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A 70-Year History of Arborescent Vegetation of Inwood Park, Manhattan, New York, U.S.

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Abstract. The arborescent vegetation located at three sites within Inwood Park, Manhattan, New York, U.S. was sampled by the quadrat method in October 2004 and May 2005 and compared with the trees present in the same quadrats on a map of trees at Inwood Park prepared by the federal Works Program Administration in 1935. Tulip poplar (*Liriodendron tulipifera*) was the dominant tree at the Moist Valley and South Slope sites in 1935 and 2005, whereas oak (*Quercus*) was the dominant genus at Dry Ridge in 1935 and 2005. Dogwood (*Cornus florida*) was the dominant subcanopy tree in 1935; it was unimportant in 2005, a victim of dogwood anthracnose. In terms of ecologic dominance, there has been no change in the first ranked genera at these sites in the past 70 years. Mean tree diameter (diameter at breast height) has increased from 32.3 cm (12.9 in) to 41.8 cm (16.7 in). The three sites have experienced a parallel pattern of increase in tree size from 1935 to 2005. Nonnative trees were not important in Inwood Park in 2005.

Key Words. Inwood Park; Manhattan; New York City; urban forests.

Within the confines of New York City, U.S. there exists natural, woody vegetation that is probably similar to the vegetation observed by 17th century Dutch settlers (Greller 1972). Today, most of this natural vegetation persists in municipal parks administered by the New York City Department of Parks and Recreation (Greller 1975; Stalter 1981).

During the 1930s, federal money was supplied through the Works Program Administration (WPA) to map, identify, and record the diameter at breast height (dbh at 1.37 m [4.5 ft]) of all trees in Inwood Park. After the completion of the WPA project in 1935, a map with tree identification, location, and dbh data was filed away and forgotten for nearly 40 years (Stalter 1981). The objective of this study was to compare community structure of the trees of Inwood Park as mapped in 1935 with that present in October 2004 through May 2005.

METHODS

The current study was conducted in Inwood Park (81 ha [200 ac]), located in northwest Manhattan (Figure 1). The quadrat method was used to sample trees presently growing in the park. Only trees with a dbh greater than 7.6 cm (3 in) were selected and measured in this study. Twenty-five 10 m × 10 m (33 ft × 33 ft) quadrants were established at each of the three sites at Inwood Park: 1) Moist Valley, a forest dominated by *Liriodendron tulipifera*, 40°52′25″N, 73°55′26″W; 2) South Slope, a south-facing moist forest dominated by *Liriodendron tulipifera*, 40°52′21″N, 73°55′26″W; and 3) Dry Ridge, a ridge-top dominated by oak species, 40°52′15″N, 73°55′22″W. The trees present in the 25 quadrats at each site in October 2004 through May 2005 were mapped on the original 1935 tree map of Inwood Park prepared by the WPA workers during the Great Depression in the United States. Although the purpose of the WPA was to put people to work rather than to pursue forestry, nevertheless, these tree data have historical value for understanding forest change in New York City.

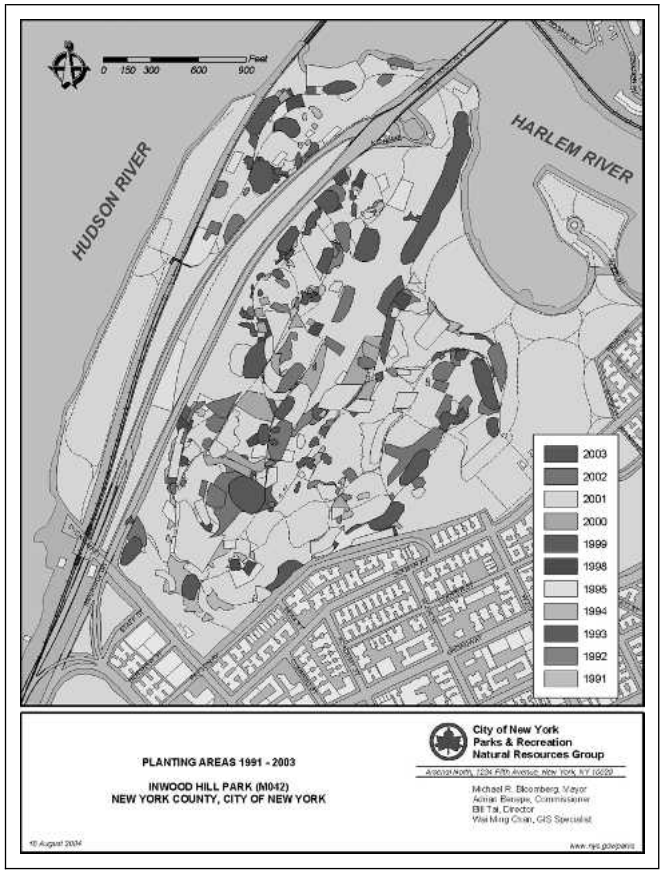

Figure 1. Inwood Park, in the northern tip of Manhattan, New York. Color-coded tree planting sites 1991 to 2003 by New York City Parks and Recreation. The geographic distribution of these plantings exceeded the range of our three study sites whose GPS coordinates are given in "Methods."

