.8	40.00	2	59.3	0.50	1	3.3
Muhlenbergia frondosa							1										0.25	1	3
Muhlenbergia tenuiflora				1		1					0.25	1	3.7	0.50	1	5.9			
Panicum flexile	15		1	23	6	7	63	8	8	10	9.75	3	26.2	6.50	2	18.5	22.25	4	41.2
Plantago major	1		26	6	3	15	8	5	27	5	8.25	3	23.7	9.00	2	21.5	11.25	4	26
Poacea sp.	6	37			1	3	12	1	3		10.75	2	24.5	2.00	2	13	4.00	3	13.4
Polygonum lapathifolium	10		1	8	4		1	6		4	4.75	3	17.9	2.00	1	7.7	2.75	3	11.7
Primula mistassinica							3										0.75	1	3.7
Pyrola asarifolia				1			2				0.25	1	3.7				0.50	1	3.3
Ranunculus abortivus				2		3	2	3			0.50	1	4.2	1.50	1	7.1	1.25	2	7
Rorippa palustris					1					4				0.50	1	5.9	1.00	1	4
Salsola tragus		22	1		2				4		5.75	2	16.2	1.00	1	6.5	1.00	1	4
Sphenopholis obtusata						1								0.50	1	5.9			
Sporobolus compositus				4	4						1.00	1	5	2.00	1	7.7			
Trifolium pratense	4			3			8	13		3	1.75	2	9.6				6.00	3	16.2
Verbena hastata							1	2									0.75	2	6.3
Vernonia noveboracensis	1										0.25	1	3.7						
TOTAL	158	124	63	89	167	173	195	96	87	155	108.50			170.00			133.25		
Species Count	14	5	9	17	17	13	16	13	9	12	11.25			15.00			12.50		
Species Richness	14	15	15	22	17	21	16	19	21	24									

Table 8. Bulrush community (BR) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (BR1-BR10) in Site 1 (St1) and Site 2 (St2). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

BR % Cover	BR1	BR2	BR3	BR4	BR5	BR6	BR7	BR8	BR9	BR10	St1AV	St1FQ	ST1IV	St2AV	St2FQ	ST2IV
Agrostis stolonifera				1	8	20					4.67	2	13.8	0.25	1	5.0
Alisma triviale			3	2										1.25	2	10.8
Calamagrostis canadensis	60	75	2	1	2		2				0.67	2	8.8	34.5	4	53.4
Eleocharis ovata									2		0.33	1	4.4			
Equisetum arvense					2	30					5.33	2	14.7			
Eupatorium purpureum							15	10	2	2	4.83	4	22.0			
Hypericum perforatum					0.5						0.08	1	4.1			
Leersia oryzoides			2											0.5	1	5.3
Linum usitatissimum			2	2										1	2	10.5
Lycopus americanus					1						0.17	1	4.2			
Monarda fistulosa			25	0.5										6.375	2	15.9
Polygonum lapathifolium			2	1			20	10			5.00	2	14.3	0.75	2	10.3
Populus deltoides		0.5												0.125	1	4.9
Schoenoplectus fluviatilis	55	40	55	70	60	45	80	90	30	40	57.50	6	95.9	55	4	73.8
Schoenoplectus tabernaemontani									1		0.17	1	4.2			
Solidago caesia		2												0.5	1	5.3
Trifolium pratense				1	3	3					1.00	2	9.3	0.25	1	5.0
Vernonia noveboracensis						1					0.17	1	4.2			
TOTAL	115	117.5	91	78.5	76.5	99	117	110	35	42	79.92			100.5		
Species Count	2	4	7	8	7	5	4	3	4	2	4.17			5.25		
Species Richness	2	4	9	11	7	8	10	10	12	12						
Seeded	60	75	4	1	2		2		1		0.83			35		

Table 9. Clover community (CL) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (CL1-CL10) in each study site (St1, St2, and St3). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

CL % Cover	CL1	CL2	CL3	CL4	CL5	CL6	CL7	CL8	CL9	CL10	St1AV	St1FQ	ST1IV	St2AV	St2FQ	ST2IV	St3AV	St3FQ	ST3IV
Agrostis stolonifera	2	20		0.5													5.6	3.0	16.3
Alisma triviale				5													1.3	1.0	4.6
Ambrosia artemisiifolia			2	2		0.5			1	0.5	0.38	2	14.7	0.3	1.0	16.9	1.0	2.0	7.3
Total *Carex* sp.	0.5		1						0.5		0.13	1	7.3				0.4	2.0	6.5
Hypericum perforatum	1		0.5	3				30			7.50	1	15.0				1.1	3.0	10.5
Juncus effusus	1			0.5				2			0.50	1	7.7				0.4	2.0	6.5
Lathyrus palustris	5	2															1.8	2.0	8.3
Oxalis corniculata			0.5														0.1	1.0	3.2
Polygonum lapathifolium	1						1				0.25	1	7.4				0.3	1.0	3.4
Polygonum persicaria									1		0.25	1	7.4						
Populus deltoides	1																0.3	1.0	3.4
Potentilla norvegica		1															0.3	1.0	3.4
Ribes americanum			1														0.3	1.0	3.4
Rumex obtusifolius	2	2		10	30	30	5		35	40	20.00	3	42.4	30.0	2.0	60.5	3.5	3.0	13.6
Solidago hispida	1																0.3	1.0	3.4
Solidago odora				1													0.3	1.0	3.4
Solidago rugosa				1													0.3	1.0	3.4
Tanacetum vulgare					5									2.5	1.0	18.9			
Taraxacum officinale	1																0.3	1.0	3.4
Trifolium pratense	50	70	75	45	75	80	90	45	70	60	66.25	4	98.1	77.5	2.0	103.6	60.0	4.0	88.9
Vernonia noveboracensis		2															0.5	1.0	3.7
Vicia tetrasperma	2																0.5	1.0	3.7
TOTAL	67.5	97	80	68	110	110.5	96	77	107.5	100.5	95.25			110.3			78.1		
Species Count	12	6	6	9	3	3	3	3	5	3	3.50			3.0			8.3		
Species Richness	12	14	17	20	3	4	3	5	8	8									
Seeded	1			1.5				2			0.50						0.6		

Table 10. Old Field community (OF) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (OF1-OF10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

OF % Cover	OF1	OF2	OF3	OF4	OF5	OF6	OF7	OF8	OF9	OF10	AV	FQ	IV
Agrostis stolonifera		2									0.20	1	1.5
Alisma triviale		1	1			1	40	20	4	10	7.70	7	19.3
Ambrosia artemisiifolia	8	20	15	8	10	40	5		4	15	12.50	9	28.7
Aureolaria virginica									20		2.00	1	4.1
Bromus ciliatus								2			0.20	1	1.5
Daucus carota						2		1			0.30	2	2.8
Galium sp.									0.5		0.05	1	1.2
Geum rivale									1		0.10	1	1.3
Hypericum perforatum	10	5	0.5	2	5	0.5					2.30	6	10.3
Juncus effusus		2									0.20	1	1.5
Juncus tenuis	20	20	40	25	75	50	8	10			24.80	8	45.4
Leersia oryzoides	1										0.10	1	1.3
Lythrum salicaria								0.5			0.05	1	1.2
Monarda fistulosa					1						0.10	1	1.3
Panicum sp.								1			0.10	1	1.3
Poaceae sp.1	3	5	3			1			1		1.30	5	7.7
Poaceae sp.2	2	10					2				1.40	3	5.5
Polygonum amphibium	2										0.20	1	1.5
Polygonum lapathifolium	1						2	0.5	10		1.35	4	6.6
Polygonum persicaria	1	1	2								0.40	3	4.1
Ranunculus abortivus				3							0.30	1	1.6
Rumex acetosella	0.5										0.05	1	1.2
Rumex obtusifolius						1					0.10	1	1.3
Salsola tragus	2	20	10		10	10					5.20	5	13.4
Solidago sp.	4	2	2	3							1.10	4	6.3
Taraxacum officinale								1			0.10	1	1.3
Teucrium canadense				2	1	2		0.5	1		0.65	5	6.8
Toxicodendron radicans			1								0.10	1	1.3
Trifolium arvense					1	4					0.50	2	3.1
Trifolium pratense		1	8	2	10	30	0.5		1		5.25	7	15.8
TOTAL	54.5	89	82.5	45	113	141.5	57.5	36.5	42.5	25	68.70		
Species Count	12	12	10	7	8	11	6	9	9	2	8.60		
Species Richness	12	16	17	19	21	23	23	27	30	30			
Seeded	1	2									0.30		

Table 11. Planted Site 1 area in 2010, two months after planting and seeding (1P10), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P20). Analysis also included species richness and total percent cover and species count.

