

## INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

**The quality of this reproduction is dependent upon the quality of the copy submitted.** Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps.

ProQuest Information and Learning  
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA  
800-521-0600

UMI<sup>®</sup>



## **NOTE TO USERS**

**This reproduction is the best copy available.**

UMI<sup>®</sup>



A

**The Ecology of an Urban Woodland in Queens County, New York**

by

**CARSTEN W. GLAESER**

A dissertation submitted to the Graduate Faculty in Biology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

2004

UMI Number: 3115253

Copyright 2004 by  
Glaeser, Carsten W.

All rights reserved.

UMI<sup>®</sup>

---

UMI Microform 3115253

Copyright 2004 by ProQuest Information and Learning Company.  
All rights reserved. This microform edition is protected against  
unauthorized copying under Title 17, United States Code.

---

ProQuest Information and Learning Company  
300 North Zeeb Road  
P.O. Box 1346  
Ann Arbor, MI 48106-1346

© 2004

**CARSTEN W. GLAESER**

**All rights reserved**

This manuscript has been read and accepted for the Graduate Faculty in Biology in Satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

October 24, 2003  
Date

Dwight Kincaid

Chair of Examining Committee  
Dr. Dwight Kincaid, Lehman College

January 22, 2004  
Date

Richard L. Chappell

Executive Officer  
Dr. Richard L. Chappell

Jack Valdovinos

Dr. Jack Valdovinos, Lehman College

Thomas S. Jensen

Dr. Thomas Jensen, Lehman College

Suroj Tiwari

Dr. Suroj Tiwari, Academy of Mt. St. Ursula

Richard Stalter

Dr. Richard Stalter, St. John's University

\_\_\_\_\_  
Supervising Committee

The City University of New York

## Abstract

The Ecology of an Urban Woodland in Queens County, New York:

by

Carsten W. Glaeser

Advisor: Dr. Dwight Kincaid

A forest census was conducted in a 167 ha urban woodland in Forest Park, Queens County, NYC. All woody stems  $\geq 2.0$  cm DBH within a permanent and contiguous, professionally surveyed 0.5 ha plot were identified, labeled, measured for diameter, height and x, y coordinates. The plot contained 771 stems from 22 woody taxa in 15 genera and 13 families, reflecting a Shannon-Wiener diversity index of 2.17 and Simpson's Index of 0.162. Five species were singletons and three species were non-native. Stem density was 1542 stems ha<sup>-1</sup>. Stem diameters ranged from 2.0 to 116.7 cm (mean DBH 8.55 cm). The largest trees were oaks (*Q. rubra*, *Q. velutina* and *Q. alba*). Lower and upper quartiles of the stem size generated a small diameter class dominated by *Betula lenta*, *Phellodendron amurense*, *Cornus florida* and *Prunus serotina*. The large diameter class was dominated by *Quercus rubra*, *Betula lenta*, *Q. velutina* and *Cornus florida*. During the latter half of the 20<sup>th</sup> century botanists classified Forest Park as an oak, mixed dicot-dogwood forest. This census revealed a young tree population largely

dominated by pioneer species. The dominance hierarchy by importance values placed *Betula lenta* as the dominant taxon followed by *Quercus rubra*, *Phellodendron amurense* and *Cornus florida*. *Phellodendron amurense* Rupr. (Rutaceae) is a non-native invasive tree from Asia introduced into Forest Park in 1935. Within its natural range it is shade-intolerant yet in Forest Park it is shade-tolerant. As an inference from the observed *P. amurense* stem relative density of 20.4% to the entire Forest Park woodland, the 50 quadrats were bootstrapped 500,000 times. This yielded 95% confidence intervals suggesting a stem density as low as 11.9% and as high as 30.9%.  $K^{\text{th}}$  nearest-neighbor analysis for *P. amurense* revealed an aggregated distribution with a mean NN distance of 1.55 m. Mantel tests of spatial autocorrelation revealed that close trees tend to have similar basal area. Ecological dominance in this urban forest is being shifted away from its historical legacy by the factors of disturbance and the rapid invasion of non-native trees.

Keywords: urban woodland, bootstrap methods, non-native invasive, *Phellodendron amurense*.

## Dedication

I dedicate this dissertation to the memory of my mother Edith Elisabeth Gläser nee Hennemann (1927-1994) who was my first teacher and unfortunately did not live to see the completion of this dissertation. It is from her lessons on the need to pay attention to detail, the rewards of ones labor, persistence, orderliness and a love for nature that became the foundation for this endeavor.

## Acknowledgements

The four years of dissertation research could not have been accomplished without the help and encouragement by many individuals. I acknowledge and thank the following;

I am most grateful to my advisor, Dr. Dwight Kincaid for his broad and deep insight into ecology, his wizardry with analytical programs and for his advise and guidance throughout the dissertation process. I acknowledge and gratefully thank the members of my academic committee for their time and assistance. Their opinions were fair, critical and helpful in moving this project towards completion. Those members were Dr. Tom Jensen, Lehman College; Dr. Jack Valdovinos, Professor Emeritus, Lehman College; Dr. Richard Stalter, St. John's University and Dr. Suroj Tiwari, Academy of Mount St. Ursula.

I thank my friends, colleagues, students and faculty at Lehman College for being spiritually and academically supportive, with special thanks to Dolores Vitanza who provided assistance in every aspect of academic life. I thank Dr. Joe Rachlin and Dr. Tom Jensen for the many semesters of adjunct teaching. For their support, I thank Susan Voge and Gene Laper of the Lehman College Library; I thank John Dono and his staff from the Lehman College Academic Computer Center.

At the CUNY Graduate Center, I thank Dr. Richard Chappell and Ms. Joan Reid for their support.

I thank the many past and present friends of the New York City Department of Parks that include- Adrian Benepe, New York City Parks Commissioner and Liam Kavanagh; Josephine Scalia and her staff of the Forest Park Administration; Mike Feller and Marge Gargiullo of the DPR Natural Resources Group.

I thank the Brooklyn Botanic Garden Herbarium staff for accepting the census vouchers and their assistance at solving taxonomic issues of the local flora.

I thank the Boy Scouts of America's programs and leadership by whose early introduction to outdoor life, developed my love for nature, ecology and my place within it.

Finally, I am most thankful to my father, my brother Eric and friends for being supportive and who unknowingly contributed immensely towards the completion of this project. I am most thankful to my wife, Denia for her patience, support and maintaining the fort throughout the study. Finally, I want to especially thank my daughter Madelein Klara for understanding her father's time way from play and for her willingness to play field assistant throughout the year.

## Table of Contents

Chapter 1. Ecological characteristics of an urban wooded park in Queens County, NY

	Pages
I. Introduction	1
II. Invasive Plants	4
III. Invasive Insects: Asian Longhorned Beetle	6
IV. Woodland Description	8
III. Research Intent	11
IV. Project Area and Site Selection	12
V. Topics under Investigation	14

Chapter 2. Forest flora and community structure: I

I. Introduction	21
II. History of Forest Park	22
III. Methods	25
III.1 Plot Sampling	26
III.2 Soil Sampling	28
IV. Results	29
IV.1 Stem Diameters	31
IV.2 Basal Area	34
IV.3 Vertical Structure	35
IV.4 Height and Diameter relationships	36
IV.5 Importance Value	36
IV.6 Family Importance Value	40
IV.7 Kettles and Flat Uplands	41
V. Conclusions	42

Chapter 3. Forest flora and community structure: II

I. Introduction	96
II. Methodology	99
II.1 Statistical Sampling	99
III. Results	100
III.1 Tree and Shrub Distribution by Diameter	100
III.1a Small-sized Diameter Stems	101
III.1b Mid-sized Diameter Stems	102
III.1c Large-sized Diameter Stems	104
III.2 Vertical Structure	106
III.3 Regression Analysis	108
III.4 Species of Gap-phase Replacement	108
IV. Conclusions	111

## Table of Contents

Chapter 4. Initial findings of the non-native invasive *Phellodendron amurense* Rupr.

	Pages
I. Introduction	128
II. Taxonomy and Invasion History	133
III. Methods	138
IV. Results	138
IV.1 Stem Density	139
IV.2 Diameter Distribution	141
IV.3 Vertical Structure	143
IV.4 Regression Analysis	143
V. Conclusion	144

Chapter 5. Spatial point patterns of an urban woodland, Forest Park, Queens, New York

I. Introduction	164
II. Methods	166
II.1 Study Site	166
II.2 Field Sampling	167
II.3 Statistical Methods	168
III. Results	169
IV. Conclusion	171
Appendix A. Resampling Stats Program- Bootstrap Sampling	181
Appendix A.1 Resampling Stats Program - 95% Confidence Interval	184
Appendix B. Vascular flora of Forest Park	188
Appendix C. Dataset of the Forest Park Census	192
Appendix D. Dataset of <i>Phellodendron amurense</i>	218
Literature Cited	224

## List of Illustrations

**Chapter 1.**

<u>Figures</u>		Pages
Figure 1.1	The Northern Woods of Forest Park	17
<u>Tables</u>		
Table 1.1	Tree Censusing History	18
Table 1.2	Woodland Designation	20

**Chapter 2.**

<u>Figures</u>		
Figure 2.1	Site Map	45
Figure 2.2	50 x 100m study plot schematic	46
Figure 2.2.a	Site schematic and point pattern of woody stems	47
Figure 2.3	Sampling methodology	48
Figure 2.4	Randomization species-area curve	49
Figure 2.5	Frequency distribution of stem diameters	50
Figure 2.6	Frequency distribution of Height	51
Figure 2.7	Regression scattergram of diameter versus height	52
Figure 2.8	Frequency distribution of ecologically dominant families	53
Figure 2.9	Histogram of importance value ranking by family	54
Figure 2.10	Dominance-hierarchy curve	55
Figure 2.11	Collectors effort curve	56
Figure 2.12	Diversity-density map of quadrats	57
Figure 2.13	Descriptive statistics of diversity and density	58
Figure 2.14	Dotmap of 771 stems	59
Figure 2.14 (a-b)	Dotmap of <i>Betula lenta</i> and <i>Quercus rubra</i>	60
Figure 2.14 (c-d)	Dotmap of <i>Phellodendron amurense</i> and <i>Cornus florida</i>	61
Figure 2.14 (e-f)	Dotmap of <i>Quercus velutina</i> and <i>Prunus serotina</i>	62
Figure 2.14 (g-h)	Dotmap of <i>Quercus alba</i> and <i>Carya tomentosa</i>	63
Figure 2.14 (i-j)	Dotmap of <i>Carya ovata</i> and <i>Carya glabra</i>	64
Figure 2.14 (k-l)	Dotmap of <i>Fagus grandifolia</i> and <i>Sassafras albidum</i>	65
Figure 2.14 (m-n)	Dotmap of <i>Vaccinium corymbosum</i> and <i>Cornus alternifolia</i>	66
Figure 2.14 (o-p)	Dotmap of <i>Castanea dentata</i> and <i>Lindera benzoin</i>	67
Figure 2.14 (q-r)	Dotmap of <i>Rhamnus frangula</i> and singletons	68
Figure 2.15a	Histogram of stem diameter and height of <i>Betula lenta</i>	69
Figure 2.15b	Histogram of stem diameter and height of <i>Quercus rubra</i>	70
Figure 2.15c	Histogram of stem diameter and height of <i>P. amurense</i>	71
Figure 2.15d	Histogram of stem diameter and height of <i>Cornus florida</i>	72
Figure 2.15e	Histogram of stem diameter and height of <i>Quercus velutina</i>	73
Figure 2.15f	Histogram of stem diameter and height of <i>Prunus serotina</i>	74
Figure 2.15g	Histogram of stem diameter and height of <i>Quercus alba</i>	75
Figure 2.15h	Histogram of stem diameter and height of <i>Carya tomentosa</i>	76
Figure 2.15i	Histogram of stem diameter and height of <i>Carya ovata</i>	77

## List of Illustrations

Figure 2.15j	Histogram of stem diameter and height of <i>Carya glabra</i>	78
Figure 2.15k	Histogram of stem diameter and height of <i>Fagus grandifolia</i>	79
Figure 2.15l	Histogram of stem diameter and height of <i>Sassafras albidum</i>	80
Figure 2.16	Bootstrap 95% confidence intervals of importance values	81

Tables

Table 2.1	Ecological dominance ranking by taxa	82
Table 2.2	Descriptive statistics of taxa	83
Table 2.3	Ecological dominance Ranking of Taxa in Kettles	84
Table 2.4	Descriptive statistics of taxa in kettles	85
Table 2.5	Ecological dominance ranking of taxa on flat uplands	86
Table 2.6	Descriptive statistics of taxa on flat uplands	87
Table 2.7	Importance value ranking by family	88
Table 2.8	Descriptive statistics of family	89
Table 2.9	Sample statistics of approximate randomisation analysis	90
Table 2.10	Bar diagram of species abundance	92
Table 2.11	Pascal's Triangle	93
Table 2.12	Soil nutrient elements	94
Table 2.13	Gini coefficients for basal area and height	95

**Chapter 3.**Figures

Figure 3.1	Diameter (dbh) frequency distributions (a) small size class,(b) mid-size class; (c) large-size class	113
Figure 3.2	Height frequency distributions (a) small size class,(b) mid-size class; (c) large-size class	114
Figure 3.3	Diameter versus height scattergrams (a) small size class,(b) mid-size class; (c) large-size class	115
Figure 3.4	Dotmap of Gap-phase species	116
Figure 3.5	Diameter frequency distributions; Gap-phase species	117
Figure 3.6	Height frequency distributions; Gap-phase species	118
Figure 3.7	Diameter versus height scattergrams; Gap-phase species	119

## List of Illustrations

Tables

Table 3.1	Structural characteristic of the six dominant taxa	120
Table 3.2	Importance values of small diameter stems	121
Table 3.3	Descriptive statistics of small diameter stems	122
Table 3.4	Importance values of mid-size diameter stems	123
Table 3.5	Descriptive statistics of mid-size diameter stems	124
Table 3.6	Importance values of large diameter stems	125
Table 3.7	Descriptive statistics of large diameter stems	126
Table 3.8	Structural characteristic of gap-phase species	127

**Chapter 4.**Figures

Figure 4.1	Voucher sample of <i>Phellodendron amurense</i>	147
Figure 4.2	<i>Phellodendron amurense</i> in the woodland	148
Figure 4.3	<i>Phellodendron amurense</i> as a street tree	149
Figure 4.4	Norway maple along the Forest Park perimeter	150
Figure 4.5	Dotmap of Amur corktree	151
Figure 4.6.a	Frequency distribution tree diameter	152
Figure 4.6.b	Frequency distribution tree height	152
Figure 4.6.c	Diameter versus height scattergrams	152
Figure 4.7.a	Frequency distribution a) small diameters, b) mid-size diameters, c) large diameter	153
Figure 4.8.a	Frequency distribution a) fruiting trees, b) non-fruiting trees, c) scattergrams	154
Figure 4.9	3-D Visualization of density, diameter and height	155
Figure 4.10	95% confidence intervals for top seven taxa	156

Tables

Table 4.1	Description of five ornamental corktrees	157
Table 4.2	Woodland classification by author	158
Table 4.3	Importance value ranking of top seven taxa	159
Table 4.4	Descriptive statistics of top seven taxa	160
Table 4.5	Descriptive statistics of diameter size classes	161
Table 4.6	Paired t-tests for differences in mean density	162
Table 4.6.a	Descriptive statistics of seven abundant taxa	162
Table 4.7	<i>Phellodendron amurense</i> phenology in Forest Park	163

**Chapter 5**Figures

Figure 5.1	Spatial point pattern of all trees (n=771).	173
Figure 5.2	Spatial point pattern of all <i>Phellodendron amurense</i> (n=158).	174

## List of Illustrations

Tables

Table 5.1	Descriptive statistics of NN analysis for 771 stems	175
Table 5.2	Descriptive statistics of NN analysis for <i>P. amurense</i>	176
Table 5.3	Monte Carlo Simulation for CSR	177
Table 5.4	Spatial descriptors for <i>Phellodendron amurense</i>	178
Table 5.5	Spatial autocorrelation of <i>Phellodendron amurense</i>	179
Table 5.6	Spatial associations among five taxa	180

## Chapter 1

### **Ecological characteristics of an urban wooded park in Queens County, New York**

#### I. Introduction

Large and dense secondary and mature forests are few amidst heavily populated human settlements and in industrialized cities. The New York metropolitan area that includes the outer boroughs such as Queens County of western Long Island are unique in that forested areas, many greater than 60 ha have been preserved as parks for at least 100 years. Forested areas were once continuous, heterogenous and covered much of the western tip of Long Island in the post-glacial period, with prairie covering large tracts on Long Island (Stalter and Lamont 1987). However, over this same 100 years increasing human population and post-war urban development decimated many of the plant communities. Any significant remnant communities exist only within forested fragments as parks.

The New York City agency of the Department of Parks and Recreation (NYC DPR) are commissioned to manage more than 10,522 ha of public property within the 828 km<sup>2</sup> that defines New York City and the outer boroughs. Of this, 2,833 ha are classified as undeveloped for recreation and 1,988 ha (or 70%) of the 2,833 ha remain

forested, existing as the most prominent natural resource compared to other remaining community types (i.e. naturalized meadows, wetlands and marshes, and areas in transition) within the park system (Sisinni and Emmerich 1995). Queens County is 290 km<sup>2</sup> or 29,008 ha. The extant natural areas including wetlands comprise only 5% of the area of northern Queens County, 135 km<sup>2</sup> or 13,500 ha (Greller 1975). This is about a two-fold decrease since Harper's evaluation for northern Queens County of nearly 10% deciduous forest (Harper 1917(a, b). It is however unknown as to how much of the vascular flora of Queens County has been extirpated due to loss of natural areas and land development. By way of example, of the 1082 native plant species historically reported in Richmond County (Staten Island), 40.9% have no known contemporary natural populations (Robinson et al. 1994).

A partial taxonomic record of the woody flora and woodland composition of all local wooded parks including Forest Park was performed during the 1935-1937 WPA projects by the Robert Moses Administration (New York City Department of Parks-Mapping Division 1936). This census has been used comparatively by several authors (Stalter 1981; Rudnický and McDonnell 1989; Loeb 1982) however the reliability of the NYC DPR topographic inventories has been questioned and tree identification was often only to genus (Loeb 1982). These contour maps contain spatial point patterns or dotmaps of all known arborescent taxa measured at  $\geq 7.6$  cm (3.0 inches). The 0.5 ha plot area

was superimposed onto this map and revealed some interesting facts of the past composition of the stand.

In 1935, the stand consisted of a density of 272 stems  $\text{ha}^{-1}$  represented by 5 genera and 7 species. Tree diameters ranged from  $\geq 7.6 - 76.2$  cm (mean DBH 29.71, SD 17.11) with a total basal area of  $0.125 \text{ m}^2$ . The most abundant taxa were *Quercus* sp. represented by *Q. alba*, *Q. rubra* and *Q. velutina*, with a density of 122 stems  $\text{ha}^{-1}$ . The oak diameters ranged from  $\geq 25.4 - 76.2$  cm (mean DBH 44.76 cm, SD 12.69) with a combined basal area of  $0.103 \text{ m}^2$ . The largest tree was *Quercus velutina* (76.2 cm DBH).

By way of comparison to my 1999-2000 census with a DBH cut-point at  $\geq 7.6$  cm, the 0.5 ha plot contained a density of 382 stems  $\text{ha}^{-1}$  represented by 8 genera and 13 species. The diameters ranged from  $\geq 7.6 - 116.7$  cm (mean DBH 22.59, SD 21.45) and a total basal area of  $0.145 \text{ m}^2$ . *Quercus* spp. remained as the most abundant taxa and similarly represented by *Q. alba*, *Q. rubra* and *Q. velutina* with a density of 70 stems  $\text{ha}^{-1}$ . The diameters range from  $\geq 27.6 - 116.7$  cm (mean DBH 59.61, SD 21.08) with a combined basal area of  $0.109 \text{ m}^2$ . The largest tree is a *Quercus rubra* (116.7 cm DBH).

The municipality of Queens County exceeds 2.3 million inhabitants (2000 Census). The negative impact of large numbers of visitors to the park is evident in the wooded sections of nearly all Queens County parks (personal observation). It is within urban areas that ecosystem disruption (i.e. soil compaction due to foot traffic) and the

erosion of biodiversity is likely to occur (Murphy 1988). This emphasizes the need to document ecosystem changes in the face of human induced impacts. Though these wooded parklands appear intact by casual observation, very little has been revealed quantitatively and empirically as to whether woodland ecosystems are resilient and self-sustaining. Municipal ecologists, foresters and administrators would be better served if a full vegetation census of this parkland ecosystem was undertaken and repeated at decade intervals.

## II. Invasive Plants

Forest Park as in almost all other urban parks contains populations of invasive non-native tree species, many of which are common to the novice, e.g., *Acer plantanoides* L. (Norway maple); *A. pseudo-platanus* L. (sycamore maple) and *Ailanthus altissima* (Mill.) Swingle (tree-of-heaven). The presence of non-native flora is expected considering the immense immigrant population spanning a 400 year history of NYC. Non-native flora are also expected because of numerous disturbances within natural areas. It is known that an important stage for the invasion by plants is that a disturbance must occur. Disturbances promote biological invasion (Rejmanek 1989). It is also known that biological invasives pose a serious threat to ecological communities and diversity (Lodge 1993). Simberloff (2000) noted that introduced species are a cause of

species extinction and endangerment. It is estimated that at least 4,500 species of foreign origin have established free-living populations within the United States. About 300 species are truly invasive and have invaded natural areas (Marinelli 1996).

The Amur corktree (*Phellodendron amurense* Rupr., Rutaceae) is an arborescent non-native invasive tree introduced to FP during an ornamental landscape planting along the Interboro Parkway (Jackie Robinson Parkway) in 1935 (New York City Department of Parks and Recreation 1990). *Phellodendron amurense* is considered a shade-intolerant species from the temperate forests of northern China and Japan (Ishizuka and Sugawara 1989; Namikawa et. al 1997; Ning and Dafang 1990; Toshiya and Kamitani 1999) and is associated with young forest gaps (Watanabe and Kubota 1996).

Over a 65 year period (1935-2000) Amur corktree established a self-sustaining population throughout much of the interior woods. It is considered “shade-intolerant” in the forests of Japan (Ishizuka and Sugawara 1986; Toshiya and Kamitani 1999) yet is found in dense shade conditions in Forest Park. Shoot growth however appears suppressed within the shaded interior and greater heights expressed within tree-fall gaps and along parkland edges. Both *Phellodendron japonicum* and *P. amurense* were noted in the FP management plan as having a prolific population and that they have reduced the amount of native trees. This has not been quantified. The precise taxonomy of both *P. amurense* and *P. japonicum* is presently under question. It is speculated that there exists only one taxon, *P. amurense* (Dr. Jinshuang Ma, personal communication).

The Amur corktree has been target for control and eradication by DPR personnel (New York City Department of Parks 1990, 1996). The successful control of this species throughout the woodland is not evident. As with many invasive non-native plants, eradication and control is highly unlikely. However, hard empirical data on corktree ecology outside its natural range in China and Japan is lacking. The need to understand corktree distribution and its impact on native flora has made a study on this species an important component of my dissertation. A full treatment on the population biology of *Phellodendron amurense* within FP is found in Chapter 4.

### III. Invasive Insects: Asian Longhorned Beetle

As a center for world shipping and trade for import and export commodities as well as a destination for the seemingly endless flow of new immigrants, New York City is a likely destination for the introduction of non-indigenous biological organisms. Though many non-native plant species have been identified within the NYC region, invasion by non-native organisms within the metropolitan area is not just limited to invasive plants, witness the Asian Longhorned Beetle (*Anoplophora glabripennis* (Motschulsky), Cerambycidae).

In 1996 New York City and the boroughs on Long Island were placed under strict quarantine by order of United States Department of Agriculture (USDA) and Animal and

Plant Inspection Service (APHIS) for the control of the Asian Longhorned Beetle (ALB). *Anoplophora glabripennis* is native to Japan, Korea and southern China. (United States Department of Agriculture, Forest Service 1999). ALB is a trunk boring pest of hardwood trees and was introduced to the borough of Brooklyn, New York by wooden packing crates shipped from the Peoples Republic of China (PRC) during the mid to late 1980s. A wood boring beetle, it was feeding and propagating mainly within the upper canopy of street trees unsuspectedly for approximately 10 years prior to its detection in Kings County, NY. While it has been largely a threat to street tree populations, its presence in dense wooded parkland is relatively unknown. The NYC DPR Central Forestry warns against the installation of several commonly planted ornamental trees that are known hosts for ALB. These trees are: *Acer platanoides*, *A. rubrum*, *A. campestre*, *A. ginnala*, *Celtis occidentalis*, *Fraxinus* spp., *Ulmus* spp. and *Sorbus alnifolia*.

The USDA-APHIS, through service contracts with local arborists whom inspect, monitor, control, inject and remove infected host trees, resulted in expenditures of approximately \$ 35 million dollars for NYC in 2002 (NYC DPR Central Forestry, personal communication). ALB populations have been identified in several locations in three of the five boroughs of NYC and in neighboring New Jersey. The most recent infestation occurred during the week of April 14, 2003. ALB was discovered in the Forest Park golf course less than a half-mile distance from the current 0.5 ha study plot.

Evidence of beetle bore holes were observed in 13 trees, all Norway maples and horse chestnuts. Citing the urgency of the insect in a wooded park, NYC Parks Commissioner Adrian Benepe held a press conference in May 2003 on location issuing a call to action to enlist the public's help in locating other infected sites. He stated that since the original discovery of the insect in 1996, 3773 trees have been removed throughout the boroughs.

It is expected that *Anoplophora glabripennis* will eventually utilize food resources and habitat found in more dense woodlands north of the city or in urban woodlands such as Forest Park. During the two years of field visits to the study plot scouting of the upper branches of trees for insect bore holes as well as wood frass around the tree base as evidence of the ALB has been in practice. No evidence of beetle activity was noticed from November 1999 to September 2003.

#### IV. Woodland Description

Forest Park (FP) is a 217 ha (538 acre) park located in Queens County (42° 30' north latitude and 73° 51' west longitude). It is a multi-use park with a 167 ha mature woodland, the largest nearly continuous woodland of western Long Island (Greller 1979; New York City Forest Park Management Plan 1996). Precipitation mean in the New York City region for 2000-2001 was 1200 mm (normal) and 1167 mm (actual). The park is geographically situated along the Harbor Hill terminal moraine of the mid-Wisconsin

age glaciation (Sanders 1974; Greller et. al 1979). The moraine created a distinct topographically elevated northern Queens County, over the southern lowland Jamaican Plain. Elevation readings from the 1935 topographic survey ranged from 23.0 to 45.0m a.s.l..

Edaphic conditions vary from Montauk fine sandy loam with complex slope and hilly (MDE) to Montauk fine sandy loam with complex slope undulating to rolling (MDC). The Montauk series consists of very deep, well-drained soils on upland hills and ridges (New York City Department of Parks and Recreation 1990). The overall knob and kettle topography is well vegetated with both herbaceous and woody flora (Table 1.1). In contrast to neighboring Alley Park and Cunningham Park, most all kettles in Forest Park lack standing water with the exception of single seasonal kettle (personal observation; Greller et al. 1979).

Harper (1917a,b) was the first to describe and comment on the plant communities throughout all of Queens County. This was followed by depression period public works projects (WPA) of 1933-1936 which focused on the development of parklands that included surveys and mapping of trees within naturally wooded areas throughout New York City (NYC Department of Parks Mapping Division 1936). Quantification of taxa in NYC wooded parklands began only in the 1970s by several local investigators utilizing a variety of inconsistent census methodologies (see Table 1.1). The initial 1935-37 NYC

Department of Parks & Recreation (DPR) tree censuses occurred in many wooded parklands during a period when the last of the “open spaces” were being developed for housing, industry or for recreation. In the latter part of the century, the DPR wooded parklands again received attention by local ecologists that resulted in censuses in Bronx County (Profous and Loeb 1984; Loeb 1982, 1986; Rudnický and McDonnell 1989; Yost et. al 1991; Loeb 1992; Sisinni and Emmerich 1995), Queens County (Greller 1972; Lefkowitz and Greller 1973; Greller 1975; Greller 1977a, 1977b; Greller et. al 1979; Greller 1979; Stalter 1981; Loeb 1982; Greller 1985; Greller and Garcia 1986; Greller et. al 1991), Staten Island (Beugler and Parisio 1981; Robinson et al. 1994) and a more recent and continuing citywide floristic survey, The New York City Metropolitan Flora Project (Brooklyn Botanic Gardens 1999). The documentation of the local flora as provided by the above investigators and others in the 20<sup>th</sup> century resulted in a designation or classification of New York City woodlands, and other regionally similar naturally wooded parks, by type (Table 1.2). The consensus among investigators such as Braun (1950) placed New York City forest types, along the glaciated sections as basically, mixed oak forests. Brodo (1968) referred to these forests as predominantly red oak forests and oaks may appear visually dominant due to their size. The closest general description of forest type from this table is perhaps by Peters (1952), who described the forests of Long Island as eastern mixed-hardwood. This is a good description as it takes into account changes in forest composition over time and does not place ecological

dominance on any single taxon. The more recent designation was by Greller et al. (1979) who stated “the forest is referable to a xeric phase of the oak, mixed dicot-dogwood type (Figure 1.1).

Chestnut (*Castanea dentata*) stands of course have long disappeared. For woodlands such as Forest Park, the chestnut blight dramatically altered the forest composition by 1917 (New York City Department of Parks and Recreation 1990). Remnant *Castanea dentata* are rare and found only as poles and adventitious sprouts from stumps. They rarely grow to height of several meters before being killed back by the canker forming fungi, *Endothia parasitica*.

## V. Research Intent

Over the past several decades there has been an effort to define species biodiversity within local urban woodlands. However, defining biodiversity in terms of population dynamics, community structure and the state of ecosystem health has not yet been fully attained. It is the intent of this research to report on plant diversity and the status of forest health in an urban woodland. This was accomplished by censusing a permanent 0.5 ha plot in the woodland of Forest Park. All arborescent taxa  $\geq 2.0$  cm at DBH were measured and taxa verified using Gleason and Cronquist (1991). Voucher

specimens were donated to the Brooklyn Botanic Garden Herbarium. The following questions were posed to guide current and future research efforts.

(1) What is the floristic and structural composition of the forest stand? (2) How are the taxa distributed and what are the ecologically dominant species? (3) What is the population biology of non-native invasive trees and what is their influence on the local flora? (4) Have anthropogenic disturbances such as tree falls combined with pioneer type invasive trees changed the forest? (5) Based on my research findings, what recommendations can be offered to NYC DPR natural resource managers?

#### VI. Project Area and Site Selection

A permanent plot within the 29 ha Northern Woods of Forest Park was selected for the study because of the need for long-term, quantitative ecology within close proximity to a densely populated area. This is the first permanent plot currently in the woodlands of Queens County. Among ecologists it is well known that long-term changes in the structure and composition of a woodland are best determined by periodic re-measurement of permanent plots (Fain et al. 1994).

Site selection for the 0.5 ha plot occurred in Fall 1999 and was based on; (a) a site least likely to have had extreme disturbance by park users, (b) a site where NYC DPR woodland restoration efforts had not yet disturbed the natural vegetation cover and, (c) a

forest stand that contained a reasonably homogenous canopy as a sign of a mature stand.

A professionally surveyed permanent plot of 50 x 100 m (0.5 ha) divided into 50-

10 x 10 m quadrats delineated my study plot within the 29 ha Northern Woods.

The use of a large rectangular homogenous plot rather than smaller dispersed plots was because (a) it is a method preferred by many terrestrial ecologists for tree sampling and for obtaining reliable quantitative results (Greller et al. 1979, Greller et al. 1982; Campbell et al. 1986; Greller and Garcia 1986; Loeb 1986; Brower et al. 1988; Rudnicky and McDonnell 1989; Ferreira and Prance 1998), (b) the need to reduce the accumulation of sampling error by marginal (edge) effects amplified by multiple smaller plots (Mueller-Dombois and Ellenberg 1974) and, (c) spatial studies (Cartesian coordinates of trees) can only be performed utilizing large rectangular or square sampling plots rather than small plots or linear transects using point center quarter methods (Mori et al. 2001).

Forest Park was the first wooded parkland in Queens County evaluated for a natural areas management plan by the NYC DPR Natural Resources Group (1990). The management plan notes that FP contains the most extensive undisturbed forests in all of Queens County and is primarily covered by red, black and white oaks (80%). Of the 219 ha mapped for the management plan, 76% or 166 ha were classified as closed forest/woodland. By this plan, all natural areas in the park have been classified into seven management zones. The location of my study plot for this census is located within

the Northern Forest located north of the Montauk Railroad Line and south of the Jackie Robinson Parkway (Interboro Parkway) (Figure 2.1).

The FP woodland is surrounded by dense human settlements in the Village of Richmond Hill to the south and Kew Gardens to the east. The park is bisected by several transportation corridors: the Interboro Parkway (Jackie Robinson) to the north, Myrtle Avenue to the southwest and Metropolitan Avenue to the east. There is a park-drive from the eastern entrance at Metropolitan Avenue to Victory Field, adjacent to Woodhaven Boulevard to the west. The interior woods contain a lengthy 3m wide, horse riding path and a maze of meandering foot and bicycle paths. All paths within the study plot vary in use intensity and run 292 m in length that covers approximately 438 m<sup>2</sup> of area or 8.7% of the total area of the plot. The long-term ecological impact of the many unregulated paths (i.e. soil compaction, trampling ) through the woodland is currently unknown.

## VII. Topics under Investigation

The following five chapters present the research results on the ecology of the arborescent taxa in the 0.5 ha study plot in Forest Park. It was intended to define the floristic composition, the ecological dominance and the community structure as defined by the spatial distribution of the trees and the influence of that distribution microclimate.

Chapter 2, “Forest flora and community structure: I” introduced the census objectives and the results of the analysis of entire dataset with descriptive statistics of tree size, dotmaps with  $n=771$  trees, species-area curve, collectors-effort curves, dominance-hierarchy curves, importance value tables and Gini Coefficients. Bootstrap techniques were used for determining confidence intervals.

Chapter 3, “Forest flora and community structure: II” expanded on Chapter 2 with tree subsets selected from upper and lower DBH quartiles as well as subsets of pioneer-type trees. An analysis of these subsets occurred by descriptive statistics, frequency distributions, regression models, importance value tables, and contingency tables for Jaccard similarity and phi coefficient among taxa (Jaccard 1908; Kaufman and Rousseeuw 1990; Kincaid et al. 2000).

Chapter 4, “Initial findings of the non-native and invasive tree, *Phellodendron amurense* Rupr. in Forest Park, Queens” is the first study on the ecology of the Amur corktree within the Atlantic port of entry. Its natural range is northern Asia. As subset of the FP census, a full treatment for descriptive statistics was provided. This included a frequency distribution for tree diameter and height, spatiality by dotmaps, regression models, size correlation and importance values.

Chapter 5, “Spatial point patterns of trees in the woodland of Forest Park” presented methodologies for determining the spatial arrangement of all 771 stems and for

the individual species of *Phellodendron amurense* and *Betula lenta*. Analysis of point patterns (tree stems) involved the application of several statistical tools (Diggle et al. 1976; Diggle 1983, 2001; Ripley 1981). Monte Carlo provided a measurement to whether taxa are random in distribution, aggregated or over-dispersed, and to what degree over any spatial scale. In some cases randomization tests (or permutation tests) were also used to provided insight to whether an observed pattern in nature was or was not likely to have arisen by chance. Nearest neighbor (NN) analysis was performed by considering only distances from any given tree to its nearest (or further) neighbor. NN examined potential competition by observing clustering between different species. This preliminary spatial analysis is preparation for future univariate (single-species) and bivariate spatial point patterns to be quantified using Ripley's  $K$  function coupled with Monte Carlo tests for significance.



**Figure 1.1** A view of the 29 ha Northern Woods of Forest Park and the location of the 0.5 ha study plot. Originally classified as an oak, mixed dicot-dogwood type forest its composition is currently under transition. The dominant taxa are sweet birch, red oaks and a recent invasive tree, Amur corktree.

Table 1.1 Historical accounts of plant census in wooded parklands of Queens County, New York and vicinity, noting sampling methodologies and size measurements.

	Author	Date	Publication	Title	Methodology	Measurement
1.	Greller A.M.	1972	Bull. Torrey Bot. Club 99: 202-206.	Observations on the forests of northern Queens County, Long Island from colonial times to present.	10 x 10 m plots	
2.	Lefkowitz A. and Greller A. M.	1973	Bull. Torrey Bot. Club 100: 313-318.	The distribution of tree species on the uplands of Cunningham Park, Queens County, NY.	PCQ <sup>1</sup>	Trees >7.6 cm Sapl. <7.6 cm
3.	Greller A. M.	1975	Environ. Conservation 2:61-69.	Persisting vegetation of northern Queens County, New York with proposals for its conservation.	Combined data Items 1 and 2	
4.	Greller A. M.	1977	Bull. Torrey Bot. Club 104:170-176.	A vascular flora of the forested portion of Cunningham Park, Queens County, New York with notes on the vegetation.	Floristic inventory	
5.	Greller A. M. et al.	1979	Bull. Torrey Bot. Club 106:135-139.	The upland oak-dominated community of Forest Park, Queens County, New York.	33- 10x15 m plots 36- 1 m <sup>2</sup> plots	Trees >7.6 cm Herbs < 1 m
6.	Greller A.M.	1979	Bull. Torrey Bot. Club 106:45.	A vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and additions-I.	Floristic inventory	
7.	Stalter R.	1981	Bull. Torrey Bot. Club 108:312-325.	A thirty-nine year history of the arborescent vegetation of Alley Park, Queens County, NY.	PCQ <sup>1</sup> 30- 2 x 4m plots	Trees >7.6 cm Sapl. <7.6 cm
8.	Loeb R. E.	1982	Bull. Torrey Bot. Club 109:537-541.	The reliability of the New York City Department Of Parks and Recreation forest records.	2 x 4 m plots	Trees >10 cm Sapl. 2.5-10cm

Table 1.1 continued.

9.	Greller A.M. et al.	1982	Bull. Torrey Bot. Club 109:219-225.	An oak,hickory-dogwood forest on central Long Island, New York.	50 x 50 m plot	Trees > 3 m ht. Shrub <1.5 m
10	Greller A. M.	1985	Bull. Torrey Bot. Club 112:312.	A vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and additions-II.	Floristic inventory	
11.	Greller A. M. and O.L. Garcia	1988	Bull. Torrey Bot. Club 113:36-41.	Variation in canopy composition of the forest of Alley Park, Queens County, New York.	Varied sized plots, Diagonal transect	Trees > 10 cm
12.	Greller A. M. et al.	1991	Bull. Torrey Bot. Club 118:330-332.	A vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and additions-III.	Floristic inventory	
13.	Stalter R. et al.	2000	Ecosystems and Sustainable Development.	Plant biodiversity in an urban wildlife refuge of New York City.	Floristic inventory	
14.	Stalter R. et al.	2001	In Vivo 22:4-10.	The vascular flora of Bayswater State Park, New York City, NY.	Floristic inventory	
15.	Glaeser C.W.	2003	Dissertation	The ecology of urban woodland in Forest Park,, Queens County, N.Y.	50 x 100 m plot 50- 1 m <sup>2</sup> quadrat	Stems > 2 cm Herbs < 1 m

1- Point center quarter method (Mueller-Dombois and Ellenberg 1974)

Table 1.2. Woodland designations of Forest Park and Cunningham Park based on similar local and regional vegetative composition.

<u>Author</u>	<u>Reference Year</u>	<u>Region</u>	<u>Woodland Designation</u>
Harper R.M.	1917	Northern Queens County	Rich woods
Bromley S.W.	1935	Southern New England	Mixed mesophytic forest type of the oak Region
Braun E.L.	1950	Eastern North America	Mixed mesophytic forest type in the oak-chestnut region- glaciated section of the eastern deciduous forest.
Peters G.H.	1952	Long Island	Eastern mixed hardwood forest
Collins S.	1956	Alpine, New Jersey	Oak community
Brodo I.	1968	Northern Long Island	Red oak forests
Good R.E. & N.F. Good	1970	Northern Long Island	Oak, mixed dicot-dogwood type
Lefkowitz A. & A.M. Greller	1973	Cunningham Park	Upland forests and rich woods
Greller A.M. et al.	1979	Forest Park	Oak, mixed dicot-dogwood type
Greller A.M. et al.	1982	Central Long Island	Oak, hickory-dogwood

## Chapter 2

### Forest flora and community structure: I.

#### I. Introduction

From the late 19<sup>th</sup> century through the 20<sup>th</sup> century development along the urban - suburban interface altered much of the original landscape on western Long Island. New York City now devoid of much natural landscape nevertheless contains greater than 3,000 species of vascular flora within a 50 mile radius of Columbus Circle, Manhattan (Brooklyn Botanic Garden 1999). Temperate forest fragments, once part of a larger contiguous forest ecosystem, remain as forested islands in parks and provide habitat. Forest Park (FP) in Queens County, New York is the largest continuous urban forest on the western end of Long Island, New York and contains much of the local flora (Greller et al. 1979; NYC DPR 1990, 1991).

The several published and unpublished floristic inventories of Queens County plus one quantitative census of Forest Park revealed some aspects of the forest structure however our understanding of woodland ecology in Forest Park remains limited. Knowledge of the forest flora and ecology are critical for understanding the dynamics of

a forest ecosystem and for management planning. Presented here is the first effort to define forest diversity in Forest Park since Greller et al. (1979).

## II. History of Forest Park

In 1892 the New York State legislature authorized a search for parkland. The first parcel of 218 ha was purchased in 1895 by the Brooklyn Parks Department with additional acquisitions into 1898. The parkland was transferred to the City of New York with the consolidation of Greater New York in 1898. Brooklyn Forest Park as well as other parks in Brooklyn and Queens was managed by the Brooklyn Parks Department until the Department of Parks, Queens was established in 1911. Brooklyn Forest Park was renamed Forest Park. Forest Park served as a multi-use park intended to provide a variety of recreational facilities and activities as well as areas that remained natural. Much of the land-use within the park area from the colonial period to the end of the 19<sup>th</sup> century involved timber harvesting, farming and cattle grazing. These activities were halted when the park was established (NYC DPR 1990). Forest Park remains poorly studied for its importance to urban ecology yet contains the largest plant communities in Queens County (Greller 1972; Greller et al. 1979).

The preservation of a large tract of oak, mixed-dicot forest amidst a human population, now exceeding 2.3 million inhabitants was a crucial step in the conservation

of biodiversity for that time. Greller et al. (1979) performed the first quantitative study on its flora. In 1990 the Department of Parks & Recreation Urban Forest Education Program (UFEP) prepared a management plan for all urban forests within NYC. There were two major goals of the management plan: (a) the mitigation of human disturbance and (b) the maintenance of continuous naturally regulated native forest plant communities, not driven primarily by disturbance. This citywide plan was followed by a Management Plan for Forest Park (NYC DPR 1996), the first wooded parkland in Queens County evaluated for a natural areas management plan by the NYC DPR Natural Resources Group. This was followed by management plans for other wooded parks such as neighboring Cunningham Park and Alley Pond Park (Tim Wenskus, personal communication).

The Forest Park plan identified vital plant communities and set priorities for woodland conservation. The management plan noted that FP contained the most extensive undisturbed forests in all of Queens County with an estimated 80% coverage of red, black and white oaks. Of the 219 ha considered for the management plan, an estimated cover of 76% (166 ha) was noted as closed forest/woodland. All natural areas in the park were classified into seven management zones based on the plant communities identified. The location of my study plot is within the 29 ha (72 acre)

Northern Forest Management Zone located 25 m north of the Montauk Railroad and 300 m south of the Jackie Robinson Parkway (Figure 2.1).

The distribution and rate of growth of forest stands are influenced by many soil characteristics described by their physical, chemical and biological properties (Forbes 1955). Forest Park (42° 30' north latitude and 73° 51' west longitude) is situated along the Harbor Hill terminal moraine of the southern point of the Glaciated Appalachian Plateau formed by the Wisconsin glaciation (Sanders 1974; Greller et al. 1979; Cunningham and Ciolkosz 1984). The soil texture of Forest Park vary from Montauk fine sandy loam with a complex slope and hilly to Montauk fine sandy loam with complex slope undulating to rolling. The Montauk texture series consists of very deep, well-drained soils on upland hills and ridges (New York City Department of Parks and Recreation 1990). Soil sample cores were collected and lab tested by the NYC DPR Central Park Soils Lab and Cornell University Analytical Lab in 1999 for pH and micro-nutrients (Table 2.12).

The overall knob and kettle topography is well vegetated with both herbaceous and woody flora. In contrast to neighboring Alley Pond Park and Cunningham Park, kettles in Forest Park lack standing water (Greller et al. 1979; personal observations). Elevation readings throughout the Forest Park woodland taken from 1935 NYC Department of Parks topographic maps series describe the elevation range from 18.0 to

42.0 m a.s.l.. The topography within my 0.5 ha study plot ranged from 24.0 m to 29.0 m a.s.l..

### III. Methods

The study site was selected in Fall 1999 and was based on; (a) a site least likely to have been disturbed by park users, (b) a site where NYC DPR woodland restoration efforts did not disturb the natural vegetation cover and, (c) a forest stand that contained a reasonable homogenous canopy as signs of a mature stand. A professionally surveyed permanent plot of 50 x 100 m (0.5 ha) divided into (50) 10 x 10 m quadrats delineated the sampling area within the 29 ha North Forest, set to true north (Figure 2.1 and 2.2). The quadrat corners and each 10 m interval were permanently marked with steel reinforcement bars and colored ribbon and indicated by GPS coordinates measured listed below.

<u>Plot Corners (x,y)</u>	<u>GPS Coordinates</u>
0,0 m	N 40° 42' 20.54" W 73° 50' 34.86"
50,0 m	N 40° 42' 20.59" W 73° 50' 33.17"
0,50 m	N 40° 42' 23.43" W 73° 50' 36.04"
50,100 m	N 40° 42' 23.80" W 73° 50' 23.80"

The choice of a large rectangular plot rather than smaller dispersed plots was made because (a) it is a preferred method by terrestrial ecologists for tree sampling and for obtaining reliable quantitative results (Campbell et al. 1986; Greller and Garcia 1986; Loeb 1986; Brower et al. 1998; Rudnický and McDonnell 1989; Ferreira and Prance 1998), (b) it reduces the accumulation of sampling error by marginal effects aggravated by multiple smaller plots (Mueller-Dombois and Ellenberg 1974) and (c) spatial studies using Cartesian coordinates can only be performed utilizing large rectangular or square sampling plots (Mori et al. 2001).

### III.1. Plot Sampling

This census began in Fall 1999 and continued through the Summer 2000. Much consideration was given to the minimum woody stem diameter. Stem diameter

measurements have often been left to the discretion of the investigator and hence minimum measurements vary. Campbell et al. (1986) and Ferreira and Prance (1998) used tree size classes of  $\leq$  and  $\geq$  10 cm DBH. Nadkarni et al. (1995) used DBH classes that included large ( $>$  30 cm DBH), medium (10 – 30 cm DBH) and small (2- 10 cm DBH). Studies of arborescent vegetation in Forest Park (Greller et al. 1979) and in Alley Pond Park (Stalter 1981) applied a DBH measurement of  $\geq$  7.6 cm, DBH. Rudnický and McDonnell (1989) used a diameter  $\geq$  15 cm, DBH for a woodland study at the New York Botanic Garden (NYBG).

For this study, I measured all stems  $\geq$  2.0 cm at diameter breast height (1.37 m), regardless of tree or shrub characteristic. Diameter determination for a multiple-stems was obtained by merging basal area across the stems and then solving for diameter.

An internally graduated telescoping Leitz Height Scale (essentially a vertical ruler) was used to measure tree and shrub heights to 7.63 m (25'). Height was approximated for trees exceeding 7.63 m (25'). The x,y coordinate of all stems was measured (Figure 2.2a and 2.3). Each taxon within the plot was identified to species. Nomenclature follows Gleason and Cronquist (1993). Voucher material was pressed, labeled and donated to the Brooklyn Botanic Garden Herbarium, Brooklyn NY.

Importance values (IV) for species and families were computed from a computer program by Kincaid. The use of Species Importance Values (SIV) and Family

Importance Values (FIV) are common quantitative tools to assess dominance hierarchy of taxa within the plant community (Mueller-Dombois and Ellenberg 1974; Grellier et al. 1979; Mori et al. 1983; Campbell et al. 1986; Ferreira and Prance 1998). Importance values are the summation of relative density + relative frequency + relative dominance x (100). By definition of the importance value method, the summation of importance values of all taxa within the plot totaled 300.0. Bootstrap confidence intervals of IV at 95% were applied to the top seven ecologically dominant taxa to measure our uncertainty about importance values across the larger Forest Park. The larger the sample size (n) the more accurate the parent value, the less confidence limits.

### III. 2 Soil Sampling

The distribution and rate of growth of forest stands are influenced by a great many soil characteristics comprised of chemical, physical and biological factors that include bound nutrients (Forbes 1955). The presence of important soil nutrient elements are more likely to be located in abundance within the upper soil profile of a typically vegetated temperate landscape. This profile is referred to as O and A horizons which consists of a large accumulation of decomposed and partly decomposed detritus and amorphous organic matter (histic epipedon zone), (Clark et al. 2000). To determine the distribution and abundance of these elements in the Forest Park plot, soil analysis tests

were performed. At a central location within quadrats, forest detritus was cleared and a soil sample was extracted. Within the top layer (O horizon), organic matter was measured to a depth ranging from 2.0 - 5.0 cm. This layer is darker in color than the lower A horizon because of accumulated decomposed and partly decomposed organic matter or humus. The soil within the A and O horizon was sampled in 15 quadrats. A 20.0 cm core extraction was made with the use of an 18 inch slotted soil sampler. The soils were air dried at room temperature for 5 days. The 15 extractions were pooled into 5 samples and forwarded to analytical labs (Cornell CALS Nutrient Analysis Lab, Ithaca, NY and NYC DPR Central Park Soils Lab, NY). The available mineral elements and pH are listed in Table 2.12.

#### IV. Results

Seven hundred and seventy-one (771) stems were identified that included 22 tree and shrub species in 15 genera and 13 families, within the 0.5 ha plot. The mean number of species per 10 x 10 m quadrat was 5.60 and the mean number of stems per quadrat was 15.48. The stem density for all trees and shrubs measured at  $\geq 2.0$  cm DBH was 1542 stems  $\text{ha}^{-1}$ . Mean stem density is 270 stems  $\text{ha}^{-1}$  at the 10 cm cut-point. This is a similar density to neighboring Alley Pond Park which, at the 10 cm DBH cut-point had a mean density of 245.5 stem  $\text{ha}^{-1}$  (Loeb 1992).

Quantitative indices were developed by ecologists to quantify species diversity within a community with extrapolation from species richness (the number of species in a community) and evenness (the relative abundance of the species). A suitable quantitative measurement of diversity is the Shannon Index of diversity (also known as the Shannon-Weiner Index). For the study plot, the Shannon Index ( $H'$ ) was 2.176. The minimum value of  $H'$  is zero, which states that the community contains a single species.  $H'$  increases as species richness and evenness increases (Shannon 1948; Brower et al. 1998; Molles 1999).

The other commonly used index is the Simpson's Index. Simpson considered the proportion of the total number of individuals in each species. It is based in part on an index of dominance that is inversely related to evenness and richness (Huston 1994). Statistically, it is the probability that two individuals selected randomly and without replacement belong to the same species. In the study plot, the Simpson's Index is 0.1624.

The chief use of the species-area curve in a plant census has been to indicate minimal plot size and minimal numbers of plots required for adequate sampling (Rice and Kelting 1955). The species-area curve (the accumulation of tree species as a function of the sample area) was prepared in this study by approximate randomization analysis (Mori et al. 2001). This involves shuffling of plot combinations 500 times without replacement (Figure 2.4). In Figure 2.4, the mean number of species per plot is the

middle curve. A minimum (lower) and maximum (upper) curve are the minimum and maximum number of species found in the randomization of quadrats. Here, the mean curve markedly increased and does not level off at plot 50, suggesting that censusing a larger area would reveal more taxa. The jaggedness of the minimum and maximum curves was due to the relatively small sampling numbers of the approximate randomization test (NS=500). Note however that the maximum values on the species-area curve leveled off at quadrat 15. This suggested that a maximum number of species (22 taxa) could be found in 15 quadrats, inferentially. Some of the output mean values derived from the approximate randomization analysis are in Table 2.9.

Table 2.10 is a bar diagram of discrete frequency distribution species abundance for the 22 taxa. Figure 2.11 is a Collectors-Effort Curve. Figure 2.13 displays the Dominance-Hierarchy curve from data obtained through the statistical map of diversity and density (Figure 2.12).

#### IV.1. Stem Diameters

The DBH ranged from 2.0 – 116.7 cm (mean 8.55 cm, SD 13.44). The largest taxa with a DBH range of 73.3 cm – 116.7 cm were the oaks (Fagaceae) that included *Q. rubra*, *Q. velutina* and *Q. alba*. They comprised 9.0% of the sampled population. The largest trees were *Quercus rubra* (116.7 cm) followed by *Q. velutina* (84.5 cm, 79.0 cm

and 95.0 cm) and *Q. alba* (81.5 cm). Tests for goodness of fit for tree diameter revealed that the Weibull fit ( $p < 0.01$ ) provided a visual improvement over a log normal fit ( $p < 0.01$ ).

The frequency distribution of stem diameters (DBH) was determined for the entire dataset (Figure 2.5). This DBH distribution forms a J-curve. The abundant small size trees and shrubs sampled were skewed toward the right with the few large and mature taxa. By inspection the 2.0 – 6.0 cm size interval was largely represented by *Betula lenta* (n=152) followed by *Phellodendron amurense* (n=128), *Cornus florida* (n=74) and *Prunus serotina* (n=57).

*P. amurense* has a smaller mean DBH (4.76 cm, SD 3.69) than the mean DBH of *B. lenta* (6.29 cm, SD 6.92). *Cornus florida* has a greater mean DBH (5.98 cm, SD 4.63) than *P. amurense*. The second interval bar (6.0 – 10.0 cm) drops considerably and represents 6% of the sampled stems that is largely composed of *Betula lenta* (n=39), *Cornus florida* (n=29), *Phellodendron amurense* (n=19) in order of abundance. The distribution was typical for a mature stand that contains an abundance of small stems in contrast to a few large ones. However the skewed phenomenon of stem diameter distribution at early stages of growth is widely accepted as a general trend (Hara 1988). The variability in frequency distributions and descriptive statistics for tree diameter of the 12 dominant taxa in the 0.5 ha plot are presented in Tables 2.15 (a-1).

The frequency distribution of tree diameter was studied for the top three ecologically dominant families in the Forest Park plot (Figure 2.8) with dominance based on species importance value as described in Section IV.5. Fagaceae was unique in this group since it was the only family to be represented by three genera and five species. In Figure 2.8 (a), the diameter frequency distribution of the Fagaceae (n=74) peaked at the 2.0 – 6.0 cm DBH interval. This interval bar represents 27% of the Oak Family and consisted of *Fagus grandifolia*, *Castanea dentata*, *Quercus alba* and *Q. rubra* in decreasing order of abundance. The adjacent and lesser interval bar, representing 12% of the population contained largely *Quercus rubra*.

The Betulaceae (n=217), represented by *Betula lenta* though first in ecological importance by species was second in ecological importance by family. The diameter frequency distribution peaked in the first interval bar (2.0 – 6.0 cm) and represented 69% of the sampled sweet birch population. The lesser interval bar represented only 37% of the sample.

The Cornaceae is represented by two species; *Cornus florida* and *C. alternifolia*. The 2.0 – 4.5 cm DBH interval bar in Figure 2.8(c) for diameter frequency distribution represented 47% of the dogwood population. The interval was dominated by *C. florida* or 88% of the dogwoods. The adjacent 4.5 – 7.0 cm DBH interval bar represented 25% of the dogwood population and contained 96% of the *C. florida*.

#### IV.2. Basal Area

The basal area (BA, cm<sup>2</sup>) is the sum of the stem cross-sectional area at DBH (cm) for all taxa. Relative dominance is a taxonomic ranking extrapolated from the basal area of a species / the total basal area of all taxa. Basal area (cm<sup>2</sup>) was converted to m<sup>2</sup>.

Within the 0.5 ha plot, the total basal area for all species was 15.03 m<sup>2</sup>. The taxa with the greatest BA were *Quercus rubra*, BA= 5.71 m<sup>2</sup> and with a relative dominance of 37%. This is followed by *Q. velutina* BA= 3.68 m<sup>2</sup> and *Q. alba* BA= 1.87 m<sup>2</sup>, with a relative dominance of 24 % and 12.2 % respectively (Table 2.1).

Gini coefficients (*G*) were furnished for the 12 dominant taxa using basal area to measure size inequality among individual taxon. Gini coefficients range between 0 to 1, zero representing an exact equality (all plants having the same size) and one, representing extreme inequality (Dixon 1993). Bootstrap 95% confidence intervals of *G* (NS=999) was applied to measure our uncertainty about *G* (Table 2.13). *Fagus grandifolia* (n=13) ranks low in abundance yet it contained the highest inequality by basal area (*G*= 0.8728). Its confidence interval ranges from 0.553 to 0.946. *Betula lenta* (n=217) ranks first in abundance yet it is second in inequality for basal area (*G*= 0.7978). Its confidence interval ranges from 0.692 to 0.842.

### IV.3. Vertical Structure

Tree and shrub height measurements define the vertical structure of this woodland community. Height ranged from 1.47 – 32.44 m with a mean height of 6.96 m, (SD 5.50). The frequency distribution of all heights revealed an inverse J- distribution (Figure 2.6), where height peaked within the 2.0– 5.0 m height interval. This height-class interval contained a frequency of 274 individuals or 35.5% of the sampled population. This interval was dominated by *Betula lenta* (n=82), followed by *Phellodendron amurense* (n=75), *Cornus florida* (n=46), *Prunus serotina* (n=37), *Carya* sp. (n=24) and *Sassafras albidum* (n=10). The variability in frequency distributions and descriptive statistics for tree and shrub height of the 12 dominant taxa are presented in Tables 2.15 (a-l). Tests for goodness of fit for tree diameter revealed only visual improvement of Weibull fit ( $p < 0.01$ ) and the log normal fit ( $p < 0.01$ ).

Gini coefficients ( $G$ ) were furnished for the 12 dominant taxa using heights to measure inequality among individual taxon. The Gini coefficients range between 0 to 1. Zero represented an exact equality (all plants having the same size) and one, representing extreme inequality (Dixon 1993). Bootstrap 95% confidence intervals of  $G$  for height (NS=999) was applied to measure our uncertainty about  $G$  (Table 2.13). *Fagus grandifolia* (n=13) contains tree heights that are relatively equal ( $G= 0.4713$ ). Its confidence interval ranges from 0.249 to 0.510. *Quercus velutina* (n=10) ranks the

nearest to equality for tree heights ( $G=0.7978$ ). Its confidence interval ranges from 0.335 to 0.287.

#### IV.4. Height and Diameter Relationships

The dataset for woody diameter and height was submitted to regression analysis with the resulting scattergrams (Figure 2.7). A polynomial regression of tree height versus tree diameter revealed extremely strong evidence for a causal relationship for height and diameter and that height is not just a random occurrence ( $r^2 = 0.881$ ,  $P < 0.0001$ ).

#### IV.5 Importance Values

Three quantitative parameters were obtained from this census - density, frequency and basal area. Importance values (with a total value of 300.0) for individual taxa are a summation of relative density (%), relative frequency (%) and relative dominance (%), (Mueller-Dombois and Ellenberg 1974). Importance values were computed for the 22 woody species and the 13 families in the 0.5 ha plot. The species were arranged in a dominance hierarchy from high to lesser importance (Table 2.1). Importance values carry measurable weight for describing the contribution by individual taxa to the plant

community. Basic descriptive statistics, such as number of trees (abundance), percentage of representation in quadrats and mean diameter are given in Table 2.2.

*Betula lenta* (n=217, IV = 51.99) was the ecologically dominant species in the plot. Sweet birch is highly abundant and was found in 40 of the 50 sampled quadrats (80%). At 28.03%, it had the highest density of all taxa. The species ranking second in density is *Phellodendron amurense* (n=158, IV=33.3) with a relative density of 20.67%. Sweet birch had a relative frequency of 14.18% and relative dominance of 9.77% with a summed basal area of 1.48 m<sup>2</sup>.

The second ranked species was *Quercus rubra* (n=33, IV = 49.96). The relative density for this species was 4.26% and a relative frequency of 8.15%. Its relative dominance was 37.54% with a basal area of 5.71 m<sup>2</sup>. Red oak were found in 23 of the 50 sampled quadrats (46%).

The third ranked species was the non-native, invasive *Phellodendron amurense* (n=158, IV= 33.57). The importance value of Amur corktree was nearly similar to the native *Cornus florida* (IV = 32.43). With a density (20.4%) it ranked second to *Betula lenta* in density (28%). Amur corktree was found in 28 of the 50 sampled quadrats (56%). It had a relative frequency of 9.92%. Its relative dominance is 2.97% with a basal area of 0.452 m<sup>2</sup>. A more detailed analysis of the population biology of *P. amurense* will be presented in a later chapter.

The fourth species in the dominance ranking was *Cornus florida* (n=115, IV = 32.43). *Cornus florida*, an understory tree ranked third in terms of relative density (14.9%). *Sassafras albidum*, *Lindera benzoin*, *Vaccinium corymbosum* and *Ilex verticillata* rank low in ecological dominance. Note that the *Lindera benzoin*, *Ilex verticillata* and *Vaccinium corymbosum* are shrubs. *Cornus florida* is as abundant as *Betula lenta* with a representation in 40 of the 50 sampled quadrats (80%). It had a relative frequency of 14.18%. The relative dominance was 3.38% with a basal area of 0.515 m<sup>2</sup>, nearly equivalent to *Prunus serotina* which ranked sixth in ecological dominance. The dominance ranking and abundance of *C. florida* is of interest because of its susceptibility to numerous fungus foliage pathogens such as anthracnose (*Discula* spp.) that, left unchecked results in tree mortality (Dirr 1990).

*Quercus velutina* (n=10, IV= 28.07) ranked fifth in overall ecological dominance yet ranked tenth by relative density (1.29%). The black oaks were low in abundance and high in basal area and ranked second in terms of basal area (3.68 m<sup>2</sup>). It was found in only 8 of the 50 sampled quadrats (16%). It had a relative frequency of 2.83%.

