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# PHYTOSOCIOLOGICAL STUDIES OF FLOYD BENNETT FIELD, BROOKLYN, NEW YORK

by

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## Abstract

PHYTOSOCIOLOGICAL STUDIES OF

FLOYD BENNETT FIELD, BROOKLYN, NEW YORK

by

Douglas Siril Abeywickrama Wijesundara

Adviser: Professor Andrew M. Greller

Vegetation was studied in the North Forty Area of Floyd Bennett Field (FBF), Brooklyn, and New York. FBF is a former airfield constructed by filling several salt marsh islands with various kinds of waste materials including dredge fills, construction debris and domestic waste. There were 125 species belonging to 81 genera and 44 families. Of these, 41 species (33%) were exotic. There were 16 major communities within the North Forty area. In classifying communities in the North Forty, two agglomerative clustering algorithms (Minimum Variance clustering and Complete Linkage) were used to cluster the data matrices that were constructed using five distance measures (Euclidean Distance, Chord Distance, Geodesic Distance, Bray-Curtis Dissimilarity and Similarity Ratio). Several metric and nonmetric ordination techniques were used to see the relationships of different communities to each other and environmental factors. In spite of the small size of the study area and overwhelming dominance of a few species, Euclidean Distance and Complete Linkage clustering used in this study yielded meaningful clusters corresponding to recognizable plant communities

in the field. There were two main successional trends. It is evident that there is a difference in the rate of succession that is due to differences in substrata. Succession in sterile, dry, sandy dredge fill is slower, while in areas filled with domestic waste and construction debris it is much faster.

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# Chapter 1. INTRODUCTION

"There is a tree that grows in Brooklyn. Some people call it the tree of heaven. No matter where its seed falls, it makes a tree which struggles to reach the sky. It grows in boarded-up lots and out of neglected rubbish heaps. It grows out of cement. It grows lushly ... survives without sun, water, and seemingly without earth. It would be considered beautiful except that there are too many of it"
(Smith, 1943)

The above classic quote from Betty Smith beautifully describes the tree of heaven (Ailanthus altissima) in Brooklyn, New York. It also hints of the gradual greening of 'neglected rubbish heaps', 'boarded-up lots', cement and other wastelands in an urban habitat.

Ecology of urban areas has not received much attention until recent times (Adams and Leedy, 1987;Sukopp, 1990; Berger, 1990). Rather, the emphasis in ecology has been on biotypes close to nature, especially forests, waters and moors, and later fields and grasslands. To many people, town and nature is still the ultimate contradiction (Sukopp, 1990).

Survival of plants under extreme conditions in urban areas is important in many aspects. These plants may eventually reclaim the habitat and make it suitable to many other plants. In addition, they may help maintain the wildlife in the area.

Plants growing on landfills or on highly polluted sites in urban areas are good examples of ruderals, which means plants growing on rubble, ruins or heaps of mortar (Ellenberg, 1988;Grime, 1979). The present study deals with ruderal-dominated vegetation developing on Floyd Bennett Field (FBF) which is a landfill area in metropolitan New York.

Before filling, that area was known as Barren Island and consisted of a series of marsh islands similar to those now existing in Jamaica Bay (Black, 1981;Lent and Litwin, 1989a). It was first occupied by Canarsie Indians in Pre-Columbian times. Barren Island came under the town of Flatlands established by the Dutch settlers in western Long Island in the 17th century. By the late 19th and early 20th centuries. Barren Island had become a small community of about 7000 people within Flatlands and Borough of Brooklyn, with a city-owned incinerator, garbage dump, a glue factory, main street, taverns, a movie theater, shops, a school, and a post office (Blakemore, 1981). There is no record of extensive agriculture in the area.

About 140 acres of FBF are periodically mowed or burnt in order to maintain a low vegetation suitable for wildlife (Greller et al unpublished). Woody vegetation has developed in the rest of the area. Much of the unmanaged area is shrubby with scattered trees. Little is known about the phytosociology and ecology of the unmanaged portions of FBF.

**1. A. Previous studies on vegetation of FBF**

Ecological studies done at the FBF include those of birds (Lent and Litwin 1989a, 1989b), reptiles (Cook, 1996) or management and policy issues of urban wildlife habitats (Dames and Moore 1976; Tanacredi, 1983,1987; Cook and Tanacredi 1990). Grady and Rogers (1984) applied the Mueller-Dombois and Ellenburg (1974) system to classify the vegetation in FBF. They constructed a 1:2400 base map using aerial photographs overlaid with the Universal Transverse Mercator (UTM) system. Vegetation/habitat maps were prepared before the establishment of grassland habitat management program in the FBF by Cunningham (1980), Dames and Moore (1976), Solecki (1984) and US Department of Interior (1979). Hartig and Rogers (1984) studied fire ecology of Phragmites australis (tall reed grass). Rogers et al (1984) studied the growth of Myrica pensylvanica and estimated that this shrub would replace all grasslands in 35 years or less if left undisturbed. A tentative checklist of the flora of Gateway National Recreation area was compiled by Venezia and Cook (1991) using field observations and previous lists prepared by other workers (Bridges 1976a; Cook 1984; Greller 1984; Riepe et al 1984;Stalter et al 1982; Venezia 1982; Venezia 1990). Greller et al (unpublished) carried out a phytosociological analysis of a managed grassland area in the FBF.

However, no work has been done on phytosociology of the unmanaged areas.

## 1. B. Data analysis in phytosociology

Data analysis using multivariate statistical methods has become a vital part phytosociology since the introduction of these techniques to plant ecology by Williams and Lambert (1959). Widespread use of computers and availability of ready-made software packages helped multivariate analysis to become popular.

In the preface of her classic book entitled "The Interpretation of Ecological Data", Pielou (1984) stated " ...There is a world of difference between the person who uses a ready-made program to find the eigenvalues and eigenvectors of a large matrix and who understands what these things are, and the person who delegates the whole task of doing a principal component analysis (for instance) to such a program with no understanding of what the analysis does." Furthermore, a total dependence on a ready-made program for data analysis may limit data analysis. Every research project is unique in some way. A ready-made program developed for a standard set of conditions may not accommodate all the possible research projects. Although program packages reduce the amount of expertise necessary for data analysis, they have the negative side effect of providing results without understanding the concepts (Fisher and Bemmerlein, 1989).

Although there are numerous classification methods available (Legendre and Legendre, 1983), ecologists use only a limited number of clustering methods. The availability of ready-made computer programs appears to guide their choice rather than the suitability of algorithms (Mucina and Van der Maarel, 1989). TWINSPAN (Hill, 1979) is a good example for such a program used by many phytosociologists.