Table 1. Species importance values (IV) in percentages for the 1935 and the 2005 census.[z]

Dominance rank	N	Relative density	Relative frequency	Relative dominance	Importance value
Moist Valley, 1935					
1. *Liriodendron tulipifera*	9	26.5 (26.5)	26.7 (26.7)	57.1 (57.1)	110.2 (110.22)
2. *Quercus* spp.	6	17.7 (44.1)	16.7 (43.3)	25.0 (82.1)	59.4 (169.57)
3. *Acer* spp.	8	23.5 (67.6)	20.0 (63.3)	5.6 (87.7)	49.1 (218.69)
4. *Fraxinus americana*	2	5.9 (73.5)	6.7 (70.0)	3.5 (91.2)	16.0 (234.70)
5. *Ulmus americana*	2	5.9 (79.4)	6.7 (76.7)	2.1 (93.3)	14.7 (249.36)
6. *Carpinus caroliniana*	2	5.9 (85.3)	6.7 (83.3)	1.3 (94.6)	13.9 (263.21)
7. *Cornus florida*	2	5.9 (91.2)	6.7 (90.0)	1.0 (95.6)	13.6 (276.78)
8. *Betula lenta*	1	2.9 (94.1)	3.3 (93.3)	1.5 (97.1)	7.7 (284.52)
9. *Catalpa* spp.	1	2.9 (97.1)	3.3 (96.7)	1.5 (98.5)	7.7 (292.26)
10. *Juglans cinera*	1	2.9 (100)	3.3 (100)	1.5 (100)	7.7 (300.00)
Moist Valley, 2005					
1. *Liriodendron tulipifera*	10	22.7 (22.7)	25.7 (0.257)	46.1 (46.1)	94.6 (94.55)
2. *Acer saccharum*	10	22.7 (45.5)	20.0 (0.457)	15.2 (61.3)	58.0 (152.49)
3. *Quercus rubra*	4	9.1 (54.5)	8.6 (0.543)	20.4 (81.8)	38.1 (190.60)
4. *Fraxinus americana*	4	9.1 (63.6)	11.4 (0.657)	0.9 (82.6)	21.4 (212.00)
5. *Quercus alba*	2	4.6 (68.2)	2.9 (0.686)	6.8 (89.4)	14.2 (226.18)
6. *Carya cordiformis*	2	4.6 (72.7)	5.7 (0.743)	3.0 (92.5)	13.3 (239.48)
7. *Ulmus americana*	2	4.6 (77.3)	5.7 (0.800)	2.9 (95.3)	13.1 (252.59)
8. *Betula lenta*	2	4.6 (81.8)	5.7 (0.857)	1.6 (97.0)	11.9 (264.50)
9. *Celtis occidentalis*	3	6.8 (88.6)	2.9 (0.886)	0.2 (97.2)	9.9 (274.40)
10. *Aralia spinosa*	2	4.6 (93.2)	2.9 (0.914)	0.3 (97.5)	7.7 (282.08)
11. *Quercus velutina*	1	2.3 (95.5)	2.9 (0.943)	2.4 (99.9)	7.6 (289.66)
12. *Prunus serotina*	1	2.3 (97.7)	2.9 (0.971)	0.04 (100)	5.2 (294.83)
13. *Tsuga canadensis*	1	2.3 (100)	2.9 (1.000)	0.04 (100)	5.2 (300.00)
South Slope, 1935					
1. *Liriodendron tulipifera*	25	31.3 (31.3)	31.5 (31.5)	68.0 (68.0)	130.7 (130.68)
2. *Quercus* spp.	14	17.5 (48.8)	20.4 (51.9)	12.1 (80.1)	50.0 (180.68)
3. *Acer* spp.	12	15.0 (63.8)	11.1 (63.0)	6.7 (86.7)	32.8 (213.44)
4. *Cornus florida*	11	13.8 (77.5)	13.0 (75.9)	2.1 (88.8)	28.8 (242.23)
5. *Betula lenta*	5	6.3 (83.8)	5.6 (81.5)	3.2 (92.0)	15.0 (257.26)
6. *Carya* spp.	5	6.3 (90.0)	5.6 (87.0)	2.9 (95.0)	14.7 (271.99)
7. *Juglans cinera*	2	2.5 (92.5)	3.7 (90.7)	2.9 (97.9)	9.1 (281.12)
8. *Fraxinus americana*	2	2.5 (95.0)	1.9 (92.6)	0.5 (98.4)	4.9 (285.97)
9. *Nyssa sylvatica*	1	1.3 (96.3)	1.9 (94.4)	0.7 (99.1)	3.9 (289.76)
10. *Prunus* spp.	1	1.3 (97.5)	1.9 (96.3)	0.4 (99.5)	3.5 (293.30)
11. *Celtis occidentalis*	1	1.3 (98.7)	1.9 (98.1)	0.2 (99.8)	3.4 (296.65)
12. *Sassafras albidum*	1	1.3 (100)	1.9 (100)	0.2 (100)	3.4 (300.00)
South Slope, 2005					
1. *Liriodendron tulipifera*	12	20.0 (20.0)	17.3 (17.3)	45.5 (0.455)	82.8 (82.80)
2. *Quercus rubra*	7	11.7 (31.7)	11.5 (28.8)	28.0 (0.735)	51.3 (134.04)
3. *Prunus serotina*	9	15.0 (46.7)	15.4 (44.2)	0.9 (0.744)	31.2 (165.28)
4. *Carya cordiformis*	6	10.0 (56.7)	11.5 (55.8)	7.3 (0.817)	28.9 (194.15)
5. *Sassafras albidum*	8	13.3 (70.0)	13.5 (69.2)	1.2 (0.829)	28.0 (222.16)
6. *Quercus alba*	3	5.0 (75.0)	5.8 (75.0)	7.0 (0.899)	17.8 (239.94)
7. *Cornus florida*	5	8.3 (83.3)	7.7 (82.7)	0.8 (0.908)	16.9 (256.80)
8. *Ulmus americana*	3	5.0 (88.3)	3.9 (86.5)	3.6 (0.944)	12.5 (269.29)
9. *Quercus prinus*	2	3.3 (91.7)	3.9 (90.4)	4.7 (0.991)	11.9 (281.18)
10. *Betula lenta*	1	1.7 (93.3)	1.9 (92.3)	0.6 (0.997)	4.2 (285.34)
11. *Acer saccharum*	1	1.7 (95.0)	1.9 (94.2)	0.12 (0.998)	3.7 (289.04)
12. *Acer rubrum*	1	1.7 (96.7)	1.9 (96.2)	0.07 (0.999)	3.7 (292.70)
13. *Hamamelis virginiana*	1	1.7 (98.3)	1.9 (98.1)	0.07 (1.000)	3.7 (296.37)
14. *Fraxinus americana*	1	1.7 (100)	1.9 (100)	0.04 (1.000)	3.6 (300.00)
Dry Ridge, 1935					
1. *Quercus* spp.	31	77.5 (77.5)	69.2 (69.2)	95.0 (95.0)	241.7 (241.69)
2. *Betula lenta*	4	10.0 (87.5)	11.5 (80.8)	1.8 (96.7)	23.3 (265.00)