*Prunus serotina* (n=85, IV = 27.14) ranked sixth in ecological dominance. Black cherry had a relative density of 11% and was the third most frequently encountered tree species with a relative frequency of 12.7%. The relative dominance was 3.35% with a basal area of 0.516 m<sup>2</sup>. Wild black cherry was found in 36 of the 50 quadrats (72%).

Five singletons were found within the Forest Park plot. Singletons were those species represented by one individual. These were *Acer rubrum*, *A. platanoides*, *Liriodendron tulipifera*, *Ilex verticillata* (shrub) and *Nyssa sylvatica*.

Bootstrap 95% confidence intervals delineates numerical upper and lower limits where point-estimates, such as importance values may have a 0.95 chance of existing (NS=10,000). No probability values are applied (Hayek and Buzas 1997). Confidence intervals were determined for seven of the ecologically dominant taxa (Figure 2.17). The lower and upper bounds ( $L_1$ ,  $L_2$ ) are the confidence limits for the importance value. The taxa with the larger sample size (n) e.g., *Betula lenta* (n=217), *Phellodendron amurense* (n=158), *Cornus florida* (n=115) and *Prunus serotina* (n=85) have a smaller confidence interval and therefore a more reliable importance value. In terms of inferential ecological dominance for the NYC urban woodland at large, the dominance ranking of e.g., *Phellodendron amurense* may be from rank number 2 to rank number 6. This inference was determined by observing the overlap of  $L_1$  and  $L_2$  of individual taxa in the table below.

Rank	Taxa	Importance Value	$L_1$	$L_2$
1.	<i>Betula lenta</i>	51.99	47.75	58.18
2.	<i>Quercus rubra</i>	49.55	34.53	64.48
3.	<i>Phellodendron amurense</i>	33.34	32.19	35.22
4.	<i>Cornus florida</i>	32.44	31.02	34.66
5.	<i>Quercus velutina</i>	28.07	14.49	42.49
6.	<i>Prunus serotina</i>	27.14	25.77	29.26
7.	<i>Quercus alba</i>	17.44	8.54	28.60

#### IV.6 Family Importance Values

The use of importance value (IV) for tree families was applied to several inventories (Mori et al. 1983; Campbell et al. 1986; Ferreira and Prance 1998). Importance values were calculated for the 13 arborescent families (Table 2.7) and descriptive statistics for those families (Table 2.8).

The Fagaceae were the most dominant and richest arborescent family. It was represented by five species and collectively contained 74 individuals- *Quercus rubra* (n=33), *Q. velutina* (n=10), *Q. alba* (n=13), *Castanea dentata* (n=5) and *Fagus grandifolia* (n=13) with a total IV of 102.57 out of a possible 300.00. The relative density was a low 9.56 %. The relative frequency was 16.04%, equivalent to that of the top three ranking families. Fagaceae had a relative dominance of 77.2% and a combined basal area of 11.71 m<sup>2</sup>. This surpassed the next dominant family eight-fold in terms of basal area. Fagaceae were found in 39 of the 50 sampled quadrats (78.0 %).

The second ranked family was Betulaceae represented by a single species, *Betula lenta* (n=217, IV= 54.27). Considering their abundance, sweet birch had a relative density of 28.03%, a relative frequency of 16.46%, a basal area of 1.48 m<sup>2</sup> and a relative dominance of 9.66%.

The third ranked family was Cornaceae, represented by two species *Cornus florida* and *C. alternifolia* with 124 individuals and an importance value of 36.02. The

dogwoods are found in 80% of the quadrats surveyed. They contain a relative frequency and relative density of 16%, the third most dense of the family groups and maintain a near equivalent relative frequency with Fagaceae and Betulaceae. The relative density is a markedly low 3.4 %.

The fourth in family ranking are the Rutaceae, represented by *Phellodendron amurense* with 158 individuals with an importance value of 34.93. The Amur corktree has a relative density of 20.4 %, the second highest density to the Betulaceae. Amur cork tree is located in 56% of the quadrats. A histogram of ecological ranking by family importance values is presented in Figure 2.9.

#### IV.7 Kettles and Flat Uplands

The landscape of Forest Park has been described as a knob and kettle topography and is typical of landscapes formed by advancing glaciers. An analysis of woody vegetation within kettles (> 10 % slope) and flat uplands ( $\leq$  10% slope) was performed for topographical influence on species richness. Kettles covered 74% of the 0.5 ha plot and contained 20 species (n=537). There are no real knobs in the study plot. Flat uplands covered 26% of the plot and contained 17 species (n=234). Based on importance values, the five ecologically dominant taxa within the kettles were *Quercus rubra* ( $\bar{n}$ =31, IV = 60.19), *Betula lenta* (n=151, IV = 48.97), *Phellodendron amurense*

(n=107, IV = 32.62), *Cornus florida* (n=71, IV =31.02) and *Prunus serotina* (n=60, IV = 26.89). *Betula lenta* had a relative density of 28.1% followed by *Phellodendron amurense* with a density of 19.9% (Tables 2.3 and 2.4).

The three ecological dominant taxa within the flat uplands were *Betula lenta* (n=66, IV =65.28), *Quercus velutina* (n= 2, IV = 52.26), *Cornus florida* (n= 44, IV = 36.29), *Phellodendron amurense* (n=51, IV = 35.67) and *Prunus serotina* (n= 25, IV = 28.12). *Phellodendron amurense* had a relative density of 21.8% followed by *Cornus florida* with a relative density of 21.8% (Table 2.5 and 2.6).

## V. Conclusions

The 0.5 ha plot within the 29 ha North Forest Management Zone in Forest Park, contains an interesting diversity of trees and shrubs of DBH  $\geq$  2.0 cm. This low DBH cut-point accounted for many trees that would have been excluded had the cut-point been 7.6 cm DBH measurement, as was used in previous inventories (Greller et al. 1979; Stalter 1981; Greller and Garcia 1986). Twenty-two species resulted from sampling 771 stems  $\geq$  2.0 cm DBH. In fact, 22 species were identified within the 2.0 – 7.6 cm DBH range (n=580). This is an increase by nine tree species, had the DBH cut-point of 7.6 cm been used. Of these 22 species, 19 are native to the temperate northeast and three are non-native, invasive species- *Phellodendron amurense*, *Acer platanoides* and *Rhamnus frangula*.

The 22 species in the Forest Park census contrasts to previous census in neighboring wooded parks. Species abundance that resulted from census with DBH cut-points of 7.6 cm or 10.0 cm, follow. Greller et al. (1979) identified 14 tree species within an equivalent sampling area in Forest Park; 23 species were identified in Alley Park (Stalter 1981); 29 species in various stands in Alley Park (Grella and Garcia 1986); 24 species in Cunningham Park (Lefkowitz and Grella 1973). Glaeser (1999, unpublished results) identified 26 tree species in Cunningham Park at the 2.0 cm DBH cut-point. The NYC DPR Natural Resources Group reported 27 woody taxa (16 tree species and 11 shrubs) for Forest Park (M. Garguillo, personal communication). In addition, I performed a census along two- 200 m linear transects in two random locations that revealed 19 woody taxa (13 trees and 6 shrubs).

It is theorized that forest disturbances (of any type and scale) result in gaps that are heterogenous whereby placing a stand in “ transition.” The recovery from disturbance often results in a mosaic of patches at different stages of a forest cycle. Trees found within gaps may consist of either pioneer or climax (non-pioneer) species or both, adding to stand diversity. Numerous studies have related forest composition to the size and frequency of those disturbances (Brokaw and Schneider 1989;Whitmore 1989; Veblen 1989).

Plant communities in general respond to disturbances differently, either from the effects of logging, as revealed in subtropical pre-montane forests (Ramirez 2001) or from

people pressure, fires or natural tree falls as observed in Forest Park. I believe that past disturbances within the study plot promoted a distribution of tree DBH more typical of pioneer species than of climax (non-pioneer) canopy species. This may have implications for the future composition of the forest.

Of the 12 dominant trees and shrubs, three trees share characteristics associated with pioneers in disturbed sites. The characteristics of the pioneer-class are those trees that produce copious amounts of small, well-dispersed seeds, have seeds that can only germinate in full-sun and are short lived (Whitmore 1989). *Betula lenta*, *Phellodendron amurense* and *Prunus serotina* share some of those pioneer characteristics and are of special interest because of their high representation within the plot (density and frequency). A more detailed analysis of the dominant taxa and pioneer trees are addressed in Chapter 3.

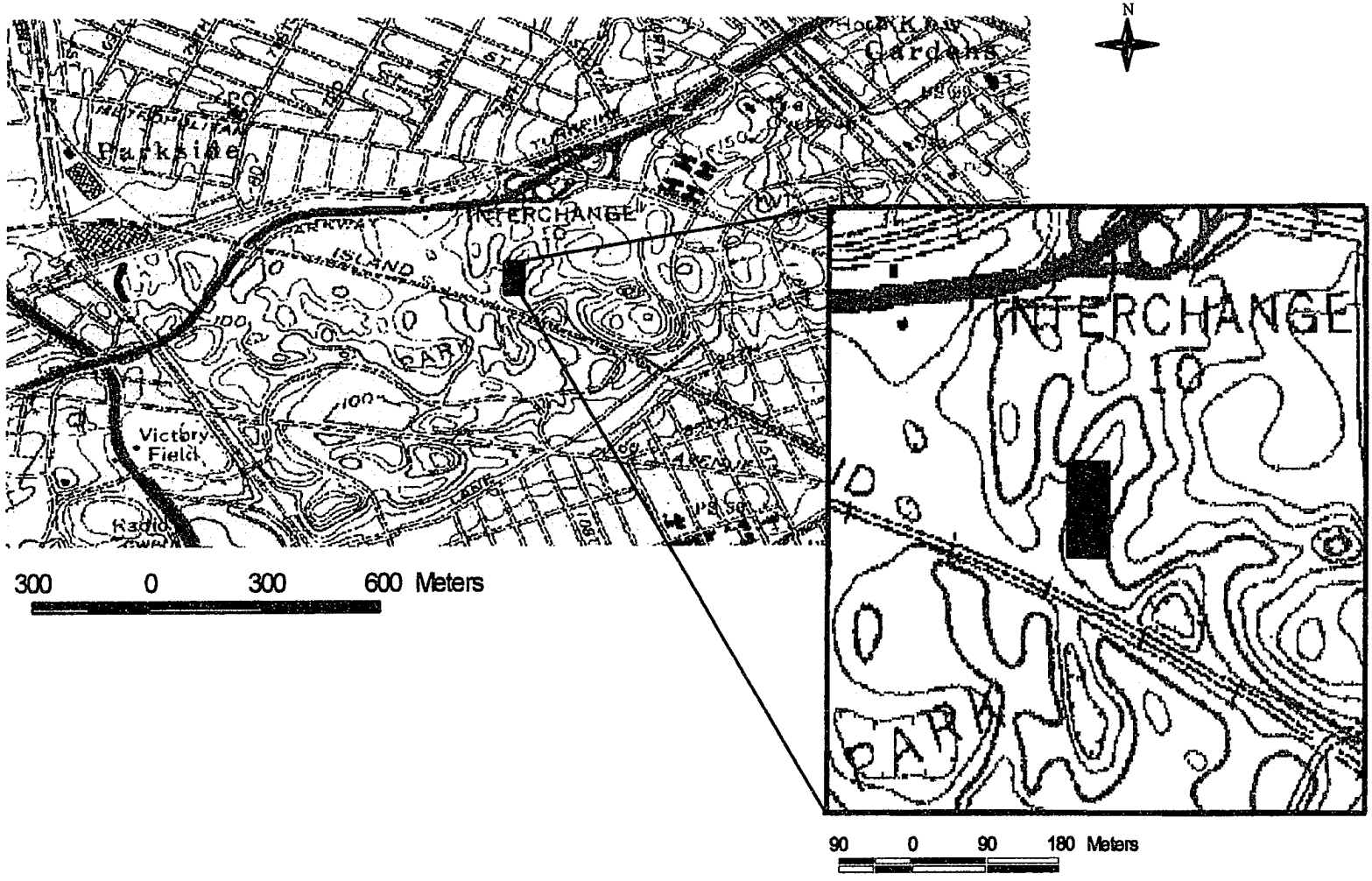


Figure 2.1 View displaying the 50 x 100 m study plot of Forest Parks 29 ha Northern Woods and the surrounding urban area.

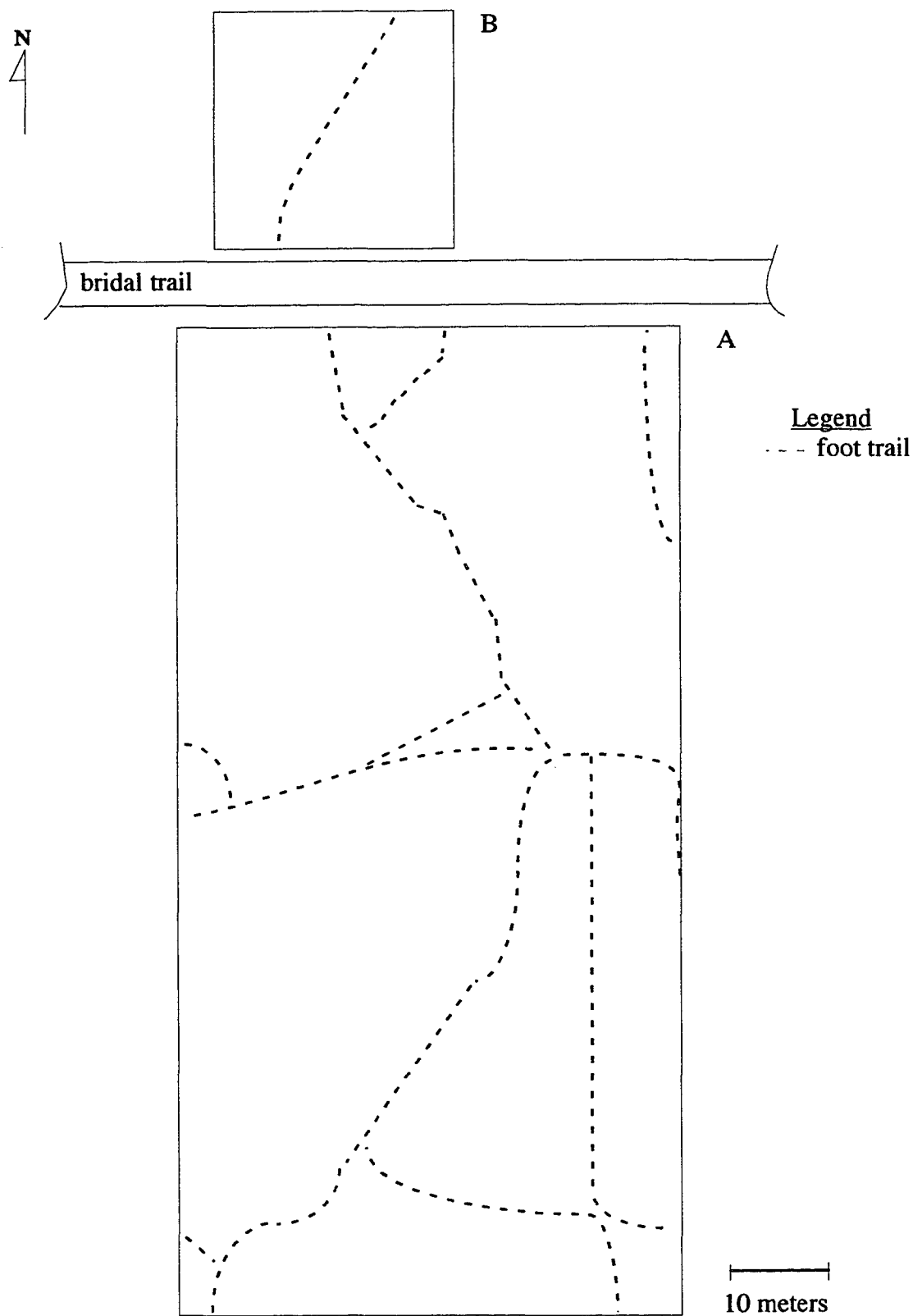


Figure 2.2 Schematic of the Forest Park study site with; (A) the 50 x 100 m plot for the 1999 tree census and, (B) the 25 x 25 m clear-cut plot for a long-term study on woodland regeneration. The plots are separated by a bridal path.

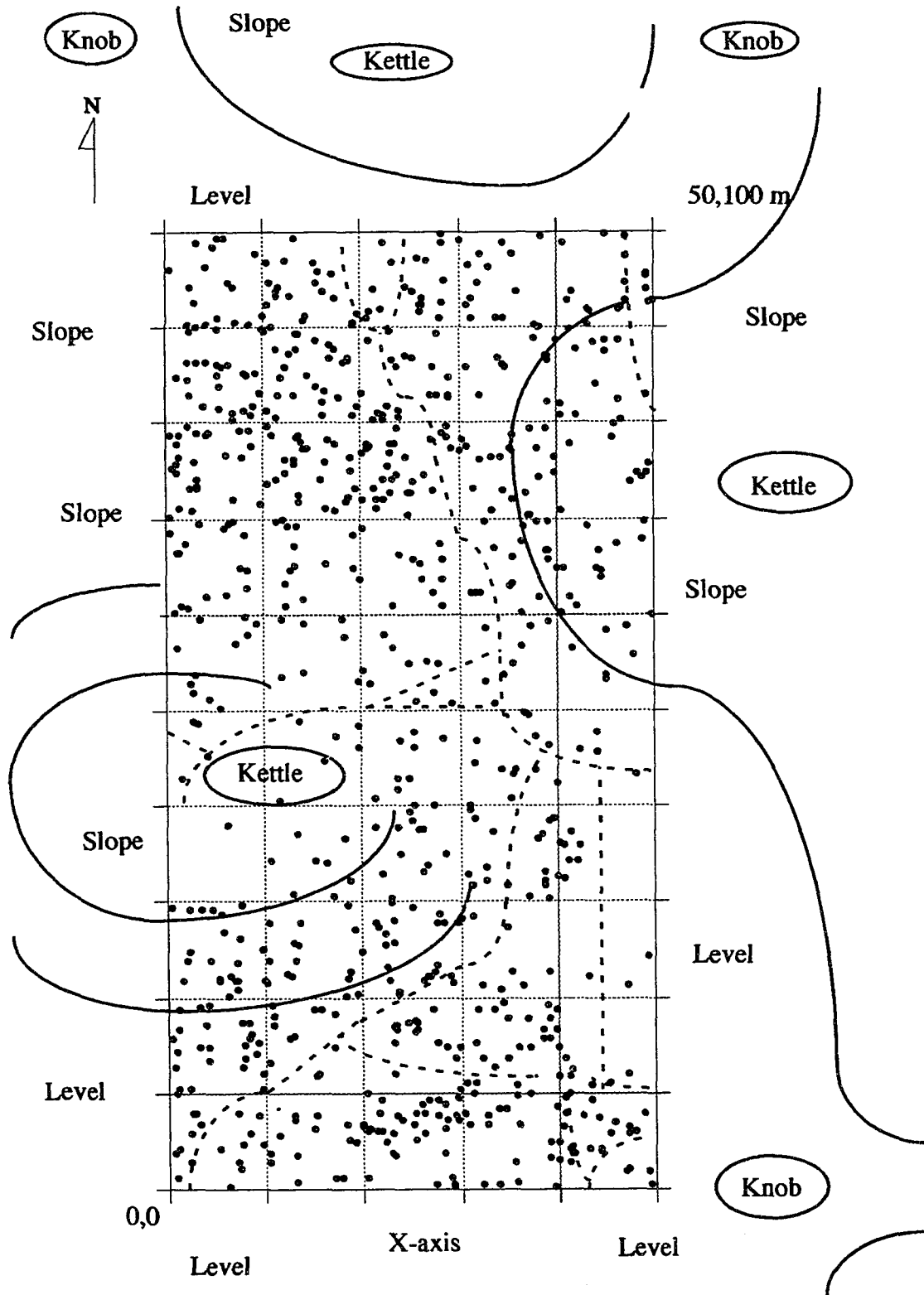


Figure 2.2.a Layered schematic of the 0.5 ha (50 x 100 m) plot in Forest Park noting knobs and kettles, sloped and level areas, foot trails ( - - - ) and dots marking the distribution of all trees (n=771).

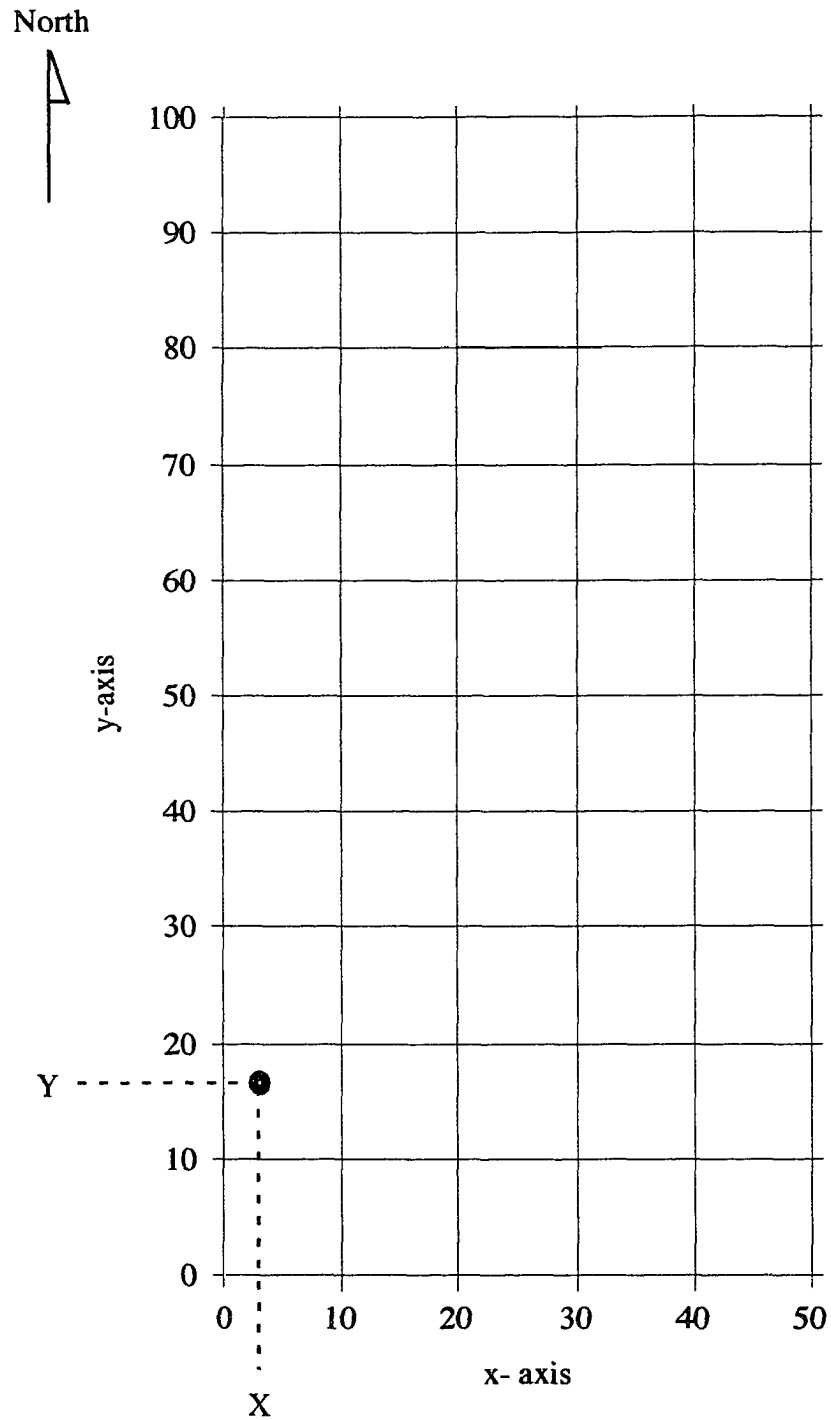


Figure 2.3 Sampling methodology for a 0.5 ha woodland census. Plot measurements are 50 x 100 m (165 ft. x 330 ft.) divided into fifty-10 x 10 m quadrats. Cartesian coordinates (x,y) locate each woody stem.

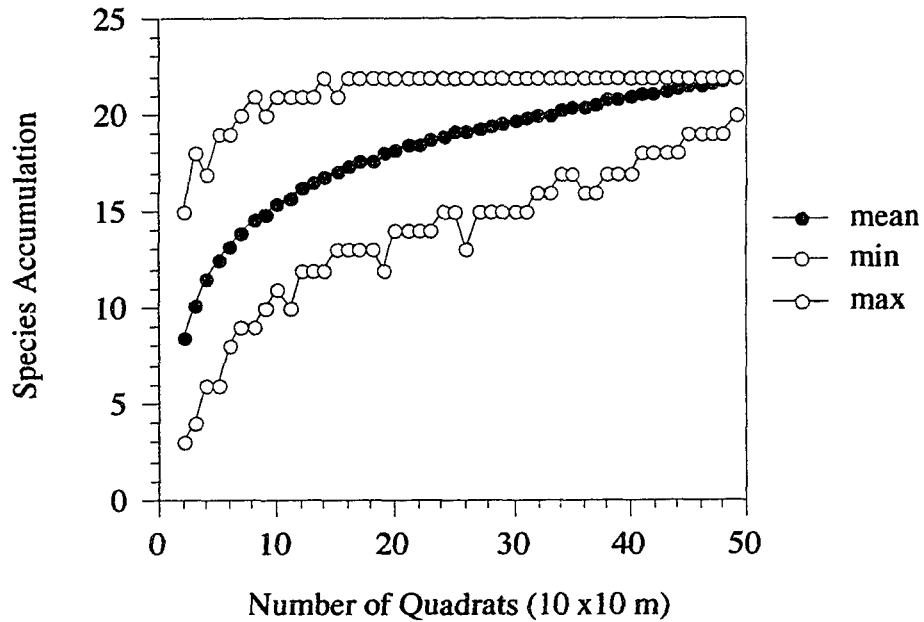
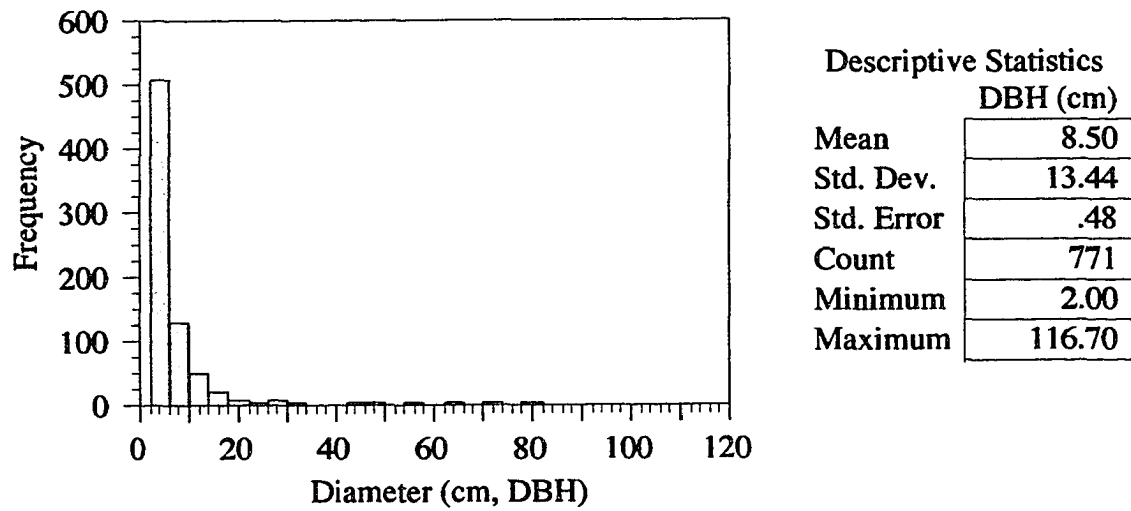
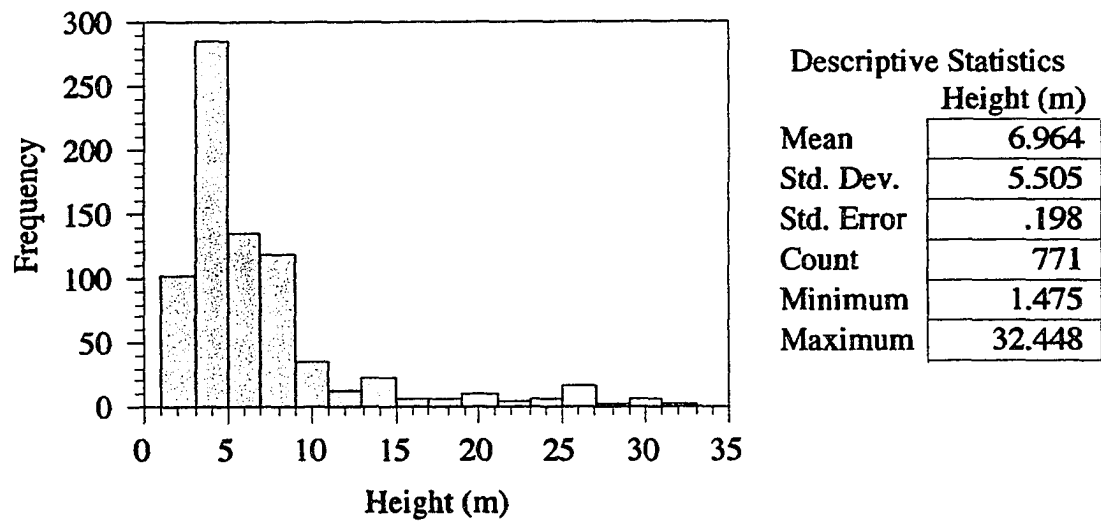


Figure 2.4 Randomization Species-Area Curves generated from sampling quadrat combinations  $NS=500$  without replacement in Forest Park. The lower curve represents the minimum number of species, the middle curve the mean number of species and the upper curve the maximum number of species attained for each combination of quadrats (computer program by Kincaid). The "jagged" nature of the minimum and maximum curve is due to the fact that 500 samples is a low number of samples relative to the unfavorable combinatorics (see Table 2.9).



**Figure 2.5** Frequency distribution and descriptive statistics of all tree and shrub diameters within the 0.5 ha plot in Forest Park (n=771). Stem diameters ranged from 2.0 - 116.7 cm, DBH (Weibull fit,  $w^2=9.376$ ,  $p < 0.01$ ).



**Figure 2.6** Frequency distribution and descriptive statistics of all tree and shrub heights (1.47 - 32.5 m) in the 0.5 ha plot of Forest Park (n=771).

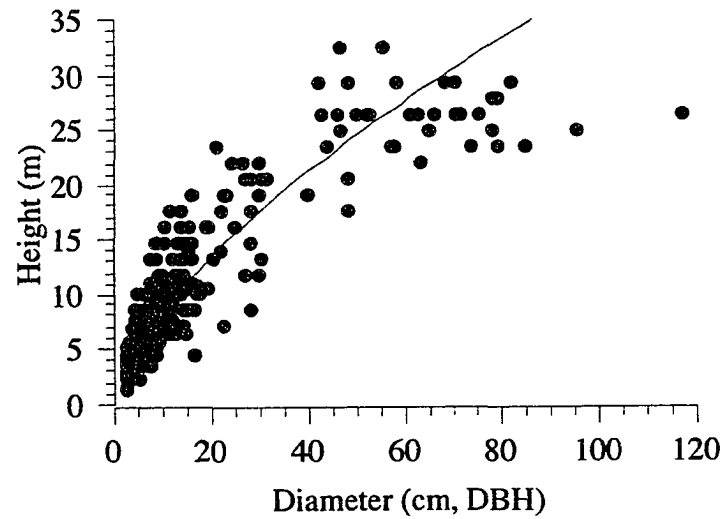
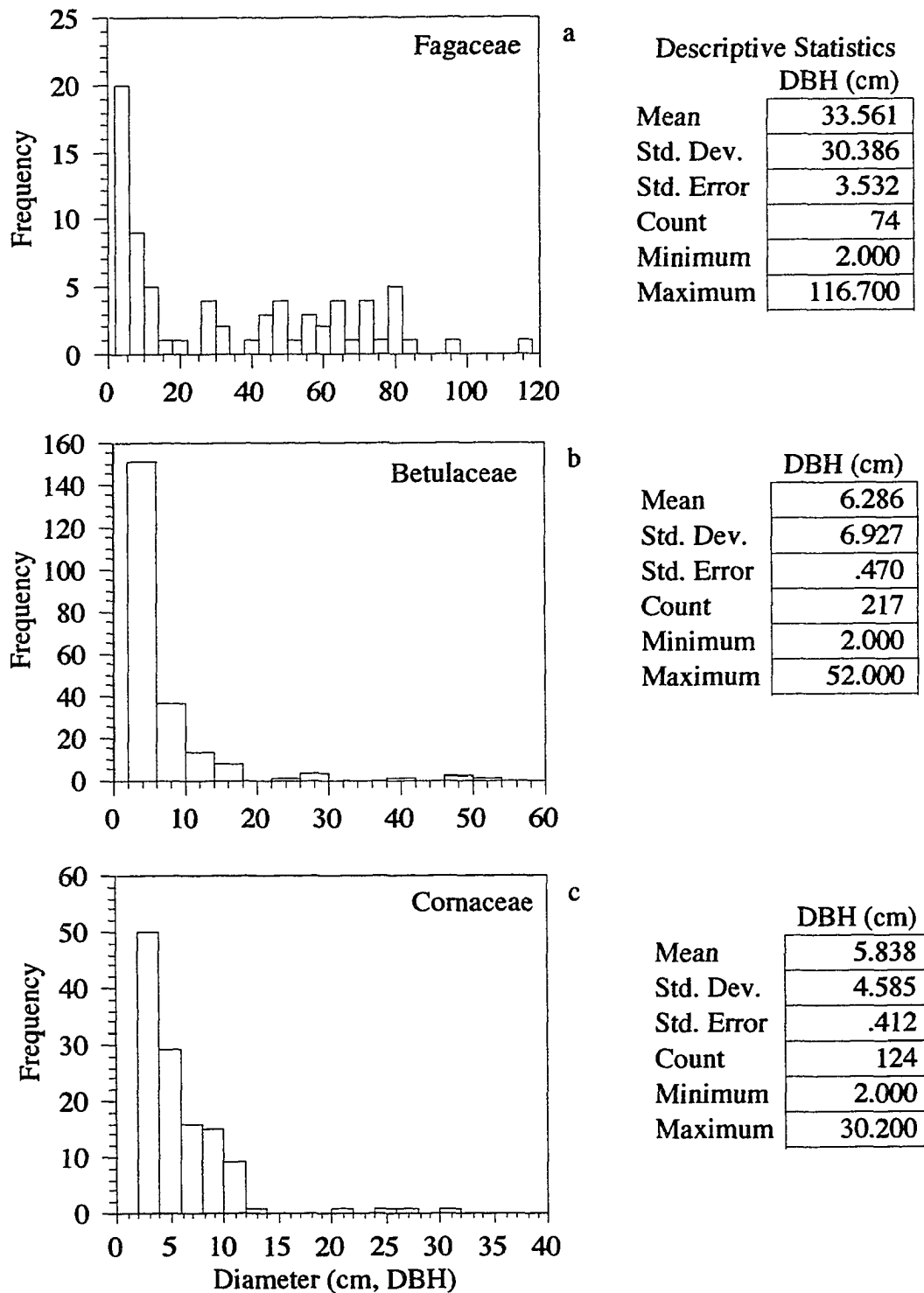


Figure 2.7 Diameter versus Height scattergram of all woody stems in the 0.5 ha plot in Forest Park (n=771) resulting from a power regression analysis ( $Y = 1.949 * (X^{0.648})$ ;  $p < 0.0001$ ).



**Figure 2.8** Frequency distribution of stem diameters of three ecologically dominant families of the 0.5 ha plot in Forest Park ranked by family importance values (FIV); (a) Fagaceae, FIV=102.89, (b) Betulaceae, FIV=54.27 and (c) Cornaceae, FIV=36.02.

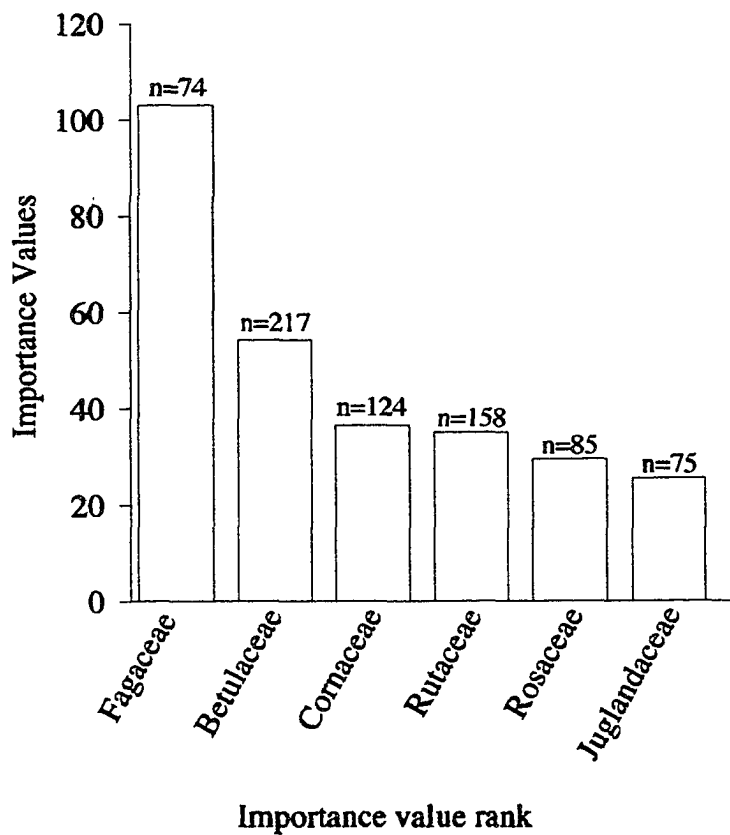


Figure 2.9 Top six ecologically dominant tree families of the 0.5 ha plot in Forest Park ranked by importance values and noting tree abundance within each family.

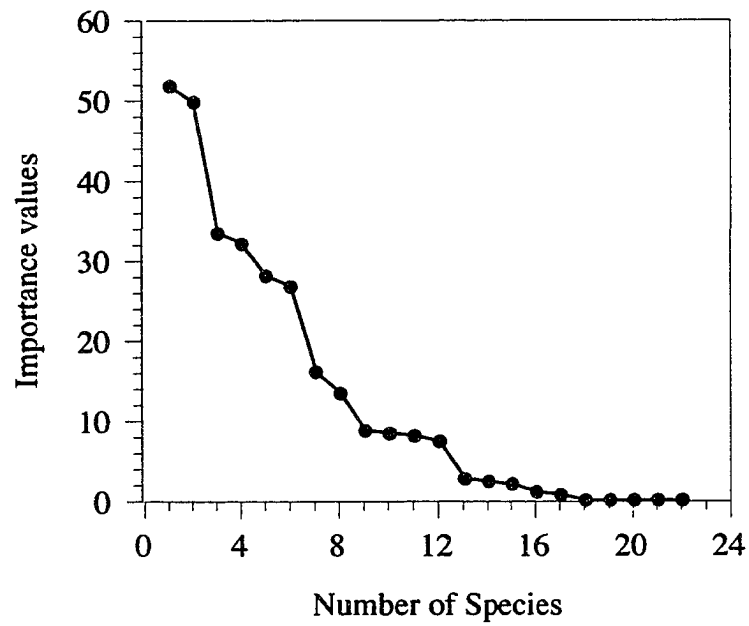


Figure 2.10 Dominance-hierarchy curve as represented by the 22 taxa in the 0.5 ha plot in Forest Park by species importance values.

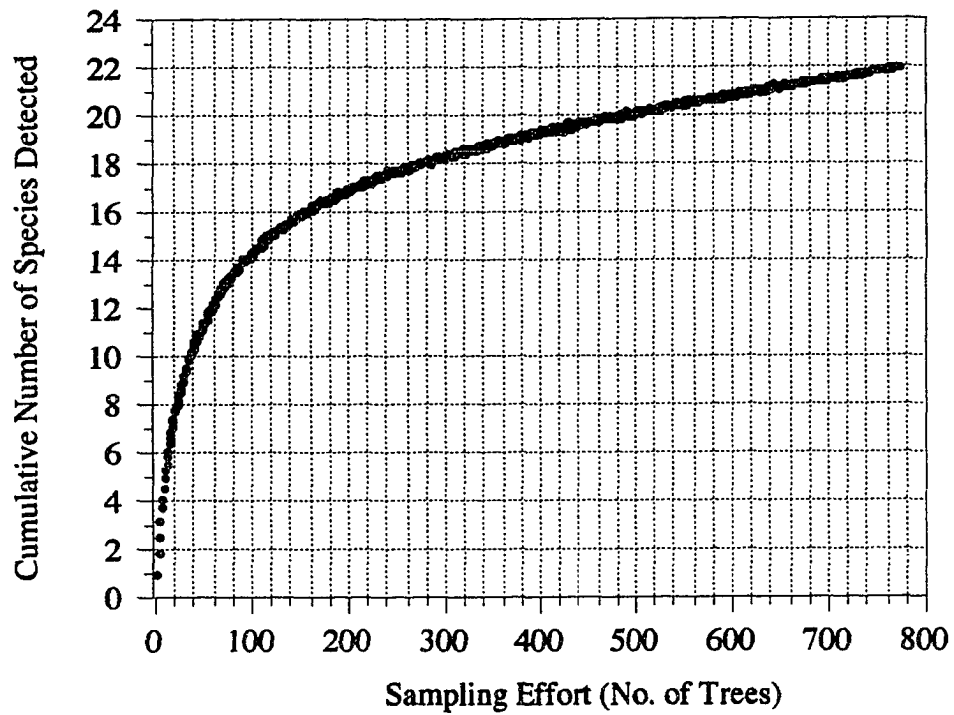


Figure 2.11 Collectors-Effort Curve for the 0.5 ha plot in Forest Park (n=771) resulting in a cumulative 22 woody species. NS=500 randomizations per number of trees (2 to 770).

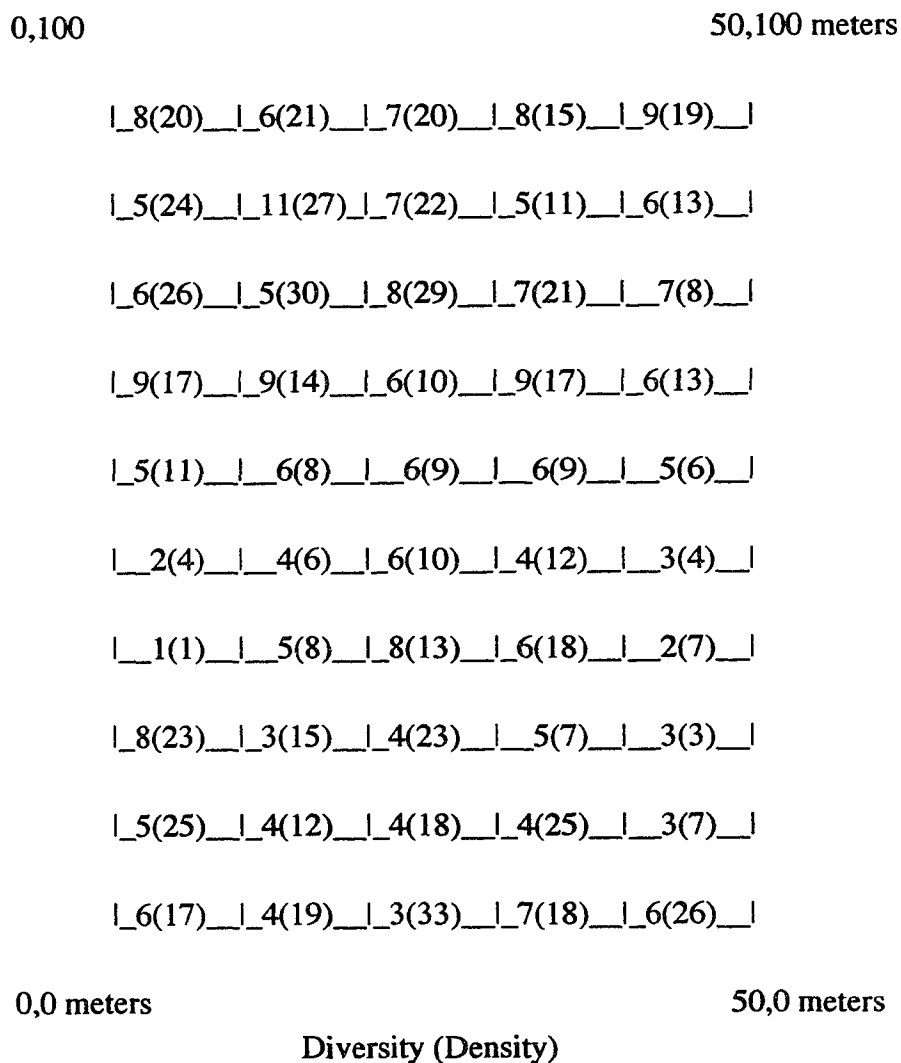


Figure 2.12 Statistical map of the arborescent census in Forest Park. Values for trees and shrubs per quadrat across the entire 50 x 100m plot represent diversity (richness) followed by density (in parentheses) for each of the 50, 10 x 10 m quadrats.

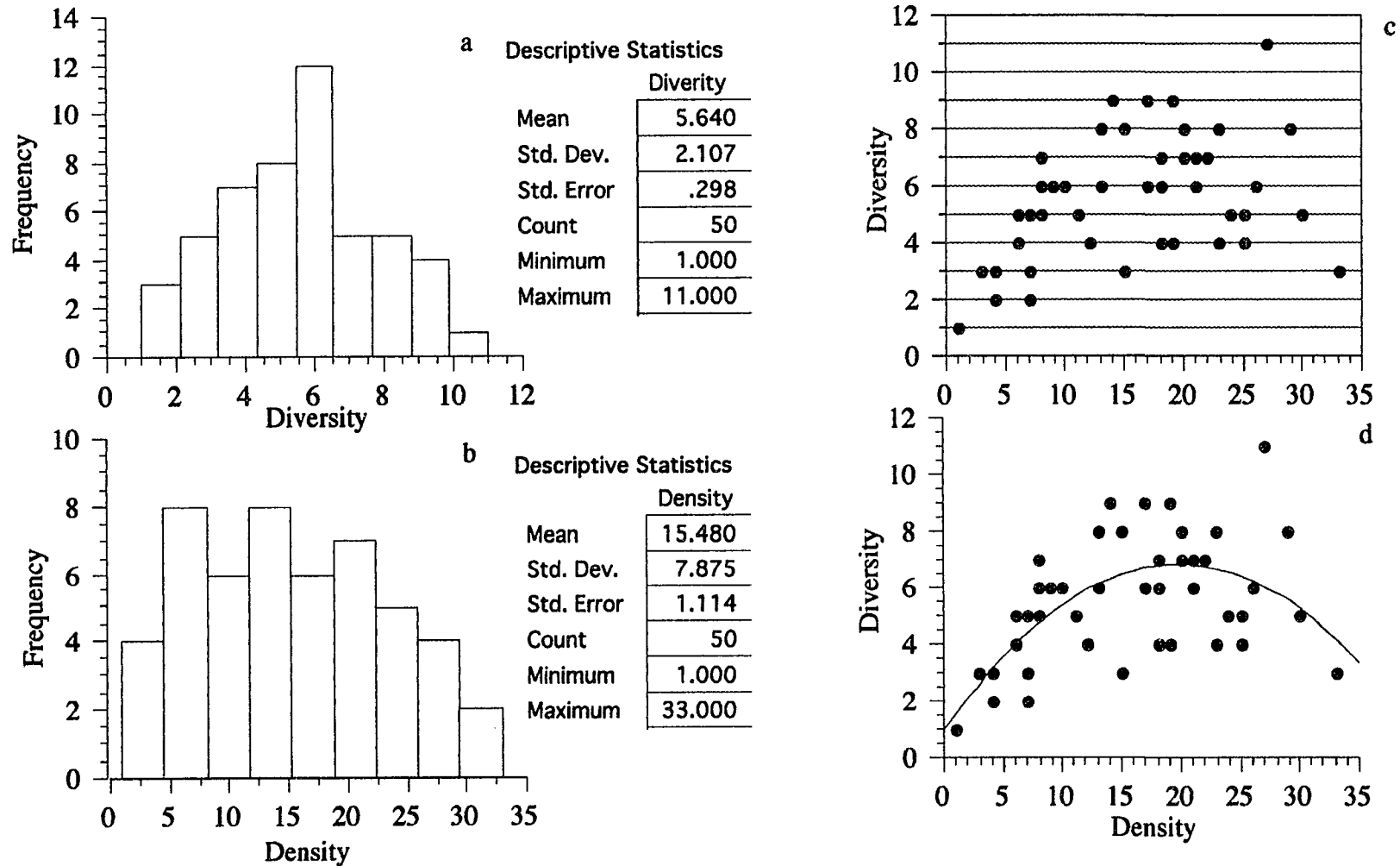


Figure 2.13 (a-d). Descriptive statistics of the diversity-density map of Figure 2.12; (a) Frequency distribution of species diversity (richness), (b) frequency distribution of density, (c) scattergram of density versus diversity and (d) regression analysis of density versus diversity ( $Y = 0.98 + 0.591 * X - 0.0158 * X^2$ ;  $r^2 = 0.362$ ,  $p < 0.0001$ ).

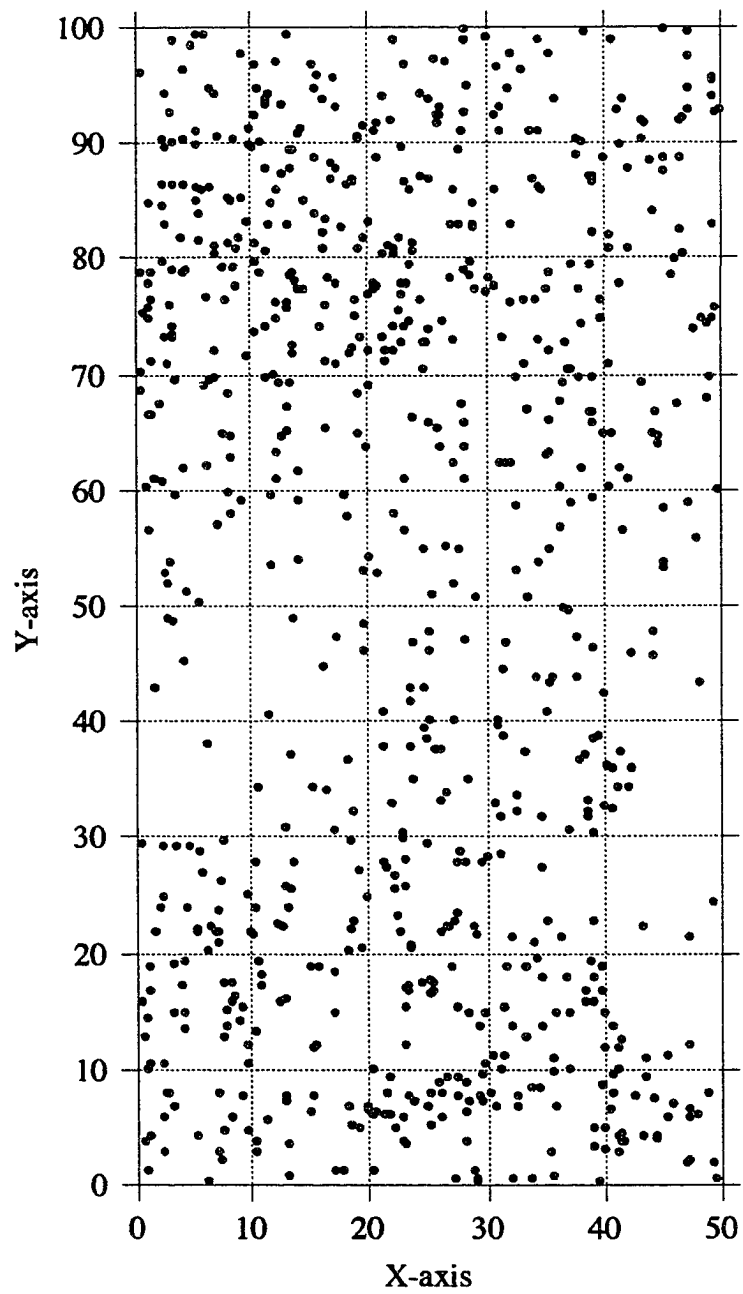


Figure 2.14. Dotmap of all trees and shrubs within the 0.5 ha plot of Forest Park (n=771).

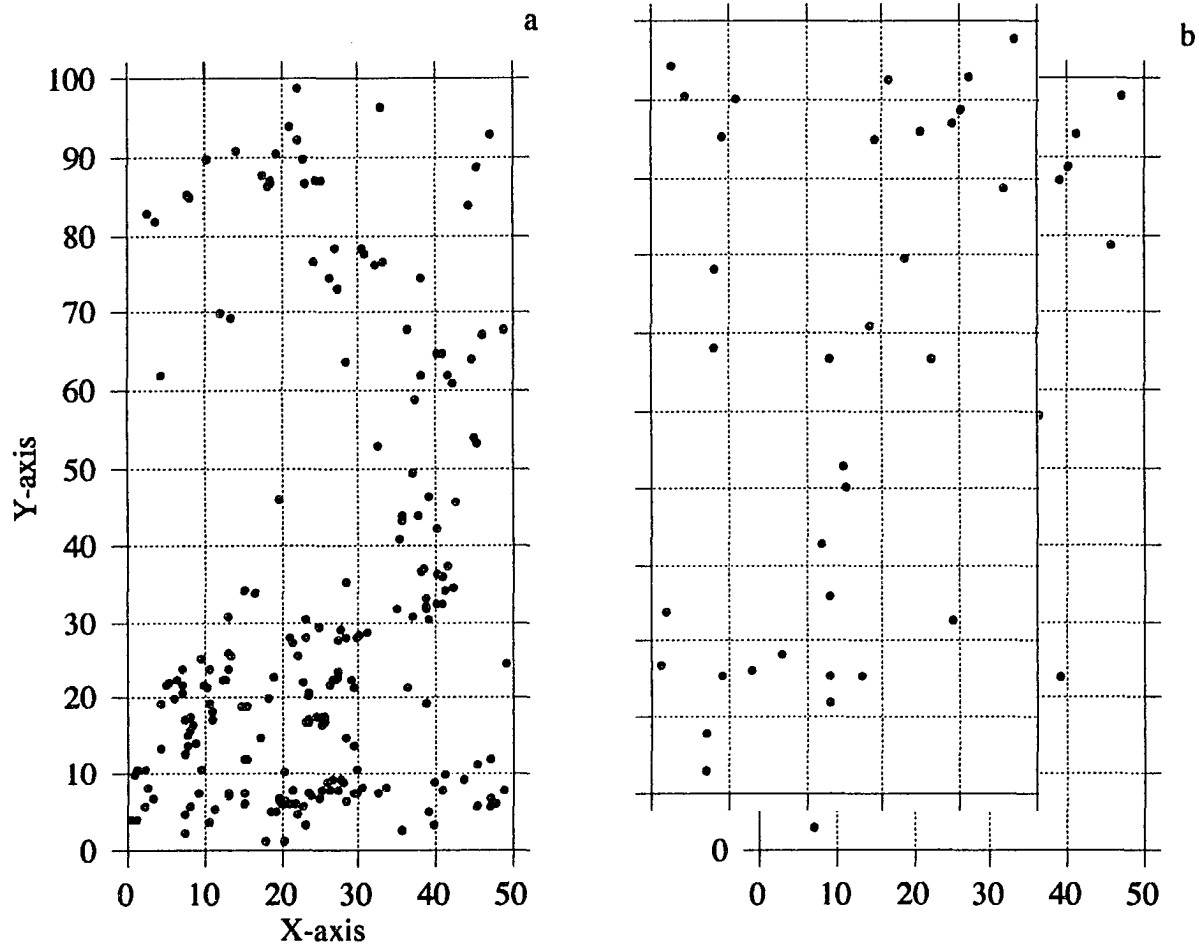


Figure 2.14 (a-r). Dotmaps from tree stem coordinates (x,y) displaying the spatial distribution of the all 22 taxa within the 0.5 ha plot of Forest Park. Maps are in decreasing order by importance values. The two top taxa are (a) *Betula lenta* (n=217) and (b) *Quercus rubra* (n=33).

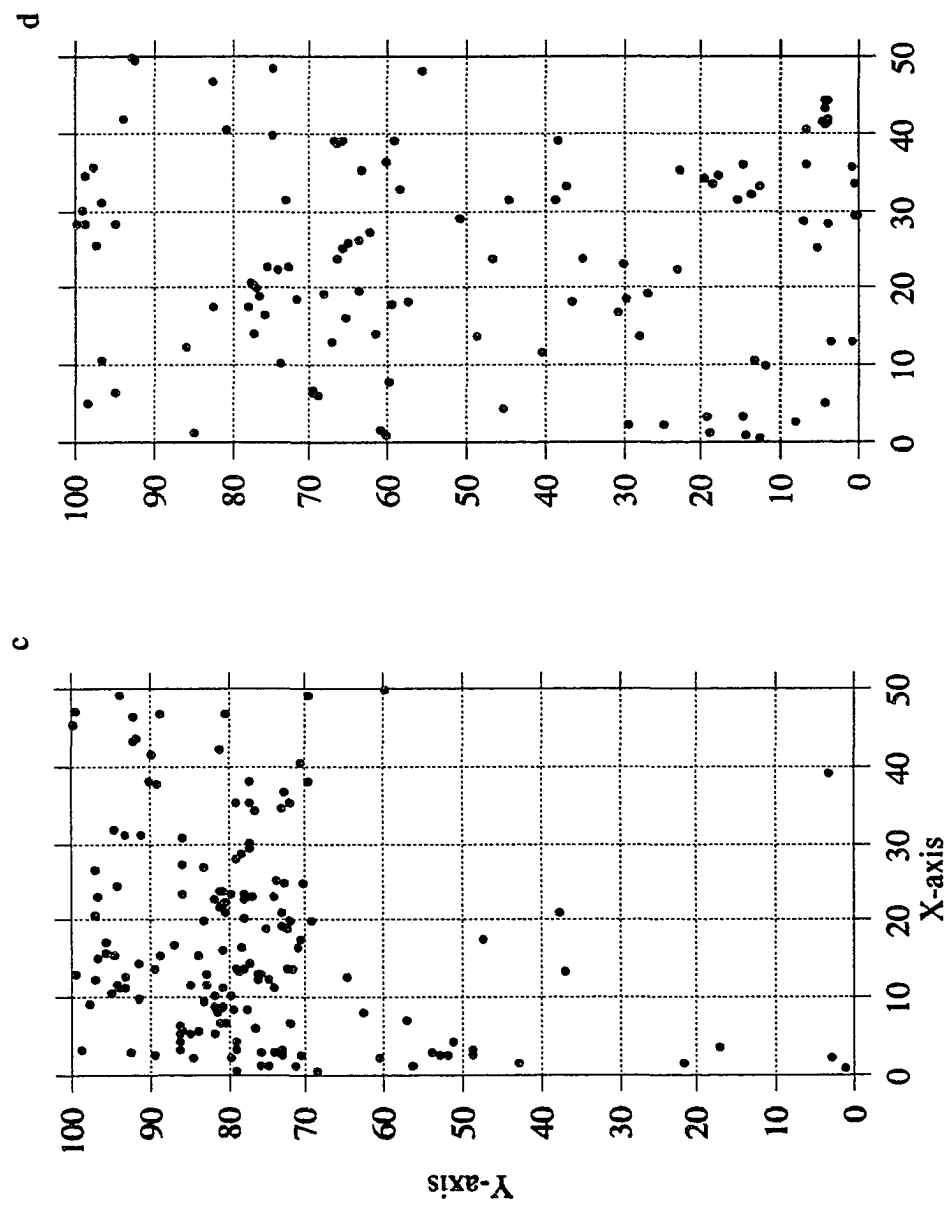
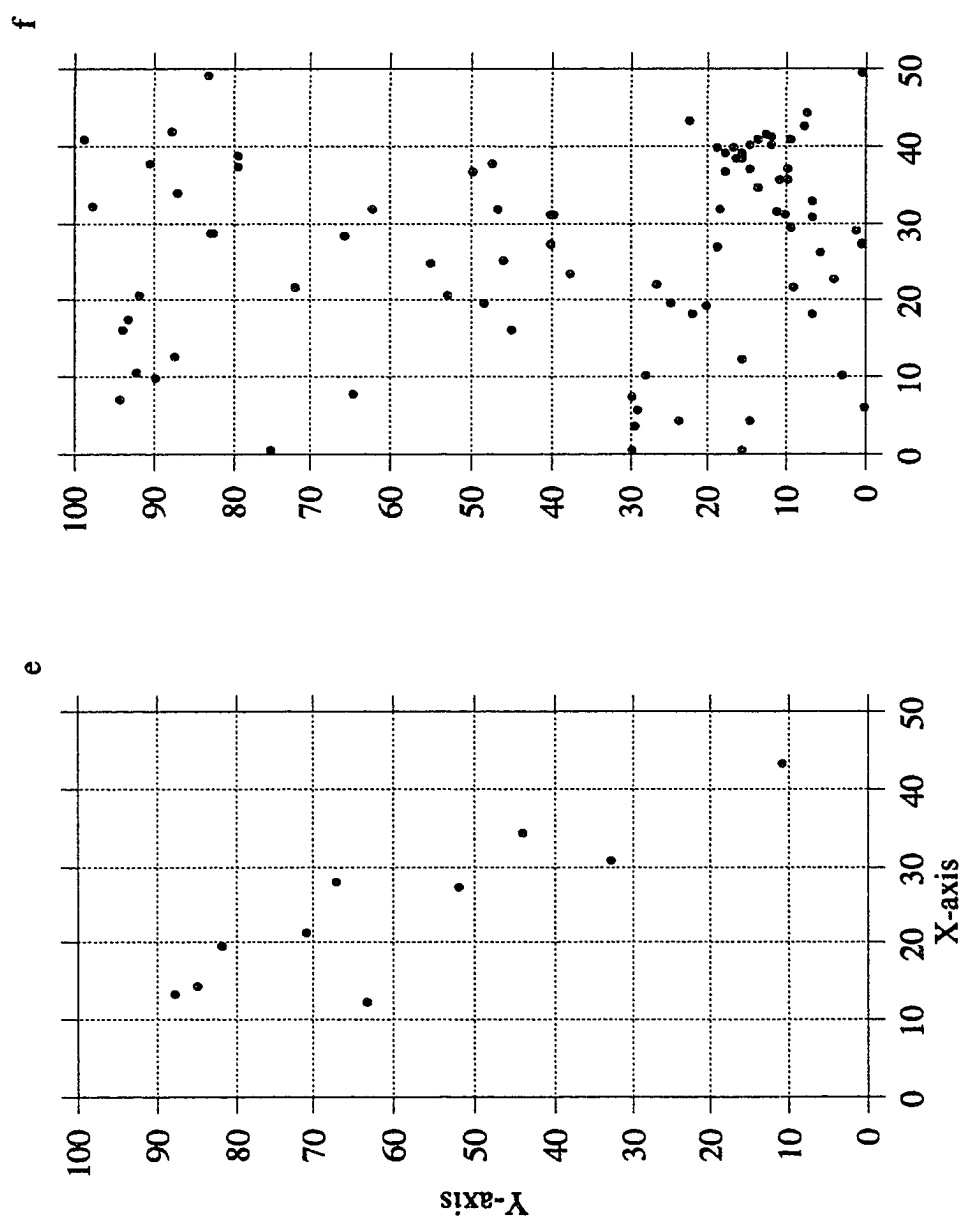


Figure 2.14 (c-d). Dotmaps: (c) *Phellodendron amurense* (n=158) and (d) *Cornus florida* (n=115).



