WINGFIELD PINES WETLAND PLANT MONITORING REPORT
2017 SAMPLING SEASON

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ABSTRACT

The primary objective of the plant monitoring study at Wingfield Pines is to assess the restoration of the wetland at the southern end of the property, which began in 2009. Secondary objectives include the investigation of temporal and spatial changes in the herbaceous and woody plant communities due to succession, as well as, examining the impact of non-native species. The methods to achieve the objectives include: (1) randomly placed, permanent sampling plots measuring the abundance and diversity of herbaceous and woody plants, (2) growth measurements of sapling indicator species and (3) timed-meander surveys of wildflowers. Between 2010 and 2017, herbaceous plants exhibited a non-statistically significant correlation between species richness and spring precipitation. The dominant plants are creeping jenny (*Lysimachia nummularia*), blunt broom and fox sedges (*Carex tribuloides* and *C. vulpinoidea*), reed canary grass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*), which account for 62% of all herbaceous plants. Woody plant diversity and density peaked in 2012-13, and has since then resulted in little change. The dominant plants include eastern cottonwood (Populus deltoides), boxelder (*Acer negundo*) and American elm (*Ulmus americana*). The biotic integrity of the wetland plant community is assessed using the mean coefficient of conservatism and floristic quality index. The low scores for the coefficient and index, which average 2.8 out of 10 and 21, respectively between 2010 and 2017, suggest a disturbed community in early succession. This is confirmed by the species richness and dominant species of both herbaceous and woody plants. However, there is a steady increase in the coefficient and index since 2010, which indicates that succession is progressing. Furthermore, the abundance of non-native species is declining; but with an increase in coverage of reed canary grass and purple loosestrife. In conclusion, Wingfield Pines is still in its early stages of succession as shown by multiple measurements. Allowing the plant community to naturally progress is critical to the health of the wetland, as well as, proper management of non-native species.

INTRODUCTION

This report summarizes the wetland plant surveys conducted between 2010 and 2017 to assess the abundance, diversity and growth rates of herbaceous and woody plants at Wingfield Pines. Wingfield Pines is an 87-acre floodplain along Chartiers Creek managed by Allegheny Land Trust. The conservation area is located within the townships of Upper St. Clair and South Fayette in the southwestern corner of Allegheny County.

Wingfield Pines was purchased by Allegheny Land Trust in 2002. Previously, it was strip mined for coal in the mid-1900s and later became a golf course and swim club in the late 1900s. In 2009, a wetland treatment system was constructed at the northern end of Wingfield Pines, with the intent to remove iron from abandoned mine drainage originating from underground. A portion of the treatment system was constructed on an existing wetland. To prevent any net loss of wetland at Wingfield Pines, Allegheny Land Trust and partners restored the wetland at the southern end of the property. In 2009, nearly 500 woody plants of 21 different species were planted in an area of approximately 16 acres (**Fig. 1**).

Figure 1. Location of Wingfield Pines in Pennsylvania.

Since 2008, Matthew Opdyke, Associate Professor at Point Park University, has supervised annual plant surveys of the southern wetland to monitor restoration efforts. Annual sampling consists of measuring the abundance, dominance and diversity of

herbaceous and woody plants at permanent sampling plots, as well as, measuring the growth of sapling indicator species to assess the succession of woody plants. In addition to annual sampling, wildflower surveys are conducted in some years in the spring, summer and fall to assess changes in species and flowering periods. This study assists Allegheny Land Trust with meeting their conservation management objectives of Wingfield Pines and provides valuable teaching material for education purposes.

MATERIALS AND METHODS

Permanent Sampling Plots

Ten permanent sampling plots are randomly distributed throughout an area of 16 acres (0.065 km^2) at the southern end of Wingfield Pines (**Fig. 2**). On average, plots 1-4 and 8-9 are prone to flooding in the spring and soils remain somewhat- to moderately-saturated during the summer. Plots 5 and 6 are frequently flooded in the spring and soils are typically saturated year-round. Plots 7 and 10 are the driest plots, which may be saturated in the spring but are rarely flooded. While plots 1-4 and 8-9 are dominated by obligate and facultative wetland plants, plots 7 and 10 are dominated by facultative and facultative upland plants.

At each sampling plot, herbaceous plants are identified and their percent cover is estimated in a 9 ft^2 (0.8 m^2) subplot. The subplot is nested within a larger 4,310 ft^2 (400 m^2) plot, in which woody plants are identified and counted. A complete species count of herbaceous plants is also conducted in the larger, woody plant plots. Sampling is conducted in late June, unless flooding delays the sampling.

