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Year 2015 Results and Final Analysis of Trends Following Five Years of Vegetation Monitoring in 20 Constructed Bioswales Along Interstate 294,Touhy Avenue to Lake-Cook Road, Cook County, IL

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INTRODUCTION

A vegetation monitoring program was established in 2011 in a series of 20 constructed wetlands termed bioswales along approximately an 11-mile section of Interstate 294 (I-294) in northern Cook County, Illinois, from Touhy Avenue to Lake-Cook Road (Figure 1). The principal goals of the monitoring are to document and assess vegetation trends in the bioswales according to performance standards. Specifically, selected invasive species (Table 1) are not to be among the five most dominant species based on vegetative cover in individual bioswales. In addition to determining invasive species abundance patterns, native and non-native species density and richness and indices of floristic quality also have been tracked as performance measures and total species inventories have been conducted during June and September for each year of the monitoring period.

Bioswale installation and planting was completed in 2010 with four designs. Bioswale Types 1 and 2 are wet swale designs, incorporating check dams, planted with seeds and plugs. They differ in planting design with Type 1 seeded with Bioswale Seed Mixtures 1 and 2 and Bioswale Type 2 seeded with Seed Mixture Type 2. Both types were augmented with live-plant plugs. Types 3 and 4 are dry swales. Type 4 differs in having an 8 inch-diameter under-drain pipe. Both are seeded with a Native Grass Seed Mixture. All bioswales are buffered with a Native Slope Seed Mixture (consisting of a mix of native and non-native species) and also were seeded with non-native grasses as a cover crop. Species composition in bioswale seed mixtures, cover crops, slope plantings, and plugs were listed in a previous report (Taft et al. 2012). Some bioswales were constructed with a combination of bioswale types. Bioswale type and total length also previously were summarized (Taft et al. 2012). Annual monitoring results from 2011-2014 previously have been described (Taft et al. 2012, 2013, 2014, 2015).

2015 Study Objectives - This report documents the vegetation parameters relevant to the performance standards in bioswales from sample data collected in June and September 2015, the final year of monitoring. Species composition, diversity (based on species richness and species density), percent cover, and floristic quality from 2015 sample data are described and compared to previous sample data. Vegetation trends from the 2011 baseline are examined and a comparison is made between the baseline and 2015 final sample data.

METHODS

Sample Design – Vegetation in bioswales was surveyed with quadrats for quantitative sampling and also with general species inventories. The surveyed vegetation was limited to the bioswale and did not include the planted slopes. In places, species planted on the side slopes have become established in the bioswales, presumably due to seeds sloughing down slope. Consequently, the distinction between slope and bioswale was not always clear and best judgment was used to identify the bioswale boundaries.

Each bioswale was sampled with a total of five 1-m^2 (1 m x 1 m) quadrats evenly stratified across each unit. Distance between samples and the coordinates for each sample were listed previously (Taft et al. 2012). Where the sample plots fell on concrete structures (e.g., check dams), the location was adjusted typically 3-5 m to the north or south depending on proximity to the nearest representative swale position. Because of the need for management including mowing, and in anticipation of scouring flood events, no permanent markers were used to mark sample locations. Each plot was placed in the center of the bioswale and geo-referenced with an Ashtech MobileMapper 100 handheld GPS receiver.

Data collected from each vegetation sample quadrat includes species presence and percent cover for individual species estimated with a modified Daubenmire cover-class scale (0<1 %, 1<5%, 5<25%, 25<50%, 50<75%, 75<95%, 95-100%). All species rooted within quadrat frames were recorded; percent bare ground, including open-water zones, also was estimated in each quadrat using the same scale. In addition to these quantitative samples, a total inventory of vascular plant species was recorded in each bioswale. Vegetation monitoring and surveys during 2015 were conducted in June (June 9-12) and repeated in September (September 9-11).

Vegetation and Statistical Analysis - Species abundance is measured by frequency, percent cover, and importance value (IV 200). IV 200 was calculated as the sum of relative frequency and relative cover. Calculated vegetation parameters include native and non-native species density (number of species in each quadrat), richness (total species in the five sample quadrats at each bioswale), percent cover, and metrics used in Floristic Quality Assessment (FQA). FQA indices include Mean Coefficient of Conservatism and the Floristic Quality Index (Taft et al.

1997). Mean wetness coefficients based on Reed (1988) also were examined for species recorded in sample plots.

Among the data properties for many means-comparison statistical tests is central normal tendency (normal distribution). Normality for bioswale sample data was determined with the Shapiro-Wilk test. Attempts to transform non-normal data by various methods (e.g., log10, log normal, and square-root adjustments) typically were unsuccessful, including most of the time-series data. For data meeting expectations for parametric statistical tests, mean comparisons between sample periods (all five years from 2011-2015) for June and September sample data were made with repeated measures analysis of variance (RM-ANOVA). Comparisons between wet and dry swales (Planting Types 1 and 2 vs. 3 and 4) were made with two-sample t-tests. Comparison between the baseline (2012) and final sample (2015) were made with paired t-tests. For data failing to meet normality expectations, the Friedman's test (a non-parametric alternative to RM-ANOVA) was applied for repeated measures (Chi-square statistic), the Mann-Whitney U was applied for two sample tests, and the Wilcoxon test was applied for paired samples. Results from both parametric and non-parametric tests are shown for non-normal data sets. Contrary results (e.g., significant with parametric test, insignificant non-parametric test) were infrequent and usually observed for marginally significant outcomes; for non-normal data, the non-parametric result is given priority in interpretation. Tests were carried out with SPSS statistical software (IBM SPSS Statistics ver. 23.0 2014). Data are characterized at two levels of organization: bioswale and bioswale type. The vegetation parameters follow Whittaker (1975) and Taft et al. (2006) and were calculated as follows:

Ground Layer Vegetation Diversity Measures

Native Species Density: Mean number of native species/quadrat (1 m^2)

Non-Native Species Density: Mean number of non-native species/quadrat (1 m^2)

Native Species Richness: Total number of native species

Non-native Species Richness: Total number of non-native species

Ground Layer Structure

Percent Cover: Sum of the average cover for each species in sample area

Percent Bare Ground: Average estimate of bare ground for each quadrat

Floristic Quality Assessment

Mean Coefficient of Conservatism (Mean C): Σ CC/S, where CC = Coefficient of Conservatism and S = total species richness

Floristic Quality Index (FQI): Mean C (√N) where N = native species richness

Mean C_N and **FQI_N** are calculated using only native species

Wetness Coefficients

Mean Coefficient of Wetness: Σ WC, where WC = Wetness Coefficient for each species was determined from the national list of wetland species (Reed 1988). Wetness rankings for Illinois species are included in Taft et al. (1997). Wetness coefficients are on an 11-point scale and range from 5 (upland) to -5 (obligate wetland species). Species ranked with 0 are facultative.

Botanical nomenclature primarily follows Mohlenbrock (1986). For consistency, the same nomenclature has been used throughout this study. Updated nomenclature (Mohlenbrock 2014) corresponding to species names utilized in the report is included in Appendix 2. Non-native species in the report will be indicated with an asterisk (*).

RESULTS AND DISCUSSION

2015 Summary - Combined Overall Results from 20 Bioswales

June Sample Data – One hundred and three vascular plant species were recorded in quadrat samples in the 20 bioswales (total of 100 1-m^2 quadrats), including 55 native and 48 non-native species (Table 2). Compared to 2014 data, richness of native species increased 25% from 44 and non-native species increased 26% from 38 species (Taft et al. 2015). Vegetative cover was 82.5% and bare ground was estimated to be 39.4% (Table 2). Compared to June 2014, vegetative cover increased from 63.4% and bare ground decreased from 43.8%. The five most dominant species, in descending rank order of importance (sum of relative frequency and cover), were *Scirpus fluviatilis, Solidago sempervirens**, *Dipsacus laciniatus**, *Festuca arundinacea**, and *Bromus inermis** accounting for 52% of the total cover and 40.2% of the total importance and for all species (Appendix 1). *Cirsium arvense** ranks sixth in total importance and *Scirpus*

acutus, a native sedge formerly among the top ranking species dropped to 7th rank with a slight decline in frequency although a slight increase in percent cover.

Two of the top six ranking species, *Dipsacus laciniatus** and *Cirsium arvense**, are among the invasive taxa identified in the performance criteria (Table 1) as plants that should not be dominant. Since June 2014, *Dipsacus laciniatus** increased from 8% to 22% frequency and 0.24% to 7.4% cover and *Cirsium arvense** increased from 11% to 19% frequency and from 3% to 5.6% cover. Both of these species appear to have been targets for control efforts in the bioswales. However, a meta-analysis of invasive species control efforts indicates that secondary invasions including noxious plants often follow targeted removal of invasive species, in part due to insufficient competition from native species (Pearson et al. 2016). It appears that targeted control efforts for invasive species such as *C. arvense** and *D. laciniatus**, without compensating additional efforts to establish native species, may be contributing towards the observed trends favoring invasive species.

September Sample Data – Eighty-six vascular plant species were recorded in quadrat samples in the 20 bioswales, including 43 native and 43 non-native species (Table 2). Compared to September 2014 sample data, native species number was unchanged and non-native species increased from 36 (Taft et al. 2015). Estimates for percent vegetative cover and bare ground were 73.8% and 40.9%, respectively (Table 2). Non-native cover (42%) exceeded native cover (31.8%) by 24%. Compared to 2014, vegetative cover decreased from 94.5% and bare ground increased from 22.8%. The five most dominant species were *Scirpus fluviatilis, Dipsacus laciniatus*, Typha angustifolia*, Solidago sempervirens*,* and *Scirpus acutus* accounting for about 58% of the cover and 45.4% of the total importance for all species (Appendix 1). Compared to the June 2015 sample, *Cirsium arvense** declined from 19% to 10% frequency. However, some bioswales were mowed just prior to September sampling possibly contributing in the observed difference.

In general, compared to 2014 samples, during June vegetative cover and richness of both native and non-native species increased while during September total vegetative cover declined and the only change in species richness was an increase in non-native species. June differences in vegetative cover appear inversely correlated with total precipitation: during April-June 2014 total

rainfall in Des Plains, IL was 15.4 inches while during the same period in 2015 total precipitation was 12 inches. July-September rainfall in 2014 totaled 10.2 inches compared to 9.1 inch during 2015. One emerging pattern is that invasive species of concern have become among the dominant species. All vegetative trends are examined in greater detail in the following sections.

Species Changes Between June and September 2015 Sample Periods –Species decreasing the greatest in frequency (by >5 occurrences out of a total of 100 quadrats) between the June and September 2015 sample periods were *Agropyron repens**, *Scirpus tabernaemontani*, *Cirsium arvense**, *Daucus carota**, *Lactuca canadensis*, *Festuca arundinacea**, *Bromus japonicus**, and *Alliaria petiolata**. Species increasing the greatest were *Aster subulatus**, *Echinochloa muricata*, *Setaria glauca**, *Cirsium vulgare**, and *Typha angustifolia** (Table 3). Some changes likely are attributable to seasonality of growth with cool season species declining between June and September and warm-season species increasing. However, some bioswales were mowed prior to the September samples possibly contributing to some observed differences. For example, the apparent September decline in abundance of *Cirsium arvense**, a species without basal leaves, may be attributable to inability to detect plants after intensive mowing. In contrast, *Cirsium vulgare**, another regulated noxious thistle and one of the increasing species, has distinctive basal leaves and is recognizable after mowing.

Bioswales that were mowed at least in part include BS #5, 6, 12, 15, 18, and 19. Some of these had large populations of *Dipsacus laciniatus** and mowing may have been an effort at control for this species. However, viable seed can be produced within 30 days after flowering and can remain viable for three years with peak periods of emergence in April and October (Bentivegna and Smeda 2011). Furthermore, mowing flowering heads of *D. laciniatus** is known to nevertheless result in the production of viable seed on cut stems (Solecki 1989) as well as contribute to seed dispersal (Bentivegna and Smeda 2011). Post-emergence herbicides can be effective at temporary control, but repeated treatments are needed to outlast the seed bank. However, as previously noted such affected areas can be prone to secondary invasions, particularly when the cover of native vegetation is too limited to provide competition against invading species (Pearson et al. 2016). For more effective control of teasel, a combination approach involving host-specific herbicides and supplemental planting of desirable native species is needed.

Mean Species Richness, % Cover, and Floristic Quality – 2015 Results

June Sample Data (five 1-m^2 plots/bioswale) – Mean bioswale species density was 5.39 ±0.74 (standard error) including 2.17 ±0.25 native and 3.22 ±0.63 non-native species (Table 2). There was a maximum species density of 13.7 at BS #13 where non-native species were predominant, similar to other dry bioswales (Figure 2A). Total species richness ranged from a minimum of 5 (BS #1 and 3) to 36 (BS #12); native species richness varied from a minimum of 3 (BS #11) to 23 (BS #12) (Figure 3A). Percent native species ranged widely from 15%-80% with 9 of 20 bioswales supporting less than 50% native richness (Figure 3C). Bioswales with native species greater than 50% cover mostly were low diversity units (generally, 10 or fewer total species). Bioswales with the lowest totals for native species density and richness primarily are of the dry swale design (Type 3 and 4). Average species density in 1-m^2 sample plots and total richness in bioswales are highly correlated ($r = 0.93$, $df = 18$, $P < 0.0001$ [using native species, $r = 0.90$, $df = 18$, $P = < 0.0001$]).

Overall mean vegetative cover ranged widely from about 27% (BS #10) to 145% (BS #6) (Figure 4A). Half (N = 10) of the bioswales exceeded 50% cover of native species; seven of the remaining bioswales with low native cover are of the dry and dry/wet swale designs (Figure 4C). Cover of species from plug or bioswale seed mix sources (Figure 5A) was predominant at some, primarily wet-design bioswales (BS # 1, 2, 3, 8, 19, 20, and 21); species included in slope/grass seed mixes were of greater predominance at other, primarily dry-design bioswales (BS #6, 11, 13, and 14); adventive (unplanted) species were common at many sites, primarily among dry and dry/wet-design swales (BS #5, 6, 7, 11, 12, 13, 14, 15, 17, and 18).

Average FQA indices are summarized in Table 2. Mean Coefficient of Conservatism (Mean C) was 1.67 (Mean $C_N = 2.38$), a decline from 2014, and the Floristic Quality Index was 2.5 ($FQI_N = 3.39$), similar to 2014. Among bioswales, Mean C ranged from ≤ 0.07 (BS #6 and 11) to 3.3 (BS #1) and FQI ranged from 0.09 (BS #6) to 4.6 (BS #1); 18 of 20 bioswales had Mean C below 3.0 and 15 of 20 bioswales had FQI below 4.0; dry swale designs have the lowest FQA scores and hybrid wet/dry bioswales tend to be intermediate in FQA scores between wet and dry swale designs (Figure 6A).

September Sample Data (five 1-m^2 plots/bioswale) – Average species density was 4.58 ±0.42

including 1.90 ±0.22 native and 2.68 ±0.39 non-native species (Table 2) and ranged from 1.8 (BS #3) to 8.4 (BS #14). Non-native species were prominent in several bioswales; mean non-native species density was equal or greater than native in 11 of 20 bioswales (Figure 2B). Mean native species richness was 6.15 ±0.66 (Table 2) and ranged from 0 to 13; mean non-native species richness was 7.85 ±1.0 and ranged from 1 to 16 (Figure 3B). Percent native species richness was greater than or equal to non-native species in 9 of the 20 bioswales (Figure 3D). Average species density in 1-m^2 sample plots and total richness for all quadrats in each bioswale are highly correlated ($r = 0.94$, $df = 18$, $P < 0.00001$ [based on native species, $r = 0.86$, $df = 18$, $P < 0.0001$]).

Cover ranged widely (Figure 4B) from about 35% (BS #3) to 112% (BS #14). Non-native species comprised greater than 50% of the cover in 10 of 20 bioswales, particularly in dry swales (Figure 4D). Native species are particularly common at BS #1-3, 8, 9, 16, and 19-21, predominately wet swale designs (Figure 4D [a short section of BS 19 is of the dry design]). Similar to the June sample data, species planted as plugs and in bioswale seed mixes dominated some sites (BS #1-3, 8, 19-21), species planted in slope/grass seed mixes are prominent in others (BS #5, 6, 13, 14), and adventive species (taxa not included in the plantings) were dominant at several others including BS #5-7, 10-18 (Figure 5B).

The FQA indices based on total species composition declined slightly from the June sample data (Table 2). Mean Coefficient of Conservatism (Mean C) was 1.56 ±0.24 (Mean C_N = 2.54 ±0.3) and the mean Floristic Quality Index (FQI) was 2.36 ±0.38 (FQI_N = 3.45 ±0.48). Mean C ranged from 0.0 to 3.4 and FQI ranged from 0.0 to 5.5 in BS #6 and BS #1, respectively. Most (14 of 20) bioswales had Mean C less than 2.5 and FQI less than 4.0; dry swale designs have the lowest FQA scores and hybrid wet/dry bioswales are intermediate in FQA scores between wet and dry swale designs (Figure 6B).

Mean Differences Between Wet and Dry Swale Designs

Comparisons were made between wet swale designs (Bioswale Types 1 and 2 combined) and dry swale designs (Types 3 and 4 combined) for parameters of species density, percent cover and bare ground, floristic quality, and wetness. With the exception of June native species density and June total percent cover (the latter marginally different), significant differences were detected for all variables in both June and September (Table 4). Native species density was

higher in wet swales than dry swales and non-native species density was greater in dry compared to wet swales. Percent cover was greater in dry compared to wet swales; bare ground (including open-water) was greater in wet swales compared to dry swales. Mean C and FQI were much greater in wet swales compared to dry swales. As expected, wetness is greater in wet compared to dry swales.

Dominant Species from Plot Sample Data

June Sample Data - Based on relative cover, 32 different species (72% non-native) were among the top-five ranking dominants for any one bioswale. The top-five ranking dominants comprise an average of 90.1% of the total vegetative cover (ranging from 65% to 100%) in the June sample data (Table 5). The dominant species found most frequently (≥ 30% of bioswales) were *Bromus inermis**, *Scirpus acutus, Scirpus fluviatilis, Solidago sempervirens**, and *Typha angustifolia** (Table 5).

Five particularly invasive species (from Table 1) were among dominant species in bioswales: *Cirsium arvense** (BS #5, 11, 13, 19), *Dipsacus laciniatus** (BS #7, 11-14), *Melilotus* spp.* (BS #14), *Phragmites australis** (BS #1, 5, 16), and *Poa pratensis** (BS #11, 14, 18, 19) (Table 5). According to performance standards (Illinois Tollway 2007), these species should not rank in the top five most-abundant species in the vegetative cover. During June 2015, an invasive species ranked among top 5 dominants at 10 of the 20 bioswales, an increase from 7 bioswales in 2014. Multiple invasive species are dominants at BS #5, 11, 13, 14, and 19. *Cirsium arvense* is wind dispersed while the other species can be water, wind, or gravity dispersed; *Phragmites australis* is capable of extensive vegetative spread. All of these species are quite common in the landscape of northeastern Illinois and have wide range of moisture tolerance.