(*continued*)

Table 1. Species importance values (IV) in percentages for the 1935 and the 2005 census.[z] (*continued*)

Dominance rank	N	Relative density	Relative frequency	Relative dominance	Importance value
3. *Prunus* spp.	3	7.5 (95.0)	11.5 (92.3)	1.5 (98.2)	20.5 (285.54)
4. *Acer* spp.	1	2.5 (97.5)	3.9 (96.2)	1.2 (99.5)	7.6 (293.11)
5. *Robinia pseudoacacia*	1	2.5 (100)	3.9 (100)	0.5 (100)	6.9 (300.00)
Dry Ridge, 2005					
1. *Quercus rubra*	43	43.0 (43.0)	28.4 (28.4)	47.0 (47.0)	118.4 (118.37)
2. *Quercus velutina*	7	7.0 (50.0)	9.0 (37.3)	13.2 (60.2)	29.2 (147.52)
3. *Quercus alba*	7	7.0 (57.0)	9.0 (46.3)	11.8 (72.0)	27.8 (175.30)
4. *Prunus serotina*	11	11.0 (68.0)	14.9 (61.2)	1.4 (73.4)	27.3 (202.58)
5. *Quercus prinus*	8	8.0 (76.0)	10.5 (71.6)	4.9 (78.2)	23.3 (225.88)
6. *Liriodendron tulipifera*	7	7.0 (83.0)	4.5 (76.1)	11.1 (89.4)	22.6 (248.48)
7. *Quercus coccinea*	3	3.0 (86.0)	4.5 (80.6)	3.6 (92.9)	11.1 (259.53)
8. *Betula lenta*	3	3.0 (89.0)	4.5 (85.1)	2.5 (95.5)	10.0 (269.53)
9. *Morus alba*	3	3.0 (92.0)	4.5 (89.6)	0.5 (95.9)	7.9 (277.47)
10. *Tilia cordata*	2	2.0 (94.0)	1.5 (91.0)	1.0 (96.9)	4.5 (281.93)
11. *Aesculus hippocastanum*	1	1.0 (95.0)	1.5 (92.5)	1.3 (98.2)	3.8 (285.71)
12. *Robinia pseudoacacia*	1	1.0 (96.0)	1.5 (94.0)	0.8 (98.9)	3.3 (288.98)
13. *Fraxinus americana*	1	1.0 (97.0)	1.5 (95.5)	0.7 (99.6)	3.2 (292.16)
14. *Carya cordiformis*	1	1.0 (98.0)	1.5 (97.0)	0.2 (99.8)	2.7 (294.82)
15. *Populus deltoides*	1	1.0 (99.0)	1.5 (98.5)	0.2 (100)	2.7 (297.48)
16. *Prunus avium*	1	1.0 (10.0)	1.5 (100)	0.02 (100)	2.5 (300.00)

[z]IV is the sum of relative density, relative frequency, and relative dominance. In the 1935 census, some taxa were identified only to genus. Integers denote the ecologic dominance rank of each species as measured by the IV method.