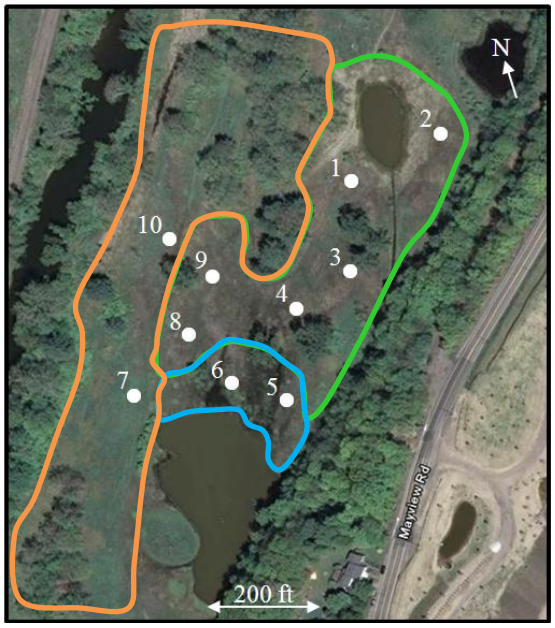

Figure 2. Location of permanent sampling plots in the southern wetland. Soil types are separated into three regions (blue = highly-saturated soils, green = moderately-saturated soils, orange = poorly-saturated soils).

Sapling Growth Study

In 2009, eight sapling indicator species were identified for inclusion in the sapling growth study, including planted and native-born saplings. By the following year, nearly 50% of planted saplings died, which resulted in the establishment of new criteria for choosing sapling species for the growth study. The criteria requires saplings to have a minimum height of 3.3 ft (1.0 m), exhibit healthy growth as well as the healthy growth of neighboring saplings of the same species and must be located in the southern wetland. Using these criteria, there are six sapling indicator species: American elm (*Ulmus americana*), American sycamore (*Platanus occidentalis*), balsam poplar (*Populus balsamifera*), boxelder (*Acer negundo*), pin oak (*Quercus palustris*) and silver maple

(*Acer saccharinum*). Only two of the fourteen pin oaks and two of the thirteen silver maples in the study were planted, all other saplings are native-born.

Sampling began in 2010 with approximately six individuals per sapling species. By 2012, the number of individuals per species increased to twelve. Saplings are marked by GPS coordinates and tagged for easy identification. Sapling height is measured from the ground to the tip of the highest leaf using a telescopic surveying rod for shorter saplings and a Suunto PM-5 clinometer for taller saplings. Trunk diameter is measured at 1.6 ft (0.50 m) above the ground for shorter saplings and again at diameter breast height (DBH) at 4.5 ft (1.4 m) above the ground for taller saplings using DBH tape. Measurements are taken in late June, unless flooding delays the sampling.

Wildflower Surveys

The timed-meander method is used to investigate changes in wildflower species and flowering periods as succession progresses. The southern end of Wingfield Pines is divided into two sampling areas based on the results of the permanent sampling plots (**Fig. 3**). The facultative wet area contains wildflowers classified within the complete spectrum of upland to wetland obligate species. The wet area contains plants that are predominantly facultative, facultative wetland and wetland obligate species.

The sampling areas are individually surveyed by meandering through them for approximately one hour per area; identifying all wildflowers in bloom. Sampling was conducted in May, June and September in 2012; in May and June in 2015; and in May, June and September in 2017.

Figure 4 provides an illustration of the complete sampling design for permanent sampling plots, sapling growth study and wildflower surveys.

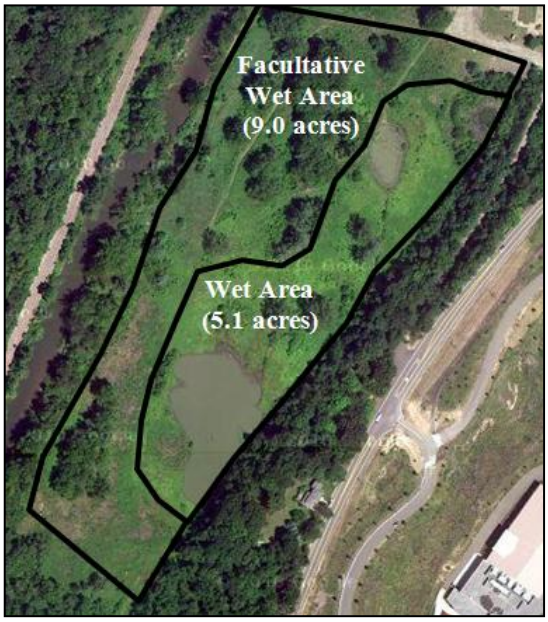

Figure 3. Location of the sampling areas used for the timed-meander wildflower surveys.