September Sample Data - Based on relative cover, 39 different taxa (54% non-native) were recorded among the top-five ranking dominants for each bioswale. Sum relative cover for the five species among each bioswale averages 89.9%, ranging from 61% to 100% vegetative cover in the September sample data (Table 6). The dominant species found most frequently (≥ 30% of sites) were *Bromus inermis**, *Dipsacus laciniatus**, *Festuca arundinacea**, *Poa pratensis**, *Scirpus acutus, Scirpus fluviatilis, Solidago sempervirens**, and *Typha angustifolia** (Table 6).

Six taxa considered invasive species (Table 1) were among the top-ranking taxa in bioswales during September 2015: *Cirsium arvense** (BS # 6 and 12), *Cirsium vulgare** (BS # 11), *Coronilla varia** (BS # 6), *Dipsacus laciniatus** (35% of sites: BS #5-7, 11-14), *Phragmites australis* (BS #1, 5, 14, 16), and *Poa pratensis** (BS #11, 14, 15, 18, 19, 20) (Table 6). During September 2015, an invasive species ranked among top 5 dominants at 13 of the 20 bioswales, an increase from 2014 when the total was 50% of sites. Multiple invasive species were among top-ranking taxa at five sites (BS #5, 6, 11, 12, 14).

Total Species Inventory

Combining data from June and September, a total of 232 vascular plant taxa were recorded in quantitative and general surveys (Appendix 2), an increase from 207 in 2014. Total richness recorded from comprehensive inventories in each bioswale averaged 59.5 but ranged widely from 25 (BS #9) to 99 (BS #20) (Figure 7A). Similar to 2014, non-native species equaled or exceeded native species at 11 of 20 bioswales. Most species in each bioswale were adventive and not among species included in planting seed mixes or plugs (Figure 7B).

Total richness from quadrat sample data in each bioswale was a modest-to-good predictor for total richness from general inventories for both June and September, respectively ($r = 0.50$, $df = 18$, $P = 0.03$ and $r = 0.71$, $df = 18$, $P < 0.001$); however, correlations between total species richness and mean species density were less strong. Total richness was only significantly correlated to mean species density in September ($r = 0.53$, $P = 0.026$).

Bioswale Differences from 2011 to 2015

Overall Trends

For June bioswale inventory results, there was a decline in overall mean species richness from about 47 in 2011 to 34 in 2012 with little change to 2015 (Figure 8a). Similarly, total richness recorded in September initially declined from 47 species; however, since 2014 there has been a gradual increase to 43 species recorded in 2015 (Figure 8b). Changes in proportions of cover according to bioswale planting mixes and adventive species (species not included in planting mixes) from sample data show gradual shifts and the patterns differ between June and September (Figure 9). June sample data indicate that initially species from the slope/grass seed mix and cover crop mix were dominant; however, both these planting types have declined.

Cover crop species were absent by 2013 while species from the slope/grass seed mix have gradually declined from 49% to 13% relative cover. Species from the combined plug/bioswale seed mixes increased to 2013 and since have declined. Most prominent of changes have been among adventive species which increased from 13% relative cover in 2011 to 57% in 2015. September trends of relative cover among planting types also show a decline in Cover Crop species; however, in contrast to June sample data the remaining planting mixes and total adventive species are relatively little changed (Figure 9).

Mean Parameters from Sample Data (1-m^2 plot sample data from 20 bioswales)

Results from means comparisons (e.g., RM-ANOVA) for June and September sample data from 2011 to 2015 for parameters of species richness, species density, percent cover and bare ground, floristic quality, and wetness are in Table 7. For native and non-native species richness there have been mostly minor changes since the baseline sample (Figures 10A, 10B). June native richness increased slightly in 2015 and June non-native species richness has been declining until a 2015 increase; September non-native richness has been increasing steadily. Only the June differences for non-native species richness are significant based on the Friedman's (nonparametric) test results (Table 7). Native species density during June has been variable (Figure 10C) and the changes are significant with difference found primarily between the 2011 baseline and 2012 (Table 7). June non-native species density declined until a 2015 increase (Figure 10 D) and the differences are significant (Table 7).

Differences in June percent cover of native and non-native species have been pronounced. Percent June native cover increased dramatically from the baseline, and then declined until a modest 2015 increase (Figure 11A); June non-native cover has declined until a 2015 increase (Figure 11B) and the differences for both trends are highly significant (Table 7). September percent cover for both native and non-native species has been less dynamic with no clear trends (Figure 11A, 11B); only the differences for native cover are significant. Percent bare ground in June and September has varied annually with no clear trend; however the year-to-year time differences are significant.

Floristic quality as measured with the Mean Coefficient of Conservatism and Floristic Quality Index have shown parallel changes during June and September characterized by modest increase followed by decline with 2015 sample data returning to near the baseline levels (Figure

12A, 12B); the overall trends are not significant (Table 7). Initially, September sample data scored slightly higher than June; by 2015, June sample data scores slightly higher than September (Figure 12A, 12B). Degree of wetness represented in the species composition has been unchanged during June samples but has declined (become drier) during September samples with the major differences between the 2011 baseline and all subsequent samples (Table 7).

Differences in Species Abundance

From June 2011 to June 2015, major decreasing species (change in frequency ≥ 10 percent) were *Puccinellia distans*, Lolium multiflorum*, Lolium perenne*, Taraxacum officinale**, *Trifolium hybridum**, *Carex pseudo-cyperus**, and *Scirpus tabernaemontani*. Major increasing species (change in frequency ≥ 10 percent) during the same period have been *Scirpus fluviatilis, Dipsacus laciniatus*, Solidago sempervirens**, *Cirsium arvense**, *Scirpus acutus, Poa pratensis*, Typha angustifolia**, *Bromus inermis**, *Artemisia vulgaris**, and *Lactuca canadensis* (Table 8). Although *Scirpus fluviatilis* is one of the increasing species and in 2015 the most dominant species overall, during the September 2015 many colonies appeared to be declining in vigor or dead, either from disease or applications of herbicides. From September 2011 to September 2015, major decreasing species (change in frequency ≥ 10 percent) were *Scirpus tabernaemontani, Echinochloa crus-galli*, Puccinellia distans*,* and *Lolium multiflorum**. Major increasing species have been *Solidago sempervirens**, *Scirpus acutus*, *Bromus inermis**, *Dipsacus laciniatus**, *Typha angustifolia**, and *Poa pratensis** (Table 9).

Bioswale Design Types – Within-Subjects Differences (2011 – 2015)

Since the 2011 baseline sample, the four bioswale types (2 wet swale and 2 dry swale designs) differ in the degree of change among parameters of species density, percent cover, floristic quality, and wetness (Table 10). Bioswale Type 1, a wet swale design and the most common (61% of sample plots), had the greatest degree of between-year changes with significant differences detected for native species density, June non-native species density, percent cover, percent bare ground, and June wetness. Difference in June Mean C and FQI were only detected with the RM-ANOVA test result; however, the Friedman test result of no difference should take priority since the data did not meet the expectation of central normal tendency (Table 10). In general, similar to overall trends for all sample plots, most parameters (e.g., species density,

percent cover and bare ground) have been variable but without clear trends. Trends for some parameters resulted in a return to approximately baseline conditions. For example, in paired statistical tests between the 2011 baseline and 2015 sample data (Table 11), only four of 14 parameters were discernably different. Significant differences in Type 1 bioswales were limited to September non-native species density (increased from 1.15 to 1.7 species), June percent cover and bare ground (increased and decreased, respectively), and September wetness (significantly drier based on species composition). Type 2 bioswales (10% of plots) have been little changed since the baseline sample. June total percent cover and September percent bare ground demonstrated significant year-to-year fluctuations (Table 10); however, there were no paired differences between baseline and final 2015 samples (Table 11).

Bioswale Type 3, a dry swale design (22% of plots), also was relatively unchanged. Significant year-to-year time differences were detected for non-native species density in both June and September, September percent cover and bare ground, and June wetness (Table 10). However, only the decrease in June wetness was significant; a difference in September non-native species density was marginally significant with the Wilcoxon paired samples test (Table 11). Bioswale Type 4, also a dry swale design (7% of plots), demonstrated time differences for non-native species density (both samples), and September Mean C (Table 10). However, only the difference in September wetness (dryness increased) was significant in paired baseline and 2015 comparisons (Table 11).

SUMMARY CONCLUSIONS

In 2015, there was greater native species density, richness, and percent cover in the June sample compared to the September sample (reverse from 2014) and wet swales had greater native and lesser non-native species compared to dry swales. Dominant species in June and September sample data (among top-five ranking species in both samples) were *Scirpus fluviatilis, Solidago sempervirens**, and *Dipsacus laciniatus**. Invasive species were among the top-5 dominant species in June and/or September in 13 of 20 (65%) bioswales. Species include *Cirsium arvense**, *Cirsium vulgare**, *Coronilla varia**, *Dipsacus laciniatus**, *Melilotus* spp.*, *Phragmites australis,* and *Poa pratensis**. Areas targeted for control efforts of invasive species populations can be prone to secondary invasion (Pearson et al. 2016). To limit secondary invasions, invasive species control efforts should be followed by efforts to establish native

species.

Trends since the 2011 baseline sample indicate a gradual increase in total species richness in June and September total species inventories since an initial decline from the 2011 baseline to 2012. However, quantitative sample data indicate few lasting change in native species richness and density since the baseline sample. There have been between-year changes for several parameters, but in many cases the 2015 results are statistically indistinguishable from the 2011 baseline. Percent cover has been relatively dynamic with increases and decreases but no clear trends. Year 2 of monitoring (2012) had the greatest total native percent cover. There has been a steady decline in June non-native cover until 2015 while September cover of non-native species has been variable with no clear trend. Floristic quality has been variable with some planting types and more stable in others. In general, overall Mean C and FQI initially were greater in September compared to June; however, by 2015 the reverse was true. In general the results from FQA are suggestive of low floristic integrity which corresponds to habitat quality. Overall mean wetness, according to species composition, has declined (become drier) but only the difference for September is significant; June data have returned to approximate the baseline wetness. Wet swale Type 1 has been the most dynamic of the bioswale designs with changes among many parameters characterized primarily by non-linear trends of increase followed by decline (for species richness and percent cover variables) and a decline followed by increase in percent bare ground.

Wet swales have greater native species density and lower non-native species density compared to dry swales while dry swales have greater cover and lower bare ground compared to wet swales. Floristic quality is greater among wet swales than dry swales. Wetness is much greater among wet swales than dry swales and the differences are greater in June than in September.

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Table 1. List of invasive species that should not be among the five most abundant species in bioswales based on relative vegetative cover (Illinois Toll Highway Authority 2007). *indicates non-native species.

Scientific Name	Common Name
Acer negundo	Box Elder
*Alliaria petiolata**	Garlic Mustard
Ambrosia spp.	Ragweed
Cirsium spp.*	Non-Native Thistle
*Coronilla varia**	Crown Vetch
Dipsacus spp.*	Teasel
Lonicera spp.*	Honeysuckle
*Lythrum salicaria**	Purple Loosestrife
Melilotus spp.*	Sweet Clover
*Pastinaca sativa**	Wild Parsnip
*Phalaris arundinacea**	Reed Canary Grass
Phragmites australis	Common Reed
*Poa pratensis**	Kentucky Bluegrass
Rhamnus spp.*	Buckthorn
*Rosa multiflora**	Multiflora Rose
Salix interior	Sandbar Willow

Table 2. Summary data from June and September 2015 sample periods for (A) overall (100 sample quadrats [1-m^2]) and (B) means from all 20 bioswales. Bioswales along I-294, Cook County, IL. SE = standard error.

(A) Overall (N = 100 plots)	**June**		**September**	
	Mean	**SE**	**Mean**	**SE**
Native species richness	55		43	
Non-native species richness	48		43	
Total species richness	103		86	
% Vegetative cover (native)	33.16	3.62	31.79	3.69
% Vegetative cover (non-native)	49.37	5.44	42.04	4.37
% Vegetative cover (total)	82.53	4.72	73.84	4.16
% Bare ground	39.41	2.77	40.89	2.99

(B) Bioswale Means (N = 20)	**June**		**September**	
	Mean	**SE**	**Mean**	**SE**
Species Density (native)	2.17	0.25	1.90	0.22
Species Density (non-native)	3.22	0.63	2.68	0.39
Total Species Density	5.39	0.74	4.58	0.42
Species Richness (native)	7.60	1.14	6.15	0.66
Species Richness (non-native)	9.30	1.66	7.85	1.10
% Cover (native)	33.16	5.88	31.79	5.57
% Cover (non-native)	49.37	9.96	42.04	6.30
% Cover (total)	82.53	7.10	73.83	4.98
% Bare Ground (unvegetated)	39.41	4.51	40.89	4.59
Mean C_N	2.38	0.28	2.54	0.30
Mean C	1.67	0.23	1.56	0.24
FQI_N	3.39	0.38	3.45	0.48
FQI	2.50	0.33	2.36	0.38
Wetness	-1.66	0.58	-1.54	0.63

Table 3. Differences in frequency of occurrence out of 100 quadrat samples in bioswales between June and September 2015 samples showing only species changing by 3 or more occurrences. Bioswales located along I-294 in northern Cook County, IL. *Non-native species.

Declining Species	Change in Frequency	Increasing Species	Change in Frequency
*Agropyron repens**	-10	*Aster subulatus**	14
Scirpus tabernaemontani	-10	*Echinochloa muricata*	9
*Cirsium arvense**	-9	*Setaria glauca**	9
*Daucus carota**	-9	*Cirsium vulgare**	6
Lactuca canadensis	-9	*Typha angustifolia**	6
*Festuca arundinacea**	-8	*Polygonum persicaria**	5
*Bromus japonicus**	-8	*Scirpus acutus*	5
*Alliaria petiolata**	-6	*Sonchus arvensis* var. *glabrescens**	5
Ambrosia artemisiifolia	-5	*Oxalis dillenii*	3
*Capsella bursa-pastoris**	-5	*Peltandra virginica*	3
Polygonum pensylvanicum	-5	*Rumex altissimus*	3
*Taraxacum officinale**	-5	*Scirpus paludosus*	3
*Thlaspi arvense**	-5		
*Lactuca serriola**	-5		
*Melilotus alba/officinalis**	-4		
Aster pilosus	-4		
Carex stipata	-4		
Verbena hastata	-4		
*Artemisia vulgaris**	-3		
Conyza canadensis	-3		
*Poa compressa**	-3		
*Poa pratensis**	-3		
*Puccinellia distans**	-3		
*Solidago sempervirens**	-3		
*Trifolium hybridum**	-3		

Table 4. Results from two-sample t-tests for comparison of year 2015 means between wet swales (bioswale design types 1 and 2) and dry swales (bioswale design types 3 and 4). Samples are quadrat data (N = 100) from 20 bioswales along I-294 in northern Cook County, Illinois. Significant differences are shown in **bold**. Due to lack of central normal tendency with most parameters for both groups, the non-parametric Mann-Whitney U means comparison test was applied where needed.

PARAMETERS	Wet Swales (N = 71)	SE	Dry Swales (N = 29)	SE	t stat	df	*P*	Mann-Whitney U	*P*
Bioswale Species Density									
Native Spp. Density - June	2.30	±0.19	1.86	±0.44	1.06	98.0	0.291	1,290.5	**0.043**
Native Spp. Density - Sept.	2.27	±0.18	1.00	±0.25	3.91	98.0	**<0.001**	489.5	**<0.001**
Non-Native Spp. Density -	1.56	±0.26	7.28	±0.65	-8.16	37.5	**<0.001**	139.5	**<0.001**
Non-Native Spp. Density -	1.75	±0.22	4.97	±0.44	-7.24	42.8	**<0.001**	1,775.0	**<0.001**
% Cover & % Bare Ground									
Cover - June	70.20	±4.94	112.71	±8.74	-4.46	98.0	**<0.001**	526.0	**<0.001**
Cover - Sept.	68.68	±4.44	86.48	±9.07	-1.97	98.0	0.052	1,227.0	0.134
Bare Ground - June	48.22	±3.04	17.83	±3.72	5.71	98.0	**<0.001**	1,695.0	**<0.001**
Bare Ground - Sept.	46.38	±3.51	27.45	±4.97	2.98	98.0	**0.004**	642.0	**0.003**
Floristic Quality Assessment									
Mean C - June	2.21	±0.17	0.23	±0.06	11.03	85.8	**<0.001**	1,837.5	**<0.001**
Mean C - September	2.05	±0.16	0.25	±0.07	10.06	90.3	**<0.001**	266.5	**<0.001**
FQI - June	3.34	±0.26	0.44	±0.15	9.51	97.2	**<0.001**	1,801.5	**<0.001**
FQI - September	3.20	±0.28	0.33	±.09	9.90	82.3	**<0.001**	266.0	**<0.001**
Wetness									
June	-3.47	±0.25	2.30	±0.25	-16.44	77.3	**<0.001**	58.0	**<0.001**
September	-3.44	±0.26	2.63	±0.28	-13.78	96.0	**<0.001**	1,933.5	**<0.001**

Table 5. Data from June 2015 bioswale samples for 1-m^2 samples (5 recorded at each bioswale) showing five (or more, depending on ties) top-ranking dominant species based on relative vegetative cover and the proportion of total cover comprised by these species. Bioswales located along I-294 in Cook County, IL. *Non-native species. Taxa shown in red are regarded as highly invasive species.

