Bulletin of the Torrey Botanical Club 118(3), 1991, pp. 312–325

TORREYA

The vegetation of the Wave Hill natural area, Bronx, New York[1]

Susan E. Yost,[2,3] Susan Antenen[4] and Gregg Hartvigsen[5]

Forest Project, Wave Hill, Bronx, NY 10471

ABSTRACT

YOST, S. E., S. ANTENEN AND G. HARTVIGSEN (Forest Project, Wave Hill, Bronx, NY 10471). The vegetation of the Wave Hill natural area, Bronx, New York. Bull. Torrey Bot. Club 118: 312–325. 1991.—A vegetation survey of the Wave Hill natural area, an urban woodland in the Bronx, NYC, was conducted in 1987. A permanent grid of 10 × 10 meter quadrats was established throughout the three ha natural area. Importance values were calculated in 238 quadrats. The most important arborescent species were *Robinia pseudoacacia, Quercus rubra,* and *Acer platanoides.* The most important non-arborescent species were *Ampelopsis brevipedunculata, Lonicera maackii,* and *Alliaria petiolata.* Four vegetation associations were recognized: oak–maple, black locust, black birch, and open areas. The high percentage (48%) and importance of non-native species is related to Wave Hill's urban location and land-use history. *Ampelopsis brevipedunculata,* the most important of the non-arborescent species, is a vine which appears to inhibit the growth of other species in open areas. A list of the 276 species of vascular plants identified is included in an appendix.

Key words: Wave Hill, Bronx, New York City, urban natural area, vegetation survey, importance values, non-native species, plant species list, vegetation management, *Ampelopsis brevipedunculata.*

Plant species composition in urban woodlands often reflects not only the vegetation typical of the region, but also a history of anthropogenic disturbance. This disturbance includes woodland fragmentation, soil surface disturbance, and the introduction of non-native plant species. The natural area at Wave Hill, Bronx, N.Y. has variety of plant communities strongly influenced by the area's urban location and land-use history. Regrowth and partial clearing following landscaping for 19th-century estates has resulted in a mosaic of second-growth woodlands and open areas, with a mixture of native and non-native species. The natural area shares similarities with other woodlands in the New York City region, which have been described in a number of studies (Airola and Buchholz 1982; Frankel 1978; Greller 1972, 1977a, 1977b; Greller *et al.* 1979, 1982; Greller and Garcia 1986; Honkala and McAninch 1980, 1981; Lefkowitz and Greller 1973; Loeb 1986; Profous and Loeb 1984; Rudnicky and McDonnell 1989; Serrao and Dicker 1988; Stalter 1981). Few of these studies calculate importance values for herb, shrub and vine species, as well as for trees; or emphasize the importance of non-native species. The relatively small size of the Wave Hill natural area facilitates a very detailed vegetation survey.

This paper documents the flora, vegetation associations, and species importance values of the Wave Hill natural area. The importance of native and non-native species of vascular plants are compared. The vegetation survey and analysis, conducted in 1987, is part of a long-term project to document vegetation change and monitor

[1] This study was supported by Wave Hill, Bronx, NY 10471.

[2] We thank the following for their help: D. Burhans for work on the herbarium, graphics and manuscript; S. Kludjian for mounting herbarium specimens; A. Cronquist for assistance with nomenclature; N. Dicker for identification of grasses; T. Siccama for help with computer programs; D. Kincaid for advice on statistical applications; M. Maciarello and C. Lumer for comments on the manuscript; and L. Freund and the members of the 1987 summer crew (R. Hill, R. Marrero and D. Sherman) for assistance in the vegetation survey.

[3] Current address: 7 South Layton Avenue, Wyoming, DE 19934.

[4] Current address: The Nature Conservancy, 250 Lawrence Hill Road, Cold Spring Harbor, NY 11724.

[5] Current address: Biological Research Laboratories, 130 College Place, Syracuse, NY 13244-1220.

Received for publication June 22, 1990, and in revised form November 26, 1990.

management of the natural area. The survey included the establishment of permanent quadrats covering three hectares, of which 2.38 hectares were analyzed. The results of a soil analysis are also reported.

Study Site. The three hectare natural area is located on the 11 ha grounds of Wave Hill, a New York City-owned cultural and environmental center in the Riverdale section of the Bronx, N.Y. (40°53′45″N, 73°54′35″W). The natural area is on the southwest facing slope of Riverdale Ridge, 400 meters east of the Hudson River and adjacent to the 23 ha Riverdale Park. It is within the region described as oak–chestnut forest (glaciated section) by Braun (1950). The bedrock is Fordham gneiss.

New York City receives 112 cm rainfall/yr on average, with mean monthly temperatures ranging from 0°C in January to 25°C in July (Ruffner and Bair 1987).

The Riverdale Ridge area has undergone several phases of anthropogenic disturbance, including extensive clearing during the Revolutionary War, and landscaping for estates beginning in the 1840's. Since the construction of the Henry Hudson Parkway in 1937, the area surrounding Wave Hill has become increasingly urbanized.

Wave Hill was a private estate from 1843 until 1960, when the land was donated to New York City by the George Perkins family. Since then, the upper sections of the Wave Hill grounds have been maintained as ornamental gardens, and the hillside has become the present-day natural area. The land which became the natural area was maintained as landscaped woods, grassy slopes and a small orchard during the first half of the twentieth century. Management was discontinued from 1960 to 1980. In 1980 the Wave Hill Forest Project was initiated to conserve the native plant community of the natural area (Antenen 1986). Management by the Forest Project has consisted of favoring regeneration of native species by reducing the abundance of the most invasive non-native species and planting some native species. Although this vegetation survey was conducted after several years of management by the Forest Project, the major change has been a reduction in the still-high importance of non-native species.

Plant species establishment in the natural area has been heavily influenced by the ornamental plantings in the vicinity. The former Wave Hill estate owners introduced numerous non-native plants, including Norway and sycamore maples (*Acer platanoides* L., *A. pseudoplatanus* L.), black locust (*Robinia pseudoacacia* L.), and paper mulberry (*Broussonetia papyrifera* (L.) Vent.). Herbs such as hosta (*Hosta ventricosa* Salisb.), glory-of-the-snow (*Chionodoxa luciliae* Boiss. and *C. sardensis* Hort. Barr & Sugden), lily of the valley (*Convallaria majalis* L.) and English Ivy (*Hedera helix* L.) have spread from plantings. It is difficult to determine when and where other introduced ornamentals, now well distributed, were planted. The local abundance of porcelainberry (*Ampelopsis brevipedunculata* (Maxim.) Trautv.) and Amur honeysuckle (*Lonicera maackii* Maxim.) indicate that these species were probably initially planted in the Wave Hill vicinity. Other more widespread introduced plants such as Japanese honeysuckle (*Lonicera japonica* Thunb.) and mugwort (*Artemisia vulgaris* L.), which are common in many city parks, were probably introduced accidentally. Our main sources of historical information on Wave Hill's vegetation are a map of the large trees drawn in 1939, and photographs taken in 1911 and 1937.

The natural area has been subject to a variety of soil disturbances. The former estate owners, in addition to clearing and planting, installed numerous trails. Water drainage problems continue to cause soil erosion in several areas. There is, however, little soil compaction due to trampling.