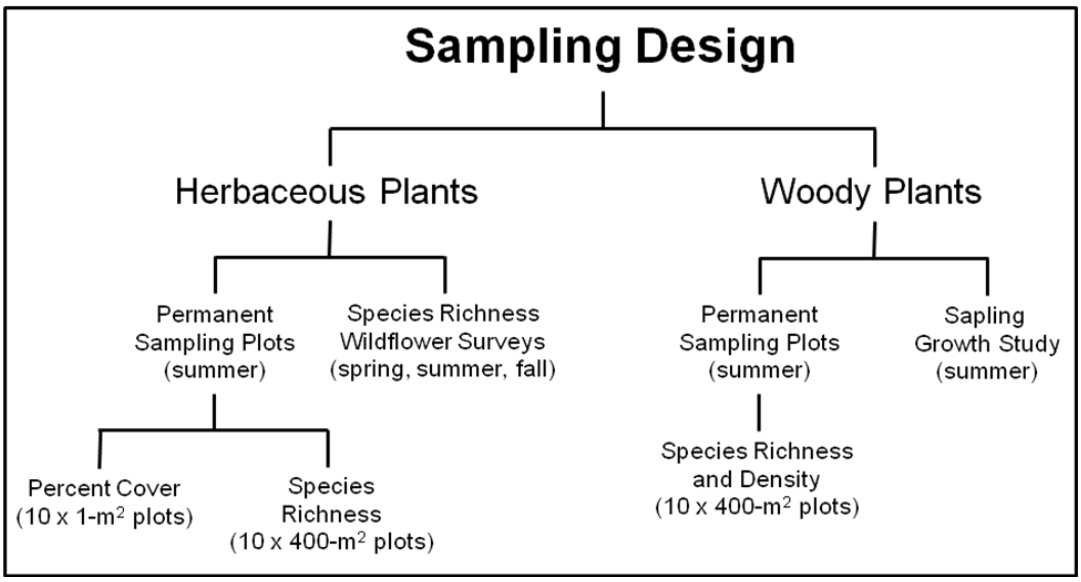

Figure 4. Sampling design including permanent sampling plots, sapling growth study and wildflower surveys.

Data Analysis

Species diversity of herbaceous and woody plants is represented by species richness, which is the total number of species identified from all sampling plots in a given year in the larger, 400-m^2 permanent sampling plots. Dominance of herbaceous plants is represented by their importance value, which is the mean of relative dominance (percent cover) and relative frequency in the smaller, 0.8-m^2 permanent sampling plots. Importance value ranges from 0 to 100%, with the dominant species having the greatest value. Dominance of woody plants is represented by their density in the larger, 400-m^2 permanent sampling plots.

Biotic integrity of the wetland plant community and succession are assessed using the mean coefficient of conservatism and floristic quality index. A coefficient of conservatism score, which ranges from 0 to 10, is applied to each native herbaceous and woody plant identified in larger, 400-m^2 permanent sampling plots. Plants with lower scores thrive in early stages of succession and are opportunistic invaders. Plants with higher scores thrive in later stages of succession and exhibit a narrow range of ecological tolerances. Mean coefficient of conservatism is the average scores of all plants identified in sampling plots in a given year. The floristic quality index multiplies the mean coefficient of conservatism by the sample size, which provides an analysis of the plant community in relation to species diversity.

RESULTS AND DISCUSSION

Permanent Sampling Plots: Herbaceous Plants

Figure 5 shows the diversity of herbaceous plants among the larger, 400-m^2 permanent sampling plots. Although there is no statistically significant trend between 2010 and 2017, the variability of species richness is somewhat impacted by April and May precipitation. There is a negative correlation between the two parameters, indicating that greater precipitation results in a decrease in species richness. Two of the wettest spring seasons, which occurred in 2011 and 2014 (total April and May precipitation = 25 and 22 cm, respectively), had the lowest species richness (50 and 49, respectively). Alternatively, one of the driest spring seasons, which occurred in 2016 (total April and May precipitation = 15 cm), had the highest species richness (63).

Spring precipitation affects species richness because it is a critical time period when plants are receiving water during their fastest periods of growth. Too little precipitation stunts their growth; while too much precipitation results in flooding, which negatively affects the growth of plants by reducing oxygen levels in the soil. The reason why there is no statistically significant trend is due to the complex life history of plants and plant succession, which results in changes in the plant community over time.