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.
*Agropyron repens**												10.0									5
*Agrostis alba**																8.2					5
Alisma plantago-aquatica																				0.2	5
Apocynum sibiricum					5.2																5
*Artemisia vulgaris**				12.0		15.6															10
Aster simplex					5.2																5
*Bromus commutatus**																	31.6				5
*Bromus inermis**				10.1							21.2	13.8		3.6			33.5	9.9			30
*Bromus japonicus**					45.8									29.3			6.9				15
Carex sp. [sterile]																	5.6				5
*Cirsium arvense**				12.0						46.5		17.6						4.0			20
*Daucus carota**														13.0							5
*Dipsacus laciniatus**						16.2				25.5	6.9	11.0	12.4								25
*Festuca arundinacea**						8.4				18.9			47.3	3.6		6.6					25
*Juncus compressus**															16.1	11.5					10
Lactuca canadensis										2.2											5
*Lactuca serriola**											7.1										5
*Leucanthemum vulgare**					6.0																5
*Melilotus alba/officinalis**													4.4								5
*Phragmites australis**	12.4			24.1											19.2						15
*Poa compressa**													4.3								5
*Poa pratensis**										2.6			4.3				13.9	4.0			20
*Puccinellia distans**		0.3						6.5												0.2	15
Sagittaria latifolia																			6.6	1.1	10
Sagittaria sp.									13.3												5
Scirpus acutus	11.0	0.3	16.6				9.2				6.9				13.8			20.5	6.8	18.8	45
Scirpus americanus		0.3	3.3				15.3														15
Scirpus fluviatilis	66.3	86.9	66.0		19.4	8.4	43.1	59.5			6.9				30.7			58.8	57.3	66.3	60
Scirpus paludosus								13.0													5
Scirpus tabernaemontanii		8.6	0.1				8.7	1.5											6.6		25
*Solanum dulcamara**									11.1												5
Solidago canadensis											6.9										5
*Solidago sempervirens**		3.7		24.2		8.4		17.5	11.1		16.3		10.4	23.5	13.3	21.9			6.8		55
*Taraxacum officinale**					11.2																5
*Thlaspi arvense**												12.8									5
*Typha angustifolia**	7.4		13.9			13.0	18.8		13.3					7.5		35.6			13.1	13.4	45
Typha latifolia	3.0								46.1												10
Verbena hastata										2.2	6.9										10
Sum Relative Cover	100.0	100.0	100.0	82.4	92.7	70.1	95.1	98.1	94.8	98.0	79.0	65.2	83.1	80.4	93.1	83.9	91.4	97.1	97.2	100.0	90.1

Table 6. Data from September 2015 bioswale samples for 1-m^2 samples (5 recorded at each bioswale) showing five top-ranking dominant species based on relative vegetative cover and the proportion of total cover comprised by these species. Bioswales located along I-294 in Cook County, IL. *Non-native species. Taxa shown in red are regarded as highly invasive.

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.
Alisma plantago-aquatica								1.2													5
*Artemisia vulgaris**				5.5	1.1	34.0															15
Aster drummondii											5.8										5
*Aster subulatus**		8.7						1.4	4.2							18.1					20
*Atriplex patula**																			3.4		5
*Bromus inermis**				20.9	23.8					2.1		13.5					22.2	7.6			30
Carex vulpinoidea											14.6										5
*Chenopodium album**											5.8										5
*Cirsium arvense**					5.4						5.8										10
*Cirsium vulgare**										16.3											5
*Coronilla varia**					1.1																5
*Daucus carota**														5.3							5
*Dipsacus laciniatus**				18.8	68.1	22.5				71.8	7.0	13.7	20.6								35
Echinochloa muricata															8.9						5
Elymus virginicus						17.0															5
Eupatorium serotinum											5.8										5
*Festuca arundinacea**				13.4						7.0	17.5	10.5	23.9	6.2							30
*Juncus compressus**															13.6	7.9					10
Lactuca canadensis																	8.1				5
*Lactuca serriola**																		3.0			5
Lemna minor	0.1																				5
Peltandra virginica	0.1																		3.4		10
*Phragmites australis**	10.7			5.5									10.0		13.6						20
*Poa pratensis**										1.4			7.8	26.7			20.3	12.7	3.4		30
Polygonum pensylvanicum		0.1																			5
*Polygonum persicaria**																			3.4		5
*Puccinellia distans**		0.1																			5
Ranunculus sceleratus	0.1							1.2												0.2	15
Sagittaria latifolia		26.3																	9.3	4.5	15
Scirpus acutus	6.1		29.8			3.0	0.8	6.3						42.2	10.1			33.0	8.7	23.5	50
Scirpus americanus			8.5				21.4												3.4		15
Scirpus fluviatilis	67.8	59.7	8.8			4.2	50.4	35.6	4.7						25.7	6.3		40.6	44.2	55.8	60
Scirpus paludosus			8.8			0.6	0.8	8.3												0.2	25
Scirpus tabernaemontani							0.1														5
*Setaria glauca**						0.6					5.8	10.6									15
Solidago altissima											5.8										5
*Solidago sempervirens**	0.1			18.8	0.5	10.5	17.0	12.3	9.9		15.8		13.2	6.2		11.7	20.3				60
Sonchus arvensis var. *glabrescens**									7.9			12.5					8.1				15
*Typha angustifolia**	14.9	5.1	44.0			7.5	9.5	33.6	59.1							34.3			12.7	15.8	50
Totals	100.0	100.0	100.0	83.0	100.0	100.0	100.0	99.8	85.8	98.6	90.1	60.7	75.4	86.6	71.9	78.4	79.1	97.0	92.0	100.0	89.9

Table 7. Repeated Measures Analysis of Variance (RM-ANOVA) comparisons of means from 2011-2015 bioswale sample data (sample size = 5 quadrats [each 1-m^2]/bioswale, N = 20 bioswales) for parameters of species richness, species density, percent cover, Floristic Quality Assessment, and wetness. Significant differences ($P < 0.05$) are shown in bold. Pairwise (between-year) significant differences are indicated by different superscript letters following standard error (SE).

PARAMETERS	2011 SE	2012 SE	2013 SE	2014 SE	2015 SE	$F_{(df)}$	*P*	Chi-square[1]	*P*
Bioswale Species Richness (five quadrats - 1-m^2)									
Native Spp. Richness - June	6.05 ±1.00	6.45 ±0.57	6.00 ±0.71	5.45 ±0.72	7.60 ±1.14	2.17 (4, 76)	0.080	7.41	0.116
Native Spp. Richness - Sept.	5.55 ±0.59	5.70 ±0.60	5.65 ±0.54	5.85 ±0.62	6.15 ±0.66	0.30 (4, 76)	0.779	3.21	0.523
Non-Native Spp. Rich. - June	8.95 ±1.39	9.25 ±1.31	8.20 ±1.46	7.60 ±1.33	9.30 ±1.66	2.26 (4, 76)	0.071	10.76	**0.029**
Non-Native Spp. Rich. - Sept.	6.00 ±1.04	5.85 ±0.88	6.10 ±0.86	7.15 ±1.19	7.85 ±1.10	2.25 (2.77, 52.6)	0.098		
Bioswale Species Density (mean richness/1-m^2)									
Native Spp. Density - June	1.76 ±0.30[a]	2.40 ±0.23[b]	1.98 ±0.21[ab]	1.65 ±0.17[a]	2.17 ±0.25[a]	3.72 (2.39, 45.3)	**0.025**	13.56	**0.009**
Native Spp. Density - Sept.	1.92 ±0.22	2.04 ±0.20	1.90 ±0.19	1.75 ±0.17	1.90 ±0.22	0.74 (4, 76)	0.566		
Non-Native Spp. Density - June	3.52 ±0.63[a]	3.15 ±0.49[a]	2.58 ±0.49[b]	2.63 ±0.53[b]	3.22 ±0.63[a]	4.74 (4, 76)	**0.002**	19.63	**0.001**
Non-Native Spp. Density - Sept	1.91 ±0.33[ab]	2.02 ±0.33[ab]	1.93 ±0.30[a]	2.53 ±0.48[bc]	2.68 ±0.39[c]	3.25 (2.38, 45.2)	0.040	7.20	0.126
% Cover and BG (avg. quad. cover [n = five 1-m^2])									
Native Species Cover - June	10.98 ±2.38[a]	51.76 ±8.81[b]	42.41 ±8.16[b]	26.21 ±5.03[c]	33.16 ±5.88[c]	15.92 (4, 76)	**<0.001**	27.92	**<0.001**
Native Species Cover - Sept.	44.46 ±6.96[ab]	50.60 ±6.63[a]	34.50 ±4.48[b]	40.78 ±6.32[ab]	31.79 ±5.57[b]	3.52 (4, 76)	**0.011**		
Non-Native Spp. Cover - June	63.42 ±10.46[a]	54.19 ±8.53[ab]	43.42 ±9.08[c]	36.96 ±8.27[c]	49.37 ±9.96[b]	8.66 (4, 76)	**<0.001**	23.65	**<0.001**
Non-Native Spp. Cover - Sept.	35.55 ±6.90	40.17 ±8.60	35.30 ±7.59	53.70 ±10.75	42.04 ±6.30	2.77 (2.63, 49.3)	0.058	8.72	0.068
Total Cover - June	74.40 ±10.21[ac]	106.26 ±7.88[b]	86.01 ±6.77[a]	63.40 ±7.11[c]	82.53 ±7.10[c]	7.05 (4, 76)	**<0.001**		
Total Cover - Sept	80.00 ±8.39[ab]	90.77 ±4.11[a]	70.18 ±5.66[b]	94.49 ±8.19[a]	73.84 ±4.98[b]	3.36 (2.43, 46.1)	**0.035**		
Bare Ground - June	47.52 ±6.87[a]	27.94 ±4.78[b]	38.68 ±4.19[a]	43.79 ±5.56[a]	39.41 ±4.51[a]	3.97 (2.97, 56.4)	**0.013**	13.89	**0.008**
Bare Ground - Sept.	41.42 ±4.99[a]	28.46 ±4.27[bc]	34.00 ±5.62[ab]	22.82 ±4.57[c]	40.89 ±4.59[a]	4.92 (4, 76)	**0.001**	9.67	**0.046**
Floristic Quality Assessment									
Mean C - June	1.39 ±0.23	1.77 ±0.25	1.77 ±0.25	1.86 ±0.28	1.68 ±0.24	2.83 (2.3, 43.7)	0.063		
Mean C - September	1.71 ±0.24	1.95 ±0.26	1.86 ±0.24	1.64 ±0.23	1.56 ±0.24	1.92 (2.22, 42.2)	0.155		
FQI - June	2.19 ±0.37	2.98 ±0.40	2.73 ±0.41	2.50 ±0.38	2.50 ±0.33	2.40 (2.16, 41.0)	0.100		
FQI - September	2.70 ±0.39	3.07 ±0.43	2.79 ±0.37	2.40 ±0.36	2.37 ±0.38	2.52 (2.22, 42.1)	0.087		
Wetness									
June	-1.71 ±0.61	-1.25 ±0.62	-1.50 ±0.59	-1.69 ±0.63	-1.62 ±0.61	0.13 (1.06, 19.11)	0.734		
September	-2.70 ±0.56[a]	-2.21 ±0.59[b]	-2.18 ±0.55[b]	-2.11 ±0.56[b]	-1.82 ±0.60[b]	5.30 (2.50, 44.9)	**0.005**		

[1] Friedman's test statistic for non-normal data that could not be successfully transformed.

Table 8. Differences in frequency of occurrence and percent cover out of 100 quadrat samples in bioswales between June 2011 and 2015 samples showing only species changing by 3 or more occurrences. Bioswales located along I-294 in northern Cook County, IL. *Non-native species.

Decreasing Species	Freq. - June 2011	Freq. - June 2015	Chg. Freq.	% Cover - June 2011	% Cover - June 2015	Chg. % Cover
*Puccinellia distans**	47	5	-42	17.21	0.17	-17.04
*Lolium multiflorum**	35	0	-35	21.39	0.00	-21.39
*Lolium perenne**	28	0	-28	5.70	0.00	-5.70
*Taraxacum officinale**	27	9	-18	0.50	0.12	-0.38
*Trifolium hybridum**	19	3	-16	3.45	0.19	-3.26
Carex pseudo-cyperus	11	1	-10	0.76	0.03	-0.73
Scirpus tabernaemontani	27	17	-10	3.93	1.08	-2.85
*Abutilon theophrasti**	7	1	-6	0.04	0.01	-0.03
*Echinochloa crus-galli**	6	0	-6	0.20	0.00	-0.20
Sagittaria sp. (sterile)	10	4	-6	0.13	0.19	0.07
*Festuca duriuscula**	5	0	-5	1.78	0.00	-1.78
Peltandra virginica	5	0	-5	0.03	0.00	-0.03
Ranunculus abortivus	5	0	-5	0.03	0.00	-0.03
*Juncus compressus**	10	5	-5	0.13	1.08	0.96
Carex vulpinoidea	4	0	-4	0.12	0.00	-0.12
Sagittaria latifolia	7	4	-3	0.23	0.22	-0.02
Cephalanthus occidentalis	3	0	-3	0.02	0.00	-0.02
Dicot seeding	3	0	-3	0.01	0.00	-0.02
Plantago rugelii	3	0	-3	0.04	0.00	-0.04
*Thlaspi perfoliatum**	3	0	-3	0.39	0.00	-0.39
*Medicago lupulina**	4	1	-3	0.17	0.03	-0.14
*Chenopodium album**	5	2	-3	0.03	0.04	0.01

Increasing Species	Freq. - June 2011	Freq. - June 2015	Chg. Freq.	% Cover - June 2011	% Cover - June 2015	Chg. % Cover
Scirpus fluviatilis	18	40	22	1.28	18.36	17.08
*Dipsacus laciniatus**	2	22	20	0.04	7.36	7.32
*Solidago sempervirens**	22	40	18	0.62	6.65	6.03
*Cirsium arvense**	3	19	16	0.02	5.59	5.58
Scirpus acutus	6	22	16	0.40	4.56	4.16
*Poa pratensis**	1	15	14	0.03	1.79	1.76
*Typha angustifolia**	2	16	14	1.23	5.29	4.07
*Bromus inermis**	11	22	11	0.45	5.45	5.01
*Artemisia vulgaris**	1	11	10	0.01	2.21	2.20
Lactuca canadensis	1	11	10	0.01	0.33	0.32
*Bromus japonicus**	0	8	8	0.00	1.85	1.85
*Agropyron repens**	8	14	6	0.24	0.83	0.59

*Alliaria petiolata**	0	6	6	0.00	0.06	0.06
Polygonum sp.	0	5	5	0.00	0.05	0.05
Conyza canadensis	0	4	4	0.00	0.07	0.07
Scirpus americanus	0	4	4	0.00	0.79	0.79
*Thlaspi arvense**	1	5	4	0.01	0.67	0.67
Phragmites australis	2	6	4	0.53	2.66	2.13
*Lactuca serriola**	8	12	4	0.12	0.83	0.71
*Convolvulus arvensis**	0	3	3	0.00	0.21	0.21
Lemna minor	0	3	3	0.00	0.02	0.02
*Poa compressa**	0	3	3	0.00	0.21	0.21
Polygonum pensylvanicum	0	3	3	0.00	0.07	0.07
Aster pilosus	1	4	3	0.01	0.02	0.02
Solidago canadensis	1	4	3	0.01	0.42	0.41

Table 9. Differences in frequency of occurrence and percent cover out of 100 quadrat samples in bioswales between September 2011 and 2015 samples showing only species changing by 3 or more occurrences. Bioswales located along I-294 in northern Cook County, IL. *Non-native species.

Decreasing Species	% Freq. - Sept. 2011	% Freq. - Sept. 2015	Chg. % Freq.	% Cover - Sept. 2011	% Cover - Sept. 2015	Chg. % Cover
Scirpus tabernaemontani	43	7	-36	12.44	0.11	-12.33
*Echinochloa crus-galli**	27	1	-26	8.92	0.01	-8.92
*Puccinellia distans**	20	2	-18	4.00	0.16	-3.84
*Lolium multiflorum**	12	0	-12	4.64	0.00	-4.64
*Setaria faberi**	7	2	-5	1.12	0.06	-1.06
*Lolium perenne**	5	0	-5	0.22	0.00	-0.22
*Taraxacum officinale**	9	4	-5	0.61	0.17	-0.45
*Trifolium hybridum**	5	0	-5	0.22	0.00	-0.22
*Carex pseudo-cyperus**	7	3	-4	1.46	0.04	-1.42
Elymus canadensis	5	1	-4	0.08	0.01	-0.07
Ambrosia artemisiifolia	7	4	-3	1.96	0.34	-1.63
*Abutilon theophrasti**	3	0	-3	0.16	0.00	-0.16
Cephalanthus occidentalis	3	0	-3	0.09	0.00	-0.09
Eupatorium maculatum	3	0	-3	0.19	0.00	-0.19
Sagittaria brevirostra	3	0	-3	0.56	0.00	-0.56

Increasing Species	% Freq. - June 2011	% Freq. - June 2015	Chg. Freq.	% Cover - June 2011	% Cover - June 2015	Chg. % Cover
*Solidago sempervirens**	9	37	28	1.35	5.23	3.88
Scirpus acutus	6	27	21	0.37	5.71	5.34
*Bromus inermis**	2	21	19	0.18	3.24	3.06
*Dipsacus laciniatus**	5	23	18	0.87	8.67	7.81
Typha angustifolia	5	22	17	1.57	8.04	6.48
*Poa pratensis**	0	12	12	0.00	2.48	2.48
Echinochloa muricata	0	9	9	0.00	0.78	0.78
*Festuca arundinacea**	12	20	8	3.15	3.26	0.12
*Artemisia vulgaris**	1	8	7	0.38	1.93	1.55
*Cirsium vulgare**	1	8	7	0.02	0.75	0.73
*Cirsium arvense**	5	10	5	0.39	0.68	0.29
*Agropyron repens**	0	4	4	0.00	0.34	0.34
*Polygonum persicaria**	1	5	4	0.03	0.37	0.34
*Sonchus arvensis**	1	5	4	0.15	1.11	0.96
Eupatorium serotinum	0	3	3	0.00	0.56	0.56
*Juncus compressus**	1	4	3	0.03	1.06	1.03
Polygonum pensylvanicum	0	3	3	0.00	0.04	0.04
Rumex altissimus	0	3	3	0.00	0.02	0.02
Sagittaria latifolia	6	9	3	1.93	1.52	-0.41
Scirpus americanus	0	3	3	0.00	1.15	1.15

Table 10. Repeated Measures Analysis of Variance (RM-ANOVA) comparisons of means from 2011-2015 bioswale (BS) types for parameters of species richness, species density, percent cover, Floristic Quality Assessment, and wetness. Significant differences (P < 0.05) are shown in bold (unless counter to Friedman test results for non-normal data). Pairwise (between-year) significant differences are indicated by different superscript letters following SE. Planting types are: 1 = Wet Swale Design (BS Mix Type 1 & 2), 2 = Wet Swale Design (BS Mix Type 2), 3 = Dry Swale Design (Native Grass Mix), 4 = Dry Swale Design (Native Grass Mix. w/ Underdrain).