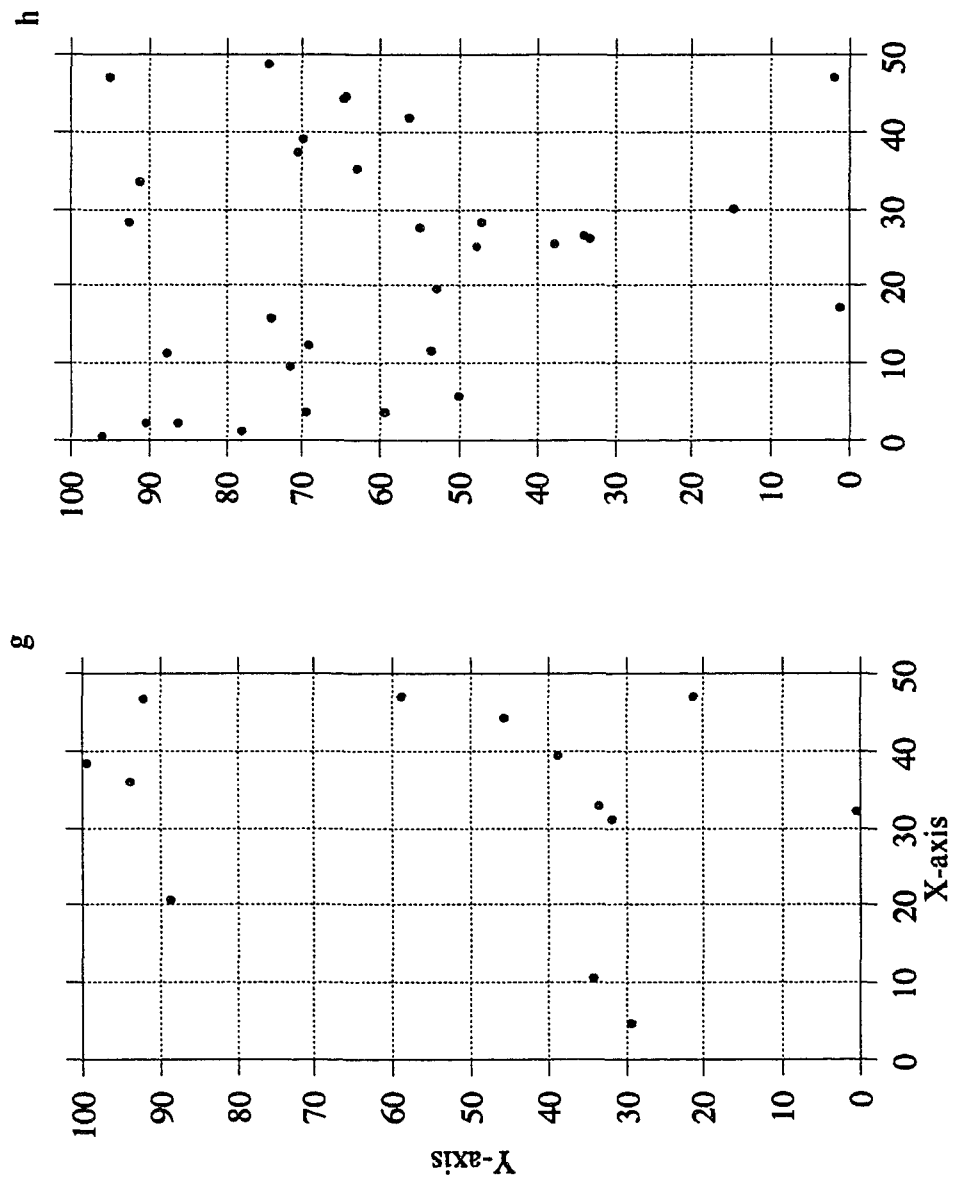


Figure 2.14 (g-h). Dotmaps: (g) *Quercus alba* (n=13) and (h) *Carya tomentosa* (n=33).

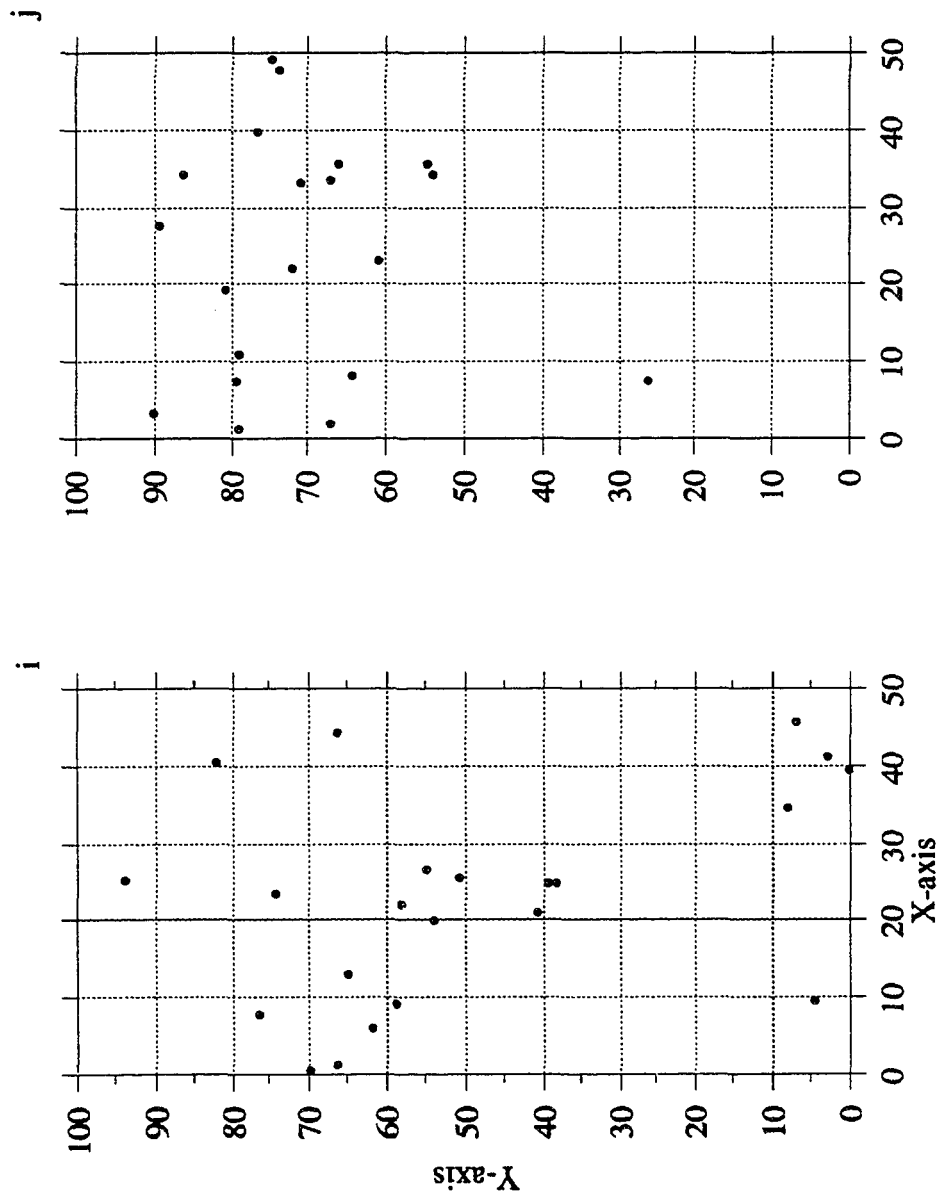


Figure 2.14 (i-j). Dotmaps: (i) *Carya ovata* (n=22) and (j) *Carya glabra* (n=20).

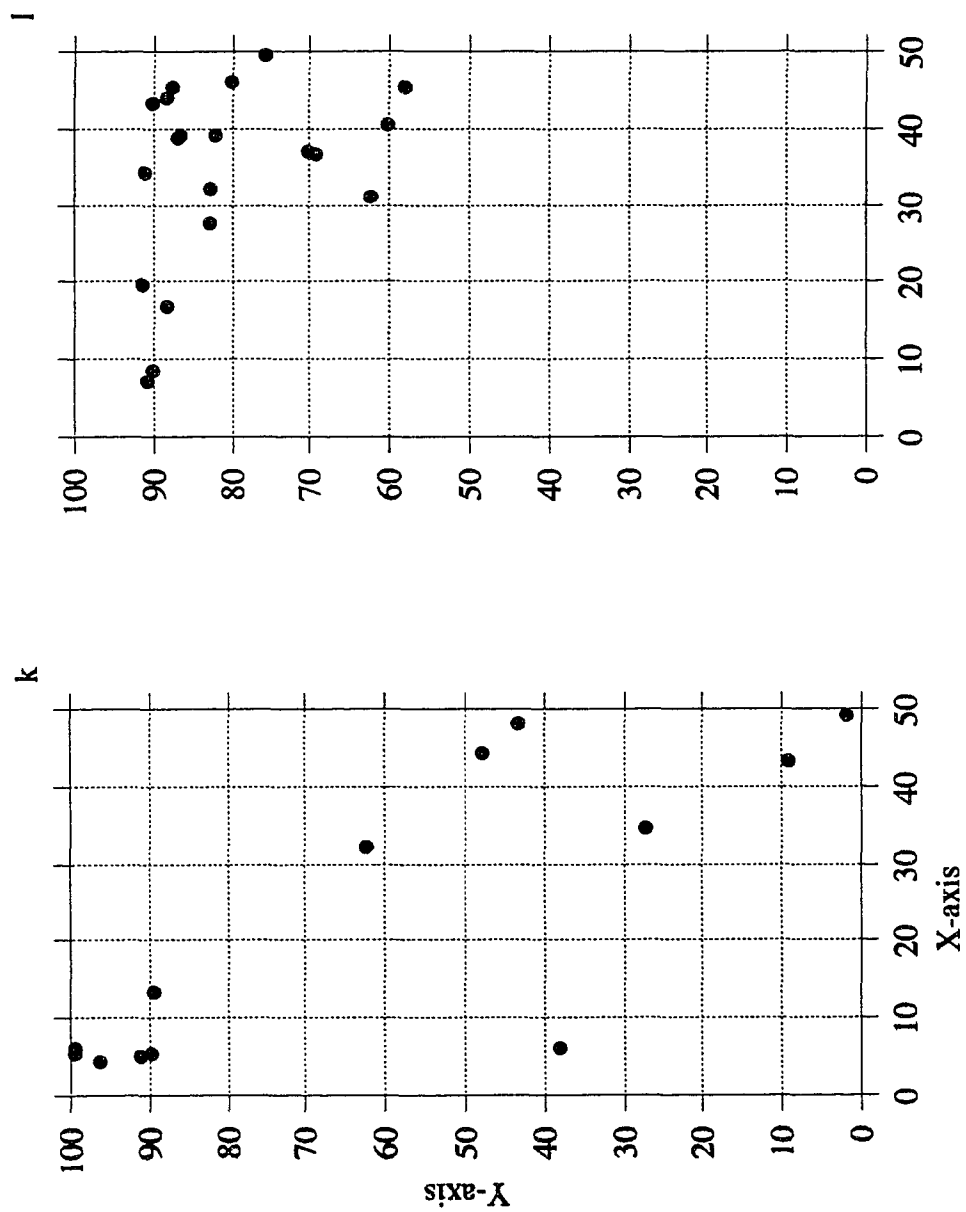


Figure 2.14 (k-l). Dotmaps: (k) *Fagus grandifolia* (n=13) and *Sassafras albidum* (n=20).

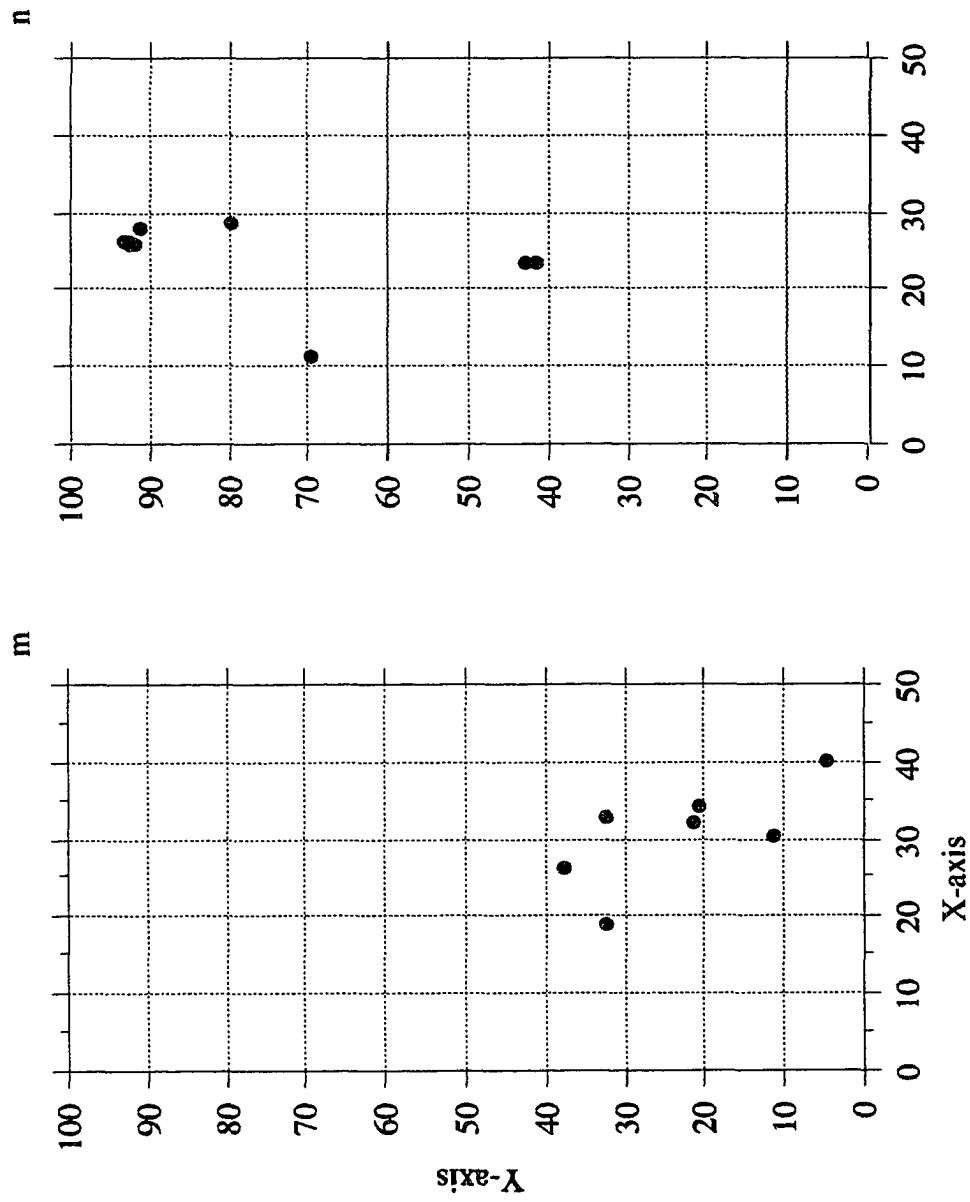


Figure 2.14 (m-n). Dotmaps: (m) *Vaccinium corymbosum* (n=7) and (n) *Cornus alternifolia* (n=9).

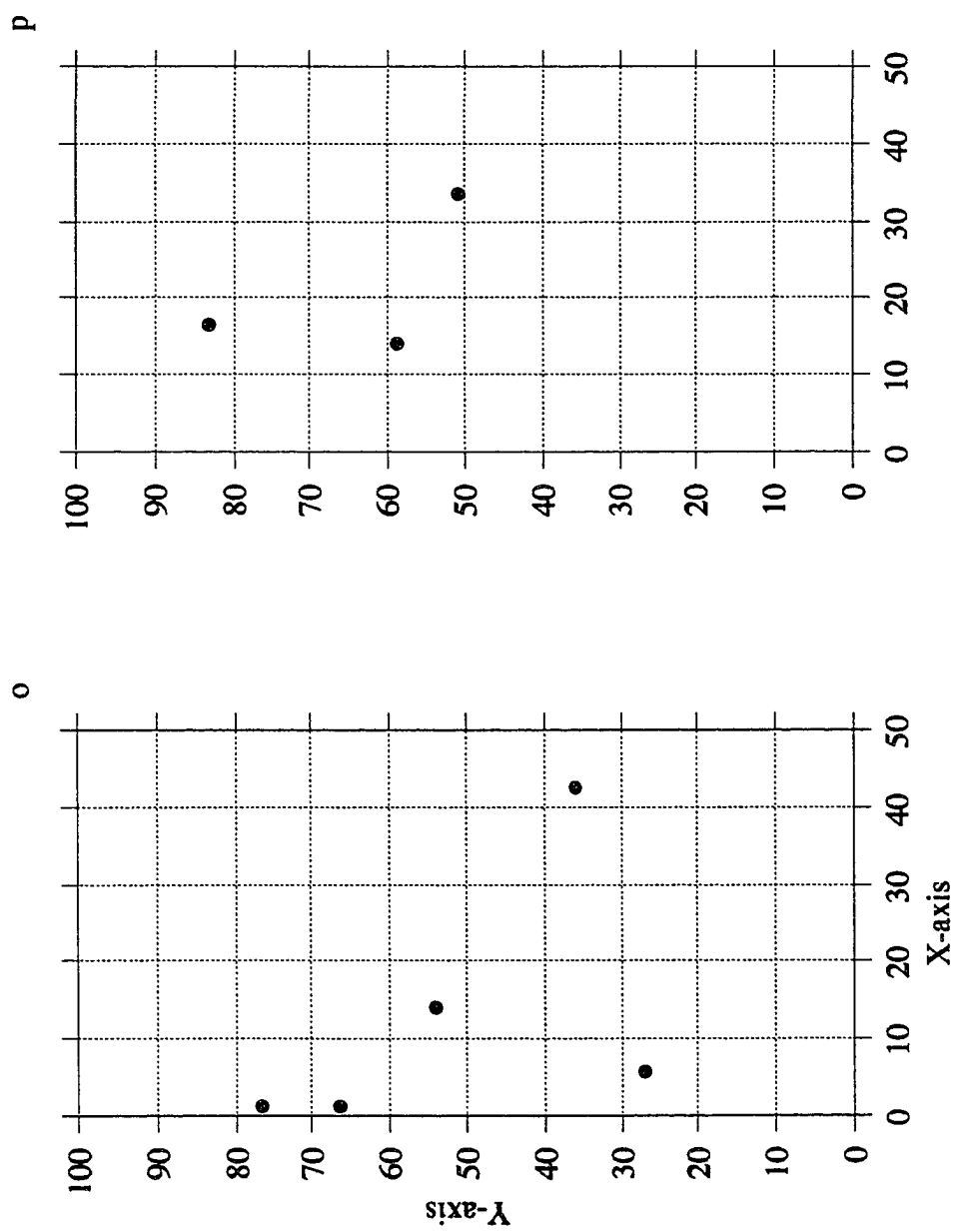


Figure 2.14 (o-p). Dotmaps; (o) *Castanea dentata* (n=5) and *Lindera benzoin* (n=3).

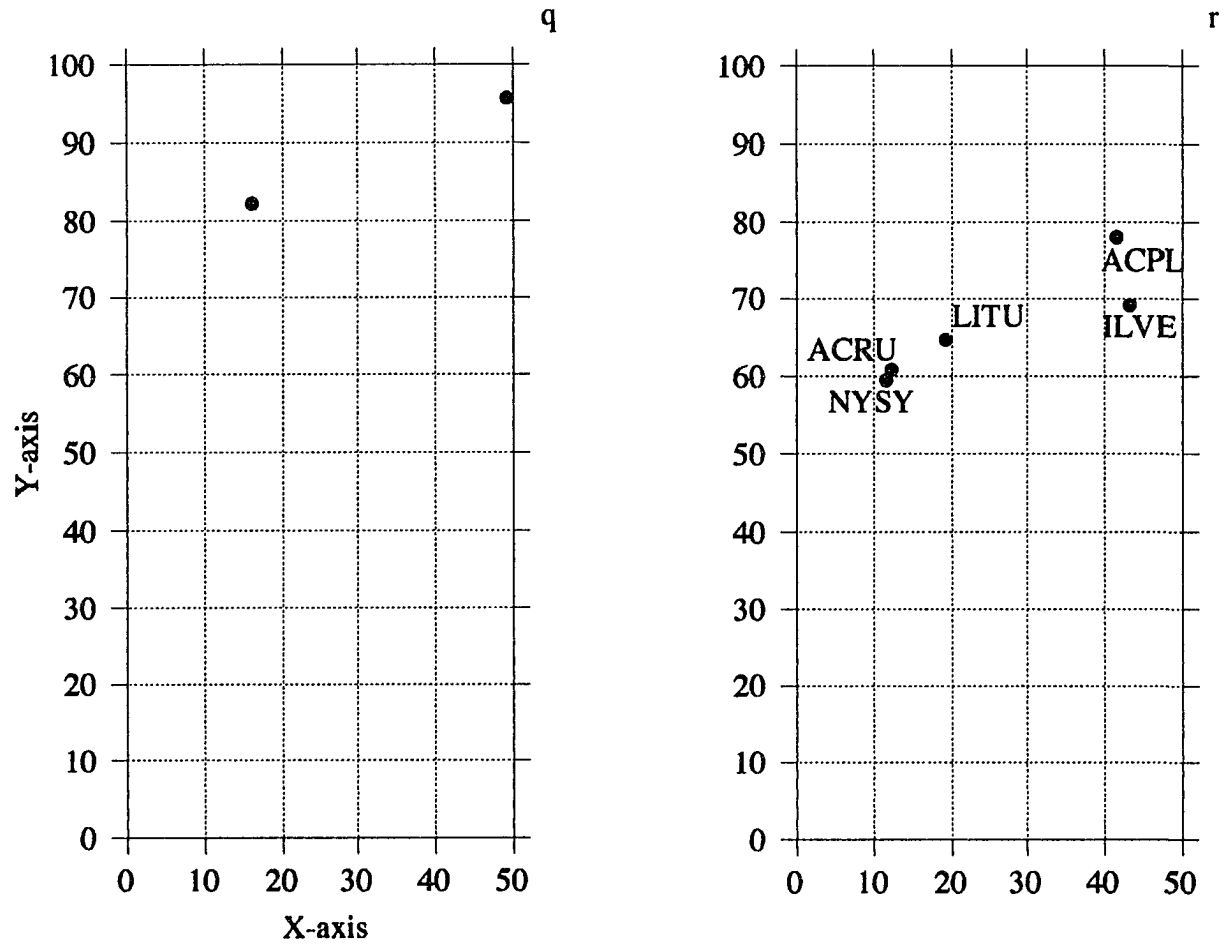
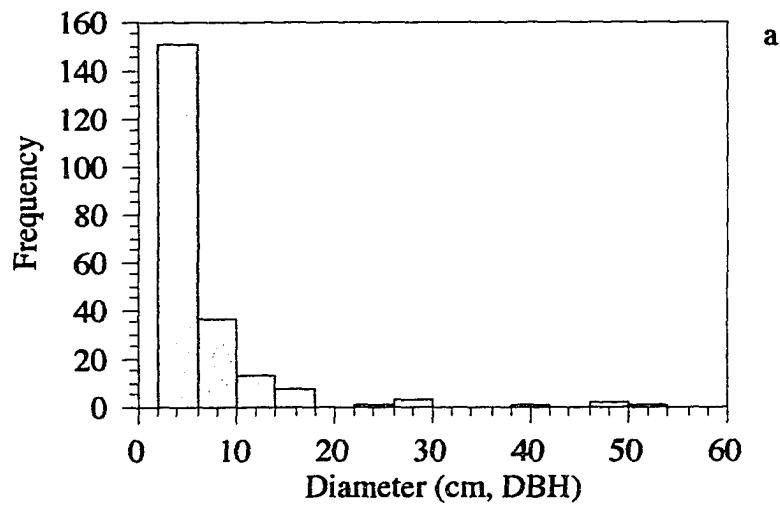


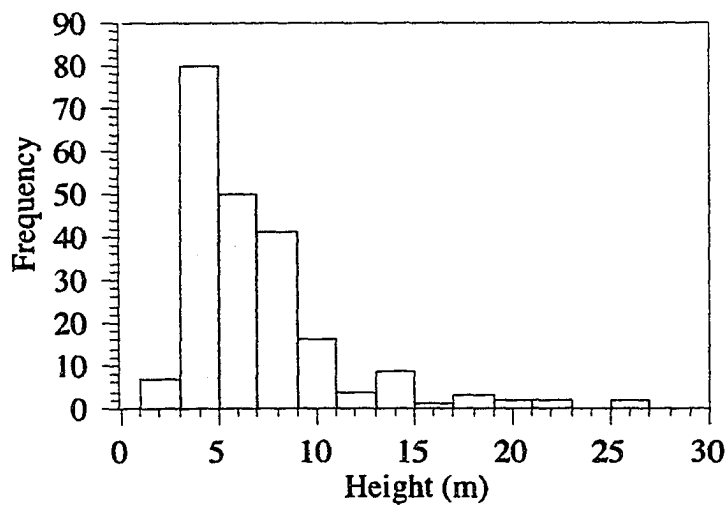
Figure 2.14 (q-r). Dotmaps: (q) *Rhamnus frangula* (n=3) and (r) Five singletons, *Acer rubrum*-ACRU, *Acer platanoides*-ACPL, *Nyssa sylvatica*-NYSY, *Liriodendron tulipifera*-LITU and *Ilex verticillata*-ILEX.



a

## Descriptive Statistics

	DBH (cm)
Mean	6.286
Std. Dev.	6.927
Std. Error	.470
Count	217
Minimum	2.000
Maximum	52.000



b

## Descriptive Statistics

	Height (m)
Mean	6.982
Std. Dev.	4.065
Std. Error	.276
Count	217
Minimum	2.950
Maximum	26.549

Figure 2.15a Frequency distribution of (a) tree diameter (DBH) and for (b) tree height (m) of *Betula lenta* in the 0.5 ha plot of Forest Park.

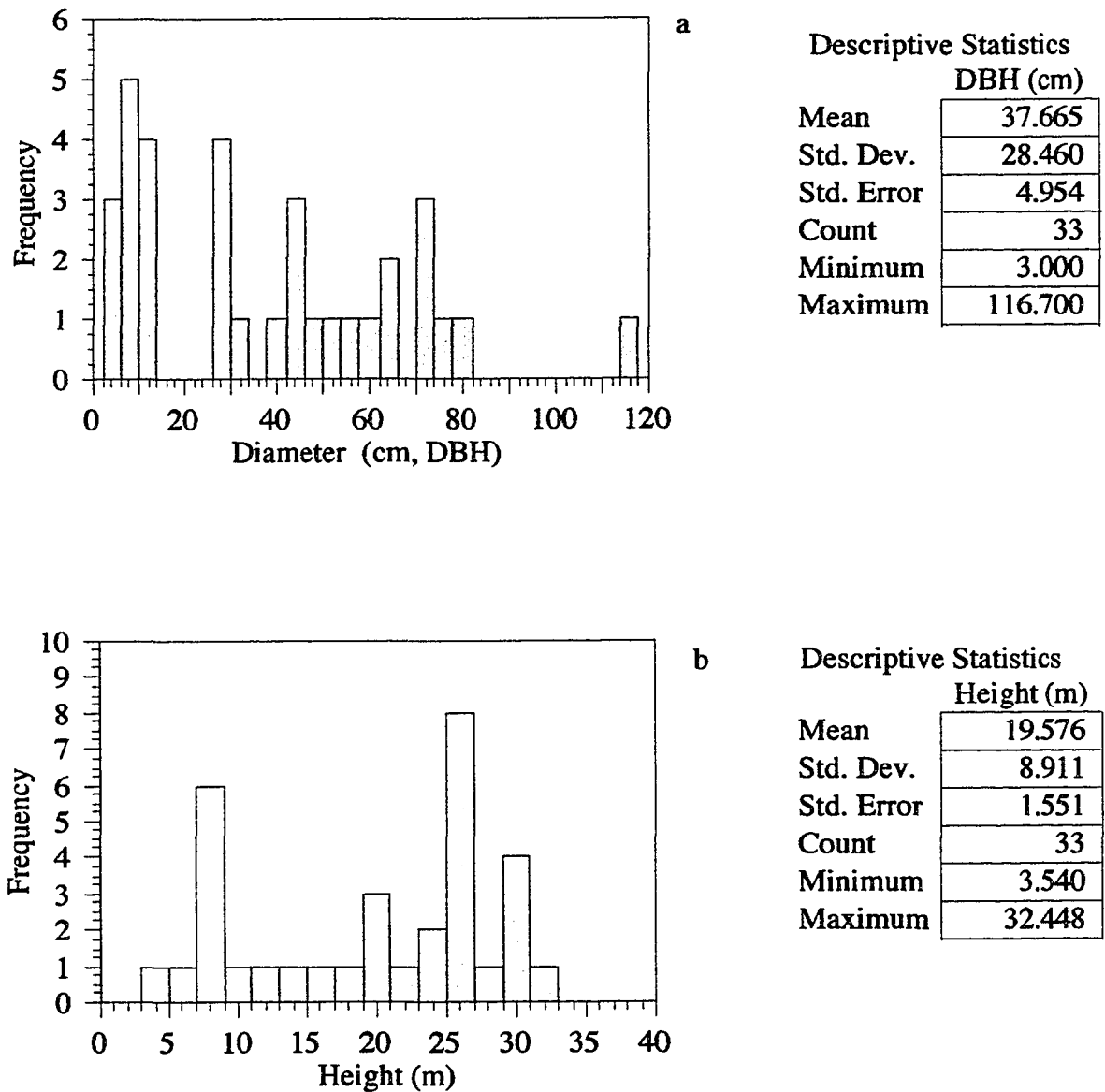


Figure 2.15b. Frequency distribution of (a) tree diameter (DBH) and for (b) tree height (m) of *Quercus rubra* (n=33) within the 0.5 ha plot.

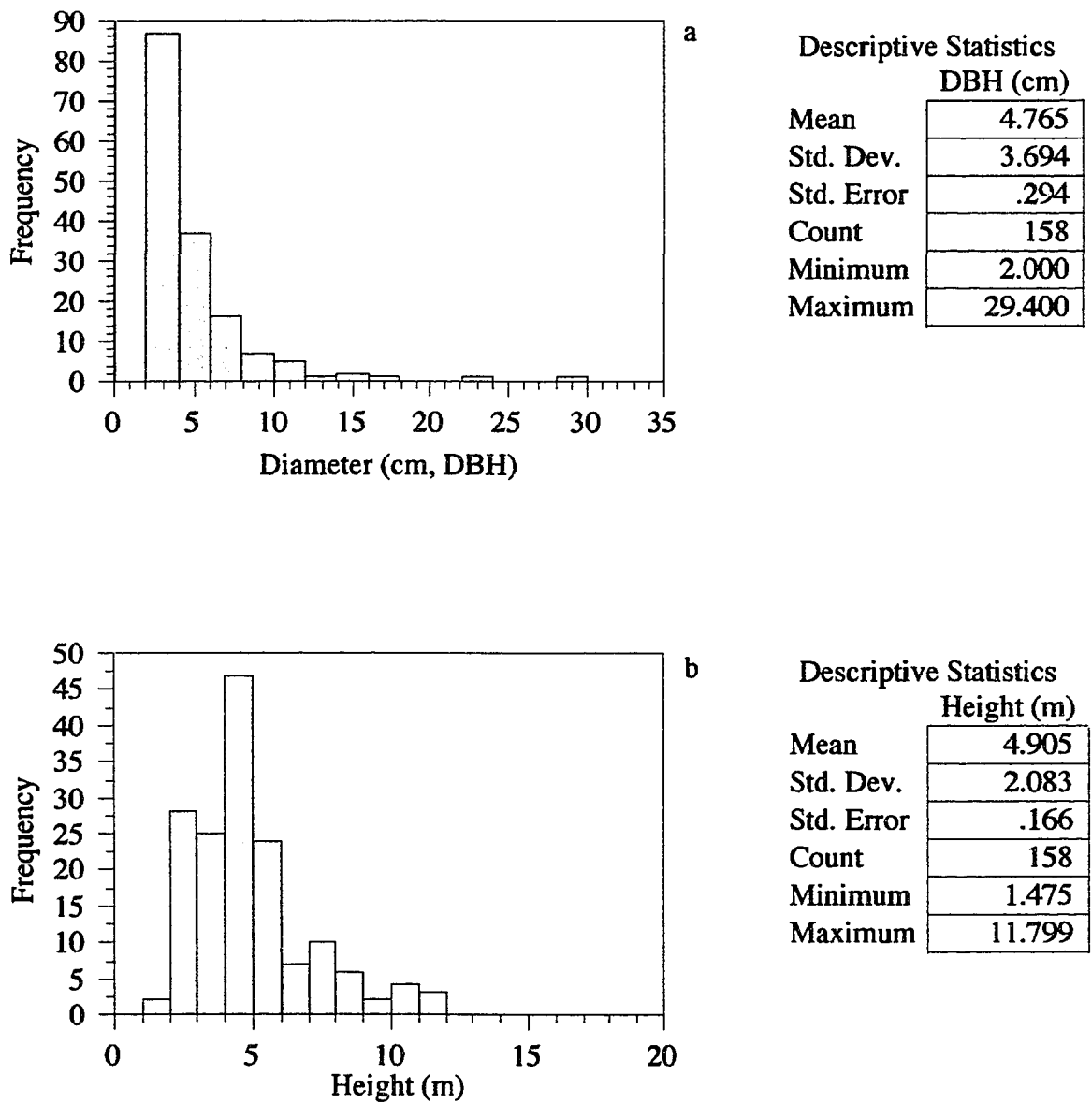
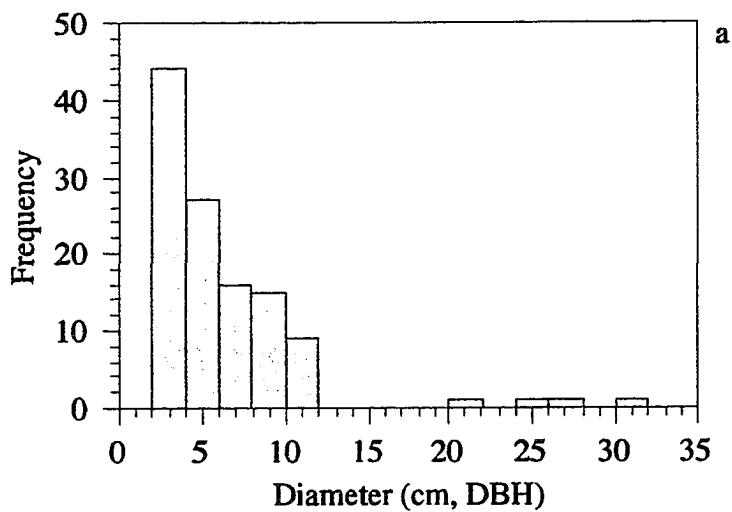
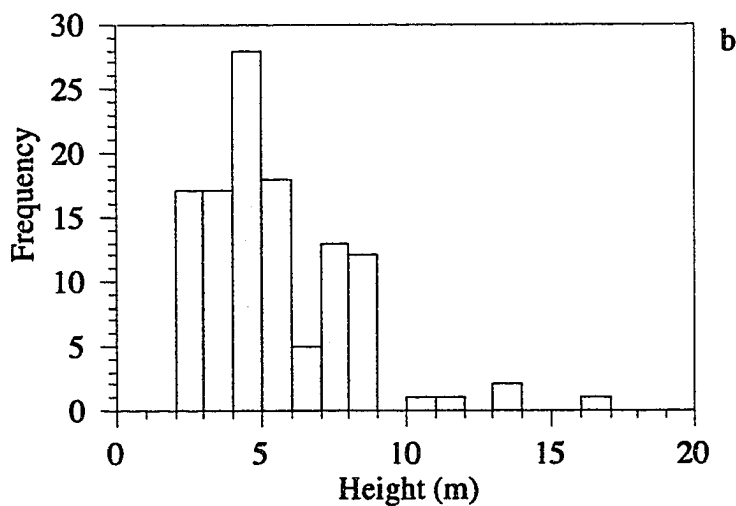


Figure 2.15c Frequency distribution of (a) tree diameter (DBH) and for (b) tree height (m) of *Phellodendron amurense* (n=158) within the 0.5 ha plot.



Descriptive Statistics	
DBH (cm)	
Mean	5.979
Std. Dev.	4.639
Std. Error	.433
Count	115
Minimum	2.000
Maximum	30.200



Descriptive Statistics	
Height (m)	
Mean	5.441
Std. Dev.	2.468
Std. Error	.230
Count	115
Minimum	2.360
Maximum	16.224

Figure 2.15d Frequency distribution of (a) tree diameter (DBH) and for (b) tree height (m) of *Cornus florida* (n=115) within the 0.5 ha plot.

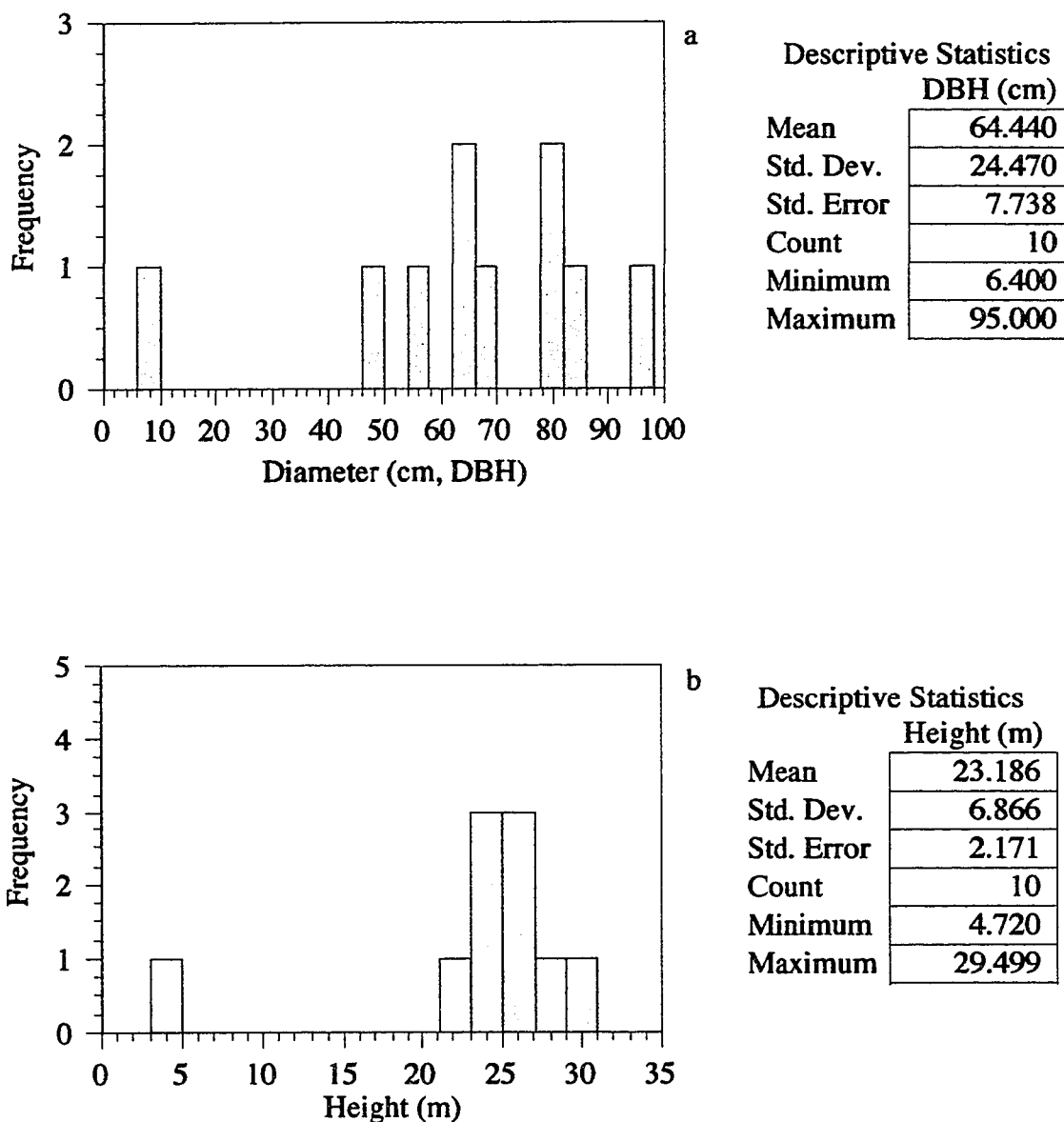


Figure 2.15e Frequency distribution of (a) tree diameter (DBH) and for (b) tree height (m) of *Quercus velutina* (n=10) within the 0.5 ha plot.

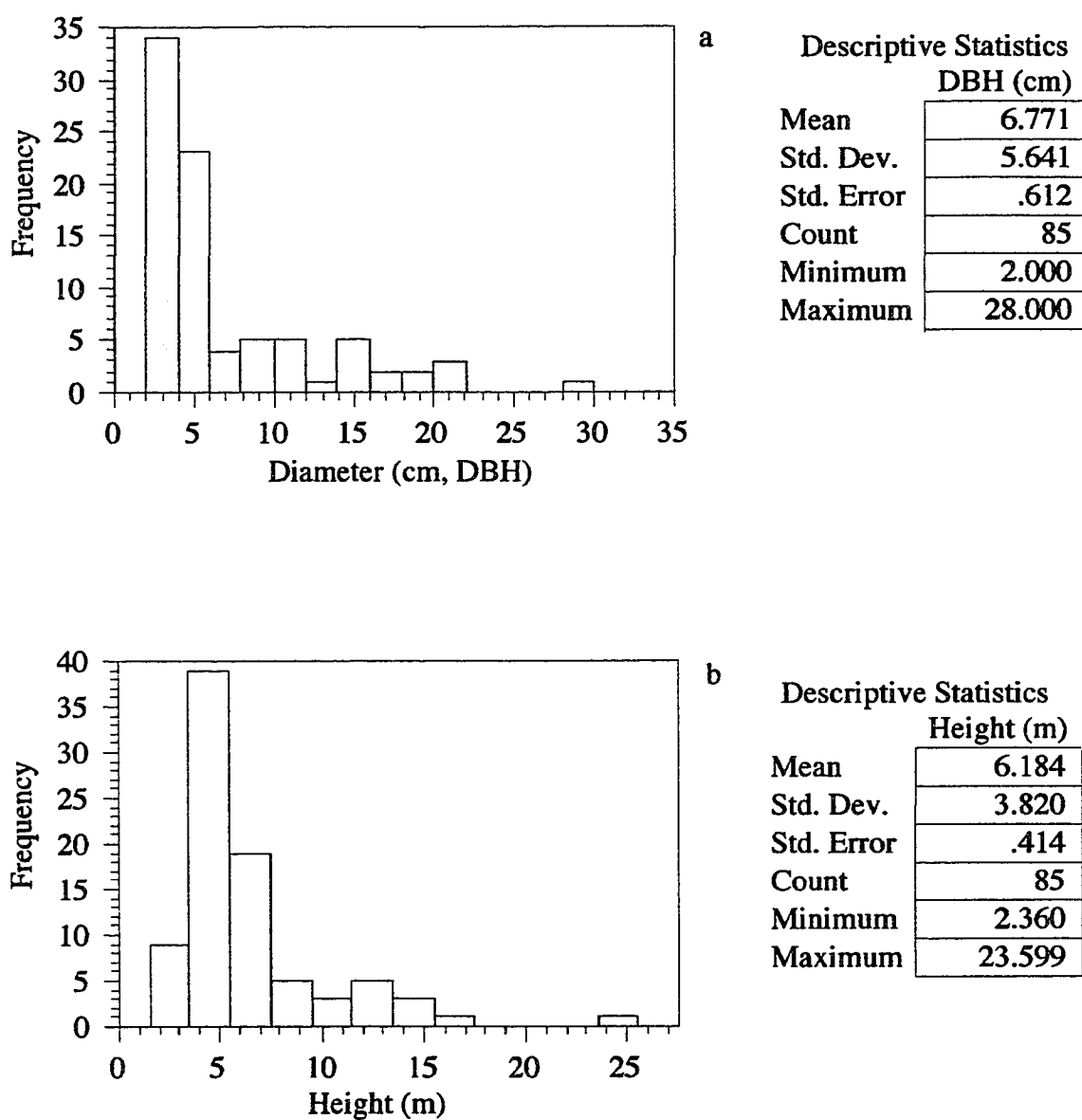
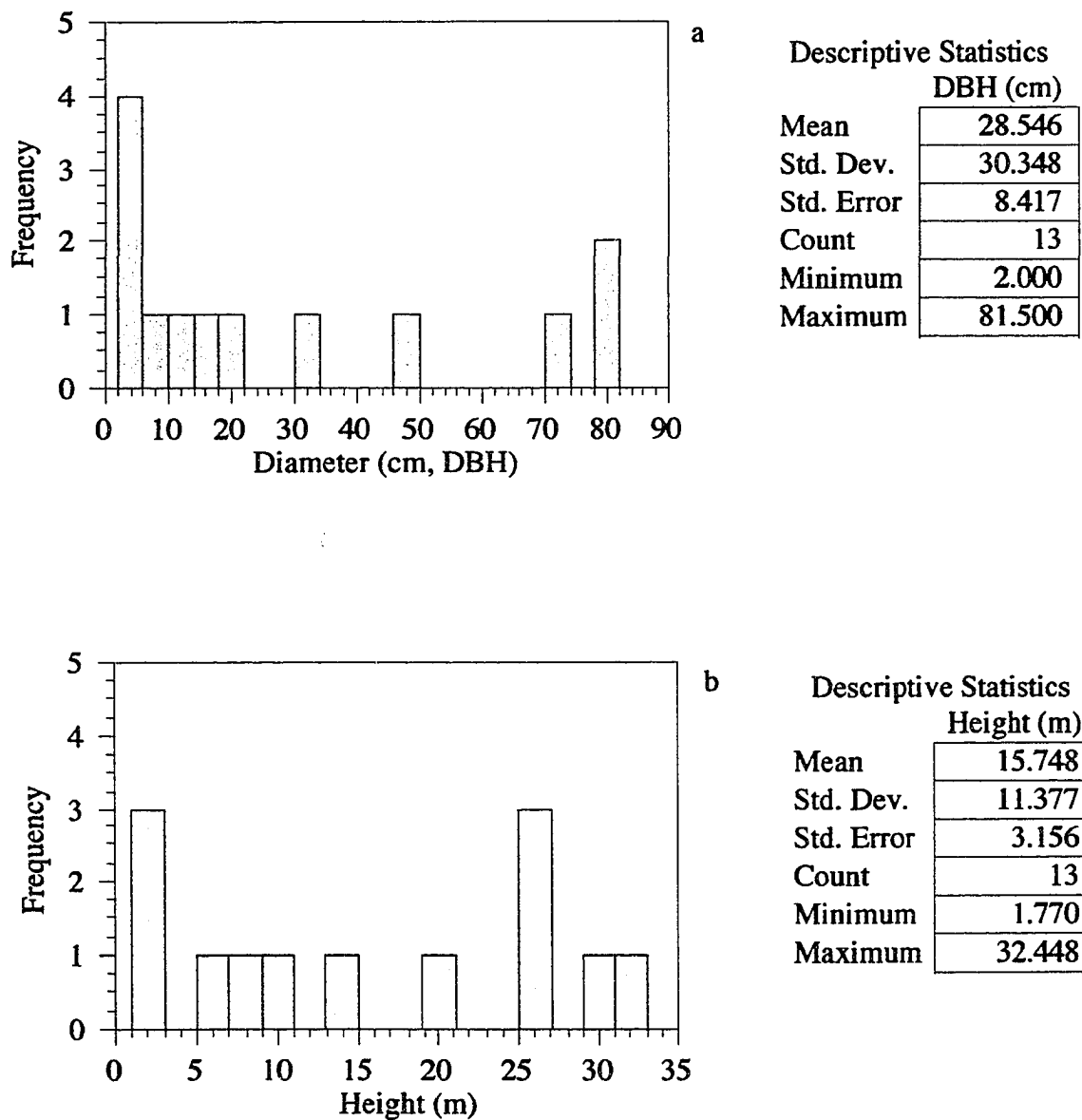


Figure 2.15f Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Prunus serotina* (n= 85) within the 0.5 ha plot.



**Figure 2.15g** Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Quercus alba* (n= 13) within the 0.5 ha plot.

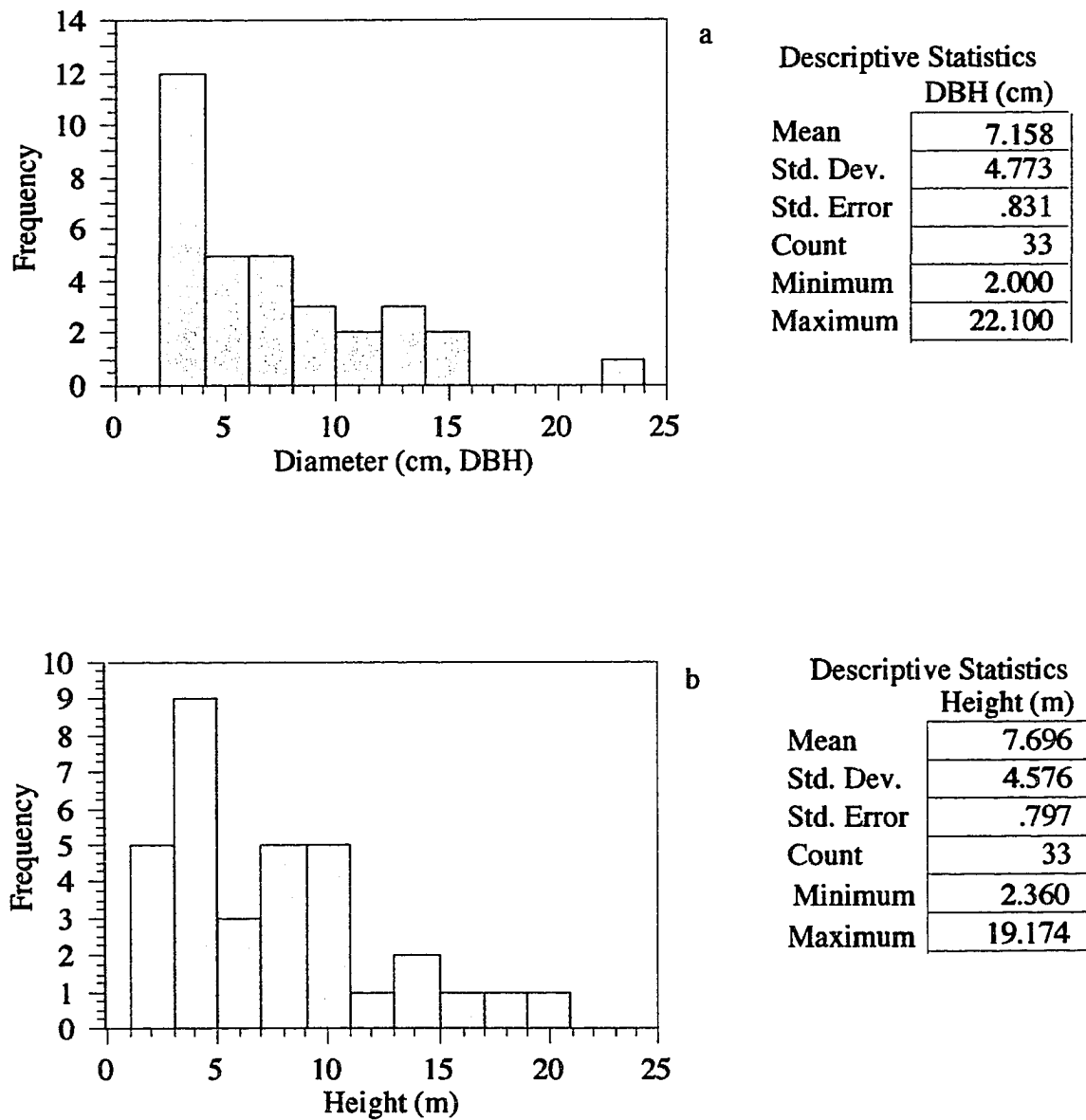


Figure 2.15h Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Carya tomentosa* (n=33) within the 0.5 ha plot.

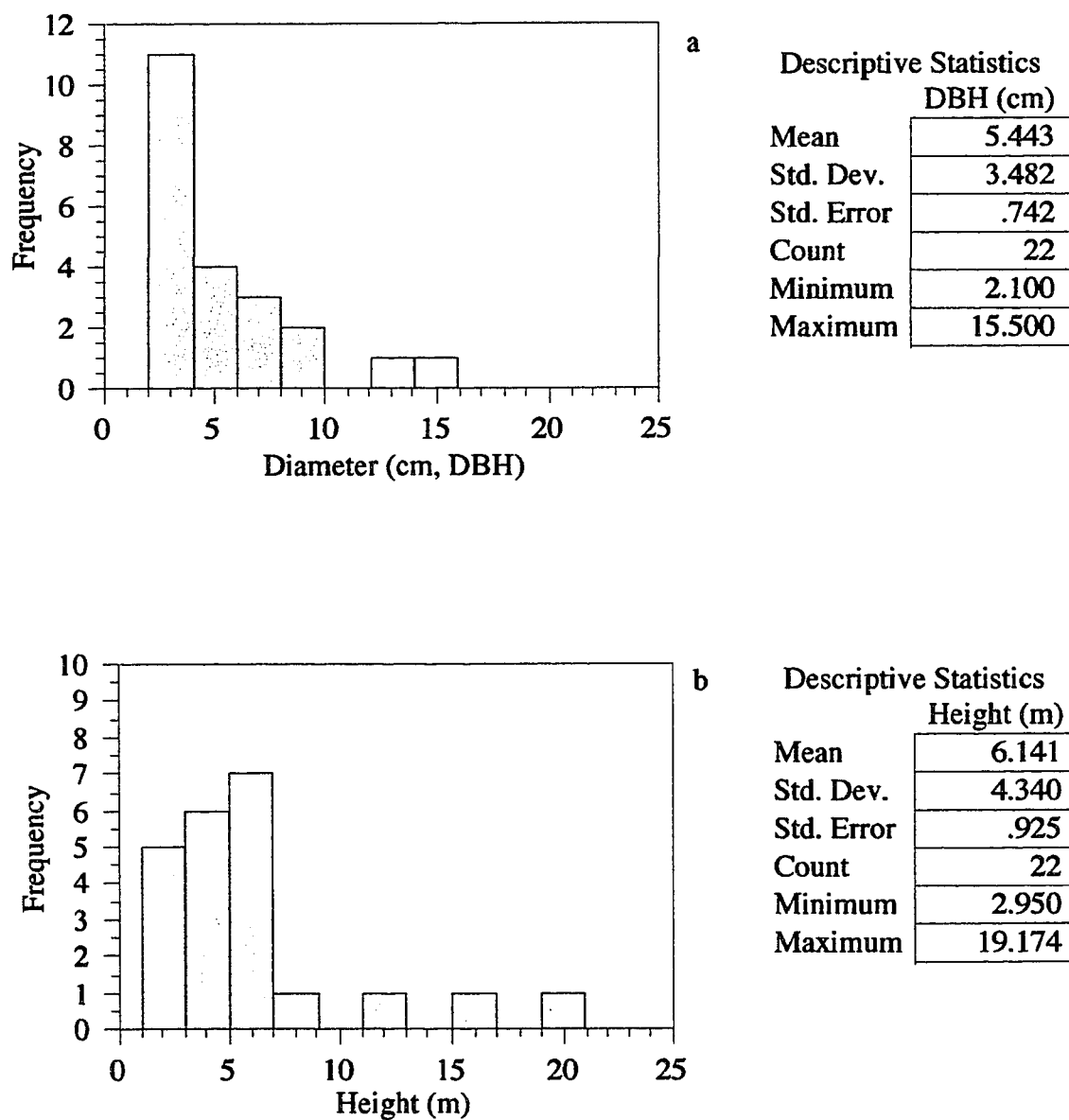
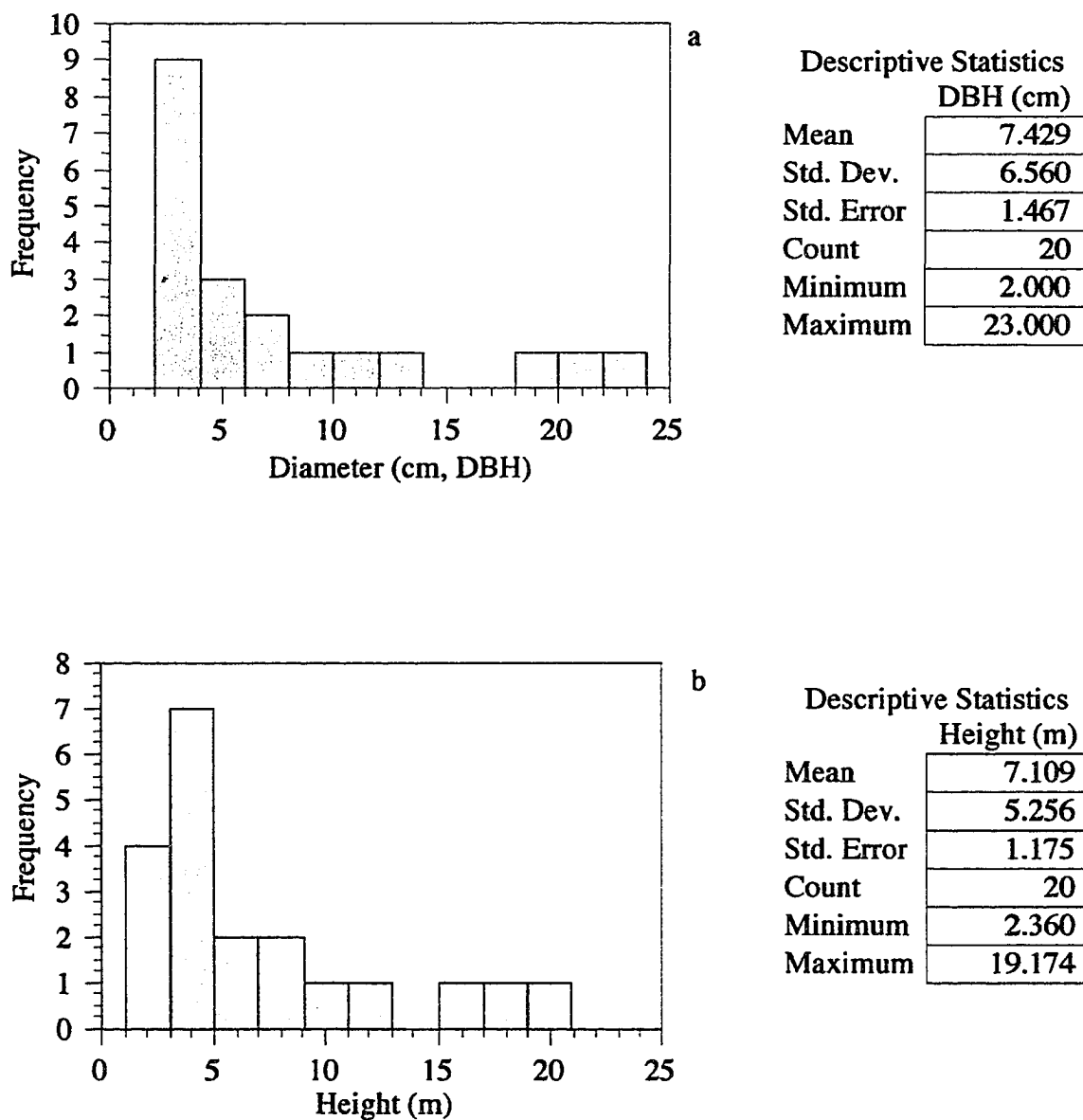
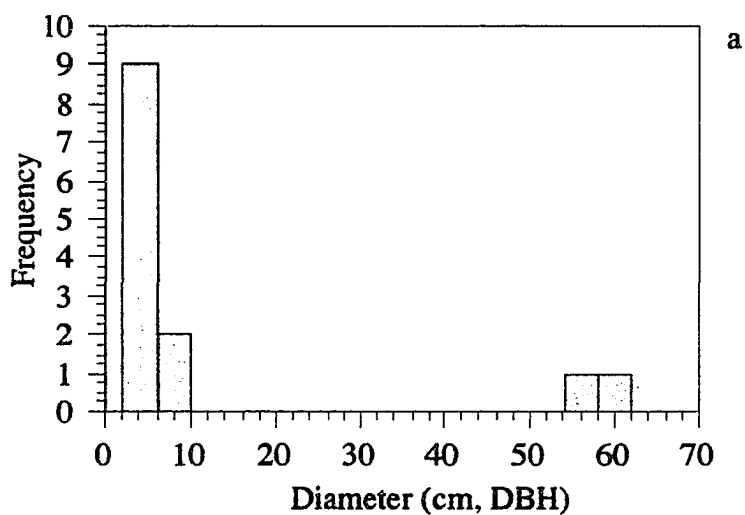


Figure 2.15i Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Carya ovata* (n=22) within the 0.5 ha plot.

