

Survey of Taltree Arboretum & Gardens Vegetation: Final Field Report

Submitted to

Taltree Arboretum & Gardens Foundation

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Introduction

Taltree Arboretum & Gardens is located in Valparaiso, Indiana, covering approximately 150 hectares (360 acres) of woodlands, prairie and oak-savanna, gardens, and supporting facilities. The Taltree woodlands are typical of secondary growth after abandonment of agricultural practice. Also, a significant portion of the old field has been converted to prairie through introduction of seeds of native species during 1996 – 2000. Despite the Arboretum's significance in terms of botanical and ecological interest, little is known about the plant species that occur in the woodland. Also, the number and composition of the established species in the restored prairie after the propagation of the seeds of native species have not fully been investigated yet. Purdue University Calumet, upon a contract with Taltree, has conducted a survey of flora in the woodlands, restored prairie, and old field during 2008 - 2009. This report describes the survey methods, results, general assessment, and recommendations for the management of the woodlands and restored prairie.

Methods

Woodland: The woodland was divided into five areas:

- 1) Heron Pond Woodland North is located between the founder's residence and the Heron Pond.
- 2) Heron Pond Woodland South is located south of the main office, along County Road 500 West.
- 3) Eastern Woodland West is west of the savanna wetland.
- 4) Eastern Woodland East is located east of the reforestation area.
- 5) Riparian Woodland is located in the southwestern corner of the prairie.

A total of 12 transects were established. Three transects traversed from west to east in the Heron Pond Woodland North (Transects W1, W2 & W3AB) and two transects ran from north to south in the Heron Pond Woodland South (W4 & W5). One transect ran from south to north in the Eastern Woodland West (W6), and four north-south transects were set in the Eastern Woodland East (W9, W10, W11 & W12). Two continuous transects followed the running direction of the valley contour in the Riparian Woodland (W7 & W8). Permanent sample plots were established from the beginning to the end of each transect at 30 meter intervals. This yielded a total of 124 sample plots (Figure 1).

All vascular plants that occurred in the sample plots were identified as to species and sorted into three layers: overstory/understory trees, shrubs, and herbaceous plants. Overstory and understory trees included those whose woody stems had apparent central trunks or stems with a DBH (diameter at breast height) of 5 cm or greater. Shrubs included individuals of multiple stems without a central trunk, spreading or climbing stems, and tree seedlings (diameter at stem base < 5 cm). Density and basal area of each overstory/understory tree and shrub species were determined in 10 m x 10 m and 2 m x 2 m square grid, respectively, in each sample plot. Basal area of each trunk/stem was calculated by multiplying π by the squared value of stem/trunk radius. The radius was measured at breast height (1.2 m from ground surface) for each overstory/understory tree trunk and at the base of each shrub stem. The importance value (IV) of each overstory/understory tree species was calculated by adding relative dominance (100 x fraction of each species basal area to total basal area) and relative density (100 x fraction of each species density to total density) in each plot. These values were then fed to a data

matrix for DCA (Detrended Correspondence Analysis) ordination. The species with fewer than IV of 1 were excluded from the DCA. In addition, one-way analysis of variance (ANOVA), followed by Tukey Test at $\alpha = 0.05$, was used to compare the stem densities of non-native shrubs in the Heron Pond Woodland North and South, the Eastern Woodland East and West, and the Riparian Woodland.

Ground covers by the foliage of two major shrub species (*Parthenocissus quinquefolia* – Virginia creeper; *Rosa multiflora* – multiflora rose) were determined in 15 randomly-selected plots. In each plot, cover of each plant species was estimated by counting hitting frequency of the plant to a wooden stick (2 cm x 2 cm x 150 cm) that was lowered at 100 points within the 2 m x 2 m square. Models of linear regression were constructed based on the correlations between stem density and ground cover by foliage. Ground covers by foliage of the two species were then calculated by plugging their stem densities in the models for the other plots.

Herbaceous species included all individuals with non-woody stems. Cover of all herbaceous species was estimated by counting hitting frequency of the plant to a wooden stick (2 cm x 2 cm x 150 cm) that was lowered at 100 points within each of the 2 m x 2 m grid. One-way analysis of variance (ANOVA), followed by Tukey Test at $\alpha = 0.05$, was used to compare the hitting frequencies of non-native herbaceous species in the Heron Pond Woodland North and South, the Eastern Woodland East and West, and the Riparian Woodland.

Prairie and Old Field: A total of eight transects were established in the restored prairie, running from north to south. One transect was established in the area which was seeded in 1996 (Transect P1). The area that was seeded in 1998 had six transects (P2, P3, P7, P8, P9 & P10), and the area that was seeded in 2000 had two transects (P4 & P5). Three transects were set in the old field, located north of East Woodland East (O1, O2 & O3), running from south to north. Permanent sample plots (2 m x 2 m) were established from the beginning to the end of each transect at 20 m intervals, yielding a total of 98 plots in the prairie and 15 plots in the old field (Figure 1). All plant species in each plot were identified as to species. Cover of all species was estimated by counting hitting frequency of the plant to a wooden stick (2 cm x 2 cm x 150 cm) that was lowered at 100 points within each plot. The cover values from the prairie and old field were then fed into a data matrix for DCA ordination. Target community for the restored prairie vegetation was assembled based on the species compositions of initial seed mix (Table 1) that were sown during 1996 – 2000. The species with less than 1% cover were excluded from the DCA.

Results

Woodlands

Overstory and understory trees: A total of 39 species (37 native and 2 non-native) were identified. Mean (\pm standard error) density was $180,000 \pm 12,404$ trunks and stems per hectare, covering $0.33 \pm 0.02\%$ of the ground surface ($33 \pm 2 \text{ m}^2 \cdot \text{ha}^{-1}$). *Prunus serotina* (black cherry) covered the largest basal area (26% of the total basal area), followed by *Carya ovata* (shagbark hickory; 17%), *Quercus ellipsoidalis* (Hill's oak; 9%), and *Quercus macrocarpa* (bur oak; 8%). *Crataegus mollis* (red haw) showed the highest density (22% of the total density), followed by *C. ovata* (17%) and *P. serotina* (15%). The two exotic understory species (*Lonicera tatarica* – bush honeysuckle and *Eleagnus angustifolia* –

Russian olive) took less than 1% of the total basal area and 4% of the total density (Table 2). The largest tree trunk was an individual of *Q. macrocarpa* (DBH 100 cm) that was found in one of the plots in the Riparian Woodland, followed by a *Q. alba* (DBH 87 cm) in the Eastern Woodland West, and a *Q. ellipsoidalis* (DBH 73 cm) in the Heron Pond Woodland North. Based on the DBH's, these trees are estimated to be 200-250, 150-200, and 100-150 years old, respectively.

As stated, a majority of the woodland plots were dominated by *Prunus serotina*, and this species is located in the center of DCA ordination graph (Figure 2). From this point, three major succession trajectories were revealed—two toward upland communities and one toward swamp community. The two upland communities were dominated by *Quercus velutina*, *Q. ellipsoidalis*, and *Carya ovata* (the lower-left part of Figure 2), and *Juglans nigra* (black walnut) and *Q. macrocarpa* (the upper-left part of Figure 2). The swamp community was a depression dominated by *Cephalanthus occidentalis* (button bush) and *Salix* spp. (willow) in the middle-right side of Figure 2. Meanwhile, Riparian plots, dominated by *Acer negundo* (boxelder), were located on the trajectory path to the swamp community.

Shrubs: A total 28 species were found in the shrub layer. Of these species, 25 were native and 3 were non-native to eastern North America. Mean (\pm standard error) density was 397,175 stems per hectare. *Parthenocissus quinquefolia* (Virginia creeper) and *Rosa multiflora* (multiflora rose) constituted 90% of the total stem density. The three exotic shrub species (*R. multiflora*, *Berberis thunbergii* – Japanese barberry, and *Lonicera tatarica* – bush honeysuckle) took approximately 10% of the total density (Table 3).