Loeb (1982) questioned the reliability of the New York City Department of Parks and Recreation's (NYCDPR) forest records. Loeb (1982) compared three tree map studies: the NYCDPR's topographic map series at Seton Falls Park in northern Bronx using forest records prepared in 1936 by the NYCDPR, his personal research in 1979, and a tree map prepared by Quinn Associates, Philadelphia, Pennsylvania, in 1981. Loeb surveyed a 5 ha (12.5 ac) portion of Seton Falls Park Forest and concluded that there were errors in identifications, tree diameter measurements, and "oversights in recording of species on the maps of the park." Loeb (1982) concluded, "Totally accurate arboreal species lists cannot be made from these records because some minor groups of species may not be included and misidentifications can cause the inclusion of species that were not present. Reliable statements of population density and dominance changes can only be made for dominant taxa." To address Loeb's concerns in this study, all species of oaks (*Quercus*) and all species of maples (*Acer*) were lumped as genera when comparing across years, so that past species misidentifications would not be an issue.

Table 2. Density per ha of saplings (trees of diameter at breast height less than 7.6 cm (3 in)) at three sites in 2005, Inwood Park, New York.

Species	Moist Valley	South Slope	Dry Ridge
Morus alba	350		250
Acer platanoides	200	50	50
Fraxinus spp.	250	700	350
Acer saccharum	400	100	
Carya cordiformis	100	350	100
Liriodendron tulipifera	150	150	
Quercus alba	150		350
Celtis occidentalis	50	50	250
Quercus prinus	100		
Tilia cordata		50	
Prunus serotina		150	3500
Quercus rubra		50	450
Sassafras albidum		100	450
Prunus avium		100	250
Betula lenta		50	
Acer rubrum			850
Crataegus spp.			50
Pyrus calleryana			50
Pyrus malus			400

The trees identified within each quadrat in 2005 in the three sites mentioned were compared with trees identified within the same quadrats at the same sites located on the WPA map (City of New York, Department of Parks, Topographical Division 1935). Density (percent of total trees), frequency (percent of all points of occurrence across quadrats), relative dominance (percent total basal area), and importance value (IV, sum of relative density, relative frequency, and relative dominance) were calculated for all arborescent species in 1935 and 2005. Tree species were listed in decreasing order of IV (Kent and Coker 1992). Change in tree size (dbh) was subjected to two-way analysis of variance with date (1935, 2005), the three study sites, and the interaction term as effects (Sokal and Rohlf 1995). Shannon diversity (Pielou 1975) was calculated for the arborescent taxa in each study site for 1935 and 2005. Data were merged from the 1935 and 2005 census and correspondence analysis (Manly 2006) was used to ordinate the three study sites and the nine most dominant genera of trees.

Saplings (dbh less than 7.6 cm [3 in]) were sampled in 25 2 m × 4 m (6.6 ft × 13.2 ft) quadrants placed in the lower right corner of each 10 m × 10 m (33 ft × 33 ft) quadrant in 2005. No sapling data are available for 1935. Nomenclature follows Gleason and Cronquist (1991).

RESULTS AND DISCUSSION

At the Moist Valley in 1935 and in 2005, tulip poplar (*Liriodendron tulipifera*), red oak (*Quercus rubra*), and sugar maple (*Acer*

saccharum) ranked one through three in relative density, relative dominance, and IV (Table 1). Together, they composed approximately 88% of the relative dominance (total basal area) of all tree species at this site. At Moist Valley, *Liriodendron* and *Acer saccharum* ranked first and second, respectively, in relative frequency, whereas oaks ranked third.

At the moist, south-facing South Slope, *Liriodendron* and species of oaks ranked first and second in relative density and relative dominance in 1935 and 2005. Together these species composed approximately 80% of the total basal area at this site. Frequency values for all tree species were low at the South Slope; *Liriodendron* ranked first in relative frequency followed by the oaks.

At Dry Ridge, oak dominated. Five oak species, red oak (*Quercus rubra*), black oak (*Q. velutina*), chestnut oak (*Q. prinus*), white oak (*Q. alba*), and scarlet oak (*Q. coccinea*), composed 95% of the relative dominance at Dry Ridge in 1935 and 80.4% of the relative dominance in 2005. Oak species together composed 78% of the relative density, 69% of the relative frequency, and a summed IV of 242 out of a possible 300 in 1935.

Density values (number per ha) for saplings, trees with dbh less than 7.6 cm (3 in), are presented in Table 2. Dry Ridge has the greatest number of saplings per hectare (7,350). Black cherry (*Prunus serotina*), an edge and/or successional species, was most abundant (3,500 per ha). Few *P. serotina* with a dbh greater than 7.6 cm (3 in) were observed at Dry Ridge; most occurred at the sunlit edge of the forest.

The South Slope and Moist Valley sites had fewer saplings than Dry Ridge. White ash (*Fraxinus*) was most abundant at the South Slope (700 per ha) followed by hickory (*Carya*) (350 ha). *Liriodendron*, the dominant canopy species at South Slope had 150 per ha as did *P. serotina*.