This study examines the statistical treatment of FBF ruderal vegetation using a visual recognition of vegetational associations followed by a variety of standard multivariate techniques. Various methods were used to compute distance matrices, clustering, and ordination. The purpose of using these methods was to see how well the vegetational associations detected in the field could be recognized by each method. Data analysis was done using computer programs written for appropriate techniques. Detailed discussions of these methods are presented in chapters 2 and 5.

**1. C. Objectives of the present study**

The objectives of my study are:

a) Identify different vegetation types within the non-managed areas in FBF;
b) Identify plant communities (associations) or groupings within them using multivariate statistical methods;
c) Characterize each community using floristic composition;

d) Compare the communities recognized by various methods with the communities identified in the field;

d) Identify edaphic factors correlated with .plant community distribution and

e) Infer successional tendencies among the various vegetation types.

## 1. D. Hypothesis

The following hypothesis will be tested during the course of this study.

The structure, composition, and physiognomy of vegetation types found in different areas of FBF can be correlated with the nature of the substrate on which they are growing.

# Chapter 2. MATERIALS AND METHODS

## 2. A. Study area

Floyd Bennett Field (FBF) of the Gateway National Recreation Area is located in the southeast corner of Brooklyn, New York, on the north shore of Jamaica Bay (Figure 1). The total extent of this area is about 579 ha. FBF is a former airfield constructed by filling saltmarshes (Figure 2) with various kinds of waste materials including dredge spoils, construction debris and domestic waste (Blakemore, 1981; Lent and Litwin, 1989). In 1970 it was decommissioned as a US Naval Airfield and it was handed over to the National Park Service in 1972 (Tanacredi, 1995). FBF is now maintained as a part of Gateway National Recreation Area. Most sections of FBF are periodically cleared, mowed or burned in order to maintain a low vegetation suitable for wildlife. Some areas are left out of this practice and a substantial vegetation cover is developing as a consequence. North Forty (the largest non-managed area) was selected for this study.

## 2. B. Sampling

Four major types of vegetation were identified by reconnaissance within the North Forty area: 1) monotypic Phragmites stands, 2) shrub thickets, 3) dry grasslands, and 4) woodlands.

The different vegetation units within the North Forty area were distinguished on a recent, black-and-white, low altitude aerial photograph (04 - 06-1992; Photo No. 4079-11-1652; scale 1inch=200ft) by visually different patterns, textures, tones and colors. Using a clear overlay these units were outlined to prepare a working vegetation map of the area. Sampling methods were chosen according to the structure of the vegetation type.

### 2. B. a. Sampling in Shrub thickets and Phragmites stands

Line interception method (cf. Greller et al, 1979) was used in the sampling of shrub thickets and Phragmites sites. As the vegetation was dense in most areas, it was necessary to clear a path along the line using a machete. These lines were demarcated using a compass and a measuring tape. The perpendicular interception cover of each different plant or colony was measured along these transect lines. These cover readings were taken at each meter along the line. A measuring tape was laid along the line for this purpose. Length of the transect was decided according to the homogeneity of the vegetation (with the use of areal photograph). Herbarium specimens were collected for each different plant for identification and deposited in the Biology Department herbarium at Queens College.

A total of 31 lines were sampled within the study area (Figure 3).

Sampling unit size is critical in ecological investigations as it can influence classifications and ordinations (Podani, 1989). In analyzing the data, a 15 meter line segment was selected as a sampling unit (i.e., cover readings for each different species within a 15 m segment were added up). This size was selected because 15 m was the length of the smallest transect line. The total number of sampling units (line segments) was 216.

### 2. B. b. Sampling woodland vegetation

In the woodland areas all the trees over 5 cm dbh were measured. Diameter measurements were taken using a tree caliper. Herbarium specimens were taken for the different species for identification. If a tree was branched below dbh level, all branches were measured. The species present in the undergrowth in each woodland were also recorded and herbarium specimens were taken for identification. A total of 13 different woodland sites were sampled in this study.

### 2. B. c. Grassland vegetation

In North Forty, the area covered by dry grassland was not as extensive as that of the Phragmites marsh stands. A 1 m x 1 m quadrat made of wood was used to sample this vegetation. Quadrats were placed regularly at 10 m intervals along a line within grasslands (Causton, 1988). Within each quadrat, percentage above-ground cover of each species was recorded. Herbarium specimens were collected from different species for identification.

Five representative areas were selected for sampling (Figure 3). In each area four transect lines (sites) were sampled. The total number of quadrats sampled was 100.

### 2. C Soil sampling

Soil samples were taken, using a soil auger, from the top 30 cm of the woodland, shrubland, dry grassland and Phragmites sites.

Soil samples were taken from each different plant community at the time of vegetation sampling. A total of 30 samples were collected for analysis. These samples were air-dried for 48 hours and sieved using a 2 mm sieve before analyzing. Analyses were carried out to determine, a) pH (in water), b) exchange acidity, c) total N, d) available $NO_3$, e) available, P, K, Mg, Ca, Fe, Al, Cu, Mn and Zn, f) moisture content, and g) organic matter content (Appendix 3).

Samples were analyzed at the Chemistry Department of Queens College and Cornell Nutrition Analytical Laboratories.

### 2. D. Multivariate Analysis of data

All vegetation data used in this study were percentages. Percentages are similar to compositional data (Aitchison, 1986) in being subject to a unit-sum constraint (i.e, sum of entries in each row is 100 per cent, or 1). Ignoring this constraint would lead to an inadequate or irrelevant analysis (Aitchison, 1986). In this study all percentage cover data were transformed into degrees by angular transformation before the analysis (Sokal and Rohlf, 1995). Arcsine transformation (angular transformation) converts proportions or percentages to angles whose sine is the given proportion or percentage. This is done by first getting the square root of the percentage and then finding the arcsine of that value. The result will be the angle in radians. This can be converted to degrees by multiplying by 180 and dividing it by $\pi$. The whole transformation can be written as follows.

$$\text{Angle in degrees} = (\text{Arcsine}\sqrt{percentage}) \times \frac{180}{\pi}$$

All computations except Canonical Correspondence Analysis (CCA) and Detrended Correspondence Analysis (DCA) were done using SAS - PC Version 6.12 (SAS, 1989,1993), CANOCO (Ter Braak, 1988) was used for computing CCA and DCA. SAS programs used in the analysis are given in Appendix 2.

## 2. D a. Calculation of distance matrices

Five dissimilarity measures, i.e., Bray-Curtis Dissimilarity, Chord Distance, Euclidean Distance, Geodesic Distance, and Similarity Ratio were used in constructing distance matrices.