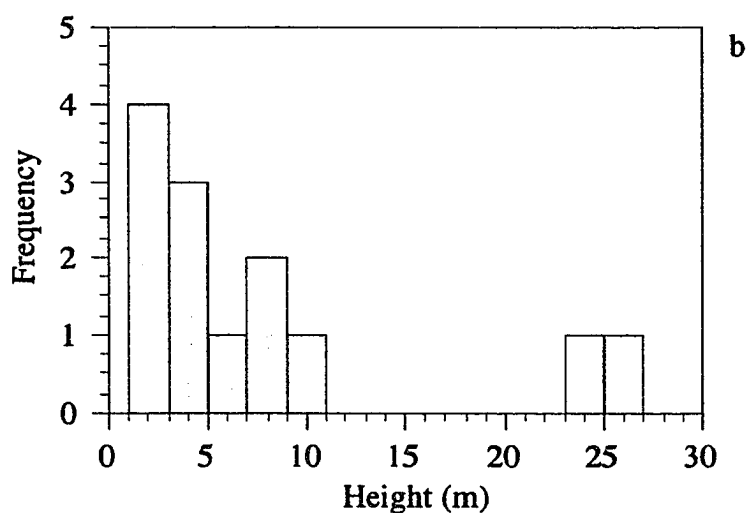


**Figure 2.15j** Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Carya glabra* (n=20) within the 0.5 ha plot.



Descriptive Statistics

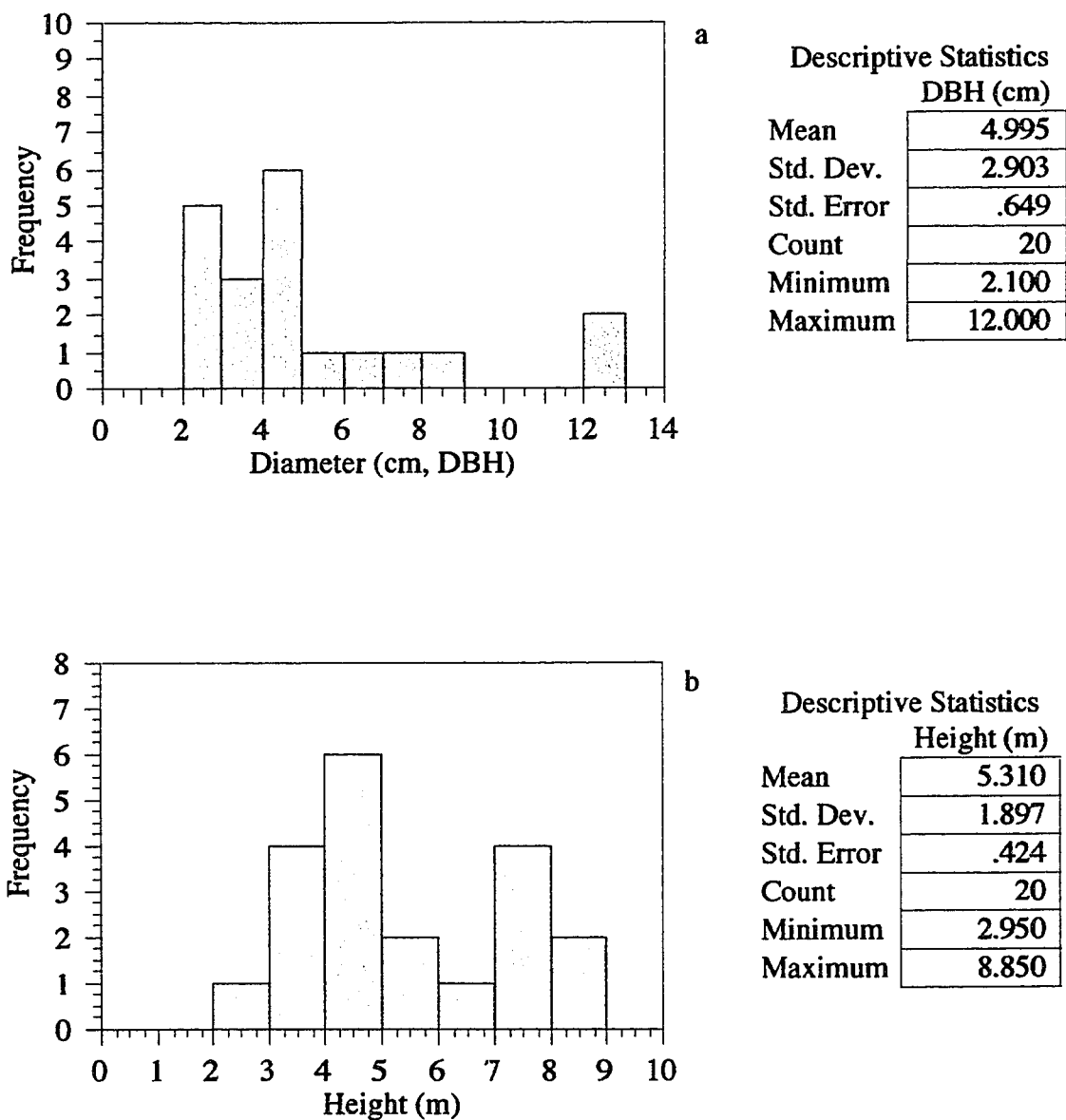
DBH (cm)	
Mean	13.088
Std. Dev.	20.242
Std. Error	5.614
Count	13
Minimum	2.800
Maximum	60.500



Descriptive Statistics

Height (m)	
Mean	8.246
Std. Dev.	7.894
Std. Error	2.190
Count	13
Minimum	2.360
Maximum	26.549

Figure 2.15k Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Fagus grandifolia* (n=13) within the 0.5 ha plot.



**Figure 2.151** Frequency distribution of (a) tree diameters (DBH) and (b) tree heights (m) for *Sassafras albidum* (n=20) within the 0.5 ha plot.

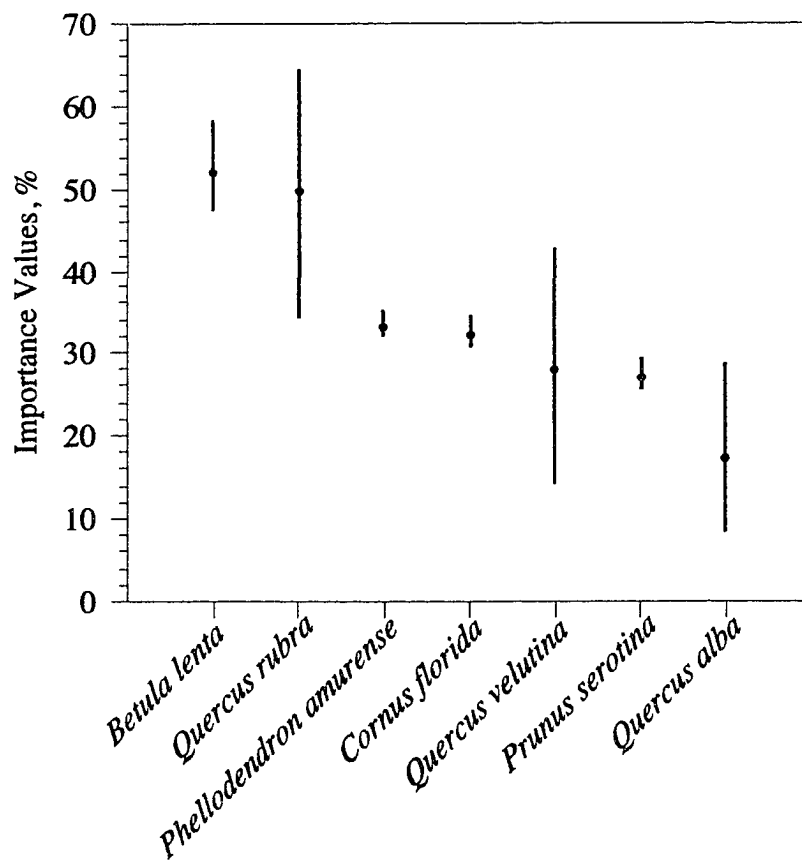


Figure 2.16 Importance values of seven ecologically dominant taxa with 95% bootstrap confidence intervals. The upper and lower limits of the error bars indicate  $L_1$  and  $L_2$  of the confidence interval. Bootstrap samples with replacement occurred for 771 trees (NS=10,000).

Table 2.1 Woody taxa within the 0.5 ha plot in Forest Park listed in order of ecological dominance by importance values (n=771).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	IV (cum.)
<i>Betula lenta</i> L.	217	0.28145 (0.281)	0.14184 (0.142)	0.09664 (0.097)	51.9937 ( 51.994)
<i>Quercus rubra</i> L.	33	0.04280 (0.324)	0.08156 (0.223)	0.37114 (0.468)	49.5501 (101.544)
<i>Phellodendron amurense</i> Rupr.	158	0.20493 (0.529)	0.09929 (0.323)	0.02924 (0.497)	33.3458 (134.890)
<i>Cornus florida</i> L.	115	0.14916 (0.678)	0.14184 (0.465)	0.03349 (0.531)	32.4494 (167.339)
<i>Quercus velutina</i> Lam.	10	0.01297 (0.691)	0.02837 (0.493)	0.23938 (0.770)	28.0724 (195.411)
<i>Prunus serotina</i> Ehrh.	85	0.11025 (0.802)	0.12766 (0.621)	0.03353 (0.803)	27.1432 (222.555)
<i>Quercus alba</i> L.	13	0.01686 (0.818)	0.03546 (0.656)	0.12209 (0.926)	17.4412 (239.996)
<i>Carya tomentosa</i> (Poir) Nutt.	33	0.04280 (0.861)	0.08156 (0.738)	0.01235 (0.938)	13.6709 (253.667)
<i>Carya ovata</i> (Miller) K. Koch	22	0.02853 (0.890)	0.05319 (0.791)	0.00707 (0.945)	8.8796 (262.546)
<i>Carya glabra</i> (Miller) Sweet	20	0.02594 (0.916)	0.04965 (0.840)	0.00980 (0.955)	8.5390 (271.085)
<i>Fagus grandifolia</i> Ehrh.	13	0.01686 (0.933)	0.02482 (0.865)	0.03970 (0.994)	8.1381 (279.223)
<i>Sassafras albidum</i> (Nutt.) Nees	20	0.02594 (0.958)	0.04610 (0.911)	0.00336 (0.998)	7.5403 (286.764)
<i>Vaccinium corymbosum</i> L.	7	0.00908 (0.968)	0.02128 (0.933)	0.00026 (0.998)	3.0612 (289.825)
<i>Cornus alternifolia</i> L.f.	9	0.01167 (0.979)	0.01418 (0.947)	0.00127 (0.999)	2.7125 (292.537)
<i>Castanea dentata</i> (Marshall) Borkh.	5	0.00649 (0.986)	0.01773 (0.965)	0.00015 (0.999)	2.4364 (294.974)
<i>Lindera benzoin</i> (L.) Blume	3	0.00389 (0.990)	0.01064 (0.975)	0.00006 (1.000)	1.4591 (296.433)
<i>Rhamnus frangula</i> L.	3	0.00389 (0.994)	0.00709 (0.982)	0.00029 (1.000)	1.1274 (297.560)
<i>Acer rubrum</i> L.	1	0.00130 (0.995)	0.00355 (0.986)	0.00004 (1.000)	0.4886 (298.049)
<i>Acer platanoides</i> L.	1	0.00130 (0.996)	0.00355 (0.989)	0.00004 (1.000)	0.4883 (298.537)
<i>Liriodendron tulipifera</i> L.	1	0.00130 (0.997)	0.00355 (0.993)	0.00003 (1.000)	0.4878 (299.025)
<i>Ilex verticillata</i> (L.) A. Gray	1	0.00130 (0.999)	0.00355 (0.996)	0.00003 (1.000)	0.4875 (299.512)
<i>Nyssa sylvatica</i> Marshall	1	0.00130 (1.000)	0.00355 (1.000)	0.00003 (1.000)	0.4875 (300.000)

Table 2.2 Descriptive statistics of the 22 woody taxa within the 0.5 ha plot in Forest Park in order of ecological dominance by importance value, noting abundance, representation among quadrats and mean DBH (n=771).

Species	No. of Trees	Quadrats, %	Mean DBH	IV
<i>Betula lenta</i> L.	217	80	6.29	51.99
<i>Quercus rubra</i> L.	33	46	37.66	49.55
<i>Phellodendron amurense</i> Rupr.	158	56	4.76	33.35
<i>Cornus florida</i> L.	115	80	5.98	32.45
<i>Quercus velutina</i> Lam.	10	16	64.44	28.07
<i>Prunus serotina</i> Ehrh.	85	72	6.77	27.14
<i>Quercus alba</i> L.	13	20	28.55	17.44
<i>Carya tomentosa</i> (Poiret) Nutt.	33	46	7.16	13.67
<i>Carya ovata</i> (Miller) K. Koch	22	30	6.34	8.88
<i>Carya glabra</i> (Miller) Sweet	20	28	7.43	8.54
<i>Fagus grandifolia</i> Ehrh.	13	14	14.63	8.14
<i>Sassafras albidum</i> (Nutt.) Nees	20	26	4.99	7.54
<i>Vaccinium corymbosum</i> L.	7	12	2.60	3.06
<i>Cornus alternifolia</i> L. f.	9	8	4.04	2.71
<i>Castanea dentata</i> (Marshall) Borkh.	5	10	2.34	2.44
<i>Lindera benzoin</i> (L.) Blume	3	6	2.00	1.46
<i>Rhamnus frangula</i> L.	3	4	4.00	1.13
<i>Acer rubrum</i> L.	1	2	2.90	0.49
<i>Acer platanoides</i> L.	1	2	2.80	0.49
<i>Liriodendron tulipifera</i> L.	1	2	2.60	0.49
<i>Ilex verticillata</i> (L.) A. Gray	1	2	2.50	0.49
<i>Nyssa sylvatica</i> Marshall	1	2	2.50	0.49
Sum =	771			300.00

Table 2.3 Woody taxa located within kettles (> 10% slope) of the 0.5 ha plot in Forest Park, listed in order of ecological dominance by importance values (IV), (n=537).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	IV (cum.)
1 <i>Quercus rubra</i> L.	31	0.058 (0.058)	0.100 (0.100)	0.444 (0.444)	60.19 (60.19)
2 <i>Betula lenta</i> L.	151	0.281 (0.339)	0.133 (0.233)	0.075 (0.519)	48.97 (109.17)
3 <i>Phellodendron amurense</i> Rupr.	107	0.199 (0.538)	0.100 (0.333)	0.027 (0.546)	32.62 (141.78)
4 <i>Cornus florida</i> L.	71	0.132 (0.670)	0.148 (0.481)	0.030 (0.577)	31.02 (172.80)
5 <i>Prunus serotina</i> Ehrh.	60	0.112 (0.782)	0.124 (0.605)	0.033 (0.610)	26.89 (199.69)
6 <i>Quercus velutina</i> Lam.	8	0.015 (0.797)	0.029 (0.633)	0.190 (0.800)	23.37 (223.07)
7 <i>Quercus alba</i> L.	9	0.017 (0.814)	0.033 (0.667)	0.129 (0.929)	17.90 (240.97)
8 <i>Carya tomentosa</i> (Poiret) Nutt.	23	0.043 (0.857)	0.071 (0.738)	0.008 (0.937)	12.19 (253.16)
9 <i>Sassafras albidum</i> (Nutt.) Nees	19	0.035 (0.892)	0.057 (0.795)	0.004 (0.941)	9.66 (262.81)
10 <i>Fagus grandifolia</i> Ehrh.	11	0.020 (0.912)	0.029 (0.824)	0.044 (0.985)	9.31 (272.12)
11 <i>Carya glabra</i> (Miller) Sweet	15	0.028 (0.940)	0.052 (0.876)	0.011 (0.996)	9.14 (281.26)
12 <i>Carya ovata</i> (Miller) K. Koch	12	0.022 (0.963)	0.043 (0.919)	0.003 (0.999)	6.81 (288.06)
13 <i>Vaccinium corymbosum</i> L.	6	0.011 (0.974)	0.024 (0.943)	0.000 (0.999)	3.52 (291.59)
14 <i>Lindera benzoin</i> (L.) Blume	3	0.006 (0.980)	0.014 (0.957)	0.000 (0.999)	2.00 (293.58)
15 <i>Rhamnus frangula</i> L.	3	0.006 (0.985)	0.010 (0.967)	0.000 (0.999)	1.55 (295.13)
16 <i>Cornus alternifolia</i> L. f.	3	0.006 (0.991)	0.010 (0.976)	0.000 (1.000)	1.54 (296.67)
17 <i>Castanea dentata</i> (Marshall) Borkh.	2	0.004 (0.994)	0.010 (0.986)	0.000 (1.000)	1.34 (298.00)
18 <i>Acer platanoides</i> L.	1	0.002 (0.996)	0.005 (0.990)	0.000 (1.000)	0.67 (298.67)
19 <i>Ilex verticillata</i> (L.) A. Gray	1	0.002 (0.998)	0.005 (0.995)	0.000 (1.000)	0.67 (299.33)
20 <i>Nyssa sylvatica</i> Marshall	1	0.002 (1.000)	0.005 (1.000)	0.000 (1.000)	0.67 (300.00)

Table 2.4 Descriptive statistics of woody taxa within kettles (> 10% slope) located in the 0.5 ha plot of Forest Park. Kettles cover 74% of the plot area (n=537).

Species	No. of		Mean	IV
	Trees	Quadrats, %	DBH (cm)	
1. <i>Quercus rubra</i> L.	31	56.76	38.85	60.19
2. <i>Betula lenta</i> L.	151	75.68	6.13	48.97
3. <i>Phellodendron amurense</i> Rupr.	107	56.76	4.85	32.62
4. <i>Cornus florida</i> L.	71	83.78	6.27	31.02
5. <i>Prunus serotina</i> Ehrh.	60	70.27	7.31	26.89
6. <i>Quercus velutina</i> Lam.	8	16.22	58.11	23.37
7. <i>Quercus alba</i> L.	9	18.92	36.96	17.9
8. <i>Carya tomentosa</i> (Poiret) Nutt.	23	40.54	6.28	12.19
9. <i>Sassafras albidum</i> (Nutt.) Nees	19	32.43	5.13	9.66
10. <i>Fagus grandifolia</i> Ehrh.	11	16.22	14.79	9.31
11. <i>Carya glabra</i> (Miller) Sweet	15	29.73	8.35	9.14
12. <i>Carya ovata</i> (Miller) K. Koch	12	24.32	5.44	6.81
13. <i>Vaccinium corymbosum</i> L.	6	13.51	2.55	3.52
14. <i>Lindera benzoin</i> (L.) Blume	3	8.11	2.00	1.99
15. <i>Rhamnus frangula</i> L.	3	5.41	4.00	1.55
16. <i>Cornus alternifolia</i> L. f.	3	5.41	3.83	1.54
17. <i>Castanea dentata</i> (Marshall) Borkh.	2	5.41	2.75	1.33
18. <i>Acer platanoides</i> L.	1	2.7	2.80	0.67
19. <i>Ilex verticillata</i> (L.) A. Gray	1	2.7	2.50	0.67
20. <i>Nyssa sylvatica</i> Marshall	1	2.7	2.50	0.67
	Sum	537		300.00

Table 2.5. Woody taxa located on flat uplands (0–10% slope) within the 0.5 ha plot of Forest Park listed in order of ecological dominance by importance values (IV), (n=234).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	IV (cum.)
1. <i>Betula lenta</i> L.	66	0.282 (0.282)	0.167 (0.167)	0.204 (0.204)	65.28 (65.28)
2. <i>Quercus velutina</i> Lam.	2	0.009 (0.291)	0.028 (0.194)	0.486 (0.690)	52.26 (117.54)
3. <i>Cornus florida</i> L.	44	0.188 (0.479)	0.125 (0.319)	0.050 (0.740)	36.29 (153.82)
4. <i>Phellodendron amurense</i> Rupr.	51	0.218 (0.697)	0.097 (0.417)	0.042 (0.782)	35.67 (189.49)
5. <i>Prunus serotina</i> Ehrh.	25	0.107 (0.803)	0.139 (0.556)	0.035 (0.817)	28.12 (217.61)
6. <i>Carya tomentosa</i> (Poiret) Nutt.	10	0.043 (0.846)	0.111 (0.667)	0.036 (0.853)	18.95 (236.56)
7. <i>Quercus alba</i> L.	4	0.017 (0.863)	0.042 (0.708)	0.093 (0.946)	15.18 (251.74)
8. <i>Carya ovata</i> (Miller) K. Koch	10	0.043 (0.906)	0.083 (0.792)	0.013 (0.959)	13.95 (265.69)
9. <i>Carya glabra</i> (Miller) Sweet	5	0.021 (0.927)	0.042 (0.833)	0.004 (0.963)	6.71 (272.40)
10. <i>Quercus rubra</i> L.	2	0.009 (0.936)	0.028 (0.861)	0.028 (0.992)	6.47 (278.88)
11. <i>Cornus alternifolia</i> L. f.	6	0.026 (0.962)	0.028 (0.889)	0.006 (0.998)	5.95 (284.82)
12. <i>Castanea dentata</i> (Marshall) Borkh.	3	0.013 (0.974)	0.042 (0.931)	0.000 (0.998)	5.49 (290.31)
13. <i>Fagus grandifolia</i> Ehrh.	2	0.009 (0.983)	0.014 (0.944)	0.001 (0.999)	2.33 (292.65)
14. <i>Vaccinium corymbosum</i> L.	1	0.004 (0.987)	0.014 (0.958)	0.000 (0.999)	1.84 (294.49)
15. <i>Acer rubrum</i> L.	1	0.004 (0.991)	0.014 (0.972)	0.000 (1.000)	1.84 (296.33)
16. <i>Liriodendron tulipifera</i> L.	1	0.004 (0.996)	0.014 (0.986)	0.000 (1.000)	1.84 (298.17)
17. <i>Sassafras albidum</i> (Nutt.) Nees	1	0.004 (1.000)	0.014 (1.000)	0.000 (1.000)	1.84 (300.00)

Table 2.6 Descriptive statistics of woody taxa located along flat uplands (0-10% slope) within the 0.5 ha plot of Forest Park. Flat uplands cover 26% of the plot area (n=234).

Species	No. of		Mean	
	Trees	Quadrat, %	DBH (cm)	IV
1. <i>Betula lenta</i> L.	66	92.31	6.63	65.28
2. <i>Quercus velutina</i> Lam.	2	15.38	89.75	52.26
3. <i>Cornus florida</i> L.	44	69.23	5.51	36.29
4. <i>Phellodendron amurense</i> Rupr.	51	53.85	4.59	35.67
5. <i>Prunus serotina</i> Ehrh.	25	76.92	6.34	28.12
6. <i>Carya tomentosa</i> (Poiret) Nutt.	10	61.54	9.17	18.95
7. <i>Quercus alba</i> L.	4	23.08	20.43	15.18
8. <i>Carya ovata</i> (Miller) K. Koch	10	46.15	5.45	13.95
9. <i>Carya glabra</i> (Miller) Sweet	5	23.08	4.68	6.71
10. <i>Quercus rubra</i> L.	2	15.38	19.27	6.47
11. <i>Cornus alternifolia</i> L. f.	6	15.38	4.15	5.95
12. <i>Castanea dentata</i> (Marshall) Borkh.	3	23.08	2.07	5.49
13. <i>Fagus grandifolia</i> Ehrh.	2	7.69	3.75	2.33
14. <i>Vaccinium corymbosum</i> L.	1	7.69	2.90	1.84
15. <i>Acer rubrum</i> L.	1	7.69	2.90	1.84
16. <i>Liriodendron tulipifera</i> L.	1	7.69	2.60	1.84
17. <i>Sassafras albidum</i> (Nutt.) Nees	1	7.69	2.50	1.84
	Sum	234		300.00

Table 2.7. Tree and shrub families of the 0.5 hectare plot in Forest Park listed in order of ecological dominance by importance values (n=771).

Family	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	Importance Value (cum.)
Fagaceae	74	0.09598 (0.096)	0.16049 (0.160)	0.77246 (0.772)	102.8932 (102.893)
Betulaceae	217	0.28145 (0.377)	0.16461 (0.325)	0.09664 (0.869)	54.2702 (157.163)
Cornaceae	124	0.16083 (0.538)	0.16461 (0.490)	0.03476 (0.904)	36.0200 (193.183)
Rutaceae	158	0.20493 (0.743)	0.11523 (0.605)	0.02924 (0.933)	34.9394 (228.123)
Rosaceae	85	0.11025 (0.853)	0.14815 (0.753)	0.03353 (0.967)	29.1921 (257.315)
Juglandaceae	75	0.09728 (0.951)	0.13169 (0.885)	0.02922 (0.996)	25.8185 (283.133)
Lauraceae	23	0.02983 (0.981)	0.06173 (0.947)	0.00342 (0.999)	9.4985 (292.632)
Ericaceae	7	0.00908 (0.990)	0.02469 (0.971)	0.00026 (1.000)	3.4027 (296.035)
Rhamnaceae	3	0.00389 (0.994)	0.00823 (0.979)	0.00029 (1.000)	1.2412 (297.276)
Aceraceae	2	0.00259 (0.996)	0.00823 (0.988)	0.00008 (1.000)	1.0907 (298.366)
Magnoliaceae	1	0.00130 (0.997)	0.00412 (0.992)	0.00003 (1.000)	0.5447 (298.911)
Aquifoliaceae	1	0.00130 (0.999)	0.00412 (0.996)	0.00003 (1.000)	0.5444 (299.456)
Nyssaceae	1	0.00130 (1.000)	0.00412 (1.000)	0.00003 (1.000)	0.5444 (300.000)

Table 2.8. Tree and shrub families of the 0.5 ha plot in Forest Park listed in order of ecological dominance by importance values (IV), number of trees, percentage representation among quadrats and mean diameter at DBH (n=771).

Family	No. of Trees	Quadrats, %	Mean DBH	IV
Fagaceae	74	78	33.83	102.89
Betulaceae	217	80	6.29	54.27
Cornaceae	124	80	5.84	36.02
Rutaceae	158	56	4.76	34.94
Rosaceae	85	72	6.77	29.19
Juglandaceae	75	64	6.99	25.82
Lauraceae	23	30	4.60	9.50
Ericaceae	7	12	2.60	3.40
Rhamnaceae	3	4	4.00	1.24
Aceraceae	2	4	2.85	1.09
Magnoliaceae	1	2	2.60	0.54
Aquifoliaceae	1	2	2.50	0.54
Nyssaceae	1	2	2.60	0.54
Sum =	771			300.00

Table 2.9. Samples of approximate randomization analysis of 10, 20, 30, 40 and 48 plot samples out of 50 total plots, as an output for the formation of the species-area curve (Figure 2.4). NS=500 randomizations of 50 quadrats.

Sample size and combinations	Species richness	Frequency	Probability	Mean species richness/sample
10 plot sample				
<u>10 combinations out of 50</u>				
				15.468
	11	6	0.012	
	12	11	0.022	
	13	42	0.084	
	14	99	0.198	
	15	99	0.198	
	16	102	0.204	
	17	77	0.154	
	18	44	0.088	
	19	16	0.032	
	20	2	0.004	
	21	2	0.004	
20 plot sample				
<u>20 combinations out of 50</u>				
				18.13
	13	1	0.002	
	14	4	0.008	
	15	18	0.036	
	16	59	0.118	
	17	89	0.178	
	18	129	0.258	
	19	99	0.198	
	20	61	0.122	
	21	34	0.068	
	22	6	0.012	

Table 2.9. (continued)

<u>Sample size and combinations</u>	<u>Species richness</u>	<u>Frequency</u>	<u>Probability</u>	<u>Mean species richness/sample</u>
30 plot sample				
<u>30 combinations out of 50</u>				
				19.704
	16	1	0.002	
	17	28	0.056	
	18	70	0.140	
	19	119	0.238	
	20	128	0.256	
	21	109	0.218	
	22	45	0.090	
40 plot sample				
<u>40 combinations out of 50</u>				
				20.97
	18	8	0.016	
	19	51	0.102	
	20	88	0.176	
	21	154	0.308	
	22	199	0.398	
48 plot sample				
<u>48 combinations out of 50</u>				
				21.784
	18	1	0.002	
	20	24	0.048	
	21	57	0.114	
	22	418	0.836	

Table 2.10. Bar diagram of discrete frequency distribution and species abundance for the 22 taxa of the 0.5 ha plot in Forest Park. Abundance categories with zero frequency are not printed. Five of the 22 species (22.7%) are singletons- species represented by only a single tree, and 31.8% of the species are doubletons (n=771). \* equals 1 taxon.

<u>No. of Trees</u>		<u>Frequency of species</u>	<u>Relative Frequency Distribution</u>
1	*****	(5)	(0.227)
3	**	(2)	(0.318)
5	*	(1)	(0.364)
7	*	(1)	(0.409)
9	*	(1)	(0.455)
10	*	(1)	(0.500)
13	**	(2)	(0.591)
20	**	(2)	(0.682)
22	*	(1)	(0.727)
33	**	(2)	(0.818)
85	*	(1)	(0.864)
115	*	(1)	(0.909)
158	*	(1)	(0.955)
217	*	(1)	(1.000)

Table 2.11. The combinatorics of randomization analysis are based on Pascal's Triangle ( ${}^n C_r$ ). It is often used for calculating binomial coefficients where a combination of  $n$  things are taken  $r$  at a time.  $n$  represents 50 quadrats and increased at  $r$  quadrats at a time. For the 50 quadrat Forest Park study, a sequence of increasing values are obtained then peak at 25 quadrats ( ${}^{50}C_{25}$ ). Values then decrease towards quadrat 48 ( ${}^{50}C_{48}$ ). The high number of combinations for ordinary ecological inventories is why approximate rather than exact randomization analysis is performed.

${}^{50}C_2$	= 1,225
${}^{50}C_3$	= 19,600
${}^{50}C_4$	= 230,300
${}^{50}C_5$	= 2,118,760
${}^{50}C_6$	= 15,890,700
${}^{50}C_7$	= 99,884,400
${}^{50}C_8$	= 536,878,650
${}^{50}C_9$	= 2,505,433,700
${}^{50}C_{10}$	= $\sim 1 \text{ e } 10$
${}^{50}C_{25}$	= $\sim 1.3 \text{ e } 14$
${}^{50}C_{40}$	= $\sim 1 \text{ e } 10$
${}^{50}C_{41}$	= 2,505,433,700
${}^{50}C_{42}$	= 536,878,650
${}^{50}C_{43}$	= 99,884,400
${}^{50}C_{44}$	= 15,890,700
${}^{50}C_{45}$	= 2,118,760
${}^{50}C_{46}$	= 230,300
${}^{50}C_{47}$	= 19,600
${}^{50}C_{48}$	= 1,225

Table 2.12. Results of total element analysis from soils of the 15 sampled quadrats within the 0.5 ha plot of Forest Park. Values 0.0 are below detection limits. Results computed for oven dry soil weight (110 ° C) unless moisture percentage is not available.

Nutrient Sample	Quadrats	Quadrats	Quadrats	Quadrats	Quadrats
	1-3-5	16-18-20	26-28-30	36-38-40	46-48-50
Moisture content, %	0.992	1.046	1.560	0.830	0.946
Cd (mg/Kg)	0.000	0.000	0.090	0.000	0.000
Cu (mg/Kg)	4.930	10.680	8.760	6.870	7.940
Ni (mg/Kg)	20.330	15.440	15.030	13.640	14.670
Cr (mg/Kg)	36.650	39.350	33.950	34.930	34.490
Co (mg/Kg)	8.860	11.170	9.350	9.380	7.190
Zn (mg/Kg)	27.380	31.480	38.030	29.700	33.270
Mn (mg/Kg)	251.700	265.200	450.800	281.600	299.200
Ca, %	0.137	0.182	0.250	0.131	0.209
Mg, %	0.201	0.223	0.219	0.174	0.215
Al, %	0.820	1.140	1.080	0.730	0.970
Fe, %	2.030	2.423	2.074	2.204	2.067
P (mg/Kg)	341.800	329.300	332.000	380.400	402.600
S (mg/Kg)	0.000	0.000	0.000	0.000	0.000
B (mg/Kg)	0.000	16.710	1.390	3.380	2.330
Ti, %	0.322	0.349	0.256	0.268	0.273
K, %	0.872	0.967	0.907	0.931	0.973
Na, %	0.580	0.638	0.600	0.606	0.627
N, ppm	1.000	< 1.000	1.000	< 1.000	< 1.000
pH	4.670	4.700	4.720	4.930	4.930

Table 2.13. Tree basal area and tree height inequality measured by Gini Coefficients ( $G$ ) with bootstrap confidence intervals (NS=999). Values for the 12 dominant taxa displayed. Total  $G = 0.8927$  for basal area and  $G = 0.3556$  for tree height for all 771 trees.

Species	N	Tree Basal Area		Tree Height	
		Observed Gini Coefficient	95% Confidence Intervals	Observed Gini Coefficient	95% Confidence Intervals
1. <i>Betula lenta</i>	217	0.7978	0.6919 to 0.8415	0.2810	0.2479 to 0.3076
2. <i>Quercus rubra</i>	33	0.6263	0.4820 to 0.7287	0.2590	0.1808 to 0.3235
3. <i>Phellodendron amurense</i>	158	0.6718	0.5622 to 0.7423	0.2247	0.1978 to 0.2463
4. <i>Cornus florida</i>	115	0.6687	0.5374 to 0.7391	0.2375	0.2074 to 0.2640
5. <i>Quercus velutina</i>	10	0.3206	0.1500 to 0.5097	0.1366	0.0335 to 0.2867
6. <i>Prunus serotina</i>	85	0.7062	0.6450 to 0.7449	0.3026	0.2544 to 0.3410
7. <i>Quercus alba</i>	13	0.7097	0.4824 to 0.8562	0.4264	0.2524 to 0.5389
8. <i>Carya tomentosa</i>	33	0.6237	0.5012 to 0.6926	0.3290	0.2615 to 0.3729
9. <i>Carya ovata</i>	22	0.6946	0.4464 to 0.7522	0.3389	0.1895 to 0.3972
10. <i>Carya glabra</i>	20	0.7402	0.5901 to 0.7891	0.3916	0.2820 to 0.4322
11. <i>Fagus grandifolia</i>	13	0.8728	0.5538 to 0.9462	0.4713	0.2491 to 0.5199
12. <i>Sassafras albidum</i>	20	0.5770	0.3730 to 0.6298	0.2012	0.1468 to 0.2255

Gini Coefficient, 0 to 1: 0 = exact equality, 1 = extreme inequality.

## Chapter 3

### Forest flora and community structure: II.

#### 1. Introduction

The mechanism and dynamics of a woodland community, how communities respond to forest disturbances and tree-fall gaps and how these communities add to the diversity of flora has been a pressing topic of inquiry by many forest ecologists (Hibbs 1979; Shugart 1984; Sipe and Bazzaz 1995; Hubbell 1999; Vandermeer et al. 2000). Particular to the urban temperate woodland in Forest Park is the mechanisms by which the plant community responds and maintains itself after a disturbance. Disturbances affect community structure and dynamics in different ways at various hierarchical levels and spatial scales (McCarthy and Facelli 1990). Disturbances may be frequent and severe at one extreme or minor and rare at the other. Severe forest disturbances may be large, high intensity brush fires. Minor and rare disturbances may be described by the occasional tree fall (Martin 1999). It is the process of re-growth and regeneration, the replacement with new and different taxa that results in the recovery of the plant community of this woodland. It is also the process of differential recruitment and

mortality in gaps of different sizes, by shade-tolerant and shade-intolerant species that lead to changes in landscape diversity (Brokaw and Scheiner 1989).

In Forest Park, disturbances such as tree falls by mature trees are omnipresent but are low intensity and rare occurrences. Decomposed tree stumps, decaying logs and an abundance of young trees and saplings are common throughout the Forest Park woods providing evidence of a mature woodland in transition. Recent fires in the study plot are not evident however past fires are evident elsewhere. A fire-log is maintained by the Forest Park Administration (Scalia, personal communication). Fires and woodland recovery was documented in several urban parks by Loeb (2001).

This chapter was formulated to explore the diversity of the Forest Park arborescent community by revealing the structure and the distribution of species relative to the material presented in Chapter 2. This chapter contains two sections. Section 1, (III.1) Tree and Shrub Distribution by Diameter, describes subsets from the main dataset that were extracted by applying the statistical *quartiles* (25 percentiles). Quartile derived size-classes were explored for dominance hierarchy, tree and shrub diameter and height frequency distributions and linear regression tests. Section 2, (III.2.a-c) Species of gap-phase replacement, describes the abundant pioneer trees and which are ecologically dominant within the plot. Three tree species had characteristics typical of pioneer species and are highlighted in this section. Treatment of frequency distribution for tree diameter,

height and scattergrams from regression analysis on diameter versus height were performed.

## II. Methods

The data obtained from the 0.5 ha study plot for analysis in this chapter are equivalent to the methods described in Chapter 2.

### II.1. Statistical Sampling

For Section 1, upper and lower quartiles (25%) of the main dataset were used to divide stems into subsets consisting of small-size diameter class (lower quartile) and large-size diameter class (upper quartile). A mid-size class comprised the middle 50% of the population sampled. The diameter size-classes were small size-class diameter (2.0 – 2.8 cm DBH, n=202); mid size-class diameter (2.8 – 7.48 cm DBH, n=372) and large-size-class diameter (7.48 – 116.7 cm DBH, n=197). This approach is in contrast to several authors who utilized other methods (largely non-statistical) for determining size-class. Brewer (2001) created two arbitrary diameter size-classes: small size-class (10.0 – 19.99 cm) and large size-class (20.0 – 113.0 cm DBH); Auclair and Cottham (1971) treated arborescent data as; saplings- 1.0-4.0 inch (2.54 – 10.16 cm), sub-canopy trees- 4.0-8.0 inch (10.16-20.32 cm) and canopy trees-  $\geq$  8.0 inches (20.32 cm); Parker et al.

(1985) placed all diameters within 10 cm size–class intervals. For Forest Park, a “sapling” class was not applied though the small size-class trees can be considered saplings. Brewer (2001) considered stems at  $\geq 1.5$  m tall and  $\leq 10$  cm DBH to be saplings. The measurement for tree height was described in Chapter 2. The analysis of the height dataset provided a quantitative accounting of tree and shrub height for the individual taxa within each of the diameter size–classes.

### III. Results

#### III.1 Tree and Shrub Distribution by Diameter

Lower and upper quartiles (or the 25 percentile) statistically partitioned this population into small and large-size diameter classes and a central 50-percentile mid-size diameter class. A detailed analysis of the three diameter size classes is presented here. The basic structural characteristics of the top three ecologically dominant taxa within each of the diameter size classes were detailed with a comparison to the other taxa in the dataset (Table 3.8). *Betula lenta* is ranked as one of the top three taxa in all size-class groups. It is the dominant taxa within the small and mid-size diameter classes and is second to *Quercus rubra* within the large-size class. *Phellodendron amurense* is second in dominance within the small and mid-size classes and ranked seventh in the large-size diameter class.

### III.1.a Small Diameter Stems

The species richness within the small diameter (DBH) trees and shrubs were 13 families represented by 19 woody species. Stem density was 402 stems ha<sup>-1</sup> and a basal area (BA) of 0.893 m<sup>2</sup>. Of the overall small-size stems the most frequent small taxa encountered were *Betula lenta* with a relative frequency of 20.2%, followed by *Phellodendron amurense* (16.66%), *Cornus florida* (15.7%) and *Prunus serotina* (12.2%). *Betula lenta* also displayed the greatest relative density by 26.8%, followed by *Phellodendron amurense* (24.3%), *Cornus florida* (14.4%) and *Prunus serotina* (11.9%). Relative dominance, an extrapolation of basal area placed *Betula lenta* with the highest relative dominance (26.5%), followed by *Phellodendron amurense* (24.4%), *Cornus florida* (14.7%) and *Prunus serotina* (12.2%).

These high values marked *Betula lenta* as the ecologically dominant taxon within the small size-class hierarchy (IV=76.54). This hierarchy was followed, in decreasing order of importance by *Phellodendron amurense* (IV=65.45), *Cornus florida* (IV=44.98) and *Prunus serotina* (IV=36.43)(Table 3.3 and Table 3.4).

The small diameter size represented 25% (n=202) of the sampled population within a diameter range of 2.0 – 2.8 cm (mean DBH 2.36 cm, SD 0.266). This narrow distribution range is in strong contrast to the broad diameter range of the large size trees (n=197) with a DBH range of 7.48 – 116.7cm. The narrow spread of the frequency

distribution within the small-size class was taken at 0.25 cm histogram intervals and the first three intervals were analyzed (Figure 3.1a). The most abundant stems were within the 2.0 - 2.25 cm histogram interval that represented 42.6% (n=86) of the small diameter population. *Betula lenta* (29%) was highly representative in this interval, followed by *Phellodendron amurense* (22%) and *Cornus florida* (15%). The adjacent diameter histogram interval (2.25 - 2.50 cm) decreased nearly three-fold to a representative 15.8% (n=32) of the small diameter population. *Phellodendron amurense* was most abundant (31.2%) followed by *Betula lenta* (21.8%). The 2.50 - 2.75 cm interval peaked with a representative 32.6% (n= 66) of the small size population. The most frequent taxa here were *Betula lenta* (28.7%) and *Phellodendron amurense* (24.2%).

### III.1.b. Mid-size Diameter Stems

The mid-size diameter class (n=372) contained the most abundant stems of the size-class partitions. Within this size class, diameters ranged from 2.8 – 7.48 cm DBH (mean DBH 4.62 cm, SD 1.22)(Table 3.5). The largest tree was a *Cornus florida* (7.48 cm DBH). The species richness within this group was 17 families distributed among 10 tree species. Stem density was 744 stems ha<sup>-1</sup> and a basal area (BA) of 6.66 m<sup>2</sup>.

The most frequent mid-size diameter taxa encountered were *Betula lenta* with a relative frequency of 18.59%, followed by *Phellodendron amurense* (14.74%), *Cornus*

*florida* (17.94%) and *Prunus serotina* (11.53%). *Betula lenta* also displayed the greatest relative density (31.45%) followed by *Phellodendron amurense* (24.19%), *Cornus florida* (14.78%) and *Prunus serotina* (9.67%). Relative dominance, an extrapolation of basal area placed *Betula lenta* with the highest relative dominance (31.64%) followed by *Phellodendron amurense* (22.53%), *Cornus florida* (16.19%) and *Prunus serotina* (9.40%). These high values marked *Betula lenta* as the ecologically dominant taxon within the mid-size class hierarchy (IV= 81.68). This hierarchy was followed in decreasing order of importance by *Phellodendron amurense* (IV= 61.47), *Cornus florida* (IV= 48.92) and *Prunus serotina* (IV= 30.62), (Table 3.4 and Table 3.5).

An analysis of individual taxon and their diameter frequency distributions occurred at 1.0 cm histogram intervals (Figure 3.1.b, Table 3.5). Within the mid-size diameter stems (2.8 – 7.48 cm, n=372) *Betula lenta* was the most abundant. *Betula lenta* represented 31.18% of the all taxa followed by *Phellodendron amurense* (24.73%) and *Cornus florida* (14.78%). *Carya* spp. was represented by 10.75% of the population and *Prunus serotina* represented 9.67% of the taxa.

Of the histogram intervals analyzed for distribution, the first interval (2.8 – 3.8 cm) accounted for 31.98% of the taxa in this size class. Of the top four taxa within this interval it was the *Phellodendron amurense* that represented 31.90% of all individuals followed by *Betula lenta* (26.0%), *Cornus florida* (11.76%) and *Prunus serotina* (7.56%).

The adjacent histogram interval (3.8- 4.8 cm) accounted for 26.8% of the taxa and was represented by *Betula lenta* (40.0%) followed by *Phellodendron amurense* (23.0%), *Cornus florida* (13.0%) and *Prunus serotina* (9.0%). The third histogram interval (4.8 – 5.8 cm) accounted for 20.69% of the taxa and was represented by *Betula lenta* (31.16%), *Cornus florida* (18.18%), *Phellodendron amurense* (18.18%) and *Prunus serotina* (16.88%).

Several minor taxa were also accounted for within this diameter size but in low abundance. The least abundant taxa were *Quercus* spp. with an alarming representation of only four (4) individuals followed by *Fagus grandifolia* (n=8) and *Sassafras albidum* (n=11).

### III.1.c Large Diameter Stems

The upper quartile (25%) of the population marked all large diameter trees (n=197) with a diameter range of 7.48-116.7 cm DBH (mean DBH 22.13 cm, SD 21.27).

This size class contained 7 families distributed among 13 tree species. No shrubs were represented in this size class. The stem density was 394 stems ha<sup>-1</sup> with an overall basal area of 145.48 m<sup>2</sup>. The forest canopy of the study plot is made up of these 13 species.

The large diameter frequency distribution was similar in frequency distribution as the entire population (n=771)(Figure 2.1 (c) and Figure 3.1 (c)).

The most frequent large diameter taxa encountered were *Betula lenta* with a relative frequency of 19.1%, followed by *Quercus rubra* (16.31%), *Cornus florida* (14.89%) and *Prunus serotina* (12.7%). *Betula lenta* also displayed the greatest relative density by 23.35%, followed by *Cornus florida* (15.7%), *Quercus rubra* (14.7%) and *Prunus serotina* (12.6%). Two *Quercus* sp. displayed the greatest relative dominance in this size-class in strong contrast to the other large-sized taxa. The taxon that displayed ecological dominance in this size class was *Quercus rubra* (IV= 70.25) followed by five other top taxa- *Betula lenta* (IV= 51.11), *Quercus velutina* (IV= 34.84), *Cornus florida* (IV= 33.34), *Prunus serotina* (IV= 28.50) and *Q. alba* (IV= 23.12) (Table 3.6 and Table 3.7). Unique among these six dominant taxa were the *Betula lenta*, though second in ecological dominance, it had the highest relative density (23.35%). This was nearly two-fold in density compared to next lowest in density, *Cornus florida*.

Applying 4.0 cm histogram intervals for frequency distribution analysis, 46.2% of the large stems were represented in the first interval (7.48-11.48 cm). Of these, four taxa dominated the first histogram interval. These were, *Cornus florida* (29.6%), *Betula lenta* (25%), *Phellodendron amurense* (13.2%) and *Prunus serotina* (8.7%). The second histogram interval (11.48-15.48 cm) decreased in abundance almost three-fold to 17.2%. The 4 taxa that dominated the second histogram interval were *Betula lenta* (32%), *Prunus serotina* (23.5%), *Carya ovata* (11.7%) and *Phellodendron amurense* (8.8%).

Collectively, the first two intervals contained 63% (n=125) of the large tree population. The three abundant taxa within these two intervals (an 8.0 cm diameter range) were those also identified in a previous section as pioneer species. *Betula lenta* dominated both intervals with a representative 28.8%. This was followed by *Prunus serotina* (12.8%) and *Phellodendron amurense* (12.0%). The frequency distribution of the remaining intervals decreased consistently throughout the remaining diameter size class. It was within these remaining intervals where only the Fagaceae were represented by *Quercus rubra* (n=29), *Q. alba* (n=9), *Q. velutina* (n=9) and *F. grandifolia* (n=3).

### III.2 Vertical Structure

The tree and shrub height distribution within the small-size diameter class (2.0 – 2.8 cm DBH) was analyzed using 0.5 m histogram intervals within a height range of 1.47 – 5.90 m (Figure 3.2(a)). The mean height was 3.44 m (SD 0.77). The most abundant height-interval that accounted for 29.70% of the taxa was between 3.5 – 4.0 m. This histogram interval was dominated in decreasing order of abundance by *Betula lenta*, *Phellodendron amurense*, *Prunus serotina* and *Cornus florida*. The second most abundant histogram interval was between 2.5 – 3.0 m height, represented 28.2% of the trees and was dominated in decreasing order of abundance by *Phellodendron amurense*, *Cornus florida*, *Betula lenta* and the *Carya* spp.. The tallest tree in this diameter size

class was a single *Betula lenta* at 5.90 m height. The next tallest tree was *Sassafras albidum* at 5.31m. The shortest tree was *Phellodendron amurense* at 1.47 m height.

The height distribution within the mid-size diameter stems (2.8 – 7.48 cm, DBH) was analyzed by applying 0.5 m histogram intervals for a height range of 2.36 – 13.27 m (Figure 3.2 (b)). The mean height was 5.34 m (SD 1.67). The most abundant height-interval was 4.0 - 4.5 m and accounted for 25.53% of the taxa. The most abundant interval was represented in decreasing order by *Phellodendron amurense*, *Betula lenta*, *Cornus florida* and *Prunus serotina*. The tallest tree in this height distribution was *Betula lenta* at 13.47 m. The shortest tree was a single *Phellodendron amurense* at 2.36 m.

The height distribution for the large diameter stems (7.48 – 116.7 cm, DBH) was analyzed by applying 1.0 m histogram intervals to the height range of 4.72 - 32.44 m. The mean tree height was 13.6 m (SD 7.12). The most abundant height histogram interval was 6.0 – 8.0 m height that accounted for 19.28% of the taxa and was represented in decreasing order of abundance by *Cornus florida*, *Betula lenta*, *Prunus serotina* and *Phellodendron amurense*. The second most abundant histogram interval was 10.0 – 12.0 m that accounted for 18.78% and was represented by *Betula lenta*, *Phellodendron amurense*, *Carya spp.* and *Prunus serotina*. The tallest tree was *Quercus rubra* and *Q. alba* at 32.45 m and the shortest tree was a *Phellodendron amurense* at 4.72 m.

### III.3 Regression Analysis

Regression was used to model the relationship between tree and shrub diameter with height. Scattergrams generated by regression analysis revealed a clustering of stems within small-size DBH measurements (x) and height (y) (Figure 3.3a). Polynomial regression provided a *minor increase in the coefficient of determination-  $r^2$*  over simple linear regression tests (Sokal and Rohlf 1995). For the small diameter stems ( $r^2 = 0.117$ ,  $p < 0.0001$ ); mid-size diameter stems ( $r^2 = 0.412$ ,  $p < 0.0001$ ) and for large diameter trees ( $r^2 = 0.808$ ,  $p < 0.0001$ ).

### III.4 Species of gap-phase replacement

Several of the taxa within the study plot display characteristics typical of gap-phase regeneration species that respond to disturbances. Small-scale disturbances such as tree falls are frequent within 29 ha Northern Woods of Forest Park. Small-scale disturbances can be colonized by opportunistic, non-climax, shade-tolerant species. This is in contrast to disturbances that would occur from timber harvesting where large-scale clearance results in the eventual colonization by many types of herbaceous and woody taxa (Smith 1980). Three tree species in the Forest Park plot have characteristics typical of pioneer (non-climax) species. These are *Betula lenta* (sweet birch), *Phellodendron amurense* (Amur corktree) and *Prunus serotina* (wild black cherry). Their spatial

distribution is presented in the dotmap (Figure 3.4). The dominance hierarchy for the three pioneers by decreasing order of importance value were: sweet birch (IV= 51.99, n=217), Amur corktree (IV= 33.35, n=158) and wild black cherry (IV= 27.14, n=85).

The diameter distributions (DBH) of these taxa are consistent with colonizing species that display multiple small diameter individuals and very few large diameter individuals. Within the diameter histogram intervals, an increased frequency was represented in the small intervals and a reduced frequency in the larger intervals (Figure 3.5 (a-c)). Upon comparison, the mean diameter for sweet birch was 6.28 cm (SD 6.93), black cherry was 6.77 cm (SD 5.64) and Amur corktree was 4.76 cm (SD 3.69)(Table 3.1). Sweet birch contained the largest diameter range (2.0 – 52.0 cm);the largest tree was 47.5 cm DBH located in quadrat 49. Both wild black cherry and the Amur corktree were well below this diameter range and contained only a 2.0 – 28.0 cm and 2.0 – 29.4 cm range respectively. The largest wild black cherry was 28.0 cm DBH and located in quadrat 50. The largest Amur corktree was 29.4 cm DBH and located in quadrat 50.

Among the larger diameter frequency distributions, the sweet birch population was represented by 42% within the 2.0 – 4.0 cm histogram interval and 26.7% of the population in the 4.0 – 6.0cm histogram interval. Overall, 86.6% of the population was represented in the 2.0-10.0 cm interval. The 10.0 – 52.0 cm histogram interval contained a low frequency with only 13.3% of the represented population (Figure 3.5 (a)).

Kolmogorov-Smirnov two-sample tests for unsigned differences for DBH were performed for the grouping variables *Betula lenta*, *Phellodendron amurense* and *Prunus serotina*. Only p- values are reported.

	<i>Betula lenta</i>	<i>P. amurense</i>	<i>Prunus serotina</i>
<i>Betula lenta</i>	----		
<i>Phellodendron amurense</i>	0.0283	----	
<i>Prunus serotina</i>	0.3977	0.0379	----

The frequency distribution of wild black cherry represented 40% of its population in the 2.0-4.0 cm interval and 27% in the 4.0 – 6.0 cm interval. These two intervals (range 2.0-6.0 cm) comprised 67% of the wild black cherry trees. In the 10.0-30.0 cm interval range, only 32.9% are represented (Figure 3.4 b). For the Amur corktree diameter distribution, 55% of the population was represented in the 2.0 – 4.0 cm histogram interval and 23.4% in the 4.0 – 6.0 cm histogram interval. These two intervals represented 78.4% of the population. The remaining 21.6% of the population was distributed among the 6.0 – 30.0 cm diameter interval range citing relatively few large diameter individuals (Figure 3.5 (c)).

Tree height for these taxa were compared (Figure 3.6 (a-c)). The height range for *Betula lenta* was 2.95 – 26.55 m and a mean height of 6.98 m (SD 4.06). The tallest sweet birch was an approximated 26.75 m and located in subplot 30. The height range for *Phellodendron amurense* was 1.47 – 11.8 m with a mean height of 4.90 m (SD 2.08). The tallest corktree was 11.8 m and located in subplot 50. The height range for *Prunus*

*serotina* was 2.36 - 23.6 m with a mean height of 6.16 m (SD 3.82). The tallest wild black cherry was approximately 23.6 m and located in quadrat 24.

An analysis of frequency distribution for tree height of the three pioneers was performed. All pioneers had an unexplained low frequency in the initial 1.47-3.47 m histogram interval with a substantial increase in abundance in the adjacent 3.47 – 5.47 m height interval. The low abundance of the shortest trees or shrubs can be explained by the likely rapid release of suppressed trees following a disturbance. Sweet birch contained 3.65% of the population in the 1.47-3.47 m histogram interval. It peaked within the 3.47 – 5.47 m histogram interval that represented 44.2% of the population. Of the overall distribution, 90% of the population was represented in the 1.47 – 11.47 m range and 21% of the population in the 11.47 – 27.47 m range (Figure 3.6).

Amur corktree had 30% of its population in the initial 1.47-3.47 m height histogram interval. Population abundance peaked in the 3.47- 5.47 m interval with a representative 53% of its population and then decreased in the 5.47 – 7.47 m interval to 16.5% of the population. Of the overall height distribution, 88.6% of the population was represented in histogram intervals ranging from 1.47 – 7.47 m and 11.2% of the population was represented in the intervals 7.47 – 13.47 m (Figure 3.6 (b)).

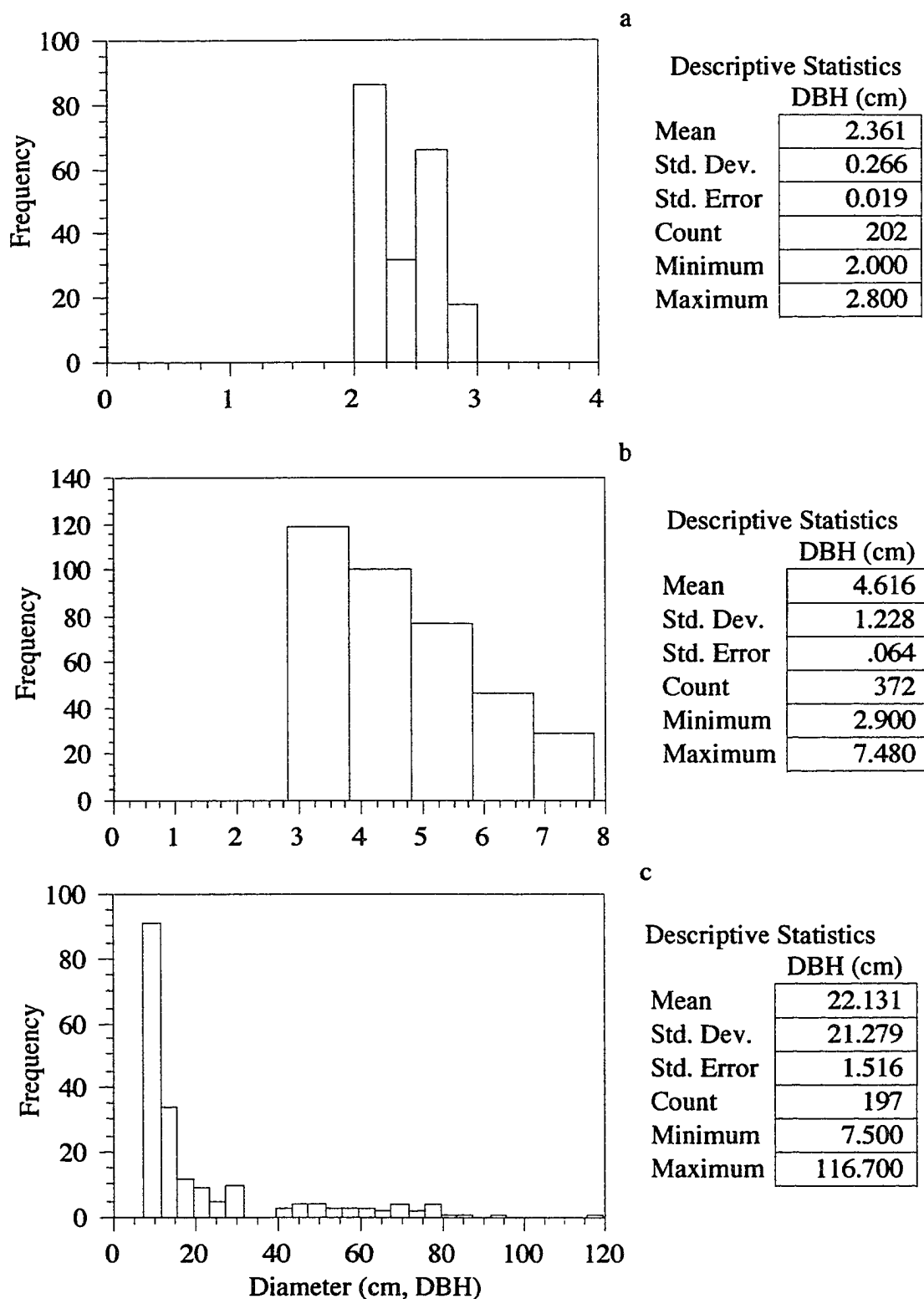
Wild black cherry had 10.5% of its population represented within the 1.47-3.47 m histogram interval. It peaked in the 3.47-5.47 m interval that represented 45.8% of the population and decreased to 22.3% of the population within the 5.47 - 7.47 m interval.

78% of the population was found within the height interval range of 1.47 - 7.47 m. A significant frequency decrease occurred in the intervals ranging from 7.47 - 25.47 m that represented 21.1% of the population (Figure 3.6 (c)).

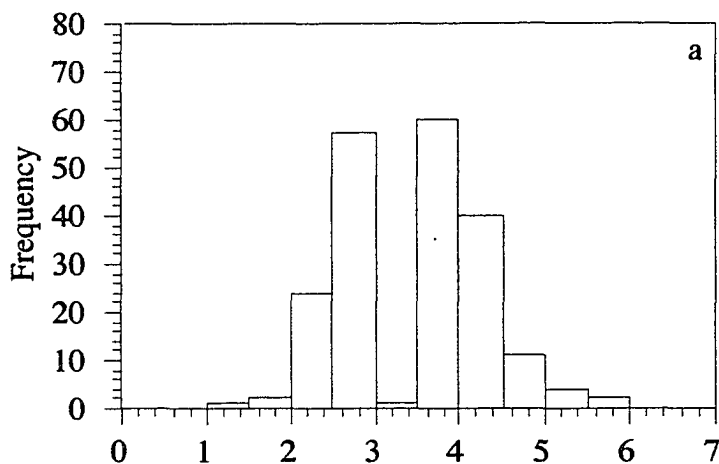
#### IV. Conclusion

The theory of forest dynamics dictates that within the gap-phase of a forest cycle there are likely to be different taxa present than that are found within non-gap or non-disturbance areas. Those species present within gaps can be either climax or pioneer species depending on the cycle. *Betula lenta* is one of three gap-phase taxa with pioneer characteristics. It presented elevated ecological dominance of the overall taxa described in Chapter 2. However, across the diameter size classes it also maintained elevated ecological dominance. Forest disturbances, when and where it occurred provided an opportunity for this species to obtain dominance in the community to the exclusion of other small to mid-sized non-pioneer species. *Phellodendron amurense*, a relatively recent non-native invader maintained ecological dominance across the small to mid-sized diameter classes. *Cornus florida*, a lower stratum, non-canopy species also displayed elevated importance values across all diameter size classes. The elevated importance values of flowering dogwood in the face of many fungal pathogens and wood boring insects merits further investigation in its role within the community.

The future composition and ecology of this woodland is that low representation by saplings and poles of climax (non-pioneer) species will continue to be evident. The reduced numbers of canopy species will significantly impact on the overall ecology of this woodland. The loss of an emerging canopy, generally provided by climax species will restrict the full range of microclimatic influences needed to maintain a rich and abundant herbaceous and arborescent community. This can lead to a loss or reduction of vegetative cover and as habitat, will inevitably impact other important forest organisms. Moreover, this chapter provided research results that supports the role of successional species, in contrast to existing canopy species, as important components of this woodland ecosystem.