At Moist Valley, *Acer saccharum* ranked first in number of saplings (400 ha). *Acer saccharum* was the second most abundant large tree followed by *Liriodendron*. The sapling number for *Liriodendron* was 150 per ha. The alien white mulberry (*Morus alba*), *Fraxinus* spp., and the alien Norway maple (*Acer platanoides*) were represented by 350, 250, and 200 saplings, respectively.

At South Slope, density and frequency data for saplings trees with a dbh less than 7.6 cm are presented in Table 2. Bitternut (*Carya cordiformis*) saplings were more abundant than *Quercus* and *Liriodendron*. At Dry Ridge, *Prunus serotina* was the most abundant sapling outnumbering *Quercus rubra*, the second ranked sapling, by fourfold. Dry Ridge had the greatest number of saplings/ha and the greatest diversity of tree sapling species. *Quercus rubra*, the dominant tree at Dry Ridge, ranked third in number of saplings per hectare, 450, as did sassafras (*Sassafras albidum*) (Table 2).

There has been no change in the first ranked taxon at each of the three study sites over 70 years from 1935 and 2005 (Table 1). At the Moist Valley and South Slope sites, *Liriodendron tulipifera* was the dominant tree, whereas *Quercus* was the dominant genus at Dry Ridge. Tree of heaven (*Alianthus altissima*) and ginkgo (*Ginkgo biloba*), both nonnative species, were no longer found at Moist Valley. The ginkgo was obviously planted in the last century or earlier and probably was outshaded as the forest matured. *Alianthus altissima* is not shade-adapted and probably succumbed in the competition for light, although this species may have potential to invade gaps in the forest canopy (Knapp and Canham 2000). Canadian hemlock (*Tsuga canadensis*), identified at Moist Valley in 2005, was planted by the Parks Department.

At South Slope, oaks have increased in relative dominance, whereas maples (*Acer* spp.) and sweet birch (*Betula lenta*) have declined since 1935. Hickory (*Carya*) and American elm (*Ulmus americana*) have increased in relative dominance (Table 1). At Dry Ridge, oaks have dominated for the past 70 years. The relative dominance value for all oaks has decreased slightly from 95% to 80% (Table 1). At Dry Ridge, cherry (*Prunus*) has shown a slight decline in relative dominance but had the greatest number of individuals in the (less than 7.6 cm dbh) sapling class (Table 2). *Prunus serotina*, an earlier successional species, does not compete well with the more shade-tolerant oaks at Dry Ridge.

Early in the 20th century in northern Queens County, New York, Harper (1917) reported that *Q. velutina*, *Q. alba*, *Carya* spp., and American chestnut (*Castanea dentata*, dying) accounted for 41% of the trees. In Queens County, Greller (1972) identified 43 "witness trees" listed in deeds and surveyor records to delineate property lines from 1685 to 1764. Among the witness trees listed were 14 black oak (33%), seven walnuts, *Carya* spp. (16%), six white oaks (14%), five chestnuts (12%), and 11 additional individual tree species. At Inwood Park, oaks comprise the majority of the individuals at Dry Ridge and are

Table 3. Comparison of relative density of trees in the forests of Inwood Park in the 1935 and 2005 study.

Taxon	1935 Census		2005 Census
1. *Quercus*	0.331	*Quercus*	0.427
		Q. rubra	0.265
		Q. alba	0.059
		Q. prinus	0.049
		Q. velutina	0.039
		Q. coccinea	0.015
2. *Liriodendron tulipifera*	0.214		0.142
3. *Acer*	0.136	*Acer*	0.059
		A. saccharum	0.054
		A. rubrum	0.005
4. *Cornus florida*	0.084		0.025
5. *Betula lenta*	0.065		0.029
6. *Carya cordiformis*	0.032		0.044
7. *Fraxinus americana*	0.026		0.029
8. *Prunus*	0.026	*Prunus*	0.108
		P. serotina	0.103
		P. avium	0.005
9. *Juglans cinera*	0.019		—
10. *Carpinus caroliniana*	0.013		—
11. *Ulmus americana*	0.013		0.025
12. *Catalpa* spp.	0.006		—
13. *Celtis occidentalis*	0.006		0.015
14. *Liquidambar styraciflua*	0.006		—
15. *Nyssa sylvatica*	0.006		—
16. *Robinia pseudoacacia*	0.006		0.005
17. *Sassafras albidum*	0.006		0.039
18. *Morus alba*	—		0.015
19. *Tilia cordata*	—		0.010
20. *Aralia spinosa*	—		0.010
21. *Aesculus hippocastanum*	—		0.005
22. *Hamamelis virginiana*	—		0.005
23. *Populus deltoides*	—		0.005
24. *Tsuga canadensis*	—		0.005

Table 4. Tree plantings at Inwood Park during Fall 2004 to Fall 2005.[z]

Species	Number of trees		
	Fall 2004	Spring 2005	Fall 2005
Quercus rubra	173	122	195
Liriodendron tulipifera	120	105	109
Celtis occidentalis	100	70	16
Acer rubrum	96		15
Quercus alba	52	36	12
Pinus strobus	37		21
Quercus prinus	29	74	75
Acer saccharum	14		95
Quercus palustris	12		51
Quercus velutina	10	12	
Carpinus caroliniana	9	9	
Ostrya virginiana	7		
Amelanchier canadensis	1		
Betula lenta	1	74	57
Fraxinus americana		36	
Quercus × *heterophylla*		30	
Carya cordiformis		19	
Liquidambar styraciflua		15	16
Betula nigra		10	
Betula populifolia			14
Juglans cinerea			12
Nyssa sylvatica			12
Carya ovata			6