Although the shrub basal area covered only $0.04 \pm 1\%$ of the ground surface ($4 \pm 1 \text{ m}^2 \cdot \text{ha}^{-1}$), their foliage cover was extensive. Table 4 shows the regression models for *Parthenocissus quinquefolia* and *Rosa multiflora*. Following these models, the foliage of the two species dominated the Taltree woodland ground layer, covering 48% (*Parthenocissus*) and 47% (*Rosa*). Of the stem densities of the three non-native species, *R. multiflora* was highest in the Heron Pond Woodland South (Transects 4 & 5; $199,570 \pm 42,643 \text{ stems} \cdot \text{ha}^{-1}$), followed by the Eastern Woodland East (Transects 9 – 12; $176,350 \pm 27,141 \text{ stems} \cdot \text{ha}^{-1}$), the Heron Pond Woodland North (Transects 1 – 3; $134,480 \pm 43,450 \text{ stems} \cdot \text{ha}^{-1}$), and the Riparian Woodland (Transects 7 & 8; $50,000 \pm 24,842 \text{ stems} \cdot \text{ha}^{-1}$). However, the differences of non-native stem densities among the four areas were not significant statistically.

Herbaceous plants: A total of 66 species (42 native and 24 non-native) occurred on $58.1 \pm 5.1\%$ of the 12,400 survey points in the 124 woodland floor plots. Two non-native species (*Alliaria officinalis* – garlic mustard and *Polygonum cuspidatum* – Japanese knotweed) were most common on the woodland floor, and another non-native, *Phalaris arundinacea* (reed canary grass), dominated the herbaceous layer of buttonbush swamp within the Heron Pond Woodland. A few patches of native sedges (e.g., *Carex stricta* – tussock sedge) were found within the *P. arundinacea* stands. The 24 exotic species shared nearly 50% of the total hitting frequency. *Impatiens* spp. (touch-me-not), followed by *Geum aleppicum* (yellow avens) and *Sanicula gregaria* (clustered snakeroot), were the most common native species (Table 5). Occurrences of the 24 non-native herbaceous species were significantly higher ($p < 0.05$) in the Riparian Woodland and the Heron Pond Woodland South than in the Eastern Woodland (East and West) and the Heron Pond Woodland North (Figure 2). *Allium vineale* (wild garlic) was the most common non-native species in the Riparian Woodland ($26.6 \pm 10.3\%$), and *A. officinalis* was most common in the

Heron Pond Woodland South ($43.7 \pm 8.6\%$). Meanwhile, *P. cuspidatum* was most common in the Heron Pond Woodland North ($6.2 \pm 1.2\%$), Eastern Woodland West (8.4 ± 2.0), and Eastern Woodland East (3.5 ± 1.0).

Prairie and Old Field

Prairie: A total of 84 species were found with mean (\pm standard error) hitting frequency of $211.9 \pm 4.9\%$. This means that 2.11 species hit the stick on average in 9,800 survey points. Of the 85 species, 44 were in the list of the species that were sown in 1996-2000 and 41 occurred voluntarily in the restored prairie. These 44 species constitute 88% of the 50 species (Table 6) that were sown during the period of 1996-2000. The combined hitting frequencies of the 44 species were 168% (79% of the total hitting frequency). *Andropogon gerardii* (big bluestem) was the most common species, comprising 26% of the total hitting frequency. *Solidago* spp. (goldenrod) *Monarda fistulosa* (wild bergamot), and *Eryngium yuccifolium* (rattlesnake master) took 20%, 10%, and 6% of the total hitting frequency, respectively. Thirty of the 41 voluntary species were not native to eastern North America. These 30 non-native species shared approximately 17% of the total hitting frequency. *Poa* spp. (bluegrasses), *Agrostis alba* (redtop grass), and *Trifolium* spp. (clovers) were the most common non-native species (Table 6).

Old Field: A total of 28 species (12 native and 16 non-native), with mean (\pm standard error) hitting frequency of $230.7 \pm 13.7\%$, were found in the 15 old field plots. *Solidago* spp., followed by three non-native grasses (*Poa* spp., *Phalaris arundinacea*, and *Dactylis glomerata* – orchard grass), showed the highest hitting frequency. The 16 non-native species comprised over 60% of the total hitting frequency (Table 7).

Vegetation Trajectory: The DCA ordination in Figure 3 clearly suggests a divergence of the vegetation in the restored prairie plots (signified with letters A, B & C) from the old field plots (signified with the letter O in the middle left). The older plots in particular (“A” plots in the upper-right; restored in 1996) are located in closer proximity to the target community (signified with the letter “T” in the middle right), whereas the recent plots (“C” plots in the lower-left; restored in 2000) are closer to the old field community.

Discussion and Recommendations

Woodlands

The Taltree woodlands are best characterized as secondary growth. The estimated ages of the larger *Quercus* trunks suggest that the woodland probably began to develop 150 -200 years ago. Also, the woodlands are in a divergent stage from the dominance of *Prunus serotina* to the co-dominance of *Quercus-Carya* and *Juglans*. In addition, small packets of swamps are dominated by *Cephalanthus occidentalis* and *Salix* spp. (Table 2 and Figure 2). Extensive occurrence of *Quercus ellipsoidalis* may be a unique characteristic of the Taltree woodlands. Although it has been reported to occur in glacial outwash areas throughout the upper Midwest, occurrences of *Q. ellipsoidalis* are not common in northwestern Indiana. The overstory vegetation is in fairly good condition as reflected by the absence of non-native species. The presence of non-native species (*Lonicera tatarica* and *Eleagnus angustifolia*)

was not extensive in the understory layer. However, these species may pose a threat of further expansion and therefore need to be removed.

Infestation of *Rosa multiflora* in the shrub layer is a major concern (Table 3). This species not only competes against native shrubs but also chokes native tree seedlings and herbaceous species by blocking sunlight. Indeed, the density of native tree seedlings was very low in the Taltree woodland floors. The mean seedling density of *Carya ovata* was merely 1,680 stems per hectare, less than 6% of its canopy tree density (30,081 stems ha⁻¹). The combined mean density of *Quercus ellipsoidalis*, *Q. macrocarpa*, and *Q. velutina* was 100 stems per hectare, less than 2% of their canopy tree density. No seedlings of *Juglans nigra* were found on the woodland floor, while its mean canopy tree density recorded 2,661 stems per hectare (Tables 1 and 2). Without such seedlings, *Carya*, *Juglans*, and *Quercus* may not sustain their dominance in the near future. Therefore, removal of *R. multiflora* is essential to encourage native tree seedlings to grow. Presence of other non-native shrubs (*Berberis thunbergii*, *Lonicera tatarica*, and *Morus alba*) was not as extensive as *R. multiflora*. However, these species also need to be removed to prevent further expansion. In addition, although not occurring in our study plot, we spotted *Celastrus orbiculatus* (Asiatic bittersweet) in a side trail off the Bluebird Trail in the east of the Savanna Wetland. Infestations by the invasive exotic species were particularly visible on the edges of the woodland and lower elevations where the water table was likely high. For example, we observed heavy infestations of these species near the drainage ditches in the Heron Pond Woodland South. In the Eastern Woodland East, the occurrence of these species was concentrated in the drainage ditch in the eastern and southern ends. We recommend these areas to be the highest priority for removal of exotic species.