	BIOSWALE TYPE 1 (N = 61)								
PARAMETERS	**2011** SE	**2012** SE	**2013** SE	**2014** SE	**2015** SE	$F_{(df)}$	***P***	Chi-square[1]	***P***
Species Density/1-m^2									
Native Spp. Density - June	1.87 ±0.26^{ac}	2.70 ±0.20^{b}	2.08 ±0.18^{ac}	1.80 ±0.15^{a}	2.25 ±0.20^{c}	$5.53_{(3.4, 205.6)}$	**0.001**	26.13	**< 0.0001**
Native Spp. Density - Sept.	2.23 ±0.19^{ab}	2.48 ±0.17^{a}	2.02 ±0.15^{b}	1.93 ±0.15^{b}	2.11 ±0.17^{ab}	$2.43_{(4, 240)}$	**0.048**	11.31	**0.023**
Non-Native Spp. Density - June	1.90 ±0.33^{a}	2.08 ±0.33^{a}	1.36 ±0.29^{bc}	1.26 ±0.23^{b}	1.54 ±0.29^{ac}	$5.60_{(3.4, 202.3)}$	**0.001**	23.65	**< 0.0001**
Non-Native Spp. Density - Sept.	1.15 ±0.19	1.31 ±0.20	1.18 ±0.19	1.33 ±0.21	1.71 ±0.23	$2.23_{(3.32, 199.2)}$	0.080	9.02	0.061
% Cover and Bare Ground									
Total Cover - June	50.30 ±7.27^{a}	105.16 ±6.97^{b}	69.76 ±5.86^{c}	51.92 ±5.01^{a}	72.75 ±5.40^{c}	$21.95_{(3.3, 199.2)}$	**< 0.001**	53.40	**< 0.0001**
Total Cover - Sept	76.84 ±6.99^{ab}	84.89 ±4.36^{a}	60.16 ±5.14^{c}	76.03 ±4.85^{ab}	65.79 ±4.64^{bc}	$4.25_{(3.21, 192.3)}$	**0.005**	14.37	**0.006**
Bare Ground - June	62.53 ±4.66^{a}	32.13 ±4.05^{b}	47.79 ±4.29^{cf}	55.21 ±4.03^{ac}	47.40 ±3.26^{d}	$13.79_{(3.4, 201.6)}$	**< 0.0001**	40.11	**< 0.0001**
Bare Ground - Sept.	47.89 ±4.66^{a}	33.02 ±4.19^{b}	44.79 ±4.53^{a}	32.40 ±4.01^{b}	46.56 ±3.87	$4.25_{(4, 240)}$	**0.002**	15.32	**0.004**
Floristic Quality Assessment									
Mean C - June	1.74 ±0.21^{ac}	2.31 ±0.20^{bc}	2.27 ±0.18^{bc}	2.50 ±0.20^{b}	2.18 ±0.19^{c}	$3.54_{(3.2, 190.9)}$	**0.014**	4.42	0.352
Mean C - September	2.26 ±0.18	2.37 ±0.18	2.40 ±0.20	2.14 ±0.17	2.06 ±0.18	$1.10_{(2.97, 178.3)}$	0.352	0.25	0.993
FQI - June	2.77 ±0.36^{a}	3.86 ±0.34^{b}	3.46 ±0.30^{ab}	3.30 ±0.25^{ab}	3.25 ±0.28^{a}	$2.58_{(3.29, 197.5)}$	**0.049**	7.29	0.121
FQI - September	3.62 ±0.32	3.89 ±0.32	3.49 ±0.29	3.08 ±0.26	3.15 ±0.31	$2.09_{(3.29, 197.1)}$	0.097	5.18	0.269
Wetness									
June	-3.29 ±0.34^{ac}	-2.84 ±0.37^{b}	-2.85 ±0.38^{ab}	-3.44 ±0.33^{c}	-3.23 ±0.34^{c}	$3.45_{(3.3, 142.6)}$	**0.015**	11.75	**0.019**
September	-4.13 ±0.21	-3.89 ±0.21	-3.80 ±0.22	-3.83 ±0.24	-3.65 ±0.28	$1.93_{(3.35, 171.1)}$	0.119	7.16	0.128

	BIOSWALE TYPE 2 (N = 10)								
PARAMETERS	**2011** SE	**2012** SE	**2013** SE	**2014** SE	**2015** SE	$F_{(df)}$	***P***	Chi-square[1]	***P***
Species Density/1-m^2									
Native Spp. Density - June	2.80 ±0.57^{ab}	3.70 ±0.40^{b}	2.30 ±0.30^{a}	1.80 ±0.33^{a}	2.60 ±0.60^{a}	$2.24_{(4, 36)}$	0.083	7.80	0.099
Native Spp. Density - Sept.	2.50 ±0.37	2.50 ±0.27	3.00 ±0.52	2.10 ±0.35	3.20 ±0.71	$1.28_{(4, 36)}$	0.296		
Non-Native Spp. Density - June	2.00 ±0.54	2.40 ±0.76	1.30 ±0.62	1.20 ±0.39	1.70 ±0.63	$1.91_{(4, 36)}$	0.130		
Non-Native Spp. Density - Sept.	1.80 ±0.47	1.60 ±0.34	1.40 ±0.31	1.60 ±0.52	2.00 ±0.72	$0.34_{(1.85, 16.7)}$	0.704	0.90	0.924
% Cover and Bare Ground									
Total Cover - June	90.65 ±21.25^{ab}	133.95 ±20.86^{a}	102.60 ±10.89^{a}	47.60 ±13.41^{b}	54.65 ±11.42^{b}	$5.26_{(4, 36)}$	**0.002**		
Total Cover - Sept	101.00 ±17.66	86.35 ±11.01	73.30 ±8.18	91.15 ±11.04	86.30 ±13.17	$0.57_{(4, 36)}$	0.683		

Bare Ground - June	39.25 ±13.41	25.20 ±9.35	29.80 ±5.52	53.50 ±9.32	53.25 ±8.67	$2.06_{(1.7, 15.7)}$	0.164	5.67	0.225
Bare Ground - Sept.	23.70 ±8.37	34.15 ±11.56	13.90 ±4.46	20.00 ±7.95	45.30 ±8.54	$2.18_{(4, 36)}$	0.091	11.20	**0.024**
Floristic Quality Assessment									
Mean C - June	2.80 ±0.45	2.53 ±0.32	2.89 ±0.46	2.72 ±0.45	2.41 ±0.42	$0.75_{(4, 36)}$	0.563		
Mean C - September	2.17 ±0.38	2.37 ±0.24	2.24 ±0.42	2.20 ±0.44	2.01 ±0.36	$0.20_{(4, 36)}$	0.939		
FQI - June	4.23 ±0.67	4.64 ±0.47	4.59 ±0.86	3.91 ±0.84	3.84 ±0.76	$0.65_{(4, 36)}$	0.629		
FQI - September	3.55 ±0.72	3.77 ±0.57	4.14 ±0.85	3.51 ±0.84	3.50 ±0.65	$0.30_{(4, 36)}$	0.878		
Wetness									
June	-3.84 ±0.48[a]	-2.51 ±0.56[b]	-3.39 ±0.56[ab]	-3.98 ±0.30[a]	-3.57 ±0.49[ab]	$2.97_{(4, 36)}$	0.032	8.24	0.083
September	-4.19 ±0.32	-3.30 ±0.64	-3.59 ±0.27	-4.15 ±0.31	-3.56 ±0.26	$1.63_{(4, 32)}$	0.191	7.22	0.125

BIOSWALE TYPE 3 (N = 22)

PARAMETERS	**2011** SE	**2012** SE	**2013** SE	**2014** SE	**2015** SE	$F_{(df)}$	***P***	Chi-square[1]	***P***
Species Density/1-m^2									
Native Spp. Density - June	1.23 ±0.33	1.05 ±0.24	1.45 ±0.35	1.27 ±0.27	2.00 ±0.54	$1.21_{(4, 84)}$	0.313	1.68	0.795
Native Spp. Density - Sept.	0.86 ±0.21	0.86 ±0.20	1.09 ±0.21	1.09 ±0.23	1.00 ±0.33	$0.32_{(2.62, 55.1)}$	0.788	2.76	0.598
Non-Native Spp. Density - June	7.27 ±0.62[a]	5.86 ±0.49[bc]	5.00 ±0.55[b]	6.46 ±0.63[ac]	7.14 ±0.75[ac]	$2.92_{(4, 84)}$	**0.026**		
Non-Native Spp. Density - Sept.	3.18 ±0.55[a]	3.86 ±0.34[a]	3.77 ±0.28[a]	5.96 ±0.54[b]	4.59 ±0.53[b]	$5.97_{(2.80, 58.7)}$	**0.002**	16.29	**0.003**
% Cover and Bare Ground									
Total Cover - June	119.96 ±10.76	99.91 ±9.14	106.86 ±11.5	93.84 ±7.1	117.11 ±9.3	$1.36_{(2.56, 53.7)}$	0.267	6.76	0.149
Total Cover - Sept	73.71 ±11.37[a]	108.30 ±6.56[b]	90.32 ±6.63[a]	145.93 ±8.68[c]	93.39 ±10.56[ab]	$10.87_{(4, 84)}$	**< 0.0001**	29.10	**< 0.0001**
Bare Ground - June	17.95 ±5.87	21.25 ±5.19	27.16 ±6.09	16.36 ±2.42	11.30 ±2.58	$_{1.60\ (2.8, 58.7)}$	0.202	8.26	0.082
Bare Ground - Sept.	38.86 ±9.42[a]	14.52 ±4.48[b]	16.34 ±6.61[b]	1.73 ±0.67[c]	21.30 ±4.46[ab]	$5.34_{(2.44, 51.3)}$	**0.005**	22.44	**< 0.0001**
Floristic Quality Assessment									
Mean C - June	0.14 ±0.05	0.18 ±0.05	0.25 ±0.08	0.22 ±0.06	0.20 ±0.06	$0.75_{(4, 84)}$	0.563	1.33	0.857
Mean C - September	0.24 ±0.08	0.53 ±0.17	0.42 ±0.11	0.27 ±0.08	0.19 ±0.06	$2.43_{(2.62, 55.0)}$	0.083	5.59	0.232
FQI - June	0.26 ±0.11	0.24 ±0.07	0.41 ±0.14	0.32 ±0.09	0.42 ±0.18	$0.47_{(2.8, 59.7)}$	0.696	1.35	0.854
FQI - September	0.31 ±0.11	0.68 ±0.21	0.57 ±0.18	0.34 ±0.10	0.29 ±0.10	$2.03_{(2.61, 55.1)}$	0.128	3.52	0.475
Wetness									
June	2.02 ±0.24[a]	2.72 ±0.21[b]	2.07 ±0.29[ab]	2.54 ±0.21[b]	2.58 ±0.17[b]	$2.92_{(4, 76)}$	**0.026**	9.67	**0.046**
September	1.53 ±0.48	1.92 ±0.44	1.97 ±0.33	2.04 ±0.27	2.59 ±0.41	$1.47_{(1.98, 29.6)}$	0.246	4.14	0.388

BIOSWALE TYPE 4 (N = 7)

PARAMETERS	**2011** SE	**2012** SE	**2013** SE	**2014** SE	**2015** SE	$F_{(df)}$	***P***	Chi-square[1]	***P***
Species Density/1-m^2									
Native Spp. Density - June	1.00 ±0.58	2.14 ±0.55	2.29 ±0.57	1.29 ±0.75	1.43 ±0.72	$0.89_{(4, 24)}$	0.484	4.89	0.299
Native Spp. Density - Sept.	1.71 ±0.29	1.29 ±0.29	1.86 ±0.60	1.71 ±0.36	1.00 ±0.22	$1.08_{(4, 24)}$	0.380	3.97	0.411

Non-Native Spp. Density - June	8.00 ±1.36[a]	5.00 ±0.72[ab]	7.43 ±1.34[a]	4.57 ±0.97[b]	7.71 ±1.39[a]	$4.01_{(4, 24)}$	**0.013**		
Non-Native Spp. Density - Sept.	4.71 ±0.57[ac]	3.00 ±0.79[b]	3.43 ±0.84[ab]	3.57 ±0.78[ab]	6.14 ±0.63[c]	$6.66_{(2.10, 12.6)}$	**0.010**	16.13	**0.003**
% Cover and Bare Ground									
Total Cover - June	118.00 ±11.57	96.14 ±15.00	138.36 ±15.86	90.29 ±9.65	98.86 ±21.82	$1.98_{(4, 24)}$	0.130	6.48	0.166
Total Cover - Sept	97.29 ±9.40	93.21 ±15.97	89.79 ±21.01	98.43 ±6.90	64.79 ±16.14	$0.99_{(4, 24)}$	0.430		
Bare Ground - June	21.43 ±4.15	16.29 ±5.84	8.14 ±2.42	16.64 ±7.97	38.36 ±10.06	$2.61_{(4, 24)}$	0.061	6.56	0.161
Bare Ground - Sept.	18.43 ±7.02	24.43 ±8.45	24.14 ±13.18	9.71 ±8.81	46.79 ±13.27	$1.56_{(4, 24)}$	0.216	7.55	0.109
Floristic Quality Assessment									
Mean C - June	0.24 ±0.20[a]	0.92 ±0.28[b]	0.60 ±0.17[ab]	0.18 ±0.11[ab]	0.31 ±0.18ab	$3.10_{(4, 24)}$	0.035	5.43	0.246
Mean C - September	0.77 ±0.24[a]	2.09 ±0.49[b]	1.11 ±0.52[ab]	0.85 ±0.35[ab]	0.44 ±0.21	$3.54_{(4, 24)}$	**0.021**		
FQI - June	0.35 ±0.28[a]	1.55 ±0.51[b]	0.99 ±0.31[a]	0.34 ±0.25[a]	0.50 ±0.32[a]	$2.79_{(4, 24)}$	0.049	5.03	0.284
FQI - September	1.06 ±0.39	2.39 ±0.50	1.67 ±0.78	1.30 ±0.58	0.54 ±0.21	$2.54_{(4, 24)}$	0.066		
Wetness									
June	2.53 ±0.52	2.21 ±0.18	2.39 ±0.38	2.82 ±0.30	2.21 ±0.21	$1.79_{(4, 24)}$	0.163	6.01	0.198
September	1.04 ±0.46	2.27 ±0.53	2.13 ±0.37	1.92 ±0.24	1.95 ±0.33	$1.95_{(4, 20)}$	0.141		

[1] Friedman's test statistic for non-normal data that could not be transformed (means and SE from untransformed, non-normal data); significance test takes priority due to lack of central normal tendency, an expectation of RM-ANOVA.

Table 11. Results from paired samples tests (paired t tests and for non-normal data that could not be successfully transformed the Wilcoxon paired samples test) comparing the results from the 2011 baseline to the 2015 final sample in bioswales along I-294 in Cook County, IL.

BIOSWALE TYPE 1 (N = 61)

PARAMETERS	2011	SE	2015	SE	t stat	df	*P*	Wilcoxon	*P*
Bioswale Species Density									
Native Spp. Density - June	1.87	0.26	2.25	0.20	-1.59	60	.118	659.5	0.099
Native Spp. Density - Sept.	2.23	0.19	2.11	0.17	0.57	60	.573	428.0	0.577
Non-Native Spp. Density -	1.90	0.33	1.54	0.29	1.71	60	.092	290.0	0.152
Non-Native Spp. Density -	1.15	0.19	1.70	0.23	-2.33	60	**.023**	483.0	**0.016**
% Cover & % Bare Ground									
Cover - June	50.30	7.27	72.75	5.40	-3.35	60	**.001**	1,277.0	**0.001**
Cover - Sept.	76.84	6.99	65.79	4.64	1.41	60	.162		
Bare Ground - June	62.53	4.66	47.40	3.26	3.30	60	**.002**	337.0	**0.002**
Bare Ground - Sept.	47.89	4.66	46.56	3.87	.231	60	.818	679.0	0.746
Floristic Quality Assessment									
Mean C - June	1.74	0.21	2.18	0.19	-2.06	60	.044	945.5	0.080
Mean C - September	2.26	0.18	2.06	0.18	1.04	60	.301	577.0	0.308
FQI - June	2.77	0.36	3.25	0.28	-1.28	60	.204	953.5	0.124
FQI - September	3.62	0.32	3.15	0.31	1.39	60	.169	619.5	0.290
Wetness									
June	-3.18	0.34	-3.26	0.33	0.33	46	.740	250.0	0.793
September	-4.15	0.20	-3.62	0.27	-2.74	52	**.008**	440.0	**0.015**

BIOSWALE TYPE 2 (N = 10)

PARAMETERS	2011	SE	2015	SE	t stat	df	*P*	Wilcoxon	*P*
Bioswale Species Density									
Native Spp. Density - June	2.80	0.57	2.60	0.60	0.21	9	.836	25.5	0.836
Native Spp. Density - Sept.	2.50	0.37	3.20	0.71	-0.96	9	.363		
Non-Native Spp. Density -	2.00	0.54	1.70	0.63	0.67	9	.520	9.5	0.435
Non-Native Spp. Density -	1.80	0.47	2.00	0.71	-0.27	9	.794	15.0	0.865
% Cover & % Bare Ground									
Cover - June	90.65	####	54.65	11.42	1.52	9	.164		
Cover - Sept.	101.00	####	86.30	13.16	0.86	9	.413	19.0	0.386
Bare Ground - June	39.25	####	53.25	8.67	-0.77	9	.461	29.0	0.441
Bare Ground - Sept.	23.70	8.37	45.30	8.54	-1.86	9	.095	24.0	0.088
Floristic Quality Assessment									
Mean C - June	2.80	0.45	2.41	0.42	1.49	9	.171		
Mean C - September	2.17	0.38	2.01	0.36	0.40	9	.698		
FQI - June	4.23	0.67	3.84	0.76	0.57	9	.584		
FQI - September	3.55	0.72	3.46	0.65	0.18	9	.864		
Wetness									
June	-3.84	0.48	-3.57	0.49	-0.74	9	.478	20.0	0.310
September	-4.19	0.32	-3.56	0.26	-2.05	8	0.07		

BIOSWALE TYPE 3 (N = 22)

PARAMETERS	2011	SE	2015	SE	t stat	df	*P*	Wilcoxon	*P*
Bioswale Species Density									
Native Spp. Density - June	1.23	0.33	2.00	0.53	-1.21	21	.239	103.0	0.205
Native Spp. Density - Sept.	0.86	0.21	1.00	0.33	-0.43	21	.672	43.5	0.719
Non-Native Spp. Density -	7.27	0.62	7.14	0.75	0.16	21	.875		
Non-Native Spp. Density -	3.18	0.55	4.59	0.52	-2.18	21	.041	155.5	0.056
% Cover & % Bare Ground									
Cover - June	119.96	####	117.11	9.34	0.30	21	.767		
Cover - Sept.	73.70	####	93.39	10.56	-1.66	21	.112	159.5	0.126
Bare Ground - June	17.95	5.87	11.30	2.58	1.35	21	.191	21.5	0.298
Bare Ground - Sept.	38.86	9.42	21.30	4.46	2.00	21	.059	51.5	0.080
Floristic Quality Assessment									
Mean C - June	0.14	0.05	0.20	0.06	-0.71	21	.488	96.0	0.356
Mean C - September	0.24	0.08	0.19	0.06	0.51	21	.614	33.0	0.638
FQI - June	0.26	0.11	0.42	0.18	-0.74	21	.467	94.5	0.394
FQI - September	0.31	0.11	0.29	0.09	0.14	21	.886	37.0	0.875
Wetness									
June	2.02	0.23	2.62	0.17	-2.74	20	**.013**		
September	1.53	0.48	2.59	0.41	-1.68	15	.114		