All these methods are widely used in ecology (Legendre and Legendre, 1983). Of these, Euclidean Distance was favored by some workers because it is a metric measure (Sneath and Sokal, 1973). Ludwig and Reynolds (1988) found that Chord Distance performs very satisfactorily over a diversity of ecological data sets. Bray-Curtis dissimilarity and Similarity ratio were also found effective in numerical phytosociology by many researchers (Hajdu, 1981; Beals, 1984; Var der Maarel, 1989). Ludwig and Reynolds (1988) report that Bray-Curtis dissimilarity produces similar results to Chord Distance and Geodesic Distance.

The following notations are used in all formulae.

s = number of species, $x_{ij}$=cover value of the $i^{th}$ species of the $j^{th}$ site; $x_{ik}$=cover value of the $i^{th}$ species of the $k^{th}$ site.

Euclidean Distance was calculated using the following formula.

$$\sqrt{\sum_{i=1}^{s}(x_{ij}-x_{ik})^2}$$

Bray-Curtis Dissimilarity was calculated using the following formula.

$$1 - \frac{2\sum_{i=1}^{s} \min(x_{ij}, x_{ik})}{\sum_{i=1}^{s} (x_{ij} + x_{ik})}$$

$\min(x_{ij}, x_{ik})$ is the minimum cover value of the $i^{th}$ species of the $j^{th}$ site and cover value of the $i^{th}$ species of the $k^{th}$ site.

Chord Distance was calculated as follows.

$$\sqrt{2 \times \frac{1 - \sum_{i=1}^{s} x_{ij} x_{ik}}{\sqrt{(\sum_{i=1}^{s} x_{ij}^2 + \sum_{i=1}^{s} x_{ik}^2)}}}$$

Geodesic Distance was calculated as follows.

$$\text{Arc cos}\left[\frac{\sum_{i=1}^{s} x_{ij} x_{ik}}{\sqrt{(\sum_{i=1}^{s} x_{ij}^2 + \sum_{i=1}^{s} x_{ik}^2)}}\right]$$

The following formula was used to compute Similarity Ratio.

$$1 - \frac{\sum_{i=1}^{s} x_{ij} x_{ik}}{\left(\sum_{i=1}^{s} x_{ij}^{2} + \sum_{i=1}^{s} x_{ik}^{2} - \sum_{i=1}^{s} x_{ij} x_{ik}\right)}$$

## 2. D. b. Classification

Minimum Variance (Ward, 1963) and Complete Linkage (Pielou, 1984) were the clustering algorithms used in classification. These two clustering methods are widely used in phytosociology with satisfactory results (Kovar and Leps, 1986; Peinado et al, 1995; Mucina, 1989; Pysek and Srutek, 1989; Escudero and Pajaron, 1994; Nimis, 1989).

### 2. D. b. 1. Minimum Variance Clustering

In minimum variance clustering the distance between two clusters is the sum of squares between the two clusters added up over all the variables (Ward, 1963). At each step, those two clusters to be united whose fusion yields the least increase in within-cluster sum of squares (Pielou, 1984). This method also tends to join clusters with small number of observations and biased toward producing clusters of fairly equal size (Milligan, 1980). However, it is a useful technique when there is reason to suspect that some sites belong to one or more homogeneous classes (Pielou, 1984).

### 2. D. b. 2. Complete Linkage Clustering (CLC)

CLC begins with uniting the two closest points in the distance matrix. In here the distance between two clusters is the maximum distance between a point in one cluster and a point in the other cluster. This method yields clusters that are fairly equal in size. This is because the distance between the farthest points between two large clusters is often large even if they are very similar. As a result, it is more likely that an isolated point at a moderate distance will be united with one of the large clusters than that they (two large clusters) will unite each other (Pielou, 1984). For that reason, outliers will get attached to clusters early in the clustering process. This is usefull if relatively intense grouping strategy is needed (Lance and Williams, 1967).

### 2. D. c. Ordination

The term ordination was first introduced by Goodall (1954) to identify a series of techniques used for arranging vegetation samples in relation to a multidimensional species space. Ordination is a technique for presenting a multidimensional swarm of data in a such a way that any intrinsic pattern hidden in the data becomes apparent (Pielou, 1984). This is in fact an ordering of data along possible gradients (Gauch, 1982).

Ordination techniques can be grouped as indirect and direct gradient analysis (Gauch, 1982). In indirect ordinations, sampling units are arranged within a reduced dimensional system based on their differences (or similarities) in species composition. In these methods environmental gradients are not studied directly but inferred from species composition data. One important purpose of the present ecological investigation is to determine how distributions of species relate to environmental factors.

Several indirect methods of ordinations were applied in order to find out a suitable method that offers the best resolution of the underlying structure in the data. The methods used included both metric and nonmetric ordinations. As in classification in this study, all data used in ordination were transformed using Arcsine transformation (Sokal and Rohlf, 1995).

**2. D. c. 1. Metric Ordination Methods**

Metric ordination methods preserve the metric information (Sneath and Sokal, 1973) contained in the data. All these techniques involve construction of new dimensions from the original data. These newly constructed dimensions are linearly uncorrelated and are arranged in order of importance. Ordination diagrams are obtained by plotting the data using the first few dimensions that account for the greatest variability. Principal Component Analysis, Principal Coordinate Analysis, Correspondence Analysis, Detrended Correspondence Analysis, and Canonical Correspondence Analysis were the metric ordination methods used in this study.

**a) Principal Component Analysis**

If we recognize n sites with p species, the basic purpose of Principal Component Analysis is to account for the total variation among these n sites in p dimensional space by forming a new set of orthogonal, composite variates. Each member of the new set of variates is a linear combination of the original set of measurements. The linear combinations will be generated in such a manner that each successive composite variate will account for a smaller portion of total variation. Hence the first composite (principal component) will have the largest variance, the second will have a variance smaller than the first but larger than the third and so on. In general the number of new composite variables that will be needed to account adequately for the total variation is less than p.

In a multi-sample situation, PCA does not always produce the best results (Neff and Marcus, 1980; James and McCulloch, 1990). This is beacuse PCA confounds within- and between group variation (James and McCulloch, 1990). Separate analyses for the woodland group, shrub group and dry grassland group were done for that reason.

**b) Correspondence Analysis (CA)**

Correspondence Analysis of Bènzècri(1973) is a method of representing both species and site scores simultaneously in equivalent scales on the same ordination diagram. This method, similar to Hill's (1974a) Reciprocal Averaging technique (Pielou, 1984), is useful in portraying relationships between sites (objects) and species (variables) simultaneously (Hill 1974b; Reyment and Jöreskog, 1993).

**c) Detrended Correspondence Analysis (DCA)**

Detrended Correspondence Analysis (DCA) is a method devised to overcome the arch-effect and scale contraction effect of Correspondence Analysis (Hill, 1980). This is done by dividing the ordinated data (obtained from CA) into several short segments with dividing lines perpendicular to the first axis, and then sliding the segments with respect to one another.