Methods. During the summer and fall of 1987, we established a grid of 10 × 10 m quadrats throughout the three ha site. The quadrats were permanently marked using 0.5 m metal pipes at 20 m intervals along the grid. We selected 238 quadrats for the vegetation analysis (Fig. 1), omitting partial quadrats and two small areas dominated by planted trees.

Vascular plant species were identified and categorized as herbs, shrubs, vines, and trees. Trees were surveyed in three size classes: "seedlings" <1 m in height, "saplings" ≥ 1 m in height and with a diameter at breast height (dbh) of <5 cm, and "trees" ≥ 5 cm dbh. The seedling and sapling size classes were combined for presentation in the Tables.

Percent cover was estimated within each quadrat for every species. All trees were counted. In addition, for trees ≥ 5 cm dbh, diameters were measured and locations mapped within each quadrat.

Importance values (IV's) were calculated for all species in the 238 quadrats as follows: for herbs, shrubs, and vines we averaged relative

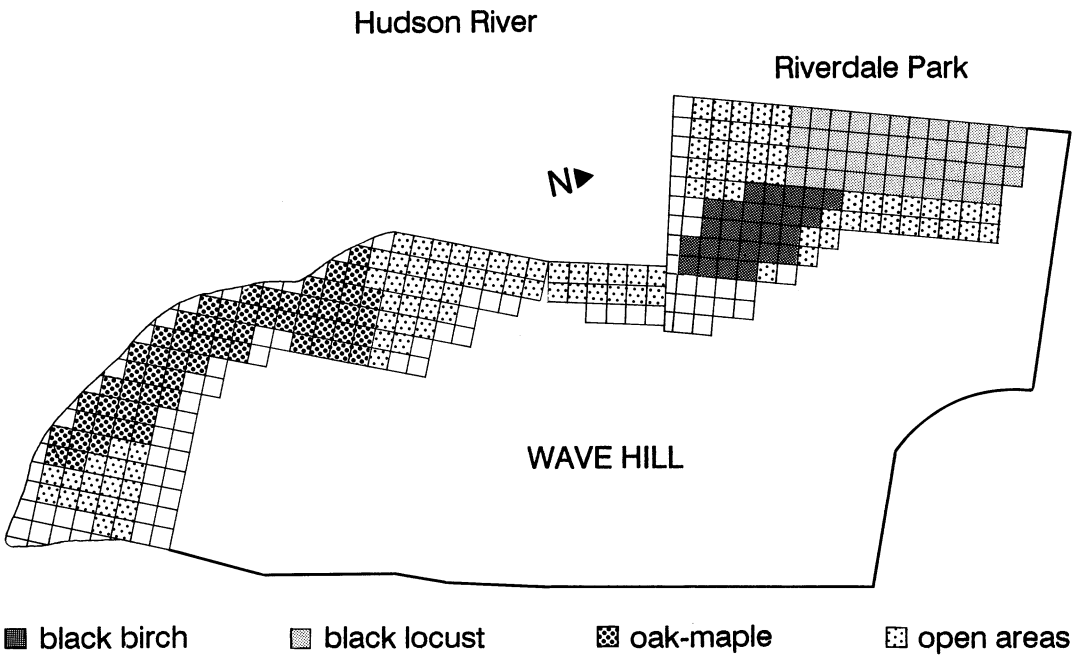

Fig. 1. Map of the three hectare Wave Hill natural area showing permanent 10 × 10 m quadrats. The 238 shaded quadrats were analyzed. Four major vegetation associations were recognized: oak–maple, black locust, black birch, and open areas.

cover (RC) and relative frequency (RF); for seedlings and saplings we averaged relative density (RD), RC, and RF; and for trees, we averaged relative basal area (RBA), RD, and RF (Curtis and McIntosh 1951). IV's were based on a maximum value of 100.

Voucher specimens collected from the natural area are housed in the Wave Hill herbarium. Nomenclature follows Gleason and Cronquist (1963) and Cronquist (personal communication). Bailey and Bailey (1976) was used to identify a few of the ornamental species. Taxonomic classification follows Cronquist's system (Cronquist 1981). Designation of species as native to New York State is based on Mitchell (1986). Spring ephemerals not present at the time of the vegetation survey were collected later and included in the species list. The 23 species introduced by the Forest Project are marked with a [p].

Species diversity was calculated for trees ≥ 5 cm dbh using the Brillouin Index (Magurran 1988). The more commonly used Shannon Index was also calculated. The natural log was used in calculating both indices.

Pearson's product-moment correlation analysis (Sokal and Rohlf 1981) was used to measure the association between tree seedling density and the covers of porcelainberry and Amur honeysuckle in the 238 quadrats. Correlation analysis was also used to measure the relationship of tree cover with covers of porcelainberry and Amur honeysuckle, in order to investigate the habitat preferences (wooded versus open) of these two species.

Soil samples were collected from the A and B horizons of two wooded sections of the natural area, the black locust association and the oak–maple association. Two soil pits were dug in each association, and the replicate samples from each horizon combined. The samples were then air dried, passed through a 2 mm sieve, and sent to the Cornell University Soil Laboratory for analysis.

Results. Forest cover comprised 56% of the 2.38 ha of natural area analyzed, with the remaining 44% dominated by meadows and shrub/vine communities. Four associations were recognized by dominant species: an oak–maple association (0.60 ha), a relatively young black locust association (0.47 ha), a black birch association (0.26 ha), and open areas (1.05 ha) (Fig. 1).

We found 276 species of vascular plants in 206 genera and 85 families (Appendix). This includ-

Table 1. Total number of species, and percent non-native species, for herbs, shrubs, vines, and trees in the Wave Hill natural area. A high percentage of all the species (48%) were non-natives.

	Number of species	% non-native
Herbs	171	49
Shrubs	35	46
Vines	20	55
Trees	50	44
Total	276	48

ed 50 tree, 35 shrub, 20 vine and 171 herb species (Table 1).

Of the 276 total species, 132 (48%) were not native to New York State (Table 1).

The diversity of trees ≥5 cm dbh was 2.57 (Brillouin Index) and 2.66 (Shannon Index).

For the natural area as a whole, the ten most important species of trees and seedlings and saplings are presented in Table 2. There were 1102 trees ≥5 cm dbh. The dominant species were black locust, red oak (*Quercus rubra* L.) and Norway maple. We counted 11,275 seedlings and saplings, and the dominant species were sugar maple (*Acer saccharum* Marsh.) and Norway and sycamore maples.

Native and non-native tree species were almost equally well represented, both in number and in importance. Non-natives comprised 44% of the 50 species of trees (Table 1), and four of the ten most important species in each size class

Table 2. Importance value components in the natural area (238 quadrats), for the ten most important species of trees, seedlings and saplings, and herbs, shrubs and vines. IV, importance value; BA, basal area; Den, density; Freq, frequency; Ave. cover, average cover. Non-native species are marked with *.