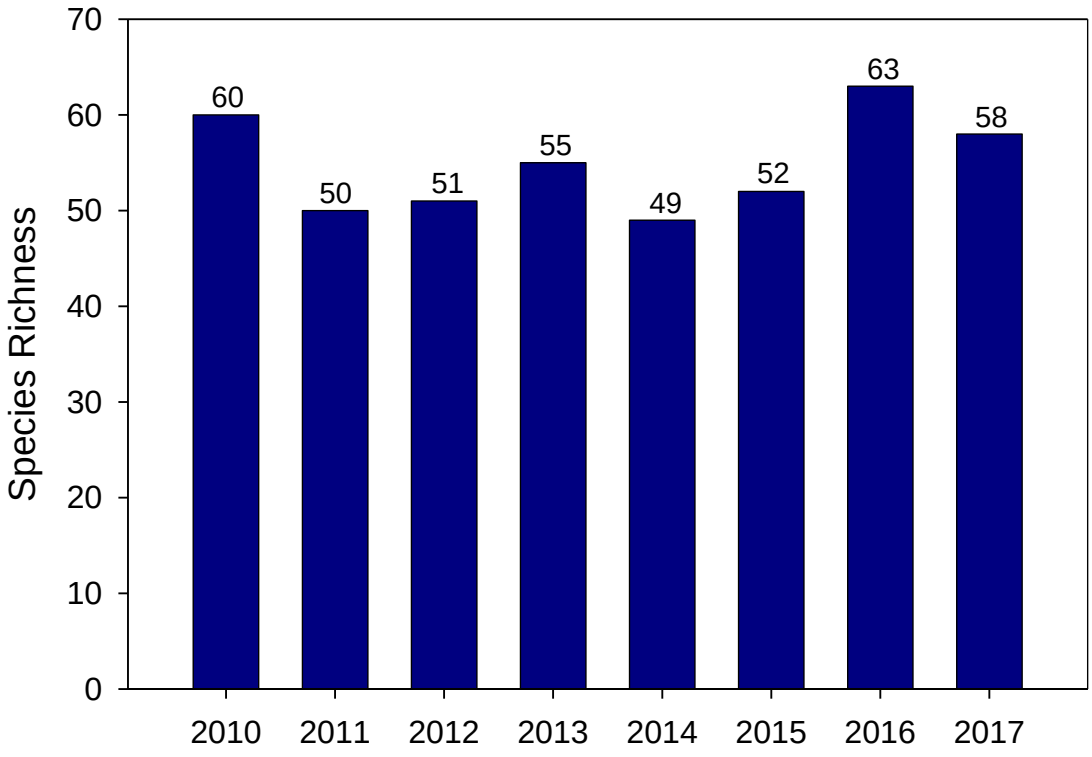

Figure 5. Total species richness of herbaceous plants in the larger, 400-m^2 permanent sampling plots.

In addition to the precipitation-species richness relationship, the wetland plant community is transitioning away from a facultative upland community toward a facultative wetland community. The modified Wentworth Index, which is based on the plants' dominance and wetland classification statuses, was 2.8 in 2010. By 2017, the

index value had steadily declined to 2.2. An index value above 4.0 indicates a predominance of upland plants, whereas, a value below 2.0 indicates a predominance of wetland plants. This transition indicates a successful restoration project as wetland plants replace those planted when Wingfield Pines was a golf and swim club.

Plant dominance is based on the mean importance values of plants between 2010 and 2017 surveyed from the smaller, 0.8-m^2 permanent sampling plots. The average make up of the plant community is 55% forbs and 45% graminoids. Creeping jenny (*Lysimachia nummularia*) has dominated the plant community since 2010 (**Table 1**). Its dominance is due to a wide tolerance for soil saturation and shade. Blunt broom and fox sedges (*Carex tribuloides* and *C. vulpinoidea*) are the only native species in the top four dominant plants. Its importance values have not changed in the past eight years. Reed canary grass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*) have both increased in dominance during the past eight years, having increased from 5% to 15%. Both plants grow exceptionally dense, preventing the growth of other plants.

Table 1. Mean species importance values of the dominant herbaceous plants that account for 62% of all herbaceous plants from the smaller, 0.8-m^2 permanent sampling plots.

Species	Life Form	Native Status	Mean Species Importance Value
Creeping Jenny (*Lysimachia nummularia*)	Forb	Introduced	23
Blunt Broom + Fox Sedges (*Carex tribuloides* + *C. Vulpinoidea*)	Graminoid	Native	19
Reed Canary Grass (*Phalaris arundinacea*)	Graminoid	Introduced	12
Purple Loosestrife (*Lythrum salicaria*)	Forb	Introduced	8

Permanent Sampling Plots: Woody Plants

Prior to planting shrubs and saplings during the 2009 restoration, woody plants had a species richness of 12 and density of 120 per 400-m^2. Both richness and density increased until approximately 2012, when competition for resources caused the community to stabilize. Little has changed in the richness and density of the woody plant community since 2013 (**Fig. 6**). Evidence of succession is starting to appear with changes in the dominance of individual species. Boxelder (*Acer negundo*), which is an early-succession species, is declining; and American elm (*Ulmus americana*), which is a mid-succession species, is increasing (**Table 2**). However, succession is a slow process that can take decades before any directional trend can be confirmed.