1P10 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	AV	FQ	IV
Abutilon theophrasti									1						1						0.10	1.0	1.1
Acalypha rhomboidea	10	6	15	5	1	4	2	10	20	5			20	10					4	1	5.65	7.0	12.9
Alisma triviale											8	10		3				2.0			1.15	2.0	3.2
Ambrosia artemisiifolia	5	15	3	10	35	15	35	20	40	25	8	3		10	15	3	25	30.0	20	4	16.05	9.5	25.9
Aster thin leaf purple stem																2					0.10	0.5	0.6
Bidens sp.		1		2	5			2						10	4	5	15	10.0			2.70	4.5	7.3
Carex spp.	7	15	10	15	5	10	1	8	1	5	3	15	15	2	3	2	5	0.5	10	10	7.13	10.0	17.4
Convolvulus arvensis									20												1.00	0.5	1.5
Cyperus odoratus			1		2			2			10	3		1		2	1				1.10	4.0	5.2
Epilobium hirsutum											2	5	5					1.0		8	1.05	2.5	3.6
Equisetum sylvaticum	3		2	5																	0.50	1.5	2.0
Glyceria striata																			5		0.25	0.5	0.8
Hordeum jubatum	8	15	30	15	15	5	50	20	20	10			10	20	5	5	15	5.0	8	10	13.30	9.0	22.6
Juncus tenuis																				25	1.25	0.5	1.8
Lycopus virginicus												1	6		2			1.0	30	5	2.25	3.0	5.3
Oxalis corniculata								1					1							1	0.15	1.5	1.7
Panicum capillare				2				2		1				3	2	2		1.0			0.65	3.5	4.2
Poaceae sp.			5		10	8				1		2		20							2.30	3.0	5.4
Polygonum lapathifolium	2	1	8	3	1	8	2	1		1	8	2	3	1	2	3	1	35.0	3	1	4.30	9.5	14.0
Rumex obtusifolius			5		15	5	35	2		8											3.50	3.0	6.6
Schoenoplectus fluviatilis				1	1	3														3	0.40	2.0	2.4
Setaria faberi	2	1		5		3		1													0.60	2.5	3.2
Sonchus oleraceus	6						2														0.40	1.0	1.4
Taraxacum officinale					4		2	1													0.35	1.5	1.9
Trifolium pratense	80	10	7	8	60	10	20	25	15	15	2	1	25	45	60	20	45	40.0	60	25	28.65	10.0	39.2
Xanthium stromarium		45	3	4		20		1											2		3.75	3.0	6.9
TOTAL	123	109	89	75	154	91	149	96	117	71	42	42	87	125	94	44	107	125.5	142	94	98.83		
Species Count	9	9	11	12	12	11	9	14	7	9	8	9	9	11	9	9	7	10.0	9	12	9.80		
Species Richness	9	11	14	16	17	17	17	18	20	20	23	24	24	24	24	25	25	25.0	26	27			

Table 12. Planted Site 1 area in 2011, a year after planting and seeding (1P11), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P20). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

1P11 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	AV	FQ	IV
Agrostis stolonifera	70	60	25	80	40	60	40	20		15	60	8	35	5	15	10	2	20	35	5	30.25	9.5	40.5
Ambrosia artemisiifolia						2		2	1	2					4						0.55	2.5	3.6
Asclepias incarnata								2													0.10	0.5	0.7
Bidens sp.		5					2							2							0.45	1.5	2.3
Bidens tripartita						2															0.10	0.5	0.7
Calystegia sepium								15													0.75	0.5	1.3
Carex sp.		10	3	5	1	15	4	25	20	15	1	2	1	15	1	10	2	5	2	15	7.60	9.5	18.9
Carex vulpinoidea											10										0.50	0.5	1.1
Convolvulus arvensis								20													1.00	0.5	1.6
Daucus carota													3								0.15	0.5	0.8
Epilobium hirsutum										1	33	20		15	10	12	30		17	40	8.90	4.5	14.0
Equisetum sylvaticum	1		80																		4.05	1	5.1
Eupatorium perfoliatum																	3		3	2	0.40	1.5	2.2
Hordeum jubatum		1					3		2	3				1							0.50	2.5	3.5
Juncus effusus													2								0.10	0.5	0.7
Juncus tenuis																				25	1.25	0.5	1.8
Lactuca serriola	60	2								5								2	2		3.55	2.5	6.4
Linum usitatissimum		5					30	15	20		3	15	10		25	15	25		5	3	8.55	6	15.5
Lycopus americanus							25	3	10					5	5	30	25	35	30	35	10.15	5	15.8
Lysimachia ciliata																	4	2		1	0.35	1.5	2.2
Lythrum salicaria		1																			0.05	0.5	0.7
Melissa officinalis						5															0.25	0.5	0.9
Oxalis corniculata						1															0.05	0.5	0.7
Plantago major											2		2		2		5	3		2	0.80	3	4.4
Polygonum lapathifolium						3	4	1	1					2							0.55	2.5	3.6
Populus deltoides															1						0.05	0.5	0.7
Rumex obtusifolius														5							0.25	0.5	0.9
Schoenoplectus fluviatilis	1	5		2	3	1									2		1	1			0.80	4	5.7
Solidago nemoralis												5									0.25	0.5	0.9
Solidago rugosa															2	8	2				0.60	1.5	2.4
Symphyotrichum sp.	1	2	10										2								0.75	2	3.2
Taraxacum officinale							5														0.25	0.5	0.9
Trifolium pratense	5	10	15	1	2		5	10			20	30	10		20	25	10	20	25	5	10.65	8	20.0
Trifolium repens									5	4											0.45	1	1.7
Verbena hastata					2																0.10	0.5	0.7
Xanthium strumarium		40	35	5	70	30		10	5	4											9.95	4	14.4
TOTAL	138	141	168	93	118	119	118	123	64	49	129	80	65	50	87	110	109	88	119	133	105.05		
Carex spp.		10	3	5	1	15	4	25	20	15	11	2	1	15	1	10	2	5	2	15	8.10	9.5	
Species Count	6	11	6	5	6	9	9	11	8	8	7	6	8	8	11	7	11	8	8	10	8.15		
Species Richness	6	12	12	12	13	18	20	23	24	25	27	28	30	31	33	33	35	35	35	36			
Seeded					2			2			12		4		4	8	10	3	3	4	2.60		

Table 13. Planted Site 1 area in 2012, two years after planting and seeding (1P12), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P20). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

1P12 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	AV	FQ	IV
Agrostis stolonifera	10	10	5	20	15	5	25	5	5	20	60	10	35	2	5	25	30	15	45	45	19.60	10	42.1
Ambrosia artemisiifolia				2									1	0.5	0.5						0.20	2	4.0
Calystegia sepium					45	5															2.50	1	4.9
Carex sp.		2								20		2	10	15			1	3			2.65	3.5	9.7
Carex lupulina										1							2				0.15	1	2.0
Cicuta bulbifera									1												0.05	0.5	1.0
Cirsium vulgare						20															1.00	0.5	2.1
Elymus canadensis				2		10															0.60	1	2.6
Epilobium hirsutum	80	85	90	25		5	25	35	3			30	20	60	35	25	20	30	15		29.15	8	49.8
Equisetum sylvaticum										50											2.50	0.5	3.9
Eupatorium perfoliatum		1												10	3					2	0.80	2	4.7
Euthamia graminifolia												15									0.75	0.5	1.8
Fraxinus pennsylvanica								1													0.05	0.5	1.0
Juncus canadensis			15																		0.75	0.5	1.8
Juncus effusus					25																1.25	0.5	2.4
Juncus tenuis								1	1		25	3								1	1.55	2.5	6.5
Lactuca serriola				40		40	25							2	20	45		1	1	1	8.75	4.5	18.9
Leersia oryzoides											3		15								0.90	1	2.9
Lysimachia ciliata									1												0.05	0.5	1.0
Lythrum salicaria																	10				0.50	0.5	1.5
Melissa officinalis											0.5										0.03	0.5	1.0
Oxalis corniculata				2																	0.10	0.5	1.1
Plantago major								2		1											0.15	1	2.0
Rudbeckia hirta						1															0.05	0.5	1.0
Rumex obtusifolius				5																	0.25	0.5	1.2
Solidago canadensis		10				5	20		10					2	2	20	10	20	3	20	6.10	5.5	17.6
Symphyotrichum lanceolatum								10	2												0.60	1	2.6
Symphyotrichum novae-angliae									20												1.00	0.5	2.1
Taraxacum officinale							1	15	15												1.55	1.5	4.7
Trifolium pratense	1																0.5				0.08	1	2.0
TOTAL	91	108	110	96	85	91	96	69	58	92	88.5	60	81	91.5	65.5	115	73.5	69	64	69	83.65		
Carex sp.		2								21		2	10	15			3	3			2.80	3.5	
Species Count	4	6	4	8	4	9	6	8	10	6	5	6	6	8	7	5	8	6	5	6	6.35		
Species Richness	3	6	7	12	14	16	17	21	24	26	28	29	29	29	29	29	30	30	30	30			
Seeded		1		2	25	10		2	20	2	3	15	15	10	3		2			2	5.60		

Table 14. Control area that was not planted or seeded in 2010 (C10) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (3C1-1C10) in each study site (St1, St2, and St3). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