Species	BA m^2/ha	Den no./ha	Freq %	IV
Trees ≥5 cm dbh (N = 1102, 40 species)				
**Robinia pseudoacacia*	3.39	109.24	31.93	20.49
Quercus rubra	3.54	40.34	23.11	14.11
**Acer platanoides*	1.43	68.91	24.37	12.16
**Acer pseudoplatanus*	1.02	39.08	16.39	7.75
**Morus alba*	0.96	24.79	10.92	5.63
Betula lenta	0.83	20.17	10.50	4.94
Prunus serotina	0.31	26.05	13.87	4.89
Acer saccharum	0.90	10.08	9.66	4.19
Carya cordiformis	0.55	11.76	8.82	3.47
Quercus velutina	0.33	15.13	8.40	3.21
Species	**Ave. cover %**	**Den no./ha**	**Freq %**	**IV**
Seedlings and saplings (N = 11,275, 50 species)				
Acer saccharum	3.84	1120.59	31.09	15.30
**Acer platanoides*	3.61	714.71	51.26	13.21
**Acer pseudoplatanus*	2.51	629.83	61.76	11.55
Prunus serotina	2.87	313.45	49.16	9.17
Carya cordiformis	1.53	391.60	61.43	8.39
Fraxinus americana	1.13	224.79	43.70	5.65
Quercus rubra	0.67	152.94	49.16	4.78
**Ailanthus altissima*	0.91	243.28	28.99	4.66
**Robinia pseudoacacia*	0.70	172.69	42.02	4.56
Sassafras albidum	0.53	218.07	21.43	3.49
Species	**Ave. cover %**		**Freq %**	**IV**
Herbs, shrubs, and vines (186 species)				
**Ampelopsis brevipedunculata*	12.82		70.17	9.70
**Lonicera maackii*	12.51		74.37	9.64
**Alliaria petiolata*	7.53		85.29	7.01
**Lonicera japonica*	7.29		68.49	6.37
Parthenocissus quinquefolia	3.48		51.26	3.59
Aster divaricatus	2.15		55.04	2.91
**Rubus phoenicolasius*	1.56		44.12	2.24
**Rosa multiflora*	1.22		48.74	2.17
Toxicodendron radicans	1.23		42.44	1.99
Ambrosia trifida	1.38		39.08	1.98

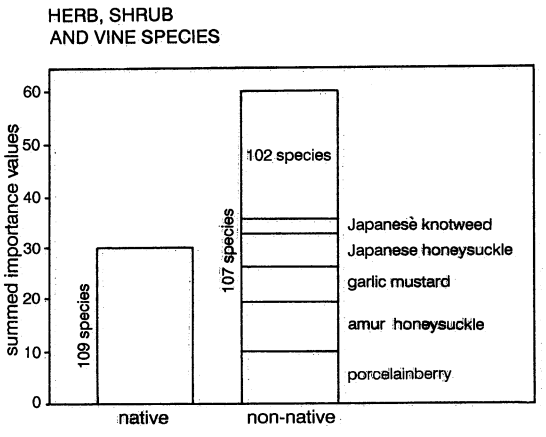

Fig. 2. Comparison of summed importance values for 109 native and 107 non-native species of herbs, shrubs and vines. Non-native species were twice as important as native species. The five most important non-native species were more important than all 109 native species combined. Non-vegetation (rocks, trail, etc.) comprise an additional IV of 10.

(Table 2). When native and non-native trees were compared by summing their IV's, they were also similar in importance (tree size class: summed IV of native species 48.8, non-natives 51.2; seedlings and saplings: natives 57.6, non-natives 42.4). Non-native trees had greater total density, whereas native trees had greater total basal area and frequency.

Four trees over one meter in diameter were found: a sugar maple (111.0 cm dbh), silver maple (*Acer saccharinum* L.) (107.5 cm), red oak (104.7 cm), and a tupelo (*Nyssa sylvatica* Marsh.) (101.4 cm). Other large trees included a tulip tree (*Liriodendron tulipifera* L.) (78.0 cm) and sassafras (*Sassafras albidum* (Nutt.) Nees) (53.6 cm). Many of the large trees had a growth form typical of open-grown trees, and were surrounded by younger trees.

Sixty three dead trees were observed. These represented 5.7% of all trees counted, and 5.6% of the total basal area. The two most important species among dead trees were white ash (*Fraxinus americana* L.) and black locust.

Two native trees, American elm (*Ulmus americana* L.) and tulip tree, were more abundant 50 years ago, according to a 1939 map of the large trees at Wave Hill. In 1987, no American elms and only a few tulip trees were present, and large stumps of these species remained in the oak–maple association. Although many large white ashes died at Wave Hill in the 1980's, this species was still well represented among seedlings and saplings (Table 2). There were no American chestnut trees (*Castanea dentata* (Marsh.) Borkh.) on the 1939 map.

The three most important species in the herbs, shrubs and vines category were porcelainberry, Amur honeysuckle, and garlic mustard (*Alliaria petiolata* (Bieb.) Cav. & Grande), all non-native species (Table 2). Other important non-natives were Japanese honeysuckle (especially in the black locust and black birch associations), multiflora rose (*Rosa multiflora* Thunb.) and wineberry (*Rubus phoenicolasius* Maxim.). The spring ephemerals glory-of-the-snow (*Chionodoxa luciliae* and *C. sardensis*), not listed in Mitchell (1986), had spread extensively from planted specimens. Of the 18 species of grasses, 13 were non-native. More than half of the vine species were non-natives (Table 1).

Several native species of herbs and vines common to the New York City region were also abundant in the natural area (Table 2). White wood aster (*Aster divaricatus* L.), an herbaceous perennial, occurred in over half of the quadrats, particularly in the oak–maple and black birch associations. Virginia creeper (*Parthenocissus quinquefolia* (L.) Planch.) was frequently found growing on the trunks of black locust. Ragweed (*Ambrosia trifida* L.), pokeweed (*Phytolacca americana* L.) and Canada goldenrod (*Solidago canadensis* L.) were important herbs in open areas. A few species of spring ephemerals, such as spring beauty (*Claytonia virginica* L.), trout lily (*Erythronium americanum* Ker), white trillium (*Trillium grandiflorum* (Michx.) Salisb.), and bellwort (*Uvularia perfoliata* L.), were abundant in areas of the oak–maple association where competition from such species as English ivy was low. The most important native shrubs were blackberry (*Rubus allegheniensis* Porter), northern dewberry (*R. flagellaris* L.), and blackhaw (*Viburnum prunifolium* L.).

Although non-native herbs, shrubs and vines were similar to natives in species richness (Table 1), non-natives were far more important (Fig. 2). The summed IV of the non-natives was twice that of the native species, and the summed IV of just the five most important non-native species exceeded the summed IV of all 109 native species (Fig. 2).

There were significant negative correlations between tree seedling density and the covers of both porcelainberry (Pearson $r = -0.22$, $P < 0.001$), and Amur honeysuckle ($r = -0.21$, $P < 0.05$). The cover of trees ≥ 5 cm dbh had a significant negative correlation with cover of porcelainberry ($r = -0.38$, $P < 0.001$), but not with

Table 3. Importance value components in the oak–maple association (60 quadrats) for the 10 most important species of trees, seedlings and saplings. IV, importance value; BA, basal area; Den, density; Freq, frequency; Ave. cover, average cover. Non-native species are marked with *.