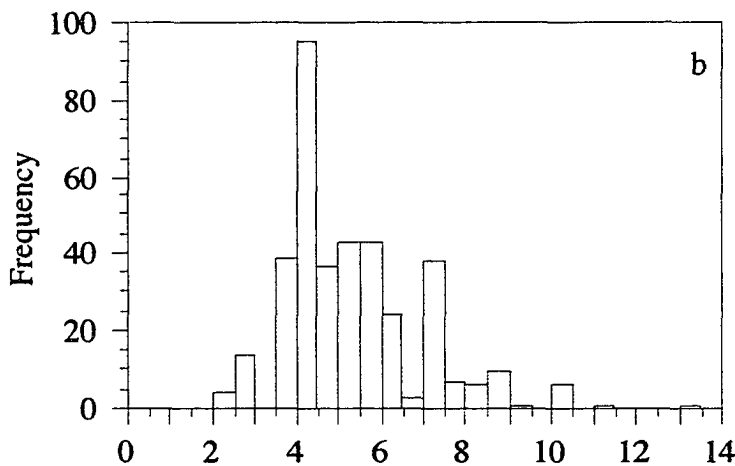


**Figure 3.1** Frequency distribution of woody stem diameters (DBH) in the 0.5 ha plot of Forest Park in size-classes based on the lower and upper quartiles; (a) small-size class (2.0 - 2.8 cm),  $n=202$ , (b) mid-size class (2.8 - 7.48 cm),  $n=372$  and (c) large-size class (7.48 - 116.7 cm),  $n=197$ .



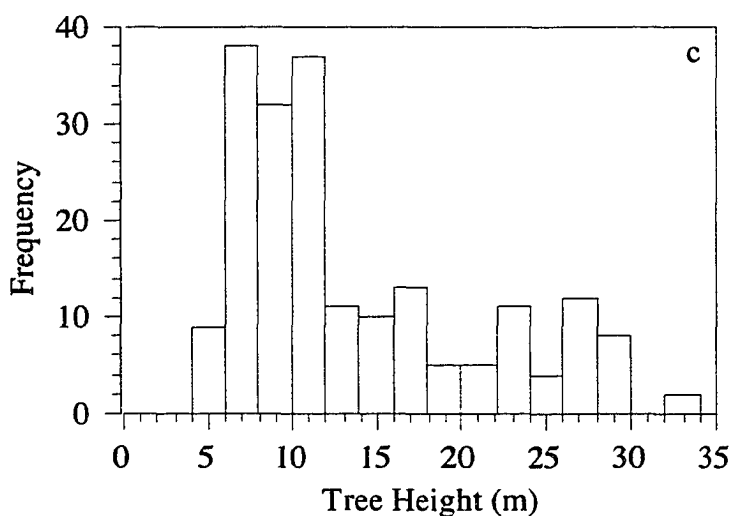
**Descriptive Statistics**

Height (m)	
Mean	3.449
Std. Dev.	0.770
Std. Error	0.054
Count	202
Minimum	1.475
Maximum	5.900



**Descriptive Statistics**

Height (m)	
Mean	5.343
Std. Dev.	1.675
Std. Error	0.087
Count	372
Minimum	2.360
Maximum	13.274



**Descriptive Statistics**

Height (m)	
Mean	13.628
Std. Dev.	7.126
Std. Error	0.508
Count	197
Minimum	4.720
Maximum	32.448

Figure 3.2 Frequency distribution of woody stem heights (m) for ; (a) small-size tree height (1.47-5.9 m); (b) mid-size tree height (2.36-13.27 m) and (c) large-size tree height (4.7-32.44 m).

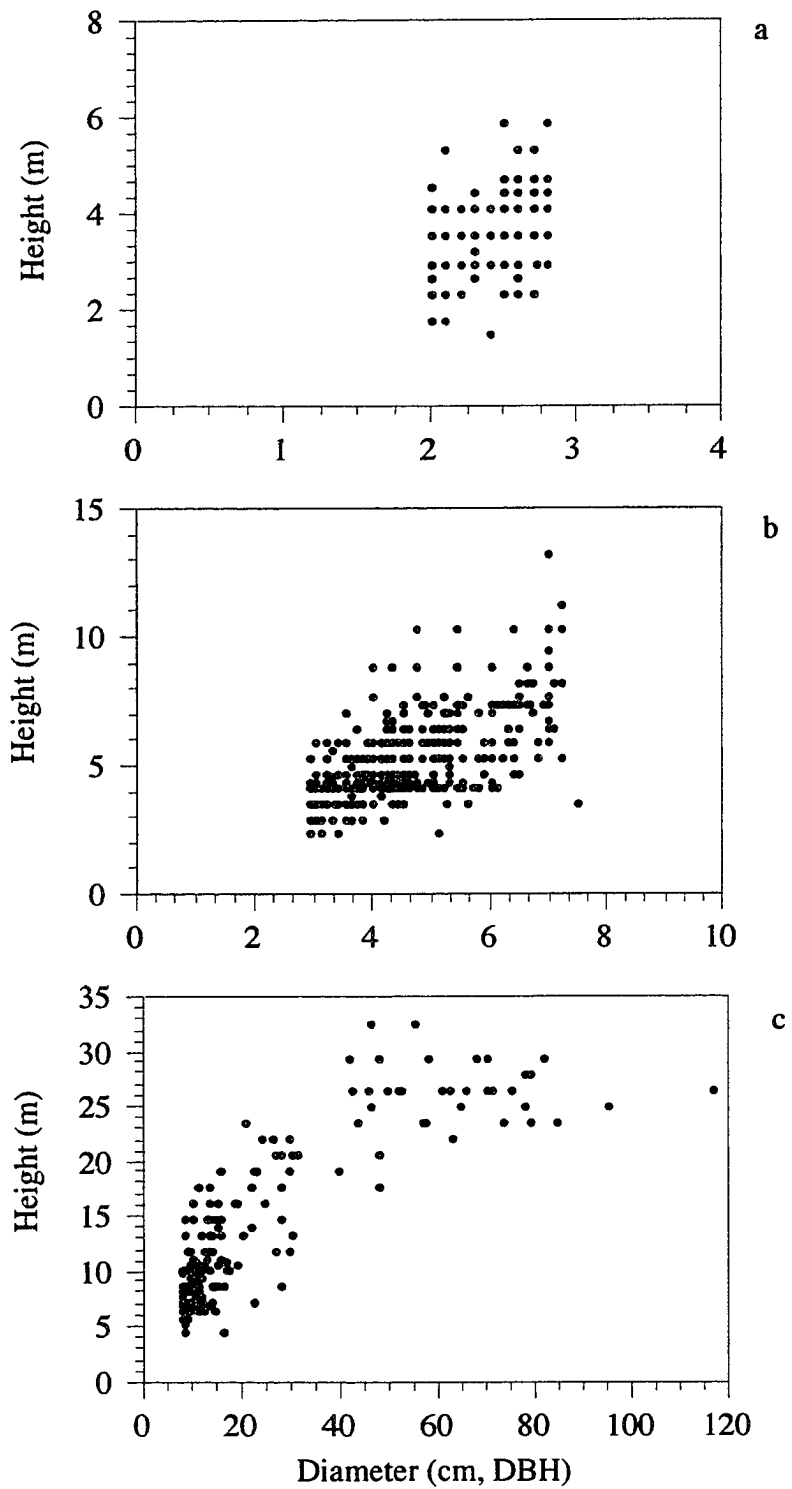


Figure 3.3 Diameter versus Height scattergram of woody stems in the 0.5 ha plot in Forest Park by diameter classes; (a) small-size class (2.0–2.8 cm), n=202; (b) mid-size class (2.8–7.48 cm), n=372 and (c) large-size class (7.48–116.7 cm), n=197.

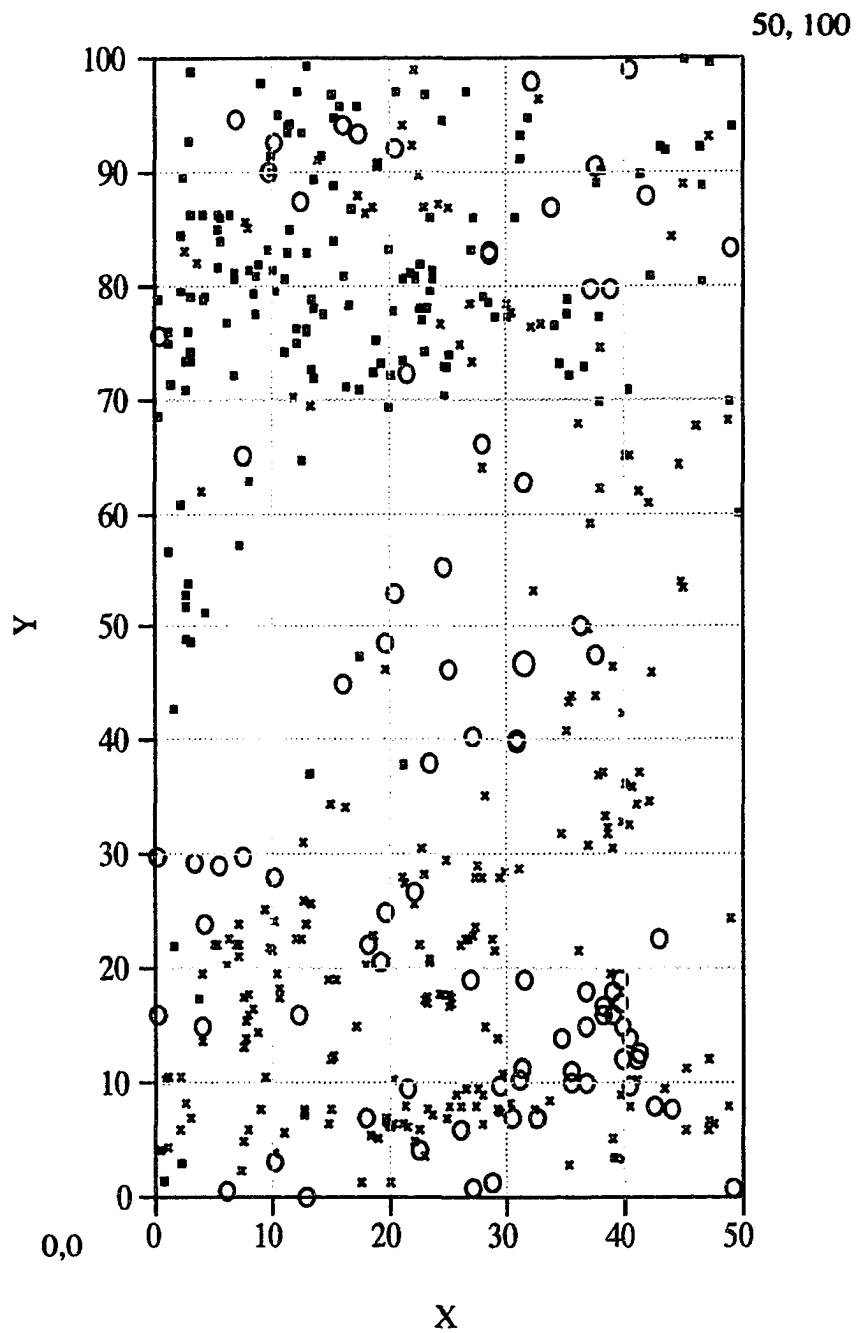
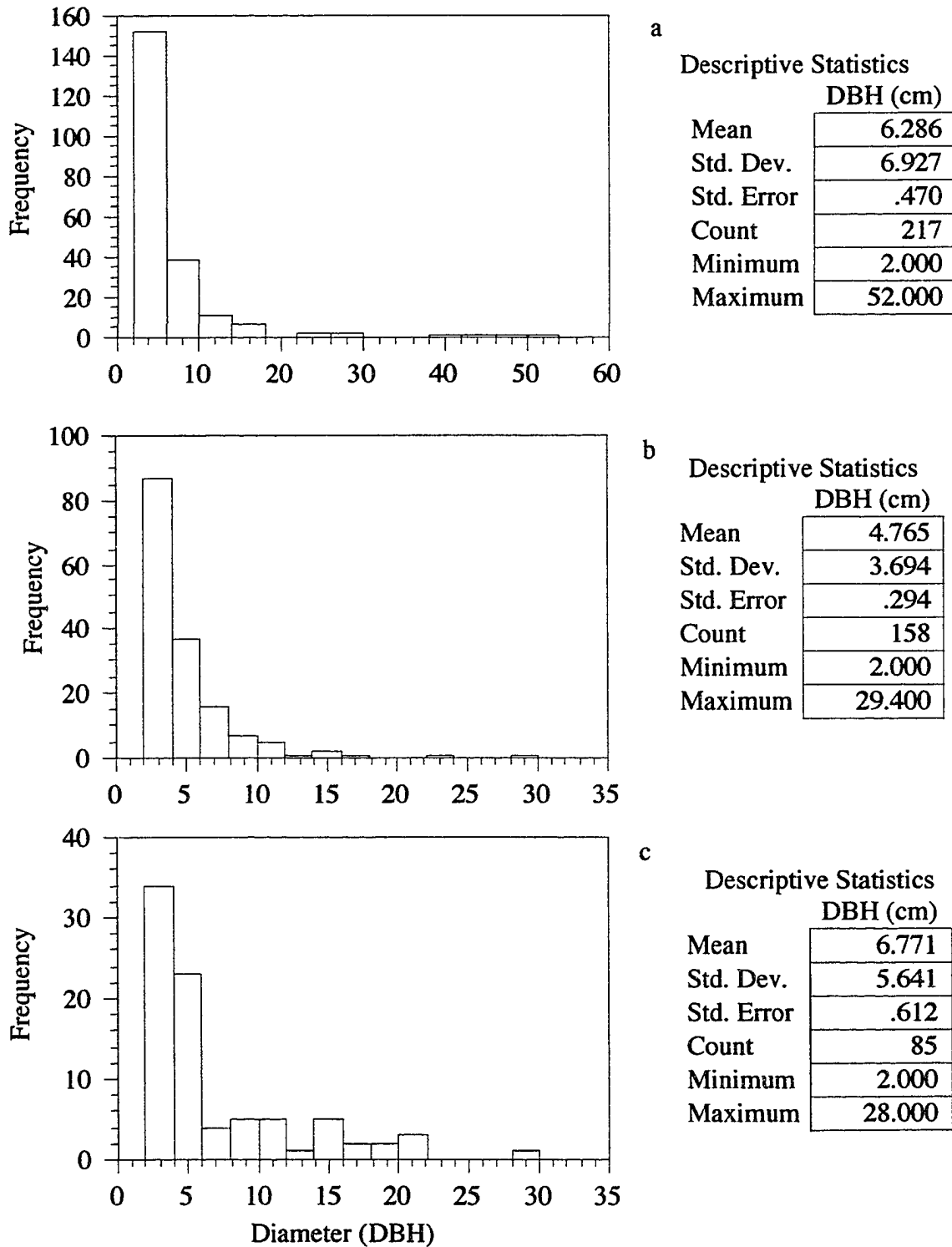


Figure 3.4 Spatial point pattern of three gap-phase (pioneer) species in the 0.5 ha plot of Forest Park; *Betula lenta* x ; *Phellodendron amurense* ■ ; *Prunus serotina* ○ .



**Figure 3.5** Frequency distributions of tree diameters (DBH) of the three abundant gap-phase species in the 0.5 ha plot in Forest Park; (a) *Betula lenta* (n=217), (b) *Phellodendron amurense* (n=158) and (c) *Prunus serotina* (n=85).

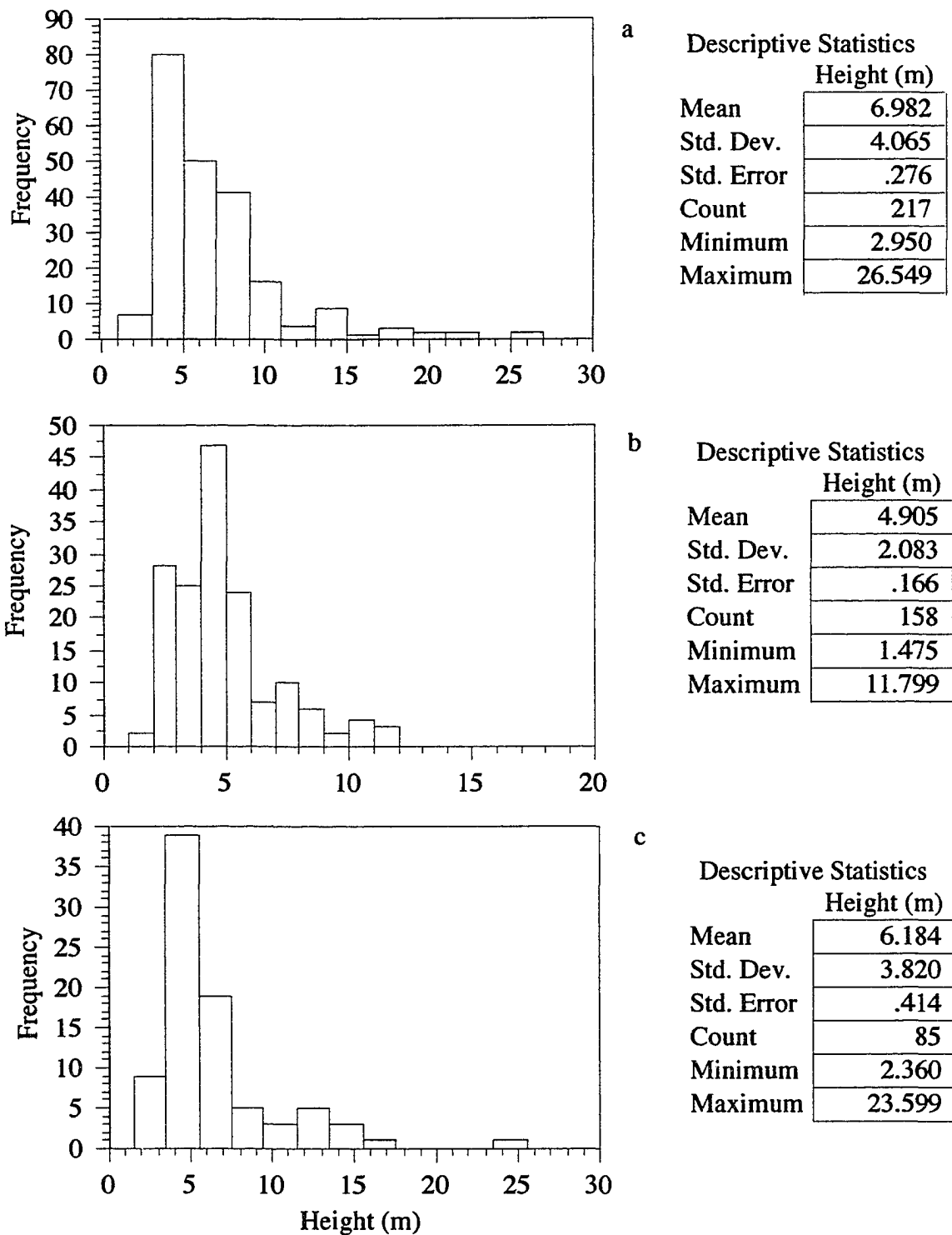


Figure 3.6 Frequency distributions of tree heights (m) of three abundant gap-phase species in the 0.5 ha study plot; (a) *Betula lenta* (n=217), (b) *Phellodendron amurense* (n=158) and (c) *Prunus serotina* (n=85).,

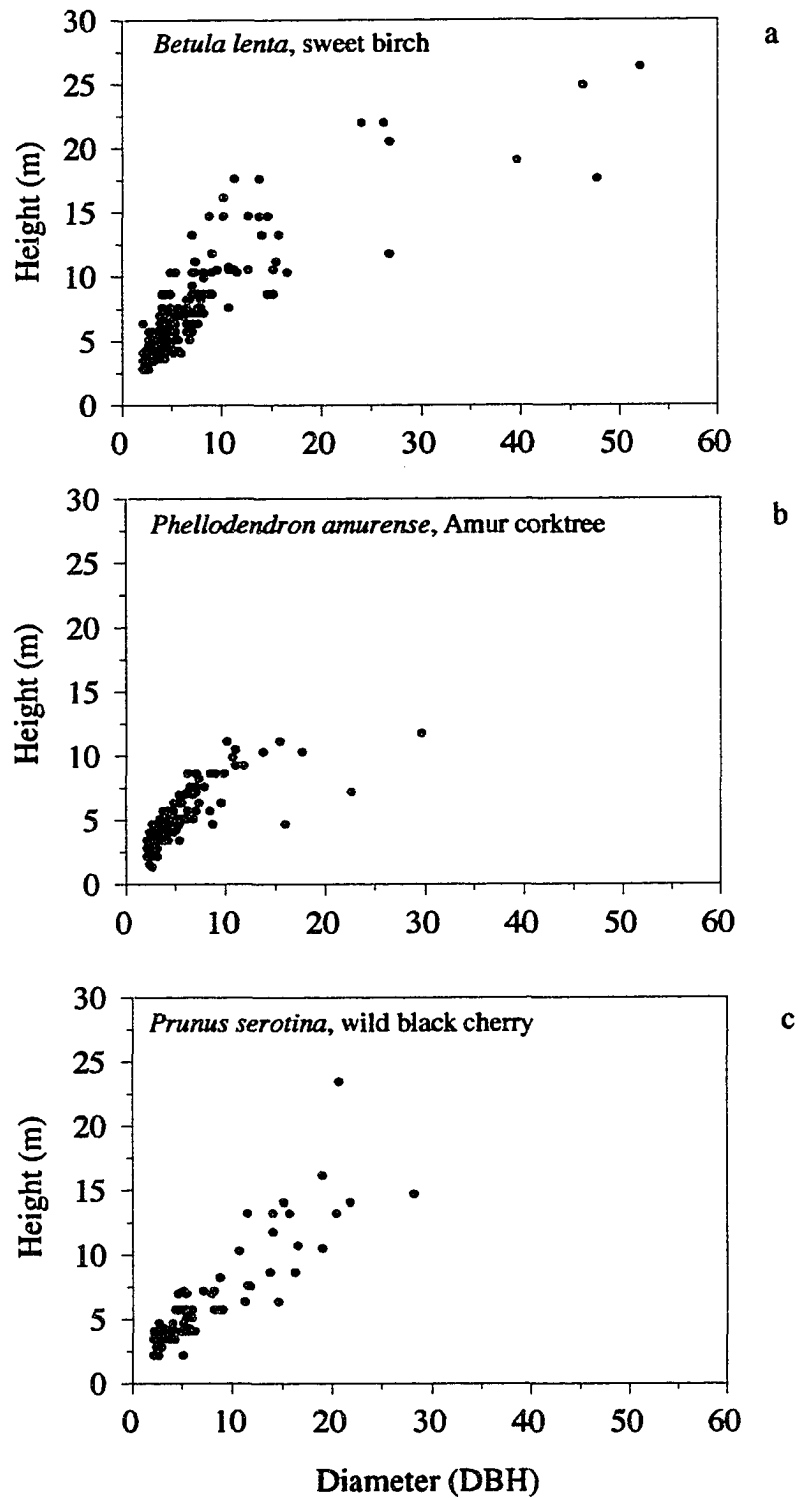


Figure 3.7 Diameter versus Height scattergrams of polynomial regression of gap-phase species in the 0.5 ha plot. (a) *Betula lenta* ( $p < 0.0001$ ,  $n=217$ ), (b) *Phellodendron amurense* ( $p < 0.0001$ ,  $n=158$ ) and (c) *Prunus serotina* ( $p < 0.0001$ ,  $n=85$ ).

Table 3.1 Basic structural characteristics of six ecologically dominant taxa within the 0.5 ha plot in Forest Park, Queens County, NY.

Species	BELE	QURU	PHAM	COFL	QUVE	PRSE	Others	Total
Density (tree ha <sup>-1</sup> )	434	66	316	230	20	170	306	1542
Diameter (cm)								
total trees (0.5 ha <sup>-1</sup> )	217	33	158	115	10	85	153	771
mean	6.29	37.66	4.76	5.98	64.44	6.77	8.41	8.50
standard deviation	6.93	28.46	3.69	4.64	24.47	5.64	13.23	13.44
minimum	2.00	3.00	2.00	2.00	6.40	2.00	2.00	2.00
maximum	52.00	116.70	29.40	30.20	95.00	28.00	81.50	116.70
skewness	4.162	0.651	3.373	2.943	-1.255	1.590	3.849	4.088
Basal Area (m <sup>2</sup> ha <sup>-1</sup> )	1.487	5.713	0.450	0.515	3.685	0.516	2.938	15.30
Composition (BA,%)	9.70	37.33	2.90	3.30	24.07	3.30	19.19	100.00

Species Acronym: BELE- *Betula lenta*; QURU- *Quercus rubra*; PHAM- *Phellodendron amurense*; COFL- *Cornus florida*; QUVE- *Quercus velutina*; PRSE- *Prunus serotina*.

Table 3.2 Taxa of small-size stems (2.0 –2.8 cm) in the 0.5 ha plot in Forest Park by order of ecological dominance ranked by importance values (n=202).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	Importance values (cum.)
<i>Betula lenta</i> L.	54	0.26866 (0.269)	0.20175 (0.202)	0.26501 (0.265)	73.5419 ( 73.542)
<i>Phellodendron amurense</i> Rupr.	49	0.24378 (0.512)	0.16667 (0.368)	0.24407 (0.509)	65.4521 (138.994)
<i>Cornus florida</i> L.	29	0.14428 (0.657)	0.15789 (0.526)	0.14769 (0.657)	44.9866 (183.981)
<i>Prunus serotina</i> Ehrh.	24	0.11940 (0.776)	0.12281 (0.649)	0.12215 (0.779)	36.4360 (220.417)
<i>Vaccinium corymbosum</i> L.	5	0.02488 (0.801)	0.04386 (0.693)	0.02273 (0.802)	9.1467 (229.563)
<i>Sassafras albidum</i> (Nutt.) Nees	5	0.02488 (0.826)	0.03509 (0.728)	0.02691 (0.829)	8.6870 (238.250)
<i>Cornus alternifolia</i> L. f.	6	0.02985 (0.856)	0.02632 (0.754)	0.03038 (0.859)	8.6544 (246.905)
<i>Carya glabra</i> (Miller) Sweet	5	0.02488 (0.881)	0.03509 (0.789)	0.02397 (0.883)	8.3937 (255.298)
<i>Carya tomentosa</i> (Poiret) Nutt.	4	0.01990 (0.900)	0.03509 (0.825)	0.01809 (0.901)	7.3079 (262.606)
<i>Castanea dentata</i> (Marshall) Borkh.	4	0.01990 (0.920)	0.03509 (0.860)	0.01483 (0.916)	6.9820 (269.588)
<i>Carya ovata</i> (Miller) K. Koch	4	0.01493 (0.935)	0.02632 (0.886)	0.01586 (0.932)	5.7103 (275.299)
<i>Quercus alba</i> L.	3	0.01493 (0.950)	0.02632 (0.912)	0.01498 (0.947)	5.6223 (280.921)
<i>Lindera benzoin</i> (L.) Blume	3	0.01493 (0.965)	0.02632 (0.939)	0.01057 (0.957)	5.1810 (286.102)
<i>Fagus grandifolia</i> Ehrh.	2	0.00995 (0.975)	0.01754 (0.956)	0.01381 (0.971)	4.1304 (290.232)
<i>Acer platanoides</i> L.	1	0.00498 (0.980)	0.00877 (0.965)	0.00691 (0.978)	2.0652 (292.298)
<i>Liriodendron tulipifera</i> L.	1	0.00498 (0.985)	0.00877 (0.974)	0.00595 (0.984)	1.9701 (294.268)
<i>Ilex verticillata</i> (L.) A. Gray	1	0.00498 (0.990)	0.00877 (0.982)	0.00550 (0.989)	1.9252 (296.193)
<i>Nyssa sylvatica</i> Marshall	1	0.00498 (0.995)	0.00877 (0.991)	0.00550 (0.995)	1.9252 (298.118)
<i>Rhamnus frangula</i> L.	1	0.00498 (1.000)	0.00877 (1.000)	0.00507 (1.000)	1.8820 (300.000)

Table 3.3 Descriptive statistics of small-size stems (2.0-2.8 cm, DBH) in the 0.5 ha plot in Forest Park ranked by importance values (n=202).

Species	No. of Trees	Quadrats, %	Mean DBH (cm)	Importance value
<i>Betula lenta</i> L.	54	46	2.35	73.54
<i>Phellodendron amurense</i> Rupr.	49	38	2.36	65.45
<i>Cornus florida</i> L.	29	36	2.39	44.99
<i>Prunus serotina</i> Ehrh.	24	28	2.39	36.44
<i>Vaccinium corymbosum</i> L.	5	10	2.26	9.15
<i>Sassafras albidum</i> (Nutt.) Nees	5	8	2.46	8.69
<i>Cornus alternifolia</i> L. f.	6	6	2.38	8.65
<i>Carya glabra</i> (Miller) Sweet	5	8	2.35	8.39
<i>Carya tomentosa</i> (Poiret) Nutt.	4	8	2.25	7.31
<i>Castanea dentata</i> (Marshall) Borkh.	4	8	2.05	6.98
<i>Carya ovata</i> (Miller) K. Koch	4	6	2.43	5.71
<i>Quercus alba</i> L.	3	6	2.00	5.62
<i>Lindera benzoin</i> (L.) Blume	3	6	2.00	5.18
<i>Fagus grandifolia</i> Ehrh.	2	4	2.80	4.13
<i>Acer platanoides</i> L.	1	2	2.80	2.07
<i>Liriodendron tulipifera</i> L.	1	2	2.60	1.97
<i>Ilex verticillata</i> (L.) A. Gray	1	2	2.50	1.93
<i>Nyssa sylvatica</i> Marshall	1	2	2.50	1.93
<i>Rhamnus frangula</i> L.	1	2	2.40	1.88
Sum	202			300.00

Table 3.4 Taxa of mid-size diameter stems (2.8 – 7.48 cm) in the 0.5 ha plot in Forest Park by order of ecological dominance ranked by importance values (n=372).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	Importance values(cum.)
<i>Betula lenta</i> L.	117	0.31452 (0.32)	0.18590 (0.19)	0.31642 (0.32)	81.68 (81.68)
<i>Phellodendron amurense</i> Rupr.	90	0.24194 (0.56)	0.14744 (0.33)	0.22530 (0.54)	61.47 143.15)
<i>Cornus florida</i> L.	55	0.14785 (0.70)	0.17949 (0.51)	0.16191 (0.70)	48.92 192.08)
<i>Prunus serotina</i> Ehrh.	36	0.09677 (0.80)	0.11538 (0.63)	0.09405 (0.80)	30.62 (222.70)
<i>Carya tomentosa</i> (Poiret) Nutt.	18	0.04839 (0.85)	0.08974 (0.72)	0.05311 (0.85)	19.12 (241.82)
<i>Carya ovata</i> (Miller) K. Koch	14	0.03763 (0.89)	0.07051 (0.79)	0.03821 (0.89)	14.64 (256.46)
<i>Sassafras albidum</i> (Nutt.) Nees	11	0.02957 (0.92)	0.05128 (0.84)	0.02560 (0.92)	10.65 (267.10)
<i>Carya glabra</i> (Miller) Sweet	9	0.02419 (0.94)	0.04487 (0.89)	0.02361 (0.94)	9.27 (276.37)
<i>Fagus grandifolia</i> Ehrh.	8	0.02151 (0.96)	0.03205 (0.92)	0.02397 (0.96)	7.75 (284.12)
<i>Quercus rubra</i> L.	4	0.01075 (0.97)	0.01923 (0.94)	0.01153 (0.97)	4.15 (288.27)
<i>Rhamnus frangula</i> L.	2	0.00538 (0.98)	0.01282 (0.95)	0.00603 (0.98)	2.42 (290.70)
<i>Cornus alternifolia</i> L. f.	2	0.00538 (0.98)	0.01282 (0.96)	0.00468 (0.98)	2.29 (292.98)
<i>Vaccinium corymbosum</i> L.	2	0.00538 (0.99)	0.01282 (0.97)	0.00288 (0.99)	2.11 (295.09)
<i>Quercus alba</i> L.	1	0.00269 (0.99)	0.00641 (0.98)	0.00545 (0.99)	1.45 (296.54)
<i>Quercus velutina</i> Lam.	1	0.00269 (1.00)	0.00641 (0.99)	0.00483 (1.00)	1.39 (297.94)
<i>Castanea dentata</i> (Marshall) Borkh.	1	0.00269 (1.00)	0.00641 (0.99)	0.00144 (1.00)	1.05 (298.99)
<i>Acer rubrum</i> L.	1	0.00269 (1.00)	0.00641 (1.00)	0.00099 (1.00)	1.01 (300.00)

Table 3.5 Descriptive statistics of mid-size diameter stems (2.8 – 7.48 cm, DBH) in the 0.5 ha plot in Forest Park ranked by importance values (n=372).

Species	No. of Trees	Quadrats, %	Mean DBH (cm)	Importance values
<i>Betula lenta</i> L.	117	58	4.71	81.68
<i>Phellodendron amurense</i> Rupr.	92	46	4.43	61.47
<i>Cornus florida</i> L.	55	56	4.85	48.92
<i>Prunus serotina</i> Ehrh.	36	36	4.57	30.62
<i>Carya tomentosa</i> (Poiret) Nutt.	18	28	4.83	19.12
<i>Carya ovata</i> (Miller) K. Koch	14	22	4.61	14.64
<i>Sassafras albidum</i> (Nutt.) Nees	12	16	4.62	10.65
<i>Carya glabra</i> (Miller) Sweet	9	14	4.60	9.27
<i>Fagus grandifolia</i> Ehrh.	8	10	4.73	7.75
<i>Quercus rubra</i> L.	4	6	4.78	4.15
<i>Rhamnus frangula</i> L.	2	4	4.80	2.42
<i>Cornus alternifolia</i> L. f.	2	4	4.45	2.29
<i>Vaccinium corymbosum</i> L.	2	4	3.45	2.11
<i>Quercus alba</i> L.	1	2	4.17	1.46
<i>Quercus velutina</i> Lam.	1	2	6.40	1.39
<i>Castanea dentata</i> (Marshall) Borkh.	1	2	3.50	1.05
<i>Acer rubrum</i> L.	1	2	2.90	1.01
Sum	372			300.00

Table 3.6 Taxa of large-size diameter stems (7.48 – 116.70 cm) in the 0.5 ha plot in Forest Park by order of ecological dominance ranked by importance values (n=197).

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	Importance value (cum.)
<i>Quercus rubra</i> L.	29	0.14721 (0.147)	0.16312 (0.163)	0.39213 (0.392)	70.25 (70.25)
<i>Betula lenta</i> L.	46	0.23350 (0.381)	0.19149 (0.355)	0.08613 (0.478)	51.11 (121.36)
<i>Quercus velutina</i> Lam.	9	0.04569 (0.426)	0.04965 (0.404)	0.25304 (0.731)	34.84 (156.20)
<i>Cornus florida</i> L.	31	0.15736 (0.584)	0.14894 (0.553)	0.02711 (0.758)	33.34 (189.54)
<i>Prunus serotina</i> Ehrh.	25	0.12690 (0.711)	0.12766 (0.681)	0.03041 (0.789)	28.50 (218.03)
<i>Quercus alba</i> L.	9	0.04569 (0.756)	0.05674 (0.738)	0.12883 (0.918)	23.12 (241.16)
<i>Phellodendron amurense</i> Rupr.	19	0.09645 (0.853)	0.08511 (0.823)	0.01912 (0.937)	20.07 (261.23)
<i>Carya tomentosa</i> (Poir.) Nutt.	11	0.05584 (0.909)	0.06383 (0.887)	0.01052 (0.947)	13.02 (274.25)
<i>Carya glabra</i> (Miller) Sweet	6	0.03046 (0.939)	0.03546 (0.922)	0.00914 (0.956)	7.51 (281.75)
<i>Fagus grandifolia</i> Ehrh.	3	0.01523 (0.954)	0.02128 (0.943)	0.03738 (0.994)	7.39 (289.14)
<i>Carya ovata</i> (Miller) K. Koch	4	0.02030 (0.975)	0.02837 (0.972)	0.00302 (0.997)	5.17 (294.31)
<i>Sassafras albidum</i> (Nutt.) Nees	4	0.02030 (0.995)	0.02128 (0.993)	0.00222 (0.999)	4.38 (298.69)
<i>Cornus alternifolia</i> L. f.	1	0.00508 (1.000)	0.00709 (1.000)	0.00094 (1.000)	1.31 (300.00)

Table 3.7 Descriptive statistics of large-size diameter stems (7.48-116.7 cm, DBH) in the 0.5 ha plot in Forest Park ranked by importance values (n=197).

<u>Species</u>	No. of Trees	Quadrats, %	Mean DBH (cm)	Importance value
<i>Quercus rubra</i> L.	29	46	42.2	70.25
<i>Betula lenta</i> L.	46	54	15.63	51.11
<i>Quercus velutina</i> Lam.	9	14	70.89	34.84
<i>Cornus florida</i> L.	31	42	11.54	33.34
<i>Prunus serotina</i> Ehrh.	25	36	14.14	28.5
<i>Quercus alba</i> L.	9	16	44.05	23.12
<i>Phellodendron amurense</i> Rupr.	19	24	12.53	20.07
<i>Carya tomentosa</i> (Poiret) Nutt.	11	18	12.75	13.02
<i>Carya glabra</i> (Miller) Sweet	6	10	15.93	7.51
<i>Fagus grandifolia</i> Ehrh.	3	6	41.83	7.39
<i>Carya ovata</i> (Miller) K. Koch	4	8	11.43	5.17
<i>Sassafras albidum</i> (Nutt.) Nees	4	6	10.7	4.38
<i>Cornus alternifolia</i> L. f.	1	2	13.2	1.31
Sum	197			300.00

Table 3.8 Basic structural characteristics of three ecologically dominant taxa within each of the diameter size classes in the 0.5 ha Forest Park plot.

Species	Small-size			Mid-size			Large-size			Others	Total
	BELE	PHAM	COFL	BELE	PHAM	COFL	QURU	BELE	QUVE		
Density (Tree ha <sup>-1</sup> )	108	98	58	234	180	110	58	92	18	586	1542
Diameter (cm, dbh)											
total trees (0.5 ha <sup>-1</sup> )	54	49	29	117	90	55	29	46	9	293	771
mean	2.35	2.36	2.39	4.64	4.43	4.85	42.20	15.10	70.89	8.46	8.50
standard deviation	0.26	0.27	0.27	1.20	1.27	1.22	27.38	11.02	14.35	10.43	13.36
minimum	2.00	2.00	2.00	2.90	2.90	2.90	8.50	7.50	49.50	2.00	2.00
maximum	2.80	2.80	2.80	7.20	7.10	7.48	116.70	52.00	95.00	81.50	116.70
skewness	0.19	-1.38	0.16	0.58	-0.69	0.30	0.58	2.13	0.19	4.21	4.08
Basal Area (m <sup>2</sup> ha <sup>-1</sup> )	0.236	0.217	0.131	2.10	2.78	1.07	57.05	12.53	36.81	40.11	153.04
Composition (BA, %)	0.150	0.140	0.080	1.37	1.82	0.699	37.27	8.18	24.05	26.22	100.00

Species Acronyms: BELE- *Betula lenta*; COFL- *Cornus florida*; PHAM- *Phellodendron amurense*; QURU- *Quercus rubra*; QUVE- *Quercus velutina*.

## Chapter 4

### **Initial findings on the non-native invasive *Phellodendron amurense* Rupr. in Forest Park, Queens, New York.**

#### I. Introduction

Among ecologists there is a growing belief that in the long-term, the impact of non-native invasive species may rank second only to habitat destruction as threats to local biodiversity (Elton 1958; Vitousek and Walker 1989; Cronk and Fuller 1995; Cox 1999; Reichard and White 2001). This applies to our temperate urban forests as it does to tropical and aquatic ecosystems. Over the centuries, non-native species of plants have been introduced in New York City to the extent that they now exist as 42% to 48% of the higher (vascular) plant species present in some local forests (Yost et al. 1991; Stalter et al. 2000). The majority of woody plant introductions into the United States were for horticultural purposes. Most of the plants that have been introduced are not invasive, however a small proportion escaped cultivation and became pests in natural areas (Reichard and White 2001). Here I report on one of these non-native invasive species, *Phellodendron amurense* Rupr..

In 1856 this species was intentionally introduced into the United States in appreciation of its attractive and interestingly flat-topped crown (Dirr 1990). Alarming, and despite the knowledge of its ability to invade natural plant communities the Amur corktree was endorsed and promoted by the USDA Forestry Service as late as 1994 as a species suitable for a range of growing conditions that includes the entire continental United States with no mention of any invasive potential (Gilman and Watson 1994). Citing the seriousness of invasive plants many governmental and non-governmental organization websites addressed the ecological impacts of biologically invasive species including recommendations for control (Hiebert and Stubbendiek 1993). However, and to this day few list *P. amurense* in their plant databases or discuss its ecological status and degree of invasiveness. These organizations include, the Animal and Plant Health Inspection Service (USDA-APHIS), the Agricultural Research Service- Invading Database System (USDA-ARS), Natural Resources Conservation Service- National Plant Data Center (USDA-NRCS, [www.plants.usda.gov/plants](http://www.plants.usda.gov/plants)), The Nature Conservancy ([www.tncweeds.ucdavis.edu/alert/archive](http://www.tncweeds.ucdavis.edu/alert/archive)) and the Global Compendium of Weeds ([www.hear.org/gcw](http://www.hear.org/gcw)).

The New York Metropolitan Flora Project (NYMFP) website of the Brooklyn Botanic Garden as of April 2003 does not list *P. amurense* but cites only *P. japonicum* as

non-native, non-invasive and rare. The published version of the NYMFP (1999) lists both *P. amurense* and *P. japonicum* but with no reference to its invasive character. The New York Botanic Garden, Bronx, NY has one website link to a Federal and State Noxious Weed List. This list contains only herbaceous non-native invasives and excludes common local arborescent “noxious” invasives such as *Acer platanoides*, *Ailanthus altissima* and *Phellodendron amurense*. In the “Invasive Plants of the United States” subsection of the NYBG Virtual Herbarium (from a list prepared by the USDA) *P. amurense* was not listed. NYBG also has a large naturalized population of Amur corktree along the Bronx River within the garden and along the adjacent Bronx River Park. This population is likely to have escaped cultivation from their ornamental corktree collection located elsewhere in the garden.

Non-native plant taxa are termed “invasive” if they persist as large, widely distributed, and self-sustaining populations that occur within successional mature, plant communities. The term “naturalized” refers to non-native taxa persisting as self-sustaining populations. Invasives are of course naturalized but not all naturalized plant taxa become invasives. While all naturalized non-native plants are successful in colonizing roadsides, open parkland and the disturbed edges of fragmented urban forests, some invasives may permanently insert themselves into the successional rhythms of the

forest interior as well as being abundant at the chronically disturbed forest edge. A non-native plant species is “escaped” from cultivation if individuals occasionally can be found growing in spots where they were not planted by humans. “Cultivated” refers to the situation where every single individual of a non-native species is present as a result of having been planted horticulturally. Thus, for non-native species of plants we have the continuum: cultivated => escaped => naturalized => invasive, exemplified by *Ginkgo* (cultivated), English ivy (occasionally escaped), white mulberry (naturalized), and Japanese honeysuckle (invasive) as NYC woody plant examples, respectively.

From the land management perspective in NYC, many non-native plant species are difficult to control, much less eradicate. Control becomes a year-round task for managers in the agricultural, forestry, and horticultural sectors with treatment relying on intensive labor and the application of toxic organophosphate herbicides. Permanent control of many invasive species of plants is highly improbable (Elton 1958). This is due to the large numbers of adult plants with rapid growth rates yielding copious numbers of seeds that are well-dispersed by wind and/or by animals, that long-persist in the soil and germinate easily. Local eradication may simply create environmental conditions favorable for recolonization by the eradicated. Once “escaped” from cultivation and firmly established in an ecosystem, invasive plant taxa often reduce local biodiversity by

exterminating native plant taxa by simply taking up “space” in the community (pre-emptive competition) by virtue of their much wider ecological niches, seasonally expanded phenology, rapid apical growth, often potent chemical defenses and high fecundity.

Well-known to the layperson, Norway maple (*Acer platanoides*) is a prime example of an invasive tree species in the urban forests of NYC that reduces local biodiversity of plants and animals (Webb and Kaunzinger 1993; Kloepfel and Abrams 1995; Anderson 1999; Martin 1999; Webb et al. 2001). Despite its beauty, NYC botanists and ecologists hold Norway maple in contempt because it can maintain itself across all vertical strata of our forests, thus exterminating native species of trees adapted to and restricted to the mid-understory (e.g., flowering dogwood, sassafras, witch hazel and holly) and exterminating native shrubs (e.g., blueberry and spicebush). These native mid-canopy trees and lower-level shrubs produce a heterogeneous array of seeds and fruits that sustain wildlife. In the absence of Norway maple, they would fill these vertical niches.

Norway maple may be contrasted with another extremely abundant and well-known non-native, shade intolerant species from Asia, tree-of-heaven (*Ailanthus altissima* (Miller) Swingle) (Hu 1979). Lacking the botanical beauty of Norway maple,

tree-of-heaven as “the” weedy-tree of NYC, nevertheless graces many an otherwise barren patch of concrete, fence-row, waste lot and alleyway. It is naturalized in NYC and elsewhere but not invasive into the interior of forests. However, Knapp and Canham (2000) recently identified the strong canopy potential of tree-of-heaven in interior forest gaps in Dutchess County, NY. Does the hardly noticed, Amur cork tree have the potential to follow the Norway maple or the tree-of-heaven model.

## II. Taxonomy and Invasion History

*Phellodendron amurense* is native to the forests of northern China, Manchuria, and Japan. It is one of a group of nine related species of trees from east Asia introduced into the United States by the horticulture industry for street trees or ornamental shade trees in parks, arboreta, botanical gardens and cemeteries (Rehder 1940; Table 4.1). *P. amurense* may grow 11-15 m high with an even greater spread of its crown. The tree synthesizes aromatic ethereal oils giving it a pungent sweet-sour aroma. It is dioecious with female trees flowering in June and bearing seed in October. A recent 2002 report on noteworthy plants in the New York portion of the “Torrey range” cites *P. amurense* as invasive in two known locations- the grounds of the New York Botanical Garden and in Forest Park (Lamont and Young 2002).

A technical description of *Phellodendron amurense* follows. Deciduous dioecious trees, 10-20 m tall with thick, deeply fissured corky bark; branches thick, glabrous. Leaves, turpentine-like odor when bruised, opposite, petiolate 20-30 cm long; leaflets 5-13 membranaceous, narrowly ovate or oblong-ovate, 4-12 cm long, 1.5-5.0 cm wide, apex caudate-acuminate, base rounded or obliquely obtuse; margins minutely serrate, lower surface glaucous when young and usually almost glabrous, but when young usually ciliate, rarely slightly pubescent near base (Figure 4.2). Inflorescences terminal on branches, cymes, 7-14 cm long, 5-8 cm across, axes nearly glabrous, pedicel short. Flowers in June, 6 mm long in puberulous panicles 6-8 cm. Petals oblong or narrowly ovate 4 mm long, white pubescent inside. Stamens 5; filaments with white hairs at base, reduced and scaly in female flowers. Pistil 1, reduced in male flowers, ovary 5-loculed; ovule one in each locule. Fruits ripen in September and October. Drupes, nearly globose, ca. 1 cm across, blackish, stones 5, 1 seeded, seeds with scant endosperm. Chromosome number  $2n = 80$ . *P. amurense* is a tree grown for their handsome foliage turning yellow in Autumn. Introduced about 1856. Zone III. Greek *phellos*- cork, and *dendron*-tree, referring to the corky bark (Rehder 1940; Iwatsuki et al. 1999).

A taxonomic disparity exists among the genus not because of differences in inflorescence, twigs or bark but in its vegetative variability. Degrees of leaf pubescence

or glabrousness varies on all corktrees and is speculated to be phenotypic plasticity.

The corktree has been referred to by most NYC Department of Parks Forest Park

publications as *Phellodendron amurense*. Other species of corktree may exist in Forest

Park. Grellier (1979) cited this taxa as *P. japonicum* and that it grew in Forest Park.

Keying the taxon from several references by local taxonomists has failed to reveal any

differences between Grellier's *P. japonicum* and *P. amurense* (personal communication,

Dr. Jinshuang Ma). Dr. Jinshuang Ma hypothesizes that thickness of the corky bark may

distinguish the *Phellodendron* species, though this needs to be tested. I refer to this tree

as *Phellodendron amurense* with a confirmation by Dr. Jinshuang Ma (BBG). Molecular

tests are being pursued by matching woodland leaf samples with samples from

taxonomically verified living collections at the Brooklyn Botanic Garden (Glaeser and

Matthews, unpublished).

In China, seed dispersal is by natural seed fall adjacent to the parent tree as

augmented by the birds *Bombycilla ganrula centralasiae* and *Turdus* spp.. Its

topographic range is 10 -1140 m in Japan to 700 m in north China (PRC) and up to 1500

m in south China (Ning and Dafang 1990). In Hokkaido, Japan, *P. amurense* is a rapidly

growing, shade -intolerant, pioneer that regenerates immediately after disturbance on

mesic sites. They are fast growing in early years and are able to escape rapidly from

competing vegetation (Ishizuka and Sugawara 1989; Yoshida and Kamitani 1999). In a mixed stand *P. amurense* had relative basal area of 4.7% and a density of 188.9 stems  $\text{ha}^{-1}$  (Namikawa et al. 1997). Along riparian corridors in *Quercus-Ulmus* forests of central Japan, *P. amurense* occurred in small patches among mature tree populations. It is light demanding, fast-growing and has dormant seeds with a longevity of ten years or more (Sakai et al. 1999). In contrast, I observed that *P. amurense* becomes established in disturbed mesic sites in full sun in Forest Park (Figure 4.2).

The Amur cork tree has been planted as a street and shade tree throughout the five boroughs and along roadways of NYC (Figure 4.3). I have observed it in the New York Botanical Garden (Bronx, NY) and the Brooklyn Botanical Garden as a living specimen, as a grove of shade-trees in Cypress Hills National Cemetery, Queens and within many of the regional NYC parks and playgrounds (e.g., Prospect Park, Kings County; Kissena Park, Queens County).

The NYC Department of Transportation planted *P. amurense* along the Interboro Parkway in 1935 (NYC DPR 1990). The population apparently was apparently the seed source for the gradual movement of this species into the woods of Forest Park where it appears to have established self-sustaining populations. Forest Park is a 217.8 ha (538 ac.) regional park with a 167.14 ha continuous woodland. It lies to the southwest of

Queens County (42°30' north latitude and 73°51' west longitude). The topography is knob and kettle with elevation ranging from 31m to 55 m above sea level. Managed by the New York City Department of Parks and Recreation and other city agencies, the woods were described as a predominantly oak, mixed-dicot dogwood type forest with *Quercus rubra* (red oak) and *Q. velutina* (black oak) as visually dominant (Table 4.2)

This species has been the subject of no scientific study into its ecology as a relatively recent invader of the forests of NYC. Observing the abundance of this taxon in the woods of Forest Park, several questions arose on its ecological role and impact.

(1) What is the population dynamics of this taxon? (2) What is its ecological ranking compared to the native taxa? (3) How does its current phenology compare to that within its native range? (4) How does it compare with the density and frequency of its neighbors? (5) Based on quantitative information, statistical analysis and bootstrap sampling can we predict the future ecological impact of this species on the urban forest at Forest Park?

I pursue these questions within the framework of a multi-year quantitative ecological census of all the woody plants in a permanent, 0.5 ha study plot. A separate report/chapter on Amur corktree is needed because of its status as a non-native invasive

species within a predominantly native hardwood stand. I report my initial findings for *Phellodendron amurense*.

### III. Methods

In Fall 1999 a 50 x 100 m study plot (0.5 ha) was established by a professional surveyor in a centrally located section of the 29 ha Northern Woods of Forest Park, approximately 600 m south from the Jackie Robinson Parkway (Interboro Parkway). Divided into 50- 10 x 10 m subplots, a full census was performed and all 771 woody plants of  $\geq 2.0$  cm (diameter at breast height). Trees were identified to species, given serial numbers, measured for DBH and height, and located by x,y coordinates. Data analysis was performed using Statview, (SAS) JMP and computer programs written by Dwight Kincaid. Nomenclature of taxa were according to Gleason and Cronquist (1993).

### IV. Results

*Phellodendron amurense* was represented by 158 trees, an astounding 20.8% of all the trees in the 0.5 ha plot. A sex ratio was determined. Of the 158 individuals 13.29% were fruiting females and 86.7% were either juvenile females or males. This sex ratio is expected to change over the next few years as the gender of more trees is

determined. A dotmap of the distribution of corktree stems with comparative fruiting versus non-fruiting trees is presented in Figure 4.5. In terms of summed tree trunk basal area, a reasonable and conventional measure of ecological dominance, *P. amurense* accounted for only 3%; but the trees are young, reflecting their small size and are a recent wave of invasion from the adjacent Jackie Robinson (Interboro) Parkway.

Amur corktree was ranked for ecological dominance with the other taxa in the study plot by species importance values (IV). Of the top ten of twenty-two overall taxa identified by the woodland census, *P. amurense* ranked third in ecological dominance with an IV of 33.34 (Table 4.3). Interestingly and despite the high IV ranking when compared with mean DBH, *P. amurense* has the lowest mean diameter of the top ten taxa (Table 4.4).

#### IV.1 Stem Density

Stem density of *P. amurense* was 316 stems ha<sup>-1</sup>, a relative density of 20.49% and a 2.9% basal area (0.450 m<sup>2</sup> ha<sup>-1</sup>). This was second to *Betula lenta* that had a stem density of 434 stem ha<sup>-1</sup>, a relative density of 28.14%, a basal area of 9.6% (relative dominance). The second taxon of ecological dominance was *Quercus rubra* with a stem density of 66 stems ha<sup>-1</sup>, relative density of 4.28% and a 37.11% basal area (relative

dominance). Ominous for the future composition of the forest is the currently very low 2.9% basal area (relative dominance) of Amur corktree as this biomass is supplied by its very high, 20.49% relative abundance (relative density) of individuals (Table 4.3).

The 158 trees of Amur corktree comprised 20.49% of the 771 total trees in the 0.5 ha plot. We wish to make inference from the observed statistic of 20.49% to Forest Park as a whole. Therefore, the 50 quadrats were bootstrapped 500,000 times to yield 95% confidence intervals for the 20.49% using the bootstrap percentile method (see below and Appendix A).

Category	Observed	95% Confidence Interval	Max, Min. of Sampling Distribution
Amur corktree, n=158	20.49%	11.91%, 30.97%	3.69%, 49.11%
All trees, n=771	771	664, 879	551, 1027

Bootstrap confidence intervals were determined for the total density of 771 trees by the same method (NS=10,000)(Figure 4.10). *P. amurense* importance value 95% confidence intervals overlaps with *Q. rubra*, *C. florida* and *Q. velutina*. The upper limit of the confidence interval for the IV of *P. amurense* ( $L_2 = 35.22$ ) is much lower than the upper limit for *B. lenta* ( $L_2 = 47.75$ ). This suggests that in terms of inferential ecological

dominance for NYC forests, the dominant ranking of Amur corktree may be from IV rank number 2 to rank number 6.

Paired t-tests for differences in mean tree density were performed for the most abundant taxa in the 50 quadrats with *P. amurense* compared to other abundant taxa (Table 4.6 and Table 4.6.a).

#### IV.2 Diameter Distribution

Diameter size class was determined by the application of quartiles that resulted in an upper and lower 25% of the population (Table 4.6). Quartiles produced a small-size diameter class range of 2.0–2.6 cm (n= 43, mean DBH 2.30 cm, SD 0.235), a mid-size diameter size class range of 2.6-5.25 cm (n= 72, mean DBH 3.71cm, SD 0.738) and large-size diameter class range of 5.3 – 29.4 cm (n=43, mean DBH 8.98 cm, SD 4.87). Frequency distributions for the three diameter classes were determined (Figure 4.7(a-c)). A low sample size (n) within each of the size-classes resulted in a negative kurtosis (platykurtic curve) for both small and mid-size diameters. (–1.542 and –1.048, respectively)(Figure 4.7.a and b). Small diameter (Weibul fit,  $p < .01$ ) and mid diameter (Weibul fit,  $p < 0.01$ ). The large diameter distribution displayed a greater abundance of trees within the 5.0 - 7.0 cm histogram interval (Weibul fit,  $p < 0.01$ )(Figure 4.7.c).

For the small-size diameter class a frequency distribution with a histogram interval of 0.25 cm diameter was applied. This yielded a peak 44% representation of small Amur corktrees within the histogram interval of 2.0-2.25 cm. This was followed by a 23.25% representation within the 2.25-2.50 cm interval and a 32.5% representation within the 2.5-2.75 cm interval. Of the platykurtic mid-size diameter class, the first four histogram intervals were relatively constant representing 19.4%, 22.2%, 19.4 and 20.8% of the mid-size population. The large-size diameter distribution with a histogram intervals of 2.0 cm resulted in a 20.9% representation within the 4.0-6.0 cm interval and a peak 37.2% representation in the 6.0-8.0 cm. The frequency of individuals decreased in the intervals from 8.0-30.0 cm. See Table 4.5 for comparative descriptive statistics for each of the diameter size classes.

A few trees of Amur cork have achieved nearly dominant canopy positions since the “inoculation” of Amur cork in this local area of Queens in 1935 (e.g. trees adjacent to the Jackie Robinson Parkway). The current, modal DBH size class is 2.0 to 4.0 cm (89 out of 158 trees) and stems  $\leq 8.0$  cm DBH comprise 89% of the Amur cork sample. The current, modal size class for tree height is 4.0 to 5.0 m (48 out of 158 trees) with a maximum height of 11.79 m (Figure 4.6b).

---

#### IV.3 Vertical Structure

As determined from the diameter distribution above *P. amurense* is a relatively young population. This is equally expressed by the height distribution (vertical structure) where the larger percentage of trees are < 6.0 m height. The height distribution range is 1.47 – 11.79 m (mean height 4.9, SD 2.08)(Figure 4.6b). The most abundant corktrees are within the 4.0 – 5.0 m histogram height interval representing 29.7% of the corktree population. The next group of abundant trees are within the 2.0-3.0 m histogram interval that represented 17.7% of the corktree population. Overall, 80% of the corktrees are between 1.47 – 6.0 m height (Weibull fit,  $p < 0.01$ ).

#### IV.4 Regression Analysis

A polynomial regression test was performed for tree diameter and height that formed a scattergram plot (Figure 4.6c). The resulting coefficient of determination ( $r^2 = 0.742$ ,  $p < 0.0001$ ) for polynomial fit improved over the simple regression test. Polynomial regression tests was performed again after the elimination of two stunted trees from the dataset (noted as outliers) to determine if they influence the fit test. The polynomial fit resulted in  $r^2 = 0.821$ ,  $p < 0.0001$

## V. Conclusion

Frequent disturbances from tree falls, tree deaths, brush fires, and human trampling in the Forest Park woodland may be responsible for the abundance tree species associated with disturbed sites (e.g., *Betula lenta*, *Prunus serotina* and *P. amurensis*). Trees adapted to disturbance quickly fill newly opened canopy space by advance regeneration (growth release of long-suppressed trees (maples)), clonal spread (sassafras) or by abundant seed production (black cherry, sweet birch). Just how such rapidly invasive species like *P. amurensis* manage to out-colonize our native colonizers has not been determined. The probability of successful invasions however seems to be crucially dependent on the extent and type of disturbance, on the number of non-native propagules deposited on the community per year and how long the community is exposed to the import of propagules (Rejámnek 1989).

Obviously, if the relatively small trees of *P. amurensis* mature in the woodland to the sizes they are capable of in their natural range in eastern Asia and to the sizes of planted Amur cork that presently exist along the nearby roadside of the Jackie Robinson Parkway (Interboro Parkway), then the ecological dominance and the structure of this urban forest will shift by extermination away from dominance by native species of trees.

Five mature Amur corktrees located along the edge of the adjacent Jackie Robinson Parkway achieved considerable diameter size (mean DBH 55.25 cm, SD 18.36) and tree height (mean height 14.41 m, SD 2.16). Trees of this size class have not yet been identified within the woodland interior. Amur corktree has been identified as a shade-intolerant species within its native range in China and Japan. It is likely that its success throughout Forest Park as an invader may be due to shade-tolerance rather than intolerance. This paradigm needs to be explored further. Regardless, since entering the vicinity of Forest Park in 1935 the Amur cork tree has already achieved a substantial foothold in the woods of Forest Park, with an estimated 21% share of the trees, presuming the 0.5 ha plot is representative.

The bootstrap 95% confidence intervals of the observed 20.49% relative density of Amur corktree indicate that parametric relative density of this species for all of Forest Park may range as low as 11.9% to as high as 31.0% of all trees. Interestingly, from the bootstrap sampling distribution (NS=500,000) of Amur corktree relative density, the minimum relative density was 3.69% and the maximum of 49.11%. Bootstrap 95% confidence intervals was similarly applied to species importance values (IV). This revealed that, in terms of ecological dominance *P. amurense* can have a potential

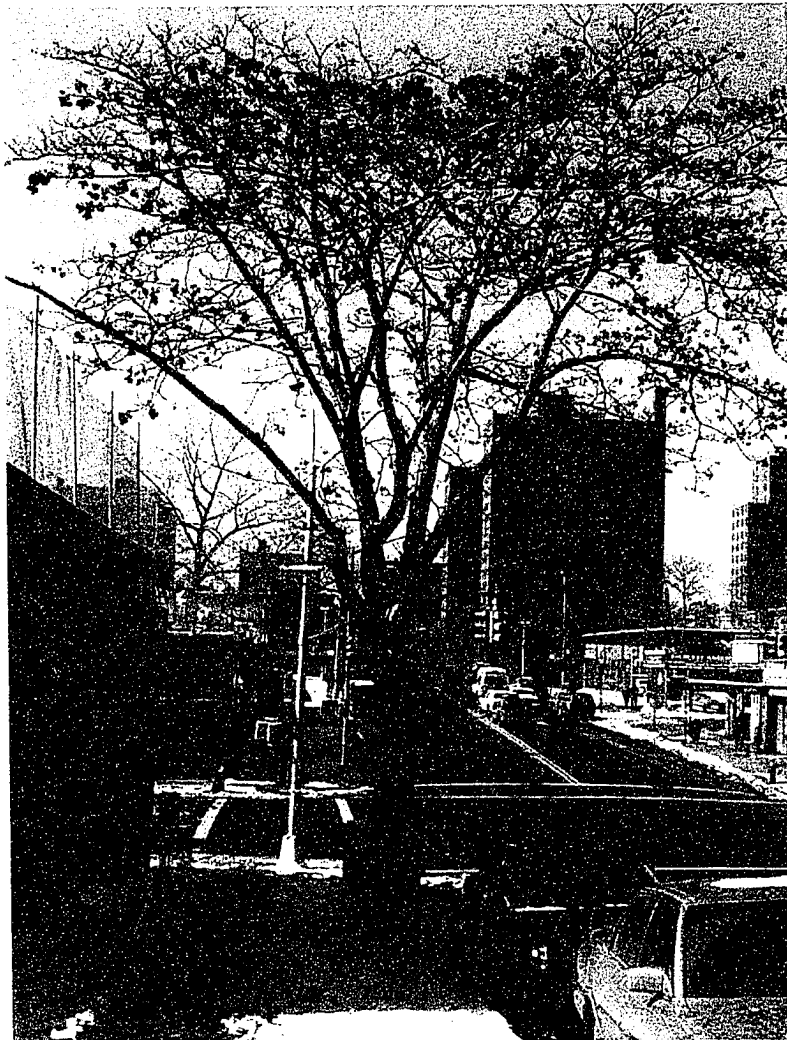
dominance ranking that potentially ranges from rank two or less or, to rank five or more.