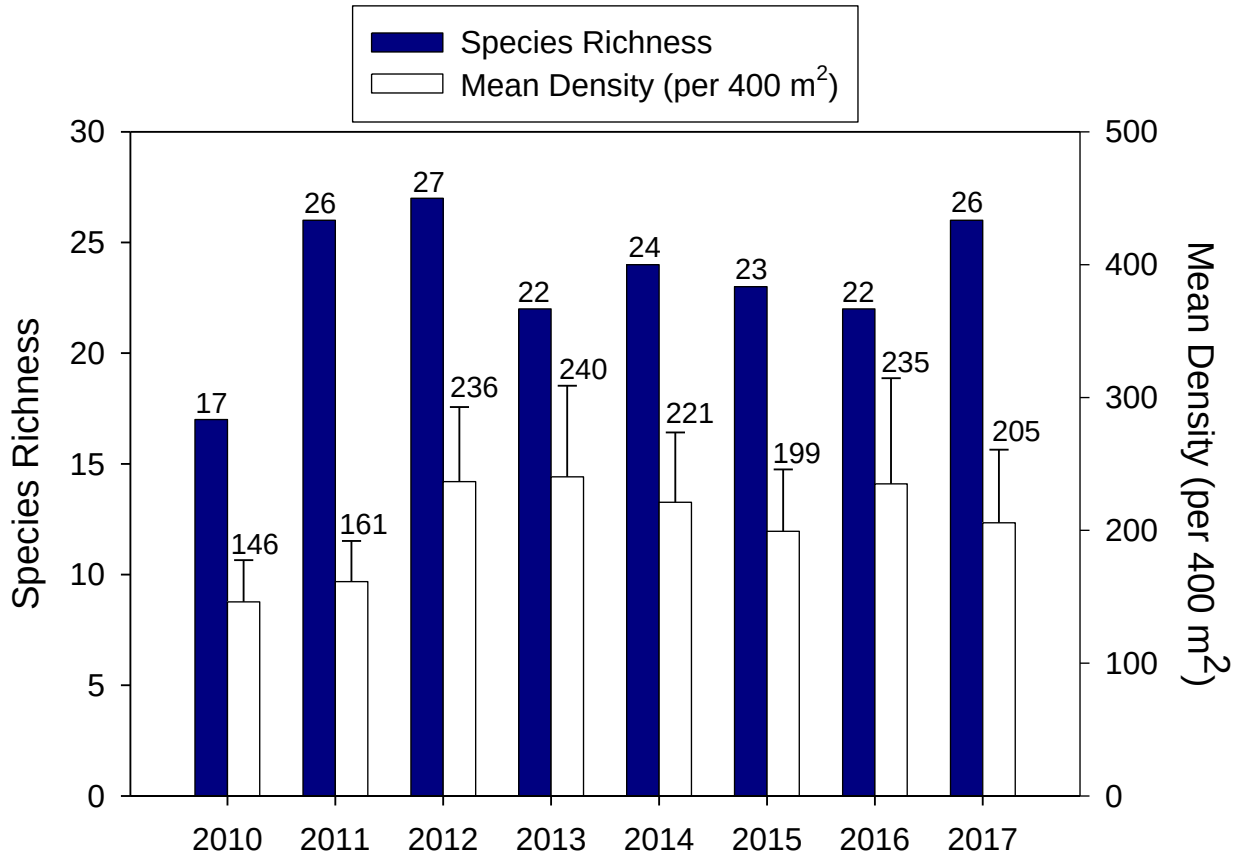

Figure 6. Total species richness and mean density of woody plants in the larger, 400-m^2 permanent sampling plots. Standard error is shown as vertical bars for mean density.

Table 2. Mean density per 400 m^2 of the three dominant woody plant species that account for 55% of all woody plants from the larger, 400-m^2 permanent sampling plots.

Species	2010	2011	2012	2013	2014	2015	2016	2017
Eastern Cottonwood (*Populus deltoides*)	3	1	71	82	62	51	91	69
Boxelder (*Acer negundo*)	86	77	80	67	63	57	49	53
American Elm (*Ulmus americana*)	35	51	56	57	63	59	66	52

Permanent Sampling Plots: Succession and Non-Native Plants

Combining measurements of herbaceous and woody plants from the larger, 400-m^2 permanent sampling plots is used to calculate the mean coefficient of conservatism and floristic quality index. These parameters allow an assessment of the biological integrity of the wetland plant community and confirm that succession is occurring.