Species	BA m^2/ha	Den no./ha	Freq %	IV
Trees ≥5 cm dbh (N = 356, 27 species)				
Quercus rubra	9.62	111.67	58.33	25.58
**Acer platanoides*	2.35	135.00	46.67	16.08
**Acer pseudoplatanus*	2.03	68.33	33.33	10.32
**Robinia pseudoacacia*	2.59	63.33	28.33	10.21
Acer saccharum	2.35	31.67	30.00	8.24
Quercus velutina	0.79	30.00	15.00	4.44
Betula lenta	0.48	26.67	15.00	3.84
Fraxinus americana	0.57	8.33	6.67	1.97
**Morus alba*	0.17	11.67	6.67	1.64
Liriodendron tulipifera	0.80	3.33	3.33	1.62
Species	**Ave. cover %**	**Den no./ha**	**Freq %**	**IV**
Seedlings and saplings (N = 5450, 40 species)				
Acer saccharum	14.16	4111.67	61.67	29.58
**Acer platanoides*	7.37	1435.00	88.33	14.94
**Acer pseudoplatanus*	4.26	1258.33	90.00	11.68
Fraxinus americana	3.12	640.00	80.00	8.05
Quercus rubra	1.77	316.67	81.67	5.77
Prunus serotina	1.40	328.33	86.33	4.99
Carya cordiformis	0.96	196.67	73.33	4.32
Celtis occidentalis	0.75	63.33	36.67	2.27
**Robinia pseudoacacia*	0.35	98.33	35.00	1.99
**Cladrastis lutea*	0.54	53.33	30.00	1.80

cover of Amur honeysuckle ($r = -0.08$, $P > 0.05$). In all cases, N = 238.

In addition, importance values were calculated separately for species within each of four associations. In the oak–maple association, which was maintained as a landscaped woodland during the first half of the 1900's, the most important species were red oak, Norway maple and sycamore maple in the tree size class; and sugar, Norway and sycamore maples in the seedling and sapling class (Table 3).

In the black locust association, which was maintained as a semi-open meadow until approximately 1960, the most important species were black locust and black cherry (*Prunus serotina* Ehrh.) among trees, and black cherry and bitternut hickory (*Carya cordiformis* (Wang.) Koch) among seedlings and saplings (Table 4). Tupelo seedlings and saplings had a high IV in this association, but were restricted to a few quadrats immediately beneath one large tupelo tree, and were probably root sprouts.

In the black birch association, the most important trees were black birch (*Betula lenta* L.) and Norway maple. The most important seedlings and saplings were Norway maple, bitternut hickory and sycamore maple.

In all three of the wooded associations just described, the most important species of herb and shrub were garlic mustard and Amur honeysuckle. The most important vines were English ivy in the oak–maple association, Virginia creeper in the black locust association, and Japanese honeysuckle in the black birch association.

Open areas contained relatively few trees, and were comprised of shrub- and vine-dominated areas and managed meadows. The most common tree seedlings in this association were species typical of disturbed sites such as native sassafras, which grew abundantly in a repeatedly cut area, and tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle), a native of Asia. Another Asian species, white mulberry (*Morus alba* L.) growing along edges and in gaps, ranked high in importance among trees. The dominant species in the herbs, shrubs and vines category were porcelainberry, Amur honeysuckle, and garlic mustard. Mugwort, ragweed, and a number of grass species were also abundant (Table 5).

Soil characteristics for the two associations sampled are shown in Table 6. In both associations, the depth of the A horizon was 6–7 cm, and the B horizon 18–20 cm. The soil in the oak–maple association was a fine sandy loam. In the

Table 4. Importance value components in the black locust association (47 quadrats), for the 10 most important species of trees and seedlings and saplings. IV, importance value; BA, basal area; Den, density; Freq, frequency; Ave. cover, average cover. Non-native species are marked with *.

Species	BA m^2/ha	Den no./ha	Freq %	IV
Trees ≥5 cm dbh (N = 357, 24 species)				
**Robinia pseudoacacia*	9.84	357.45	74.47	43.95
Prunus serotina	1.09	91.49	44.68	11.83
Quercus rubra	1.40	29.79	19.15	6.31
Sassafras albidum	0.84	27.66	19.15	5.20
Nyssa sylvatica	1.90	19.15	4.26	4.86
Carya cordiformis	0.29	21.28	17.02	3.64
Quercus velutina	0.48	23.40	12.77	3.55
Quercus alba	0.27	19.15	14.89	3.23
**Morus alba*	0.54	21.28	8.51	3.04
Ulmus rubra	0.43	12.77	6.38	2.18
Species	**Ave. cover %**	**Den no./ha**	**Freq %**	**IV**
Seedlings and saplings (N = 1741, 35 species)				
Prunus serotina	9.11	706.38	74.47	23.11
Nyssa sylvatica	3.47	687.23	21.28	12.25
Carya cordiformis	1.47	389.36	91.49	9.75
**Robinia pseudoacacia*	0.83	321.28	72.34	7.35
**Acer pseudoplatanus*	0.92	312.77	65.96	7.12
Fraxinus americana	0.90	187.23	61.70	5.76
Quercus rubra	0.58	123.40	53.19	4.34
Sassafras albidum	0.39	217.02	38.30	4.23
**Morus alba*	0.64	125.53	38.30	3.78
**Broussonetia papyrifera*	0.92	155.32	21.28	3.70

black locust association the soil was loam (A horizon) and fine sandy loam (B horizon). Soil pH ranged from 4.8 to 5.4.

Discussion. The natural area at Wave Hill is a long and narrow urban woodland comprised of a variety of plant communities ranging from open areas to relatively mature woods. The herb, shrub, and vine layers are often dense, with cover of certain non-native species approaching 100% in some quadrats. The more mature section of the woods is dominated by native oaks, while some of the most important co-dominants are introduced trees, such as Norway and sycamore maples. Some of the trees in the present-day woods are probably remnants from old second-growth forest, some were planted as part of estate landscaping, and others have become established from local seed sources following cessation of estate landscaping and clearing. Other natural areas in New York City, for example Inwood Hill Park (Loeb 1986), have developed in a similar fashion.

Table 5. Importance value components in the open areas association (105 quadrats), for the 10 most important species of herbs, shrubs and vines (142 spp. total). IV, importance value; Ave. cover, average cover; Freq, frequency. Non-native species are marked with *.

Species	Ave. cover %	Freq %	IV
**Ampelopsis brevipedunculata*	27.76	87.50	16.04
**Lonicera maackii*	24.28	71.59	13.85
Poaceae	6.89	57.14	6.58
**Alliaria petiolata*	6.39	72.73	5.57
**Lonicera japonica*	4.61	50.00	3.93
**Polygonum cuspidatum*	5.71	31.82	3.79
Ambrosia trifida	2.91	46.59	3.02
**Rosa multiflora*	2.30	45.45	2.69
**Artemisia vulgaris*	3.15	34.09	2.68
**Galium aparine*	1.86	39.05	2.25

The percentage of non-native species found in the Wave Hill natural area (48%) (Table 1) is high compared to New York State as a whole (36%) (Mitchell 1986). It is also high compared to several other natural areas in the New York City vicinity: Bronx River Park (31.6% non-native species, Frankel 1978, 1979), Van Cortlandt Park (28.7%, Profous and Loeb 1984), and Pelham Bay Park (31.5%, Kunstler and Natural Resources Group 1987). A history of soil disturbance and a large available seed pool of non-native species are important factors in the in-

Table 6. Soil horizon characteristics in the black locust (Bl. Loc.) and oak–maple (O–M) associations. Total values are reported. (A minus sign indicates analyte at limit of detection.)