C10 % Cover	3C1	3C2	3C3	3C4	2C5	2C6	2C7	1C8	1C9	1C10	St1AV	St1FQ	St1IV	St2AV	St2FQ	St2IV	St3AV	St3FQ	St3IV
Abutilon theophrasti							2	1	1		0.67	2	9.3	0.7	1.0	4.1			
Ambrosia artemisiifolia	5		25	50	4	6	5	25	50	1	25.33	3	36.2	5.0	3.0	15.5	20.0	3.0	31.3
Bidens sp.					4	8	6			75	25.00	1	27.2	6.0	3.0	16.5			
Total *Carex* sp.	2	1	2	0.5	2			0.5	2		0.83	2	9.5	0.7	1.0	4.1	1.4	4.0	15.2
Cyperus odoratus					1									0.3	1.0	3.8			
Glyceria striata					15					1	0.33	1	4.6	5.0	1.0	8.6			
Hordeum jubatum	30	1	15	1	5	15	4	10	15	1	8.67	3	21.0	8.0	3.0	18.6	11.8	4.0	26.1
Leersia oryzoides					15									5.0	1.0	8.6			
Lycopus virginicus							3			20	6.67	1	10.4	1.0	1.0	4.5			
Lysimachia ciliata			1														0.3	1.0	3.7
Oxalis corniculata			0.5	1													0.4	2.0	7.3
Panicum capillare								2			0.67	1	5.0						
Polygonum hydropiperoides					4									1.3	1.0	4.8			
Polygonum lapathifolium			2	1			2	2	2	1	1.67	3	14.6	0.7	1.0	4.1	0.8	2.0	7.7
Rorippa sp.					2									0.7	1.0	4.1			
Rumex crispus			5							4	1.33	1	5.6				1.3	1.0	4.8
Rumex obtusifolius						3		2			0.67	1	5.0	1.0	1.0	4.5			
Schoenoplectus fluviatilis							1							0.3	1.0	3.8			
Sonchus oleraceus	10	80															22.5	2.0	30.5
Symphyotrichum sp.	5						10							3.3	1.0	6.9	1.3	1.0	4.8
Symphyotrichum lanceolatum				10													2.5	1.0	6.1
Thatch				15													3.8	1.0	7.4
Trifolium pratense			30	15	10	60	75	75	35		36.67	2	42.2	48.3	3.0	60.2	11.3	2.0	18.7
Triticum aestivum						2	8		2		0.67	1	5.0	3.3	2.0	10.3			
Vicia tetrasperma	50	2															13.0	2.0	20.5
Xanthium strumarium		10	10		8		10		1		0.33	1	4.6	6.0	2.0	13.1	5.0	2.0	12.1
TOTAL	102	94	91.5	93.5	71	94	126	117.5	108	103	109.50			97.0			95.3		
Species Count	6	5	10	7	12	6	11	8	8	7	7.67			9.7			7.0		
Species Richness	6	7	13	15	12	14	19	8	10	14									
Seeded					15									5.0					

Table 15. Control area in 2011 (C11) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (3C1-1C10) in each study site (St1, St2, and St3). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

C11 % Cover	3C1	3C2	3C3	3C4	2C5	2C6	2C7	1C8	1C9	1C10	St1AV	St1FQ	St1IV	St2AV	St2FQ	St2IV	St3AV	St3FQ	St3IV
Agrostis stolonifera			5	5	15	40		10	40	30	26.67	3	34.8	18.3	2.0	33.2	2.5	2.0	6.5
Ambrosia artemisiifolia	2	1				2		2	2		1.33	2	9.8	0.7	1.0	6.7	0.8	2.0	5.1
Bidens sp.						35				20	6.67	1	9.8	11.7	1.0	19.5			
Calystegia sepium				20													5.0	1.0	6.1
Total *Carex* sp.	3	3			2	1		1	1		0.67	2	9.2	1.0	2.0	12.9	1.5	2.0	5.7
Epilobium hirsutum								3			1.00	1	5.2						
Eupatorium perfoliatum			3														0.8	1.0	2.9
Euthamia graminifolia			20	30	30	3	90							41.0	3.0	65.5	12.5	2.0	14.2
Helianthus pauciflorus				2													0.5	1.0	2.7
Hordeum jubatum	1					1								0.3	1.0	6.3	0.3	1.0	2.5
Impatiens capensis			30														7.5	1.0	8.1
Juncus tenuis	4	2															1.5	2.0	5.7
Lathyrus palustris			3	20													5.8	2.0	9.0
Linum usitatissimum									60	20	26.67	2	30.5						
Lobelia inflata	5	2															1.8	2.0	5.9
Lycopus americanus								20	5	2	9.00	3	20.4						
Lysimachia ciliata	10																2.5	1.0	4.2
Lythrum salicaria			20														5.0	1.0	6.1
Oxalis corniculata	5	10			1									0.3	1.0	6.3	3.8	2.0	7.4
Plantago major	25	1							20		6.67	1	9.8				6.5	2.0	9.6
Polygonum amphibium			35	15			1							0.3	1.0	6.3	12.5	2.0	14.2
Polygonum hydropiperoides						3								1.0	1.0	7.1			
Polygonum lapathifolium								5			1.67	1	5.7						
Potentilla norvegica		15	10														6.3	2.0	9.4
Rumex obtusifolius		5	15					2	10		4.00	2	12.0				5.0	2.0	8.4
Schoenoplectus fluviatilis							5	5			1.67	1	5.7	1.7	1.0	7.8			
Setaria faberi		10															2.5	1.0	4.2
Solidago sp.	2	1		2													1.3	3.0	7.8
Solidago canadensis					20									6.7	1.0	13.7			
Solidago nemoralis						5								1.7	1.0	7.8			
Sonchus asper		10															2.5	1.0	4.2
Stachys tenuifolia				30													7.5	1.0	8.1
Symphyotrichum lanceolatum	8	40															12.0	2.0	13.8
Taraxacum officinale	2	2															1.0	2.0	5.3
Trifolium pratense						3								1.0	1.0	7.1			
Trifolium repens	30	45						15	4		6.33	2	13.9				18.8	2.0	19.0
Verbena hastata	10																2.5	1.0	4.2
Xanthium strumarium								20		70	30.00	2	33.2						
TOTAL	107	147	141	124	68	93	96	83	142	142	122.33			85.7			129.8		
Species Count	13	14	9	8	5	9	3	10	8	5	7.67			5.7			11.0		
Species Richness	13	17	24	27	5	11	13	10	12	14									
Seeded	35	1	23	30	30	3	90		20		6.67			41.0			22.3		

Table 16. Control area in 2012 (C12) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (3C1-1C10) in each study site (St1, St2, and St3). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

C12 % Cover	3C1	3C2	3C3	3C4	2C5	2C6	2C7	1C8	1C9	1C10	St1AV	St1FQ	St1IV	St2AV	St2FQ	St2IV	St3AV	St3FQ	St3IV
Agrostis stolonifera	40	20	15	70	15	95	8	45		10	18.33	2	36.4	39.3	3.0	69.0	36.3	4.0	59.4
Ambrosia artemisiifolia		25															6.3	1.0	11.6
Calystegia sepium							2							0.7	1.0	6.5			
Total *Carex* sp.					5	0.5								1.8	2.0	13.5			
Cirsium vulgare							5							1.7	1.0	7.8			
Daucus carota								1			0.33	1	9.4						
Epilobium hirsutum	25	3	40	20	25		5	60	65	65	63.33	3	90.3	10.0	2.0	24.4	22.0	4.0	42.5
Eupatorium perfoliatum	1																0.3	1.0	4.5
Euthamia graminifolia							5							1.7	1.0	7.8			
Juncus tenuis			5														1.3	1.0	5.7
Lactuca serriola					2									0.7	1.0	6.5			
Lycopus americanus							0.5							0.2	1.0	5.8			
Plantago major	2	4	10						30		10.00	1	19.0				4.0	3.0	17.2
Poacea sp.																			
Populus deltoides				0.5													0.1	1.0	4.3
Rumex obtusifolius		2															0.5	1.0	4.8
Schoenoplectus fluviatilis						1								0.3	1.0	6.0			
Solidago sp.							20							6.7	1.0	14.5			
Solidago canadensis	1				15		15	5	15	5	8.33	3	35.6	10.0	2.0	24.4	0.3	1.0	4.5
Solidago nemoralis					5									1.7	1.0	7.8			
Stachys tenuifolia									0.5		0.17	1	9.3						
Symphyotrichum lanceolatum			1														0.3	1.0	4.5
Taraxacum officinale		1	3		1									0.3	1.0	6.0	1.0	2.0	9.5
Trifolium pratense	5	15	15														8.8	3.0	22.9
Xanthium strumarium				15													3.8	1.0	8.6
TOTAL	74	70	89	105.5	68	96.5	60.5	111	110.5	80	100.50			75.0			84.6		
Species Count	6	7	7	4	7	3	8	4	4	3	3.67			6.0			6.0		
Species Richness	6	9	11	13	7	8	13	4	6	6									
Seeded	3	4	10				5				0.00						4.3		

Table 17. Natural wetland vegetation Site 1 area in 2010 (1N10) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