[z]Figure 1 maps the approximate location of tree plantings from 1991 to 2003.

common at South Slope. *Acer*, represented by 4.7% of witness trees, is represented by 45.5% and 3.4% of trees at Moist Valley and South Slope, respectively. *Castanea dentata*, represented by 11.6% of witness trees, has succumbed to chestnut blight in the early 20th century. No *Liriodendron* were included in witness tree data, yet it is the most important taxon at Moist Valley and South Slope. *Liriodendron* is an invader after disturbance (Pittillo 2007), which may account for its 23% and 20% abundance at Moist Valley and South Slope of Inwood Park, respectively (Table 1).

Quercus was the dominant tree genus in northern Queens County parks (Greller 1972, 1975). *Quercus rubra* was the dominant tree in the uplands of Cunningham Park, Queens County, New York (Lefkowitz and Greller 1973) and was the dominant tree at Dry Ridge at Inwood Park (Table 1). Lefkowitz and Greller (1973) reported that *Liriodendron tulipifera*, *Cornus florida*, *Acer rubrum*, *Quercus velutina*, and *Liquidambar styraciflua* were also common in northern Queens forests with importance values of 10% or higher in at least one of the five morainal areas sampled. *Liriodendron* also had the highest importance values at Moist Valley and South Slope at Inwood Park (Table 1).

Stalter (1981) studied the arborescent vegetation at Alley Park, New York, in 1975. The trees present at Alley Park in 1975 were compared with the tree species present at the same site on a map prepared by the WPA workers in 1936. *Quercus rubra* was ranked first in relative dominance in 1936 and 1975. Black oak, *Quercus velutina*, ranked second in relative dominance in 1936 and 1975. Black oak ranked fourth in IV in 1936 and second in 1975. Dogwood, *Cornus florida*, a subcanopy species, ranked second in IV in 1936 and third in 1975. The decline of dogwood in 1975 may have been the result of a crippling ice storm in December 1974 (Stalter 1981).

Stalter (1981) reported that *Prunus serotina* and *Cornus florida* had the greatest number of saplings in Alley Park, 417/ha and 333/ha, respectively, whereas *Q. rubra* (83/ha) and *Q. alba* (42/ha) were less abundant. *Prunus serotina* saplings were also the most abundant tree species present at Dry Ridge in the current study at Inwood Park (Table 2).

The data on tree species presented in Table 3 addressed Loeb's (1982) problem with tree species identification. Oaks and maples were lumped as genera. The two genera with the greatest percent basal area at Moist Valley and South Slope were *Liriodendron* and *Quercus*, whereas *Quercus* was dominant at Dry Ridge. These genera cannot be confused with other genera at Inwood Park. Tulip poplar, oaks, and maples composed over 80% of the relative dominance of all tree species at the three sites selected for study at Inwood Park (Table 1). The other tree species at Inwood Park were unimportant in 1935 and in 2005, no other tree species attained a percent basal area value greater than 7%.

In 2005, nonnative saplings were unimportant at Inwood Park, with the exception of white mulberry and Norway maple at the

Table 5. Species diversity and tree size at three locations in the forests of Inwood Park censused in 1935 and 2005.[z]

	1935 Census		2005 Census	
	Species	dbh (SD) maximum	Species	dbh (SD) maximum
Moist Valley	10	36.01 (24.19) 91.4 cm	13	46.01 (32.84) 139.7 cm
South Slope	13	28.51 (19.02) 121.9	14	38.00 (29.84) 99.0
Dry ridge	5	36.70 (23.67) 101.6	16	42.25 (25.21) 125.7
Total	17	32.29 (21.72) 121.9	25	41.81 (28.38) 139.7

Two-way ANOVA

Effect	df	SS	F	*P*	R^2
Date	1	5,388	8.19	0.0045	0.022
Site	2	3,836	2.915	0.0555	0.016
Date × site	2	321	0.244	0.78	0.001
Unexplained	352	231,577			0.951
Total	357	243,577			

[z]Results from 25 10 m × 10 m quadrats at each census. In the 1935 census, some taxa were identified only to genus (Table 1). Species number, mean dbh with SD, and maximum. The data are the upper table is analyzed by two-way ANOVA below.
dbh = diameter at breast height; SD = standard deviation; ANOVA = analysis of variance; SS = sum of squares for dbh.