	Horizon A		Horizon B	
	Bl. Loc.	O–M	Bl. Loc.	O–M
Cd (mg/kg)	−0.10	−0.10	−0.10	−0.10
Co (mg/kg)	17.2	17.1	20.1	18.1
Cr (mg/kg)	55.3	55.0	60.50	51.3
Cu (mg/kg)	36.6	44.2	25.7	15.7
Mn (mg/kg)	725.0	1096.0	884.1	738.0
Ni (mg/kg)	35.3	39.8	31.9	28.4
P (mg/kg)	1169.0	1300.0	876.0	950.0
Pb (mg/kg)	220.0	330.0	87.0	29.0
S (mg/kg)	509.0	706.0	352.0	201.0
Zn (mg/kg)	111.2	136.2	87.1	75.2
Al (%)	5.22	5.03	5.65	5.75
Ca (%)	0.640	0.801	0.597	0.557
Fe (%)	3.31	3.24	3.63	3.36
K (%)	1.09	1.45	1.16	1.65
Mg (%)	0.97	1.11	1.08	1.20
N (%)	0.396	0.500	0.096	0.080
Na (%)	0.405	0.358	0.449	0.428
pH in water	4.76	5.38	4.86	4.78
Organic matter (%)	9.56	11.64	2.77	3.00

vasion of plant communities by non-natives (Crawley 1986). This is the case at Wave Hill. In addition, the narrow shape and small size of the natural area and the abundant gaps in the woodland (Fig. 1) result in a large edge effect which favors the establishment of weedy species.

One of the major influences on the natural area is the high importance of non-native species, particularly a few of the non-arborescent species (Fig. 2). Management by the Forest Project is focusing on the most important of these, particularly porcelainberry and Amur honeysuckle.

Porcelainberry, a native of northeast Asia, has the highest IV among all the non-arborescent species (Table 2). It is of major concern for management (Antenen *et al.* 1989) because its dense growth inhibits establishment of other species. Porcelainberry is a particularly aggressive woody vine which forms blanket-like growth in open areas and up on the woodland edge. It appears to be shade-intolerant; this is supported by the negative correlation of porcelainberry cover with tree cover. Porcelainberry frequently grows over Amur honeysuckle, the most important shrub species. This combination occupies several gaps in the Wave Hill woods, where it forms an apparently stable shrub and vine layer. In some quadrats, there is well over 100% combined cover of porcelainberry and Amur honeysuckle, beneath which tree seedling and herb growth is negligible or non-existent. Evidence that these two species inhibit tree regeneration are the significant negative correlations between tree seedling density and both Amur honeysuckle cover and porcelainberry cover. Most of the Amur honeysuckle plants appear to have become established after landscaping ceased 30 years ago, although a few specimens are more than 44 years old based on annual ring counts. Amur honeysuckle becomes established and grows successfully in both forested and open habitats in the natural area, as it does in other areas of eastern North America (Luken 1988). This is supported by the lack of correlation of Amur honeysuckle cover with tree cover.

Garlic mustard, a European biennial now found as a woodland weed throughout the northeast (Gleason and Cronquist 1963), is the third most important species and has the highest frequency (85%) among the herbs, shrubs and vines (Table 2, Fig. 2). Garlic mustard may compete with some native herbs, particularly in quadrats where it has greater than 50% cover, as in the black locust association.

Norway maple, sycamore maple and black locust are among the most important non-native species in both size classes of trees (Table 2). The largest trees of these species were probably planted by the former Wave Hill estate owners, and have reproduced well. Norway and sycamore maples, both European species introduced as ornamental trees in the 19th century, are probably important competitors with native trees in the natural area. Black locust, a pioneer species with

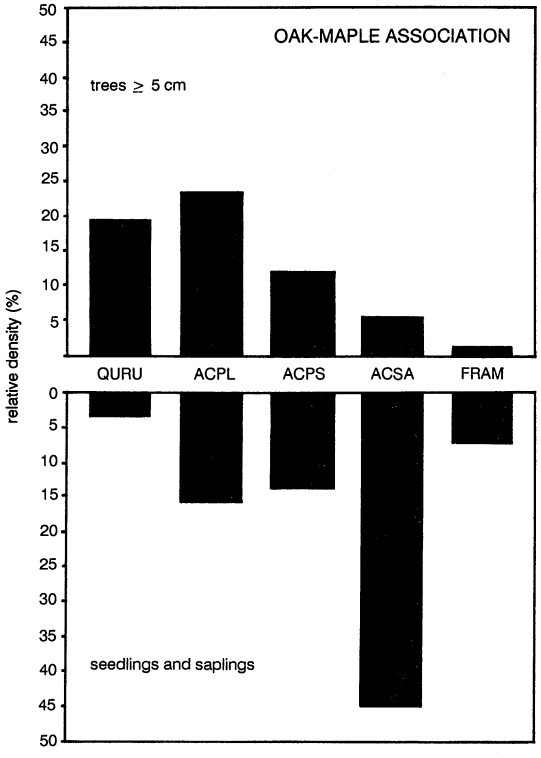

Fig. 3. Relative densities of trees and seedlings and saplings, by species, for the oak–maple association. The importance of *Acer saccharum* may increase in the future canopy. QURU = *Quercus rubra,* ACPL = *Acer platanoides,* ACPS = *Acer pseudoplatanus,* ACSA = *Acer saccharum,* FRAM = *Fraxinus americana.*

a natural range only as far east as central Pennsylvania, has escaped from cultivation in the northeastern United States (Gleason and Cronquist 1963; Fowells 1965). Beneath the canopy of black locusts in the natural area, the native bitternut hickory, white ash, black cherry and red oak are among the predominant species of seedlings and saplings (Table 4).

Red oak, black cherry, sugar maple and bitternut hickory rank high in importance among both trees and seedlings and saplings (Table 2), indicating that conditions in the natural area are favorable for the regeneration of these common native species of trees. The decline of two other native tree species, American elm and white ash, is part of broader regional trends, rather than specifically due to their urban location. The virtual elimination of American elm due to Dutch elm disease is well documented, and white ash is in decline in New York State in general (Castello *et al.* 1985). Native species of herbs, shrubs and vines are less important than non-natives, but several are common, for example white wood aster, Virginia creeper, spring beauty, and trout lily. Lack of seed source and competition with the invasive non-native species are the most obvious factors limiting the herbs.

Levels of lead and nickel in the soil are high compared to other sites in the northeast (Friedland *et al.* 1984a, 1984b, 1986), and approach the very high levels measured at the nearby New York Botanical Garden (White and McDonnell 1988). We do not know what effect these high levels of heavy metals, presumably from air pollutants, have on the vegetation.

Comparisons of the most important tree species in the different size classes indicate that the wooded sections of the natural area are shifting in composition toward more shade tolerant species. In the oak–maple association, the present-day canopy is dominated by red oak and Norway and sycamore maples. Based on relative densities of seedlings and saplings, and assuming that mortality factors between species remain relatively constant, oak may be replaced in importance by sugar maple in the future, with the Norway and sycamore maples continuing to be important (Fig. 3). There are more than 200 sugar maple seedlings and saplings in some quadrats, and their density in this association is 13 times greater than that of red oak (Table 3). However, red oak seedlings continue to become established along edges and in open areas where porcelainberry and other invasive vegetation have been cleared.