BIOSWALE TYPE 4 (N = 7)

PARAMETERS	2011	SE	2015	SE	t stat	df	*P*	Wilcoxon	*P*
Bioswale Species Density									
Native Spp. Density - June	1.00	0.58	1.43	0.72	-0.43	6	.682	9.0	0.683
Native Spp. Density - Sept.	1.71	0.29	1.00	0.22	1.99	6	.094	0.0	0.102
Non-Native Spp. Density -	8.00	1.36	7.71	1.39	0.40	6	.703		
Non-Native Spp. Density -	4.71	0.57	6.14	0.63	-2.34	6	.058		
% Cover & % Bare Ground									
Cover - June	118.00	####	98.86	21.82	0.77	6	.468		
Cover - Sept.	97.29	9.40	64.79	16.14	1.84	6	.116		
Bare Ground - June	21.43	4.15	38.36	10.06	-1.35	6	.226	17.0	0.168
Bare Ground - Sept.	18.43	7.02	46.79	13.27	-1.60	6	.162	22.0	0.173
Floristic Quality Assessment									
Mean C - June	0.24	0.20	0.31	0.18	-0.45	6	.665	8.0	0.893
Mean C - September	0.77	0.24	0.44	0.21	0.94	6	.382		
FQI - June	0.35	0.28	0.50	0.32	-0.40	6	.703	8.0	0.893
FQI - September	1.06	0.39	0.45	0.21	1.19	6	.280		
Wetness									
June	2.53	0.52	2.21	0.21	0.88	6	.414		
September	1.09	0.39	2.14	0.34	-4.21	6	**.006**		

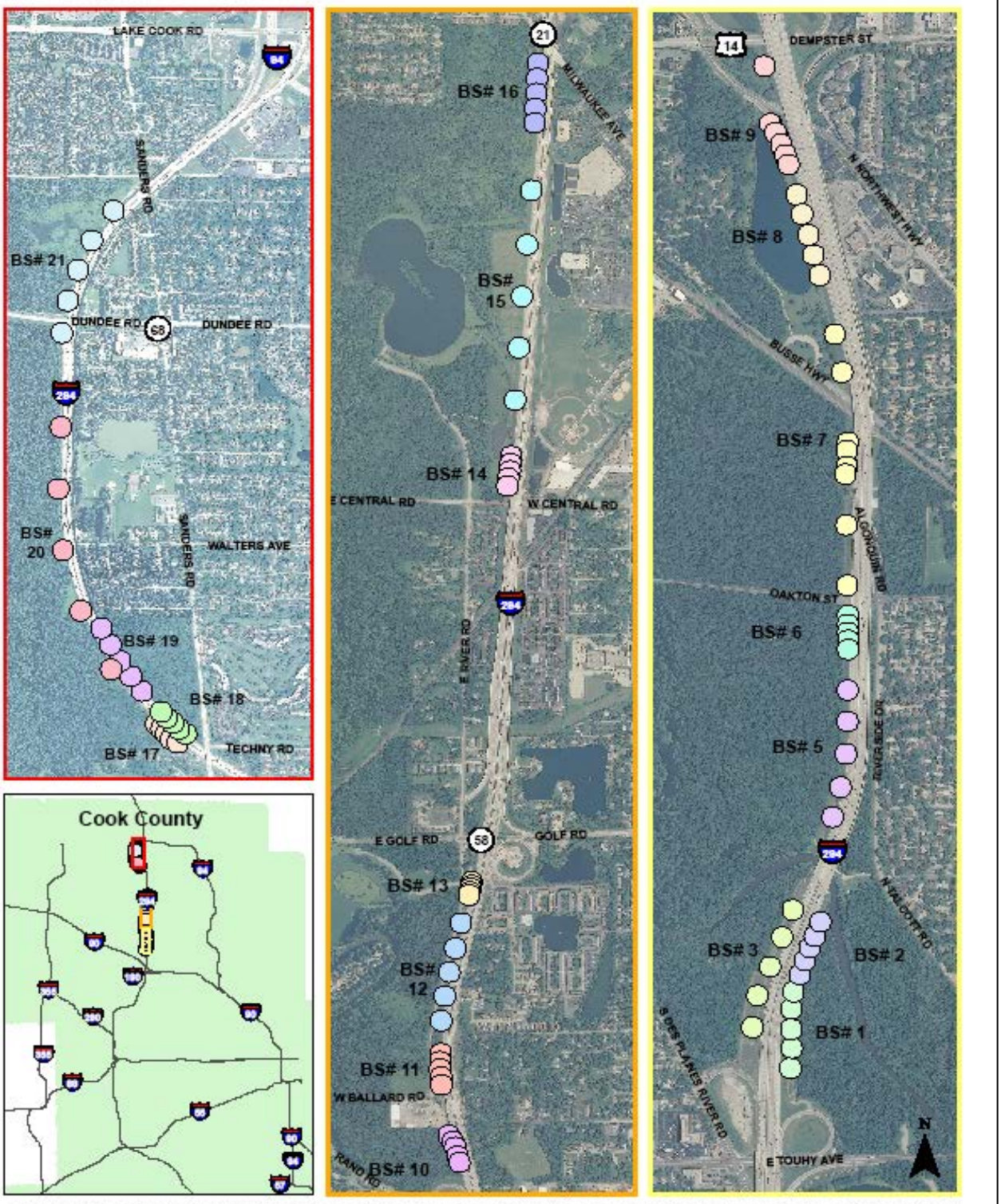

Figure 1. Vegetation plot sample locations for 20 bioswales along I-294 in northern Cook County, IL between Touhy Avenue and Lake-Cook Road.

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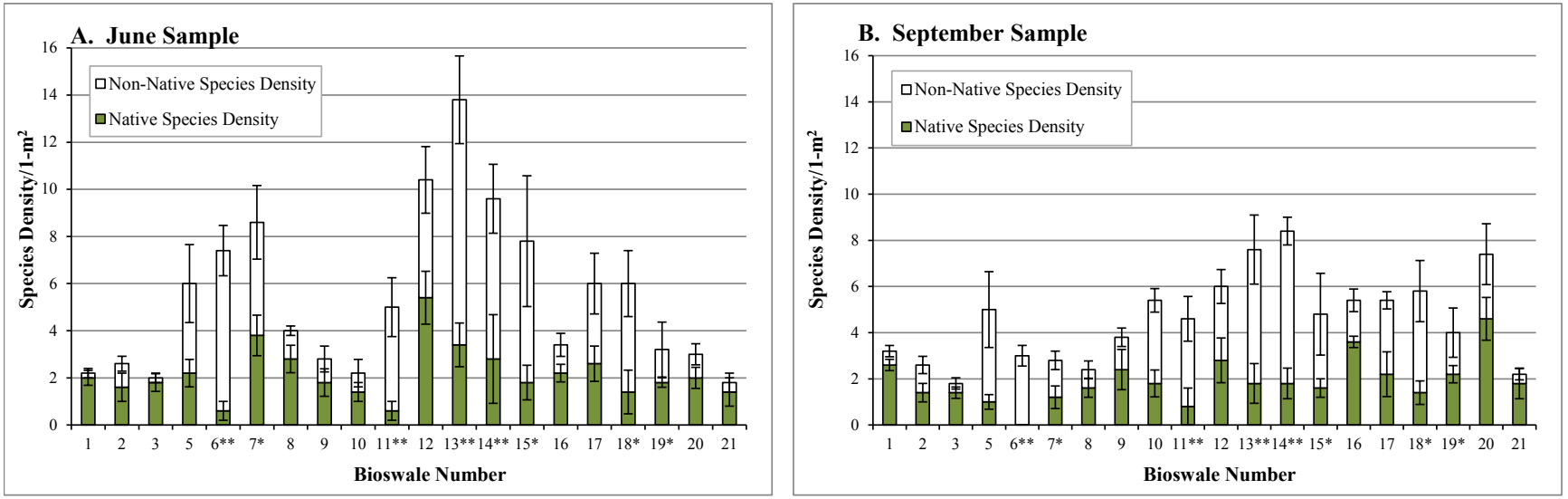

Figure 2. Mean species density recorded in five 1-m^2 quadrats at each bioswale during (A) June and (B) September 2015. Bioswales located along I-294 in northern Cook County, IL. Error bars are standard error. ** = dry swale design, * = dry/wet swales, unmarked = wet swale design.

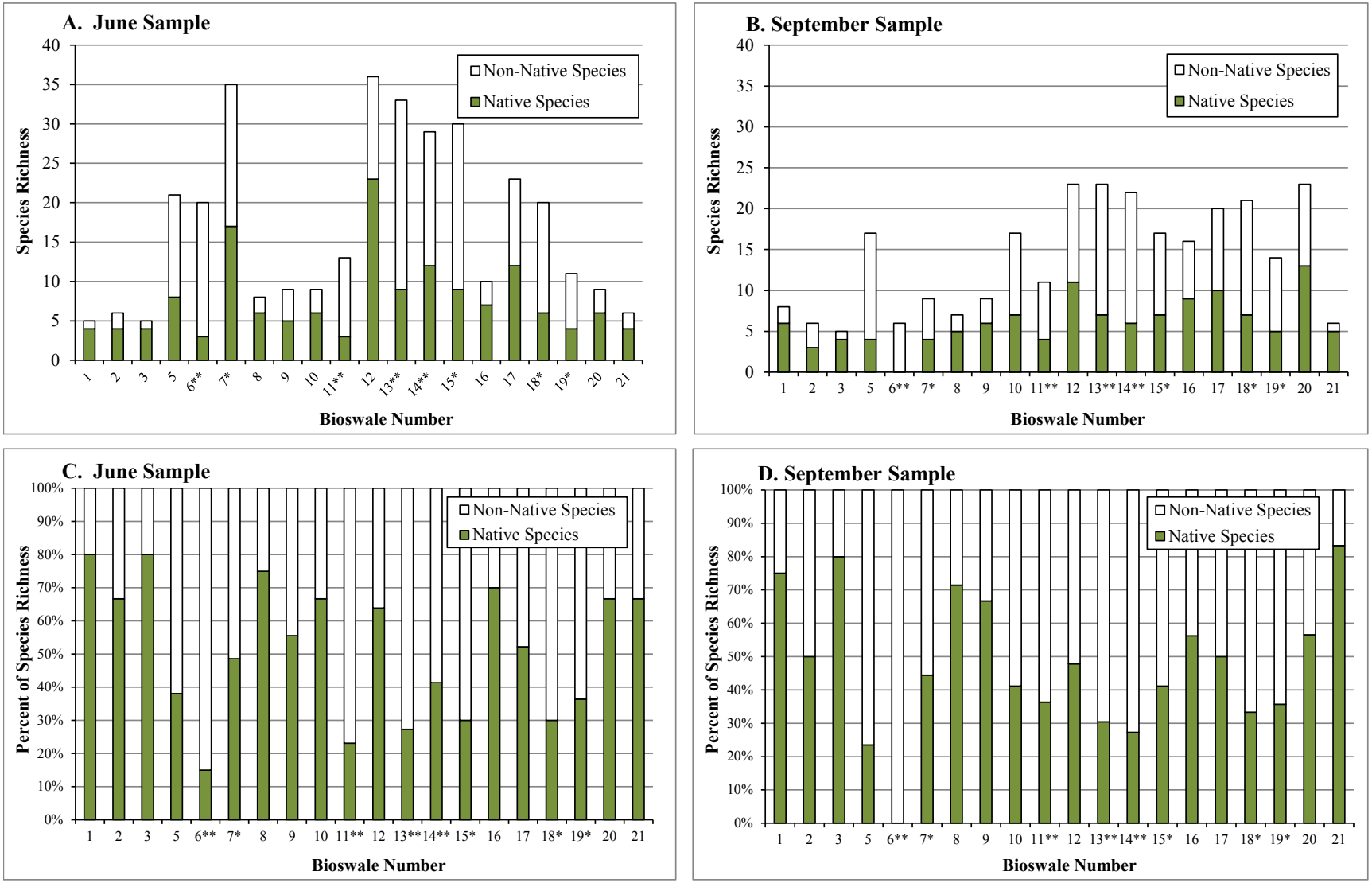

Figure 3. Species richness recorded in five 1-m^2 quadrats at each bioswale during (A) June and (B) September 2015 and proportion of native and non-native species in (C) June and (D) September 2015. Bioswales located along I-294 in northern Cook County, IL. ** = dry swale design, * = dry/wet swales, unmarked = wet swale designs.

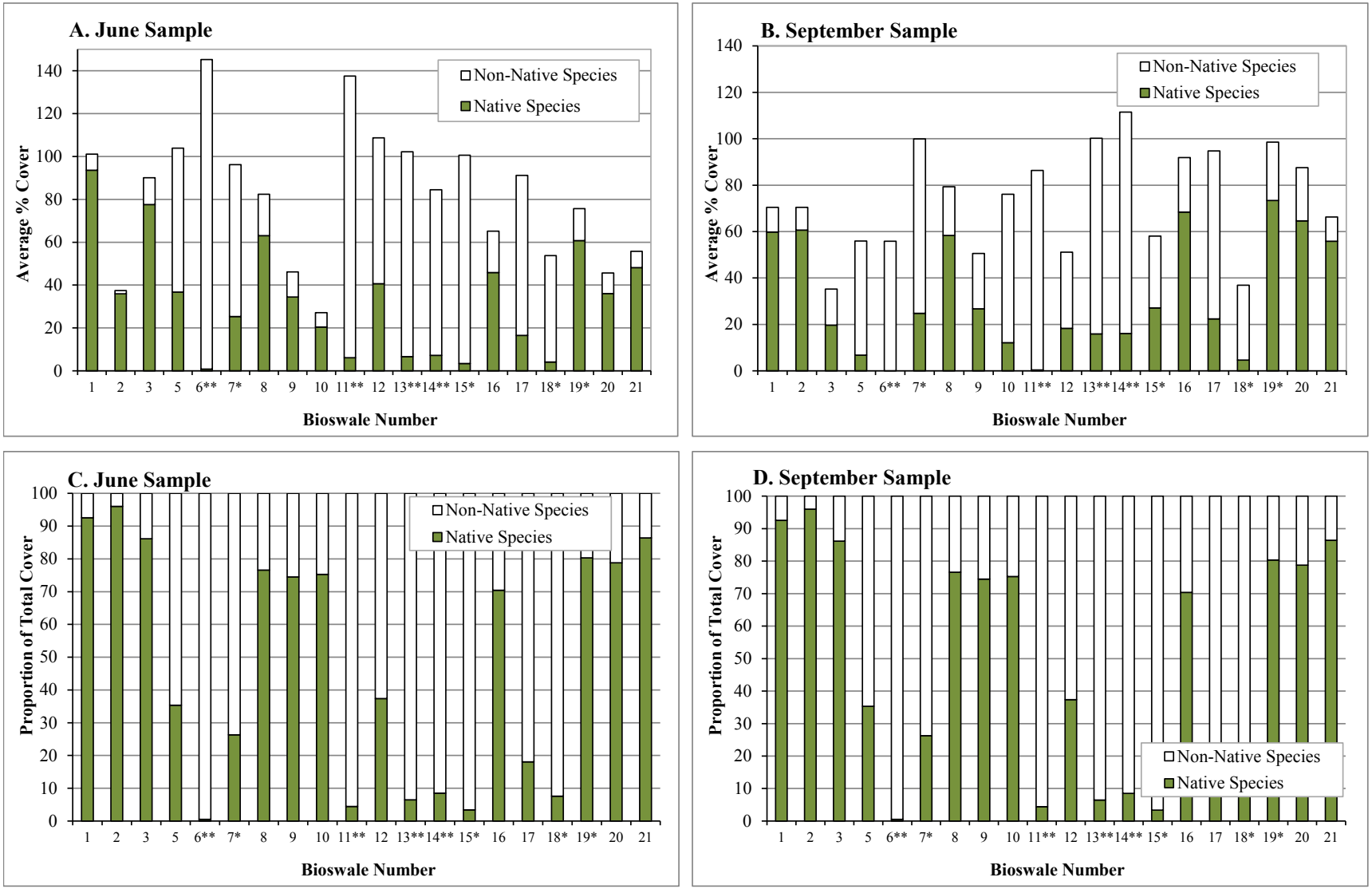

Figure 4. Total % vegetative cover recorded in five 1-m^2 sample quadrats in each bioswale during (A) June and (B) September 2015. Also shown is the proportion of native and non-native species in the (C) June and (D) September samples. Bioswales located along I-294 in northern Cook County, IL. ** = dry swale design, * = dry/wet swales, unmarked = wet swale design.

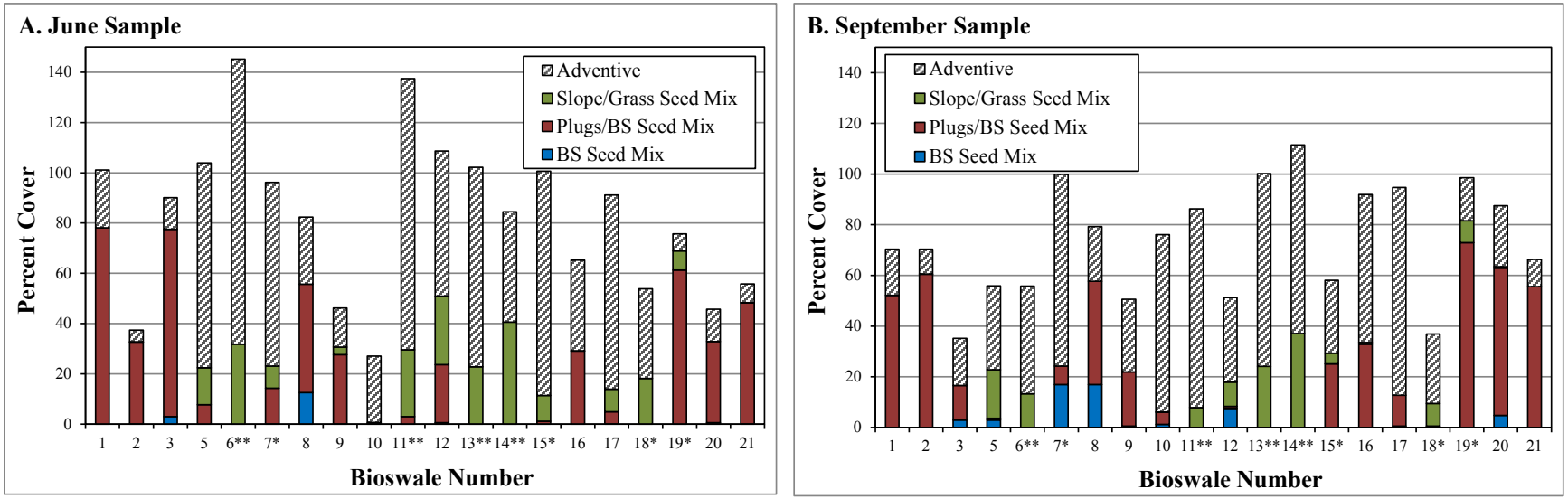

Figure 5. Percentage cover recorded during (A) June and (B) September 2015 in bioswale plot samples (five 1-m^2 quadrats/bioswale) indicating the amount from seeding, plug, and adventive sources. Bioswales located along I-294 in northern Cook County, IL. ** = dry swale design, * = dry/wet swales, unmarked = wet swale design.