The mean coefficient of conservatism is an average of all coefficient of conservative scores of native plants identified in the sampling plots. A coefficient score ranges from 0 to 10, with the lowest scores applied to ruderal species, which are highly

tolerant of disturbances. Ruderal species are equivalent to pioneer species that are the first to establish at disturbed sites. Higher scores are applied to climax species, which are better competitors for resources and intolerant of disturbances. Examples of species with low scores are annual ragweed (*Ambrosia artemisiifolia*) and boxelder, whereas, spreading dogbane (*Apocynum androsaemifolium*) and American sycamore have higher scores. The mean coefficient of conservatism between 2010 and 2017 is 2.8, which suggests that the plant community is dominated by early-succession species.

The floristic quality index provides a more informative description of the biological integrity of the plant community and species diversity by multiplying the mean coefficient of conservatism by the sample size. A site impacted by agriculture or urbanization has an average score of 18, whereas, an undisturbed forest or grassland has an average score of 33. The mean floristic quality index score between 2010 and 2017 is 21. **Figure 7** shows an increasing trend of the score since 2010, which supports the woody plant data that succession is progressing.

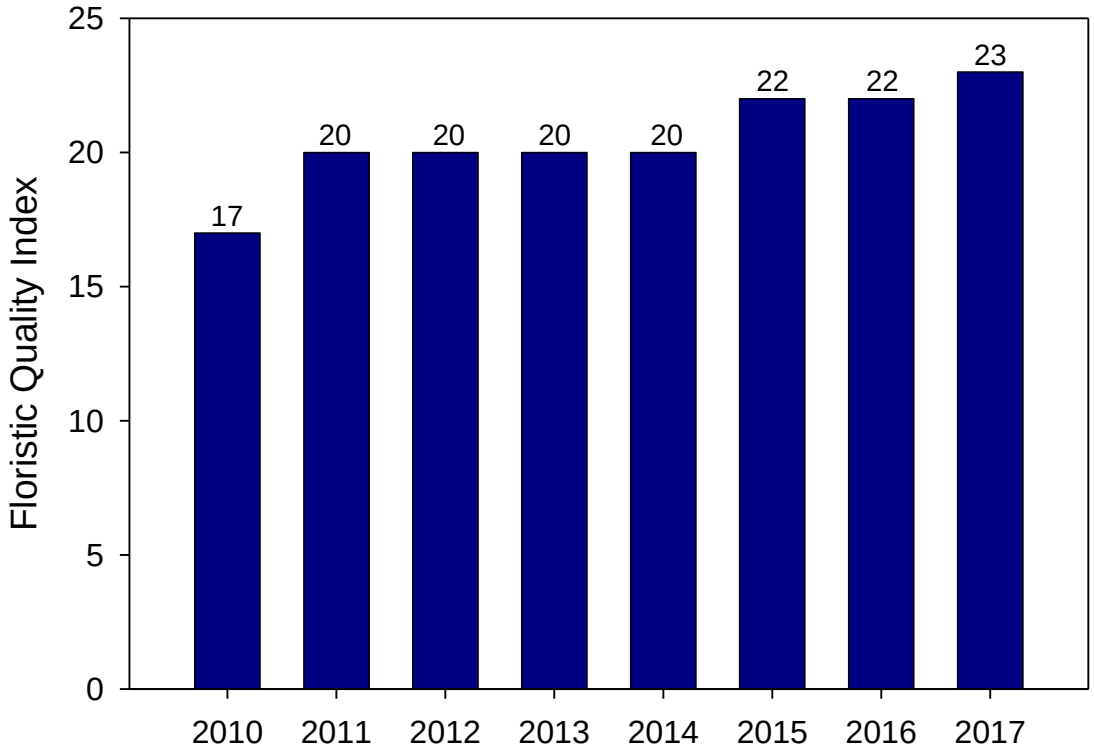

Figure 7. Floristic quality index scores calculated using herbaceous and woody plant measurements from the larger, 400-m^2 permanent sampling plots.

The conservation status of the plant community as indicated by the mean coefficient of conservatism and floristic quality index is a disturbed, urban site. One of the greatest challenges of wetland restoration, particularly in urban wetlands, is the management of non-natives. There are few non-native woody plants at Wingfield Pines but several herbaceous plants are not native to the northeast. However, the dominance of non-native species has declined from 47% in 2010 to 29% in 2017. This decline is in response to the management of the non-natives and succession. The two most

aggressive non-native species, reed canary grass and purple loosestrife, continue to expand their percent coverage. Reed canary grass has doubled its coverage since 2010 to 44% of sampling plots and purple loosestrife has increased by a magnitude of 50 since 2010 to 21% of sampling plots.