In the black birch association, the numerous seedlings and saplings of Norway maple, bitternut hickory, and sycamore maple indicate that these species may become more important components of the canopy. Similarly, in the black locust association, the importance of black locust will probably decline relative to that of more shade-tolerant species such as bitternut hickory (Fig. 4).

In summary, the vegetation composition of urban woodlands such as the one at Wave Hill combines elements of the indigenous forests of the region, along with "newer" introduced species. Human disturbance has had a large influence on the present-day vegetation. One of the major features of the natural area is the high importance of invasive non-native species, which is affecting the composition and structure of the woodland. The Forest Project is working to conserve the existing native plant community and to favor the regeneration of native species by clearing areas dominated by species such as porcelainberry and Amur honeysuckle. This 1987

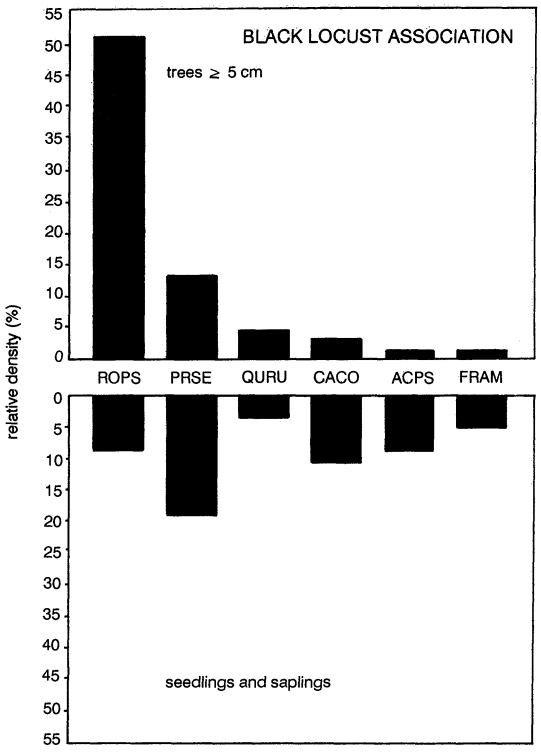

Fig. 4. Relative densities of trees and seedlings and saplings, by species, for the black locust association. The importance of *Robinia pseudoacacia* will probably decline in the future canopy. ROPS = *Robinia pseudoacacia,* PRSE = *Prunus serotina,* QURU = *Quercus rubra,* CACO = *Carya cordiformis,* ACPS = *Acer pseudoplatanus,* FRAM = *Fraxinus americana.*

vegetation survey provides detailed baseline data with which we can document vegetation change and assess the progress of management in the natural area. Future vegetation surveys will enable us to measure shifts in the relative importance of native and non-native species.

Literature Cited

AIROLA, T. M. AND K. BUCHHOLZ. 1982. Forest community relationships of the Greenbrook Sanctuary, New Jersey. Bull. Torrey Bot. Club 109: 205–218.

ANTENEN, S. 1986. Forest restoration project in New York City. Rest. Managem. Notes 4: 27–28.

ANTENEN, S., S. YOST AND G. HARTVIGSEN. 1989. Porcelainberry vine control methods explored (New York). Rest. Managem. Notes 7: 44.

BAILEY, L. H. AND E. Z. BAILEY. 1976. Hortus third. A concise dictionary of plants cultivated in the United States and Canada. Macmillan Publishing Co., Inc., London, England. 1290 p.

BRAUN, E. L. 1950. Deciduous forests of eastern North America. Hafner Press, New York. 596 p.

CASTELLO, J. D., S. B. SILVERBORG AND P. D. MANION. 1985. Intensification of ash decline in New York State from 1962 through 1980. Plant Disease 69: 243–246.

CRAWLEY, M. J. 1986. What makes a community invasible?, pp. 429–453. *In* A. J. Gray, M. J. Crawley and P. J. Edwards [eds.], Colonization, succession and stability. Blackwell Scientific Publications, Oxford, England.

CRONQUIST, A. 1981. An integrated system of classification of flowering plants. Columbia University Press, New York. 1262 p.

CURTIS, J. T. AND R. P. MCINTOSH. 1951. An upland forest continuum in the prairie–forest border region of Wisconsin. Ecology 32: 476–498.

FOWELLS, H. A. 1965. Silvics of forest trees of the United States. U.S. Department of Agriculture, Agriculture Handbook No. 271. Washington, DC. 762 p.

FRANKEL, E. 1978. A floristic survey of the vascular plants of the Bronx River Park in Westchester County, New York. Bull. Torrey Bot. Club 105: 147–155.

———. 1979. A floristic survey of the vascular plants of the Bronx River Park in Westchester County, New York. Supplement, 1977–1978. Bull. Torrey Bot. Club 106: 46–47.

FRIEDLAND, A. J., A. H. JOHNSON AND T. G. SICCAMA. 1984a. Trace metal content of the forest floor in the Green Mountains of Vermont: Spatial and temporal patterns. Water, Air, and Soil Pollution 21: 161–170.

———, ——— AND ———. 1986. Zinc, Cu, Ni and Cd in the forest floor in the northeastern United States. Water, Air, and Soil Pollution 29: 233–243.

———, ———, ——— AND D. L. MADER. 1984b. Trace metal profiles in the forest floor of New England. Soil Sci. Soc. Amer. J. 48: 422–425.

GLEASON, H. A. AND A. CRONQUIST. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. D. van Nostrand Company, New York. 810 p.

GRELLER, A. M. 1972. Observations on the forests of northern Queens County, Long Island, from colonial times to the present. Bull. Torrey Bot. Club 99: 202–206.

———. 1977a. A vascular flora of the forested portion of Cunningham Park, Queens County, New York, with notes on the vegetation. Bull. Torrey Bot. Club 104: 170–176.

———. 1977b. A classification of mature forests on Long Island, New York. Bull. Torrey Bot. Club 104: 376–382.

———, R. E. CALHOUN AND E. IGLICH. 1979. The upland, oak-dominated community of Forest Park, Queens County, New York. Bull. Torrey Bot. Club 106: 135–139.

——— AND O. L. GARCIA. 1986. Variation in canopy composition of the forest of Alley Park, Queens County, New York. Bull. Torrey Bot. Club 113: 35–41.

———, J. M. MANSKY AND R. E. CALHOUN. 1982. An oak, hickory–dogwood forest on central Long Island, New York. Bull. Torrey Bot. Club 109: 219–225.