1N10 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Acalypha rhomboidea		1		2	2						0.50	3	4.7
Alisma triviale								3			0.30	1	1.7
Ambrosia artemisiifolia						1					0.10	1	1.5
Bidens sp.						45				40	8.50	2	9.8
Total *Carex* sp.						2		0.5			0.25	2	3.1
Cornus sericea			10								1.00	1	2.2
Cyperus odoratus						3					0.30	1	1.7
Daucus carota									10		1.00	1	2.2
Eleocharis intermedia								2			0.20	1	1.6
Epilobium hirsutum		8	10		2		10		10	60	10.00	6	16.7
Equisetum sylvaticum	1		7	10							1.80	3	5.7
Glyceria striata	40	60	70	25	20	2			1		21.80	7	27.7
Hordeum jubatum				3		3					0.60	2	3.3
Leersia oryzoides	10										1.00	1	2.2
Lycopus virginicus	1	15	8	15	30		2			15	8.60	7	17.0
Lythrum salicaria	4				2		2				0.80	3	4.9
Oxalis corniculata				2							0.20	1	1.6
Polygonum lapathifolium				1		4	3				0.80	3	4.9
Rumex crispus				1		3					0.40	2	3.2
Salix sp.						2					0.20	1	1.6
Schoenoplectus fluviatilis	70	35	40	25	45	35	65	35	40		39.00	9	44.6
Schoenoplectus pungens							1				0.10	1	1.5
Solidago rugosa				35							3.50	1	4.3
Sonchus oleraceus									65		6.50	1	6.7
Trifolium pratense					2	2					0.40	2	3.2
Typha latifolia								30		15	4.50	2	6.5
Xanthium stromarium	15			3	35						5.30	3	8.6
TOTAL	141	119	145	122	138	106	133	70.5	126	130	123.05		
Species Count	7	5	6	11	8	12	7	5	5	4	7.00		
Species Richness	7	9	10	15	16	22	24	27	29	29			
Seeded	10			35							4.50		

Table 18. Natural wetland vegetation Site 1 area in 2011 (1N11) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

1N11 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Agrostis stolonifera	2				30	15	3	30	50	25	15.50	7	29.3
Ambrosia artemisiifolia	2				5	1	1				0.90	4	8.2
Barbarea vulgaris							1				0.10	1	1.9
Bidens sp.	3	1			2		2				0.80	4	8.1
Carex sp.	1				4	3	5				1.30	4	8.7
Carex vulpinoidea		1									0.10	1	1.9
Cicuta bulbifera	1										0.10	1	1.9
Equisetum arvense								30			3.00	1	5.0
Impatiens capensis										2	0.20	1	2.0
Linum usitatissimum	5							5			1.00	2	4.7
Lycopus americanus				2	3	25	10	15			5.50	5	15.0
Lythrum salicaria		1		1							0.20	2	3.9
Polygonum sp.									3		0.30	1	2.1
Schoenoplectus fluviatilis	60	50	50	60	50	60	45	40	35	65	51.50	10	73.3
Solidago nemoralis	45						2	10			5.70	3	11.6
Trifolium pratense	2										0.20	1	2.0
Typha × glauca		30	40								7.00	2	11.1
Xanthium strumarium					3		10	20	5	5	4.30	5	13.7
TOTAL	121	83	90	63	97	104	79	150	93	97	97.70		
Carex sp.	1	1			4	3	5				1.40	5	
Species Count	9	5	2	3	7	5	9	7	4	4	5.50		
Species Richness	9	12	12	13	14	14	15	16	17	18			
Seeded		1									0.10		

Table 19. Natural wetland vegetation Site 1 area in 2012 (1N12) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

1N12 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Agrostis stolonifera	3	30	10	70	40						15.30	5	29.8
Alisma trivale						1		1			0.20	2	5.1
Ambrosia artemisiifolia					2						0.20	1	2.7
Carex sp.						5	5	5			1.50	3	9.0
Carex vulpinoidea			15								1.50	1	4.2
Cornus sericea										5	0.50	1	3.0
Epilobium hirsutum			20		10				45	15	9.00	4	20.1
Leersia oryzoides	30					5		1			3.60	3	11.5
Polygonum lapathifolium						8		1			0.90	2	5.9
Schoenoplectus fluviatilis	35	30	40	45	65	30	15		30	35	32.50	9	59.3
Solidago canadensis			15								1.50	1	4.2
Solidago rugosa									5	40	4.50	2	10.1
Stachys tenuifolia							1				0.10	1	2.6
Typha x glauca						25	35	30	10		10.00	4	21.3
Xanthium strumarium	2	55									5.70	2	11.4
TOTAL	70	115	100	115	117	74	56	38	90	95	87.00		
Carex sp.			15			5	5	5			3.00	4	
Species Count	4	3	5	2	4	6	4	5	4	4	4.10		
Species Richness	4	4	7	7	8	12	13	13	14	15			
Seeded	30		15			5		1	5	40	9.60		

Table 20. Kruskal-Wallis Test *Epilobium hirsutum* % Cover Site 1

Group	N	Median	Ave Rank	Z
1P10	5	5	5.7	-2.93
1N10	6	10	13.8	-1.19
1P11	9	17	18.7	0.07
1P12	16	27.5	24.1	2.87
OVERALL	36		18.5	
	H	DF	P	
	13.12	3	0.004	
Tie Adjustment	13.18		0.004	

Table 21. Mann-Whitney Test *Epilobium hirsutum* % Cover Site 1

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
1P10 not = 1P11	19.5	40.5	5	4.5	17	0.0196	0.0194
1P10 not = 1P12	20	75	5	5	27.5	0.0044	0.0043
1N10 not = 1P12	41.5	75.5	10	20.5	27.5	0.0465	0.0458
$p \leq 0.10$							
1P10 not = 1N10	19	26	5	4	10	0.0552	0.0514

Table 22. Mann-Whitney Test *Ambrosia artemisiifolia* % Cover Sites 1 and 3

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
1P10 not = 1P11	281.5	3.5	15	91.5	2	0.0020	0.0019
3P10 not = 3PM10	220	15	30	165	5	0.0004	0.0003
3P10 not = 3P11	182	3	30	127	3	0.0001	

Table 23. Kruskal-Wallis Test *Schoenoplectus fluviatilis* % Cover Site 1

Group	N	Median	Ave Rank	Z
1N10	9	40	21.9	1.13
1P11	8	1.5	4.5	-4.26
1N11	10	50	27.4	3.14
1N12	9	35	17.6	-0.29
OVERALL	36		18.5	
	H	DF	P	
	22.29	3	< 0.0001	
Tie Adjustment	22.51			

Table 24. Mann-Whitney Test *Schoenoplectus fluviatilis* % Cover Sites 1 and 2

	W	Median1	U1	Median2	U2	P	Tie Adjustment
$p \leq 0.05$							
1N10 not = 1P11	117	40	0	1.5	72	0.0006	
1P11 not = 1N11	36	1.5	80	50	0	0.0004	
1P11 not = 1N12	36	1.5	72	35	0	0.0006	
1N11 not = 1N12	130.5	50	14.5	35	75.5	0.0143	0.0135
2N11 not = 2N12	140.5	85	14.5	2	85.5	0.0082	0.0078

Table 25. Mann-Whitney Test *Trifolium pratense* % Cover Sites 1 and 3

$p \leq 0.05$	W	U1	Median1	U2	Median2	P	Tie Adjustment
1P10 not = 1P11	432	98	22.5	222	10	0.0502	0.0489
3P10 not = 3P12	99.5	8.5	15	54.5	4	0.0172	0.0167
$p \leq 0.10$							
3P10 not = 3PM10	138.5	32.5	15	93.5	4	0.0588	0.0573
3P10 not = 3P11	130.5	31.5	15	85.5	5	0.0768	0.0751

Table 26. Planted Site 2 area in 2010, two months after planting and seeding (2P10), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P10). Analysis also included species richness and total percent cover and species count.

2P10 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	AV	FQ	IV
Abutilon theophrasti		10									1.00	1	2.3
Alisma triviale						2					0.20	1	1.4
Ambrosia artemisiifolia	35	6	20	30	45	3	2	25	10	5	18.10	10	33.1
Bidens sp.	3	5	5			2					1.50	4	6.4
Total *Carex* sp.	5	30	3	2	25	30	35	20	35	25	21.00	10	36.5
Chenopodium album					1						0.10	1	1.3
Convolvulus arvensis									2		0.20	1	1.4
Cyperus odoratus	15							2			1.70	2	4.3
Glyceria striata	2		2	1		1				1	0.70	5	6.6
Hordeum jubatum	5	4	3	6	15	2	25	10	15	8	9.30	10	22.6
Lycopus uniflorus									1		0.10	1	1.3
Lythrum salicaria						4			1		0.50	2	2.9
Oxalis corniculata								1	2		0.30	2	2.7
Panicum capillare			2						1		0.30	2	2.7
Phalaris arundinacea										1	0.10	1	1.3
Poaceae sp.	10										1.00	1	2.3
Polygonum amphibium	5										0.50	1	1.8
Polygonum lapathifolium	2		2	2	0.5	2	1	0.5		1	1.10	8	10.6
Schoenoplectus fluviatilis				3		1					0.40	2	2.8
Solanum carolinense									1		0.10	1	1.3
Symphyotrichum sp.		2						2	2		0.60	3	4.2
Trifolium pratense	3	3	10	10		65	35	20	10	10	16.60	9	30.1
Xanthium stromarium	10	10		40		8	10	6	3	3	9.00	8	20.0
TOTAL	95	70	47	94	86.5	120	108	86.5	83	54	84.40		
Species Count	11	8	8	8	5	11	6	9	12	8	8.60		
Species Richness	11	13	14	15	16	18	18	19	22	23			

Table 27. Planted Site 2 area in 2011, a year after planting and seeding (2P11), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