(Pielou, 1984). DCA was carried out using CANOCO (ter Braak, 1988) to get a better resolution from the CA ordination.

**d) Metric Multidimensional Scaling (Pricipal Coordinate Analysis).**

Multidimensional Scaling (MDS) is also a dimension reduction procedure whereby either a measure of similarity or distance between objects is utilized to form subgroups (i.e., clusters) or determine the dimensions (i.e., factors) that separate the objects on a geometric map. The objective of MDS is to develop a map or configuration that locates the objects according to a measure of similarity that has been computed for all pairs of objects. Typically, any MDS algorithm attempts to maximize the goodness of fit of the fitted distances with the actual distances (Berenson et al, 1983). Principal Coordinate Analysis is the metric multidimensional scaling procedure used in this study. Principal Coordinate Analysis of Gower (1966) is a metric multidimensional scaling technique by which the objects (sites) are plotted on an ordination diagram in such a way that the distances among them are equal to their dissimilarities. Dissimilarities are obtained by a suitable measure of dissimilarity (Pielou, 1984). I used Bray-Curtis Dissimilarity, Chord Distance, Euclidean Distance, Geodesic Distance, and

Similarity Ratio to compute dissimilarity matrices for the present study.

### 2. D. c. 2. Nonmetric Ordination Methods

Nonmetric ordinations do not involve rigid assumptions regarding the distances as do metric ordinations. These methods have also been shown to give better results for data having three or four dimensions (Gauch et al, 1981).

I used nonmetric multidimensional scaling (Kruskal, 1964), as a nonmetric ordination technique. The distance matrix used was prepared using Bray-Curtis Dissimilarity.

#### a) Nonmetric Multidimensional Scaling (NMDS).

Unlike metric multidimensional scaling, nonmetric multidimensional scaling (NMDS) attempts to maintain the rank order (monotonicity) of the distances rather than the distances themselves (Berensen et al, 1983). Therefore, in NMDS the raw data are converted into a set of rank-order distances ranging from 1 to n(n-1)/2. I did all computations using MDS procedure in SAS (Proc MDS) which uses Alternating Least Squares Scaling Algorithm (ALSCAL) (Tukane et al, 1977).

## 2. D. d. Correlation of species distributions with environmental variables (direct ordination)

In a direct gradient analysis sampling units are placed along selected environmental gradients (Bray and Curtis, 1957; Whittaker, 1967; Gauch, 1982). Therefore, the methods of direct gradient analysis involve plotting each species' abundance value against values of the environmental variable. Although this is less complicated with one or two environmental variables (Whittaker, 1967), it is practically impossible to use several variables simultaneously to find joint effects. It is necessary to use a statistical method that involves multiple regression for this purpose. Ter Braak's Canonical Correspondence Analysis (Ter Braak, 1986, 1987) is a technique of direct gradient analysis which represents a special case of multivariate regression (Ter Braak and Prentice, 1988; Palmer, 1993).

### 2. D. d. 1. Canonical Correspondence Analysis (CCA)

CCA (Ter Braak, 1986, 1987) aims at displaying information about sites, species and environmental variables on the same ordination diagram. The sites and species are presented as points while environmental variables are represented as arrows. The direction of arrow indicates which environmental variable correlates best with the sites or species. The length of the arrow is a measure of the environmental variable's relative importance (Ter Braak, 1986).

# Chapter 3. RESULTS

Four different vegetation types were identified at North Forty area in Floyd Bennett Field. A total of 125 species were sampled (Appendix 1). These taxa belong to 81 genera and 44 families. Of these, 41 species (33%) were exotic. Table 1 presents the Importance Value Index (IVI), cover and frequency values for all the species recorded. The major dominant species according to IVI values were: Phragmites australis (13.7), Celastrus orbiculatus (7.5), Parthenocissus quinquefolia (7.5), Prunus serotina (6.4), Myrica pensylvanica (6.3), Rubus allegheniensis (5.7), and Rhus copallina (4.7) (Table 1).

Nomenclature adopted for species in this study follows that of Gleason and Cronquist (1991).

## 3. A. Classification

### 3. A. a. Clustering using Minimum Variance

Figure 4 presents the 5 dendrograms obtained using Euclidean Distance, Similarity Ratio, Bray-Curtis Dissimilarity, Chord Distance and Geodesic Distance. Dendrograms obtained by Euclidean Distance and Similarity Ratio are similar in having two major cluster groups based on the dominance of Phragmites. All five dendrograms produce four cluster groups. When the dominant species in each group are used to name these groups, they can be identified as: a) Phragmites group, b) Grassland group, c) Phragmites-mixed shrub group and d) Myrica shrubland-Woodland group. The dendrograms plotted and the clusters recognized from each of the 5 clustering methods are presented in the following sections. The SAS programs written in order to produce all the dendrograms and tables are given in Appendix 2.

**1. Euclidean Distance Clustering**

Figure 5 is the dendrogram obtained for the 249 sampling units sampled in the North Forty area. This dendrogram branches into two major groups at the between-cluster sum of squares level 661.53. The 2 groups can be recognized as, a) sites dominated by Phragmites and, b) sites in which Phragmites is not a major dominant. The non-Phragmites group branches into two groups at level 478.6 while the Phragmites-dominated group branches at 470.6 to two groups. This results in four main groups (at the between-cluster sum of squares level 470.61). When the dominant species in each group are used to name these groups, they can be identified as a) Phragmites australis group, b) Phragmites australis-Rhus copallina-Rubus allegheniensis group, c) Andropogon scoparius (Schizachyrium scoparium)-Ammophila breviligulata-Corynephorus canescens group, and d) Prunus serotina-Myrica pensylvanica-Celastrus orbiculatus-Populus tremuloides group. Table 2 gives the percentage cover values of the species present in the four cluster groups. The composition and physiognomy of these four groups are presented in the following sections.

a) Phragmites australis group (11 sites)

This is a small group with 11 sites represented only by Phragmites australis. Since this group does not branch into any clusters it can be identified as one homogeneous cluster representing the dense Phragmites australis communities that occupy a vast area in North

Forty. The substrata of most of the sites included in this cluster are soggy or moist. Table 3 gives the percentage cover values of species included in this group.

b) Phragmites australis-Rhus copallina-Rubus allegheniensis group (121 sites)

Phragmites stands dominated by various shrubs and vines are included in this group (Table 3). Some of these sites are present at the ecotone between grassland and woody shrub areas. This group also includes shrubland areas disturbed by fire. At the 90 level (between-cluster sum of squares), the following seven clusters were identified within this group.

1. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster (25 sites)

   In this cluster the dominant species include Rubus allegheniensis (19.5%) Rhus copallina (13.3%) Solidago rugosa (11.7%) and Phragmites australis (9.4%). The lesser dominants are Toxicodendron radicans (7.5%), Myrica pensylvanica (6.4%) and Parthenocissus quinquifolia (6.3%). One notable feature of the sites included in this cluster was the presence of burnt stumps of Myrica pensylvanica and Ailanthus altissima.

2. Rhus copallina-Myrica pensylvanica cluster (12 sites)

   Sites included in this cluster are present in the ecotone between the grassland and the shrub areas. The major species include Rhus copallina (24.5%) and Myrica pensylvanica (23.5). Celastrus orbiculatus (8.6%) has the next highest percentage cover value. Other noticeable species are Corynephorus canescens (5.9%), Andropogon scoparius (4.7%) and Euthamia tenuifolia (3.9%).

3. Phragmites australis-Rubus allegheniensis cluster (18 sites) Phragmites stand invaded by Rubus and several vines, ferns and other herbaceous species. These include Ampelopsis brevipedunculata (6.1%), Phytolacca americana (6.0%), Solanum dulcamara (5.5%), Onoclea sensibilis (4.4%), and Epilobium coloratum(4.3%). The dominant species are Phragmites australis (30.14%) and Rubus allegheniensis (25%).

4. Baccharis halimifolia-Phragmites australis cluster (9 sites) This cluster represents the communities of Phragmites australis invaded by Baccharis halimifolia. The dominant species are Baccharis halimifolia (27.7%), Phragmites australis (15.8%). The other species in this cluster include, Toxicodendron radicans (9.5%), Rubus allegheniensis (8.2%) and Parthenocissus quinquefolia (6.6%).

5. Phragmites australis-Celastrus orbiculatus cluster (31 sites) This cluster includes Phragmites australis communities overgrown by Celastrus orbiculatus. Phragmites australis (27.1%) and Celastrus orbiculatus (23.1%) constitute for over

50% of the total cover in these sites. Rhus copallina (9.6%) has the next highest cover.

6. Phragmites australis-Parthenocissus quinquefolia cluster (13 sites)

   This cluster includes sites dominated by Phragmites australis (42.1%) and Parthenocissus quinquefolia (30.8%). Myrica pensylvanica (8.6%) is the only species that has over 5% cover in this cluster.

7. Phragmites australis cluster (13 sites)

   This cluster consists of Phragmites stands with little cover by a few other species such as Parthenocissus quinquefolia (4.1%), Phytolacca americana (4.1) and Polygonum scandens (3.9%). Phragmites australis accounts for 77.1% of the total cover.

c) Andropogon scoparius-Ammophila breviligulata-Corynephorus canescens group (20 sites).

The natural dry grassland sites sampled at North Forty area are included in this cluster group. These grasslands are present only in a small area. In most places they are being invaded by shrubs such as Myrica and Rhus. At the 90 level, the following two clusters can be recognized within this group. Table 4 gives the percentage cover values of species included in this group

1. Andropogon scoparius-Ammophila breviligulata-Panicum virgatum cluster (10 sites).

   This cluster includes grassland sites dominated by Andropogon scoparius (22.2%), Ammophila breviligulata (20.9%), Panicum virgatum (14.9%) and Corynephorus canescens (12.7%). The other species include Lechea maritima (6.9%). and Agropyron repens (5.0%). The lesser dominant but characteristic species of this cluster are: Heterotheca subaxillaris (3.3%), Conyza canadensis (2.8%), Chrysopsis falcata (2.3%), Lepidium virginicum (1.6%), Hudsonia tomentosa (1.3%), Eupatorium hyssopifolium (1.3%) and Asclepias syriaca (1%).

2. Andropogon scoparius cluster (10 sites).

   This cluster differs from the previous cluster in having a very high cover for Andropogon scoparius (67.5%). Sand dune associates such as Lechea maritima, Heterotheca subaxillaris, Hudsonia tomentosa, and Panicum virgatum are not present here. Corynephorus (9.4%) and Ammophila (8.7%) are not as dominant as in the previous grassland cluster. Euthamia graminifolia (9.3%), is a frequent species in this cluster. Sites included in this cluster are less sandy than those in the previous one.

d) Myrica pensylvanica-Prunus serotina group (97 sites)

This group includes the woodland and mature shrub areas in North Forty area. The following seven clusters can be recognized in this group at between-cluster sum-of-squares level 90. The percentage cover values of species included in this group are given in Table 5.

1. Prunus serotina cluster (4 sites)

   This is a small cluster which includes 4 woodland sites. These represent mature Prunus serotina stands with no Celastrus invasions. The percentage cover value for Prunus serotina in this cluster is 86.7% and no other species has a cover value exceeding 5%.

2. Ailanthus altissima-Morus alba (4 sites)

   This cluster includes 4 woodland sites dominated by Ailanthus altissima (62.6%) and Morus alba (23.1%). Prunus serotina (10.3%) is the other tree species present in these sites. Substrate of the sites included in this cluster consists of domestic waste and construction debris.

3. Celastrus orbiculatus-Prunus serotina cluster (14 sites)

   This represents mature stands of Prunus serotina heavily invaded by Celastrus orbiculatus vines. Celastrus orbiculatus (35.4%) and Prunus serotina (32.4%) are the two major dominants in these sites; Rhus copallina is the next.

4. Myrica pensylvanica-Betula populifolia cluster (9 sites)

   Betula populifolia woodland is represented by this cluster. Myrica pensylvanica is present in the peripheral areas in this community. Celastrus orbiculatus (14.7%), an invading vine in this community, has the highest cover followed by Betula populifolia(11.6%), Artemisia vulgaris (11%) and Myrica pensylvanica (10.2%).

5. Populus tremuloides-Sambucus canadensis-Solidago rugosa cluster (11 sites).

   This cluster represents Populus tremuloides woodland found in the North Forty area. The underlying substratum in these woodlands is very hard and in most places very shallow with only 8-10 inches of soil. Presence of concrete, glass bottles and other domestic waste suggest that this community is growing on areas where construction debris and domestic waste were dumped during the filling of Floyd Bennett Field. Populus tremuloides forms a more or less continuous canopy in these areas with a thick undergrowth of Sambucus canadensis. The dominant species in this cluster are Populus tremuloides (45.7%), Sambucus canadensis (16.3%), Solidago rugosa (13%) and Rubus pensilvanicus (11.6%). Celastrus orbiculatus (5.1%) is the only other species that has more than 5% cover in this cluster

6. Prunus serotina-Celastrus orbiculatus-Myrica cluster (40 sites)

   This cluster includes shrub sites which have a large number of Prunus serotina saplings. The major dominants in this cluster are Prunus serotina (15.2%), Celastrus orbiculatus (14.8%), Myrica pensylvanica (14.3%) and Toxicodendron radicans (11.7%). The other species that have over 5% cover are:

Parthenocissus quinquefolia (9.4%), Lonicera japonica (6.6%), Rubus allegheniensis (5.3%), and Rosa multiflora (5.1%)

7. Myrica pensylvanica-Parthenocissus quinquefolia-Toxicodendron radicans (15 sites)

   This cluster includes the Myrica thickets in the North Forty area. These sites are dominated by Myrica pensylvanica (25%) Parthenocissus quinquefolia (20.9%), Toxicodendron radicans (13.8%) and saplings of Prunus serotina (12.6%). Rosa multiflora (9.5%) is also a frequent species in such areas. These sites are basically Myrica and Rosa stands overgrown with Parthenocissus and Toxicodendron.