The herbaceous layer of the Taltree woodlands also suffers seriously from infestation of non-native species. Particularly, *Alliaria officinalis*, *Polygonum cuspidatum*, and *Phalaris arundinacea* occurred extensively throughout the woodlands (Table 5). Like *R. multiflora*, infestation of *A. officinalis* and *P. cuspidatum* was concentrated in low elevations where the water table was likely high. The occurrence of *A. officinalis* was prevalent in the Heron Pond Woodland South and the Riparian Woodland (Figure 3). *P. arundinacea* is virtually taking over the sedge meadows near the buttonbush swamps in the Heron Pond Woodland North and South. No native sedges were found in the Heron Pond Woodland South, although a few small pockets of *Carex stricta* (tussock sedge) still remained in Heron Pond Woodland North. We also found a few *Typha* spp. (cattails). These cattails could be either *T. angustifolia* (narrow-leaved cattail) or *T. x glauca* (hybrid cattail). We were not able to identify this plant as to species because only molecular techniques in a laboratory can tell the difference between the two. Regardless, both are non-natives that spread aggressively in the wetlands of eastern North America. Actually we found a quite an extensive occurrence of the *Typha* spp. along the shorelines of the Savanna Wetland. These cattails, which could either be *T. angustifolia* (narrow-leaved cattail) or *T. x glauca* (hybrid cattail), must be contained. The Eastern Woodlands (both East and West) still contain significant numbers of native species (e.g., *Actaea pachypoda* - white baneberry, *Arisaema triphyllum* – jack-in-the-pulpit, *Thalictrum thalictroides* – rue anemone, *Trillium grandifolium* – large-flowered trillium and *Polemonium van-bruntiae* – Jacob's ladder; Table 5). Special attention is needed to protect these elements from the encroachment of invasive exotic species.

Prairie

Introduction of the native species during 1996, 1998 and 2000 have successfully converted the old field to prairie vegetation (Figure 4). As stated earlier, nearly 90% of the introduced native species (with seeds) established their presence, taking nearly 80% of the total hitting frequency. However, many species emerged not necessarily in proportion to the species composition of the seed mix. For example, both *Veronicastrum virginicum* (Culver's root) and *Sorghastrum nutans* (Indian grass) comprised approximately 20% of the total seed mix (Table 1). However their hitting frequencies were less than 1% of the total. Meanwhile, the ratio of *Andropogon gerardii*, *Solidago* spp. and *Monarda fistulosa* in the prairie vegetation has far exceeded its original proportions in the seed mix (Table 1 and 6). There is a need to find a way to balance the dominance among the introduced native species because excessively high dominance by a few species may lead to reduction in species diversity.

Extensive presence of non-native species (e.g., *Poa* spp., *Agrostis alba*, and *Trifolium* spp.) is another concern. These species usually occur in the lower layer under the tall prairie plants and would likely expand their dominance once the top layer of the prairie vegetation is removed. Therefore, it is critically important to maintain the dominance of tall prairie plants to discourage the expansion of non-native species. Periodic burning, spot herbicide treatment and mechanical removal (e.g., hand-pulling) may also prevent the expansion of non-native species.

Summary

The Taltree woodlands are represented by the overstory canopy of *Prunus serotina*, *Quercus* spp., *Carya ovata*, and *Juglans nigra* with scattered spots of swamps that are dominated by *Cephalanthus occidentalis* and *Salix* spp. The unusually high density of *Quercus ellipsoidalis* and the extensive presence of native herbaceous species (e.g., *Actaea pachypoda*, *Arisaema triphyllum*, *Thalictrum thalictroides*, *Trillium grandiflorum*, and *Polemonium van-bruntiae*) in portions of the woodlands are notable for conservation of floral heritage and diversity. However, infestations by non-native species such as *Rosa multiflora*, *Alliaria officinalis*, *Polygonum cuspidatum*, and *Phalaris arundinacea* are a major threat to the native flora of Taltree. Introduction of native species (with seeds) from 1996-2000 has successfully converted the old field to prairie vegetation. Although the prairie vegetation seems in the due course of restoration trajectory, only a handful of the introduced native species (e.g., *Andropogon gerardii*, *Solidago* spp. and *Monarda fistulosa*) dominate the restored prairie vegetation excessively. Also, extensive presence of non-native species (e.g., *Poa* spp., *Agrostis alba* and *Trifolium* spp.) poses a threat of expansion in the restored prairie. A long-term monitoring (per se every 4-5 years) is needed to better understand the successional trends, including the dynamics of non-native vegetation, in both woodlands and restored prairie.

Table 1. Species composition of seed mixes*, with estimated number of seeds for each species, which were sown in 1996, 1998, and 2000.

Species	Number of seeds X 1,000 (%composition in parenthesis)			
	1996	1998	2000	Total
<i>Veronicastrum virginicum</i>	750 (13%)	24,000 (19.5%)	4,500 (27.5%)	29,250
<i>Sorghastrum nutans</i>	1328 (23%)	22,756 (18.3%)	2,656 (16.2%)	26,560
<i>Andropogon gerardii</i>	1,312 (22.7%)	22,304 (18.1%)	2,624 (16%)	26,240
<i>Schizachyrium scoparium</i>	704 (12.2%)	19,712 (16%)	1,408 (8.6%)	21,824
<i>Sporobolus heterolepis</i>	0	6,720 (5.4%)	896 (5.5%)	7,616
<i>Rudbeckia hirta</i>	300 (5.2%)	4,800 (3.9%)	800 (4.9%)	5,900
<i>Monarda fistulosa</i>	156 (2.7%)	4,992 (4.1%)	390 (2.4%)	5,538
<i>Aster novae-angliae</i>	140 (2.4%)	2,800 (2.3%)	700 (4.3%)	3,640
<i>Solidago rigida</i>	138 (2.4%)	2,208 (1.8%)	368 (2.3%)	2,714
<i>Ratibida pinnata</i>	81 (1.4%)	1,890 (1.5%)	216 (1.3%)	2,187
<i>Solidago nemoralis</i>	180 (3.1%)	1,620 (1.3%)	360 (2.2%)	2,160
<i>Aster laevis</i>	0	1,536 (1.2%)	192 (1.2%)	1,728
<i>Bouteloua curtipendula</i>	32 (0.6%)	1,120 (0.9%)	80 (0.5%)	1,232
<i>Liatris pycnostachya</i>	72 (1.2%)	768 (0.6%)	192 (1.2%)	1,032
<i>Eryngium yuccifolium</i>	48 (0.8%)	768 (0.6%)	160 (1%)	976
<i>Vernonia</i> spp.	66 (1.1%)	704 (0.5%)	88 (0.5%)	858
<i>Aster azureus</i>	0	738 (0.6%)	82 (0.5%)	820
<i>Heliopsis helianthoides</i>	26 (0.4%)	624 (0.5%)	78 (0.5%)	728
<i>Echinacea purpurea</i>	52.8 (0.9%)	528 (0.4%)	145 (0.9%)	726
<i>Lespedeza capitata</i>	20 (0.3%)	640 (0.5%)	60 (0.4%)	720
<i>Silphium laciniatum</i>	4.55 (0.1%)	624 (0.1%)	9.1 (0.1%)	637.65
<i>Amorpha canescens</i>	51 (0.9%)	510 (0.4%)	68 (0.4%)	629
<i>Parthenium integrifolium</i>	34 (0.6%)	435.2 (0.3%)	68 (0.4%)	537.2
<i>Tradescantia ohiensis</i>	24 (0.4%)	384 (0.3%)	40 (0.2%)	448
<i>Echinacea pallida</i>	40 (0.7%)	320 (0.3%)	70 (0.4%)	430
<i>Silphium integrifolium</i>	20 (0.3%)	256 (0.2%)	56 (0.3%)	332
<i>Solidago speciosa</i>	105 (1.8%)	0	210 (1.3%)	315
<i>Liatris aspera</i>	40.5 (0.7%)	243 (0.2%)	13.5 (0.1%)	297
<i>Solidago ohiensis</i>	0	0	180 (1.1%)	180
<i>Penstemon digitalis</i>	11 (0.2%)	132 (0.1%)	22 (0.1%)	165
<i>Zizia aurea</i>	0	144 (0.1%)	12 (0.1%)	156
<i>Baptisia alba</i> v. <i>macrophylla</i>	4.8 (0.1%)	128 (0.1%)	4.8 (<0.1%)	137.6
<i>Silphium terebinthinaceum</i>	6.6 (0.1%)	105.6 (0.1%)	11 (0.1%)	123.2
<i>Rudbeckia tomentosa</i>	0	0	100 (0.6%)	100
<i>Desmodium canadense</i>	4.5 (0.1%)	67.5 (0.1%)	27 (0.2%)	99
<i>Rosa carolina</i>	2.9 (0.1%)	92.8 (0.1%)	0	95.7
<i>Desmodium illinoiense</i>	3.5 (0.1%)	84 (0.1%)	7 (<0.1%)	94.5
<i>Coreopsis palmata</i>	0	50 (<0.1%)	6.25 (<0.1%)	56.25
<i>Coreopsis tripteris</i>	0	50 (<0.1%)	0	50

<i>Asclepias tuberosa</i>	0	28 (<0.1%)	0	28
<i>Ceanothus americanus</i>	0	28 (<0.1%)	0	28
Total	5,778.15	123,118.5	16,351.85	145,218.5

*The following species were also sown, but excluded from species composition of the target communities because their estimated numbers of seeds were not available: *Euphorbia corollata*, *Gentiana flavida*, *Dalea candidum*, *Dalea purpureum*, *Physostegia virginiana*, *Potentilla arguta*, *Pycnanthemum flexuosum* & *Pycnanthemum virginianum*

Table 2. Mean (\pm one unit of standard error) basal area and density of overstory and understory trees in 124 plots of Taltree Arboretum & Gardens. The species that are not native to eastern North America are signified with an asterisk (*).