HONKALA, D. A. AND J. B. MCANINCH. 1980. The New York Botanical Garden Hemlock Forest Project. The New York Botanical Garden, Cary Ar-

boretum, Department of Wildlife Resources, Millbrook, New York. Unpublished report. 27 p.
——— AND ———. 1981. The New York Botanical Garden Hemlock Forest Project, Part II. The New York Botanical Garden, Cary Arboretum, Department of Wildlife Resources, Millbrook, New York. Unpublished report. 80 p.
KUNSTLER, D. AND THE NATURAL RESOURCES GROUP. 1987. Plant species of Pelham Bay Park. New York City Parks Department. Unpublished. 8 p.
LEFKOWITZ, A. AND A. M. GRELLER. 1973. The distribution of tree species on the uplands of Cunningham Park, Queens County, New York, Bull. Torrey Bot. Club 100: 313–318.
LOEB, R. E. 1986. Plant communities of Inwood Hill Park, New York County, New York. Bull. Torrey Bot. Club 113: 46–52.
LUKEN, J. O. 1988. Population structure and biomass allocation of the naturalized shrub *Lonicera maackii* (Rupr.) Maxim. in forest and open habitats. Amer. Midl. Natur. 119: 258–267.
MAGURRAN, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton, N.J. 179 p.
MITCHELL, R. S. 1986. A checklist of New York State plants. New York State Museum Bulletin 458. 272 p.
PROFOUS, G. V. AND R. E. LOEB. 1984. Vegetation and plant communities of Van Cortlandt Park, Bronx, New York. Bull. Torrey Bot. Club 111: 80–89.
RUDNICKY, J. L. AND M. J. MCDONNELL. 1989. Forty-eight years of canopy change in a hardwood–hemlock forest in New York City. Bull. Torrey Bot. Club 116: 52–64.
RUFFNER, J. A. AND F. E. BAIR [eds.]. 1987. Weather of U.S. cities, 3rd ed., Vol. 2. Gale Research Company, Detroit, MI. 1200 p.
SERRAO, J. AND N. DICKER. 1988. Flowering plants recorded in Greenbrook Sanctuary 1946–1986, exclusive of grasses, sedges, and rushes. Bartonia 54: 116–123.
SOKAL, R. R. AND F. J. ROHLF. 1981. Biometry, 2nd ed. Freeman and Co., San Francisco, California. 859 p.
Stalter, R. 1981. A thirty-nine year history of the arborescent vegetation of Alley Park, Queens County, New York. Bull. Torrey Bot. Club 108: 485–487.
WHITE, C. S. AND M. J. MCDONNELL. 1988. Nitrogen cycling processes and soil characteristics in an urban versus rural forest. Biogeochemistry 5: 243–262.

Appendix

Vascular Flora of Wave Hill's Natural Area

Non-native species are marked with *.
Species planted since 1980 are marked with [p].

EQUISETACEAE
Equisetum arvense L.
OSMUNDACEAE
Osmunda cinnamomea L. [p]
POLYPODIACEAE
Athyrium asplenioides (Michx.) Desv.
Dennstaedtia punctilobula (Michx.) Moore [p]
Dryopteris austriaca var. *spinulosa* (Muell.) Fiori
Onoclea sensibilis L.
Polystichum acrostichoides (Michx.) Schott [p]
Thelypteris noveboracensis (L.) Nieuwl.
GINKGOACEAE
**Ginkgo biloba* L.
TAXACEAE
**Taxus cuspidata* Marsh.
PINACEAE
**Picea abies* (L.) Karst.
Pinus rigida Mill. [p]
P. strobus L. [p]
Tsuga canadensis (L.) Carr.
MAGNOLIACEAE
Liriodendron tulipifera L.
LAURACEAE
Lindera benzoin (L.) Blume
Sassafras albidum (Nutt.) Nees
ARISTOLOCHIACEAE
Asarum canadense L. [p]
RANUNCULACEAE
Aquilegia canadensis L. [p]
Cimicifuga racemosa (L.) Nutt. [p]
**Clematis terniflora* DC.
**Ranunculus ficaria* L.
Thalictrum dioicum L.
BERBERIDACEAE
**Berberis thunbergii* DC.
Caulophyllum thalictroides (L.) Michx. [p]
Podophyllum peltatum L. [p]
MENISPERMACEAE
Menispermum canadense L.
PAPAVERACEAE
**Chelidonium majus* L.
Sanguinaria canadensis L.
**Stylophorum diphyllum* (Michx) Nutt.
FUMARIACEAE
Dicentra cucullaria (L.) Bernh.
PLATANACEAE
**Platanus* × *hybrida* Brot.
HAMAMELIDACEAE
Hamamelis virginiana L. [p]
Liquidambar styraciflua L.
ULMACEAE
Celtis occidentalis L.
Ulmus rubra Muhl.
**U. pumila* L.
CANNABACEAE
**Humulus japonicus* Sieb. & Zucc.
MORACEAE
**Broussonetia papyrifera* (L.) Vent.
**Maclura pomifera* (Raf.) Schneid.
**Morus alba* L.
URTICACEAE
Pilea pumila (L.) Gray
Urtica dioica L.

JUGLANDACEAE
Carya cordiformis (Wang.) Koch.
C. glabra (Mill.) Sweet
C. tomentosa (Poir.) Nutt.
FAGACEAE
Fagus grandifolia Ehrh.
Quercus alba L.
Q. coccinea Muenchh.
Q. palustris Muenchh.
Q. rubra L.
Q. velutina Lam.
BETULACEAE
Betula lenta L.
Ostrya virginiana (Mill.) Koch
PHYTOLACCACEAE
Phytolacca americana L.
CHENOPODIACEAE
**Chenopodium album* L.
**C. urbicum* L.
AMARANTHACEAE
**Amaranthus hybridus* L.
PORTULACACEAE
Claytonia virginica L.
**Portulaca oleracea* L.
CARYOPHYLLACEAE
**Saponaria officinalis* L.
**Silene pratensis* (Raf.) Godron & Gren.
S. stellata (L.) Ait. f.
**Stellaria media* (L.) Cyrill.
POLYGONACEAE
**Polygonum aviculare* L.
**P. caespitosum* Blume
**P. cuspidatum* Sieb. & Zucc.
**P. lapathifolium* L.
**P. persicaria* L.
P. scandens L.
P. virginianum L.
**Rumex patientia* L.
**R. obtusifolia* L.
TILIACEAE
Tilia americana L.
**T. cordata* Mill.
MALVACEAE
**Abutilon theophrasti* Medic.
VIOLACEAE
Viola pubescens Ait. [p]
V. sororia Willd.
V. striata Ait. [p]
CUCURBITACEAE
Sicyos angulatus L.
BRASSICACEAE
**Alliaria petiolata* (Bieb.) Cav. & Grande
**Barbarea vulgaris* R.
**Capsella bursa-pastoris* (L.) Medic.
**Hesperis matronalis* L.
Lepidium virginicum L.
ERICACEAE
Kalmia latifolia L.
Rhododendron periclymenoides (Michx.) Shinners
STYRACACEAE
**Halesia carolina* L.
PRIMULACEAE
Lysimachia quadrifolia L. [p]
HYDRANGEACEAE
**Philadelphus coronarius* L.
SAXIFRAGACEAE
Mitella diphylla L. [p]
ROSACEAE
Amelanchier canadensis (L.) Medic. [p]
Fragaria virginiana Duchesne
**Duchesnea indica* (Andr.) Focke
Geum canadense Jacq.
Potentilla simplex Michx.
**Prunus avium* L.
P. serotina Ehrh.
**Pyrus communis* L.
**Rhodotypos scandens* (Thunb.) Makino
**Rosa multiflora* Thunb.
R. setigera Michx.
Rubus allegheniensis Porter
R. flagellaris L.
R. occidentalis L.
**R. phoenicolasius* Maxim.
**Sorbaria aitchisonii* Hemsl.
Spiraea tomentosa L. [p]
MIMOSACEAE
**Albizia julibrissin* Durazz.
CAESALPINIACEAE
**Cercis canadensis* L.
Gleditsia triacanthos L.
FABACEAE
**Cladrastis lutea* (Michx. f.) K. Koch
**Medicago lupulina* L.
**Melilotus alba* Desr.
**Pueraria lobata* (Willd.) Ohwi
**Robinia pseudoacacia* L.
**Trifolium pratense* L.
**T. repens* L.
**Trilobum hybridum* L.
**Vicia cracca* L.
ELAEAGNACEAE
**Elaeagnus umbellata* Thunb.
ONAGRACEAE
Circaea lutetiana L.
Oenothera biennis L.
NYSSACEAE
Nyssa sylvatica Marsh.
CORNACEAE
Cornus florida L.
C. racemosa Lam. [p]
CELASTRACEAE
**Celastrus orbiculatus* Thunb.
**Euonymus alata* (Thunb.) Sieb.
**E. fortunei* (Turcz.) Hand.
AQUIFOLIACEAE
Ilex opaca Ait. [p]
I. verticillata (L.) Gray [p]
BUXACEAE
**Pachysandra terminalis* Sieb. & Zucc.
EUPHORBIACEAE
Acalypha rhomboidea Raf.
**Euphorbia maculata* L.
VITACEAE
**Ampelopsis brevipedunculata* (Maxim.) Trautv.
Parthenocissus quinquefolia (L.) Planch.
Vitis aestivalis Michx.
HIPPOCASTANACEAE
**Aesculus hippocastanum* L.
ACERACEAE
**Acer palmatum* Thunb.
**A. platanoides* L.
**A. pseudoplatanus* L.
A. rubrum L.