**2. Similarity Ratio Clustering**

Figure 6 shows the dendrogram obtained by this clustering procedure. This dendrogram also branches at a high level (8.4) to two main groups. One group includes the sites dominated by Phragmites and the other includes all other sites, in which Phragmites is not among the dominant species. At the 5.44 level, four cluster groups can be recognized. They can be termed as: a) Phragmites group b) Phragmites-Rhus-Rubus-Celastrus group (Phragmites stands invaded by shrubs), c) Andropogon-Ammophila (grassland) group and d) Myrica-Prunus group (mature shrubs and woodland) group.

a) Phragmites group (28 sites)

   Sites within this group are almost totally dominated by Phragmites australis (83.6%). Only other species which shows over 5% cover is Parthenocissus australis. Except for Phytolacca americana (2.1%) and Polygonum scandens (1.8%) all other species have less than 1% cover (Table 6). This group can be considered as a single cluster, which represent the Phragmites community in the North Forty area. This corresponds to the cluster 1 in the Euclidean distance classification.

b) Phragmites-Rhus-Rubus-Celastrus group (Phragmites stands invaded by shrubs)

All Phragmites communities that are invaded by different shrub or vine species are included in this group (Table 6). This group yields the following 5 clusters at between-cluster sum of squares level 1.

1. Baccharis halimifolia-Phragmites australis cluster (9 sites)

   The sites included in this cluster are the dense Phragmites stands overgrown by Baccharis. These sites are located close to the shore. Baccharis halimifolia (27.7%) has the highest cover in this cluster while Phragmites australis accounts for 15.8% of the total cover. Toxicodendron radicans (9.5%), Rubus allegheniensis (8.2%), Parthenocissus quinquefolia (6.6%), and Populus deltoides (5.1%) are the other species that have over 5% cover.

2. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster (31 sites)

   In this cluster the Rubus allegheniensis (23.4%) has the highest cover. Rhus copallina (12%), followed by Solidago rugosa

(9.5%), and Phragmites australis (8.8%). The other species that have over 5% cover are Parthenocissus quinquefolia (5.6%) and Myrica pensylvanica (5.1%).

3. Phragmites australis-Rubus allegheniensis cluster (11 sites)
   This cluster represents the Phragmites australis stands which has gaps invaded by Rubus allegheniensis and few other plants. Phragmites australis (43.1%) has the highest cover followed by Rubus allegheniensis (16.1%). Phytolacca americana (9.7%) is growing in gaps within the dense Phragmites stands whereas Ampelopsis brevipedunculata (9.3%) and Solanum dulcamara (4.6%) are vines growing on Phragmites clumps.

4. Celastrus orbiculatus-Phragmites australis cluster (10 sites)
   This cluster includes Phragmites stands overgrown with vines of Celastrus orbiculatus. Celastrus orbiculatus (38.2%) and Phragmites australis (33.8%) are the two co-dominant species in these sites while Rubus allegheniensis (7.1%) shrubs and Morus alba (5.6%) trees are not uncommon.

5. Phragmites australis-Rhus copallina-Celastrus orbiculatus cluster (22 sites)
   The sites included in this cluster are present at the edges of predominantly Phragmites communities. Phragmites australis (25.8%) is still the most frequent species while Rhus copallina (12.6%) has the second highest cover. Vines of Celastrus

orbiculatus (11.9%) and Parthenocissus quinquefolia(9%) are also frequent in these areas. Myrica pensylvanica(5.5%) is the only other species that has over 5% cover.

c) Andropogon-Ammophila (grassland) group

This group includes the dry grassland sites sampled within North Forty area. At the level 1 the following two clusters can be recognized within this group.

1. Andropogon scoparius-Ammophila breviligulata cluster (10 sites)

   The grassland sites that are dominated by Andropogon scoparius are included in this cluster. This is same as in the classification using Euclidean distance.

2. Andropogon scoparius cluster (10 sites)

   This includes grasslands dominated almost exclusively by Andropogon scoparius (67.5%). This is the same cluster identified in the Euclidean distance classification.

c) Myrica-Prunus group (mature shrubs and woodland).

This group includes various shrub and woodland communities present in the North Forty area. These sites are drier than the Phragmites stands. In some sites the underlying substratum is very hard whereas in others it is mostly sandy. Eight clusters could be recognized at the sum of squares level 1. They are described below. Table 7 gives the percentage cover values of the species included in this group. A summary of the species in the entire group is given in Table 8.

1. Populus tremuloides-Sambucus canadensis cluster (11 sites)

   The Populus woodland sites are included here. This is the same cluster identified in the Euclidean distance clustering (3. A. a. 1. d. 3).

2. Prunus serotina cluster (4 sites)

   This includes the same Prunus serotina sites identified in the Euclidean distance clustering.

3. Celastrus orbiculatus-Prunus serotina cluster (9 sites)

   Prunus serotina woodlands overgrown with Celastrus orbiculatus vines are included in this cluster. Celastrus orbiculatus (41.8%) and Prunus serotina (38.1%) are the major dominants which constitute nearly 80% of the total cover while none of the other species have cover values over 5% within this cluster.

4. Ailanthus altissima-Morus alba cluster (4 sites)

   This includes the Ailanthus woodlands of North Forty area. There is no difference between this cluster and the one identified in the Euclidean distance classification.

5. Myrica pensylvanica-Betula populifolia cluster (9 sites)

   This cluster is similar to the Betula woodland recognized by the Euclidean distance clustering procedure.

6. Rhus copallina-Celastrus orbiculatus-Myrica pensylvanica cluster (18 sites)

   The shrubby sites located in between the grassland and the Myrica shrubland are included in this cluster. Rhus copallina (23.5%), is the major dominant species followed by Celastrus orbiculatus (17.4%), and Myrica pensylvanica (15.8%). Prunus serotina saplings constitute 7.5% of the cover while Phragmites (4.2%) and grassland species such as Corynephorus canescens (4.1%), Andropogon scoparius (3.1%), Euthamia graminifolia (2.6%) are among the lesser dominants.