Sapling Indicator Species

American sycamore, balsam poplar and pin oak are among the fastest growing saplings. Their mean growth in height during the first eight years is 2.5 ft (0.75 m) and their mean growth in diameter at 0.5 m above the ground is 0.4 in (9 mm). Boxelder had a comparable growth rate for the first three years, which began declining afterward. Its mean growth in height during the first eight years is 1.4 ft (0.44 m) and its mean growth in diameter at 0.5 m above the ground is 0.2 in (6 mm). There is not enough data to compare the American elm and silver maples.

Boxelder is a pioneer species; and the other indicator species are early- to mid-succession species. While only two of the twelve individual boxelder plants surveyed have died since 2009, their general health has gone from good to fair. The decline in boxelder is further evidence of succession supported by the permanent sampling plots. The success of American elm, American sycamore, balsam poplar, pin oak and silver maple indicate that these saplings are excellent species for restoring an urban wetland such as Wingfield Pines. As further data is collected, changes in their growth rates will be used to assess the impact on growth from flooding and other environmental factors.

Wildflower Surveys

The greatest diversity of wildflowers occurred in July, compared to May and September (**Table 3**). The July sampling date also exhibited the best scores for mean coefficient of conservatism and floristic quality index, however, scores in all three sampling dates suggest a disturbed plant community. As expected, fewer species were identified in the wet area compared to the facultative wet area. Compared to 2012 and 2015, species richness has declined in the wet area in September, while species richness has steadily increased in the facultative wet area in July.

Beyond pointing out that nearly 60 different wildflower species are found in the southern wetland in the summer and approximately half that in the spring and fall, more data is required to draw any conclusions as to the trends of wildflower species or their blooming periods.

Table 3. Species diversity and wetland plant community biotic integrity metrics for wildflower surveys conducted on May 22, July 21 and September 29 of 2017.

Sampling Date	Species Richness		Percent of Species Introduced		Mean Coefficient of Conservatism		Floristic Quality Index	
	Fac. Wet	Wet	Fac. Wet	Wet	Fac. Wet	Wet	Fac. Wet	Wet
May 22	34	13	68	69	2.4	2.7	8	5
July 21	62	25	45	36	2.7	2.9	16	12
September 29	26	4	23	0	1.9	2.0	9	4

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APPENDIX

Herbaceous wildflowers in bloom identified during the 2017 wildflower surveys. Sampling periods wildflowers were found are abbreviated: May (M), July (J) and September (S). Coefficient of conservatism values are provided for native plants.

Common Name	Scientific Name	Sampling Period	Native (N) or Introduced (I)	Coeff. of Conserv.
Alfalfa	*Medicago sativa*	J	I	
Allegheny Blackberry	*Rubus allegheniensis*	M	N	1
Allegheny Monkeyflower	*Mimulus ringens*	J	N	4
American Bellflower	*Campanulastrum americanum*	J	N	4
American Water Horehound	*Lycopus americanus*	J	N	3
Annual Ragweed	*Ambrosia artemisiifolia*	S	N	0
Beggarslice	*Hackelia virginiana*	J	N	2
Bird's-foot Trefoil	*Lotus corniculatus vcorniculatus*	J	I	
Bird Vetch	*Vicia cracca*	M	I	
Black Raspberry	*Rubus occidentalis*	M	N	1
Blue Skullcap	*Scutellaria lateriflora*	J	N	3
Bouncingbet	*Saponaria officinalis*	J	I	
Calico Aster	*Symphyotrichum lateriflorum*	S	N	2
Canada Goldenrod	*Solidago altissima*	J/S	N	1
Canada Thistle	*Cirsium arvense*	J	I	
Canadian Clearweed	*Pilea pumila*	S	N	2
Canadian Honewort	*Cryptotaenia canadensis*	M	N	3
Chicory	*Cichorium intybus*	J/S	I	
Clustered Blacksnakeroot	*Sanicula odorata*	M	N	3
Common Boneset	*Eupatorium perfoliatum*	J	N	3
Common Chickweed	*Stellaria media*	M	I	
Common Cinquefoil	*Potentilla simplex*	M	N	1
Common Comfrey	*Symphytum officinale*	M	I	
Common Cowparsnip	*Heracleum maximum*	M	N	4
Common Dandelion	*Taraxacum officinale*	M/J	I	
Common Evening Primrose	*Oenothera biennis*	S	N	1
Common Milkweed	*Asclepias syriaca*	J	N	1
Common Plantain	*Plantago major*	J	I	
Common Selfheal	*Prunella vulgaris*	J	N	0
Common St. Johnswort	*Hypericum perforatum*	J	I	
Common Yarrow	*Achillea millefolium*	M/J	I	
Common Yellow Oxalis	*Oxalis stricta*	M/J/S	N	0
Creeping Buttercup	*Ranunculus repens*	M	I	
Creeping Jenny	*Lysimachia nummularia*	M/J	I	
Crownvetch	*Securigera varia*	J/S	I	
Curly Dock	*Rumex crispus*	M/J	I	
Dames Rocket	*Hesperis matronalis*	M/J	I	
Deptford Pink	*Dianthus armeria*	J	I	
Eastern Daisy Fleabane	*Erigeron annuus*	J	N	0
Fall Phlox	*Phlox paniculata*	S	N	2