Scientific name (common name in parenthesis)	Basal area (m ² .ha ⁻¹)	Density (stems.ha ⁻¹)
<i>Prunus serotina</i> (black cherry)	8.55 \pm 1.32	26,935 \pm 3,941
<i>Carya ovata</i> (shagbark hickory)	5.66 \pm 0.81	30,081 \pm 3,377
<i>Quercus ellipsoidalis</i> (Hill's oak)	2.87 \pm 0.79	2,258 \pm 535
<i>Quercus macrocarpa</i> (bur oak)	2.63 \pm 0.96	2,339 \pm 538
<i>Fraxinus pennsylvanica</i> (green ash)	1.74 \pm 0.76	3,468 \pm 769
<i>Juglans nigra</i> (black walnut)	1.47 \pm 0.06	2,661 \pm 1,494
<i>Quercus velutina</i> (black oak)	1.39 \pm 0.60	726 \pm 285
<i>Quercus alba</i> (white oak)	1.29 \pm 0.62	1,290 \pm 458
<i>Populus deltoides</i> (eastern cottonwood)	1.22 \pm 0.72	1,452 \pm 807
<i>Pinus strobus</i> (eastern white pine)	1.01 \pm 0.64	1,210 \pm 730
<i>Crataegus mollis</i> (red haw)	0.98 \pm 0.12	39,677 \pm 3,481
<i>Salix nigra</i> (black willow)	0.82 \pm 0.62	1,935 \pm 1,143
<i>Ulmus americana</i> (American elm)	0.55 \pm 0.24	2,016 \pm 637
<i>Acer negundo</i> (boxelder)	0.47 \pm 0.28	3,710 \pm 1,428
<i>Quercus rubra</i> (northern red oak)	0.33 \pm 0.14	1,290 \pm 396
<i>Malus</i> sp. (domesticated apple)	0.30 \pm 0.23	645 \pm 274
<i>Quercus palustris</i> (pin oak)	0.29 \pm 0.29	161 \pm 161
<i>Cornus stolonifera</i> (red osier dogwood)	0.18 \pm 0.18	323 \pm 323
<i>Morus alba</i> (white mulberry)	0.15 \pm 0.15	403 \pm 403
<i>Viburnum prunifolium</i> (black haw)	0.11 \pm 0.10	6,935 \pm 5,348
<i>Quercus imbricaria</i> (shingle oak)	0.09 \pm 0.07	565 \pm 368
<i>Tilia americana</i> (basswood)	0.08 \pm 0.05	403 \pm 211
<i>Cornus florida</i> (flowering dogwood)	0.07 \pm 0.05	4,194 \pm 1,843
<i>Sassafras albidum</i> (sassafras)	0.07 \pm 0.06	968 \pm 652
<i>Cephalanthus occidentalis</i> (buttonbush)	0.05 \pm 0.04	9,274 \pm 7,816
<i>Acer saccharum</i> (sugar maple)	0.04 \pm 0.03	726 \pm 65
<i>Rhus typhina</i> (staghorn sumac)	0.04 \pm 0.02	484 \pm 225
<i>Corylus americana</i> (filbert)	0.03 \pm 0.01	16,452 \pm 5,690
<i>Lindera benzoin</i> (spicebush)	0.03 \pm 0.02	7,177 \pm 2,404
<i>Lonicera tatarica</i> (bush honeysuckle)*	0.02 \pm 0.01	5,161 \pm 3,156
<i>Robinia pseudoacacia</i> (black locust)	0.02 \pm 0.01	81 \pm 81
<i>Celtis occidentalis</i> (hackberry)	0.01 \pm 0.01	161 \pm 114
<i>Eleagnus angustifolia</i> (Russian olive)*	<0.01	1,371 \pm 631
<i>Prunus virginiana</i> (choke cherry)	<0.01	1,290 \pm 872
<i>Pyrus americana</i> (mountain ash)	<0.01	1,129 \pm 475
<i>Salix interior</i> (sandbar willow)	<0.01	242 \pm 180
<i>Betula nigra</i> (river birch)	<0.01	81 \pm 81
<i>Fraxinus nigra</i> (black ash)	<0.01	81 \pm 81
<i>Quercus bicolor</i> (swamp white oak)	<0.01	81 \pm 81

Table 3. Mean (\pm one unit of standard error) basal area and density of shrubs in 124 plots of Taltree Arboretum & Gardens. The species that are not native to eastern North America are signified with asterisk (*).

Scientific name (common name in parenthesis)	Density (stems.ha ⁻¹)	Basal area (m ² .ha ⁻¹)
<i>Parthenocissus quinquefolia</i> (Virginia creeper)	317,950 \pm 30,198	1.05 \pm 0.14
<i>Rosa multiflora</i> (multiflora rose)*	37,923 \pm 4,844	1.32 \pm 0.36
<i>Ribes oxycanthoides</i> (Canada gooseberry)	7,722 \pm 2,780	0.11 \pm 0.04
<i>Rhus toxicodendron</i> (poison ivy)	7,016 \pm 1,778	0.21 \pm 0.15
<i>Rubus occidentalis</i> (black raspberry)	6,311 \pm 1,555	0.15 \pm 0.05
<i>Rubus odoratus</i> (flowering raspberry)	3,790 \pm 1,320	0.11 \pm 0.01
<i>Lindera benzoin</i> (spicebush)	2,621 \pm 1,696	0.02 \pm 0.01
<i>Corylus americana</i> (filbert)	2,198 \pm 933	0.19 \pm 0.12
<i>Prunus serotina</i> (black cherry)	2,198 \pm 900	0.17 \pm 0.08
<i>Cornus florida</i> (flowering dogwood)	1,680 \pm 546	0.02 \pm 0.02
<i>Carya ovata</i> (shagbark hickory)	1,680 \pm 484	0.02 \pm 0.01
<i>Fraxinus pennsylvanica</i> (green ash)	1,515 \pm 495	0.04 \pm 0.02
<i>Berberis thunbergii</i> (Japanese barberry)*	1,330 \pm 982	0.02 \pm 0.02
<i>Vitis</i> sp. (wild grape)	687 \pm 199	0.19 \pm 0.10
<i>Ulmus americana</i> (American elm)	544 \pm 544	0.10 \pm 0.10
<i>Viburnum prunifolium</i> (black haw)	464 \pm 244	0.01 \pm 0.01
<i>Crataegus mollis</i> (red haw)	444 \pm 196	0.02 \pm 0.01
<i>Acer negundo</i> (boxelder)	282 \pm 115	0.03 \pm 0.01
<i>Lonicera tatarica</i> (bush honeysuckle)*	262 \pm 174	0.03 \pm 0.02
<i>Rhus typhina</i> (staghorn sumac)	202 \pm 93	<0.01
<i>Morus alba</i> (white mulberry)*	81 \pm 81	0.02 \pm 0.02
<i>Smilax rotundifolia</i> (common greenbrier)	81 \pm 64	<0.01
<i>Quercus ellipsoidalis</i> (Hill's oak)	40 \pm 40	0.02 \pm 0.02
<i>Quercus alba</i> (white oak)	40 \pm 40	<0.01
<i>Tilia americana</i> (basswood)	40 \pm 40	<0.01
<i>Prunus virginiana</i> (choke cherry)	20 \pm 20	0.02 \pm 0.02
<i>Quercus macrocarpa</i> (bur oak)	20 \pm 20	0.01 \pm 0.01
<i>Pyrus americana</i> (mountain ash)	20 \pm 20	<0.01

Table 4. Regression models for estimating ground cover of *Parthenocissus quinquefolia* (Virginia creeper) and *Rosa multiflora* (multiflora rose) in Taltree Arboretum & Gardens.