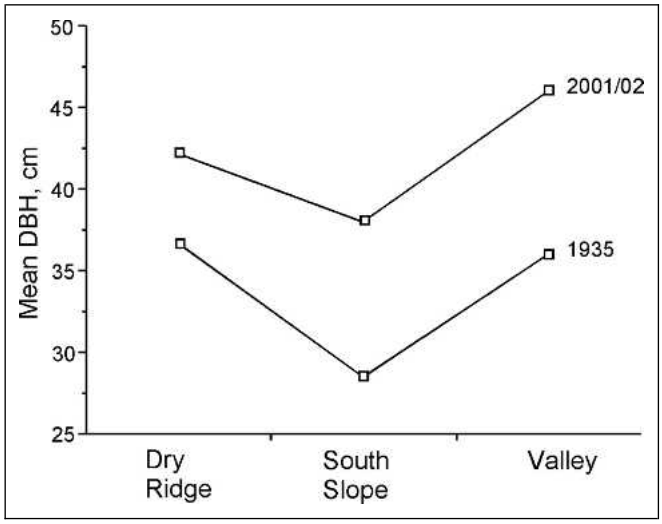

Figure 2. Interaction graph of mean diameter at breast height (dbh) for the three sites comparing the 1935 with the 2004 to 2005 census of Inwood Park, New York. In two-way analysis of variance, interaction $F_{2,353} = 0.24$, $P = 0.78$. Mean dbh has increased in parallel fashion at each site.

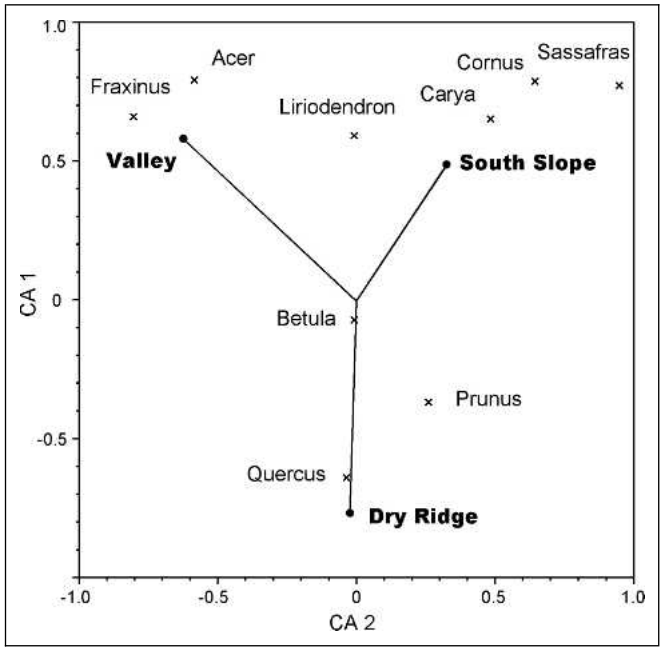

Figure 3. Correspondence analysis ordinating the three sites and the nine most dominant genera of trees. Data merged from the 1935 and 2004 to 2005 census. The rays indicate the direction and distance from the origin of the three sites as ordinated by generic composition (Anonymous 2007).

Moist Valley site. Neither of these two taxa were present at Moist Valley in 1935. Glaeser and Kincaid (2005) report a recent outbreak of a nonnative invasive tree, amur cork (*Phellodendron amurense*), in the forests of Queens County of New York City. This species ranked third in overall dominance and second in relative abundance in a 0.5 ha study plot in Forest Park, Queens (Glaeser and Kincaid 2005). The situation at Inwood Park bears monitoring because *P. amurense*, a hardy urban tree, has been planted throughout the five boroughs of New York City.

Park personnel planted trees in Inwood Park from 1991 to Fall 2005 (Table 4). Only the numbers from Fall 2004 to Fall 2005 are presented in Table 4. Over 18,000 trees of 20 species were planted across approximately 33% of the area of the park during this 14 year period. Over 90% of the plantings have survived (Richard Love, pers. comm.).

In two-way analysis of variance (ANOVA) (Table 5), mean dbh was significantly different between the 1935 and the 2005 census (32.3 cm [12.9 in] versus 41.8 cm [16.7 in], respectively; $F_{1,352} = 8.19$, $P = 0.0045$), although census date explained only 2.2% of the variation in dbh (R^2). Among the three study sites, mean dbh was not significantly different ($F_{2,352} = 2.92$, $P = 0.056$). The census date × study site interaction in ANOVA was not significant ($F_{2,352} = 0.24$, $P = 0.8$), which supports the visualization in Figure 2 that the three sites experienced a parallel pattern of increase in tree size from the 1935 to the 2005 census.

The correspondence analysis (CA) of Figure 3 displays the significant separation ($P < 0.0001$) of Dry Ridge, South Slope, and Moist Valley on the basis of the presence and abundance of the nine most dominant tree genera for the merged 1935 and 2005 census. The community data from 1935 and 2005 were merged because of their similarity. CA graphs generated for the 1935 data and independently for 2005 were nearly indistinguishable.

In the CA ordination of genera, *Quercus* was the most common of the nine genera of trees at Dry Ridge. *Prunus*, a successional species, is more common at Dry Ridge than at the other sites. *Betula* was the most evenly distributed taxon across the sites as seen by its location at the origin of the CA graph. *Liriodendron* was most common at South Slope and Moist Valley. The three genera clustered at South Slope were *Carya*, *Cornus*, and *Sassafras*. *Sassafras* was found only at South Slope. *Cornus*, a subcanopy species, favors South Slope, was present at Moist Valley, and absent at Dry Ridge. *Carya*, a climax species, occurred at all three sites, but was most common at South Slope. *Acer* was common at Moist Valley and South Slope but was represented by a single tree at Dry Ridge. *Fraxinus* was found at all three sites but was most common in Moist Valley. Shannon diversity and simple species diversity for trees has increased slightly since the 1935 census, although less so when the 2005 data are merged into genera to conform to the 1935 census (Table 6).