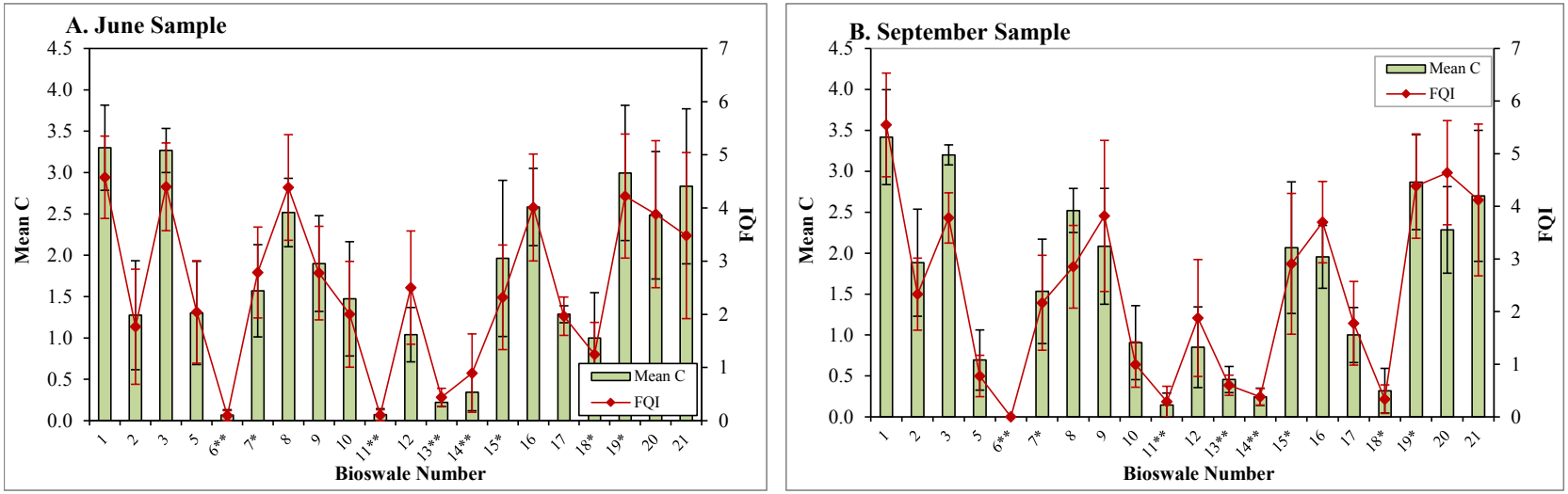

Figure 6. Results from Floristic Quality Assessment recorded from five 1-m^2 plot samples in bioswales during (A) June and (B) September 2015 along I-294 in northern Cook County, IL. Mean C = mean coefficient of conservatism; FQI = Floristic Quality Index. Error bars are standard error. ** = dry swale design, * = dry/wet swales, unmarked = wet swale design.

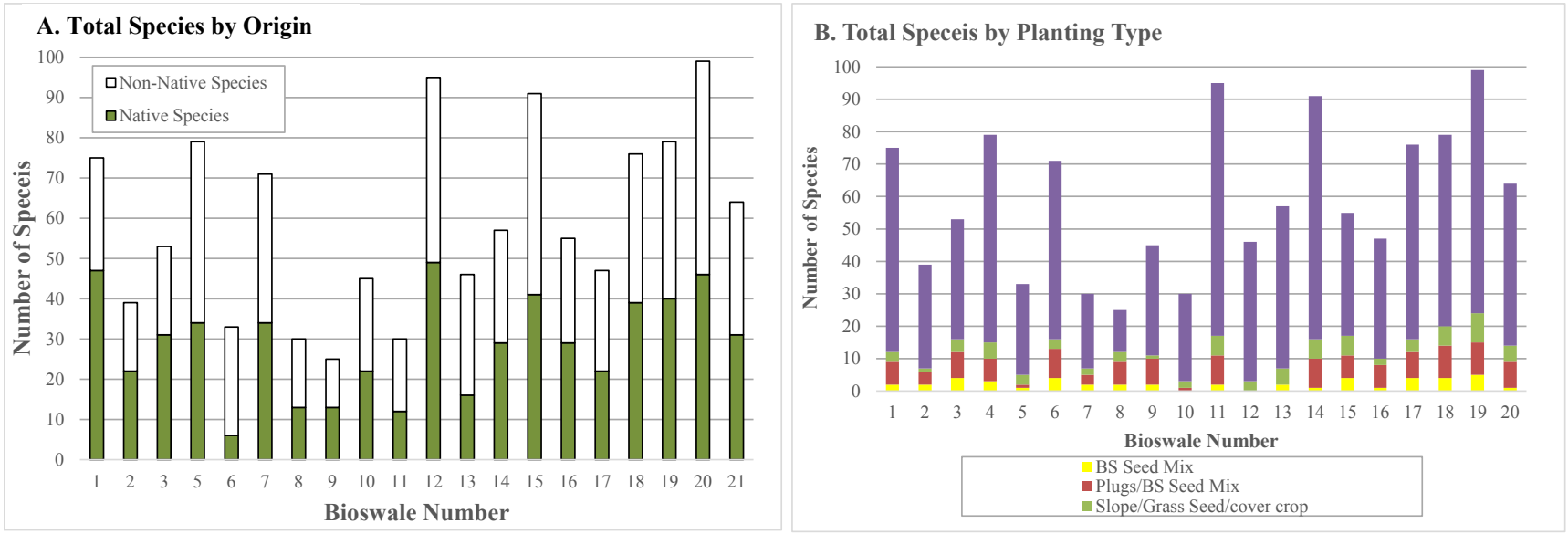

Figure 7. Total species recorded in each bioswale during 2015 including quantitative and general surveys. A) all native and non-native species and (B) amounts apparently derived from seeding, plug, and adventive sources. Bioswales located along I-294 in northern Cook County, IL.

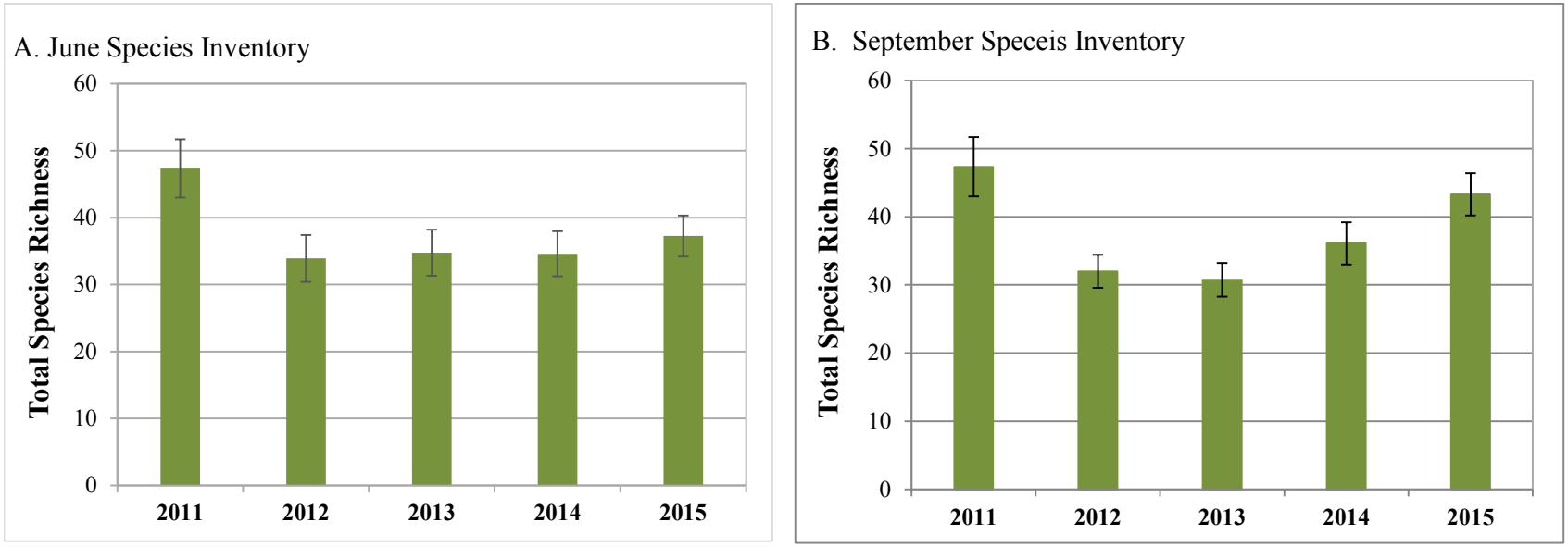

Figure 8. Mean species richness in bioswales from 2011 to 2015 in the A) June and B) September sample periods. Data are combined from quantitative sample data and botanical surveys throughout each bioswale. Bioswales located along I-294 in northern Cook County, IL. Error bars are standard error.

Figure 9. Proportion cover of planting mixes from quadrat sample data for June and September sample periods from 2011 (baseline) to 2015 in bioswales established along I-294 in northern Cook County, IL. Adventive species were not included in any planting designs.

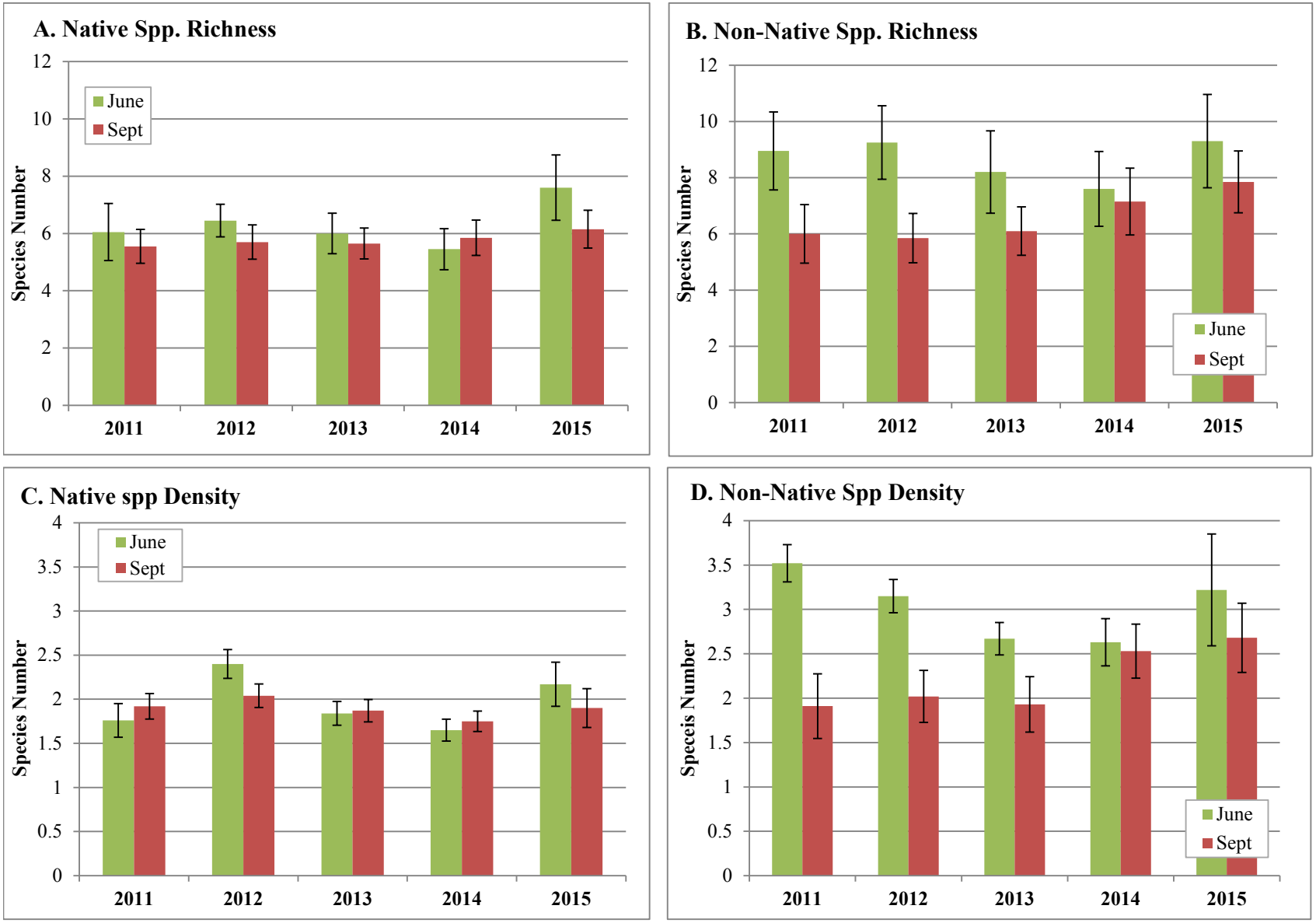

Figure 10. A) Native species richness, B) non-native species richness, C) native species density, and D) non-native species density comparing results from 2011-2015 in bioswales along I-294 in northern Cook County, IL. Error bars are standard error.

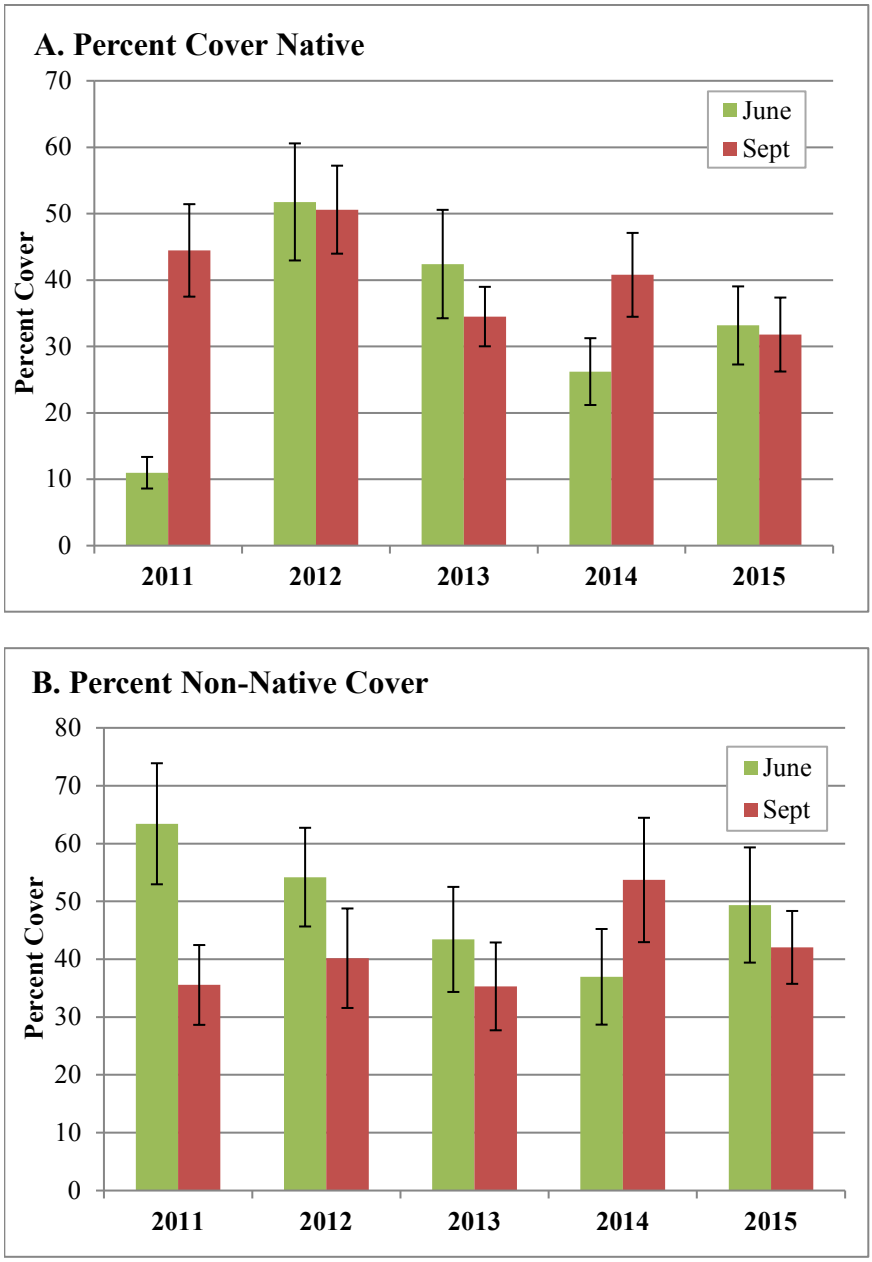

Figure 11. A) Native % cover and B) non-native % cover from 2011-2015 for vegetation in bioswales established along I-294 in northern Cook County, IL. Error bars are standard error.