Species	Model	R ²	P
<i>Parthenocissus quinquefolia</i>	Y = 30.4 + 0.14X	0.91	<0.0001
<i>Rosa multiflora</i>	Y = 36.8 + 0.64X	0.63	0.0004

X = stem density divided by 2500.

Y = ground cover by foliage

Table 5. Mean (\pm one unit of standard error) hitting frequency (cover) of herbaceous plants in 124 woodland plots of Taltree Arboretum & Gardens. The species that are not native to eastern North America are signified with an asterisk (*).

Scientific name (common name in parenthesis)	Hitting frequency (%)
<i>Alliaria officinalis</i> (garlic mustard)*	11.3 \pm 2.3
<i>Polygonum cuspidatum</i> (Japanese knotweed)*	5.6 \pm 0.7
<i>Impatiens</i> spp. (touch-me-not) ^A	4.5 \pm 1.5
<i>Phalaris arundinacea</i> (reed canary grass)*	4.1 \pm 1.6
<i>Geum aleppicum</i> (yellow avens)	4.0 \pm 0.8
<i>Sanicula gregaria</i> (clustered snakeroot)	3.9 \pm 1.1
<i>Cryptotaenia canadensis</i> (honestwort)*	3.0 \pm 0.9
<i>Geranium maculatum</i> (wild geranium)	2.5 \pm 0.8
<i>Allium vineale</i> (wild garlic)*	2.3 \pm 0.9
<i>Viola</i> spp. (violets) ^B	2.2 \pm 0.6
<i>Polygonum persicaria</i> (lady's thumb)*	1.4 \pm 0.3
<i>Galium</i> spp. (madders) ^C	1.2 \pm 0.4
<i>Podophyllum peltatum</i> (mayapple)	1.2 \pm 0.5
<i>Arisaema triphyllum</i> (small jack-in-the-pulpit)	1.1 \pm 0.2
<i>Hydrophyllum virginianum</i> (Virginia waterleaf)	1.0 \pm 0.5
<i>Agrimonia gryposepala</i> (agrimony)	1.0 \pm 0.2
<i>Claytonia virginica</i> (spring beauty)	0.6 \pm 0.2
<i>Dentaria laciniata</i> (cut-leaved toothwort)	0.6 \pm 0.2
<i>Polygonatum biflorum</i> (smooth Solomon's seal)	0.6 \pm 0.1
<i>Thalictrum thalictroides</i> (rue anemone)	0.6 \pm 0.3
<i>Trautvetteria caroliniensis</i> (false bugbane)	0.6 \pm 0.4
<i>Carex stricta</i> (tussock sedge)	0.4 \pm 0.3
<i>Daucus carota</i> (Queen Anne's lace)*	0.4 \pm 0.3
<i>Oryzopsis asperifolia</i> (orchard grass)*	0.4 \pm 0.4
<i>Trillium grandiflorum</i> (large-flowered trillium)	0.4 \pm 0.1
<i>Anemone quinquefolia</i> (wood anemone)	0.3 \pm 0.2
<i>Carex laxifolia</i>	0.2 \pm 0.1
<i>Carex pensylvanica</i> (Pennsylvania sedge)	0.2 \pm 0.1
<i>Ranunculus aborticus</i> (small-flowered crowfoot)	0.2 \pm 0.2
<i>Taraxacum officinale</i> (dandelion)*	0.2 \pm 0.1
<i>Actaea pachypoda</i> (white baneberry)	0.1 \pm 0.1
<i>Eupatorium perfoliatum</i> (boneset)	0.1 \pm 0.1
<i>Glecoma hederacea</i> (gill-over-the-ground)*	0.1 \pm 0.1
<i>Hepatica americana</i> (round-leaved hepatica)	0.1 \pm 0.1
<i>Hydrophyllum macrophyllum</i> (waterleaf)	0.1 \pm 0.1
<i>Juncus tenuis</i> (path rush)	0.1 \pm 0.1
<i>Phytolacca americana</i> (pokeweed)	0.1 \pm 0.1
<i>Raphanus raphanistrum</i> (wild radish)*	0.1 \pm 0.1
<i>Solidago</i> spp. (goldenrods) ^D	0.1 \pm 0.1

<i>Urtica dioica</i> (stinging nettle)	0.1 ± 0.1
<i>Typha</i> spp. (cattails) ^E	0.1 ± 0.1
<i>Amphicarpa bracteata</i> (hog pignut)	<0.1
<i>Anemonella thalictroides</i> (rue anemone)	<0.1
<i>Arisaema dracontium</i> (green dragon)	<0.1
<i>Athyrium</i> sp. (lady fern)	<0.1
<i>Cerastium vulgatum</i> (moose-ear chickweed)*	<0.1
<i>Cirsium</i> spp. (thistles) ^F	<0.1
<i>Desmodium paniculatum</i> (panicled tick trefoil)	<0.1
<i>Eupatorium rugosum</i> (white snakeroot)	<0.1
<i>Lobelia cardinalis</i> (cardinal flower)	<0.1
<i>Oxalis corniculata</i> (creeping wood sorrel)*	<0.1
<i>Potentilla simplex</i> (common cinquefoil)	<0.1
<i>Polemonium van-bruntiae</i> (Jacob's ladder)	<0.1
<i>Ranunculus ambigens</i> (water-plantain spearwort)	<0.1
<i>Rumex crispus</i> (curled dock)*	<0.1
<i>Smilacina racemosa</i> (false Solomon's seal)	<0.1
<i>Stellaria media</i> (common chickweed)*	<0.1
<i>Trifolium</i> spp. (clovers) ^G	<0.1

A: *I. capensis* (spotted touch-me-not) & *I. pallida* (pale touch-me-not)

B: *V. sororia* (common blue violet) & *V. pubescens* (yellow violet)

C: *G. aparine* (cleaver)* & *G. mollugo* (wild madder)*

D: *S. nemoralis* (oldfield goldenrod) & *S. ohioensis* (Ohio goldenrod)

E: *T. angustifolia* (narrow-leaved cattail)* & *T. x glauca* (hybrid cattail)*

F: *C. arvense* (Canada thistle)*, *C. discolor* (field thistle)* & *C. vulgare* (bull thistle)*

G: *T. pretense* (red clover)* & *T. repens* (white clover)*

Table 6. Mean (\pm one unit of standard error) hitting frequency (cover) of herbaceous plants in 98 prairie plots of Taltree Arboretum & Gardens. The species that are native to North America but not sown in 1996, 1998, or 2000 are signified with an asterisk (*). The species that are exotic to North America are signified with double asterisks (**). None of the exotic species were sown.