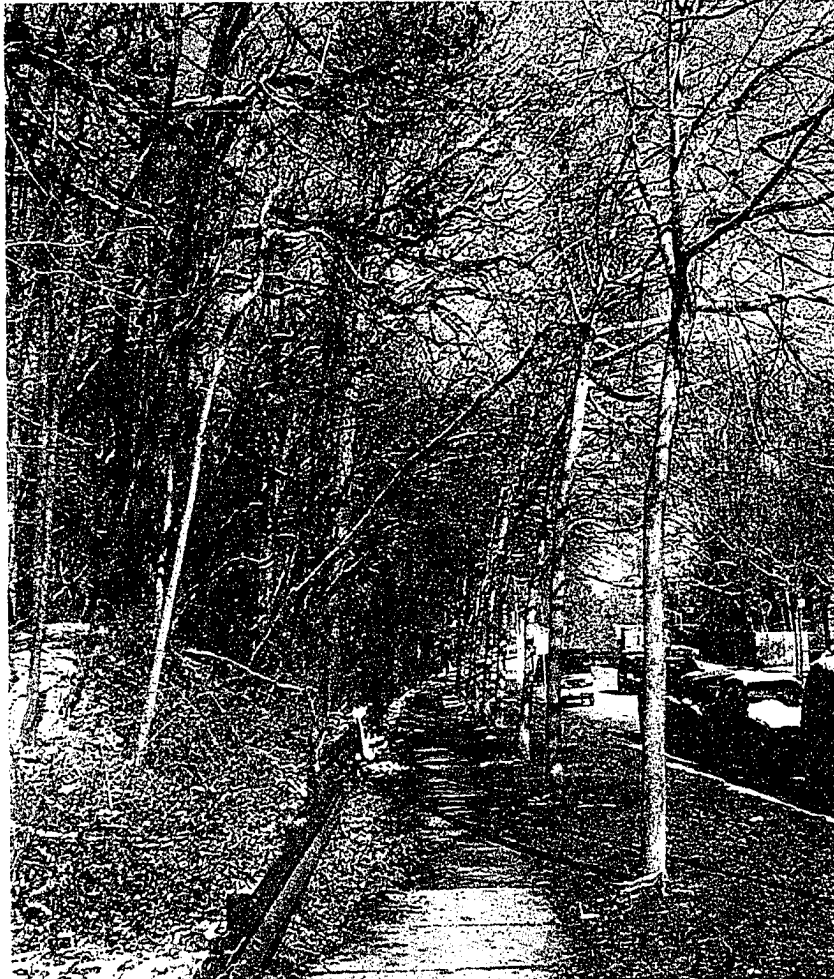
Figure 4.1 Voucher sample of *Phellodendron amurense* Rupr. (Family Rutaceae), introduced into the U.S. as an ornamental tree in 1856 and planted adjacent to Forest Park in 1936. A deciduous, dioecious tree, 10-15 m tall. Leaves pinnately compound, opposite, petiolate 25-36 cm long; leaflets 5-13, membranaceous, narrowly ovate. Margins minutely serrulate. Rarely slightly pubescent near base. Fruits 1.0 cm diameter, blackish drupes, stones 5, 1-seeded. Range from Manchuria, PRC to Hokkaido, Japan.



Figure 4.2 Seedlings and saplings of the non-native invasive *Phellodendron amurense* are common in light gaps adjacent and within the 0.5 ha Forest Park plot. *P. amurense* is considered shade-intolerant in the mixed forests of Hokkaido, Japan but not so in Forest Park.



**Figure 4.3** A mature and fruiting *Phellodendron amurense*, Third Avenue, Bronx, NY. They are a hardy street tree and have been planted throughout the five boroughs of NYC. Fruits are persistent from late fall into spring bud break.



**Figure 4.4** Other non-native invasive tree species abound within the Forest Park wooded interior and along the park perimeter. Though a common street tree, these planted Norway Maples on the green strip along Park Lane South (right) are a significant seed source for invasion into the woodland.

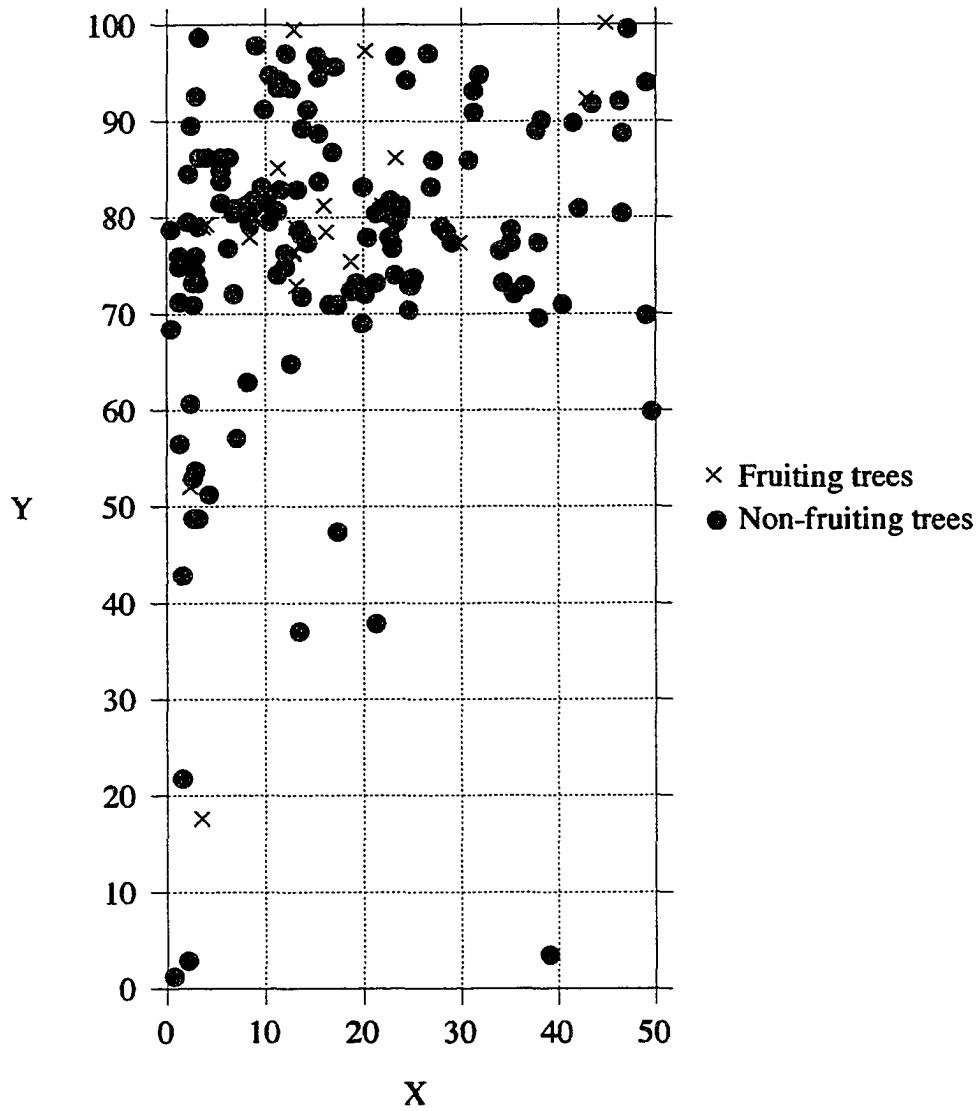


Figure 4.5 Spatial point pattern of the distribution of fruiting ( $n=22$ ) and non-fruiting trees ( $n=136$ ) of the dioecious *Phellodendron amurense* in the 0.5 ha plot of Forest Park.

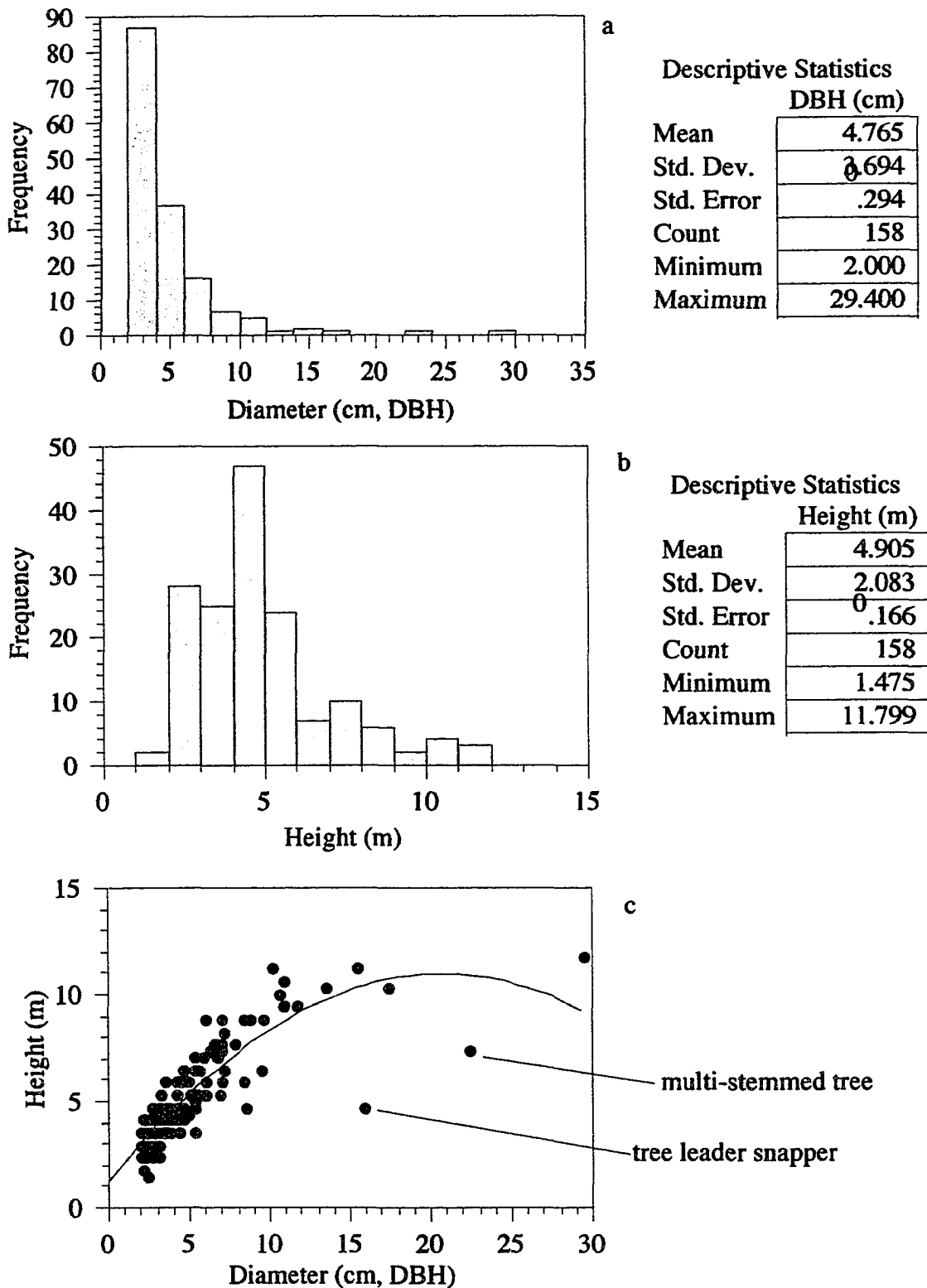


Figure 4. 6 Frequency distribution for (a) tree diameter, (b) height and, (c) diameter versus height scattergram from polynomial regression ( $r^2 = 0.742, p < 0.0001$ ) of *Phellodendron amurense* ( $n=158$ ) within the 0.5 ha plot.

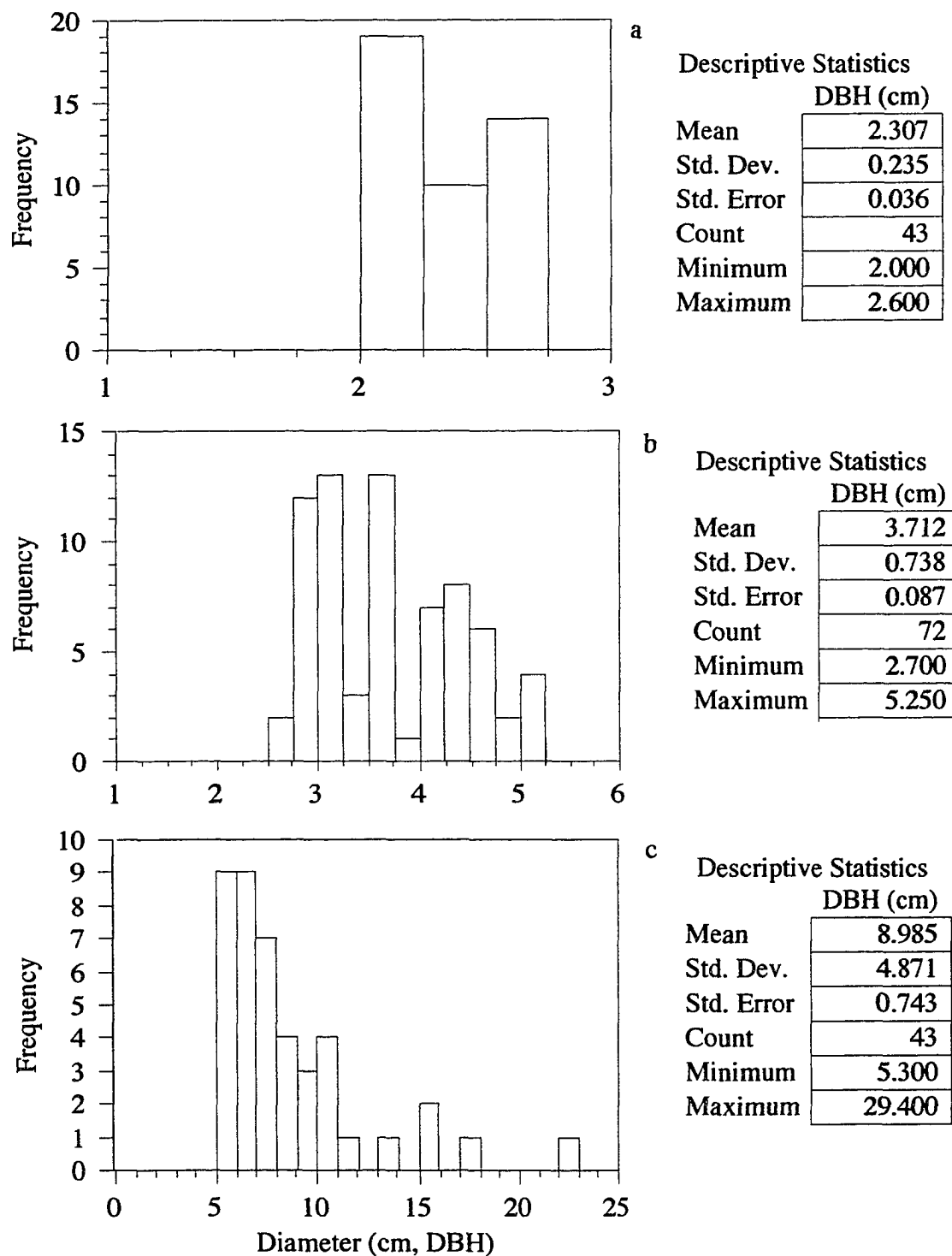


Figure 4.7 Frequency distribution of *Phellodendron amurense* diameters (DBH) based on lower and upper quartiles; (a) small diameter (2.0 - 2.6 cm, n=43), (b) mid-size diameter (2.6 - 5.25 cm, n=72) and (c) large diameter (5.25 - 29.4 cm, n=43).

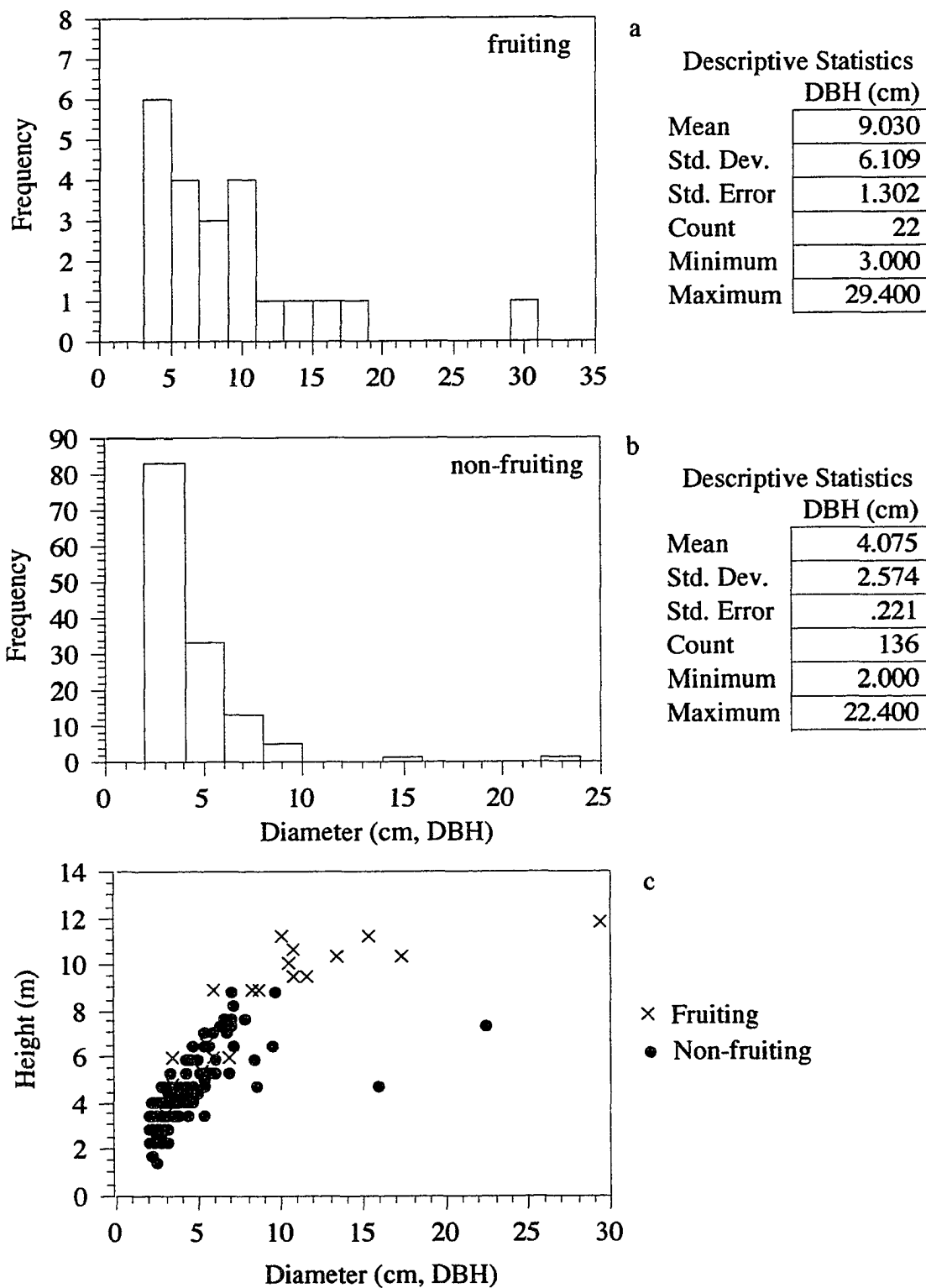
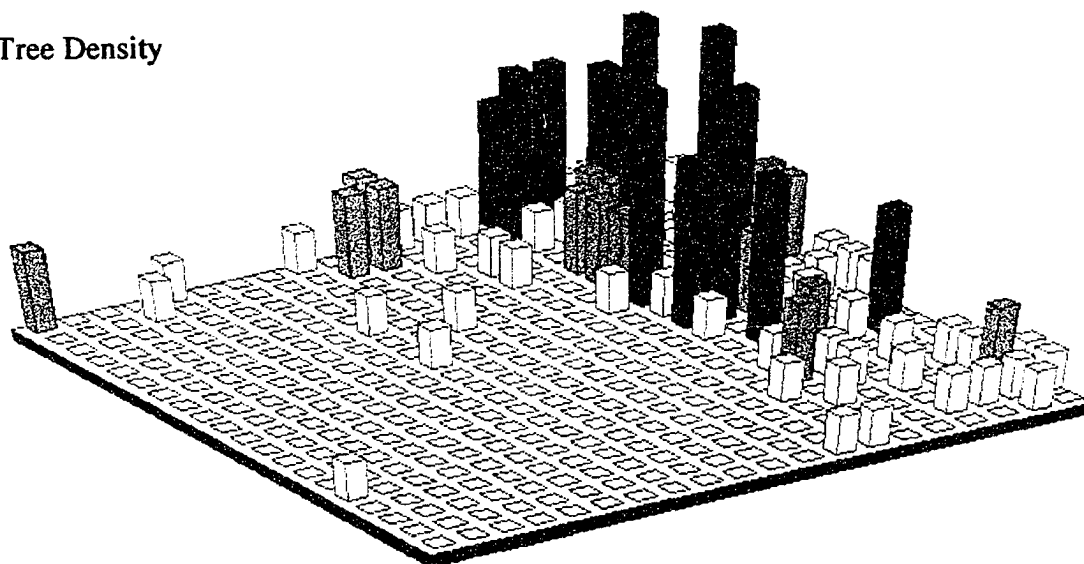
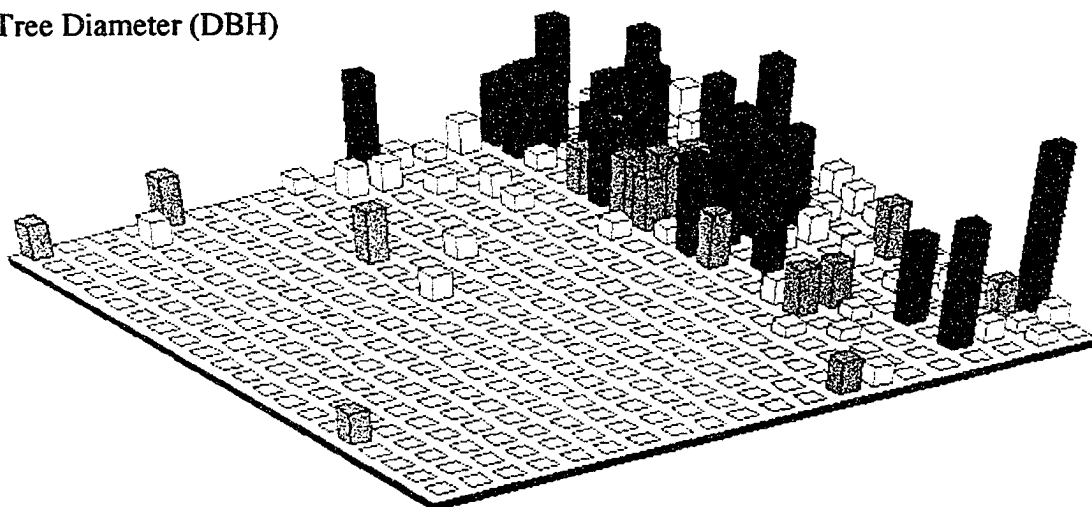


Figure 4.8 Frequency distributions of tree diameters for (a) fruiting trees ( $n=22$ ) and (b) non-fruiting trees ( $n=136$ ), (c) Tree diameter versus height scattergram for fruiting ( $r^2 = 0.635, p < .0001$ ) and non-fruiting trees ( $r^2 = 0.435, p < .0001$ ).

Tree Density



Tree Diameter (DBH)



Tree Height (m)

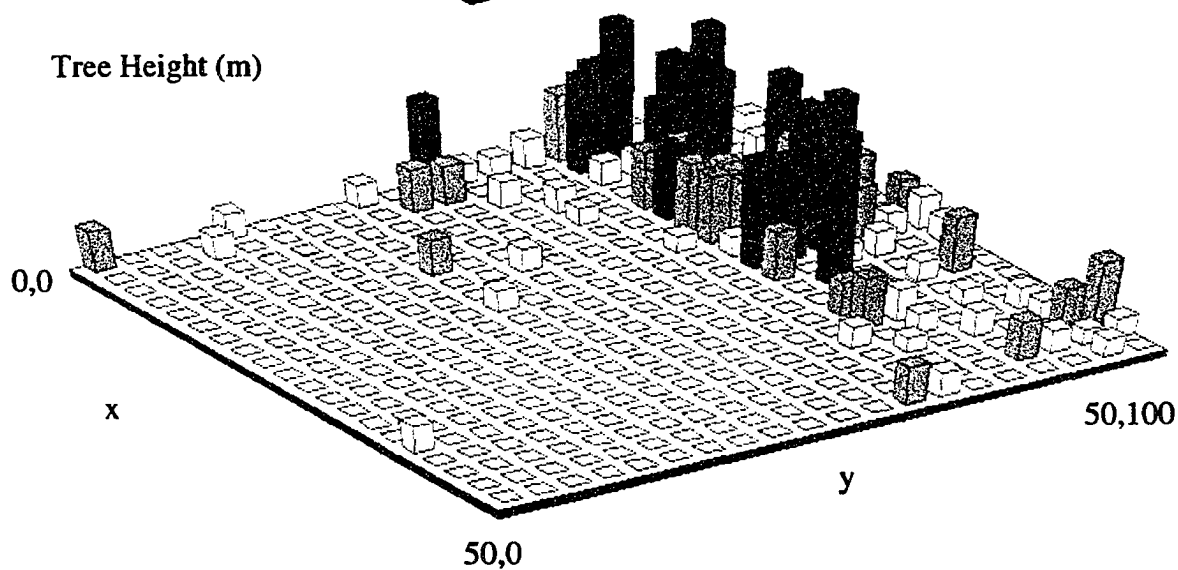


Figure 4.9 A 3-dimensional visualization of *Phellodendron amurense* for tree density, tree diameter (DBH) and height within the 50 x 100 m Forest Park plot. *P. amurense* shows the greatest density (20.5%) within the upper northwest corner of the plot. The largest diameters and tallest trees stand are represented by the darker cubes.

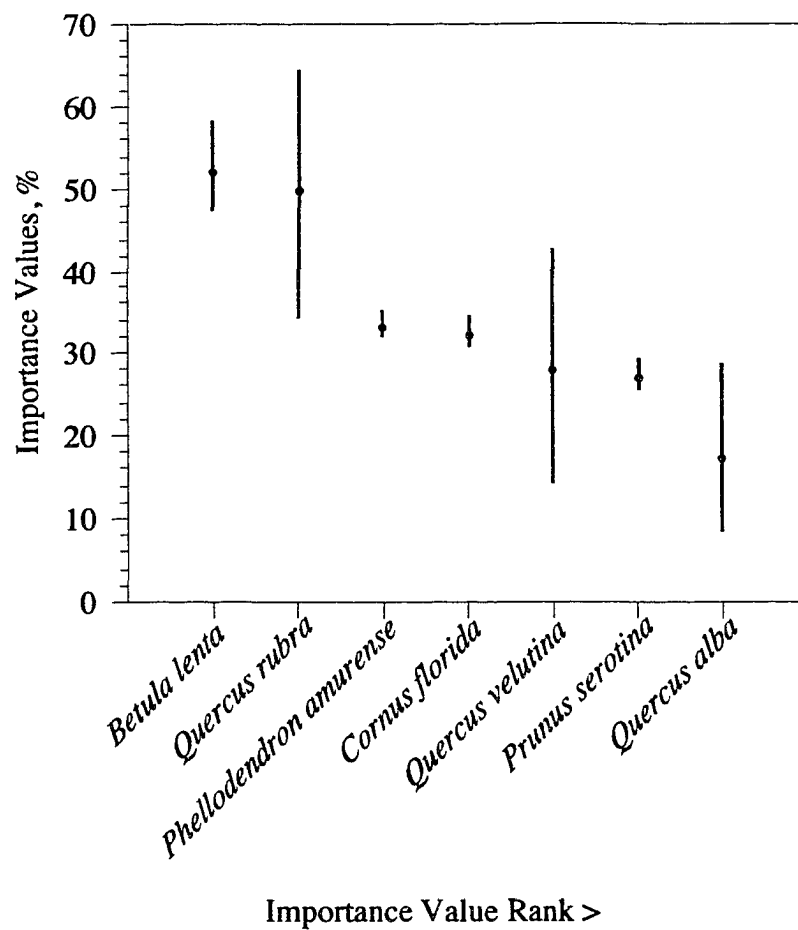


Figure 4.10 Importance values of ecologically dominant taxa with 95% bootstrap confidence intervals. The upper and lower limits of the error bars indicate  $L_1$  and  $L_2$  of the confidence interval. Bootstrap samples with replacement occurred for 771 trees (NS=10,000). IV rank decreases from left to right.

Table 4.1 Description of five tree species of the genera *Phellodendron*, Rutaceae cultivated at one time as an ornamental tree within the continental United States (Rehder 1940; Iwatsuki et al. 1999).

1. *Phellodendron amurense* Rupr. Amur corktree. Northern China, Manchuria, Japan, Hokkaido. Introduced as an ornamental tree about 1856. Zone III. Also as *P. amurense* Rupr. var. *sachalinense* F. Schmidt. Closely related to *P. piriforme* E. Wolf. Origin unknown.
2. *Phellodendron japonicum* Maxim. Corktree. Central Japan. Introduced as an ornamental tree, 1863. Zone IV. Also known as *P. nikkomontanum*.
3. *Phellodendron sachalinense* (Fr. Schmidt) Sarg. Also as *P. amurense* var. *sachalinense* Fr. Schmidt Saghal. and *P. sachalinense* (Fr. Schmidt) Sarg. var. *suberosum*. Introduced as an ornamental tree 1877. Zone III. Korea, N. Japan and W. China.
4. *Phellodendron lavalleyi* Dode.. Also as *P. amurense* var. *Lavalleyi* Sprague. Central Japan. Introduced as an ornamental tree 1863. Zone V.
5. *Phellodendron chinense* Schneid.. Also as *P. chinense glabriusculum* Schneid. or *P. sinense* Dode. Central and western China. Introduced as an ornamental tree 1907. Zone V.

Table 4.2 Local woodland designations that include Forest Park based on similar local and regional vegetative composition.

<u>Author</u>	<u>Reference Year</u>	<u>Region</u>	<u>Woodland Designation</u>
Harper R.M.	1917	Northern Queens County	Rich woods
Bromley S.W.	1935	Southern New England	Mixed mesophytic forest type of the oak region
Braun E.L.	1950	Eastern North America	Mixed mesophytic forest type in the oak-chestnut region-glaciaded section of the eastern deciduous forest.
Peters G.H.	1952	Long Island	Eastern mixed hardwood forest
Collins S.	1956	Alpine, New Jersey	Oak community
Brodo I.	1968	Northern Long Island	Red oak forests
Good R.E. & N.F. Good	1970	Northern Long Island	Oak, mixed dicot-dogwood type
Lefkowitz A. & A.M. Greller	1973	Cunningham Park	Upland forests and rich woods
Greller A.M. et al.	1979	Forest Park	Oak, mixed dicot-dogwood type
Greller A.M. et al.	1982	Central Long Island	Oak, hickory-dogwood

Table 4.3 Dominance ranking by importance values of the top 7 of 22 arborescent taxa in the 0.5 ha plot of Forest Park.

Species	No. of Trees	Relative Density (cum.)	Relative Frequency (cum.)	Relative Dominance (cum.)	IV (cum.)
1. <i>Betula lenta</i>	217	0.28145 (0.281)	0.14184 (0.142)	0.09664 (0.097)	51.9937 ( 51.994)
2. <i>Quercus rubra</i>	33	0.04280 (0.324)	0.08156 (0.223)	0.37114 (0.468)	49.5501 (101.544)
3. <i>Phellodendron amurense</i>	158	0.20493 (0.529)	0.09929 (0.323)	0.02924 (0.497)	33.3458 (134.890)
4. <i>Cornus florida</i>	115	0.14916 (0.678)	0.14184 (0.465)	0.03349 (0.531)	32.4494 (167.339)
5. <i>Quercus velutina</i>	10	0.01297 (0.691)	0.02837 (0.493)	0.23938 (0.770)	28.0724 (195.411)
6. <i>Prunus serotina.</i>	85	0.11025 (0.802)	0.12766 (0.621)	0.03353 (0.803)	27.1432 (222.555)
7. <i>Quercus alba</i>	13	0.01686 (0.818)	0.03546 (0.656)	0.12209 (0.926)	17.4412 (239.996)

Table 4.4 Descriptive statistics of 7 trees of the 22 woody taxa in the 0.5 ha plot of Forest Park listed by order of ecological dominance noting number of trees, representation among quadrats, mean DBH and species importance values (n=771). Amur corktree ranked third in ecological dominance.

Species	No. of Trees	Quadrats, %	Mean DBH (cm)	IV
1. <i>Betula lenta</i> L.	217	80	6.29	51.99
2. <i>Quercus rubra</i> L.	33	46	37.66	49.55
3. <i>Phellodendron amurense</i> Rupr.	158	56	4.76	33.35
4. <i>Cornus florida</i> L.	115	80	5.98	32.45
5. <i>Quercus velutina</i> Lam.	10	16	64.44	28.07
6. <i>Prunus serotina</i> Ehrh.	85	72	6.77	27.14
7. <i>Quercus alba</i> L.	13	20	28.55	17.44

Table 4.5 Descriptive statistics of *Phellodendron amurense* of diameter size classes with comparison to other taxa within the 0.5 ha plot in Forest Park.

	<u><i>Phellodendron amurense</i></u>				
	Small	Mid	Large	Others	Total
Density (stems ha <sup>-1</sup> )	86	154	86	1216	1542
Diameter (DBH)					
Total Trees	43	72	43	613	771
Range(cm)	2.0-2.6	2.6-5.25	5.25-29.4	2.0-116.7	2.0-116.7
Means(cm)	2.30	3.71	8.98	9.49	8.50
Standard Deviation	0.235	0.738	4.87	14.81	13.43
Skewness	0.06	0.394	2.42	3.65	4.08
Kurtosis	1.54	1.04	6.42	14.40	18.54
Basal Area (m <sup>2</sup> ha <sup>-1</sup> )	0.101	0.150	0.278	14.77	15.30
Composition (BA, %)	0.653	0.980	1.181	96.53	100.00

Table 4.6 Paired t-tests for differences in mean tree density in the 50 quadrats. Table records P-values.

	<i>B. lenta</i>	<i>C. florida</i>	<i>P. amurense</i>	<i>P. serotina</i>
<i>Betula lenta</i>	-----			
<i>Cornus florida</i>	0.0093	-----		
<i>Phellodendron amurense</i>	0.3037	0.2640	-----	
<i>Prunus serotina</i>	0.0008	0.1052	0.0930	-----

Table 4.6.a. Descriptive statistics for the four most abundant taxa in the 50 quadrats.

	No. of Trees	Quadrats, %	Mean Trees/Quadrat
<i>Betula lenta</i>	217	80	4.43
<i>Cornus florida</i>	115	80	2.35
<i>Phellodendron amurense</i>	158	56	3.23
<i>Prunus serotina</i>	85	72	1.74

Table 4.7 Dates of initiation of phenological events of Amur corktree within its native range in northeast China, PRC (Ning and Dafang 1990) and as a non-native invasive tree throughout Forest Park, Queens County, New York.

Phenological Event	Dates	
	Northeast China	Forest Park
Bud Expansion	April 25	March 30
Bud Break	May 11	April 11
New Bud Emergence	July 4	May 20
Leaf Emergence	May 21	April 23
Leaf Senescence	August 20	November 9
Floral Emergence	June 4	June 3
Fruit Emergence	June 15	June 15
Fruit Maturation	September 10	September 15
Fruit Senescence	September 25	persistant thru winter

## Chapter 5

### **Spatial point patterns of the woodland trees of Forest Park, Queens County, New York.**

#### I. Introduction

It has been over three decades since the Janzen-Connell hypothesis was proposed that stated “tree predation” to be a factor in defining the diversity of tree species within tropical forests. Janzen (1970) and Connell (1971) independently showed that host-specific enemies are highly abundant and effective in tropical forests and a likely force in maintaining high diversity and spatial dynamics within those communities. A similar postulation was posed if temperate trees undergo less Janzen-Connell spacing than do tropical trees, though this was never fully pursued (Clark and Clark 1984). However, spatial dynamics and the causal factors by which organisms are dispersed, since Janzen and Connell have become an increasingly critical investigative tool in conservation biology and forest management. Describing the spatial patterns within plant communities are necessary for defining stand history, population dynamics, competition (Haase 1995; Camarero et al. 2000), facilitation relationships and sites undergoing invasion by non-native trees. Inclusive to descriptions of spatial patterns is the generation of hypothesis

on the influence of environmental variables (i.e. photosynthetically active radiation) that influence the spatial structure of a woodland.

In earlier chapters it was explained that the Forest Park woodland is undergoing transition due to various disturbance types, though largely anthropogenic tree falls. The general unpredictable nature of tree falls and the outcome of gap-phase regeneration can have a major effect on the eventual spacing of recruits into the population (Clark and Clark 1984). A major criteria for understanding the structure of an arborescent community is to define the spatial dynamics of those members of the tree population. This can be performed at large scales (e.g. ecosystem type and biomass, canopy) or across small (or fine) scales (e.g. seedling and sapling regeneration) (Chen and Bradshaw 1999). However, the units under investigation are not always apparent (Swargryk 1990). The majority of ecological knowledge lies at finer scales. It is the fine scale patterns that refers to composition and configuration of individual trees and at this scale can pose questions such as, How are various tree species distributed across the stand? (Chen and Bradshaw 1999).

The use of spatial point patterns and analysis has not been used to describe the Forest Park woodland and in this study I begin the first attempt to do so. In order to explore the application of spatial point patterns of all woody stems in a mixed hardwood woodland we may pose several questions for which at least some preliminary data have been gathered. Although it is beyond the scope of this dissertation, analysis of  $x,y$

coordinates may be able to answer these questions. (1) How is each tree species distributed across the stand compared to CSR? (2) What is the spatial relationship among trees in terms of positive, negative or random relationships? (3) What is the spatial relationship between the small versus large sized trees?

## II. Methods

### II.1. Study Site

A north-south oriented, permanent 0.5 ha plot (50 x 100 m), sub-divided into 50-10 x 10 m subplots was established in a wooded section of the 218 ha Forest Park, Queens County. The study plot is within a 29 ha parcel of the park known as the Northern Woods, the largest contiguous tract of urban woodland in Queens County. The woodland is bordered by the Jackie Robinson Parkway to the north, the Long Island Rail Road (LIRR) to the south, Metropolitan Avenue and Woodhaven Boulevard to the east and west.

Forest Park is a hardwood forest currently characterized by several ecologically dominant trees (in decreasing order of dominance); *Betula lenta*, *Quercus rubra*, *Phellodendron amurense*, *Cornus florida*, *Q. velutina* and *Prunus serotina*. *Betula lenta* and *Phellodendron amurense* are the most abundant taxa in the plot and with a relative density of 28% and 20.5%, respectively. This woodland, as are others in northern Queens County was classified as an oak, mixed dicot-dogwood forest (Greller 1979),

though the abundance of species as mentioned above is leading to a likely change of this classification. The park overall is heavily wooded with a sparse-to-dense shrubby understory and a diverse, seasonal herbaceous layer. The topography is knob and kettle with little to no standing water in contrast other similarly contoured urban parks in northern Queens County. Because of the parks' close proximity to dense human populations, the woodland is experiencing an exceptionally high rate of human induced disturbance by local vandalism, fires and an unbroken mosaic of bike trails and footpaths. Large tree falls are omnipresent citing a mature and aging woodland with many regenerating gap-phase trees and saplings. Disturbances have resulted in the colonization and invasion by non-native invasive (NI) tree species in the interior woodland, trail edges and especially along the park perimeter.

## II.2. Field Sampling

A census of all woody taxa was performed (1999-2000) sampling stem diameter  $\geq 2.0$  cm (1.3 m, DBH), height, x and y coordinates of all stems and identification of species within the 0.5 ha quadrat method. Nomenclature was based on Gleason and Cronquist (1991). The use of a contiguous plot was necessary to fully deploy spatial point patterns and their analysis and to visualize the distribution of taxa at various scales and within the different diameter size classes.

### II.3. Statistical Methods

Statistical methods to quantify spatial point patterns have been developed and reviewed by several authors (Greig-Smith 1964; Ripley 1981; Diggle et al. 1976; Diggle, 1983; Manly 1997; Chen and Bradshaw 1999) and with particular applications to quadrat and distance methods (Diggle 1983). Distance methods quantify the non-randomness of the distribution of distances between trees with commonly used techniques that include nearest neighbor analysis, Ripley's  $K$ , Moran's  $I$ ). The quadrat method can test whether the density distribution follows a Poisson distribution or if autocorrelation exists between the plots (Chen and Bradshaw 1999). The Ripley's  $K$  function is favored because it uses more information and provides results relating to patterns at multiple scales (Chen and Bradshaw 1999). Unlike nearest-neighbor analysis that considers only distances from any given tree to its nearest neighbor, Ripley's  $K$  statistic considers distances between all pairs of stems hence providing information on multiple scales. For the 771 point patterns representing all mapped tree stems in the 0.5 ha Forest Park plot, the spatial patterns should be eventually quantified using Ripley's  $K$  ( $K(t)$ ) statistics (Ripley 1981; Diggle 1983, 2001; Szwagrzyk and Czerwczak 1993), and when the software becomes available.

Tests for complete spatial randomness (CSR) were implemented using  $K^{\text{th}}$  nearest neighbor measurements of observed versus CSR simulated trees. To ensure the significance of departures from CSR, 95% confidence intervals were established.

Jaccard similarity coefficients and phi coefficients of association were also determined for the presence/absence of five of the twenty-two taxa within the study plot. (Appendix A.1; Table 5.6). This was done as an initial test of spatial independence among the taxa (Diggle et al. 1976). Additional spatial descriptors such as spatial means and DBH-weighted centroids were calculated for the Amur corktree (Table 5.4).

### III. Results

Spatial point patterns (dotmap) from measured x,y coordinates of all individual stems (n=771) within the 0.5 ha plot was presented and analyzed for mean nearest neighbor of K<sup>th</sup> nearest neighbor distances (Table 5.1; Figure 5.1). For the 1<sup>st</sup> nearest neighbor analysis, the trees were spaced as close together as 0.10 m and as far as 5.76 m. On average tree stems were 1.21 m to another tree. For the 20<sup>th</sup> nearest neighbor analysis, the trees were spaced as close as 3.80 m and as far as 14.56 m.

Quadrats with the greatest stem density of Amur corktree (n=133) lie along the y-axis  $\geq 70$  m, an area of .15 ha or 30% of the study plot (Figure 5.2). The observed mean nearest neighbor analysis for the 1<sup>st</sup> nearest neighbor distance revealed that Amur corktrees are spaced as close together as 0.22 m and as far as 6.08 m. No tree was beyond the maximum distance of 6.08 m. On average, corktrees were within 1.55 m from a congener (Table 5.2). The observed mean nearest neighbor for the 10<sup>th</sup> nearest-neighbor distance revealed that trees were as close as 2.74 m and as far as 16.04 m.

A Monte Carlo test for randomness based on distances between points was applied. Monte Carlo simulation for complete spatial randomness (CSR) generated  $K^{\text{th}}$  nearest neighbor distances of 133 of the 158 Amur corktrees (Table 5.3). The ten “Grand Mean” distances under CSR ( $NS=99$ ) are clearly greater than the corresponding  $K^{\text{th}}$  NN distance between trees produced from the observed mean nearest neighbor analysis presented in Table 5.2. This indicates that at all spatial scales, Amur corktree is more aggregated than if it were randomly dispersed over the study plot.

Spatial descriptors provided comparative values for all corktrees ( $n=158$ ) throughout the 0.5 ha plot and for corktrees within the dense region ( $y$ -coordinate  $\geq 70$  m) ( $n=133$ ) (Table 5.4). The comparative spatial median and means for large and small corktrees do not vary significantly. The large trees were spaced a minimum of 3.62 m and a maximum of 19.2 m. The mean distance between large trees was 9.02 m. The small trees were spaced a minimum of 0.92 m and a maximum of 57.9 m. The mean distance between small trees was 7.51 m.

Mantel tests for spatial autocorrelation was applied to assess whether or not an observed association exists between tree size matrices for Amur corktrees (Manly 1997). Matrices are pairwise absolute values of differences in tree diameter (DBH), basal area, tree height and binary membership for all corktrees ( $n=158$ ) and for trees within the dense region ( $n=133$ ) (Table 5.5). It is only within the region of highest corktree density

that close trees tend to have similar DBH (and basal area). No other significant autocorrelation was found.

#### IV. Conclusion

Community disturbances of various types and degrees are apparent throughout the Forest Park woodland and the process of gap-phase regeneration is the outcome of such disturbances. Woodland regeneration involves a combination of, disturbance type, the influence by biotic and abiotic factors and the recruitment of pioneer trees that determine the composition and spatial dynamics of the plant community. The presence of invasive trees, such as the dioecious *Phellodendron amurense* that shares typical pioneer characteristics of several native trees, merits special attention. For my study, *Phellodendron amurense* received priori treatment over the other taxa because it is a relatively recent non-native invading tree, has a surprisingly high relative density of 20.4% and is one of the top ecologically dominant trees within the plot.

The question was posed, How are various tree species distributed across the stand? The application of  $K^{\text{th}}$  nearest neighbor analysis (NN) and randomization tests provided quantitative statistics of the distribution of trees within the 0.5 ha plot. The spatial pattern for the 771 stems revealed that the mean spacing between any one tree was as close together as 0.1 m and a mean spacing of 1.2 m. For the non-native invasive Amur corktree, the trees were as close as 0.22 m and a mean spacing of 1.55 m to its

nearest congener. The application of Monte Carlo simulations for complete spatial randomness (CSR) for  $K^{\text{th}}$  nearest neighbor of the corktrees revealed that all scales, the corktrees are aggregated. The spatial autocorrelation of corktrees revealed that close trees all tend to have similar DBH and basal area. The spatial mean for the 158 corktrees based on x,y coordinates is located at (17.2, 77.0). The corresponding DBH-weighted centroid is located at x,y coordinates (19.1, 77.2),(Table 5.4). From the spatial point pattern in Figure 5.2, this spatial mean and weighted centroid is clearly within the most dense region in the 0.5 ha plot.

The spatial data presented in this chapter for Amur corktree and the  $n= 771$  trees marks an initial approach to defining the current spatial ecology of the Forest Park woodland. While the results presented are preliminary, more pressing advanced spatial analysis needs to be performed in light of the impact of woody invasive trees on the greater ecology of Forest Park. This can occur when advanced spatial programs become available.

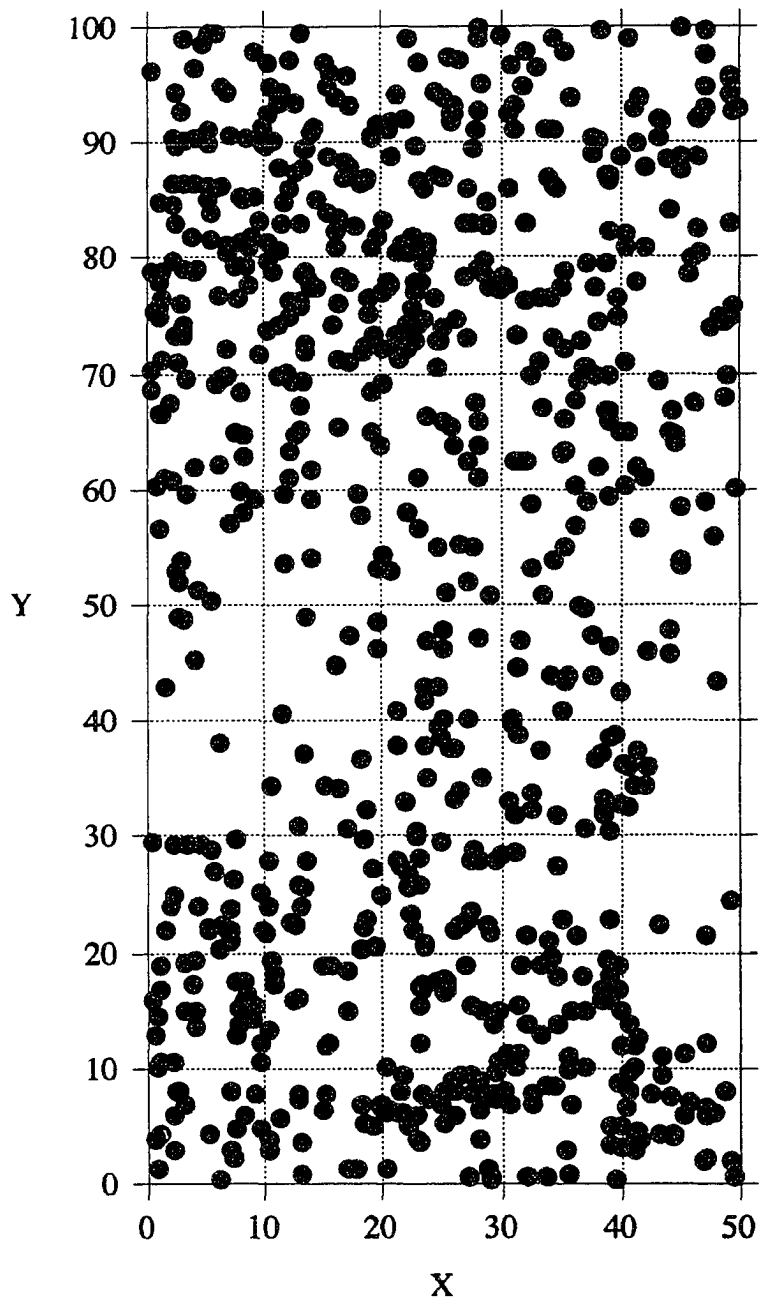


Figure 5.1 Spatial point distribution of all woody stems within the 50 x 100 m plot in Forest Park (n=771).

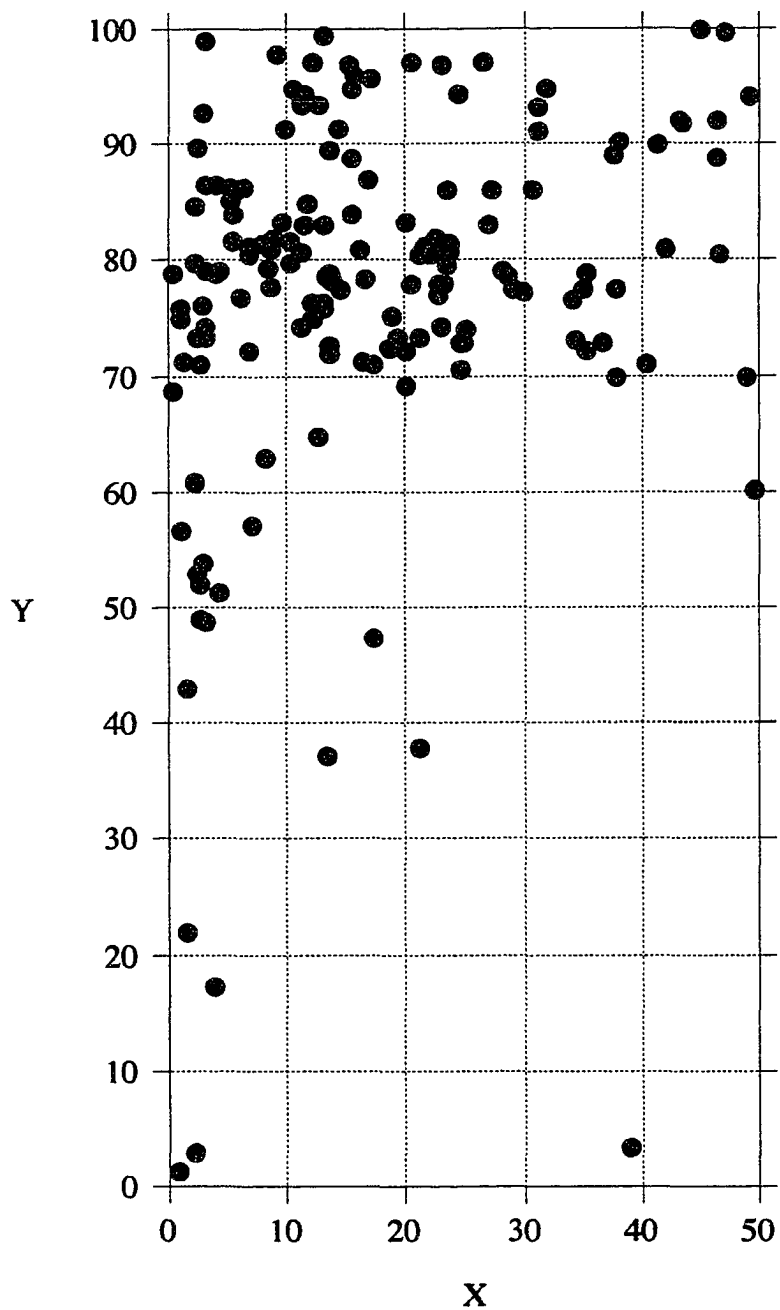


Figure 5.2 Spatial point distribution (dotmap) of stems of the non-native invasive *Phellodendron amurense* within the 50 x 100 m plot in Forest Park plot (n=158).

Table 5.1 Descriptive statistics for  $K^{\text{th}}$  nearest-neighbor (NN) for 771 stems in the 0.5 ha plot in Forest Park.

$K^{\text{th}}$ NN	No. of Trees	Mean	SD	CV%	Min.	Max.	Range
1	771	1.217	0.762	62.63	0.1	5.763	5.663
2	771	1.822	0.887	48.69	0.283	6.325	6.042
3	771	2.343	0.986	42.08	0.51	10.112	9.602
4	771	2.751	1.057	38.44	0.632	10.891	10.258
5	771	3.111	1.113	35.78	0.86	11.449	10.589
6	771	3.432	1.152	33.56	1.237	11.741	10.504
7	771	3.734	1.222	32.73	1.304	11.799	10.495
8	771	4.008	1.271	31.71	1.342	11.927	10.585
9	771	4.27	1.312	30.73	1.712	12.025	10.314
10	771	4.509	1.34	29.71	2.081	12.289	10.208
11	771	4.735	1.383	29.21	2.247	12.452	10.205
12	771	4.956	1.426	28.77	2.354	13.148	10.795
13	771	5.166	1.453	28.12	2.731	13.345	10.614
14	771	5.356	1.469	27.43	2.802	13.416	10.615
15	771	5.547	1.499	27.02	3.081	13.518	10.438
16	771	5.726	1.519	26.53	3.14	13.706	10.566
17	771	5.907	1.537	26.01	3.36	13.732	10.372
18	771	6.092	1.576	25.87	3.574	13.851	10.278
19	771	6.276	1.611	25.67	3.59	14.5	10.909
20	771	6.458	1.643	25.45	3.808	14.56	10.752

Table 5.2 Descriptive statistics of observed mean nearest-neighbor analysis of  $K^{\text{th}}$  nearest-neighbor distances for Amur corktree in the quadrats displaying the greatest stem density (y-axis > 70m).

$K^{\text{th}}$ NN	N of Trees	Mean (m)	SD	CV%	Min (m)	Max (m)	Range	Skew	Kurtosis	R (0-2) for 1 <sup>st</sup> NN
1	133	1.55	1.068	68.75	0.224	6.08	5.859	1.243	1.88	0.925
2	133	2.27	1.416	62.42	0.447	8.50	8.053	1.565	3.18	
3	133	2.85	1.672	58.65	0.800	9.30	8.497	1.470	2.16	
4	133	3.51	1.827	52.08	1.118	10.92	9.800	1.329	1.87	
5	133	3.91	1.906	48.69	1.456	11.40	9.943	1.255	1.43	
6	133	4.31	2.035	47.17	1.500	11.50	9.998	1.260	1.33	
7	133	4.69	2.100	44.76	1.612	11.70	10.091	1.237	1.11	
8	133	5.14	2.280	44.33	2.408	13.09	10.678	1.316	1.33	
9	133	5.53	2.412	43.58	2.470	14.16	11.690	1.325	1.40	
10	133	5.97	2.665	44.65	2.746	16.04	13.289	1.388	1.57	

If R= 0; then a perfectly aggregated distribution

If R= 1; then a CSR distribution

If R= 2; then a perfectly uniform distribution

Table 5.3 Results of Monte Carlo simulations for complete spatial randomness (CSR) of 133 of the 158 Amur corktrees for K = 10 nearest-neighbor depth. The 133 trees tested are found within those quadrats containing the greatest stem density (y-axis  $\geq 70\text{m}$ ).

Kth NN	CSR Sets	CSR Means			per CSR			Grand Statistics (based on normal distribution)			
		Grand Mean	Min Mean	Max Mean	Min NN distance	Max NN distance	R (0 to 2)	SD	CV%	Skew	Kurtosis
1	99	1.75	1.550	2.010	0.019	8.53	1.040	0.960	55.04	0.831	0.991
2	99	2.66	2.390	2.870	0.160	9.60		1.050	39.56	0.764	1.124
3	99	3.36	3.050	3.610	0.652	10.75		1.110	33.06	0.748	1.128
4	99	3.95	3.630	4.230	0.895	12.22		1.180	29.87	0.800	1.267
5	99	4.48	4.050	4.840	0.998	13.37		1.240	27.70	0.822	1.307
6	99	4.96	4.500	5.300	1.514	13.78		1.280	25.90	0.853	1.306
7	99	5.41	5.100	5.760	1.970	14.83		1.340	24.77	0.891	1.361
8	99	5.84	5.490	6.130	2.173	15.31		1.390	23.84	0.927	1.420
9	99	6.24	5.850	6.580	2.426	15.94		1.450	23.21	0.963	1.400
10	99	6.62	6.240	7.010	2.607	16.07		1.500	22.68	0.987	1.409

Table 5.4. Spatial descriptors for Amur corktrees in the 0.5 ha study plot (50 m (x) x 100 m (y)) in Forest Park, Queens County, NYC. Column 1: All trees in the 0.5 ha plot, DBH  $\geq 2.0$  cm, N=158. Column 2: All trees in the rectangular region of highest Corktree density (y-coordinate  $\geq 70$ m; .15 ha), N=133, DBH  $\geq 2.0$ cm. Column 3: The 90<sup>th</sup> percentile of trees based on DBH from 8.5 to 29.4cm, N=16, 0.5 ha. Column 4: The 10<sup>th</sup> percentile of trees based on DBH from 2.0 to 2.1cm, N=16, 0.5 ha. Spatial median was calculated by sowing 40,000 Poisson points across the plane and picking the point that was the minimum distance to all trees. Skewness and kurtosis were calculated relative to a normal distribution. NN refers to the nearest-neighbor, SD to standard deviation, and NA to not applicable.

	All Trees N=158	Dense Region N=133	Large Trees N=16	Small Trees N=16
Spatial median (x,y)	17.1, 77.2	18.1, 82.8	19.6, 73.6	20.0, 73.8
Spatial mean (x,y)	17.2, 77.0	18.1, 82.5	19.8, 73.7	19.9, 73.9
DBH-weighted centroid (x,y)	19.1, 77.2	20.3, 82.8	NA	NA
Height-weighted centroid (x,y)	17.3, 77.0	18.1, 82.3	NA	NA
NN statistic, R (0 to 2+)	0.774	0.925	1.021	0.85
NN distances (m)				
mean	2.08	1.55	9.02	7.51
SD	3.31	1.07	6.27	14.26
minimum	0.22	0.22	3.62	0.92
maximum	37.00	6.08	19.24	57.90
skewness	7.77	1.24	NA	NA
kurtosis	76.77	1.88	NA	NA

Table 5.5 Spatial autocorrelation of Amur corktrees analyzed by Mantel test. The geographical matrix is pairwise Euclidean distance between trees or the square root of Euclidean distance. Tree size matrices are pairwise, absolute values of differences in tree trunk diameter (DBH), trunk basal area, tree height, and binary membership (0,1) as a “small” tree ( $\leq 3.6$ cm median DBH) or a “large” tree ( $> 3.6$  cm median DBH). The “dense region” refers to a rectangular region of highest corktree density (y-coordinate  $\geq 70$ m; 0.15 ha). In the standard fashion, the geographical distance matrix was randomized  $n=999$  times (other matrix held constant) to test for significance of the observed correlation between it and each tree size distance matrix.

<u>Distance Matrices</u>		<u>Standardized Mantel Statistic (p-value)</u>	
Geographical	Tree Size	All Trees (0.5 ha) (n=158)	Dense region (0.15 ha) (n=133)
Euclidean	DBH	r= 0.0687 (.116)	r= 0.1666 (0.003)
Euclidean	Basal Area	r= 0.0884 (.079)	r= 0.2106 (0.005)
Euclidean	Height	r= - 0.0659 (.060)	r= - 0.0057 (0.173)
Euclidean	Small, Large	r= 0.0070 (0.102)	r= 0.0063 (0.173)
Euclidean <sup>0.5</sup>	DBH	r= 0.0071 (0.103)	r= 0.1501 (0.003)
Euclidean <sup>0.5</sup>	Basal Area	r= 0.0980 (0.057)	r= 0.1871 (0.003)
Euclidean <sup>0.5</sup>	Height	r= - 0.0603 (0.087)	r= - 0.0032 (0.488)
Euclidean <sup>0.5</sup>	Small, Large	r= 0.0095 (0.072)	r= 0.0131 (0.094)

Table 5.6 Spatial associations among the five dominant and most abundant taxa across the quadrats. Jaccard similarity coefficients (lower half matrix) and phi coefficients of association (upper half matrix) for presence/absence of taxa in the 50- 10 x 10 m quadrats in the Forest Park 0.5 ha plot. Number of trees is in parenthesis. Phi coefficient of association ranges from -1 to +1 (Sokal and Rohlf (1995)).