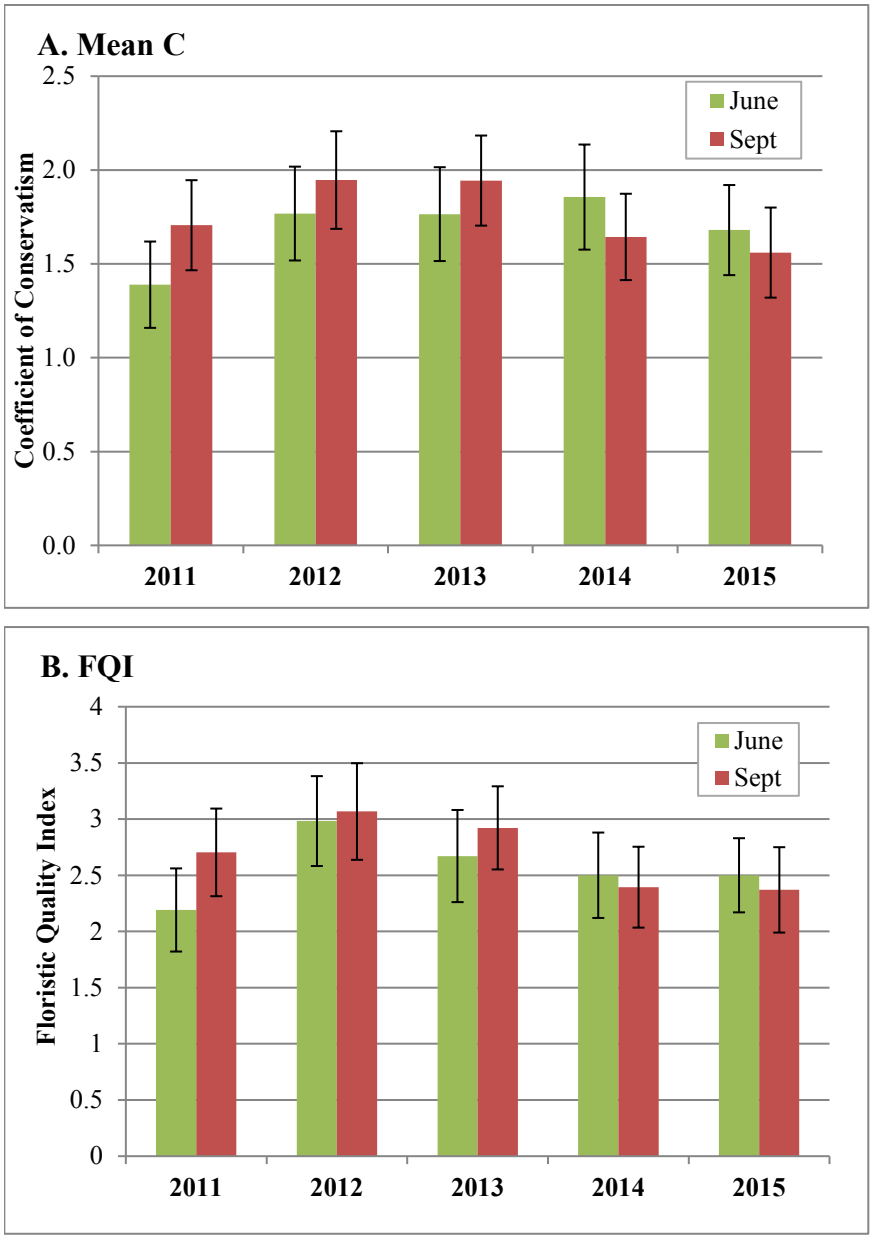

Figure 12. Results from Floristic Quality Assessment including A) Mean C and B) Floristic Quality Index (FQI) from 2011-2015 in bioswales established along I-294 in northern Cook County, IL.

Appendix 1. List of species recorded in 100 sample quadrats (1-m^2) during (A) June and (B) September 2015 in 20 bioswales along I-294 in northern Cook County, IL.

A. June Sample.	% Frequency	% Cover	IV 200
Scirpus fluviatilis	40	18.36	29.67
*Solidago sempervirens**	40	6.65	15.48
*Dipsacus laciniatus**	22	7.36	12.99
*Festuca arundinacea**	28	5.24	11.54
*Bromus inermis**	22	5.45	10.69
*Cirsium arvense**	19	5.59	10.30
Scirpus acutus	22	4.56	9.60
*Typha angustifolia**	16	5.29	9.38
*Daucus carota**	21	0.92	5.01
*Poa pratensis**	15	1.79	4.95
*Artemisia vulgaris**	11	2.21	4.71
Scirpus tabernaemontani	17	1.08	4.46
*Phragmites australis**	6	2.66	4.33
*Bromus japonicus**	8	1.85	3.72
*Agropyron repens**	14	0.83	3.60
*Lactuca serriola**	12	0.83	3.23
Scirpus paludosus	8	0.79	2.44
Lactuca canadensis	11	0.33	2.43
*Juncus compressus**	5	1.08	2.24
*Taraxacum officinale**	9	0.12	1.82
Verbena hastata	5	0.71	1.79
*Melilotus alba/officinalis**	7	0.40	1.78
*Thlaspi arvense**	5	0.67	1.74
Ambrosia artemisiifolia	9	0.05	1.72
Scirpus americanus	4	0.79	1.69
Typha latifolia	2	0.78	1.31
Solidago canadensis	4	0.42	1.24
*Bromus commutatus**	1	0.85	1.22
*Alliaria petiolata**	6	0.06	1.18
*Puccinellia distans**	5	0.17	1.13
*Rumex crispus**	5	0.10	1.05
Bidens frondosa	5	0.08	1.02
Sagittaria latifolia	4	0.22	1.00
*Capsella bursa-pastoris**	5	0.05	0.99
Polygonum sp.	5	0.05	0.99
Carex stipata	4	0.19	0.97
Sagittaria sp.	4	0.19	0.97
*Leucanthemum vulgare**	3	0.33	0.96
Agrostis alba	2	0.38	0.83
*Coronilla varia**	2	0.38	0.83
*Atriplex patula**	4	0.07	0.83
Conyza canadensis	4	0.07	0.83
*Convolvulus arvensis**	3	0.21	0.81
*Poa compressa**	3	0.21	0.81
Ranunculus sceleratus	4	0.05	0.80
*Trifolium hybridum**	3	0.19	0.78
Aster pilosus	4	0.02	0.77
Polygonum ramosissimum	4	0.02	0.77
Carex sp.	3	0.16	0.75
Polygonum pensylvanicum	3	0.07	0.64
Aster drummondii	2	0.18	0.59
Lemna minor	3	0.02	0.57

B. September Sample.	% Frequency	% Cover	IV 200
Scirpus fluviatilis	41	15.23	29.57
*Dipsacus laciniatus**	23	8.67	16.76
*Typha angustifolia**	22	8.04	15.69
*Solidago sempervirens**	37	5.23	15.16
Scirpus acutus	27	5.71	13.63
*Bromus inermis**	21	3.24	8.97
*Festuca arundinacea**	20	3.26	8.78
*Poa pratensis**	12	2.48	5.98
*Aster subulatus**	14	1.43	4.99
*Artemisia vulgaris**	8	1.93	4.35
Sagittaria latifolia	9	1.52	4.02
*Phragmites australis**	7	1.71	3.84
*Daucus carota**	12	0.63	3.47
*Setaria glauca**	9	0.95	3.25
Scirpus paludosus	11	0.62	3.23
*Cirsium arvense**	10	0.68	3.10
Echinochloa muricata	9	0.78	3.02
*Cirsium vulgare**	8	0.75	2.76
Sonchus arvensis var. *glabrescens**	5	1.11	2.59
*Juncus compressus**	4	1.06	2.31
Scirpus americanus	3	1.15	2.21
*Lactuca serriola**	7	0.26	1.87
Scirpus tabernaemontani	7	0.11	1.68
Elymus virginicus	2	0.86	1.59
*Polygonum persicaria**	5	0.37	1.59
Eupatorium serotinum	3	0.56	1.41
Lemna minor	5	0.20	1.36
*Agropyron repens**	4	0.34	1.33
Ambrosia artemisiifolia	4	0.34	1.33
Bidens frondosa	5	0.15	1.29
Ranunculus sceleratus	5	0.05	1.16
*Atriplex patula**	4	0.19	1.13
*Taraxacum officinale**	4	0.17	1.10
Solidago altissima	3	0.31	1.07
*Rumex crispus**	4	0.07	0.97
Alisma plantago-aquatica	3	0.21	0.94
Peltandra virginica	3	0.19	0.91
*Chenopodium album**	2	0.30	0.84
*Solanum dulcamara**	2	0.30	0.84
Carex vulpinoidea	1	0.38	0.73
*Carex pseudo-cyperus**	3	0.04	0.71
*Melilotus alba/officinalis**	3	0.04	0.71
Polygonum pensylvanicum	3	0.04	0.71
*Medicago lupulina**	3	0.02	0.68
Oxalis dillenii	3	0.02	0.68
Polygonum ramosissimum	3	0.02	0.68
Rumex cf. *altissimus*	3	0.02	0.68
Acer negundo	2	0.16	0.65
Lactuca canadensis	2	0.16	0.65
Leersia oryzoides	2	0.16	0.65
*Puccinellia distans**	2	0.16	0.65
Bouteloua curtipendula	2	0.06	0.52

A. June Sample.	% Frequency	% Cover	IV 200
Rumex sp.*	3	0.02	0.57
*Trifolium repens**	3	0.02	0.57
Toxicodendron radicans	2	0.16	0.56
Potamogeton sp.	2	0.06	0.44
*Chenopodium album**	2	0.04	0.41
*Cirsium vulgare**	2	0.04	0.41
*Lychnis alba**	2	0.04	0.41
Alisma plantago-aquatica	2	0.01	0.38
Fraxinus lanceolata	2	0.01	0.38
*Hordeum jubatum**	2	0.01	0.38
*Plantago major**	2	0.01	0.38
*Rhamnus cathartica**	2	0.01	0.38
Ulmus americana	2	0.01	0.38
*Arctium minus**	1	0.15	0.37
Aster sagittifolius	1	0.15	0.37
Carex annectens	1	0.15	0.37
Poaceae sp.	1	0.15	0.37
*Solanum dulcamara**	1	0.15	0.37
*Carex pseudo-cyperus**	1	0.03	0.22
Chenopodium sp.*	1	0.03	0.22
Erigeron annuus	1	0.03	0.22
*Lotus corniculatus**	1	0.03	0.22
*Medicago lupulina**	1	0.03	0.22
*Plantago lanceolata**	1	0.03	0.22
*Trifolium pratense**	1	0.03	0.22
*Abutilon theophrasti**	1	0.01	0.19
Acalypha rhomboidea	1	0.01	0.19
Ambrosia trifida	1	0.01	0.19
Apocynum sibiricum	1	0.01	0.19
Aster simplex	1	0.01	0.19
*Erucastrum gallicum**	1	0.01	0.19
Cornus racemosa	1	0.01	0.19
Crataegus sp.	1	0.01	0.19
*Dactylis glomerata**	1	0.01	0.19
Desmanthus illinoensis	1	0.01	0.19
Eupatorium serotinum	1	0.01	0.19
Fragaria virginiana	1	0.01	0.19
Geum aleppicum	1	0.01	0.19
Geum sp.	1	0.01	0.19
Hackelia virginiana	1	0.01	0.19
Hordeum pusillum	1	0.01	0.19
Lepidium sp.*	1	0.01	0.19
Oenothera biennis	1	0.01	0.19
Parthenocissus quinquefolia	1	0.01	0.19
*Polygonum persicaria**	1	0.01	0.19
Prunella vulgaris var. *elongata*	1	0.01	0.19
Prunus serotina	1	0.01	0.19
Rosa carolina	1	0.01	0.19
Sporobolus asper	1	0.01	0.19
*Verbascum blattaria**	1	0.01	0.19
*Veronica peregrina**	1	0.01	0.19
SUMMARY		82.52	200

B. September Sample.	% Frequency	% Cover	IV 200
Erechtites hieracifolia	2	0.06	0.52
*Leucanthemum vulgare**	2	0.06	0.52
*Setaria faberi**	2	0.06	0.52
*Centaurium pulchellum**	2	0.04	0.48
Carex sp.	2	0.01	0.45
*Convolvulus arvensis**	2	0.01	0.45
Erigeron annuus	2	0.01	0.45
*Leptochloa acuminata**	2	0.01	0.45
Aster drummondii	1	0.15	0.42
Carex annectens	1	0.15	0.42
Conyza canadensis	1	0.15	0.42
Lepidium sp.*	1	0.15	0.42
*Phalaris arundinacea**	1	0.15	0.42
Verbena hastata	1	0.15	0.42
Arctium minus *	1	0.03	0.26
*Coronilla varia**	1	0.03	0.26
Cyperus ferruginescens	1	0.03	0.26
Eleocharis acicularis	1	0.03	0.26
Fraxinus lanceolata	1	0.03	0.26
*Leonurus cardiaca**	1	0.03	0.26
*Lotus corniculatus**	1	0.03	0.26
Plantago rugelii	1	0.03	0.26
Populus deltoides	1	0.03	0.26
*Trifolium repens**	1	0.03	0.26
*Triticum aestivum**	1	0.03	0.26
Brassicaceae sp.*	1	0.01	0.23
Desmanthus illinoensis	1	0.01	0.23
*Echinochloa crus-galli**	1	0.01	0.23
Eleocharis erythropoda	1	0.01	0.23
Elymus canadensis	1	0.005	0.2251
*Erucastrum gallicum**	1	0.005	0.2251
Geum aleppicum	1	0.005	0.2251
*Lythrum salicaria**	1	0.005	0.2251
Polygonum hydropiperoides	1	0.005	0.2251
		73.84	200

Appendix 2. Species recorded in bioswales along I-294 in northern Cook County, IL during June and September 2015. Species listed include all those recorded in sample plots and general surveys. Cover value is estimate for entire bioswale from general surveys; the largest value was used when taxa were present in both June and September sample periods. *Non-native species. Taxa shown in red are particularly invasive.

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.	Mohlenbrock 2014
*Abutilon theophrasti**				0.5			0.5							3		0.5	3	3	0.5		35	*Abutilon theophrasti*
Acalypha rhomboidea	0.5										0.5								0.5		15	*Acalypha rhomboidea*
Acer negundo										0.5		3									10	*Acer negundo*
Acer saccharinum		0.5	0.5																		10	*Acer saccharinum*
*Achillea millefolium**																			0.5		5	*Achillea millefolium*
Agrimonia parviflora														0.5	3						10	*Agrimonia parviflora*
*Agropyron repens**				0.5	0.5	0.5				0.5		3	0.5			3	0.5		0.5		45	*Elytrigia repens*
*Agropyron smithii**	0.5		15	0.5																	15	*Elytrigia smithii*
*Agrostis alba**	0.5									0.5						0.5			0.5		20	*Agrostis gigantea*
Alisma plantago-aquatica	0.5	0.5	3	3		3		3	0.5						0.5		0.5	0.5	3	3	60	*Alisma subcordatum*
*Alliaria petiolata**					0.5	0.5			0.5		0.5	0.5									25	*Alliaria petiolata*
Allium canadense	0.5																				5	*Allium canadense*
Amaranthus sp.		0.5																			5	*Amaranthus sp.*
Ambrosia artemisiifolia	0.5	0.5		3		0.5					3	15	0.5	3			3	3	0.5	0.5	60	*Ambrosia artemisiifolia*
Ambrosia trifida											0.5	0.5									10	*Ambrosia trifida*
Andropogon gerardii																			0.5		5	*Andropogon gerardii*
Apocynum cannabinum											3		0.5								10	*Apocynum cannabinum*
Apocynum sibiricum		0.5									0.5		0.5								15	*Apocynum sibiricum*
*Arctium minus **				0.5		3					0.5			3		0.5	3	3	0.5	3	45	*Arctium minus*
*Artemisia vulgaris**			0.5	15	15	15			0.5			15	3	0.5							40	*Artemisia vulgaris*
Asclepias sullivantii													0.5								5	*Asclepias sullivantii*
Asclepias syriaca				0.5		0.5												0.5	0.5	0.5	25	*Asclepias syriaca*
Asclepias verticillata													0.5	0.5							10	*Asclepias verticillata*
Aster drummondii						0.5					3	0.5		0.5						0.5	25	*Symphyotrichum drummondii*
Aster ericoides													3	0.5							10	*Symphyotrichum ericoides*
Aster lateriflorus																	0.5		0.5		10	*Symphyotrichum lateriflorum*
Aster novae-angliae													0.5								5	*Symphyotrichum novae-angliae*
Aster pilosus		0.5		0.5	0.5	0.5	0.5					0.5	0.5					0.5	0.5		45	*Symphyotrichum pilosum*
Aster sagittifolius											0.5										5	*Symphyotrichum sagittifolium*
Aster simplex	0.5	0.5	3										0.5								20	*Symphyotrichum lanceolatum*
*Aster subulatus**	15	15	3	3	3	15	15	3	3		0.5			3	3	3	0.5	3	3	3	85	*Symphyotrichum subulatum*
*Atriplex patula**	0.5	0.5	0.5	3		0.5		0.5	3		0.5			0.5	0.5	3		3	3	3	70	*Atriplex patula*
*Barbarea vulgaris**	0.5										0.5	0.5		0.5			0.5				25	*Barbarea vulgaris*
Bidens frondosa			3	3		0.5	3	3	15		0.5		0.5		0.5	3	0.5	3	3		65	*Bidens frondosa*
Bidens vulgata				0.5					3		0.5										15	*Bidens vulgata*
Bouteloua curtipendula											0.5		0.5	3			15	3			25	*Bouteloua curtipendula*
Brassicaceae sp. 1*																	0.5				5	*Brassica 3*
Brassicaceae sp. 2*	0.5								0.5					0.5			0.5	0.5			25	*Brassicaceae sp.*
*Bromus commutatus**	0.5											3					3	0.5			20	*Bromus commutatus*
*Bromus inermis**	0.5			37.5	62.5	15		0.5		37.5	15	15	15	15	3	0.5	37.5	15	3	0.5	80	*Bromus inermis*
*Bromus japonicus**				0.5		0.5	0.5				0.5	3		3	0.5		3	0.5			45	*Bromus japonicus*
Calystegia sepium																	0.5	0.5			10	*Calystegia sepium*
*Capsella bursa-pastoris**				0.5	0.5	0.5			0.5			0.5									25	*Capsella bursa-pastoris*
*Carduus nutans**				0.5	0.5									0.5					0.5		20	*Carduus nutans*
Carex annectens	3		15	3					0.5		0.5				0.5	0.5		0.5	3		45	*Carex annectens*
Carex brevior	0.5		0.5																		10	*Carex brevior*
Carex normalis	0.5																				5	*Carex cf. normalis*
Carex cristatella			0.5																		5	*Carex cristatella*
Carex granularis	0.5																				5	*Carex granularis*
Carex muskingumensis			0.5																		5	*Carex muskingumensis*
*Carex pseudo-cyperus**	0.5		0.5	3		0.5			3		0.5			0.5	0.5	0.5		3	3	0.5	60	*Carex pseudo-cyperus*