Scientific name (common name in parenthesis)	Hitting frequency (%)
<i>Andropogon gerardii</i> (big bluestem)	51.3 \pm 3.3
<i>Solidago</i> spp. (golden rods) ^A	42.6 \pm 2.8
<i>Monarda fistulosa</i> (wild bergamot)	21.3 \pm 3.0
<i>Eryngium yuccifolium</i> (rattle snake master)	13.0 \pm 2.0
<i>Poa</i> spp. (bluegrasses) ^{B**}	9.1 \pm 2.0
<i>Agrostis alba</i> (redtop grass)**	8.4 \pm 2.6
<i>Trifolium</i> spp. (clovers) ^{C**}	8.1 \pm 1.9
<i>Penstemon digitalis</i> (penstemon)	6.7 \pm 1.5
<i>Juncus tenuis</i> (path rush)*	6.2 \pm 1.7
<i>Sporobolus heterolepis</i> (prairie dropseed)	4.9 \pm 1.2
<i>Cyperus esculentus</i> (yellow nutsedge)	4.1 \pm 1.5
<i>Schizachyrium scoparium</i> (little bluestem)	4.0 \pm 0.8
<i>Ratibida pinnata</i> (yellow coneflower)	3.9 \pm 0.8
<i>Silphium integrifolium</i> (rosinweed)	3.3 \pm 0.8
<i>Ambrosia artemisiifolia</i> (common ragweed)**	2.2 \pm 0.7
<i>Desmodium illinoense</i> (Illinois tick trefoil)	2.1 \pm 0.5
<i>Cirsium</i> spp. (thistles) ^{D**}	1.7 \pm 0.6
<i>Lespedeza capitata</i> (round-headed bush clover)	1.6 \pm 0.3
<i>Phalaris arundinacea</i> (reed canary grass)**	1.6 \pm 0.6
<i>Daucus carota</i> (Queen Anne's lace)**	1.3 \pm 0.5
<i>Rubus</i> spp. (raspberries) ^{E*}	1.3 \pm 0.7
<i>Baptisia leucantha</i> (white false indigo)	1.2 \pm 0.3
<i>Melilotus</i> spp. (sweet clovers) ^{F**}	0.9 \pm 0.5
<i>Sorghastrum nutans</i> (Indian grass)	0.9 \pm 0.9
<i>Achillea millefolium</i> (field yarrow)	0.8 \pm 0.6
<i>Aster</i> spp. (asters) ^G	0.8 \pm 0.3
<i>Heliopsis helianthoides</i> (oxeye false sunflower)	0.8 \pm 0.4
<i>Medicago sativa</i> (alfalfa)**	0.8 \pm 0.5
<i>Pycnanthemum virginianum</i> (mountain mint)	0.8 \pm 0.3
<i>Echinacea purpurea</i> (purple coneflower)	0.6 \pm 0.3
<i>Rudbeckia hirta</i> (black-eyed Susan)	0.6 \pm 0.2
<i>Erigeron</i> spp. (fleabanes) ^{H**}	0.5 \pm 0.2
<i>Parthenium intergrifolium</i> (wild quinine)	0.5 \pm 0.3
<i>Polygonum</i> spp. (smart weeds) ^{I**}	0.5 \pm 0.3
<i>Tradescantia ohiensis</i> (Ohio spiderwort)	0.5 \pm 0.1
<i>Agropyron repens</i> (quack grass)**	0.3 \pm 0.3
<i>Chrysanthemum leucanthemum</i> (oxeye daisy)**	0.3 \pm 0.2
<i>Geum aleppicum</i> (yellow avens)	0.3 \pm 0.2

<i>Lolium perenne</i> (perennial rye grass)**	0.3 ± 0.1
<i>Panicum virgatum</i> (switch grass)	0.3 ± 0.2
<i>Silphium laciniatum</i> (compass plant)	0.3 ± 0.1
<i>Taraxacum officinale</i> (dandelion)**	0.3 ± 0.2
<i>Asclepias syriaca</i> (common milkweed)*	0.2 ± 0.1
<i>Brassica rapa</i> (field mustard)**	0.2 ± 0.1
<i>Carex</i> sp. (sedge) ^J *	0.2 ± 0.1
<i>Liatris</i> spp. (blazing stars) ^K	0.2 ± 0.1
<i>Phleum pratense</i> (Timothy grass)**	0.2 ± 0.1
<i>Silphium terebinthinaceum</i> (prairie dock)	0.2 ± 0.1
<i>Eupatorium maculatum</i> (spotted Joe-Pye weed)*	0.1 ± 0.1
<i>Gentiana flavida</i> (yellow gentian)	0.1 ± 0.1
<i>Hypericum perforatum</i> (St. John's wort)**	0.1 ± 0.1
<i>Rosa carolina</i> (prairie rose)	0.1 ± 0.1
<i>Agrimonia gryposepala</i> (agrimony)*	<0.1
<i>Bouteloua curtipendula</i> (side-oats grama)	<0.1
<i>Coreopsis palmata</i> (prairie coreopsis)	<0.1
<i>Desmodium canadense</i> (showy tick trefoil)	<0.1
<i>Echinacea pallida</i> (pale purple coneflower)	<0.1
<i>Eupatorium perfoliatum</i> (boneset)*	<0.1
<i>Gallium</i> spp. (madders) ^{L**}	<0.1
<i>Oenothera biennis</i> (evening primrose)*	<0.1
<i>Oxalis europaea</i> (yellow wood sorrel)**	<0.1
<i>Plantago lanceolata</i> (English plantain)**	<0.1
<i>Potentilla arguta</i> (prairie cinquefoil)	<0.1
<i>Populus deltoides</i> (eastern cottonwood)*	<0.1
<i>Salix nigra</i> (black willow)*	<0.1
<i>Silphium perfoliatum</i> (cup plant)	<0.1
<i>Veronicastrum virginicum</i> (Culver's root)	<0.1
<i>Vicia cracca</i> (cow vetch)**	<0.1
<i>Zizia aurea</i> (golden Alexander)	<0.1

A: *S. nemoralis* (oldfield goldenrod), *S. ohioensis* (Ohio goldenrod), *S. rugosa* (stiff goldenrod) & *S. speciosa* (showy goldenrod)

B: *P. annua* (annual bluegrass), *P. compressa* (Canada bluegrass) & *P. pratensis* (Kentucky bluegrass)

C: *T. pratense* (white clover) & *T. repens* (red clover)

D: *C. arvensis* (Canada thistle), *C. discolor* (field thistle) & *C. vulgare* (bull thistle)

E: *R. occidentalis* (black raspberry) & *R. odoratus* (flowering raspberry)

F: *M. alba* (white sweet clover) & *M. officinalis* (yellow sweet clover)

G: *A. novae-angliae* (New England aster), *A. azureus* (sky-blue aster) & *A. laevis* (smooth blue aster)

H: *E. canadensis* (Canada fleabane) & *E. philadelphicus* (Philadelphia fleabane)

I: *P. cuspidatum* (Japanese knotweed) & *P. persicaria* (lady's thumb)

J: species name was not identified

K: *L. pycnostachya* (prairie blazing star) & *L. aspera* (rough blazing star)

L: *G. aparine* (cleaver)** & *G. mollugo* (wild madder)**

Table 7. Mean (\pm one unit of standard error) hitting frequency (cover) of herbaceous plants in 15 old field plots of Taltree Arboretum & Gardens. The species that are not native to eastern North America are signified by an asterisk (*).

Scientific name (common name in parenthesis)	Hitting frequency (%)
<i>Solidago</i> spp. ^A	85.3 \pm 5.7
<i>Poa</i> spp. (bluegrasses) ^{B*}	81.5 \pm 8.2
<i>Phalaris arundinacea</i> (reed canary grass)*	38.2 \pm 10.2
<i>Dactylis glomerata</i> (orchard grass)*	4.8 \pm 2.6
<i>Daucus carota</i> (Queen Anne's lace)*	3.6 \pm 1.2
<i>Stellaria media</i> (common chickweed)*	3.4 \pm 1.1
<i>Trifolium</i> spp. (clovers) ^{C*}	3.1 \pm 1.2
<i>Agrimonia gryposepala</i> (agrimony)	2.0 \pm 1.2
<i>Fragaria virginiana</i> (wild strawberry)	1.6 \pm 1.5
<i>Geum aleppicum</i> (yellow avens)	1.4 \pm 0.9
<i>Taraxacum officinale</i> (dandelion)*	1.3 \pm 0.5
<i>Chrysanthemum leucanthemum</i> (oxeye daisy)*	0.9 \pm 0.4
<i>Raphanus raphanistrum</i> (wild radish)*	0.9 \pm 0.4
<i>Gallium</i> spp. (madders) ^{D*}	0.8 \pm 0.7
<i>Hieracium pratense</i> (king devil hawkweed)*	0.6 \pm 0.4
<i>Heliopsis helianthoides</i> (oxeye false sunflower)	0.4 \pm 0.3
<i>Carex laxifolia</i>	0.3 \pm 0.3
<i>Ranunculus abortivus</i> (small-flowered crowfoot)	0.3 \pm 0.2
<i>Rumex crispus</i> (curled dock)*	0.2 \pm 0.2
<i>Claytonia virginica</i> (spring beauty)	0.1 \pm 0.1
<i>Potentilla simplex</i> (common cinquefoil)	0.1 \pm 0.1