2P11 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	AV	FQ	IV
Agrostis stolonifera	30	35	30		30	15	25	70	40	15	29.00	9	44.3
Ambrosia artemisiifolia			2	5				3			1.00	3	5.2
Bidens sp.	10		1					2	4		1.70	4	7.4
Calystegia sepium						20					2.00	1	3.6
Total *Carex* sp.	20	3	30	30	20	2	10	10	2		12.70	9	26.3
Epilobium hirsutum										4	0.40	1	1.8
Eupatorium perfoliatum										4	0.40	1	1.8
Hordeum jubatum					2						0.20	1	1.6
Juncus tenuis		10				1				5	1.60	3	5.9
Lathyrus palustris			2								0.20	1	1.6
Linum usitatissimum	35	10		2		15			20	30	11.20	6	20.6
Oxalis corniculata						1					0.10	1	1.5
Panicum sp.						5	2				0.70	2	3.5
Polygonum amphibium	4										0.40	1	1.8
Rumex obtusifolius	3	5		2		3					1.30	4	6.9
Salsola tragus	8									5	1.30	2	4.2
Schoenoplectus fluviatilis	8								10		1.80	2	4.7
Solidago canadensis		10	20			5					3.50	3	8.0
Solidago rugosa							8				0.80	1	2.3
Symphyotrichum lanceolatum				3							0.30	1	1.7
Taraxacum officinale				2		1	15				1.80	3	6.1
Trifolium repens			5	8	25			10	25		7.30	5	14.9
Xanthium strumarium	5	5		15	40		2		30	2	9.90	7	20.5
TOTAL	123	78	100	69	117	68	62	95	131	65	90.80		
Species Count	9	7	8	9	5	10	6	5	7	7	7.30		
Species Richness	9	11	15	17	18	21	22	22	22	24			
Seeded							8			4	1.20		

Table 28. Planted Site 2 area in 2012, two years after planting and seeding (2P12), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P10). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

2P12 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	AV	FQ	IV
Agrostis stolonifera		30	5	20	35	15	30	45	10	8	19.80	9	40.2
Alisma trivale					2						0.20	1	1.8
Calystegia sepium	3			15	2						2.00	3	7.4
Carex sp.	10	10	10	8	20	15		5	3	3	8.40	9	25.3
Carex lupulina		1									0.10	1	1.7
Carex vulpinoidea							20				2.00	1	4.2
Elymus canadensis								2			0.20	1	1.8
Epilobium hirsutum	50		10	30	10	20	20	40	40	45	26.50	9	48.9
Eupatorium perfoliatum		15					5				2.00	2	5.8
Euthamia graminifolia	15		25								4.00	2	8.4
Juncus effusus										5	0.50	1	2.2
Juncus tenuis	1		1						5		0.70	3	5.7
Lactuca serriola						10					1.00	1	2.9
Lathyrus palustris	10	2	3								1.50	3	6.7
Oxalis corniculata						0.5		1	0.5		0.20	3	5.0
Plantago major										1	0.10	1	1.7
Polygonum amphibium				2							0.20	1	1.8
Salix sp.				0.5							0.05	1	1.7
Schoenoplectus fluviatilis		2									0.20	1	1.8
Solidago canadensis	2		5						2	10	1.90	4	8.8
Symphyotrichum lanceolatum						20					2.00	1	4.2
Taraxacum officinale					1		10	5	2		1.80	4	8.7
Trifolium pratense									3		0.30	1	2.0
Trifolium repens							0.5				0.05	1	1.7
Verbena hastata			8								0.80	1	2.6
TOTAL	91	60	67	75.5	70	80.5	85.5	98	65.5	72	76.50		
Carex sp.	10	11	10	8	20	15	20	5	3	3	10.50	10	
Species Count	7	6	8	6	6	6	6	6	8	6	6.50		
Species Richness	7	11	12	14	16	19	21	22	23	25			
Seeded	15	16	33				25	2		6	9.70		

Table 29. Natural wetland vegetation Site 2 area in 2010 (2N10) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

2N10 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Convolvulus arvensis				4	10						1.40	2	5.7
Epilobium hirsutum			50								5.00	1	6.9
Glyceria striata	40	35	10	20	15	20	15		5	15	17.50	9	36.2
Impatiens capensis			2		10						1.20	2	5.5
Leersia oryzoides								20			2.00	1	4.1
Lycopus americanus	2	4	8						2		1.60	4	10.2
Lythrum salicaria			3								0.30	1	2.5
Phalaris arundinacea		3									0.30	1	2.5
Polygonum amphibium								4	10	5	1.90	3	8.3
Rumex crispus	10	2									1.20	2	5.5
Schoenoplectus fluviatilis	30	35	15	50	80	55	80	90	90	95	62.00	10	80.6
Schoenoplectus pungens						1					0.10	1	2.3
Symphyotrichum sp.	10		5	25	4				5		4.90	5	15.5
Xanthium stromarium	15	5							25	15	6.00	4	14.4
TOTAL	107	84	93	99	119	76	95	114	137	130	105.40		
Species Count	6	6	7	4	5	3	2	3	6	4	4.60		
Species Richness	6	7	10	11	11	12	12	14	14	14			
Seeded								20			2.00		

Table 30. Natural wetland vegetation Site 2 area in 2011 (2N11) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

2N11 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Agrostis stolonifera	10			40	10						6.00	3.00	15.2
Calystegia sepium				4						3	0.70	2.00	7.1
Total *Carex* sp.									1		0.10	1.00	3.3
Chenopodium album		5									0.50	1.00	3.7
Equisetum sylvaticum									10		1.00	1.00	4.2
Euthamia graminifolia	15	30	15			2					6.20	4.00	18.6
Leersia oryzoides						15	80	10			10.50	3.00	19.4
Lythrum salicaria		20									2.00	1.00	5.1
Polygonum amphibium									10	3	1.30	2.00	7.7
Schoenoplectus fluviatilis	50	70	95	98	80	90	25	75	90	95	76.80	10.00	103.4
Solidago nemoralis	25										2.50	1.00	5.5
Xanthium strumarium									3	2	0.50	2.00	6.9
TOTAL	100	125	110	142	90	107	105	85	114	103	108.10		
Species Count	4	4	2	3	2	3	2	2	5	4	3.10		
Species Richness	4	6	6	7	7	8	8	8	12	12			
Seeded	15	30	15			17	80	10			16.70		

Table 31. Natural wetland vegetation Site 2 area in 2012 (2N12) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (N1-N10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

2N12 % Cover	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	AV	FQ	IV
Agrostis stolonifera									40		4.00	1.00	6.5
Calystegia sepium		15	45	40	15			20	10	1	14.60	7.00	33.2
Total *Carex* sp.				1							0.10	1.00	2.9
Epilobium hirsutum	45	60	25	40	10	35		45			26.00	7.00	43.9
Leersia oryzoides			2		20	30	50				10.20	4.00	20.7
Lysimachia cilita									1		0.10	1.00	2.9
Poacea sp.										15	1.50	1.00	4.2
Polygonum amphibum			2								0.20	1.00	3.0
Polygonum lapathifolium									0.5		0.05	1.00	2.8
Salix exigua								2			0.20	1.00	3.0
Schoenoplectus fluviatilis	65	55	50	40	40	50	30	50	30	65	47.50	10.00	72.4
Xanthium strumarium									20		2.00	1.00	4.7
TOTAL	110	130	124	121	85	115	80	117	101.5	81	106.45		
Species Count	2	3	5	4	4	3	2	4	6	3	3.60		
Species Richness	2	3	5	6	6	6	6	7	11	12			
Seeded			2		20	30	50				10.20		

Table 32. Mann-Whitney Test *Glyceria striata* % Cover Site 2

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
2P10 not = 2N10	15	45	1	0	15	0.0034	0.0030

Table 33. Kruskal-Wallis Test *Schoenoplectus fluviatilis* % Cover Site 2

Group	N	Median	Ave Rank	Z
2N10	10	67.5	15.6	0.02
2N11	10	85	20.6	2.24
2N12	10	50	10.4	-2.27
OVERALL	30		15.5	
	H	DF	P	
	6.78	2	0.034	
Tie Adjustment	6.85		0.033	

Table 34. Sedge community (SD) average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (SD1-SD10). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

SD % Cover	SD1	SD2	SD3	SD4	SD5	SD6	SD7	SD8	SD9	SD10	AV	FQ	IV
Agrostis stolonifera			1	2					3	1	0.70	4	5.8
Alisma triviale			1		5	3	10	25	10	30	8.40	7	18.8
Ambrosia artemisiifolia	3	15	5	40	35	30	20	10	10	40	20.80	10	37.6
Capsella bursa-pastoris					1						0.10	1	1.4
Total *Carex* sp.	20	60	40	15	15	10	20	10	8	10	20.80	10	37.6
Equisetum arvense				50	2	35	5	25	35	35	18.70	7	31.3
Hypericum perforatum				2	1						0.30	2	2.8
Juncus effusus	2				2						0.40	2	3.0
Oxalis corniculata				0.5			0.5			2	0.30	3	4.1
Poaceae sp.1	10		1	10	1	20	25	3	3		7.30	8	18.7
Polygonum persicaria		8	0.5	2		1		0.5		0.5	1.25	6	8.9
Populus deltoides								1	2	2	0.50	3	4.3
Potentilla norvegica	1										0.10	1	1.4
Rhynchospora sp.			1								0.10	1	1.4
Ribes americanum	3	2	3				0.5	0.5			0.90	5	7.3
Schoenoplectus fluviatilis		1									0.10	1	1.4
Solanum carolinense					2						0.20	1	1.5
Solidago hispida	1			0.5							0.15	2	2.7
Taraxacum officinale	1					1					0.20	2	2.7
Trifolium pratense	3	1		2				1		5	1.20	5	7.6
TOTAL	44	87	52.5	124	64	100	81	76	71	125.5	82.50		
Species Count	9	6	8	10	9	7	7	9	7	9	8.10		
Species Richness	9	11	14	17	19	19	19	20	20	20			
Seeded	2				2						0.40		

Table 35. Planted Site 3 area in 2010, two months after planting and seeding (3P10), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P10). Analysis also included species richness and total percent cover and species count.