A. saccharinum L.
A. saccharum Marsh.
ANACARDIACEAE
Rhus copallinum L. [p]
R. typhina L.
Toxicodendron radicans (L.) Kuntze
SIMAROUBACEAE
**Ailanthus altissima* (Mill.) Swingle
RUTACEAE
**Poncirus trifoliata* (L.) Raf.
OXALIDACEAE
Oxalis stricta L.
GERANIACEAE
Geranium maculatum L.
**G. sibericum* L.
BALSAMINACEAE
Impatiens capensis Meerb.
ARALIACEAE
**Aralia elata* (Miq.) Seem.
**Hedera helix* L.
APIACEAE
**Aegopodium podagraria* L.
Cryptotaenia canadensis (L.) DC.
**Daucus carota* L.
**Heracleum mantegazzianum* Somm. & Lev.
Osmorhiza longistylis (Torr.) DC.
APOCYNACEAE
Apocynum cannabinum L.
ASCLEPIADACEAE
Asclepias syriaca L.
SOLANACEAE
Datura stramonium L.
**Lycium barbarum* L.
Physalis heterophylla Nees
**Solanum dulcamara* L.
**S. nigrum* L.
CONVOVULACEAE
**Ipomoea purpurea* (L.) Roth
POLEMONIACEAE
Phlox divaricata L.
BORAGINACEAE
Mertensia virginica (L.) Pers. [p]
**Symphytum officinale* L.
VERBENACEAE
Verbena urticifolia L.
LAMIACEAE
**Glecoma hederacea* L.
**Lamium purpureum* L.
**Leonurus cardiaca* L.
PLANTAGINACEAE
**Plantago lanceolata* L.
**P. major* L.
P. rugelii Decne.
OLEACEAE
**Chionanthus virginicus* L.
Fraxinus americana L.
**Ligustrum vulgare* L.
SCROPHULARIACEAE
**Cymbalaria muralis* Gaertn., Mey. & Scherb.
**Verbascum blattaria* L.
**V. thapsus* L.
**Veronica arvensis* L.
BIGNONIACEAE
**Campsis radicans* (L.) Seem.
CAMPANULACEAE
Lobelia siphilitica L.
RUBIACEAE
**Galium aparine* L.
CAPRIFOLIACEAE
**Lonicera japonica* Thunb.
**L. maackii* Maxim.
**L. tatarica* L.
Viburnum acerifolium L.
V. dentatum var. *lucidum* Ait. [p]
**V. lantana* L.
V. lentago L. [p]
V. prunifolium L.
**V. sieboldii* Miq.
**V. opulus* L.
ASTERACEAE
Ambrosia artemisiifolia L.
A. trifida L.
**Arctium minus* Schk.
**Artemisia vulgaris* L.
Aster cordifolius L.
A. divaricatus L.
A. novae-angliae L.
A. simplex Willd.
Bidens frondosa L.
**Cichorium intybus* L.
**Cirsium vulgare* (Savi) Tenore
Conyza canadensis (L.) Cronq.
Erechtites hieracifolia (L.) Raf.
Erigeron annuus (L.) Pers.
E. philadelphicus L.
Eupatorium rugosum Houtt.
**Galinsoga ciliata* (Raf.) Blake
**Helianthus tuberosus* L.
Heliopsis helianthoides (L.) Sweet
Lactuca biennis (Moench) Fern.
**L. serriola* L.
**Lapsana communis* L.
Solidago caesia L.
S. canadensis L.
**Sonchus oleraceus* L.
**Taraxacum officinale* Weber
ARACEAE
Arisaema triphyllum (L.) Schott
COMMELINACEAE
**Commelina communis* L.
JUNCACEAE
Juncus tenuis Willd.
CYPERACEAE
Carex blanda (Dewey) Boott.
C. pensylvanica Lam.
C. rosea Schk.
C. tribuloides Wahl.
C. virescens Muhl.
C. vulpinoidea Michx.
Cyperus strigosus L.
POACEAE
Agrostis stolonifera L.
**Agropyron repens* (L.) Beauv.
Andropogon virginicus L.
**Arrhenatherum elatius* (L.) Mert. & Koch
**Dactylis glomerata* L.
**Digitaria sanguinalis* (L.) Scop.
**Eleusine indica* (L.) Gaertn.
Eragrostis spectabilis (Pursh) Steud.
**Lolium multiflorum* Lam.
**Miscanthus sinensis* Anderss.
Muhlenbergia schreberi Gmel.
Panicum clandestinum L.
**Phleum pratense* L.
**Poa nemoralis* L.
**P. trivialis* L.

**Setaria faberi* Herrm.
**S. glauca* (L.) Beauv.
Triodia flava (L.) Smyth.
LILIACEAE
Allium tricoccum Ait. [p]
**A. vineale* L.
**Chionodoxa luciliae* Boiss.
**C. sardensis* Hort. Barr & Sugden
**Convallaria majalis* L.
**Endymion non-scriptus* (L.) Garcke
Erythronium albidum Nutt.
E. americanum Ker
**Hemerocallis fulva* L.
**Hosta ventricosa* (Salisb.) Stern
**Narcissus pseudo-narcissus* L.
**Ornithogalum umbellatum* L.
Polygonatum biflorum (Walt.) Ell.
**Scilla sibirica* Andr.
Smilacina racemosa (L.) Desf.
Trillium erectum L.
T. grandiflorum (Michx.) Salisb.
Uvularia perfoliata L.
AGAVACEAE
**Yucca filamentosa* L.
SMILACACEAE
Smilax glauca Walt.
S. herbacea L.
S. rotundifolia L.