A: *S. nemoralis* (oldfield goldenrod), *S. odora* (sweet goldenrod) & *S. rugosa* (stiff goldenrod)

B: *P. annua* (annual bluegrass), *P. compressa* (Canada bluegrass) & *P. pratensis* (Kentucky bluegrass)

C: *T. hybridum* (alsike clover), *T. pratense* (white clover) & *T. repens* (red clover)

D: *G. aparine* (cleaver) & *G. mollugo* (wild madder)

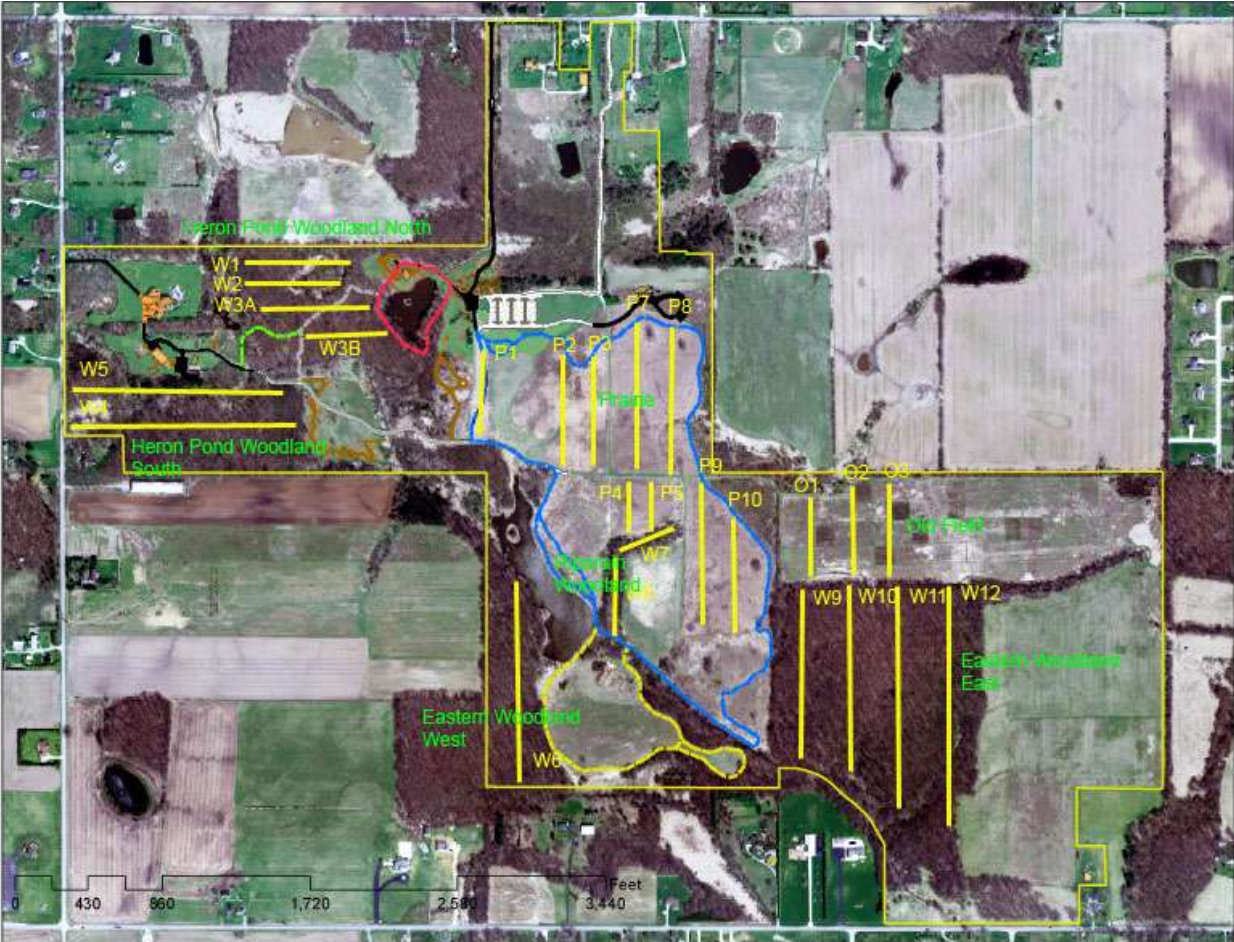


Figure 1. Sample transects in the woodlands, prairie and old field of Taltree Arboretum & Gardens.

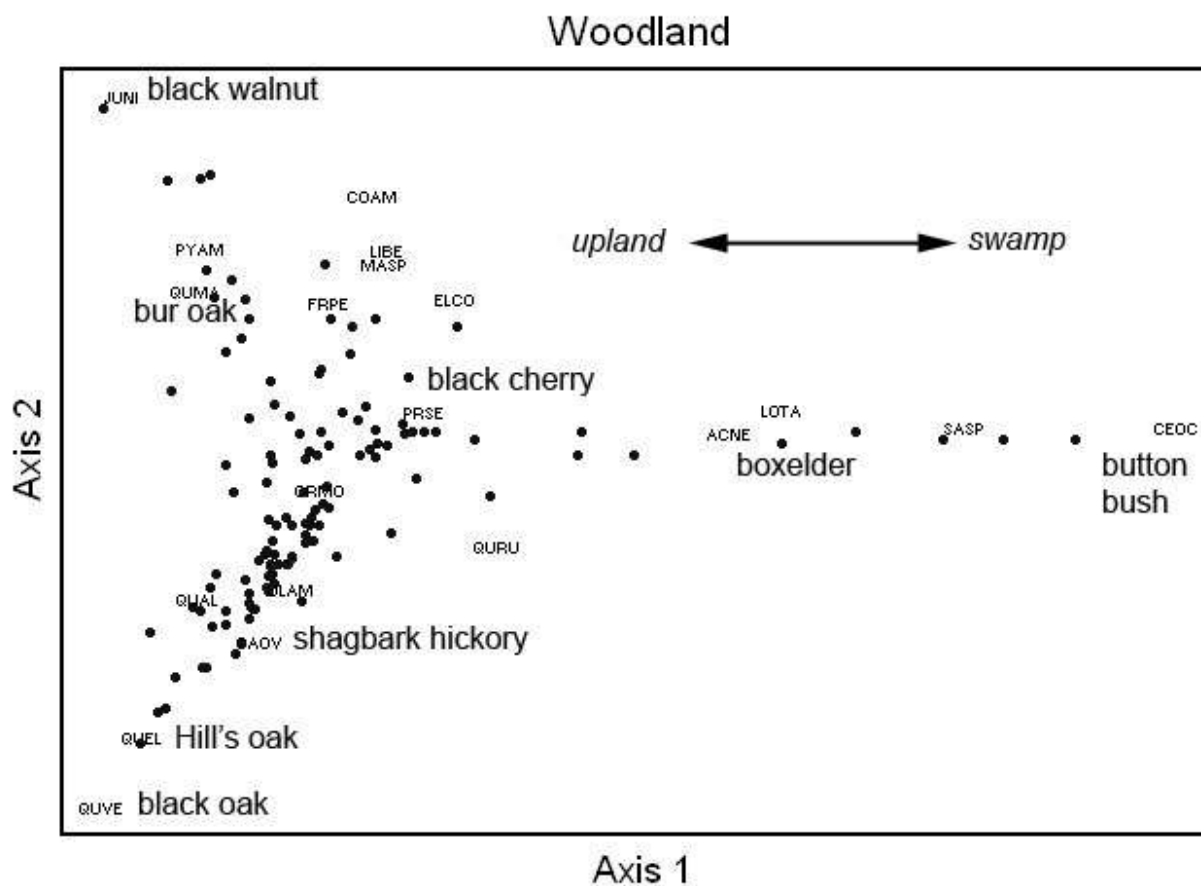


Figure 2. DCA (Detrended Correspondence Analysis) ordination of the 124 woodland plots (signified with dots) and 20 species (signified with 4-letter codes) in the Taltree Arboretum & Gardens. *Prunus serotina* (black cherry; PRSE) was the most common species, and thus located in the center of the graph. *Salix* spp. (willows; SASP) and *Cephalanthus occidentalis* (buttonbush; CEOC) increased to the right end of the Axis 1, and *Acer negundo* (boxelder; ACNE) dominated the Riparian Woodland. *Juglans nigra* (black walnut; JUNI) and *Quercus macrocarpa* (bur oak; QUMA) increased its dominance to the upper-left corner, whereas *Quercus velutina* (black oak; QUVE), *Quercus ellipsoidalis* (Hill's oak; QUEL), and *Carya ovata* (shagbark hickory; CAO) increased toward the lower-left corner.