3P10 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	AV	FQ	IV
Abutilon theophrasti	2										0.20	1	1.6
Ambrosia artemisiifolia	55	65	20	25	40	35	15	20	45	10	33.00	10	39.8
Total *Carex* sp.	10	2	2	25	5	4	2	1	1	1	5.30	10	18.2
Cyperus odoratus	1	15	5					2		1	2.40	5	8.9
Echinochloa crus-galli	2									2	0.40	2	3.1
Epilobium hirsutum			3	1							0.40	2	3.1
Hordeum jubatum	10	15	15	20	20	20	30	15	30	40	21.50	10	30.9
Panicum capillare										2	0.20	1	1.6
Polygonum lapathifolium	5		30		1			2			3.80	4	8.6
Trifolium pratense	10	10	25	35	3	55	20		15	5	17.80	9	26.6
Vicia tetrasperma		2	2			1		10		1	1.60	5	8.3
Xanthium stromarium	40		80	20	35	20	65	85	3	65	41.30	9	44.9
TOTAL	135	109	182	126	104	135	133	135	95	128	128.20		
Species Count	9	6	9	6	6	6	6	7	6	10	7.10		
Species Richness	9	10	11	11	11	11	12	12	12	13			

Table 36. Planted and mowed Site 3 area in 2010, two months after planting and seeding (3PM10), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (PM1-PM20). Analysis also included species richness and total percent cover and species count.

3PM10 % Cover	PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9	PM10	PM11	PM12	PM13	PM14	PM15	PM16	PM17	PM18	PM19	PM20	AV	FQ	IV
Ambrosia artemisiifolia	2	1	10	0.5	10	20		5	1		5	25	30	2	10	10	3	3	10	1	7.43	9.0	20.6
Total *Carex* sp.	25	20	35	15	25	5	2	10	1	2	3	3	1	20	2	1	0.5	3	30	70	13.68	10.0	29.2
Cirsium sp.	1																				0.05	0.5	0.7
Convolvulus arvensis	15	8																			1.15	1.0	2.7
Cyperus odoratus				2																	0.10	0.5	0.8
Equisetum sylvaticum													0.5	0.5			0.5				0.08	1.5	2.1
Hordeum jubatum	3	15	2	10	8	60	10	30	4	70			10		30	55	20	35	30	3	19.75	8.5	34.3
Lycopus virginicus		1																			0.05	0.5	0.7
Lysimachia ciliata	2																				0.10	0.5	0.8
Oxalis corniculata													0.5								0.03	0.5	0.7
Panicum capillare	2	8		5																	0.75	1.5	2.9
Phalaris arundinacea	10													1							0.55	1.0	2.0
Poaceae sp.	5										15										1.00	1.0	2.5
Polygonum lapathifolium												5				3	15	20		1	2.20	2.5	5.9
Polygonum punctatum									5												0.25	0.5	1.0
Rumex crispus	15	10		10								10		2				2		2	2.55	3.5	7.6
Solanum carolinense											10										0.50	0.5	1.2
Solidago nemoralis											15	25									2.00	1.0	3.7
Sonchus oleraceus		10																			0.50	0.5	1.2
Symphyotrichum sp.				1	1								1		1						0.20	2.0	2.9
Taraxacum officinale												2									0.10	0.5	0.8
Thatch		10	2	10	20	2	50	10	5	10	25	20	5	60	15		25	15		10	14.70	8.5	28.4
Trifolium dubium	2												2		1						0.25	1.5	2.3
Trifolium pratense		1	1		1	2		10		5	25	2	15	10			20	2	40	3	6.85	7.0	17.3
Vicia tetrasperma	5	5	5	10	5	4	2		10												2.30	4.0	8.0
Xanthium strumarium	10				30	10	25	35	25	2											6.85	3.5	12.6
TOTAL	122	90	56	63.5	101	103	90	100	51	89	98	93	65	95.5	60	71	84	80	110	90	85.60		
Species Count	14	11	6	8	8	6	5	5	6	4	6	8	8	6	6	5	6	6	4	6	6.70		
Species Richness	14	17	18	20	20	20	20	20	21	21	23	25	27	27	27	27	27	27	27	27			

Table 37. Planted Site 3 area in 2011, a year after planting and seeding (3P11), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P1-P20). Analysis also included seeded percent cover, species richness, and total percent cover and species count.

3P11 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	AV	FQ	IV
Abutilon theophrasti		2																			0.10	0.5	0.6
Agrostis stolonifera	15		5								2	10		3	10			10	5	1	3.05	4.5	7.4
Ambrosia artemisiifolia				2	3	8	5	5	3	2	1				1	20	3		2	3	2.90	6.5	9.5
Argentina anserina																2					0.10	0.5	0.6
Asclepias incarnata			2																		0.10	0.5	0.6
Bidens sp.														5							0.25	0.5	0.8
Calamagrostis canadensis									3		5		2								0.50	1.5	2.1
Calystegia sepium	25	60											5								4.50	1.5	5.2
Total *Carex* sp.	60	10	40	35	2	35	25	25	30	45	65	40	15	20	55	10	40	10	2	5	28.45	10	33.6
Convolvulus arvensis					8																0.40	0.5	0.9
Cyperus odoratus							1	2	40												2.15	1.5	3.4
Eleocharis ovata													5								0.25	0.5	0.8
Elymus canadensis									2										5		0.35	1	1.4
Epilobium hirsutum											2	1									0.15	1	1.2
Equisetum arvense																	5		1		0.30	1	1.3
Eupatorium perfoliatum	2	2	2																		0.30	1.5	1.9
Euthamia graminifolia					3	3															0.30	1	1.3
Hordeum jubatum			1			5	20	2	30	2					15	40	2	2			5.95	5	10.3
Impatiens capensis					2	1															0.15	1	1.2
Juncus tenuis				2								5									0.35	1	1.4
Lysimachia ciliata		2	3					10		2	2		10	2	2						1.65	4	5.7
Plantago major			10					2		25											1.85	1.5	3.1
Poaceae sp.																			40		2.00	0.5	2.1
Polygonum amphibium		2						3													0.25	1	1.3
Polygonum hydropiperoides							1		5												0.30	1	1.3
Polygonum lapathifolium						5															0.25	0.5	0.8
Polygonum persicaria								2								1	2		3		0.40	2	2.5
Polygonum punctatum						2															0.10	0.5	0.6
Populus deltoides			1																		0.05	0.5	0.6
Rumex obtusifolius	5			8									15		25		2				2.75	2.5	4.9
Salix pedicellaris									1												0.05	0.5	0.6
Schoenoplectus fluviatilis	2			2							6		8							10	1.40	2.5	3.9
Solanum carolinense					3	2														20	1.25	1.5	2.7
Solidago rugosa		15		5		4				20	3	5	3	5	3	3					3.30	5	8.2
Symphyotrichum lanceolatum										2											0.10	0.5	0.6
Taraxacum officinale																				10	0.50	0.5	1.0
Trifolium pratense		15	2	5	25	20	2		1		1			20	3			10	1	15	6.00	6.5	12.0
Trifolium repens	10									30		30	2			30					5.10	2.5	6.8
Verbena hastata										15	2	20									1.85	1.5	3.1
Vicia tetrasperma	8	15	5	10	45		65	25		3			5	2			15				9.90	5.5	13.9
Xanthium strumarium			60	70	80	40		15			50	45	65	60	40	20	80	85	15	5	36.50	7.5	37.1
TOTAL	127	123	131	141	171	125	119	99	115	146	139	156	135	117	154	126	149	117	74	69	126.65		
Species Count	8	9	11	10	9	11	7	11	9	10	11	8	11	8	9	8	8	5	9	8	9.00		
Species Richness	8	13	18	21	25	27	29	31	34	36	37	37	38	39	39	40	41	41	42	43			
Seeded	2	17	14	5	3	7		2	5	60	10	25	5	5	3	3			5		8.55		

Table 38. Planted Site 3 area in 2012, two years after planting and seeding (3P12), average percent cover (AV), frequency of occurrence (FQ), and Importance Value (IV) per species observed in randomly placed 1-m^2 quadrats (P112-P2012). Analysis also included seeded percent cover, species richness, and total percent cover, *Carex* species cover, and species count.