	1	2	3	4	5
1. <i>Betula lenta</i> (n=217)	----	- 0.140	- 0.040	0.125	0.244
2. <i>Quercus rubra</i> (n=33)	0.369	----	- 0.038	0.120	0.218
3. <i>Phellodendron amurense</i> (n=158)	0.478	0.417	----	0.161	- 0.038
4. <i>Cornus florida</i> (n=115)	0.702	0.467	0.545	----	0.133
5. <i>Prunus serotina</i> (n=85)	0.688	0.447	0.454	0.447	----

## Appendix A

Resampling Stats program: Bootstrap sampling for relative density of trees.

```

' Carsten1.sta          ver. 4.14.03 by Dwight Kincaid      Resampling Stats
' Data of Carsten Glaeser
' Forest Park, Queens, New York, 0.5 hectare quantitative ecological inventory 50 x
100m divided into 50, 10m x 10m quadrats

MAXSIZE percent$ 500000 a1 50 a2 50 ALL 50 Amur 50 Amur$ 50

' the number of trees of Amur cork in each of the 50 quadrats
DATA (2 0 0 1 0 1 0 0 0 0 1 0 0 0 0 0 1 1 0 0 3 1 0 0 0 6 0 0 0 0 3 2 0 1 2 18 19 15 7 1 16
11 10 2 3 4 12 4 4 7) Amur

' the total number of trees in each of 50, 10x10m quadrats, dbh >= 2cm
DATA (17 19 33 18 26 25 12 18 25 7 23 15 23 7 3 1 8 13 18 7 4 6 10 12 4 11 8 9 9 6 17
14 10 17) a1
DATA (13 26 29 29 21 8 24 27 20 11 13 20 21 20 15 19) a2
CONCAT a1 a2 ALL

SIZE ALL quadrats
SUM Amur NAmur ' 158, the sum of all Amur cork trees
SUM ALL NALL ' 771, the sum of all trees
let perct = 100 * (NAmur/NALL) ' our % for bootstrap confidence intervals

let NS = 500000

REPEAT NS
  SAMPLE quadrats Amur Amur$ ' get bootstrap sample
  SAMPLE quadrats ALL ALL$ ' get bootstrap sample

  SUM Amur$ NAmur$
  SUM ALL$ NALL$

  DIVIDE NAmur$ NALL$ a
  let a = a * 100
  SCORE a percent$
END

HISTOGRAM percent$
MIN percent$ MN
MAX percent$ MX
PERCENTILE percent$(2.5 97.5) CI
PRINT NAmur NALL perct NS CI MN MX

'===== code below gets 95% CI for overall tree density (the 771)

MAXSIZE Density$ 100000
let Density = NALL
let NS = 100000

```

```
REPEAT NS
  SAMPLE quadrats ALL ALL$
  SUM ALL$ NALL$
  SCORE NALL$ Density$
END

HISTOGRAM Density$
MIN Density$ MN
MAX Density$ MX
PERCENTILE Density$(2.5 97.5) CI_ALL
PRINT NS Density CI_ALL MN MX

' end
```

## Appendix A.1

Resampling Stats program: 95% bootstrap confidence intervals  
for Jaccard Similarity Coefficient and Phi Coefficient of Association.

```

=====
=====
==
==
== Jaccard_phi.sta                version April 20, 2003
==
==
== a program written in Resampling Stats
==
== by
==                               dkincaid49@yahoo.com
== Dwight Kincaid, Ph.D.        718.960.8651, fax 8236/8484
==
== Professor & Doctoral Faculty
== Department of Biological Sciences, Plant Sciences Program
== Lehman College, City University of New York
== Bronx, New York 10468 USA
==
== ABSTRACT
== This program finds bootstrap 95% confidence intervals for JACCARD
== SIMILARITY COEFFICIENT and PHI COEFFICIENT of ASSOCIATION.
== The 50 quadrats are bootstrapped.
== Data of CARSTEN GLAESER from his 0.5 ha, 50m x 100m study plot in
== Forest Park, Queens, New York. The plot is subdivided into 50,
== 10m x 10m quadrats.
==
== LEHMAN COLLEGE -- "Access to Scientific Excellence in the Bronx"
==                               - 35 years --
==
=====
=====

```

```

MAXSIZE site 50  site$ 50  Jboot$ 500000  phiBOOT$ 500000  'reserve/conserv array space

```

the 2x2

contingency table

species A

Jaccard =  $a/(a+b+c)$

present absent

-----|----- if  $ad - bc > 0$  then association positive

present a | b if  $ad - bc < 0$  then association negative

species B

-----|-----

absent c | d a,b,c,d are frequencies of quadrats

-----|-----

In integer array "site" -- "1" is frequency in cell a, "2" is b, "3" is c, "4" is d

URN 22#1 18#2 6#3 4#4 site ' for amur cork vs. Betula lenta  
 URN 24#1 16#2 4#3 6#4 site ' for amur cork vs. Cornus florida  
 URN 20#1 16#2 8#3 6#4 site ' for amur cork vs. Prunus serotina

```
let Area = 0.5 ' hectares
COUNT site < 4 abc      ' frequency for a+b+c
COUNT site = 1 a
COUNT site = 2 b
COUNT site = 3 c
COUNT site = 4 d
SIZE site quadrats
let Jaccard = a/(a+b+c)      ' Jaccard (1908)

let phi = (a+b)*(c+d)*(a+c)*(b+d) ' phi coefficient of association, scaled -1 to +1
SQRT phi phi                ' see Sokal & Rohlf (1995)
let phi = ((a*d)-(b*c))/phi

PRINT Area a b c d
PRINT quadrats Jaccard phi
```

```
let NS = 100000
```

```
REPEAT NS
  SAMPLE quadrats site site$ ' get bootstrap sample of 50 quadrats out of 50
  COUNT site$ < 4 abc$
  COUNT site$ = 1 a$
  let Jaccard$ = a$/abc$
  SCORE Jaccard$ Jboot$

  COUNT site$ = 2 b$
  COUNT site$ = 3 c$
  COUNT site$ = 4 d$
  let phi$ = (a$+b$)*(c$+d$)*(a$+c$)*(b$+d$)
  SQRT phi$ phi$
  let phi$ = ((a$*d$)-(b$*c$))/phi$
  SCORE phi$ phiBOOT$
END
```

```
HISTOGRAM Jboot$
MEAN Jboot$ Mean$ ' Mean$ measures bootstrap bias
```

```
STDEV Jboot$ SE$  
MIN Jboot$ Min_J$  
MAX Jboot$ Max_J$  
PERCENTILE Jboot$(2.5 97.5) CI_95  
PRINT NS Mean$ SE$ Min_J$ Max_J$ CI_95 Jaccard
```

```
HISTOGRAM phiBOOT$  
MEAN phiBOOT$ p_mean$ ' bootstrap bias  
STDEV phiBOOT$ p_SE$  
MIN phiBOOT$ min_phi$  
MAX phiBOOT$ max_phi$  
PERCENTILE phiBOOT$(2.5 97.5) phiCI_95  
PRINT NS p_mean$ p_SE$ min_phi$ max_phi$ phiCI_95 phi
```

```
end =====
```

## Appendix B

### Vascular plant species of Forest Park, Queens County, New York

Appendix B. Listing of vascular flora by family within and adjacent to the 0.5 ha plot of Forest Park, Queens, New York.

Family	Species
ACERACEAE	<i>Acer platanoides</i> L. <i>Acer rubrum</i> L.
ASPLENIACEAE	<i>Athyrium filix-femina</i> (L.) Roth <i>Dryopteris intermedia</i> (Muhl.) A. Gray
ASTERACEAE	<i>Eupatorium purpureum</i> L. <i>Aster divaricatus</i> L. <i>Solidago caesia</i> L. <i>Solidago</i> spp.
ANACARDIACEAE	<i>Toxicodendron radicans</i> (L.) Kuntze
AQUIFOLIACEAE	<i>Ilex verticillata</i> (L.) A. Gray.
ARACEAE	<i>Arisaema triphyllum</i> (L.) Schott.
ARALIACEAE	<i>Aralia nudicaulis</i> L.
BETULACEAE	<i>Betula lenta</i> L.
CAPRIFOLIACEAE	<i>Viburnum acerifolium</i> L.
CELASTRACEAE	<i>Celastrus orbiculata</i> Thunb.
COMMELINACEAE	<i>Commelina communis</i> L.
CORNACEAE	<i>Cornus florida</i> L. <i>Cornus alternifolia</i> L. f.
CYPERACEAE	<i>Carex pensylvanica</i> Lam. <i>Carex</i> spp.

DENNSTAEDTIACEAE	<i>Dennstaedtia punctilobula</i> (Michx.) Moore
ERICACEAE	<i>Vaccinium corymbosum</i> L.
FAGACEAE	<i>Castanea dentata</i> (Marshall) Borkh. <i>Fagus grandifolia</i> Ehrh. <i>Quercus alba</i> L. <i>Quercus rubra</i> L. <i>Quercus velutina</i> Lam.
HAMMAMELIDACEAE	<i>Liquidambar styraciflua</i> L.
JUNCACEAE	<i>Luzula multiflora</i> (Retz.) Lej.
JUGLANDACEAE	<i>Carya glabra</i> (Miller) Sweet <i>Carya ovata</i> (Miller) K. Koch <i>Carya tomentosa</i> (Poiret) Nutt.
LAURACEAE	<i>Lindera benzoin</i> (L.) Blume <i>Sassafras albidum</i> (Nutt.) Nees
LILIACEAE	<i>Polygonum biflorum</i> (Walt.) Elliot <i>Smilicina racemosa</i> (L.) Desf. <i>Allium canadense</i> L. <i>Maianthemum canadense</i> Desf.
MAGNOLIACEAE	<i>Liriodendron tulipifera</i> L.
NYSSACEAE	<i>Nyssa sylvatica</i> Marshall
OSMUNDACEAE	<i>Osmunda claytoniana</i> L. <i>Osmunda regalis</i> L.
POLYGONACEAE	<i>Polygonum pensylvanicum</i> L.
PRIMULACEAE	<i>Lysimachia quadrifolia</i> L.
PYROLACEAE	<i>Chimaphila maculata</i> (L.) Pursh.

RHAMNACEAE	<i>Rhamnus frangula</i> L.
ROSACEAE	<i>Prunus serotina</i> Ehrh. <i>Prunus avium</i> L. <i>Rubus flagellaris</i> Willd. <i>Rubus</i> spp. <i>Rosa multiflora</i> Thunb. <i>Duchesnia indica</i> (Andr.) Focke
RUTACEAE	<i>Phellodendron amurense</i> Rupr.
SMILACEAE	<i>Smilax herbaceae</i> L.
VITACEAE	<i>Parthenocissus quinquefolia</i> (L.) Planchon. <i>Vitis aestivalis</i> Michx.

Appendix C  
Dataset of the 0.5 ha Forest Park Census

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
1	1	12	<i>Betula lenta</i> L.	1	Betulaceae	2	2.50	9.00	7.80	T	4.42	4.91
2	1	13	<i>Quercus rubra</i> L.	2	Fagaceae	1	58.00	7.00	8.00	T	29.50	2642.09
3	1	10	<i>Betula lenta</i> L.	1	Betulaceae	2	5.20	7.40	4.80	T	6.49	21.24
4	1	11	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	8.00	6.00	T	3.54	3.14
5	1	16	<i>Betula lenta</i> L.	1	Betulaceae	2	4.32	7.20	2.40	T	4.42	14.66
6	1	17	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.90	6.00	0.40	T	2.95	6.61
7	1	14	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	2.40	9.40	4.90	T	2.95	4.52
8	1	15	<i>Quercus rubra</i> L.	2	Fagaceae	1	55.00	7.00	3.00	T	32.45	2375.84
9	1	9	<i>Cornus florida</i> L.	4	Cornaceae	3	4.40	5.00	4.40	T	3.54	15.21
10	1	3	<i>Betula lenta</i> L.	1	Betulaceae	2	6.81	0.40	4.00	T	5.90	36.42
11	1	4	<i>Betula lenta</i> L.	1	Betulaceae	2	2.60	1.00	4.30	T	3.54	5.31
12	1	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	0.60	1.50	T	4.42	13.85
13	1	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.00	2.00	3.00	T	2.95	3.14
14	1	7	<i>Cornus florida</i> L.	4	Cornaceae	3	2.80	2.50	8.20	T	4.42	6.16
15	1	8	<i>Betula lenta</i> L.	1	Betulaceae	2	5.10	3.00	7.00	T	6.49	20.43
16	1	5	<i>Betula lenta</i> L.	1	Betulaceae	2	7.60	2.00	6.00	T	7.67	45.36
17	1	6	<i>Betula lenta</i> L.	1	Betulaceae	2	7.70	2.40	8.20	T	7.67	46.57
18	2	13	<i>Betula lenta</i> L.	1	Betulaceae	2	2.80	17.60	1.40	T	4.42	6.16
19	2	14	<i>Betula lenta</i> L.	1	Betulaceae	2	3.80	19.00	5.10	T	4.42	11.34
20	2	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.60	13.00	0.10	T	3.54	5.31
21	2	12	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.20	17.00	1.40	T	4.42	8.04
22	2	15	<i>Betula lenta</i> L.	1	Betulaceae	2	3.50	18.40	5.30	T	5.31	9.62
23	2	18	<i>Betula lenta</i> L.	1	Betulaceae	2	3.90	19.80	6.40	T	5.90	11.95
24	2	19	<i>Betula lenta</i> L.	1	Betulaceae	2	3.30	19.60	6.60	T	4.42	8.55
25	2	16	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.97	18.00	7.00	T	3.54	6.93
26	2	17	<i>Betula lenta</i> L.	1	Betulaceae	2	4.00	19.60	7.00	T	5.90	12.57
27	2	10	<i>Cornus florida</i> L.	4	Cornaceae	3	2.00	13.00	0.90	T	2.36	3.14
28	2	3	<i>Betula lenta</i> L.	1	Betulaceae	2	9.50	11.00	5.70	T	10.62	70.88
29	2	4	<i>Betula lenta</i> L.	1	Betulaceae	2	2.50	12.80	7.30	T	4.42	4.91
30	2	1	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.72	10.20	3.00	T	2.95	5.81
31	2	2	<i>Betula lenta</i> L.	1	Betulaceae	2	2.70	10.30	3.90	T	4.13	5.73
32	2	5	<i>Betula lenta</i> L.	1	Betulaceae	2	4.85	12.80	7.50	T	7.37	18.47

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
33	2	8	<i>Betula lenta</i> L.	1	Betulaceae	2	5.60	14.80	6.40	T	7.67	24.63
34	2	9	<i>Cornus florida</i> L.	4	Cornaceae	3	2.80	13.00	3.80	T	3.54	6.16
35	2	6	<i>Betula lenta</i> L.	1	Betulaceae	2	4.80	12.80	7.80	T	7.37	18.1
36	2	7	<i>Betula lenta</i> L.	1	Betulaceae	2	4.80	15.00	7.80	T	7.37	18.1
37	3	23	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.40	26.00	6.00	T	3.54	4.52
38	3	22	<i>Cornus florida</i> L.	4	Cornaceae	3	2.50	25.00	5.40	T	2.95	4.91
39	3	25	<i>Cornus florida</i> L.	4	Cornaceae	3	6.00	28.30	7.40	T	4.42	28.27
40	3	24	<i>Betula lenta</i> L.	1	Betulaceae	2	3.20	28.00	6.50	T	4.13	8.04
41	3	19	<i>Betula lenta</i> L.	1	Betulaceae	2	3.20	27.40	9.50	T	5.31	8.04
42	3	18	<i>Betula lenta</i> L.	1	Betulaceae	2	8.00	26.00	8.00	T	10.03	50.27
43	3	21	<i>Betula lenta</i> L.	1	Betulaceae	2	2.80	27.20	7.90	T	4.72	6.16
44	3	20	<i>Betula lenta</i> L.	1	Betulaceae	2	4.00	27.90	9.00	T	7.67	12.57
45	3	31	<i>Cornus florida</i> L.	4	Cornaceae	3	3.53	29.00	0.40	T	2.95	9.79
46	3	30	<i>Cornus florida</i> L.	4	Cornaceae	3	6.00	29.00	0.80	T	4.13	28.27
47	3	33	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.00	27.00	0.80	T	2.36	3.14
48	3	32	<i>Cornus florida</i> L.	4	Cornaceae	3	2.50	28.00	4.00	T	2.95	4.91
49	3	27	<i>Betula lenta</i> L.	1	Betulaceae	2	4.20	29.20	7.80	T	4.42	13.85
50	3	26	<i>Betula lenta</i> L.	1	Betulaceae	2	4.10	29.40	7.50	T	4.42	13.2
51	3	29	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	9.00	28.80	1.40	T	5.90	63.62
52	3	28	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.50	29.30	9.80	T	4.72	4.91
53	3	17	<i>Betula lenta</i> L.	1	Betulaceae	2	7.00	26.50	9.40	T	9.44	38.48
54	3	6	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.90	22.60	4.00	T	3.54	6.61
55	3	5	<i>Betula lenta</i> L.	1	Betulaceae	2	6.50	23.00	3.60	T	6.49	33.18
56	3	8	<i>Betula lenta</i> L.	1	Betulaceae	2	2.70	22.60	6.00	T	4.42	5.73
57	3	7	<i>Betula lenta</i> L.	1	Betulaceae	2	14.00	22.00	5.00	T	13.27	153.94
58	3	2	<i>Betula lenta</i> L.	1	Betulaceae	2	2.50	20.10	6.20	T	4.72	4.91
59	3	1	<i>Betula lenta</i> L.	1	Betulaceae	2	5.50	20.10	1.30	T	4.42	23.76
60	3	4	<i>Betula lenta</i> L.	1	Betulaceae	2	3.50	20.30	6.50	T	5.31	9.62
61	3	3	<i>Betula lenta</i> L.	1	Betulaceae	2	5.30	21.00	6.30	T	4.42	22.06
62	3	14	<i>Betula lenta</i> L.	1	Betulaceae	2	2.70	24.80	7.00	T	5.31	5.73
63	3	13	<i>Betula lenta</i> L.	1	Betulaceae	2	7.00	23.50	7.30	T	8.85	38.48
64	3	16	<i>Betula lenta</i> L.	1	Betulaceae	2	2.60	25.70	9.00	T	2.95	5.31

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
65	3	15	<i>Betula lenta</i> L.	1	Betulaceae	2	5.30	25.00	8.00	T	5.90	22.06
66	3	10	<i>Betula lenta</i> L.	1	Betulaceae	2	2.60	21.20	8.00	T	5.31	5.31
67	3	9	<i>Betula lenta</i> L.	1	Betulaceae	2	2.30	21.50	6.20	T	4.42	4.15
68	3	12	<i>Betula lenta</i> L.	1	Betulaceae	2	5.40	23.20	7.80	T	7.37	22.9
69	3	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.60	21.50	9.40	T	5.90	16.62
70	4	12	<i>Betula lenta</i> L.	1	Betulaceae	2	7.50	30.20	8.20	T	6.49	44.18
71	4	13	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.30	32.50	7.00	T	7.08	22.06
72	4	10	<i>Betula lenta</i> L.	1	Betulaceae	2	5.00	35.30	2.90	T	5.90	19.63
73	4	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.70	30.50	6.90	T	3.54	5.73
74	4	14	<i>Betula lenta</i> L.	1	Betulaceae	2	7.20	32.30	7.80	T	10.32	40.72
75	4	17	<i>Cornus florida</i> L.	4	Comaceae	3	8.37	35.70	7.00	T	6.49	55.02
76	4	18	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.90	35.50	9.90	T	5.90	27.34
77	4	15	<i>Betula lenta</i> L.	1	Betulaceae	2	3.40	33.50	8.50	T	4.13	9.08
78	4	16	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	15.50	34.30	8.50	T	19.17	188.69
79	4	3	<i>Cornus florida</i> L.	4	Comaceae	3	5.30	35.50	1.00	T	4.42	22.06
80	4	4	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.00	39.30	0.40	T	3.54	7.07
81	4	1	<i>Quercus alba</i> L.	7	Fagaceae	1	46.00	32.00	0.70	T	32.45	1661.91
82	4	2	<i>Cornus florida</i> L.	4	Comaceae	3	10.15	33.50	0.80	T	7.37	80.91
83	4	5	<i>Betula lenta</i> L.	1	Betulaceae	2	4.00	39.70	3.30	T	5.31	12.57
84	4	8	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	39.00	5.20	T	4.13	3.8
85	4	9	<i>Betula lenta</i> L.	1	Betulaceae	2	5.50	39.60	8.90	T	5.31	23.76
86	4	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	6.00	39.00	3.50	T	5.31	28.27
87	4	7	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	2.90	39.90	5.00	S	2.95	6.61
88	5	17	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	2.80	43.20	9.50	T	2.95	6.16
89	5	18	<i>Betula lenta</i> L.	1	Betulaceae	2	4.10	43.40	9.50	T	3.83	13.2
90	5	19	<i>Betula lenta</i> L.	1	Betulaceae	2	3.90	48.70	8.00	T	4.42	11.95
91	5	14	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.30	42.40	7.90	T	3.54	14.52
92	5	15	<i>Betula lenta</i> L.	1	Betulaceae	2	10.50	40.50	8.00	T	7.67	86.59
93	5	16	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.80	40.50	9.70	T	4.13	18.1
94	5	20	<i>Betula lenta</i> L.	1	Betulaceae	2	4.60	47.00	6.80	T	4.42	16.62
95	5	24	<i>Carya tomentosa</i> (Poirlet) Nutt.	8	Juglandaceae	6	13.40	46.80	2.00	T	13.27	141.03
96	5	25	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	4.70	49.00	2.10	T	8.85	17.35

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
97	5	26	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.10	49.20	0.70	T	2.36	20.43
98	5	21	<i>Betula lenta</i> L.	1	Betulaceae	2	4.60	47.00	6.00	T	4.72	16.62
99	5	22	<i>Betula lenta</i> L.	1	Betulaceae	2	3.60	47.60	6.30	T	3.83	10.18
100	5	23	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.50	47.00	2.20	T	3.54	9.62
101	5	4	<i>Cornus florida</i> L.	4	Cornaceae	3	4.60	41.00	4.50	T	4.72	16.62
102	5	5	<i>Cornus florida</i> L.	4	Cornaceae	3	3.50	41.30	4.60	T	4.13	9.62
103	5	6	<i>Cornus florida</i> L.	4	Cornaceae	3	4.50	41.20	4.70	T	4.72	15.9
104	5	1	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.50	41.00	3.00	T	5.31	9.62
105	5	2	<i>Cornus florida</i> L.	4	Cornaceae	3	2.00	41.30	4.00	T	2.95	3.14
106	5	3	<i>Cornus florida</i> L.	4	Cornaceae	3	4.60	41.50	4.00	T	4.72	16.62
107	5	7	<i>Cornus florida</i> L.	4	Cornaceae	3	7.48	43.00	4.50	T	3.54	43.94
108	5	11	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.60	45.50	7.20	T	5.01	10.18
109	5	12	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	3.00	44.00	7.60	T	4.13	7.07
110	5	13	<i>Cornus florida</i> L.	4	Cornaceae	3	6.00	40.20	6.80	T	5.31	28.27
111	5	8	<i>Cornus florida</i> L.	4	Cornaceae	3	2.30	44.20	4.50	T	3.54	4.15
112	5	9	<i>Cornus florida</i> L.	4	Cornaceae	3	2.20	44.20	4.20	T	2.95	3.8
113	5	10	<i>Betula lenta</i> L.	1	Betulaceae	2	4.50	45.20	6.00	T	5.31	15.9
114	6	17	<i>Betula lenta</i> L.	1	Betulaceae	2	4.50	8.70	14.30	T	6.49	15.9
115	6	18	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	7.70	15.30	T	3.54	3.8
116	6	19	<i>Betula lenta</i> L.	1	Betulaceae	2	6.04	8.00	16.00	T	7.37	28.65
117	6	14	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.20	4.00	15.00	T	3.54	3.8
118	6	15	<i>Betula lenta</i> L.	1	Betulaceae	2	5.00	7.40	13.00	T	6.49	19.63
119	6	16	<i>Betula lenta</i> L.	1	Betulaceae	2	4.60	7.70	14.00	T	6.49	16.62
120	6	23	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	8.00	17.70	T	3.54	3.46
121	6	24	<i>Cornus florida</i> L.	4	Cornaceae	3	3.60	9.60	12.20	T	3.54	10.18
122	6	25	<i>Betula lenta</i> L.	1	Betulaceae	2	3.70	9.40	10.60	T	6.49	10.75
123	6	20	<i>Quercus rubra</i> L.	2	Fagaceae	1	42.00	9.00	15.50	T	26.55	1385.45
124	6	21	<i>Betula lenta</i> L.	1	Betulaceae	2	4.20	8.40	16.50	T	6.49	13.85
125	6	22	<i>Betula lenta</i> L.	1	Betulaceae	2	3.11	7.40	17.50	T	4.13	7.6
126	6	13	<i>Betula lenta</i> L.	1	Betulaceae	2	7.00	4.00	13.60	T	7.37	38.48
127	6	4	<i>Cornus florida</i> L.	4	Cornaceae	3	4.70	0.50	13.00	T	4.13	17.35
128	6	5	<i>Cornus florida</i> L.	4	Cornaceae	3	2.30	0.60	14.50	T	2.95	4.15

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
129	6	6	<i>Cornus florida</i> L.	4	Comaceae	3	3.40	3.00	15.00	T	3.54	9.08
130	6	1	<i>Betula lenta</i> L.	1	Betulaceae	2	4.10	0.80	10.20	T	4.72	13.2
131	6	2	<i>Betula lenta</i> L.	1	Betulaceae	2	3.30	1.00	10.60	T	4.13	8.55
132	6	3	<i>Betula lenta</i> L.	1	Betulaceae	2	4.50	2.00	10.60	T	4.72	15.9
133	6	10	<i>Cornus florida</i> L.	4	Comaceae	3	2.60	3.00	19.30	T	4.72	5.31
134	6	11	<i>Betula lenta</i> L.	1	Betulaceae	2	5.40	4.00	19.50	T	7.08	22.9
135	6	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.60	3.60	17.40	T	4.42	16.62
136	6	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.40	0.20	16.00	T	3.54	4.52
137	6	8	<i>Quercus rubra</i> L.	2	Fagaceae	1	79.00	1.00	17.00	T	28.02	4901.68
138	6	9	<i>Cornus florida</i> L.	4	Comaceae	3	4.60	1.00	19.00	T	4.42	16.62
139	7	9	<i>Betula lenta</i> L.	1	Betulaceae	2	3.00	17.00	15.00	T	4.72	7.07
140	7	8	<i>Quercus rubra</i> L.	2	Fagaceae	1	48.00	16.80	18.50	T	29.50	1809.56
141	7	7	<i>Betula lenta</i> L.	1	Betulaceae	2	4.60	15.40	19.00	T	6.49	16.62
142	7	12	<i>Betula lenta</i> L.	1	Betulaceae	2	9.00	10.70	18.30	T	8.85	63.62
143	7	11	<i>Betula lenta</i> L.	1	Betulaceae	2	3.60	15.30	12.30	T	4.13	10.18
144	7	10	<i>Betula lenta</i> L.	1	Betulaceae	2	6.72	15.00	12.00	T	8.26	35.47
145	7	3	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	10.40	19.50	T	4.13	3.46
146	7	2	<i>Betula lenta</i> L.	1	Betulaceae	2	3.50	10.60	17.40	T	7.08	9.62
147	7	1	<i>Cornus florida</i> L.	4	Comaceae	3	2.20	10.30	13.40	T	3.54	3.8
148	7	6	<i>Betula lenta</i> L.	1	Betulaceae	2	5.80	14.70	19.00	T	7.08	26.42
149	7	5	<i>Quercus rubra</i> L.	2	Fagaceae	1	41.50	12.70	16.20	T	29.50	1352.66
150	7	4	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.00	12.20	16.00	T	4.13	3.14
151	8	12	<i>Betula lenta</i> L.	1	Betulaceae	2	2.80	25.00	16.70	T	5.90	6.16
152	8	13	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.90	26.80	19.00	T	5.90	18.86
153	8	10	<i>Betula lenta</i> L.	1	Betulaceae	2	2.50	25.20	17.60	T	5.90	4.91
154	8	11	<i>Betula lenta</i> L.	1	Betulaceae	2	3.40	25.30	17.00	T	5.90	9.08
155	8	14	<i>Quercus rubra</i> L.	2	Fagaceae	1	9.50	27.20	15.50	T	7.37	70.88
156	8	17	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	2.20	29.70	15.00	T	2.95	3.8
157	8	18	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	29.60	10.70	T	3.54	3.8
158	8	15	<i>Betula lenta</i> L.	1	Betulaceae	2	6.50	28.20	15.00	T	7.67	33.18
159	8	16	<i>Betula lenta</i> L.	1	Betulaceae	2	2.90	29.20	14.00	T	4.13	6.61
160	8	3	<i>Quercus rubra</i> L.	2	Fagaceae	1	45.50	23.00	15.50	T	26.55	1625.97

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
161	8	4	Betula lenta L.	1	Betulaceae	2	4.20	23.10	17.00	T	7.08	13.85
162	8	1	Betula lenta L.	1	Betulaceae	2	6.60	20.20	10.30	T	7.37	34.21
163	8	2	Quercus rubra L.	2	Fagaceae	1	51.50	23.00	12.30	T	26.55	2083.08
164	8	5	Betula lenta L.	1	Betulaceae	2	6.00	23.00	17.10	T	7.08	28.27
165	8	8	Betula lenta L.	1	Betulaceae	2	4.40	24.40	17.70	T	5.90	15.21
166	8	9	Betula lenta L.	1	Betulaceae	2	5.00	25.00	17.80	T	6.49	19.63
167	8	6	Betula lenta L.	1	Betulaceae	2	3.20	23.20	17.40	T	5.90	8.04
168	8	7	Betula lenta L.	1	Betulaceae	2	3.80	24.20	17.70	T	4.13	11.34
169	9	17	Prunus serotina Ehrh.	6	Rosaceae	5	2.90	39.00	18.00	T	4.13	6.61
170	9	18	Prunus serotina Ehrh.	6	Rosaceae	5	4.00	39.60	17.00	T	4.72	12.57
171	9	19	Prunus serotina Ehrh.	6	Rosaceae	5	2.40	39.00	16.00	T	3.54	4.52
172	9	14	Prunus serotina Ehrh.	6	Rosaceae	5	2.60	36.60	18.00	T	4.13	5.31
173	9	15	Betula lenta L.	1	Betulaceae	2	46.00	38.70	19.50	T	25.07	1661.91
174	9	16	Prunus serotina Ehrh.	6	Rosaceae	5	3.60	39.60	19.00	T	3.54	10.18
175	9	23	Prunus serotina Ehrh.	6	Rosaceae	5	2.20	38.20	16.80	T	3.54	3.8
176	9	24	Prunus serotina Ehrh.	6	Rosaceae	5	5.40	36.70	10.10	T	5.90	22.9
177	9	25	Prunus serotina Ehrh.	6	Rosaceae	5	3.50	35.50	11.00	T	4.13	9.62
178	9	20	Prunus serotina Ehrh.	6	Rosaceae	5	2.40	39.80	15.00	T	3.54	4.52
179	9	21	Prunus serotina Ehrh.	6	Rosaceae	5	4.90	39.80	12.00	T	5.90	18.86
180	9	22	Prunus serotina Ehrh.	6	Rosaceae	5	2.90	38.20	16.00	T	4.13	6.61
181	9	13	Prunus serotina Ehrh.	6	Rosaceae	5	6.90	36.70	15.00	T	7.37	37.39
182	9	4	Cornus florida L.	4	Cornaceae	3	4.90	31.20	15.50	T	4.42	18.86
183	9	5	Prunus serotina Ehrh.	6	Rosaceae	5	3.90	31.50	18.90	T	4.42	11.95
184	9	6	Cornus florida L.	4	Cornaceae	3	4.50	33.20	18.90	T	4.13	15.9
185	9	1	Prunus serotina Ehrh.	6	Rosaceae	5	5.50	31.00	10.30	T	4.13	23.76
186	9	2	Prunus serotina Ehrh.	6	Rosaceae	5	5.20	31.20	11.30	T	5.31	21.24
187	9	3	Vaccinium corymbosum L.	13	Ericaceae	8	2.00	30.30	11.40	S	3.54	3.14
188	9	10	Cornus florida L.	4	Cornaceae	3	5.40	33.10	13.00	T	6.49	22.9
189	9	11	Prunus serotina Ehrh.	6	Rosaceae	5	4.30	34.50	14.00	T	5.90	14.52
190	9	12	Cornus florida L.	4	Cornaceae	3	8.00	35.70	15.00	T	7.37	50.27
191	9	7	Cornus florida L.	4	Cornaceae	3	6.20	34.00	19.70	T	5.31	30.19
192	9	8	Cornus florida L.	4	Cornaceae	3	4.40	34.40	18.00	T	4.13	15.21

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
193	9	9	<i>Cornus florida</i> L.	4	Comaceae	3	9.50	32.00	14.00	T	6.49	70.88
194	10	5	<i>Betula lenta</i> L.	1	Betulaceae	2	14.50	47.00	12.20	T	8.85	165.13
195	10	6	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	6.10	41.30	12.70	T	4.13	29.22
196	10	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.50	40.50	13.80	T	4.42	23.76
197	10	4	<i>Betula lenta</i> L.	1	Betulaceae	2	5.50	45.20	11.30	T	5.31	23.76
198	10	1	<i>Betula lenta</i> L.	1	Betulaceae	2	2.90	41.00	10.20	T	4.42	6.61
199	10	2	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	7.00	41.00	12.00	T	7.37	38.48
200	10	3	<i>Quercus velutina</i> Lam.	5	Fagaceae	1	95.00	43.20	11.20	T	25.07	7088.23
201	11	16	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.00	5.40	29.00	T	4.72	19.63
202	11	17	<i>Quercus alba</i> L.	7	Fagaceae	1	78.00	4.50	29.50	T	25.07	4778.37
203	11	15	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.00	7.40	29.80	T	3.54	3.14
204	11	13	<i>Betula lenta</i> L.	1	Betulaceae	2	2.70	9.90	21.70	T	5.31	5.73
205	11	14	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	2.00	7.20	26.40	T	2.36	3.14
206	11	18	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.20	3.30	29.40	T	4.13	3.8
207	11	22	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.50	4.20	24.00	T	2.36	4.91
208	11	23	<i>Castanea dentata</i> (Marshall) Borkh.	15	Fagaceae	1	2.00	5.50	27.00	T	2.36	3.14
209	11	21	<i>Cornus florida</i> L.	4	Comaceae	3	2.00	2.00	25.00	T	2.95	3.14
210	11	19	<i>Cornus florida</i> L.	4	Comaceae	3	5.60	2.10	29.50	T	3.54	24.63
211	11	20	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.20	0.30	29.70	T	2.95	3.8
212	11	12	<i>Betula lenta</i> L.	1	Betulaceae	2	2.40	9.80	21.90	T	3.54	4.52
213	11	4	<i>Betula lenta</i> L.	1	Betulaceae	2	8.50	6.00	20.30	T	8.85	56.75
214	11	5	<i>Betula lenta</i> L.	1	Betulaceae	2	3.00	6.80	22.00	T	5.90	7.07
215	11	3	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	5.00	22.00	T	4.13	3.14
216	11	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	8.50	1.40	22.00	T	4.72	56.75
217	11	2	<i>Quercus rubra</i> L.	2	Fagaceae	1	65.50	1.80	24.00	T	26.55	3369.56
218	11	6	<i>Betula lenta</i> L.	1	Betulaceae	2	2.70	6.20	22.50	T	4.72	5.73
219	11	10	<i>Betula lenta</i> L.	1	Betulaceae	2	3.80	7.00	23.80	T	4.72	11.34
220	11	11	<i>Betula lenta</i> L.	1	Betulaceae	2	8.00	9.40	25.30	T	10.32	50.27
221	11	9	<i>Betula lenta</i> L.	1	Betulaceae	2	2.50	5.20	22.20	T	4.72	4.91
222	11	7	<i>Betula lenta</i> L.	1	Betulaceae	2	3.40	7.00	21.00	T	4.72	9.08
223	11	8	<i>Betula lenta</i> L.	1	Betulaceae	2	5.40	7.00	22.00	T	7.37	22.9
224	12	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	8.50	18.20	22.20	T	5.90	56.75

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
225	12	10	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.70	19.20	20.60	T	4.13	5.73
226	12	9	<i>Betula lenta</i> L.	1	Betulaceae	2	4.50	18.00	20.30	T	7.08	15.9
227	12	12	<i>Betula lenta</i> L.	1	Betulaceae	2	6.40	18.60	23.00	T	5.90	32.17
228	12	15	<i>Cornus florida</i> L.	4	Comaceae	3	6.40	18.30	29.80	T	7.37	32.17
229	12	14	<i>Cornus florida</i> L.	4	Comaceae	3	7.00	19.00	27.20	T	8.85	38.48
230	12	13	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	10.50	19.60	25.00	T	10.32	86.59
231	12	3	<i>Betula lenta</i> L.	1	Betulaceae	2	4.20	10.30	24.10	T	6.78	13.85
232	12	4	<i>Betula lenta</i> L.	1	Betulaceae	2	15.50	13.00	24.00	T	13.27	188.69
233	12	1	<i>Betula lenta</i> L.	1	Betulaceae	2	6.40	12.00	22.70	T	7.37	32.17
234	12	2	<i>Betula lenta</i> L.	1	Betulaceae	2	5.10	12.60	22.50	T	4.13	20.43
235	12	7	<i>Cornus florida</i> L.	4	Comaceae	3	2.30	13.50	28.00	T	4.13	4.15
236	12	8	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.50	10.20	28.10	T	7.08	15.9
237	12	5	<i>Betula lenta</i> L.	1	Betulaceae	2	4.10	13.30	25.70	T	5.90	13.2
238	12	6	<i>Betula lenta</i> L.	1	Betulaceae	2	4.30	12.80	26.00	T	6.78	14.52
239	13	16	<i>Betula lenta</i> L.	1	Betulaceae	2	9.00	29.80	28.50	T	11.80	63.62
240	13	17	<i>Betula lenta</i> L.	1	Betulaceae	2	3.30	26.00	22.00	T	5.58	8.55
241	13	15	<i>Betula lenta</i> L.	1	Betulaceae	2	7.00	29.40	28.10	T	10.32	38.48
242	13	13	<i>Betula lenta</i> L.	1	Betulaceae	2	10.00	28.00	28.10	T	14.75	78.54
243	13	14	<i>Betula lenta</i> L.	1	Betulaceae	2	2.30	27.50	29.00	T	3.24	4.15
244	13	18	<i>Betula lenta</i> L.	1	Betulaceae	2	3.30	26.40	22.50	T	4.54	8.55
245	13	22	<i>Betula lenta</i> L.	1	Betulaceae	2	11.50	28.70	22.50	T	10.32	103.87
246	13	23	<i>Betula lenta</i> L.	1	Betulaceae	2	10.50	29.00	21.70	T	10.91	86.59
247	13	21	<i>Betula lenta</i> L.	1	Betulaceae	2	2.90	27.20	23.70	T	5.31	6.61
248	13	19	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	26.60	22.50	T	4.57	3.14
249	13	20	<i>Betula lenta</i> L.	1	Betulaceae	2	8.00	27.00	22.90	T	8.85	50.27
250	13	4	<i>Quercus rubra</i> L.	2	Fagaceae	1	75.00	23.00	26.00	T	26.55	4417.88
251	13	5	<i>Cornus florida</i> L.	4	Comaceae	3	3.60	22.20	23.40	T	5.31	10.18
252	13	6	<i>Betula lenta</i> L.	1	Betulaceae	2	2.60	22.00	25.80	T	3.54	5.31
253	13	1	<i>Betula lenta</i> L.	1	Betulaceae	2	7.50	23.30	20.60	T	8.85	44.18
254	13	2	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	23.30	20.90	T	4.13	3.8
255	13	3	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	22.50	22.10	T	3.54	3.46
256	13	10	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	23.00	28.20	T	3.54	3.14

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
257	13	11	<i>Betula lenta</i> L.	1	Betulaceae	2	3.90	24.70	29.60	T	4.72	11.95
258	13	12	<i>Betula lenta</i> L.	1	Betulaceae	2	10.00	27.20	27.90	T	14.75	78.54
259	13	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	4.50	22.00	26.80	T	5.90	15.9
260	13	8	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	21.00	28.00	T	4.13	3.8
261	13	9	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	21.20	27.60	T	2.95	3.14
262	14	5	<i>Quercus rubra</i> L.	2	Fagaceae	1	70.00	39.00	23.00	T	26.55	3848.46
263	14	6	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	8.50	34.50	27.50	T	10.32	56.75
264	14	7	<i>Betula lenta</i> L.	1	Betulaceae	2	4.70	31.00	28.70	T	8.85	17.35
265	14	2	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	4.00	33.90	21.00	S	4.72	12.57
266	14	1	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	2.20	31.90	21.60	S	2.95	3.8
267	14	4	<i>Cornus florida</i> L.	4	Comaceae	3	4.30	35.00	23.00	T	4.72	14.52
268	14	3	<i>Betula lenta</i> L.	1	Betulaceae	2	4.30	36.00	21.50	T	5.31	14.52
269	15	3	<i>Betula lenta</i> L.	1	Betulaceae	2	39.50	49.00	24.50	T	19.17	1225.42
270	15	1	<i>Quercus alba</i> L.	7	Fagaceae	1	2.60	47.00	21.50	T	2.95	5.31
271	15	2	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.20	43.00	22.50	T	2.95	3.8
272	16	1	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	60.50	6.00	38.10	T	26.55	2874.76
273	17	6	<i>Betula lenta</i> L.	1	Betulaceae	2	8.00	16.20	34.20	T	7.37	50.27
274	17	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	9.40	13.20	37.20	T	6.49	69.4
275	17	8	<i>Cornus florida</i> L.	4	Comaceae	3	5.40	18.00	36.80	T	4.13	22.9
276	17	5	<i>Betula lenta</i> L.	1	Betulaceae	2	5.50	15.00	34.50	T	7.37	23.76
277	17	2	<i>Cornus florida</i> L.	4	Comaceae	3	2.90	16.80	30.90	T	4.13	6.61
278	17	1	<i>Betula lenta</i> L.	1	Betulaceae	2	7.50	12.80	31.00	T	7.37	44.18
279	17	4	<i>Quercus alba</i> L.	7	Fagaceae	1	48.00	10.50	34.50	T	20.65	1809.56
280	17	3	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	2.20	18.60	32.50	S	3.54	3.8
281	18	10	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	4.80	25.40	37.70	T	7.37	18.1
282	18	9	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.60	24.80	38.70	T	4.13	10.18
283	18	8	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	2.80	24.50	39.60	T	2.95	6.16
284	18	13	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	6.60	26.00	33.40	T	8.85	34.21
285	18	12	<i>Betula lenta</i> L.	1	Betulaceae	2	8.90	28.20	35.30	T	10.32	62.21
286	18	11	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	2.70	26.00	37.70	S	3.54	5.73
287	18	3	<i>Betula lenta</i> L.	1	Betulaceae	2	3.20	22.80	30.60	T	4.72	8.04
288	18	2	<i>Cornus florida</i> L.	4	Comaceae	3	3.50	22.80	30.20	T	4.13	9.62

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
289	18	1	<i>Quercus rubra</i> L.	2	Fagaceae	1	43.50	21.80	33.00	T	23.60	1486.17
290	18	4	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	6.40	26.30	34.00	T	10.32	32.17
291	18	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	11.50	23.40	38.00	T	7.67	103.87
292	18	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.60	21.00	38.00	T	4.13	16.62
293	18	5	<i>Cornus florida</i> L.	4	Comaceae	3	2.20	23.60	35.30	T	3.54	3.8
294	19	13	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	38.40	33.30	T	4.13	3.46
295	19	14	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	38.50	32.30	T	4.13	3.46
296	19	11	<i>Betula lenta</i> L.	1	Betulaceae	2	13.50	38.20	37.30	T	17.70	143.14
297	19	12	<i>Betula lenta</i> L.	1	Betulaceae	2	8.50	37.70	36.90	T	14.75	56.75
298	19	17	<i>Quercus alba</i> L.	7	Fagaceae	1	6.80	39.30	39.00	T	5.90	36.32
299	19	18	<i>Cornus florida</i> L.	4	Comaceae	3	8.00	39.00	38.70	T	7.37	50.27
300	19	15	<i>Betula lenta</i> L.	1	Betulaceae	2	4.30	38.50	32.00	T	8.85	14.52
301	19	16	<i>Betula lenta</i> L.	1	Betulaceae	2	11.00	39.80	32.80	T	17.70	95.03
302	19	10	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	14.00	30.80	39.80	T	13.27	153.94
303	19	3	<i>Vaccinium corymbosum</i> L.	13	Ericaceae	8	2.20	32.50	32.50	S	4.13	3.8
304	19	4	<i>Betula lenta</i> L.	1	Betulaceae	2	4.70	34.60	32.00	T	10.32	17.35
305	19	1	<i>Quercus alba</i> L.	7	Fagaceae	1	11.00	31.00	32.00	T	10.32	95.03
306	19	2	<i>Quercus velutina</i> Lam.	5	Fagaceae	1	78.00	30.50	33.00	T	28.02	4778.37
307	19	5	<i>Betula lenta</i> L.	1	Betulaceae	2	5.20	36.90	30.90	T	7.08	21.24
308	19	8	<i>Cornus florida</i> L.	4	Comaceae	3	6.30	33.00	37.50	T	5.90	31.17
309	19	9	<i>Cornus florida</i> L.	4	Comaceae	3	9.50	31.30	38.80	T	11.80	70.88
310	19	6	<i>Betula lenta</i> L.	1	Betulaceae	2	12.50	38.90	30.60	T	14.75	122.72
311	19	7	<i>Quercus alba</i> L.	7	Fagaceae	1	14.00	32.50	33.80	T	7.37	153.94
312	20	5	<i>Betula lenta</i> L.	1	Betulaceae	2	6.50	40.10	36.30	T	8.26	33.18
313	20	6	<i>Betula lenta</i> L.	1	Betulaceae	2	3.10	41.30	37.40	T	3.54	7.55
314	20	7	<i>Castanea dentata</i> (Marshall) Borkh.	15	Fagaceae	1	2.20	42.20	36.00	T	2.36	3.8
315	20	2	<i>Betula lenta</i> L.	1	Betulaceae	2	2.10	41.00	34.50	T	3.54	3.46
316	20	1	<i>Betula lenta</i> L.	1	Betulaceae	2	3.20	40.50	32.60	T	4.42	8.04
317	20	4	<i>Betula lenta</i> L.	1	Betulaceae	2	2.30	40.60	36.00	T	3.54	4.15
318	20	3	<i>Betula lenta</i> L.	1	Betulaceae	2	8.00	42.00	34.60	T	8.85	50.27
319	21	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.80	3.00	48.80	T	4.72	6.16
320	21	2	<i>Cornus florida</i> L.	4	Comaceae	3	8.50	4.00	45.40	T	5.31	56.75

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
321	21	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	1.40	43.00	T	4.13	5.31
322	21	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	2.60	49.00	T	2.95	5.31
323	22	5	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	3.00	19.50	48.70	T	4.42	7.07
324	22	6	<i>Betula lenta</i> L.	1	Betulaceae	2	52.00	19.50	46.20	T	26.55	2123.72
325	22	2	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.50	16.00	45.00	T	3.54	4.91
326	22	1	<i>Cornus florida</i> L.	4	Cornaceae	3	4.80	11.30	40.70	T	5.31	18.1
327	22	4	<i>Cornus florida</i> L.	4	Cornaceae	3	8.00	13.40	49.00	T	7.37	50.27
328	22	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	17.20	47.50	T	4.13	13.85
329	23	8	<i>Quercus rubra</i> L.	2	Fagaceae	1	4.50	24.50	43.00	T	7.37	15.9
330	23	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.90	25.00	46.20	T	5.31	27.34
331	23	10	<i>Quercus rubra</i> L.	2	Fagaceae	1	8.50	25.00	40.20	T	13.27	56.75
332	23	9	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	8.50	27.00	40.30	T	8.26	56.75
333	23	3	<i>Cornus alternifolia</i> L.f.	14	Cornaceae	3	2.60	23.40	43.00	S	3.54	5.31
334	23	2	<i>Cornus alternifolia</i> L.f.	14	Cornaceae	3	4.17	23.30	41.80	S	2.95	13.66
335	23	1	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.50	21.00	41.00	T	3.54	9.62
336	23	6	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.50	28.00	47.30	T	4.72	9.62
337	23	5	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	5.20	25.00	48.00	T	6.49	21.24
338	23	4	<i>Cornus florida</i> L.	4	Cornaceae	3	10.70	23.70	47.00	T	8.85	89.92
339	24	9	<i>Betula lenta</i> L.	1	Betulaceae	2	4.70	39.80	42.50	T	7.67	17.35
340	24	8	<i>Betula lenta</i> L.	1	Betulaceae	2	7.00	37.40	44.00	T	13.27	38.48
341	24	10	<i>Betula lenta</i> L.	1	Betulaceae	2	5.20	38.90	46.50	T	5.31	21.24
342	24	12	<i>Betula lenta</i> L.	1	Betulaceae	2	2.20	36.90	49.80	T	4.13	3.8
343	24	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	20.50	37.60	47.50	T	23.60	330.06
344	24	3	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	5.00	31.50	46.90	T	7.37	19.63
345	24	1	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	14.00	30.80	40.20	T	11.80	153.94
346	24	2	<i>Cornus florida</i> L.	4	Cornaceae	3	8.50	31.20	44.70	T	8.26	56.75
347	24	4	<i>Quercus velutina</i> Lam.	5	Fagaceae	1	49.50	34.00	44.00	T	26.55	1924.43
348	24	7	<i>Betula lenta</i> L.	1	Betulaceae	2	3.40	35.50	44.00	T	4.72	9.08
349	24	6	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	35.30	43.50	T	3.54	3.14
350	24	5	<i>Betula lenta</i> L.	1	Betulaceae	2	13.50	35.00	41.00	T	14.75	143.14
351	25	4	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	4.40	44.00	48.00	T	4.42	15.21
352	25	1	<i>Betula lenta</i> L.	1	Betulaceae	2	2.40	42.20	46.00	T	3.54	4.52

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
353	25	2	<i>Quercus alba</i> L.	7	Fagaceae	1	71.00	44.00	45.80	T	26.55	3959.20
354	25	3	<i>Fagus grandifolia</i> Ehrh.	11	Fagaceae	1	56.50	48.00	43.50	T	23.60	2507.19
355	26	9	<i>Quercus rubra</i> L.	2	Fagaceae	1	70.00	8.00	58.20	T	29.50	3848.46
356	26	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.20	7.00	57.20	T	4.72	8.04
357	26	11	<i>Cornus florida</i> L.	4	Comaceae	3	5.20	7.80	59.90	T	4.13	21.24
358	26	10	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	7.00	9.00	59.20	T	5.90	38.48
359	26	7	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	11.00	5.40	50.50	T	17.70	95.03
360	26	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.70	2.80	54.00	T	4.72	5.73
361	26	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	2.40	53.00	T	5.90	13.85
362	26	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	13.50	2.50	52.00	T	10.32	143.14
363	26	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.20	4.20	51.50	T	2.36	3.8
364	26	5	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.70	3.30	59.80	T	4.13	10.75
365	26	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.50	1.00	56.70	T	3.54	9.62
366	27	6	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	6.50	19.40	53.20	T	7.37	33.18
367	27	7	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	7.00	19.80	54.30	T	6.78	38.48
368	27	8	<i>Castanea dentata</i> (Marshall) Borkh.	15	Fagaceae	1	3.50	14.00	54.20	T	2.95	9.62
369	27	2	<i>Nyssa sylvatica</i> Marshall.	22	Nyssaceae	13	2.50	11.50	59.80	T	3.54	4.91
370	27	1	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	2.00	11.50	53.80	T	2.36	3.14
371	27	3	<i>Lindera benzoin</i> (L.) Blume	16	Lauraceae	7	2.00	14.00	59.20	S	2.95	3.14
372	27	5	<i>Cornus florida</i> L.	4	Comaceae	3	11.00	17.80	59.80	T	8.85	95.03
373	27	4	<i>Cornus florida</i> L.	4	Comaceae	3	11.00	18.00	57.80	T	8.85	95.03
374	28	7	<i>Cornus florida</i> L.	4	Comaceae	3	20.00	28.90	51.00	T	13.27	314.16
375	28	8	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	3.00	26.50	55.30	T	2.95	7.07
376	28	9	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	4.50	25.20	51.20	T	3.54	15.9
377	28	3	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	6.50	22.00	58.20	T	4.72	33.18
378	28	2	<i>Quercus rubra</i> L.	2	Fagaceae	1	13.50	23.00	56.80	T	16.22	143.14
379	28	1	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	11.50	20.50	53.00	T	13.27	103.87
380	28	6	<i>Quercus velutina</i> Lam.	5	Fagaceae	1	67.50	27.00	52.00	T	29.50	3578.48
381	28	5	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	5.00	27.50	55.20	T	4.13	19.63
382	28	4	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	15.50	24.50	55.20	T	13.27	188.69
383	29	7	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	3.50	34.20	54.00	T	3.54	9.62
384	29	8	<i>Betula lenta</i> L.	1	Betulaceae	2	2.00	37.00	59.00	T	2.95	3.14

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
385	29	9	<i>Cornus florida</i> L.	4	Comaceae	3	5.00	39.00	59.50	T	5.90	19.63
386	29	3	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	8.00	36.30	50.10	T	5.90	50.27
387	29	2	<i>Betula lenta</i> L.	1	Betulaceae	2	3.84	32.30	53.20	T	4.72	11.58
388	29	1	<i>Lindera benzoin</i> (L.) Blume	16	Lauraceae	7	2.00	33.30	51.00	S	2.95	3.14
389	29	4	<i>Cornus florida</i> L.	4	Comaceae	3	24.50	32.50	58.70	T	16.22	471.44
390	29	5	<i>Quercus rubra</i> L.	2	Fagaceae	1	62.00	36.00	57.00	T	26.55	3019.08
391	29	6	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	3.80	35.30	55.00	T	2.95	11.34
392	30	3	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.70	41.50	56.60	T	4.42	10.75
393	30	2	<i>Betula lenta</i> L.	1	Betulaceae	2	16.50	44.80	54.00	T	10.32	213.83
394	30	1	<i>Betula lenta</i> L.	1	Betulaceae	2	15.00	45.00	53.50	T	8.85	176.72
395	30	4	<i>Sassafras albidum</i> (Nutt.) Nees	12	Lauraceae	7	6.50	45.00	58.50	T	7.37	33.18
396	30	5	<i>Cornus florida</i> L.	4	Comaceae	3	8.50	47.80	56.00	T	7.37	56.75
397	30	6	<i>Quercus alba</i> L.	7	Fagaceae	1	81.50	47.00	59.00	T	29.50	5216.82
398	31	13	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	8.10	3.30	69.70	T	10.32	51.53
399	31	12	<i>Cornus florida</i> L.	4	Comaceae	3	5.00	5.80	69.20	T	6.49	19.63
400	31	11	<i>Cornus florida</i> L.	4	Comaceae	3	6.30	6.30	69.70	T	7.37	31.17
401	31	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.00	2.10	60.90	T	3.54	3.14
402	31	17	<i>Castanea dentata</i> (Marshall) Borkh.	15	Fagaceae	1	2.00	1.20	66.60	T	2.95	3.14
403	31	16	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	8.70	1.80	67.50	T	8.85	59.45
404	31	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.50	0.20	68.70	T	5.31	23.76
405	31	4	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	5.10	6.00	62.30	T	5.31	20.43
406	31	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.30	8.00	63.00	T	4.42	14.52
407	31	1	<i>Cornus florida</i> L.	4	Comaceae	3	11.40	0.60	60.50	T	7.37	102.07
408	31	3	<i>Betula lenta</i> L.	1	Betulaceae	2	26.75	4.00	62.00	T	11.80	562
409	31	2	<i>Cornus florida</i> L.	4	Comaceae	3	7.50	1.50	61.00	T	6.49	44.18
410	31	9	<i>Quercus rubra</i> L.	2	Fagaceae	1	9.24	7.90	68.50	T	9.44	67.06
411	31	10	<i>Cornus florida</i> L.	4	Comaceae	3	7.00	6.60	69.80	T	7.37	38.48
412	31	8	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	9.00	0.90	66.70	T	11.80	63.62
413	31	6	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	4.50	8.00	64.70	T	4.42	15.9
414	31	7	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	2.20	7.50	65.10	T	2.95	3.8
415	32	11	<i>Cornus florida</i> L.	4	Comaceae	3	7.50	19.00	68.50	T	5.90	44.18
416	32	10	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	2.00	11.00	69.80	S	2.65	3.14

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
417	32	12	Phellodendron amurense Rupr.	3	Rutaceae	4	3.10	19.80	69.30	T	2.95	7.55
418	32	14	Cornus florida L.	4	Cornaceae	3	8.00	19.60	64.00	T	8.85	50.27
419	32	13	Liriodendron tulipifera L.	20	Magnoliaceae	11	2.60	19.00	65.00	T	3.54	5.31
420	32	9	Betula lenta L.	1	Betulaceae	2	2.20	13.30	69.40	T	4.13	3.8
421	32	3	Cornus florida L.	4	Cornaceae	3	2.60	14.00	61.70	T	2.36	5.31
422	32	4	Carya ovata (Miller) K. Koch	9	Juglandaceae	6	5.10	13.00	65.30	T	5.90	20.43
423	32	1	Quercus velutina Lam.	5	Fagaceae	1	84.50	12.00	63.50	T	23.60	5607.95
424	32	2	Acer rubrum L.	18	Aceraceae	10	2.90	12.00	61.00	T	2.95	6.61
425	32	7	Cornus florida L.	4	Cornaceae	3	6.80	13.00	67.30	T	5.90	36.32
426	32	8	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	15.60	12.30	69.40	T	14.75	191.13
427	32	5	Phellodendron amurense Rupr.	3	Rutaceae	4	2.80	12.50	64.90	T	2.95	6.16
428	32	6	Cornus florida L.	4	Cornaceae	3	8.50	16.10	65.50	T	7.08	56.75
429	33	8	Prunus serotina Ehrh.	6	Rosaceae	5	13.70	28.00	66.00	T	8.85	147.41
430	33	9	Quercus velutina Lam.	5	Fagaceae	1	62.70	27.70	67.50	T	22.12	3087.64
431	33	10	Quercus rubra L.	2	Fagaceae	1	29.30	28.00	61.20	T	19.17	674.26
432	33	7	Cornus florida L.	4	Cornaceae	3	4.00	23.50	66.50	T	3.54	12.57
433	33	3	Betula lenta L.	1	Betulaceae	2	2.40	28.00	64.00	T	4.13	4.52
434	33	2	Cornus florida L.	4	Cornaceae	3	8.43	27.00	62.50	T	8.85	55.81
435	33	1	Carya glabra (Miller) Sweet	10	Juglandaceae	6	6.10	23.00	61.00	T	7.37	29.22
436	33	6	Cornus florida L.	4	Cornaceae	3	2.20	25.00	66.00	T	2.95	3.8
437	33	5	Cornus florida L.	4	Cornaceae	3	4.80	25.70	65.40	T	5.90	18.1
438	33	4	Cornus florida L.	4	Cornaceae	3	2.90	26.00	64.00	T	2.36	6.61
439	34	13	Cornus florida L.	4	Cornaceae	3	2.60	38.70	66.80	T	4.42	5.31
440	34	12	Phellodendron amurense Rupr.	3	Rutaceae	4	2.10	37.70	69.80	T	4.13	3.46
441	34	11	Betula lenta L.	1	Betulaceae	2	2.50	36.10	67.90	T	4.13	4.91
442	34	14	Cornus florida L.	4	Cornaceae	3	2.30	39.00	67.00	T	2.95	4.15
443	34	17	Betula lenta L.	1	Betulaceae	2	4.90	39.90	65.00	T	5.90	18.86
444	34	16	Betula lenta L.	1	Betulaceae	2	2.60	38.00	62.10	T	2.95	5.31
445	34	15	Cornus florida L.	4	Cornaceae	3	2.50	39.00	66.00	T	4.13	4.91
446	34	4	Cornus florida L.	4	Cornaceae	3	10.00	36.00	60.50	T	8.26	78.54
447	34	5	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	14.90	35.00	63.20	T	16.22	174.37
448	34	3	Fagus grandifolia Ehrh.	11	Fagaceae	1	5.90	32.00	62.50	T	5.90	27.34