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.	Mohlenbrock 2014
Carex sp.	3		3	3	3						3		0.5	0.5			0.5			0.5	45	*Carex sp.*
Carex stipata						0.5					0.5			0.5	0.5	0.5	0.5	0.5	0.5		40	*Carex stipata*
Carex vulpinoidea	0.5		15			0.5			0.5		3			0.5	0.5			0.5	0.5		45	*Carex vulpinoidea*
Catalpa sp.*																			0.5		5	*Catalpa sp.*
*Centaurea maculosa**											0.5										5	*Centaurea biebersteinii*
*Centaurium pulchellum**													0.5		0.5				0.5		15	*Centaurium pulchellum*
Cephalanthus occidentalis						3		3	3		3			3		0.5	0.5	3	3	0.5	50	*Cephalanthus occidentalis*
*Chamaesyce nutans**																				0.5	5	*Chamaesyce nutans*
*Chenopodium album**											3	3					0.5			0.5	20	*Chenopodium album*
Chenopodium glaucum														3			3	0.5	0.5		20	*Chenopodium glaucum*
Chenopodium sp.														0.5							5	*Chenopodium sp.*
*Cichorium intybus**												0.5	0.5							0.5	15	*Cichorium intybus*
*Cirsium arvense**	3		0.5	3	3	15	3		0.5	62.5	15	15	0.5	3	3	3	15	15	3	3	90	*Cirsium arvense*
*Cirsium vulgare**	0.5			0.5	0.5	0.5			0.5	62.5	0.5	3		0.5	0.5	0.5		0.5	0.5	0.5	70	*Cirsium vulgare*
*Convolvulus arvensis**						0.5						3	0.5	0.5							20	*Convolvulus arvensis*
Conyza canadensis											3	3		0.5				0.5			20	*Conyza canadensis*
Cornus racemosa													0.5								5	*Cornus racemosa*
*Coronilla varia**				0.5	3	3				0.5				3		0.5		3	0.5	0.5	45	*Securigera varia*
Crataegus sp.												0.5									5	*Crataegus sp.*
Cyperus esculentus		0.5												0.5	0.5						15	*Cyperus esculentus*
Cyperus odoratus			15	0.5									3						3		20	*Cyperus odoratus*
*Dactylis glomerata**						0.5											0.5				10	*Dactylis glomerata*
*Daucus carota**				3	0.5	3	0.5		3	3	15	3	3	3	3		0.5	3	3	0.5	75	*Daucus carota*
Desmanthus illinoensis				0.5									3	0.5		0.5		0.5	0.5	0.5	35	*Desmanthus illinoensis*
*Dipsacus laciniatus**			0.5	15	62.5	3	0.5		15	62.5	15	37.5	15	0.5	0.5	3	3	15	3	0.5	85	*Dipsacus laciniatus*
*Echinochloa crus-galli**																		2			5	*Echinochloa crus-galli*
Echinochloa muricata		3	15	3			3	3	3				3	3	15	3	3		3	3	65	*Echinochloa muricata*
Eleocharis acicularis	0.5	0.5		0.5												3					20	*Eleocharis acicularis*
Eleocharis erythropoda	0.5	3	15	3										0.5				0.5	3		35	*Eleocharis erythropoda*
Elymus canadensis			0.5									0.5			0.5				3	0.5	25	*Elymus canadensis*
Elymus virginicus			3	3	0.5	3					3		0.5		0.5			0.5	0.5		45	*Elymus virginicus*
Epilobium coloratum			0.5														0.5	0.5			15	*Epilobium coloratum*
Eragrostis pectinacea																	0.5			0.5	10	*Eragrostis pectinacea*
Erechtites hieracifolia	3														15		3	3	3	0.5	30	*Erechtites hieracifolia*
Erigeron annuus	0.5									3	0.5			0.5			3				25	*Erigeron annuus*
Erigeron philadelphicus	0.5																				5	*Erigeron philadelphicus*
*Erucastrum gallicum**		0.5	0.5						0.5					0.5			3		0.5		30	*Erucastrum gallicum*
Eupatorium altissimum	3	3											3	0.5	0.5						25	*Eupatorium altissimum*
Eupatorium maculatum											0.5										5	*Eutrochium maculatum*
Eupatorium perfoliatum																	0.5		3		10	*Eupatorium perfoliatum*
Eupatorium purpureum											0.5										5	*Eutrochium purpureum*
Eupatorium serotinum	3	3	3	3		3					3		3	3	3	3	3	3			60	*Eupatorium serotinum*
Euthamia graminifolia									0.5					0.5	0.5						15	*Euthamia graminifolia*
*Festuca arundinacea**	3		0.5	15	3	15	3	3	15	15	15	37.5	37.5	15	15	3	15	15	3	3	95	*Festuca arundinacea*
Festuca ovina var. *duriuscula**											0.5								0.5		10	*Festuca ovina var. duriuscula*
*Festuca rubra**																		0.5			5	*Festuca rubra*
Fragaria virginiana											0.5		0.5							0.5	15	*Fragaria virginiana*
Fraxinus pennsylvanica var. *subintegerrima*	0.5	0.5	3	3		0.5			3	0.5		3	0.5			0.5	0.5	0.5	0.5		65	*Fraxinus lanceolata*
Galium aparine				0.5																	5	*Galium aparine*
Gaura biennis											0.5										5	*Gaura biennis*
Geum aleppicum						0.5				0.5							0.5				15	*Geum aleppicum*
Geum canadense	0.5						0.5														10	*Geum canadense*
Geum sp.						0.5															5	*Geum sp.*
Gleditsia triacanthos																		0.5			5	*Gleditsia triacanthos*

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.	Mohlenbrock 2014
Hackelia virginiana						0.5					0.5	0.5									15	*Hackelia virginiana*
*Helianthus annuus**											0.5										5	*Helianthus annuus*
Helianthus grosseserratus														0.5			0.5	3		0.5	20	*Helianthus grosseserratus*
*Hesperis matronalis**										0.5											5	*Hesperis matronalis*
*Hibiscus trionum**													0.5	0.5						0.5	15	*Hibiscus trionum*
*Hordeum jubatum**	3		0.5	3		0.5	0.5				0.5		3	3		0.5	0.5		3	0.5	60	*Hordeum jubatum*
Hordeum pusillum														0.5							5	*Hordeum pusillum*
*Hypericum perfoliatum**	0.5										0.5		0.5	0.5					0.5	3	30	*Hypericum perforatum*
Impatiens capensis																0.5	0.5				10	*Impatiens capensis*
Ipomoea sp.																		0.5			5	*Ipomoea sp.*
*Juncus compressus**	0.5	0.5	3	3				3					0.5	3	15	3	0.5	0.5	3	0.5	65	*Juncus compressus*
Juncus torreyi	0.5		3	3											0.5		0.5				25	*Juncus torreyi*
Lactuca canadensis				0.5	0.5	0.5			0.5	0.5	0.5	0.5	0.5			0.5	3	0.5		0.5	60	*Lactuca canadensis*
*Lactuca serriola**	0.5			3	0.5	0.5				0.5	3	3		0.5		0.5	15	3	3	0.5	65	*Lactuca serriola*
Leersia cf. *virginicus*	0.5																				5	*Leersia virginicus*
Leersia oryzoides	0.5			0.5												0.5	0.5	0.5	0.5		30	*Leersia oryzoides*
Lemna minor	0.5						0.5							0.5	3	0.5	0.5		3		35	*Lemna minor*
*Leonurus cardiaca**																	3		0.5		10	*Leonurus cardiaca*
Lepidium sp.*							0.5				0.5	3									15	*Lepidium sp.*
*Leptochloa acuminata**		0.5	0.5						0.5					3	0.5	0.5					30	*Leptochloa acuminata*
*Leucanthemum vulgare**	0.5			3		0.5				0.5	0.5		0.5	0.5							35	*Leucanthemum vulgare*
*Lolium multiflorum**																			0.5		5	*Lolium multiflorum*
*Lolium perenne**											0.5								0.5		10	*Lolium perenne*
*Lotus corniculatus**											0.5	3							0.5		15	*Lotus corniculatus*
*Lychnis alba**				0.5								0.5		0.5					0.5		20	*Silene pratensis*
Lycopus americanus	0.5																				5	*Lycopus americanus*
Lycopus uniflorus	0.5																				5	*Lycopus uniflorus*
*Lysimachia nummularia**	0.5	0.5																			10	*Lysimachia nummularia*
*Lythrum salicaria**				3	0.5				15	0.5	0.5		0.5	0.5			0.5	0.5	0.5	0.5	55	*Lythrum salicaria*
*Medicago lupulina**				0.5										0.5				0.5	0.5		20	*Medicago lupulina*
*Medicago sativa**						0.5								0.5							10	*Medicago sativa*
*Melilotus alba/officinalis**		0.5		3	0.5						3		3	3	0.5		0.5	0.5	3	0.5	55	*Melilotus alba/officinalis*
Monarda fistulosa																				0.5	5	*Monarda fistulosa*
*Morus alba**											0.5								0.5		10	*Morus alba*
*Nepeta cataria**	0.5			0.5							0.5	0.5					0.5				25	*Nepeta cataria*
Oenothera biennis	0.5					0.5			3		0.5	3		0.5				0.5		0.5	40	*Oenothera biennis*
Oxalis stricta										0.5	0.5						0.5			0.5	20	*Oxalis fontana*
Panicum capillare	0.5										0.5			0.5	0.5						20	*Panicum capillare*
Panicum virgatum	0.5		0.5												0.5						15	*Panicum virgatum*
Parthenocissus quinquefolia									3	0.5	0.5	0.5									20	*Parthenocissus quinquefolia*
*Pastinaca sativa**											0.5							0.5			10	*Pastinaca sativa*
Peltandra virginica	0.5		0.5	3		3		3	3					0.5			0.5	0.5	15	3	55	*Peltandra virginica*
*Phalaris arundinacea**	3	0.5		0.5						0.5				3		3	0.5	0.5	3	0.5	50	*Phalaris arundinacea*
*Phragmites australis**	0.5	0.5	0.5	3	0.5	0.5		0.5	0.5	0.5	3		3	15	37.5				0.5	3	75	*Phragmites australis*
Physalis sp.											0.5							0.5			10	*Physalis sp.*
Physalis subglabrata																	0.5	0.5			10	*Physalis subglabrata*
*Plantago lanceolata**							0.5						0.5								10	*Plantago lanceolata*
*Plantago major**	0.5	0.5				0.5								0.5							20	*Plantago major*
Plantago rugelii											0.5			0.5	0.5				0.5		20	*Plantago rugelii*
*Poa compressa**													3	0.5						0.5	15	*Poa compressa*
*Poa pratensis**			0.5	0.5	3	0.5				3	15	0.5	3	15			15	3	3	0.5	65	*Poa pratensis*
Poaceae sp.						0.5															5	Poaceae sp.
Polygonum amphibium							0.5				0.5										10	*Persicaria amphibia*
*Polygonum aviculare**						0.5															5	*Polygonum aviculare*

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.	Mohlenbrock 2014
*Polygonum cuspidatum**											3										5	*Reynoutria japonica*
*Polygonum hydropiper**	3	0.5	3	3														3			25	*Persicaria hydropiper*
Polygonum hydropiperoides																0.5					5	*Persicaria hydropiperoides*
Polygonum lapathifolium														0.5			0.5	3		0.5	20	*Persicaria lapathifolia*
Polygonum pensylvanicum		3	0.5	3		3	3	3	3		0.5			0.5			0.5	0.5	3		60	*Persicaria pensylvanica*
*Polygonum persicaria**	0.5		15		0.5	3	3	3	3		3			3	3			3	15		60	*Persicaria vulgaris*
Polygonum punctatum	3																				5	*Persicaria punctata*
Polygonum ramosissimum		0.5	15	0.5		0.5					0.5	3		3					0.5	0.5	45	*Polygonum ramosissimum*
Polygonum scandens						0.5															5	*Fallopia scandens*
Polygonum sp.					0.5	0.5					0.5					0.5		0.5		0.5	30	*Persicaria* sp.
*Populus alba**											3										5	*Populus alba*
Populus deltoides													0.5								5	*Populus deltoides*
Potamogeton sp.														0.5	0.5						10	*Potamogeton* sp.
Potentilla recta											0.5								0.5		10	*Potentilla recta*
Prunella vulgaris var. *elongata*											3		0.5								10	*Prunella vulgaris* var. *elongata*
Prunus serotina												0.5									5	*Prunus serotina*
*Puccinellia distans**		0.5		0.5		0.5		0.5					0.5	0.5	3			0.5	0.5	0.5	50	*Puccinellia distans*
Quercus macrocarpa																		0.5			5	*Quercus macrocarpa*
Ranunculus sceleratus	0.5	0.5	0.5	0.5				3						3	0.5	0.5	0.5	0.5	3	0.5	60	*Ranunculus sceleratus*
*Rhamnus cathartica**												0.5	0.5		0.5						15	*Rhamnus cathartica*
Rhus glabra											0.5										5	*Rhus glabra*
Rosa carolina											0.5										5	*Rosa carolina*
*Rosa multiflora**											0.5										5	*Rosa multiflora*
Rubus occidentalis									0.5	0.5											10	*Rubus occidentalis*
Rudbeckia hirta	0.5																				5	*Rudbeckia hirta*
Rumex cf. *altissimus*			0.5				0.5				0.5			0.5					0.5		25	*Rumex altissimus*
Rumex cf. *verticillatus*							0.5												0.5		10	*Rumex verticillatus*
*Rumex crispus**		3	3	3	0.5	3	0.5	3	3	0.5	0.5	0.5		3	3	3	0.5	3	3	3	90	*Rumex crispus*
Rumex sp.				0.5		0.5										0.5					15	*Rumex* sp.
Sagittaria latifolia	15	15	0.5	3				3	3								3	15	15	15	50	*Sagittaria latifolia*
Sagittaria sp.	0.5					0.5		0.5	0.5		0.5			0.5	0.5				0.5		40	*Sagittaria* sp.
Salix sp.																			0.5		5	*Salix* sp.
Schizachyrium scoparium													0.5	0.5	0.5		0.5		0.5	0.5	30	*Schizachyrium scoparium*
Scirpus acutus	15	3	37.5	0.5		15	37.5	62.5	3		3			37.5	15	3	3	37.5	15	37.5	80	*Schoenoplectus acutus*
Scirpus americanus	3	3	15			3	15							3	0.5		0.5	3	3		50	*Schoenoplectus pungens*
Scirpus atrovirens				15																	5	*Scirpus atrovirens*
Scirpus fluviatilis	37.5	62.5	62.5	0.5		37.5	62.5	62.5	3		3			15	37.5	3	0.5	37.5	37.5	37.5	80	*Bolboschoenus fluviatilis*
Scirpus paludosus			3	0.5	0.5	3	3	15			0.5			3	3	3	0.5	0.5	0.5	0.5	70	*Bolboschoenus maritimus*
Scirpus pendulus	0.5			15																	10	*Scirpus pendulus*
Scirpus tabernaemontani		0.5	0.5	0.5	0.5	0.5	15	3	0.5		0.5			0.5	0.5	0.5	0.5	0.5	3	0.5	80	*Schoenoplectus tabernaemontani*
*Setaria faberi**			0.5	3		0.5			3					3	0.5		3	3		0.5	45	*Setaria faberi*
*Setaria glauca**				3		0.5	0.5				3	15	0.5	3	0.5		3	3	3	0.5	60	*Setaria glauca*
*Silene vulgaris**														0.5							5	*Silene vulgaris*
*Solanum dulcamara**									3							3	0.5		3		20	*Solanum dulcamara*
Solidago altissima	0.5					3			0.5	0.5	15	3	3	3	3		3	3	0.5		60	*Solidago altissima*
Solidago nemoralis													0.5								5	*Solidago nemoralis*
*Solidago sempervirens**	3	3	3	15	3	3	15	15	3	3	15	3	15	37.5	15	15	15	0.5	15	15	100	*Solidago sempervirens*
*Sonchus arvensis**	0.5			3					3			3					15	3	3	3	40	*Sonchus arvensis*
Sonchus sp.*		0.5																			5	*Sonchus* sp.
Sorghastrum nutans						0.5								0.5							10	*Sorghastrum nutans*
Spirodela polyrhiza																			0.5		5	*Spirodela polyrhiza*
Sporobolus asper													3								5	*Sporobolus compositus*
*Suaeda calceoliformis**					0.5																5	*Salsola calceoliformis*
*Symphytum officinale**																0.5					5	*Symphytum officinale*

Bioswale #	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	% Freq.	Mohlenbrock 2014
*Taraxacum officinale**				0.5	0.5	0.5					0.5	0.5	0.5	0.5					0.5		40	*Taraxacum officinale*
*Thlaspi arvense**				0.5		0.5					0.5	3		0.5		0.5	0.5	0.5	0.5	0.5	50	*Thlaspi arvense*
*Thlaspi perfoliatum**				0.5		0.5					0.5								0.5		20	*Thlaspi perfoliatum*
Toxicodendron radicans											0.5		3								10	*Toxicodendron radicans*
*Trifolium hybridum**			0.5	0.5	0.5		0.5				0.5			0.5	0.5			0.5	0.5		45	*Trifolium hybridum*
*Trifolium pratense**				0.5	0.5														0.5		15	*Trifolium pratense*
*Trifolium repens**	0.5			0.5							0.5		3			0.5			0.5		30	*Trifolium repens*
*Typha angustifolia**	15	15	15	3	0.5	15	3	15	37.5		0.5		0.5	15	3	62.5	3	15	37.5	15	90	*Typha angustifolia*
Typha latifolia	0.5			15		0.5			3										0.5	0.5	30	*Typha latifolia*
Ulmus americana	0.5										0.5						0.5				15	*Ulmus americana*
Ulmus sp.				0.5															0.5		10	*Ulmus* sp.
*Verbascum blattaria**	0.5									0.5		0.5			0.5		3		0.5		30	*Verbascum blattaria*
Verbena hastata	0.5		3	0.5		0.5		3		0.5	0.5			3	0.5	0.5	3	3	3	0.5	70	*Verbena hastata*
Verbena urticifolia	0.5																				5	*Verbena urticifolia*
Veronica peregrina	0.5										0.5										10	*Veronica peregrina*
Vicia americana																		0.5			5	*Vicia americana*
Viola pratincola	0.5																				5	*Viola pratincola*
Vitis riparia						3				0.5	0.5								0.5		20	*Vitis riparia*
Xanthium strumarium		0.5																	3	0.5	15	*Xanthium strumarium*
Total Species	75	39	53	79	33	71	30	25	45	30	95	46	57	91	55	47	76	79	99	64	59.45	
sum % Cover (max. June/Sept.)	165	148	308	258	173	217	192	218	173	263	214	217	152	277	221	143	232	267	284	180	214.8	