3P12 % Cover	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	AV	FQ	IV
Agrostis stolonifera	10	20	8	8		10	2	30	35	15		5	10	2	5	25	5	15		2	10.35	8.5	19.9
Ambrosia artemisiifolia	0.5		0.5												0.5			0.5		0.5	0.13	2.5	3.0
Asclepias incarnata										3				2							0.25	1	1.4
Bidens frondosa																	10				0.50	0.5	1.1
Bidens tripartita																		1			0.05	0.5	0.6
Calamagrostis canadensis	1		0.5	1										2							0.23	2	2.5
Calystegia sepium		5			5		3		2					20	3						1.90	3	5.3
Carex sp.	0.5		2	5		10									20		30				3.38	3	6.8
Carex lupulina					2	5		5			3		2		1				15	10	2.15	4	6.7
Carex lurida				15							2		2						2		1.05	2	3.3
Carex vulpinoidea					25			20		30	60		40	20			5	10	35	30	13.75	5	19.3
Cicuta bulbifera													2						0.5		0.13	1	1.3
Cirsium vulgare			2																		0.10	0.5	0.7
Epilobium hirsutum	70	35	30	30	15	50	20	2	3	3		50	2	25	15	25	10	15	20	30	22.50	9.5	33.1
Eupatorium perfoliatum				3	10	8		1						5	5	0.5	1	15			2.43	4.5	7.5
Euthamia graminifolia							45													2	2.35	1	3.5
Helianthus pauciflorus														2	15						0.85	1	2.0
Juncus tenuis																		1			0.05	0.5	0.6
Lactuca serriola		0.5													0.5						0.05	1	1.2
Lathyrus palustris	50		50	35	25	30	40	25	10		40				2	4	2				15.65	6	22.3
Linum usitatissimum												2									0.10	0.5	0.7
Lycopus americanus																			5		0.25	0.5	0.8
Lysimachia ciliata										1											0.05	0.5	0.6
Melissa officinalis		8																			0.40	0.5	1.0
Oxalis corniculata											10	3									0.65	1	1.8
Plantago major	0.5								2								15	10			1.38	2	3.6
Poacea sp.				1															5		0.30	1	1.4
Polygonum amphibium	1		3																		0.20	1	1.3
Populus deltoides			0.5																		0.03	0.5	0.6
Ranunculus pensylvanicus											2										0.10	0.5	0.7
Rumex obtusifolius									3				3					2		15	1.15	2	3.4
Schoenoplectus fluviatilis							5		15			5					2	10			1.85	2.5	4.7
Solanum carolinense							20														1.00	0.5	1.6
Solidago sp.			10		35							15									3.00	1.5	4.7
Solidago canadensis	1	15		35		20	5							2		40					5.90	3.5	9.8
Solidago nemoralis	3																				0.15	0.5	0.7
Stachys tenuifolia			20	2	8	2							1		2						1.75	3	5.1
Symphyotrichum lanceolatum								3													0.15	0.5	0.7
Taraxacum officinale														8							0.40	0.5	1.0
Trifolium pratense		5			4							5	2			1		15		2	1.70	3.5	5.7
Trifolium repens									5	15	5		5		10	2					2.10	3	5.5
Verbena hastata					3																0.15	0.5	0.7
Xanthium strumarium										1			2						0.5		0.18	1.5	1.9
TOTAL	137.5	88.5	126.5	135	132	135	140	86	75	68	122	85	71	88	79	97.5	80	94.5	83	91.5	100.75		
Carex sp.	0.5		2	20	27	15		25		30	65		44	20	21		35	10	52	40	20.33	7.5	
Species Count	10	7	11	10	10	8	8	7	8	7	7	7	11	10	12	7	9	11	8	8	8.80		
Species Richness	10	14	18	21	24	24	27	28	30	33	35	36	37	39	39	39	40	42	43	43			
Seeded	1.5	0	0.5	19	40	13	45	26	2	33	65	0	44	29	6	0.5	31	35	52	42	24.23		

Table 39. Kruskal-Wallis Test *Ambrosia artemisiifolia* % Cover Site 3

GROUP	N	Median	Ave Rank	Z
3P10	10	30	39.7	4.31
3PM10	18	5	23.1	-0.16
3P11	13	3	19.3	-1.34
3P12	5	0.5	3.5	-3.53
OVERALL	46		23.5	
	H	DF	P	
	26.97	3	< 0.0001	
Tie Adjustment	27.25			

Table 40. Kruskal-Wallis Test Total *Carex* sp. % Cover Site 3

GROUP	N	Median	Ave Rank	Z
3P10	10	2	16.9	-2.92
3PM10	20	4	25.9	-2.02
3P11	20	27.5	42.4	2.67
3P12	15	7.5	40.7	1.79
OVERALL	65		33.0	
	H	DF	P	
	17.41	3	0.001	
Tie Adjustment	17.52			

Table 41. Mann-Whitney Test Total *Carex* sp. % Cover Site 3

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
3P10 not = 3P11	76	179	2	21	27.5	0.0006	0.0005
3P10 not = 3P12	76.5	128.5	2	21.5	7.5	0.0033	0.0032
3PM10 not = 3P11	308	302	4	98	27.5	0.0060	0.0059
3PM10 not = 3P12	292	218	4	82	7.5	0.0244	0.0241

Table 42. Kruskal-Wallis Test *Vicia tetrasperma* % Cover Site 3

GROUP	N	Median	Ave Rank	Z
3P10	5	2	5.9	-2.35
3PM10	8	5	11.7	-0.40
3P11	11	10	16.1	2.29
OVERALL	24		12.5	
	H	DF	P	
	7.30	2	0.026	
Tie Adjustment	7.48		0.024	

Table 43. Mann-Whitney Test *Vicia tetrasperma* % Cover Site 3

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
3P10 not = 3P11	21.5	48.5	2	6.5	10	0.0202	0.0195
$p \leq 0.10$							
3P10 not = 3PM10	23	32	2	8	5	0.0923	0.0838

Table 44. Mann-Whitney Test *Xanthium stromarium* % Cover Site 3

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
3PM10 not = 3P11	46	87	25	18	50	0.0165	0.0164
$p \leq 0.10$							
3P10 not = 3PM10	93.5	14.5	40	48.5	25	0.0807	0.0796

Table 45. Kruskal-Wallis Test Total % Cover Site 1

Group	N	Median	Ave Rank	Z
1P10	20	95	47.1	0.31
1N10	10	128	69.5	3.09
1P11	20	114	51.4	1.15
1N11	10	95	44.6	-0.12
1P12	20	86.75	30.9	-2.82
1N12	10	92.5	36.4	-1.17
OVERALL	90		45.5	
	H	DF	P	
	17.01	5	0.004	

Table 46. Mann-Whitney Test Total % Cover All Sites

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
1P10 not = 1N10	265	145	95	55	128	0.0503	0.0502
1N10 not = 1N11	135	20	128	80	95	0.0257	
1N10 not = 1P12	239	16	128	184	86.75	0.0002	
1N10 not = 1N12	145	10	128	90	92.5	0.0028	
1P11 not = 1P12	495	115	114	285	86.75	0.0223	0.0222
2P10 not = 2N11	75	80	86.5	20	106	0.0257	
2N10 not = 2P12	146	9	103	91	73.75	0.0022	
2N11 not = 2P12	150	5	106	95	73.75	0.0008	
2P12 not = 2N12	65	90	73.75	10	112.5	0.0028	
3P10 not = 3PM10	244	11	130.5	189	90	0.0001	
3P10 not = 3P12	209	46	130.5	154	90	0.0186	0.0183
3PM10 not = 3P11	248	362	90	38	126.5	<0.0001	
3P11 not = 3P12	506	104	126.5	296	90	0.0098	
$p \leq 0.10$							
1P10 not = 1P12	479	131	95	269	86.75	0.0639	0.0637
1N10 not = 1P11	196.5	58.5	128	141.5	114	0.0713	0.0710
2P10 not = 2N10	80.5	74.5	86.5	25.5	103	0.0696	0.0694
2P10 not = 2N12	80	75	86.5	25	112.5	0.0640	0.0639

Table 47. Kruskal-Wallis Test Species Count Site 1

Group	N	Median	Ave Rank	Z
1P10	20	9	71.3	5.00
1N10	10	6.5	42.3	-0.42
1P11	20	8	55.2	1.88
1N11	10	5	29.3	-2.08
1P12	20	6	35.9	-1.86
1N12	10	4	13.2	-4.15
OVERALL	90		45.5	
	H	DF	P	
	44.18	5	< 0.0001	
Tie Adjustment	44.84			