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
449	34	1	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	4.60	31.00	62.40	T	5.31	16.62
450	34	2	Prunus serotina Ehrh.	6	Rosaceae	5	28.00	31.50	62.60	T	14.75	615.75
451	34	9	Quercus rubra L.	2	Fagaceae	1	12.00	32.50	69.90	T	11.80	113.1
452	34	10	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	4.10	36.30	69.50	T	4.13	13.2
453	34	8	Carya glabra (Miller) Sweet	10	Juglandaceae	6	13.10	33.30	67.20	T	11.80	134.78
454	34	6	Cornus florida L.	4	Cornaceae	3	2.10	35.10	63.50	T	3.54	3.46
455	34	7	Carya glabra (Miller) Sweet	10	Juglandaceae	6	21.40	35.30	66.20	T	17.70	359.68
456	35	10	Ilex verticillata (L.) A. Gray	21	Aquifoliaceae	12	2.50	43.00	69.50	S, Winterberry	2.36	4.91
457	35	9	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	6.30	44.00	65.00	T	6.49	31.17
458	35	11	Betula lenta L.	1	Betulaceae	2	5.00	40.50	65.00	T	4.42	19.63
459	35	13	Betula lenta L.	1	Betulaceae	2	26.00	44.50	64.20	T	22.12	530.93
460	35	12	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	7.60	40.30	60.50	T	8.85	45.36
461	35	3	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	5.70	44.50	64.70	T	4.13	25.52
462	35	4	Phellodendron amurense Rupr.	3	Rutaceae	4	6.20	49.50	60.10	T	7.37	30.19
463	35	1	Betula lenta L.	1	Betulaceae	2	5.40	42.00	61.00	T	10.32	22.9
464	35	2	Betula lenta L.	1	Betulaceae	2	4.00	41.30	62.00	T	8.85	12.57
465	35	8	Carya ovata (Miller) K. Koch	9	Juglandaceae	6	3.75	44.20	66.80	T	4.13	11.04
466	35	7	Betula lenta L.	1	Betulaceae	2	26.70	46.00	67.50	T	20.65	559.9
467	35	5	Betula lenta L.	1	Betulaceae	2	24.00	48.70	68.00	T	22.12	452.39
468	35	6	Phellodendron amurense Rupr.	3	Rutaceae	4	3.70	48.80	69.90	T	4.72	10.75
469	36	19	Phellodendron amurense Rupr.	3	Rutaceae	4	3.50	4.20	79.10	T	4.72	9.62
470	36	20	Phellodendron amurense Rupr.	3	Rutaceae	4	7.00	2.80	76.20	T	7.67	38.48
471	36	18	Phellodendron amurense Rupr.	3	Rutaceae	4	8.80	4.00	79.00	T	8.85	60.82
472	36	16	Phellodendron amurense Rupr.	3	Rutaceae	4	7.00	2.00	79.80	T	7.37	38.48
473	36	17	Phellodendron amurense Rupr.	3	Rutaceae	4	2.90	3.00	79.20	T	3.54	6.61
474	36	21	Phellodendron amurense Rupr.	3	Rutaceae	4	2.10	6.00	76.90	T	4.13	3.46
475	36	25	Carya glabra (Miller) Sweet	10	Juglandaceae	6	2.60	7.40	79.50	T	4.13	5.31
476	36	26	Castanea dentata (Marshall) Borkh.	15	Fagaceae	1	2.00	1.20	76.60	T	2.36	3.14
477	36	24	Phellodendron amurense Rupr.	3	Rutaceae	4	5.50	8.40	79.50	T	6.49	23.76
478	36	22	Carya ovata (Miller) K. Koch	9	Juglandaceae	6	5.40	7.70	76.60	T	8.85	22.9
479	36	23	Phellodendron amurense Rupr.	3	Rutaceae	4	6.00	8.50	77.70	T	8.85	28.27
480	36	15	Carya glabra (Miller) Sweet	10	Juglandaceae	6	2.30	1.10	79.00	T	3.54	4.15

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
481	36	5	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	22.10	9.50	71.80	T	19.17	383.6
482	36	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	7.10	3.00	73.40	T	6.49	39.59
483	36	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	2.40	73.40	T	2.65	5.31
484	36	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.90	6.70	72.20	T	4.13	6.61
485	36	1	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	2.20	0.20	70.30	T	2.95	3.8
486	36	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.30	1.20	71.40	T	5.01	22.06
487	36	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.90	2.60	71.00	T	4.13	6.61
488	36	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.40	1.00	76.00	T	4.13	4.52
489	36	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	8.00	0.50	75.50	T	7.37	50.27
490	36	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.90	0.20	79.00	T	4.13	6.61
491	36	13	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	8.60	1.00	78.00	T	7.37	58.09
492	36	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.60	1.00	75.00	T	4.13	10.18
493	36	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.80	2.90	74.40	T	3.54	6.16
494	36	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.30	2.90	73.60	T	2.65	4.15
495	37	21	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	13.60	78.20	T	2.95	3.46
496	37	22	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.14	13.30	78.80	T	5.31	13.46
497	37	23	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	6.00	13.40	79.00	T	5.90	28.27
498	37	20	<i>Cornus florida</i> L.	4	Cornaceae	3	2.80	13.80	77.60	T	4.13	6.16
499	37	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.00	14.30	77.60	T	2.95	3.14
500	37	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	10.10	16.40	78.40	T	11.21	80.12
501	37	24	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	5.30	10.60	79.00	T	6.49	22.06
502	37	29	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.50	13.00	76.00	T	4.42	9.62
503	37	28	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.20	12.00	75.00	T	4.42	8.04
504	37	25	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.80	12.00	76.40	T	5.31	26.42
505	37	26	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	10.80	13.00	76.30	T	10.62	91.61
506	37	27	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.20	10.20	79.80	T	5.31	21.24
507	37	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.70	16.30	71.20	T	4.13	10.75
508	37	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.40	13.50	72.00	T	3.54	4.52
509	37	8	<i>Cornus florida</i> L.	4	Cornaceae	3	2.50	18.40	72.00	T	3.54	4.91
510	37	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	7.10	17.20	71.00	T	8.26	39.59
511	37	2	<i>Cornus florida</i> L.	4	Cornaceae	3	2.10	10.10	73.90	T	2.95	3.46
512	37	1	<i>Betula lenta</i> L.	1	Betulaceae	2	4.50	11.90	70.20	T	5.31	15.9

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
513	37	4	Phellodendron amurense Rupr.	3	Rutaceae	4	11.66	13.40	72.70	T	9.44	106.78
514	37	3	Phellodendron amurense Rupr.	3	Rutaceae	4	4.80	11.00	74.20	T	5.90	18.1
515	37	9	Phellodendron amurense Rupr.	3	Rutaceae	4	5.25	18.60	72.40	T	7.08	21.65
516	37	15	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	8.80	15.70	74.20	T	10.32	60.82
517	37	14	Cornus florida L.	4	Comaceae	3	9.70	16.30	76.20	T	7.37	73.9
518	37	17	Cornus florida L.	4	Comaceae	3	2.80	17.20	78.00	T	3.54	6.16
519	37	16	Cornus florida L.	4	Comaceae	3	7.50	19.80	77.00	T	5.90	44.18
520	37	11	Phellodendron amurense Rupr.	3	Rutaceae	4	2.00	19.20	73.30	T	2.36	3.14
521	37	10	Phellodendron amurense Rupr.	3	Rutaceae	4	2.00	19.90	72.20	T	2.95	3.14
522	37	13	Cornus florida L.	4	Comaceae	3	5.10	18.70	76.70	T	6.49	20.43
523	37	12	Phellodendron amurense Rupr.	3	Rutaceae	4	10.50	18.80	75.20	T	10.03	86.59
524	38	22	Betula lenta L.	1	Betulaceae	2	2.50	27.00	73.20	T	3.54	4.91
525	38	23	Phellodendron amurense Rupr.	3	Rutaceae	4	2.60	29.00	77.50	T	4.72	5.31
526	38	21	Betula lenta L.	1	Betulaceae	2	2.10	26.10	74.70	T	2.95	3.46
527	38	19	Phellodendron amurense Rupr.	3	Rutaceae	4	3.10	24.80	73.00	T	2.36	7.55
528	38	20	Phellodendron amurense Rupr.	3	Rutaceae	4	9.60	25.10	74.00	T	8.85	72.38
529	38	24	Phellodendron amurense Rupr.	3	Rutaceae	4	8.30	29.90	77.30	T	8.85	54.11
530	38	28	Phellodendron amurense Rupr.	3	Rutaceae	4	4.30	28.40	78.60	T	5.90	14.52
531	38	29	Cornus florida L.	4	Comaceae	3	3.20	20.60	77.80	T	5.31	8.04
532	38	27	Cornus alternifolia L.f.	14	Comaceae	3	4.72	28.50	79.90	S	4.42	17.5
533	38	25	Betula lenta L.	1	Betulaceae	2	15.10	26.80	78.50	T	10.62	179.08
534	38	26	Phellodendron amurense Rupr.	3	Rutaceae	4	5.80	27.90	79.10	T	7.08	26.42
535	38	2	Prunus serotina Ehrh.	6	Rosaceae	5	4.00	21.40	72.30	T	4.72	12.57
536	38	3	Carya glabra (Miller) Sweet	10	Juglandaceae	6	2.10	22.00	72.30	T	2.95	3.46
537	38	9	Cornus florida L.	4	Comaceae	3	5.00	22.40	75.80	T	5.31	19.63
538	38	1	Quercus velutina Lam.	5	Fagaceae	1	6.40	21.20	71.30	T	4.72	32.17
539	38	4	Cornus florida L.	4	Comaceae	3	3.70	22.60	73.00	T	5.31	10.75
540	38	7	Phellodendron amurense Rupr.	3	Rutaceae	4	6.70	23.00	74.30	T	7.08	35.26
541	38	8	Carya ovata (Miller) K. Koch	9	Juglandaceae	6	13.20	23.40	74.80	T	16.22	136.85
542	38	5	Phellodendron amurense Rupr.	3	Rutaceae	4	2.90	21.00	73.40	T	3.54	6.61
543	38	6	Cornus florida L.	4	Comaceae	3	3.40	22.10	74.30	T	4.13	9.08
544	38	16	Betula lenta L.	1	Betulaceae	2	7.20	24.30	76.60	T	11.21	40.72

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
545	38	15	<i>Cornus florida</i> L.	4	Comaceae	3	4.20	20.30	77.50	T	4.72	13.85
546	38	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.30	24.50	73.00	T	6.49	22.06
547	38	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	24.50	70.50	T	3.54	3.46
548	38	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.50	20.30	78.00	T	4.42	15.9
549	38	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.40	23.30	79.70	T	1.47	4.52
550	38	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	22.80	77.00	T	2.36	5.31
551	38	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	6.80	22.60	78.10	T	5.31	36.32
552	38	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	10.80	23.20	78.10	T	9.44	91.61
553	39	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	6.00	36.50	73.00	T	5.90	28.27
554	39	17	<i>Betula lenta</i> L.	1	Betulaceae	2	4.30	38.00	74.50	T	6.49	14.52
555	39	16	<i>Cornus florida</i> L.	4	Comaceae	3	3.80	39.50	75.00	T	5.31	11.34
556	39	21	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.60	37.00	70.70	T	2.95	10.18
557	39	20	<i>Sassafras albidum</i> (Nutt.) Nees	12	Lauraceae	7	3.40	36.70	70.50	T	4.13	9.08
558	39	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	35.20	72.30	T	3.54	5.31
559	39	15	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	2.60	39.60	76.70	T	2.36	5.31
560	39	6	<i>Betula lenta</i> L.	1	Betulaceae	2	3.60	30.50	77.70	T	4.13	10.18
561	39	5	<i>Betula lenta</i> L.	1	Betulaceae	2	3.50	32.00	76.40	T	4.13	9.62
562	39	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	34.00	76.70	T	2.36	3.46
563	39	7	<i>Betula lenta</i> L.	1	Betulaceae	2	11.00	30.10	78.40	T	10.62	95.03
564	39	2	<i>Cornus florida</i> L.	4	Comaceae	3	27.80	31.20	73.40	T	8.85	606.99
565	39	1	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	11.00	33.00	71.10	T	10.03	95.03
566	39	4	<i>Betula lenta</i> L.	1	Betulaceae	2	3.50	33.00	76.70	T	4.72	9.62
567	39	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.60	34.30	73.20	T	6.49	16.62
568	39	11	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	19.00	37.00	79.60	T	16.22	283.53
569	39	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	8.40	35.10	79.00	T	5.90	55.42
570	39	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	35.00	77.60	T	1.77	3.46
571	39	14	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	2.10	39.00	70.00	T	2.36	3.46
572	39	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.40	37.70	77.50	T	3.54	4.52
573	39	12	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	16.50	38.70	79.60	T	10.91	213.83
574	40	5	<i>Sassafras albidum</i> (Nutt.) Nees	12	Lauraceae	7	4.90	49.40	76.00	T	7.08	18.86
575	40	6	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.70	48.50	74.50	T	4.72	10.75
576	40	3	<i>Quercus rubra</i> L.	2	Fagaceae	1	116.70	45.50	78.70	T	26.55	10696.28

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
577	40	4	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	6.40	49.00	75.00	T	5.90	32.17
578	40	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	40.20	71.00	T	2.95	3.46
579	40	2	<i>Acer platanoides</i> L.	19	Aceraceae	10	2.80	41.20	78.00	T	3.54	6.16
580	40	7	<i>Carya glabra</i> (Miller) Sweet	10	Juglandaceae	6	4.68	47.50	74.00	T	4.72	17.2
581	40	8	<i>Cornus florida</i> L.	4	Cornaceae	3	2.70	48.20	75.00	T	3.54	5.73
582	41	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	4.00	86.50	T	3.54	5.31
583	41	20	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.00	3.00	86.50	T	2.95	7.07
584	41	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.00	6.20	86.40	T	3.54	7.07
585	41	18	<i>Betula lenta</i> L.	1	Betulaceae	2	2.60	9.90	89.90	T	4.13	5.31
586	41	23	<i>Cornus florida</i> L.	4	Cornaceae	3	10.80	1.00	85.00	T	7.08	91.61
587	41	24	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.34	2.00	84.70	T	3.54	8.76
588	41	21	<i>Carya tomentosa</i> (Poir.) Nutt.	8	Juglandaceae	6	13.60	2.10	86.60	T	10.32	145.27
589	41	22	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.60	2.30	89.70	T	4.72	16.62
590	41	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.40	5.30	81.80	T	4.13	9.08
591	41	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.30	6.70	80.60	T	5.90	14.52
592	41	1	<i>Betula lenta</i> L.	1	Betulaceae	2	4.30	2.40	83.00	T	5.90	14.52
593	41	2	<i>Betula lenta</i> L.	1	Betulaceae	2	7.70	3.60	82.00	T	8.26	46.57
594	41	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.70	8.60	81.00	T	4.72	10.75
595	41	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.80	8.70	82.00	T	4.13	6.16
596	41	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.20	6.70	81.20	T	5.31	8.04
597	41	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.00	7.90	81.50	T	4.72	7.07
598	41	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.20	5.40	84.00	T	4.13	3.8
599	41	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.60	5.20	85.10	T	3.54	10.18
600	41	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.50	5.20	86.30	T	5.90	9.62
601	41	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.20	5.50	86.00	T	4.13	3.8
602	41	10	<i>Quercus rubra</i> L.	2	Fagaceae	1	73.30	9.00	85.50	T	23.60	4219.87
603	41	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	6.50	9.50	83.30	T	7.67	33.18
604	41	12	<i>Betula lenta</i> L.	1	Betulaceae	2	6.65	7.80	85.50	T	7.37	34.73
605	41	11	<i>Betula lenta</i> L.	1	Betulaceae	2	14.40	8.00	85.10	T	14.75	162.86
606	42	21	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	9.40	16.60	87.00	T	6.49	69.4
607	42	22	<i>Betula lenta</i> L.	1	Betulaceae	2	2.40	18.00	86.50	T	4.13	4.52
608	42	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.40	15.30	89.00	T	5.90	15.21

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
609	42	20	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	2.10	16.60	88.50	T	5.31	3.46
610	42	23	Betula lenta L.	1	Betulaceae	2	3.00	18.50	87.00	T	3.54	7.07
611	42	26	Lindera benzoin (L.) Blume	16	Lauraceae	7	2.00	16.20	83.50	S	2.36	3.14
612	42	27	Phellodendron amurense Rupr.	3	Rutaceae	4	7.80	10.10	81.50	T	7.67	47.78
613	42	24	Betula lenta L.	1	Betulaceae	2	2.10	18.50	86.80	T	2.95	3.46
614	42	25	Betula lenta L.	1	Betulaceae	2	2.20	17.20	88.00	T	4.13	3.8
615	42	18	Phellodendron amurense Rupr.	3	Rutaceae	4	2.60	13.50	89.50	T	3.54	5.31
616	42	6	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	2.70	11.00	88.00	T	4.13	5.73
617	42	5	Prunus serotina Ehrh.	6	Rosaceae	5	5.10	12.40	87.50	T	4.13	20.43
618	42	8	Quercus velutina Lam.	5	Fagaceae	1	64.60	13.30	88.00	T	25.07	3277.6
619	42	7	Fagus grandifolia Ehrh.	11	Fagaceae	1	5.90	13.30	89.50	T	4.72	27.34
620	42	2	Phellodendron amurense Rupr.	3	Rutaceae	4	3.00	11.30	83.00	T	4.42	7.07
621	42	1	Phellodendron amurense Rupr.	3	Rutaceae	4	5.00	11.00	80.80	T	5.31	19.63
622	42	4	Cornus florida L.	4	Comaceae	3	4.00	12.00	86.00	T	4.42	12.57
623	42	3	Phellodendron amurense Rupr.	3	Rutaceae	4	3.00	11.50	85.00	T	3.54	7.07
624	42	9	Quercus velutina Lam.	5	Fagaceae	1	57.20	14.30	85.20	T	23.60	2569.7
625	42	15	Cornus florida L.	4	Comaceae	3	5.80	17.50	82.80	T	5.31	26.42
626	42	14	Phellodendron amurense Rupr.	3	Rutaceae	4	5.30	16.00	81.00	T	5.31	22.06
627	42	17	Phellodendron amurense Rupr.	3	Rutaceae	4	4.60	19.80	83.40	T	4.13	16.62
628	42	16	Carya glabra (Miller) Sweet	10	Juglandaceae	6	3.60	19.00	81.00	T	3.54	10.18
629	42	12	Phellodendron amurense Rupr.	3	Rutaceae	4	4.30	15.30	84.00	T	4.13	14.52
630	42	11	Phellodendron amurense Rupr.	3	Rutaceae	4	2.60	13.00	83.00	T	2.95	5.31
631	42	10	Quercus velutina Lam.	5	Fagaceae	1	79.00	19.50	82.00	T	23.60	4901.68
632	42	13	Rhamnus frangula L.	17	Rhamnaceae	9	6.40	16.00	82.30	T	5.31	32.17
633	43	18	Quercus alba L.	7	Fagaceae	1	2.50	20.50	88.90	T	2.36	4.91
634	43	16	Phellodendron amurense Rupr.	3	Rutaceae	4	17.40	23.40	86.00	T	10.32	237.79
635	43	17	Betula lenta L.	1	Betulaceae	2	2.10	22.60	89.80	T	3.54	3.46
636	43	20	Phellodendron amurense Rupr.	3	Rutaceae	4	3.80	26.80	83.20	T	3.54	11.34
637	43	19	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	4.00	27.50	83.00	T	4.42	12.57
638	43	5	Phellodendron amurense Rupr.	3	Rutaceae	4	4.30	22.50	82.00	T	5.90	14.52
639	43	6	Phellodendron amurense Rupr.	3	Rutaceae	4	7.00	23.50	80.80	T	8.85	38.48
640	43	7	Phellodendron amurense Rupr.	3	Rutaceae	4	6.60	23.50	81.40	T	7.37	34.21

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
641	43	4	Phellodendron amurense Rupr.	3	Rutaceae	4	2.90	21.60	81.20	T	4.13	6.61
642	43	1	Phellodendron amurense Rupr.	3	Rutaceae	4	3.70	21.00	80.60	T	4.72	10.75
643	43	2	Phellodendron amurense Rupr.	3	Rutaceae	4	2.30	22.10	80.60	T	2.95	4.15
644	43	3	Phellodendron amurense Rupr.	3	Rutaceae	4	7.00	22.00	81.00	T	5.90	38.48
645	43	8	Prunus serotina Ehrh.	6	Rosaceae	5	4.00	28.60	82.80	T	4.13	12.57
646	43	13	Betula lenta L.	1	Betulaceae	2	4.38	25.00	87.00	T	4.72	15.07
647	43	14	Betula lenta L.	1	Betulaceae	2	3.90	24.20	87.20	T	5.31	11.95
648	43	15	Betula lenta L.	1	Betulaceae	2	7.00	23.00	86.80	T	6.49	38.48
649	43	12	Carya glabra (Miller) Sweet	10	Juglandaceae	6	23.00	27.50	89.50	T	19.17	415.48
650	43	9	Prunus serotina Ehrh.	6	Rosaceae	5	2.40	28.60	83.10	T	2.95	4.52
651	43	10	Quercus rubra L.	2	Fagaceae	1	9.10	28.80	85.00	T	8.85	65.04
652	43	11	Phellodendron amurense Rupr.	3	Rutaceae	4	4.90	27.00	86.00	T	4.42	18.86
653	44	4	Carya glabra (Miller) Sweet	10	Juglandaceae	6	18.40	34.20	86.30	T	16.22	265.91
654	44	5	Prunus serotina Ehrh.	6	Rosaceae	5	14.50	33.70	87.00	T	6.49	165.13
655	44	3	Quercus rubra L.	2	Fagaceae	1	6.60	34.60	86.20	T	8.26	34.21
656	44	1	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	12.00	32.00	83.00	T	7.08	113.1
657	44	2	Phellodendron amurense Rupr.	3	Rutaceae	4	4.30	30.60	86.00	T	3.54	14.52
658	44	6	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	2.80	39.00	82.30	T	3.54	6.16
659	44	10	Phellodendron amurense Rupr.	3	Rutaceae	4	2.30	37.50	89.20	T	2.95	4.15
660	44	11	Quercus rubra L.	2	Fagaceae	1	5.00	39.90	89.00	T	5.90	19.63
661	44	9	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	2.30	38.60	87.30	T	2.95	4.15
662	44	7	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	12.00	38.90	86.70	T	6.49	113.1
663	44	8	Quercus rubra L.	2	Fagaceae	1	27.60	38.90	87.20	T	20.65	598.29
664	45	13	Phellodendron amurense Rupr.	3	Rutaceae	4	3.60	46.40	89.00	T	4.13	10.18
665	45	4	Prunus serotina Ehrh.	6	Rosaceae	5	11.60	41.80	88.00	T	7.67	105.68
666	45	5	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	3.70	43.80	88.70	T	4.13	10.75
667	45	6	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	4.00	45.00	87.70	T	4.13	12.57
668	45	1	Cornus florida L.	4	Cornaceae	3	11.00	40.30	81.00	T	7.67	95.03
669	45	2	Phellodendron amurense Rupr.	3	Rutaceae	4	15.90	42.00	81.10	T	4.72	198.56
670	45	3	Carya ovata (Miller) K. Koch	9	Juglandaceae	6	8.00	40.30	82.20	T	6.49	50.27
671	45	10	Phellodendron amurense Rupr.	3	Rutaceae	4	22.40	46.50	80.50	T	7.37	394.08
672	45	11	Prunus serotina Ehrh.	6	Rosaceae	5	2.80	49.00	83.20	T	3.54	6.16

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
673	45	12	Betula lenta L.	1	Betulaceae	2	2.00	45.00	89.00	T	2.95	3.14
674	45	7	Betula lenta L.	1	Betulaceae	2	10.00	44.00	84.20	T	16.22	78.54
675	45	8	Cornus florida L.	4	Comaceae	3	3.70	46.40	82.60	T	3.54	10.75
676	45	9	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	4.30	45.90	80.20	T	3.54	14.52
677	46	18	Prunus serotina Ehrh.	6	Rosaceae	5	2.60	9.70	90.10	T	3.54	5.31
678	46	17	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	8.10	8.40	90.40	T	8.85	51.53
679	46	20	Phellodendron amurense Rupr.	3	Rutaceae	4	3.20	9.00	98.00	T	4.13	8.04
680	46	19	Phellodendron amurense Rupr.	3	Rutaceae	4	5.00	9.80	91.50	T	5.31	19.63
681	46	7	Fagus grandifolia Ehrh.	11	Fagaceae	1	7.20	5.20	90.10	T	8.26	40.72
682	46	8	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	13.00	0.20	96.20	T	11.21	132.73
683	46	5	Quercus rubra L.	2	Fagaceae	1	11.20	2.30	94.50	T	8.26	98.52
684	46	6	Fagus grandifolia Ehrh.	11	Fagaceae	1	2.80	5.00	91.20	T	2.95	6.16
685	46	11	Cornus florida L.	4	Comaceae	3	2.90	4.70	98.70	T	3.54	6.61
686	46	12	Fagus grandifolia Ehrh.	11	Fagaceae	1	3.30	5.20	99.50	T	2.95	8.55
687	46	9	Phellodendron amurense Rupr.	3	Rutaceae	4	5.23	3.00	99.00	T	3.54	21.48
688	46	10	Fagus grandifolia Ehrh.	11	Fagaceae	1	4.24	4.00	96.60	T	4.13	14.12
689	46	14	Cornus florida L.	4	Comaceae	3	5.20	6.20	95.00	T	4.13	21.24
690	46	13	Fagus grandifolia Ehrh.	11	Fagaceae	1	3.40	5.80	99.50	T	2.36	9.08
691	46	16	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	5.20	7.00	90.80	T	7.67	21.24
692	46	15	Prunus serotina Ehrh.	6	Rosaceae	5	5.40	6.80	94.50	T	4.13	22.9
693	46	3	Quercus rubra L.	2	Fagaceae	1	3.00	4.00	90.50	T	3.54	7.07
694	46	4	Phellodendron amurense Rupr.	3	Rutaceae	4	2.60	2.80	92.80	T	3.54	5.31
695	46	1	Carya tomentosa (Poiret) Nutt.	8	Juglandaceae	6	11.10	2.00	90.50	T	7.67	96.77
696	46	2	Carya glabra (Miller) Sweet	10	Juglandaceae	6	3.50	3.10	90.20	T	4.13	9.62
697	47	19	Betula lenta L.	1	Betulaceae	2	3.50	19.00	90.70	T	5.31	9.62
698	47	18	Prunus serotina Ehrh.	6	Rosaceae	5	16.00	17.20	93.40	T	8.85	201.06
699	47	21	Betula lenta L.	1	Betulaceae	2	2.70	19.00	90.60	T	3.54	5.73
700	47	20	Sassafras albidum (Nutt.) Nees	12	Lauraceae	7	2.60	19.50	91.70	T	3.54	5.31
701	47	17	Prunus serotina Ehrh.	6	Rosaceae	5	11.10	16.00	94.00	T	6.49	96.77
702	47	6	Phellodendron amurense Rupr.	3	Rutaceae	4	3.00	10.40	95.00	T	3.54	7.07
703	47	5	Phellodendron amurense Rupr.	3	Rutaceae	4	2.00	11.40	94.40	T	2.36	3.14
704	47	8	Phellodendron amurense Rupr.	3	Rutaceae	4	3.70	12.00	97.20	T	4.42	10.75

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
705	47	7	<i>Cornus florida</i> L.	4	Comaceae	3	2.00	10.30	97.00	T	2.95	3.14
706	47	2	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	18.90	10.30	92.50	T	10.62	280.55
707	47	1	<i>Quercus rubra</i> L.	2	Fagaceae	1	10.00	10.60	90.20	T	7.37	78.54
708	47	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	11.20	94.00	T	4.72	13.85
709	47	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.10	11.20	93.50	T	2.95	3.46
710	47	14	<i>Betula lenta</i> L.	1	Betulaceae	2	6.80	13.90	90.90	T	5.31	36.32
711	47	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.70	12.50	93.50	T	4.13	5.73
712	47	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	15.20	94.80	T	2.95	5.31
713	47	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	14.20	91.50	T	2.95	5.31
714	47	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.60	15.00	97.00	T	3.54	5.31
715	47	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	15.40	13.00	99.50	T	11.21	186.27
716	47	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.30	17.00	95.80	T	2.95	4.15
717	47	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.00	15.60	96.00	T	3.54	3.14
718	48	18	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	2.20	25.90	93.30	S	2.36	3.8
719	48	17	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	2.20	25.90	92.70	S	2.36	3.8
720	48	20	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	13.20	27.80	91.20	S	7.08	136.85
721	48	19	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	4.80	28.00	92.80	T	6.49	18.1
722	48	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.40	23.00	97.00	T	5.90	15.21
723	48	5	<i>Betula lenta</i> L.	1	Betulaceae	2	12.40	21.80	92.20	T	10.62	120.76
724	48	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.00	26.50	97.30	T	4.13	7.07
725	48	7	<i>Cornus florida</i> L.	4	Comaceae	3	9.50	25.50	97.40	T	10.32	70.88
726	48	2	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	20.20	20.50	92.00	T	13.27	320.47
727	48	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.50	20.40	91.30	T	6.49	23.76
728	48	4	<i>Betula lenta</i> L.	1	Betulaceae	2	10.50	22.00	99.00	T	10.62	86.59
729	48	3	<i>Betula lenta</i> L.	1	Betulaceae	2	15.40	21.00	94.10	T	11.21	186.27
730	48	14	<i>Carya ovata</i> (Miller) K. Koch	9	Juglandaceae	6	2.10	24.90	94.00	T	2.95	3.46
731	48	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.50	24.30	94.50	T	4.13	9.62
732	48	16	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	2.60	25.80	92.60	S	2.36	5.31
733	48	15	<i>Cornus alternifolia</i> L.f.	14	Comaceae	3	2.70	25.80	92.00	S	2.36	5.73
734	48	10	<i>Cornus florida</i> L.	4	Comaceae	3	6.70	28.00	99.90	T	8.26	35.26
735	48	9	<i>Cornus florida</i> L.	4	Comaceae	3	9.20	28.00	99.00	T	8.26	66.48
736	48	12	<i>Cornus florida</i> L.	4	Comaceae	3	2.30	28.20	95.20	T	2.95	4.15

Carsten W. Glaeser, Ph.D  
CUNY- Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
737	48	11	<i>Cornus florida</i> L.	4	Cornaceae	3	10.29	29.90	99.30	T	8.26	83.16
738	49	15	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	15.00	37.60	90.50	T	14.16	176.72
739	49	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	38.00	90.20	T	4.13	13.85
740	49	9	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	7.65	32.00	98.00	T	7.08	45.96
741	49	8	<i>Betula lenta</i> L.	1	Betulaceae	2	47.50	32.80	96.50	T	17.70	1772.06
742	49	7	<i>Cornus florida</i> L.	4	Cornaceae	3	2.80	30.80	96.80	T	4.72	6.16
743	49	12	<i>Quercus alba</i> L.	7	Fagaceae	1	31.10	38.20	99.80	T	20.65	759.65
744	49	11	<i>Cornus florida</i> L.	4	Cornaceae	3	5.20	35.30	98.00	T	5.90	21.24
745	49	10	<i>Cornus florida</i> L.	4	Cornaceae	3	7.20	34.30	99.00	T	5.31	40.72
746	49	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.50	31.70	94.90	T	2.95	4.91
747	49	2	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	3.60	33.50	91.20	T	2.95	10.18
748	49	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.00	31.00	91.20	T	2.36	3.14
749	49	13	<i>Quercus alba</i> L.	7	Fagaceae	1	2.00	35.60	94.00	T	1.77	3.14
750	49	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	5.30	31.00	93.40	T	4.72	22.06
751	49	4	<i>Quercus rubra</i> L.	2	Fagaceae	1	29.30	30.50	92.70	T	22.12	674.26
752	49	3	<i>Sassafras albidum</i> (Nutt.) Nees	12	Lauraceae	7	2.50	34.20	91.30	T	3.54	4.91
753	50	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	3.33	47.00	99.70	T	3.54	8.71
754	50	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	29.40	45.00	99.90	T	11.80	678.87
755	50	19	<i>Prunus serotina</i> Ehrh.	6	Rosaceae	5	21.80	40.50	99.00	T	14.16	373.25
756	50	16	<i>Rhamnus frangula</i> L.	17	Rhamnaceae	9	3.20	49.00	95.90	S	3.54	8.04
757	50	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	4.20	43.40	92.00	T	5.31	13.85
758	50	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.90	43.00	92.20	T	2.95	6.61
759	50	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.40	46.20	92.20	T	2.95	4.52
760	50	4	<i>Sassafras albidum</i> (Nutt.) Nees	12	Lauraceae	7	3.20	43.10	90.40	T	4.13	8.04
761	50	1	<i>Quercus rubra</i> L.	2	Fagaceae	1	28.00	41.00	93.00	T	17.70	615.75
762	50	2	<i>Cornus florida</i> L.	4	Cornaceae	3	30.20	41.50	94.00	T	13.27	716.32
763	50	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.90	41.30	90.10	T	3.54	6.61
764	50	8	<i>Quercus alba</i> L.	7	Fagaceae	1	19.80	46.50	92.30	T	13.27	307.91
765	50	13	<i>Betula lenta</i> L.	1	Betulaceae	2	5.80	47.00	93.00	T	4.13	26.42
766	50	14	<i>Carya tomentosa</i> (Poiret) Nutt.	8	Juglandaceae	6	7.20	47.00	95.00	T	10.32	40.72
767	50	15	<i>Quercus rubra</i> L.	2	Fagaceae	1	30.10	47.00	97.80	T	20.65	711.58
768	50	12	<i>Rhamnus frangula</i> L.	17	Rhamnaceae	9	2.40	49.00	95.70	S	3.54	4.52

Carsten W. Glaeser, Ph.D  
CUNY - Lehman College

Forest Park, Northern Woods  
Woodland Census 1999-2000

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Fam. ID	DBH	X coord	Y coord	Tree/Shrub	Height m	BA
769	50	9	<i>Cornus florida</i> L.	4	Comaceae	3	2.30	49.70	93.00	T	2.95	4.15
770	50	10	<i>Cornus florida</i> L.	4	Comaceae	3	3.20	49.20	92.80	T	3.54	8.04
771	50	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	4	2.30	49.00	94.20	T	3.54	4.15

Appendix D  
Data subset of *Phellodendron amurense* Rupr.

Forest Park  
1999-2000 Tree Census

*Phellodendron amurense* Rupr.  
Data subset

Order	Plot	# in Plot	Taxa	Taxa ID	Family	Family ID	DBH	X	Y	Notes	SEX
1	1	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	0.60	1.50	T	M
2	1	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.00	2.00	3.00	T	M
3	4	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.00	39.00	3.50	T	M
4	6	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.60	3.60	17.40	T	F
5	11	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	8.50	1.40	22.00	T	M
6	17	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	9.40	13.20	37.20	T	M
7	18	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.60	21.00	38.00	T	M
8	21	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.80	3.00	48.80	T	M
9	21	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	1.40	43.00	T	M
10	21	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	2.60	49.00	T	M
11	22	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	17.20	47.50	T	M
12	26	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.20	7.00	57.20	T	M
13	26	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.70	2.80	54.00	T	M
14	26	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	2.40	53.00	T	M
15	26	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	13.50	2.50	52.00	T	F
16	26	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.20	4.20	51.50	T	M
17	26	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.50	1.00	56.70	T	M
18	31	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.00	2.10	60.90	T	M
19	31	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.50	0.20	68.70	T	M
20	31	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.30	8.00	63.00	T	M
21	32	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.10	19.80	69.30	T	M
22	32	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.80	12.50	64.90	T	M
23	34	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	37.70	69.80	T	M
24	35	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.20	49.50	60.10	T	M
25	35	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.70	48.80	69.90	T	M
26	36	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.50	4.20	79.10	T	F
27	36	20	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	7.00	2.80	76.20	Tree, cutdown by DPR	M
28	36	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	8.80	4.00	79.00	T	F
29	36	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	7.00	2.00	79.80	T	M
30	36	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.90	3.00	79.20	T	M
31	36	21	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	6.00	76.90	T	M
32	36	24	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.50	8.40	79.50	T	M
33	36	23	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.00	8.50	77.70	T	F

Forest Park  
1999-2000 Tree Census

*Phellodendron amurense* Rupr.  
Data subset

34	36	6	Phellodendron amurense Rupr.	3	Rutaceae	13	7.10	3.00	73.40	Tree Girdled by DPR	M
35	36	7	Phellodendron amurense Rupr.	3	Rutaceae	13	2.60	2.40	73.40	T	M
36	36	4	Phellodendron amurense Rupr.	3	Rutaceae	13	2.90	6.70	72.20	T	M
37	36	2	Phellodendron amurense Rupr.	3	Rutaceae	13	5.30	1.20	71.40	T	M
38	36	3	Phellodendron amurense Rupr.	3	Rutaceae	13	2.90	2.60	71.00	T	M
39	36	12	Phellodendron amurense Rupr.	3	Rutaceae	13	2.40	1.00	76.00	T	M
40	36	14	Phellodendron amurense Rupr.	3	Rutaceae	13	2.90	0.20	79.00	T	M
41	36	10	Phellodendron amurense Rupr.	3	Rutaceae	13	3.60	1.00	75.00	T	M
42	36	9	Phellodendron amurense Rupr.	3	Rutaceae	13	2.80	2.90	74.40	T	M
43	36	8	Phellodendron amurense Rupr.	3	Rutaceae	13	2.30	2.90	73.60	T	M
44	37	21	Phellodendron amurense Rupr.	3	Rutaceae	13	2.10	13.60	78.20	T	M
45	37	22	Phellodendron amurense Rupr.	3	Rutaceae	13	4.14	13.30	78.80	T	M
46	37	23	Phellodendron amurense Rupr.	3	Rutaceae	13	6.00	13.40	79.00	T	F
47	37	19	Phellodendron amurense Rupr.	3	Rutaceae	13	2.00	14.30	77.60	T	M
48	37	18	Phellodendron amurense Rupr.	3	Rutaceae	13	10.10	16.40	78.40	T	F
49	37	29	Phellodendron amurense Rupr.	3	Rutaceae	13	3.50	13.00	76.00		M
50	37	28	Phellodendron amurense Rupr.	3	Rutaceae	13	3.20	12.00	75.00		M
51	37	25	Phellodendron amurense Rupr.	3	Rutaceae	13	5.80	12.00	76.40	T	M
52	37	26	Phellodendron amurense Rupr.	3	Rutaceae	13	10.80	13.00	76.30	T	F
53	37	27	Phellodendron amurense Rupr.	3	Rutaceae	13	5.20	10.20	79.80	Tree, cut down by DPR	M
54	37	6	Phellodendron amurense Rupr.	3	Rutaceae	13	3.70	16.30	71.20	T	M
55	37	5	Phellodendron amurense Rupr.	3	Rutaceae	13	2.40	13.50	72.00	T	M
56	37	7	Phellodendron amurense Rupr.	3	Rutaceae	13	7.10	17.20	71.00	T	M
57	37	4	Phellodendron amurense Rupr.	3	Rutaceae	13	11.66	13.40	72.70	T	F
58	37	3	Phellodendron amurense Rupr.	3	Rutaceae	13	4.80	11.00	74.20	T	M
59	37	9	Phellodendron amurense Rupr.	3	Rutaceae	13	5.25	18.60	72.40	T	M
60	37	11	Phellodendron amurense Rupr.	3	Rutaceae	13	2.00	19.20	73.30	T	M
61	37	10	Phellodendron amurense Rupr.	3	Rutaceae	13	2.00	19.90	72.20	T	M
62	37	12	Phellodendron amurense Rupr.	3	Rutaceae	13	10.50	18.80	75.20	T	F
63	38	23	Phellodendron amurense Rupr.	3	Rutaceae	13	2.60	29.00	77.50	T	M
64	38	19	Phellodendron amurense Rupr.	3	Rutaceae	13	3.10	24.80	73.00	T	M
65	38	20	Phellodendron amurense Rupr.	3	Rutaceae	13	9.60	25.10	74.00	T	M
66	38	24	Phellodendron amurense Rupr.	3	Rutaceae	13	8.30	29.90	77.30	T	F
67	38	28	Phellodendron amurense Rupr.	3	Rutaceae	13	4.30	28.40	78.60	T	M

Forest Park  
1999-2000 Tree Census

*Phellodendron amurense* Rupr.  
Data subset

68	38	26	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.80	27.90	79.10	T	M
69	38	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.70	23.00	74.30	T	M
70	38	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.90	21.00	73.40	T	M
71	38	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.30	24.50	73.00	T	M
72	38	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	24.50	70.50	T	M
73	38	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.50	20.30	78.00	T	M
74	38	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.40	23.30	79.70	T	M
75	38	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	22.80	77.00	T	M
76	38	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.80	22.60	78.10	T	M
77	38	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	10.80	23.20	78.10	T	F
78	39	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.00	36.50	73.00	T	M
79	39	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	35.20	72.30	T	M
80	39	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	34.00	76.70	T	M
81	39	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.60	34.30	73.20	T	M
82	39	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	8.40	35.10	79.00	T	M
83	39	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	35.00	77.60	T	M
84	39	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.40	37.70	77.50	T	M
85	40	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	40.20	71.00	T	M
86	41	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	4.00	86.50	T	M
87	41	20	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	3.00	86.50	T	M
88	41	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	6.20	86.40	T	M
89	41	24	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.34	2.00	84.70	T	M
90	41	22	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.60	2.30	89.70	T	M
91	41	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.40	5.30	81.80	T	F
92	41	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.30	6.70	80.60	T	M
93	41	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.70	8.60	81.00	T	M
94	41	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.80	8.70	82.00	T	M
95	41	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.20	6.70	81.20	T	M
96	41	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	7.90	81.50	T	M
97	41	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.20	5.40	84.00	T	M
98	41	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.60	5.20	85.10	T	M
99	41	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.50	5.20	86.30	T	F
100	41	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.20	5.50	86.00	T	M
101	41	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.50	9.50	83.30	T	M

Forest Park  
1999-2000 Tree Census

*Phellodendron amurense* Rupr.  
Data subset

102	42	21	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	9.40	16.60	87.00	T	M
103	42	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.40	15.30	89.00	T	M
104	42	27	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	7.80	10.10	81.80	Tree, cut down by DPR	M
105	42	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	13.50	89.50	T	M
106	42	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	11.30	83.00	T	M
107	42	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.00	11.00	80.80	Tree, girdled by DPR	M
108	42	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	11.50	85.00	T	F
109	42	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.30	16.00	81.00	T	F
110	42	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.60	19.80	83.40	T	M
111	42	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.30	15.30	84.00	T	M
112	42	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	13.00	83.00	T	M
113	43	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	17.40	23.40	86.00	T	F
114	43	20	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.80	26.80	83.20		M
115	43	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.30	22.50	82.00	Tree, top dead w/suckers	M
116	43	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	7.00	23.50	80.80	T	M
117	43	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	6.60	23.50	81.40	T	M
118	43	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.90	21.60	81.20	T	M
119	43	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.70	21.00	80.60	T	M
120	43	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.30	22.10	80.60	T	M
121	43	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	7.00	22.00	81.00	T	F
122	43	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.90	27.00	86.00	T	M
123	44	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.30	30.60	86.00	T	M
124	44	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.30	37.50	89.20	T	M
125	45	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.60	46.40	89.00	T	M
126	45	2	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	15.90	42.00	81.10	T	M
127	45	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	22.40	46.50	80.50	T	M
128	46	20	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.20	9.00	98.00	tree, top dead w/ suckers	M
129	46	19	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.00	9.80	91.50	T	M
130	46	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.23	3.00	99.00	T	M
131	46	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	2.80	92.80	T	M
132	47	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	10.40	95.00	T	M
133	47	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.00	11.40	94.40	T	M
134	47	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.70	12.00	97.20	T	M
135	47	4	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	11.20	94.00	T	M

Forest Park  
1999-2000 Tree Census

*Phellodendron amurense* Rupr.  
Data subset

136	47	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.10	11.20	93.50	tree, top dead w/ suckers	M
137	47	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.70	12.50	93.50	T	M
138	47	16	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	15.20	94.80	T	M
139	47	15	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	14.20	91.50	T	M
140	47	10	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.60	15.00	97.00	T	M
141	47	9	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	15.40	13.00	99.50	T	F
142	47	12	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.30	17.00	95.80	T	M
143	47	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.00	15.60	96.00	T	M
144	48	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.40	23.00	97.00	T	M
145	48	8	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.00	26.50	97.30	T	M
146	48	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.50	20.40	97.30	T	F
147	48	13	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.50	24.30	94.50	T	M
148	49	14	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	38.00	90.20	T	F
149	49	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.50	31.70	94.90	T	M
150	49	1	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.00	31.00	91.20	T	M
151	49	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	5.30	31.00	93.40	T	M
152	50	17	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	3.33	47.00	99.70	T	M
153	50	18	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	29.40	45.00	99.90	T	F
154	50	5	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	4.20	43.40	92.00	T	M
155	50	6	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.90	43.00	92.20	T	M
156	50	7	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.40	46.20	92.20	T	M
157	50	3	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.90	41.30	90.10	T	M
158	50	11	<i>Phellodendron amurense</i> Rupr.	3	Rutaceae	13	2.30	49.00	94.20	T	M

Literature Cited

- Anderson R. 1999. Disturbance as a factor in the distribution of sugar maple and the invasion of Norway Maple into a modified woodland. *Rhodora* 101:264-273.
- Braun E. L. 1950. *Deciduous forests of eastern North America*. Blakiston Co. Philadelphia.
- Brodo I. 1968. *The lichens of Long Island*. New York State Museum and Science Service Bulletin 410.
- Brokaw N.V.L. and S.M. Scheiner. 1989. Species composition in gaps and structure of a tropical forest. *Ecology* 70: 538-541.
- Bromley S.W. 1935. The original forest types of southern New England. *Ecol. Monog.* 5:61-89.
- Brooklyn Botanic Garden. 1999. New York Metropolitan Flora Project. Woody Plant Workbook. Clemants S. (ed) Brooklyn Botanical Gardens.
- Brower J.E., J.H. Zar and C.N. von Ende. 1998. *Field and laboratory methods for general ecology*. WCB McGraw-Hill Publishers.
- Buegler R. and S. Parisio. 1981. A comparative flora of Staten Island 1879-1981. Staten Island Institute of Arts and Sciences, Staten Island, New York. 90 p.
- Camerero J.J., E. Gutiérrez and M. Fortin. 2000. Spatial pattern of a subalpine forest-alpine grassland ecotones in the Spanish Central Pyrenees. *For. Ecol. Mgmt.* 134:1-16.
- Campbell D.G., D. Daly, G.T. Prance, U.N Maciel. 1986. Quantitative ecological inventory of Terra Firme and Varzea tropical forests on the Rio Xingu, Brazilian Amazon. *Brittonia* 38:369-393.
- Chen J. and G.A. Bradshaw. 1999. Forest structure in space: A case study of an old growth spruce-fir forest in Changbaishan Natural Reserve, PRC. *Forest Ecol. Mgmt.* 120: 219-233.

- Clark K.L., R.O. Lawton and P.R. Butler. 2000. The Physical Environment. In: Nadkarni N.M. and N.T. Wheelwright (editors). *Monteverde: Ecology and Conservation of a Tropical Cloud Forest*. Oxford University Press, NY.
- Clark D.A. and D.B. Clark. 1984. Spacing dynamics of a tropical rainforest tree: Evaluation of the Janzen-Connell Model. *Amer. Nat.* 124: 769-788.
- Collins S. 1956. *The biotic communities of Greenbrook Sanctuary*. Palisades Nature Association, NJ.
- Connell J.H. 1971. On the role of natural enemies in preventing competitive exclusion in some marine animals and in rain forest trees. In: P.J. de Boer and G.R. Gradwell (eds), *Dynamics of populations. Proceeding of the Advanced Study Institute on Dynamics of numbers in populations*, Oosterbeek, 1970. Centre of Agricultural Publishing and Documentation, Wageningen.
- Cox G.W. 1999. *Alien Species in North America and Hawaii: Impacts on Natural Ecosystems*. Island Press, Washington DC.
- Cronk Q.C.B. and J.L. Fuller. 1995. *Plant Invaders: The threat to natural ecosystems*. Island Press, Washington DC.
- Cunningham R.L. and E.J. Ciolkosz. 1984. *Soils of the Northeastern United States*. Penn. State University, Agric. Exper. Sta., PA. Bulletin 848.
- Dirr, M.A. 1990. *Manual of Woody Landscape Plants: Their identification, ornamental character, culture, propagation and uses*. 4<sup>th</sup> Edition. Stipes Publishing Co., Illinois.
- Diggle, P., J. Besag and J.T. Gleaves 1976. Statistical analysis of spatial point patterns by means of distance methods. *Biometrics* 33:659-667.
- Diggle P.J. 1983. *Statistical Analysis of Spatial Point Patterns*. Academic Press, London.
- Diggle P.J. 2001. *Statistical Analysis of Spatial Point Patterns*. 2<sup>nd</sup> Edition Academic Press, London.

- Dixon P.M. 1993. The bootstrap and the jackknife: Describing the precision of ecological indices p. 290-318. In: Scheiner S.M. and J. Gurevitch (eds), Design and Analysis of Ecological Experiments. Chapman and Holt, NY.
- Elton C.S. 1958. The ecology of invasions by animals and plant. Univ. Chicago Press, Chicago.
- Fain J.J., T.A. Volk and T.J. Fahey. 1994. Fifty years of change in an upland forest in south-central New York: General patterns. Bull. Torrey Bot. Club 121:130-139.
- Ferreira L.V. and G.T. Prance. 1998. Species richness and floristic composition in four hectares in the Jau National Park in upland forests in Central Amazonia. Biodiversity and Conservation 7:1349-1364.
- Fortin M.J. and J. Gurevitch. 1993. Mantel Tests: Spatial structure in field experiments. p.342-359. In: Scheiner S.M. and J. Gurevitch (eds), Design and Analysis of Ecological Experiments. Chapman and Holt, NY.
- Forbes R. D. 1955. Forestry Handbook. Society of American Foresters. The Ronald Press Co., NY.
- Gilman E.F. and D.G. Watson. 1994. *Phellodendron amurense*, Amur Corktree. Fact Sheet ST-437, Environmental Horticulture Department, Florida Cooperative Extension Service, University of Florida.
- Gleason H.A. 1922. On the relation between species and area. Ecology 3:158-162.
- Gleason H.A. and A. Cronquist. 1991. Manual of the vascular plants of the northeastern United States and adjacent Canada. 2<sup>nd</sup> edition. New York Botanical Garden, Bronx, NY.
- Good R.E. and N.F. Good. 1970. Vegetation of the sea cliffs and adjacent uplands on the north shore of Long Island, New York. Bull. Torrey Bot. Club 97:204-208.
- Greig-Smith P. 1983. Quantitative Plant Ecology. Blackwell Scientific Publ. , Oxford.
- 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.

- Greller A.M. 1975. Persisting natural vegetation of northern Queens County, New York with proposals for its conservation. *Environmental Conservation*. 2:61-69.
- Greller A.M. 1977a. A vascular flora of the forested portion of Cunningham Park, Queens County, New York. *Bull. Torrey Bot. Club* 104:170-176.
- Greller A.M. 1977b. Classification of mature forests on Long Island, New York. *Bull Torrey Bot. Club*. 104:376-382.
- Greller A.M., 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.
- Greller A.M. 1979. A vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and additions-I. *Bull. Torrey Bot. Club* 106:45.
- Greller A. M., 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.
- Greller A.M. 1985. A vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and additions-II. *Bull Torrey Bot. Club* 112: 312.
- Greller A.M. and O. L. Garcia. 1986. Variation in canopy composition of the forest of Alley Park, Queens County, New York. *Bull. Torrey Bot. Club* 113:36-41.
- Greller A.M., M.K. Panuccio and C.M. Durando. 1991. The vascular flora of the forested portion of Cunningham Park, Queens County, New York: Corrections and Additions III. *Bull. Torrey Bot. Club* 118:330-332.
- Grubb P.J. 1977. The maintenance of species richness in plant communities. The importance of the regeneration niche. *Biol. Review* 52:107-145.
- Haase P. 1995. Spatial pattern analysis in ecology based on Ripley's *K*-function: Introduction and methods of edge correlation. *Journal of Veg. Science* 6: 575-582.
- Harper R.M. 1917.a. The natural vegetation of western Long Island south of the terminal moraine. *Torrey* 17:1-13.

- Harper R.M. 1917.b. The native plant population of northern Queens County, Long Island. *Torreya* 17:131-142.
- Hayek L.C. and M.A. Buzas. 1997. *Surveying Natural Populations*. Columbia University Press, NY
- Hibbs D.E. 1979. The age structure of striped maple population. *Can. J. For. Res.* 9: 504-508.
- Hiebert R. D. and J. Stubbendieck. 1993. Handbook for ranking exotic plants for management and control. Natural Resources Report, US Department of the Interior, NPS/NRMWRO/NRR93/08. Natural Resources Publ. Office, CO. [www.nature.nps.gov](http://www.nature.nps.gov)
- Hu S.Y. 1979. *Ailanthus*. *Arnoldia* 39: 29-50.
- Hubbell S. P. 1999. Light-gap disturbances, recruitment limitations and tree diversity in a neotropical forest. *Science* 283:554-496.
- Huston M. 1994. *Biological Diversity. The coexistence of species on changing landscapes*. Cambridge University Press.
- Ishizuka M. and S. Sugawara. 1989. Composition and structure of natural mixed forests in Central Hokkaido II: Effects of disturbance on the forest vegetation patterns along a topographic moisture gradient. *Journal Jap. For. Soc.* 71: 89-98.
- Iwatsuki K., D.E. Boufford and H. Ohba. 1999. *Flora of Japan, Volume IIc*. Kundasha Ltd, Japan.
- Jaccard P. 1908. Nouvelles recherches sur la distribution florale. *Bull. Soc. Vaud. Sci. Nat.* 44:223-270.
- Janzen D.H. 1970. Herbivores and the number of tree species in tropical forests. *American Naturalist* 104:501-528.
- Kaufman L. and P.J. Rousseeuw. 1990. *Finding groups in data. An introduction to cluster analysis*. John Wiley, NY. 342 p.

- Kloeppe B.D. and M.D. Abrams. 1995. Ecophysiological attributes of native *Acer saccharum* and exotic *Acer platanoides* in urban oak forests of Pennsylvania, USA. *Tree Physiology* 15:739-746.
- Knapp L.B. and C.D. Canham. 2000. Invasion of old growth forests in New York by *Ailanthus altissima*: sapling growth and recruitment in canopy gaps. *Journal Torrey Bot. Soc.* 127:307-315.
- Kincaid D.T., R. Stalter and E.E. Lamont. 2000. Strategies in computer-intensive analysis of vascular plants with applications to three US Atlantic coastal sites. In; Brebbia C.A. and P. Pascolo (eds). *Management Information Systems; GIS and Remote Sensing*. WIT Press, Boston.
- Lamont E. and S.M. Young. 2002. Noteworthy plants reported from the Torrey Range-2001. *Journal of the Torrey Bot. Soc.* 129: 363-371.
- 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.
- Lodge D. M. 1993. Biological Invasions: Lessons for ecology. *TREE* 8:133-137.
- Loeb R.E. 1982. Reliability of New York City Department of Parks and Recreation forest records. *Bull. Torrey Bot. Club* 109:537-541.
- Loeb R.E. 1986. Plant communities of Inwood Hill Park, New York County, New York. *Bull. Torrey Bot. Club* 113:46-52.
- Loeb R.E. 1992. The long-term human disturbance of an urban park forest, New York City. *For. Ecol. Mgmt.* 49:293-309.
- Loeb R.E. 2001. Fire in the urban forest: Long-term effects in old growth stands. *Arboreal Journal* 25:307-320.
- Manly B. F.J. 1997. *Randomization, Bootstrap and Monte Carlo Methods in Biology*. 2<sup>nd</sup> Edition. Chapman and Hall, London.

- Marinelli J. 1996. Defining the weed. In: Randall J.M. and J. Marinelli (eds), *Invasive Plants: Weeds of the global garden*. Handbook no. 149. Brooklyn Botanic Garden Inc.
- Martin P.H. 1999. Norway Maple (*Acer platanoides*) invasion of a natural forest stand: Understory consequences and regeneration pattern. *Biological Invasions* 1:215-220.
- McCarthy B.C. and J. M. Farcelli. 1990. Microdisturbances in old fields and forests: implications for woody seedling establishment. *Oikos* 58: 55-60.
- Molles M.C. 1999. *Ecology. Concepts and applications*. 1<sup>st</sup> edition. McGraw-Hill Publ.
- Mori S.A, B.M. Boom, A.M. de Carvalino and T.S. dos Santos. 1983. Ecological importance of Myrtaceae in an Eastern Brazilian wet forest. *Biotropica* 15:68-71.
- Mori S.A, P. Becker and D. Kincaid. 2001. Lecythidaceae of a Central Amazonian lowland forest. Implications for Conservation. In: R.O. Bierregaard, C. Gascon, T.E. Lovejoy and R. Mesquita (eds.), *Lessons from Amazonia. The ecology and conservation of a fragmented forest*. Yale University Press.
- Mueller-Dombois D. and H. Ellenberg. 1974. *Aims and methods of vegetation ecology*. John Wiley and Sons.
- Murphy D.D. 1988. Challenges to biological diversity in urban areas. In: E. O. Wilson (ed.), *Biodiversity*. National Academy Press. Washington DC.
- Namikawa K, Y. Ishikawa and J. Sano. 1997. Stand dynamics during a 12 year period in a second-growth stand in a cool temperate forest in northern Japan. *Ecol. Res.* 12:277-287.
- New York City Department of Parks and Recreation. 1936. Mapping Division. *Topographical Map of Forest Park. Section 126 and 130*. Olmstead Center, Flushing Meadow Corona Park, Flushing, New York.
- New York City Department of Parks & Recreation. 1990. *Natural Areas Management Plan, Forest Park*. Natural Resources Group.

- New York City Department of Parks & Recreation. 1991. Forest management in New York City parks. Urban Forestry Educational Program (UFEP).
- New York City Department of Parks & Recreation. 1996. Forest Park Management Plan. Urban Forestry Educational Program (UFEP).
- Ning Z. and D. Dafang. 1990. Seed dispersal, dormancy, seed bank and regeneration of Amur Cork Tree. *Journal of the Northeast Forestry Univ.* 1:16-22.
- Peters G.H. 1952. *The Trees of Long Island.* Long Island Horticultural Society, Farmingdale, NY.
- 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.
- Preston F.W. 1948. The commonness and rarity of species. *Ecology* 29:254-283.
- Randall J.M. and J. Marinelli (eds). 1996. *Invasive Plants: Weeds of the global garden.* Handbook No. 149. Brooklyn Botanic Garden Inc.
- Ramirez C.R. 2001. *Vegetation of a subtropical pre-montane moist forest in Central America.* Doctoral Dissertation, City University of New York, Graduate School and University Center. UMI Dissertation Services, Ann Arbor Michigan.
- Rehder A. 1940. *Manual of cultivated trees and shrubs.* Blackburn Press, Caldwell N.J.
- Reichard S.H. and P. White. 2001. Horticulture as a pathway of invasive plant introductions in the United States. *Bioscience* 51:103-113.
- Rejmánek M. 1989. Invasibility of Plant Communities. In: Drake J.A. (ed), *Biological Invasions: a Global Perspective.* John Wiley and Sons Ltd.
- Rice E.L. and R.W. Kelting. 1955. The species-area curve. *Ecology* 36:7-11.
- Ripley B.D. 1981. *Spatial Statistics.* John Wiley & Sons, New York.
- Robinson G.R., M.E. Yurlina and S.N. Handel. 1994. A century of change in the Staten Island flora: Ecological correlates of species losses and invasions. *Bull. Torrey Bot. Club* 121:119-129.

- Rudnický 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.
- Sakai T, H. Tanaka, M. Shibata, W. Suzuki, H. Nomiya, T. Kanazashi, S. Iida and T. Nakashizuka. 1999. Riparian disturbance and community structure of a *Quercus-Ulmus* forest in central Japan. *Plant Ecology* 140:99-109.
- Sanders J.E. 1974. Geomorphology of the Hudson Estuary. In: O. A. Roels (ed), Hudson River Colloquium. New York Acad. Sci. 250:5-38.
- Shannon C.E. 1948. A mathematical theory of communication. *Bell System Tech. Journal* 27:379-423.
- Shugart H.H. 1984. *The Theory of Forest Dynamics*. Springer-Verlag, NY.
- Simberloff D. 2000. Foreword. In: Elton C. (author) *The ecology of invasive animals and plants*. University of Chicago Press.
- Sipe T.W. and F.A. Bazzaz. 1995. Gap partitioning among maples in Central New England: Survival and Growth. *Ecology* 76: 1587-1602
- Sisinni S. M. and A. Emmerich. 1995. Methodologies, results and applications of natural resource assessment in New York City. *Nat. Areas J.* 5:175-188.
- Sokal R.R and F. J. Rohlf. 1995. *Biometry*. 3<sup>rd</sup> Edition. W.F. Freeman & Co.,NY
- 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.
- Stalter R., A. Munir, E. E. Lamont and D. Kincaid. 2000. Plant diversity in an urban wildlife refuge of New York City. In: *Ecosystems and Sustainable Development*. Y. Villacampa, C.A. Brebbia and J.L. Uso (eds.). *Adv. Ecol. Sci.* no. 10. WIT Press.
- Stalter R., S. Eshagian, A. Munir, K. Haley, S. Kollar, M. Malik, N. Tang, L. Fisher, E.E. Lamont and D. Kincaid. 2001. The vascular plants of Bayswater State Park, New York City, New York. *In Vivo* 22:4-10.

- Stalter R. and E. Lamont. 1987. Vegetation of Hempstead Plains, Mitchell Field, Long Island, New York. *Bull. Torrey Bot. Club* 114:330-335.
- Statview. SAS Institute. Cary, North Carolina.
- Szwagryzyk J. 1990. Natural regeneration of forest related to the spatial structure of trees: A study of two forest communities in Western Carpathians, southern Poland. *Vegetatio* 89: 11-22.
- Szwagryzyk J. and M. Czerwczak 1993. Spatial patterns of trees in natural forests of East-Central Europe. *Journal of Veg. Sci.* 4: 469-476.
- United States Department of Agriculture Forest Service. 1999. Northeastern Area Pest Alert. Asian Longhorned Beetle NA-PR-01-99.
- Vandermeer J., I. de la Cerda, D. Boucher, I. Perfecto and J. Ruiz. 2000. Hurricane disturbance and tropical tree species diversity. *Science* 290:788-791.
- Veblen T.T. 1989. Tree regeneration responses to gaps along a transandean gradient. *Ecology* 70:541-545.
- Vitousek P.M. and L.R. Walker. 1989. Biological Invasion by *Myrica faya* in Hawai'i: Plant demography, nitrogen fixation, ecosystem effects. *Ecol. Monog.* 59:247-265.
- Watanabe O. and Y. Kubota. 1996. Effects of gap formation on the regeneration process of a cool-temperate mixed forest in Shiretoko National Park, northern Japan. *Jap. Journal Ecology* 46: 233-243.
- Webb S. L. and C.M.K. Kaunzinger. 1993. Biological invasion of the Drew University Forest Preserve by Norway Maple (*Acer platanoides* L.). *Bull. Torrey Bot. Club* 120:342-349.
- Webb S.L., T.H. Pendergast and M.E. Dwyer. 2001. Response of native and exotic maple seedling banks to removal of the exotic invasive Norway Maple (*Acer platanoides*). *Journal Torrey Bot. Soc.* 128:141-149.
- Whitmore T.C. 1989. Canopy gaps and two major groups of forest trees. *Ecology* 70: 536-538.

- Yoshida T. and T. Kamitani. 1999. Growth of a shade-intolerant tree species *Phellodendron amurense*, as a component of a mixed-species coppice forest of Central Japan. *For. Ecol. Mgmt.* 113:57-65.
- Yost S.E., S. Antenen and G. Hartvigsen. 1991. The vegetation of the Wave Hill natural area, Bronx, New York. *Bull Torrey Bot. Club* 118:312-325.