7. Celastrus orbiculatus-Prunus serotina-Myrica pensylvanica cluster (32 sites)

   This cluster includes Myrica shrublands with Prunus saplings. Celastrus orbiculatus (16%), Prunus serotina (15%) and Myrica pensylvanica (14%), and Toxicodendron radicans (12.6%) are the four major dominant species in this cluster. Parthenocissus quinquefolia (8.4%), Lonicera japonica (8.0%), Rubus allegheniensis (6.5%), Rubus pensilvanicus (3.2%) and Rosa multiflora (3.1%) are also present in such areas.

8. Parthenocissus quinquefolia-Myrica pensylvanica-Toxicodendron scandens cluster (31 sites)

   This represents the Myrica shrubland community. Parthenocissus quinquifolia (21.4%), and Myrica pensylvanica (19.7%) are the major dominant species within these sites. Prunus serotina (11.3%), Toxicodendron scandens (10.6%) and Rosa multiflora (9.5%) are among the other important species reported within this cluster.

**3. Bray-Curtis Dissimilarity (Percentage Difference) Clustering**

The dendrogram obtained form this clustering procedure is given in Figure 7. At the between-cluster sum of squares level 5.2, four cluster groups could be identified in that dendrogram. Using the dominant species within each group, these cluster groups can be denominated as, a) Phragmites group, b) Andropogon group, c) Phragmites-Rubus-Rhus group, and d) Myrica-Prunus group. These groups are similar to the 4 groups identified in the two classifications described previously.

a) Phragmites australis group (28 sites)

   This group represents the dense Phragmites stands within the North Forty area (Table 9). At the 1.36 level the following two clusters can be identified.

   1. Phragmites australis cluster (12 sites)

      These are the sites that are almost totally covered by Phragmites (99.6%).

2. Phragmites australis-Parthenocissus quinquefolia cluster (16 sites)

   The sites included in this cluster are very similar to the previous cluster except for the presence of Parthenocissus quinquefolia (13.1%) and a few other plants including Phytolacca americana (3.7%), Polygonum scandens (1.5%), Toxicodendron radicans (1.2%). Phragmites constitutes 72.2% of the total cover

b) Andropogon scoparius group (20 sites)

As in the previous clustering procedures this group, representing the grassland, branches into two clusters at 1.27 level. At 1.36 level the following two clusters can be identified.

1. Andropogon scoparius cluster (10 sites)

   This is same as in the previous classifications.

2. Andropogon scoparius-Ammophila breviligulata cluster (10 sites)

   This is same as in previous classifications.

c) Phragmites-Rubus-Rhus group

Sites in this cluster group are mostly shrub areas dominated by Rubus allegheniensis, Rhus copallina and Phragmites australis (Table 10). The following five clusters can be recognized at the between-cluster sum of squares level 1.

1. Baccharis halimifolia-Phragmites australis- Rubus allegheniensis cluster (10 sites)

   This cluster includes the maritime, shrubland communities dominated by Baccharis halimifolia (20.5%), Phragmites australis (17.2%) and Rubus allegheniensis (12.2%). Vines such as Parthenocissus quinquefolia (6.6%) and Toxicodendron radicans are the other significant plant species found in these areas.

2. Rhus copallina-Rubus allegheniensis-Solidago rugosa cluster (23 sites)

   Shrub areas dominated by Rubus allegheniensis (18.2%) and Rhus copallina (13.7%) are included in this cluster. (11.1%) is also a very common herb in such areas. Phragmites australis (8.66%), Myrica pensylvanica (7.34%), Parthenocissus quinquefolia (6.53%) are the other plant species with over 5% cover.

3. Rhus copallina-Myrica pensylvanica-Celastrus orbiculatus cluster (16 sites)

   This cluster includes the sites in between the grassland and Myrica shrubland areas. Rhus copallina (19.8%), Myrica pensylvanica (15.5%) and Celastrus australis (11.6%) are the major dominants while Solidago rugosa (8.3%), Phragmites australis (5.1%), Ailanthus altissima (5.5%), and Corynephorus canescens (4.9%) are among the other significant species in these communities.

4. Phragmites australis-Rubus allegheniensis cluster (16 sites)

   Old Phragmites stands invaded by various shrub and herb species are included in this cluster. Phragmites australis (30.7%) is still the dominant species but Rubus allegheniensis (26%), is also very frequent. Phytolacca americana (6.4%), Solanum dulcamara (6.18%), Onoclea sensibilis (4.9%), Epilobium coloratum (4.89%), and Ampelopsis brevipedunculata (4.8%) are the other common species in such sites.

5. Celastrus orbiculatus-Phragmites australis cluster (22 sites)

   Phragmites stands overgrown with Celastrus orbiculatus are found in this cluster. Species that are frequent in these sites, in addition to Phragmites (31.3%), and Celastrus (23.8%), include Rhus copallina (11.7%), Parthenocissus quinquefolia (5.6%) and Rubus allegheniensis (5.17%).

d) Myrica-Prunus group

Sites that are either woodlands or Myrica shrublands are included in this cluster group. Table 11 gives the percentage cover values of the species recorded within this group. At the between-cluster sum of squares level 1, six clusters can be recognized.

1. Populus tremuloides cluster (12 sites)

   This represents the woodland community dominated by Populus tremuloides (47.2%). Sambucus canadensis (15.6%), forms a dense understory within this community while Solidago rugosa (12.4), Rubus pensilvanicus (12.3%), and Celastrus orbiculatus (7%) are the other common plants.

2. Prunus serotina-Ailanthus altissima-Morus alba cluster (9 sites) Prunus and Ailanthus woodlands are included in this cluster. Prunus serotina (45.7%), Ailanthus altissima (29.6%), and Morus alba (14.3%) are the main tree species. Celtis occidentalis (3.52%), and Populus tremuloides (1.6%) are the only other tree species recorded within this cluster.

3. Celastrus orbiculatus-Prunus serotina cluster (21 sites) Prunus woodlands overgrown with Celastrus are included in this cluster. Celastrus orbiculatus (33.3%) and Prunus seotina (23.6%) are the leading dominants. Toxicodendron radicans (6.03%) is also a common plant in this community.

4. Phragmites australis-Parthenocissus quinquefolia-Myrica pensylvanica cluster (15 sites)
The sites clustered in here represent the areas in between Phragmites stands and Myrica shrublands. Phragmites australis (25.7%), Parthenocissus quinquefolia (19%), Myrica pensylvanica (15%) are the most frequent species while Celastrus orbiculatus (8%), Rosa multiflora (6.48%) are the other common species within this cluster.