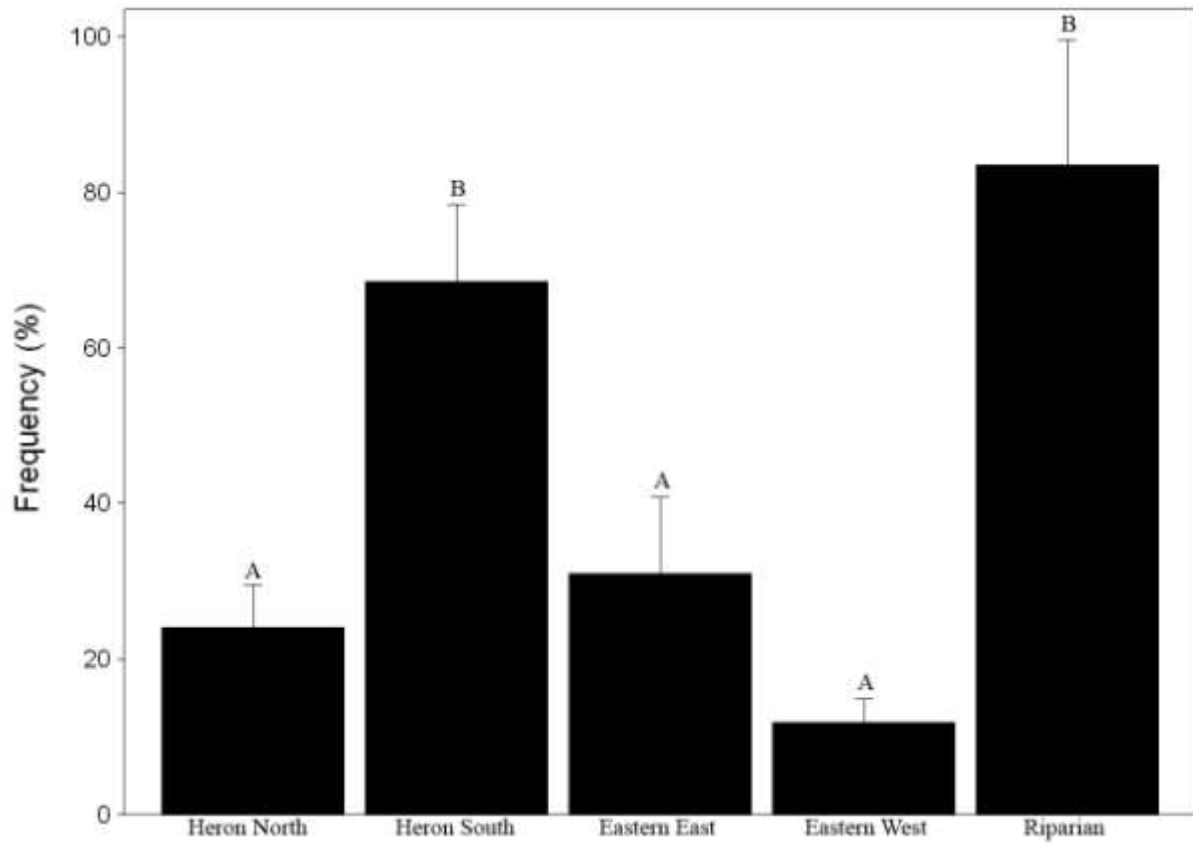


Figure 3. One-way ANOVA (analysis of variance) comparison of the occurrence frequencies of non-native herbaceous species in the Heron Woodlands North and South, the Eastern Woodlands East and West, and Riparian Woodland ($p < 0.0001$). There were two groups (signified with the letters A and B) in which the means were not significantly different from one another in the Tukey-test at $\alpha = 0.05$.

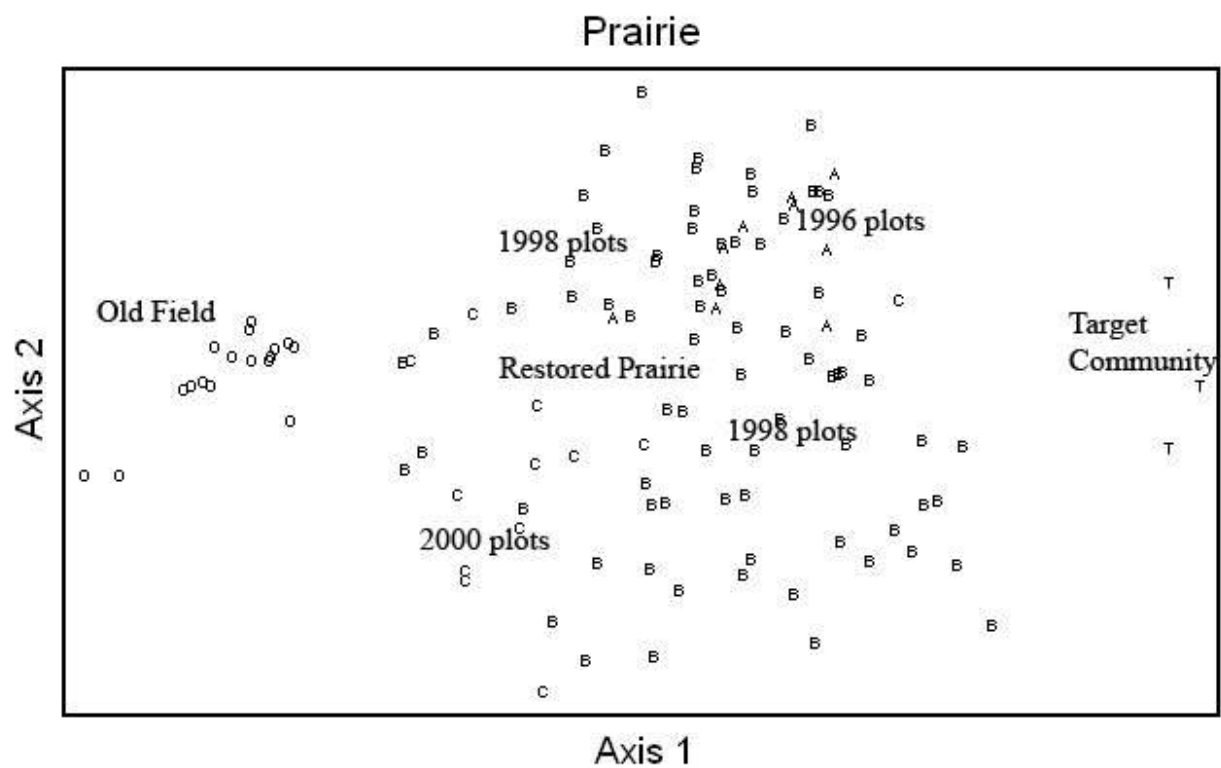


Figure 4. DCA (Detrended Correspondence Analysis) ordination of the plots in the prairie that were restored in 1996 (signified with the letter A), 1998 (B) and 2000 (C), and the old field (O). Target community (T) was assembled hypothetically based on the species composition of initial seed mixes.