Table 48. Mann-Whitney Test Species Count All Sites

	W	U1	Median1	U2	Median2	P	Tie Adjustment
$p \leq 0.05$							
1P10 not = 1N10	373.5	36.5	9	163.5	6.5	0.0056	0.0048
1P10 not = 1P11	508.5	101.5	9	298.5	8	0.0080	0.0070
1P10 not = 1N11	393	17	9	183	5	0.0003	0.0002
1P10 not = 1P12	580.5	29.5	9	370.5	6	< 0.0001	< 0.0001
1P10 not = 1N12	410	0	9	200	4	< 0.0001	< 0.0001
1N10 not = 1N12	143	12	6.5	88	4	0.0046	0.0038
1P11 not = 1N11	368	42	8	158	5	0.0114	0.0107
1P11 not = 1P12	514.5	95.5	8	304.5	6	0.0049	0.0042
1P11 not = 1N12	405.5	4.5	8	195.5	4	< 0.0001	< 0.0001
1P12 not = 1N12	382.5	27.5	6	172.5	4	0.0015	0.0012
2P10 not = 2N10	148	7	8	93	4.5	0.0013	0.0012
2P10 not = 2N11	154.5	0.5	8	99.5	3	0.0002	
2P10 not = 2P12	135.5	19.5	8	80.5	6	0.0233	0.0187
2P10 not = 2N12	153	2	8	98	3.5	0.0003	
2N10 not = 2P11	68	87	4.5	13	7	0.0058	0.0053
2N10 not = 2P12	75	80	4.5	20	6	0.0257	0.0191
2P11 not = 2N11	154	1	7	99	3	0.0002	
2P11 not = 2N12	151.5	3.5	7	96.5	3.5	0.0005	
2N11 not = 2P12	55.5	99.5	3	0.5	6	0.0002	
2P12 not = 2N12	150.5	4.5	6	95.5	3.5	0.0007	0.0005
3P10 not = 3P11	97.5	157.5	6	42.5	9	0.0122	0.0107
3PM10 not = 3P11	278	332	6	68	9	0.0004	0.0003
3PM10 not = 3P12	310	300	6	100	8	0.0071	0.0062
$p \leq 0.10$							
2N10 not = 2N11	131.5	23.5	4.5	76.5	3	0.0494	0.0447
3P10 not = 3P12	116	139	6	61	8	0.0903	0.0841

Table 49. Kruskal-Wallis Test Total % Cover Site 2

Group	N	Median	Ave Rank	Z
2P10	10	86.5	23.4	-1.40
2N10	10	103	37.9	1.46
2P11	10	86.5	26.7	-0.75
2N11	10	106	40.5	1.97
2P12	10	73.75	15.2	-3.04
2N12	10	112.5	39.4	1.77
OVERALL	60		30.5	
	H	DF	P	
	17.44	5	0.004	
Tie Adjustment	17.45			

Table 50. Kruskal-Wallis Test Species Count Site 2

Group	N	Median	Ave Rank	Z
2P10	10	8	49.4	3.74
2N10	10	4.5	23.9	-1.30
2P11	10	7	43.6	2.61
2N11	10	3	11.9	-3.68
2P12	10	6	38.3	1.55
2N12	10	3.5	15.8	-2.92
OVERALL	60		30.5	
	H	DF	P	
	39.09	5	< 0.0001	
Tie Adjustment	39.77			

Table 51. Kruskal-Wallis Test Total % Cover Site 3

Group	N	Median	Ave Rank	Z
3P10	10	130.5	49.6	2.37
3PM10	20	90	20.6	-3.87
3P11	20	126.5	48.5	3.38
3P12	20	90	30.3	-1.35
OVERALL	70		35.5	
	H	DF	P	
	24.94	3	< 0.0001	
Tie Adjustment	24.96			

Table 52. Kruskal-Wallis Test Species Count Site 3

Group	N	Median	Ave Rank	Z
3P10	10	6	28.4	-1.20
3PM10	20	6	22.6	-3.34
3P11	20	9	48.0	3.26
3P12	20	8	39.4	1.01
OVERALL	70		35.3	
	H	DF	P	
	17.54	3	0.001	
Tie Adjustment	18.04		$0.0001 < p < 0.001$	

Table 53. Remnant sedge/grass meadow associates that occurred in study site samples but were not planted or sown.

	Study Sites
Agrostis stolonifera	All Sites
Alisma triviale	All Sites
Argentina anserina	Site 3
Bidens tripartita	Sites 1 and 3
Bromus ciliatus	Site 1
Cicuta bulbifera	Sites 1 and 3
Cornus sericea	Site 1
Cyperus odoratus	All Sites
Eleocharis intermedia	Site 1
Eleocharis ovata	Sites 1 and 3
Equisetum arvense	Site 1 and 3
Equisetum sylvaticum	All Sites
Geum rivale	Site 1
Glyceria striata	Sites 1 and 2
Impatiens capensis	All Sites
Juncus canadensis	Site 1
Lathyrus palustris	Sites 2 and 3
Lycopus americanus	Sites 1 and 2
Lycopus uniflorus	Site 2
Lycopus virginicus	Sites 1 and 3
Lysimachia ciliata	Sites 1 and 3
Polygonum amphibium	All Sites
Polygonum hydropiperoides	Sites 2 and 3
Polygonum lapathifolium	All Sites
Polygonum persicaria	Sites 1 and 3
Polygonum punctatum	Site 3
Potentilla norvegica	Site 3
Ranunculus pensylvanicus	Site 3
Rudbeckia hirta	Site 3
Salix exigua	Site 2
Salix pedicellaris	Site 3
Schoenoplectus fluviatilis	All Sites
Schoenoplectus pungens	Sites 1 and 2
Schoenoplectus tabernaemontani	Site 1
Stachys tenuifolia	Site 3
Teucrium canadense	Site 1
Typha latifolia	Site 1
Vernonia noveboracensis	Site 1

Table 54. Potentially problematic species that occurred in study site samples

	Study Sites
Abutilon theophrasti	All Sites
Ambrosia artemisiifolia	All Sites
Barbarea vulgaris	Site 1
Calystegia sepium	All Sites
Capsella bursa-pastoris	Site 3
Chenopodium album	Site 2
Cirsium vulgare	All Sites
Convolvulus arvensis	All Sites
Daucus carota	Site 1
Echinochloa crus-galli	Site 3
Epilobium hirsutum	All Sites
Fraxinus pennsylvanica	Site 1
Hypericum perforatum	Sites 1 and 3
Juncus tenuis	All Sites
Lactuca serriola	Site 1
Lythrum salicaria	All Sites
Melissa officinalis	Sites 1 and 3
Panicum capillare	All Sites
Phalaris arundinacea	Sites 2 and 3
Populus deltoides	All Sites
Ranunculus abortivus	Site 1
Ribes americanum	Site 3
Rumex acetosella	Site 1
Rumex crispus	All Sites
Setaria faberi	Sites 1 and 3
Solidago canadensis	All Sites
Symphyotrichum lanceolatum	All Sites
Tanacetum vulgare	Site 2
Taraxacum officinale	All Sites
Toxicodendron radicans	Site 1
Trifolium arvense	Site 1
Trifolium pratense	All Sites
Trifolium repens	All Sites
Typha ×glauca	Site 1
Vicia tetrasperma	Site 3
Xanthium strumarium	All Sites

Table 55. Species that occurred in reference (including seed-bank emergence study soil samples – GH) and study site samples. Importance Values are stated for Kents Creek (K IV) while mean cover by combined transects (ABC) for individual species in 420 quadrats are stated for (Regional) drowned river-mouth wetlands (Wilcox *et al*. 2005b). The sampled A (75.60 m), B (75.45 m), and C (75.35 m) transects had last been flooded 5 to 30 y prior to sampling.

Species	GH Occurrence	K IV	A, B, C Mean Cover	Established Communities
Agrostis stolonifera	-	2.1	-	All Sites
Ambrosia artemisiifolia	All Sites	-	-	All Sites
Bidens tripartita	All Sites	-	-	Sites 1 and 3
Calamagrostis canadensis	Site 3	58.2	6.97	All Sites
Calystegia sepium	-	-	0.45	All Sites
Carex vulpinoidea	-	-	0.05	Site 1
Cornus sericea	-	-	7.71	Site 1
Epilobium hirsutum	-	-	0.01	All Sites
Equisetum arvense	-	-	1.09	Sites 1 and 3
Equisetum sylvaticum	-	-	1.06	All Sites
Hordeum jubatum	All Sites	-	-	All Sites
Hypericum perforatum	-	-	0.09	Sites 1 and 3
Impatiens capensis	-	19.0	8.80	All Sites
Juncus effusus	-	-	0.05	Sites 1 and 3
Lactuca serriola	Site 1	-	-	Site 1
Lathyrus palustris	-	15.8	0.11	Sites 2 and 3
Lycopus americanus	-	-	0.06	Sites 1 and 2
Lysimachia ciliata	-	-	0.79	Sites 1 and 3
Plantago major	All Sites	-	0.001	Sites 1 and 3
Polygonum amphibium	-	2.1	0.21	All Sites
Polygonum lapathifolium	All Sites	-	-	All Sites
Ranunculus abortivus	All Sites	-	0.004	Site 1
Ribes americanum	-	-	0.01	Site 3
Rumex crispus	-	-	0.06	All Sites
Salsola tragus	All Sites	-	-	Sites 1 and 2
Solidago canadensis	-	-	1.3	All Sites
Stachys tenuifolia	-	-	0.08	Site 3
Taraxacum officinale	-	-	0.15	All Sites
Teucrium canadense	-	-	0.27	Site 1
Toxicodendron radicans	-	-	0.77	Site 1
Trifolium pratense	Sites 1 and 3	-	-	All Sites
Trifolium repens	-	-	0.03	All Sites
Verbena hastata	Site 3	10.0	0.01	Sites 1 and 3
Vernonia noveboracensis	Site 1	-	-	Site 1
Xanthium strumarium	-	-	0.12	All Sites