Table 6. Shannon diversity and simple species diversity for trees at Inwood Park, New York, in 1935 and in 2005.

Year	Moist Valley	South Slope	Dry Ridge
1935			
Simple diversity	10	12	5
Shannon diversity	1.976	1.976	0.807
2005[z]			
Simple diversity	11	11	11
Shannon diversity	2.101	2.102	1.222
2005			
Simple diversity	13	14	16
Shannon diversity	2.253	2.317	2.036

[z]The 2005 site reflects species merged into genera (i.e., *Acer*, *Quercus*, *Prunus*) corresponding to the 1935 census.

CONCLUSION

There has been little change in the dominant taxa at Moist Valley, South Slope, and Dry Ridge at Inwoood Park from 1935 to 2005 (Table 1), although mean tree size (dbh) has increased (Figure 2). Tree size (dbh) was not significantly different among our three study sites. At Moist Valley and South Slope, *Liriodendron tulipifera* was dominant, whereas *Quercus* was dominant at Dry Ridge. These taxa were dominant at our sites at Inwood Park over the past 70 years. Barring major disturbances, they will continue to remain dominant in decades to come, because of their climax role in ecologic succession in our local forests of the temperate deciduous biome. Oaks have long been an important component of the forests in metropolitan New York (O'Gorman 1934; Greller 1972; Stalter 1981).

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Résumé. La végétation arborescente localisée au sein de trois sites du parc Inwood à Manhattan dans l'état de New York a été échantillonnée avec la méthode des quadrants en octobre 2004 et en mai 2005, puis comparée par la suite aux arbres présents dans les mêmes quadrants au moyen de cartes de végétation arborescente produites par l'*Administration fédérale de gestion des travaux* en 1935. Le tulipier (*Liriodendron tulipifera*) était l'arbre dominant dans les sites Moist Valley et South Slopes en 1935 et en 2005 tandis que le chêne (*Quercus* spp.) était le genre dominant dans le site Dry Ridge en 1935 et en 2005. Le cornouiller fleuri (*Cornus florida*) était l'arbre dominant du sous-étage en 1935; il est aujourd'hui peu répandu en raison de l'anthracnose du cornouiller. En terme de dominance écologique, il n'y a pas eu de changement dans la génération dominante au cours des 70 dernières années au sein des trois sites étudiés. Le diamètre moyen des arbres au DHP s'est accrû de 32,2 cm à 41,8 cm. Les trois sites ont connu un patron parallèle de croissance dans la dimension des arbres de 1935 à 2005. Les espèces non indigènes sont peu présentes au parc Inwood actuellement.

Zusammenfassung. Im Oktober 2004 und Mai 2005 wurde die Baumvegetation an drei Stellen im Inwood-Park, New York per Planquadrat-Methode aufgenommen und mit den im Jahr 1935 erfassten Bäumen des gleichen Planquadrats verglichen. 1935 und 2005 waren Tulpenbäume im Feuchten Tal und an den Südhängen die populärste Baumart, während Eichenarten im gleichen Zeitraum am Standort: Trockener Kamm dominierten. Hartriegel war 1935 die dominante Unterholzart, ist aber gegenwärtig unwichtig, ein Opfer der Hartriegel-Anthracnose. In Bezug auf ökologische Dominanz gab es in den letzten 70 Jahren keine Änderung bei den erstgenannten Arten auf den drei untersuchten Standorten. Der mittlere Baumdurchmesser stieg an von 32,2 auf 41,8 cm. Die drei Standorte erlebten von 1935 bis 2005 ähnliche Muster bei der Veränderung der Baumgröße. Die nicht-nativen Baumarten sind gegenwärtig in Inwood-Park nicht wichtig.

Resumen. La vegetación arborescente localizada en tres sitios de Inwood Park, Manhattan, New York fueron muestreadas por el método del cuadrante en Octubre de 2004 y Mayo de 2005, y fueron comparadas con los árboles presentes en los mismos cuadrantes en un mapa de vegetación arborescente en Inwood Park elaborado en 1935 por el Works Program Federal Administration. *Liriodendron tulipifera* fue el árbol dominante en los sitios Moist Valley y South Slope en 1935 y 2005, *Quercus* spp. fue el género dominante en el sitio Dry Ridge en 1935 y 2005. *Cornus florida* fue dominante en el estrato bajo en 1935; y también víctima de la antracnosis. En términos de dominancia ecológica no ha habido cambio en el primer género en estos tres sitios de estudio en los pasados 70 años. El diámetro medio normal (dbh) aumentó de 32.2 cm a 41.8 cm. Los tres sitios han experimentado un patrón paralelo de incremento en tamaño de 1935 a 2005. Las especies maderables no nativas no son importantes en Inwood Park, en el momento actual.