Field Clover	*Trifolium campestre*	M	I	
Fringed Loosestrife	*Lysimachia ciliata*	J	N	
Fuller's Teasel	*Dipsacus fullonum*	J	I	
Garden Yellowrocket	*Barbarea vulgaris*	M	I	
Garlic Mustard	*Alliaria petiolata*	M	I	
Ground Ivy	*Glechoma hederacea*	M	I	
Harvestlice	*Agrimonia parviflora*	J	N	2
Indian Strawberry	*Duchesnea indica*	M	I	
Indian-tobacco	*Lobelia inflata*	J/S	N	1
Jeruseleum Artichoke	*Helianthus tuberosus*	S	N	3
Jewelweed	*Impatiens capensis*	J	N	2
Jumpseed	*Polygonum virginianum*	J	N	3
King of the Meadow	*Thalictrum pubescens*	J	N	5
Longleaf Groundcherry	*Physalis longifolia*	J	N	1
Narrowleaf Plantain	*Plantago lanceolata*	M/J	I	
New England Aster	*Symphyotrichum novae-angliae*	S	N	2
Nightflowering Silene	*Silene noctiflora*	J	I	
Norwegian Cinquefoil	*Potentilla norvegica*	J	N	1
Orange Coneflower	*Rudbeckia fulgida*	J	N	6
Oriental Lady's Thumb	*Polygonum cespitosum*	S	I	
Oxeye Daisy	*Leucanthemum vulgare*	M/J	I	
Pale Touch Me Not	*Impatiens pallida*	J	N	3
Paleyellow Iris	*Iris pseudacorus*	M	I	
Pennsylvania Smartweed	*Polygonum pensylvanicum*	S	N	0
Perennial Pea	*Lathyrus latifolius*	J	I	
Philadelphia Fleabane	*Erigeron philadelphicus*	M	N	2
Poison Hemlock	*Conium maculatum*	M/J	I	
Purpleleaf Willowherb	*Epilobium coloratum*	S	N	1
Purple Loosestrife	*Lythrum salicaria*	J	I	
Queen Anne's Lace	*Daucus carota*	J/S	I	
Red Clover	*Trifolium pratense*	M/J/S	I	
Rough-stemmed Goldenrod	*Solidago rugosa*	S	N	2
Short's Aster	*Symphyotrichum shortii*	S	N	4
Smallspike False Nettle	*Boehmeria cylindrica*	J	N	4
Smooth Oxeye	*Heliopsis helianthoides*	J	N	5
Spotted Ladysthumb	*Polygonum persicaria*	J	I	
Spreading Dogbane	*Apocynum androsaemifolium*	J	N	6
Sticky-Willy	*Galium aparine*	M	N	0
Stiff Marsh Bedstraw	*Galium tinctorium*	J	N	4
Stinging Nettle	*Urtica dioica*	J/S	I	
Striped Cream Violet	*Viola striata*	M	N	5
Swamp Dock	*Rumex verticillatus*	M	N	6
Swamp Smartweed	*Polygonum hydropiperoides*	S	N	6
Swamp Milkweed	*Asclepias incarnata*	J	N	4
Sweetclover	*Melilotus officinalis*	M/J	I	
Thicket Bean	*Phaseolus polystachios*	J	N	3
Thymeleaf Sandwort	*Arenaria serpyllifolia*	M	I	
True Forget-me-not	*Myosotis scorpioides*	M/J	I	
Virginia Threeseed Mercury	*Acalypha virginica*	J	N	2
White Avens	*Geum canadense*	J/S	N	2

White Clover	*Trifolium repens*	M/J/S	I	
White Heath Aster	*Symphyotrichum ericoides*	S	N	2
White Panicle Aster	*Symphyotrichum lanceolatum*	J/S	N	3
White Snakeroot	*Ageratina altissima*	S	N	3
White Vervain	*Verbena urticifolia*	J	N	3
Wild Basil	*Clinopodium vulgare*	J	N	2
Wild Bergamot	*Monarda fistulosa*	J	N	3
Wild Garlic	*Allium vineale*	J	I	
Wild Parsnip	*Pastinaca sativa*	M/J	I	
Wingstem	*Verbesina alternifolia*	J	N	5