5. Myrica pensylvanica-Parthenocissus quinquefolia-Toxicodendron scandens cluster (35 sites)

This represents the Myrica shrubland community in the North forty area. Myrica pensylvanica (17.5%), Toxicodendron scandens (16.7%), Parthenocissus quinquefolia (16%), Prunus serotina (11.7%) have the highest cover values within this cluster. Celastrus orbiculatus (8.5%) are also common in these sites.

6. Myrica pensylvanica-Prunus serotina-Celastrus orbiculatus cluster (22 sites)

   Myrica shrublands dominated by saplings of Prunus serotina are included in this cluster. Myrica pensylvanica (16.9%), Prunus serotina (16.5%), Celastrus orbiculatus (11.2%), are the leading dominants. Parthenocissus quinquefolia (7.67%), Rosa multiflora (7.5%) are also common within this community.

4. **Chord distance clustering**

Figure 8 gives the dendrogram obtained form this clustering procedure. At the between-cluster sum of squares level 6.32 four cluster groups could be identified in that dendrogram. These cluster groups can be denominated as, a) Phragmites group, b) Andropogon group, c) Phragmites-Rubus-Rhus group, and d) Myrica-Prunus group. These groups are similar to the 4 groups identified in the classifications described previously.

a) Phragmites australis group (23 sites)

   As in previous classifications this group includes the areas covered almost totally by Phragmites australis (Table 12). The following two clusters could be recognized at the level 1.6.

1. Phragmites australis cluster (12 sites)

   This is same as in Bray-Curtis dissimilarity clustering

2. Phragmites australis-Parthenocissus quinquefolia cluster (21 sites)

   This cluster includes Phragmites stands with Parthenocissus quinquefolia vines. Phragmites australis (69.2%) and while Parthenocissus quinquefolia (10.1%) constitute about 80% of the total cover while other species such as Rubus allgheniensis (5.6%), Phytolacca americana (3.6%), and Polygonum scandens (2.4%) are among the less dominant but not uncommon species within this cluster.

b) Andropogon scoparius-Ammophila breviligulata group (20 sites)

As in previous classifications this group includes grassland sites that are arranged in the following two clusters (at the sum of square level 1.89) level the following two clusters can be identified.

1. Andropogon scoparius cluster (10 sites)

   This is same as in the previous classifications.

2. Andropogon scoparius-Ammophila breviligulata cluster (10 sites)

   This is the same as in previous classifications.

c) Phragmites-Rubus-Rhus group (12 sites)

As in previous classifications, the sites in this cluster group are mostly shrub communities dominated by Rubus allegheniensis, Rhus copallina and Phragmites australis (Table 13). The following six clusters can be recognized at the between-cluster sum of squares level 1.4.

1. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster (25 sites)

   This cluster includes sites that are dominated by Rubus allegheniensis (19.5%), Rhus copallina(13.3%) and Solidago rugosa (11.7%). The other common species are Phragmites australis (9.4%), Toxicodendron radicans (7.5%), and Myrica pensylvanica (6.4%).

2. Rhus copallina-Celastrus orbiculatus-Myrica pensylvanica cluster (24 sites)

   The ecotone sites between Myrica shrubland and grassland are included in this cluster. Rhus copallina (17.6%), Celastrus orbiculatus (15.8%) and Myrica pensylvanica (12.6%) are the dominant species with highest cover. Prunus serotina (6.2%), Solidago rugosa (5.8%) are the other frequent species while Betula populifolia(4.3%), Artemisia vulgaris (4.1), Corynephorus canescens (3.4%) are among the less common but characteristic species in this cluster.

3. Baccharis halimifolia-Phragmites australis cluster (9 sites)
   Communities co-dominated by Baccharis halimifolia (27.7%) and Phragmites australis (15.8%) are included in this cluster. Toxicodendron radicans (9.5%), Rubus allegheniensis (8.2%) and Parthenocissus quinquefolia (6.6%) are also common in these sites.

4. Rubus allegheniensis- Phragmites australis cluster (12 sites)
   Old Phragmites stands with various shrub and herb species are included in this cluster. Rubus allegheniensis (25.2%), is the dominant species with Phragmites australis (17%), as next species with high cover. Ampelopsis brevipedunculata (8.2%), Phytolacca americana (7.5%), Solanum dulcamara (6.6%), Onoclea sensibilis (6.5%), and Epilobium coloratum (6.5%) are the other common species in such sites.

5. Phragmites australis-Rhus copallina cluster (12 sites)
   This cluster represents the transition between Phragmites stands and Myrica shrublands. The leading dominants in this cluster are: Phragmites australis (29%), Rhus copallina (21.9%) and Parthenocissus quiquefolia (10%), Celastrus orbiculatus (8.3%), Festuca rubra (8.2%) and Phytolacca americana (4.7%) are the only other species that have over 5% cover value in this cluster.

6. Phragmites australis-Celastrus orbiculatus cluster (20 sites)
   Phragmites stands overgrown with Celastrus vines are included

in this cluster. Phragmites australis (27.9%) and Celastrus orbiculatus (27.2%) are co-dominants. Myrica pensylvanica (5.6%), Rubus allegheniensis (5.6%) and Parthenocissus quinquefolia (5%) are the other species that have over 5% cover within this cluster,

d) Myrica-Prunus group

Woodlands and Myrica shrublands are included in this cluster group (Table 14). At the between-cluster sum of squares level 1, six clusters can be recognized within this cluster group.

1. Ailanthus altissima-Morus alba cluster (7 clusters)

   Ailanthus woodlands are represented in this cluster. Major dominants in here are Ailanthus altisima (37.3%), Morus alba (26.4%), and Prunus serotina (10.3%). Celastrus orbiculatus is also common in these sites.

2. Prunus serotina cluster (4 sites)

   This cluster represents mature Prunus woodlands. Prunus serotina (86.7%) is the only species that has over 5% cover in these sites.

3. Celastrus orbiculatus-Prunus serotina cluster (9 sites)

   Prunus woodlands heavily overgrown with Celastrus vines are represented in this cluster. Celastrus orbiculatus (41.8%) and Prunus serotina (38.1%) are the two co-dominant species that constitute about 80% of the total cover in these sites.

4. Populus tremuloides cluster (11 sites)

   This represents the woodland community dominated by Populus tremuloides (45.7%). Sambucus canadensis (16.3%), forms a dense understory within this community while Solidago rugosa (13%), Rubus pensilvanicus (11.6%), and Celastrus orbiculatus (5.1%) are the other common plants..

5. Celastrus orbiculatus-Prunus serotina-Myrica pensylvanica cluster(32 sites)

   Myrica shrublands dominated by saplings of Prunus serotina are included in this cluster. Myrica pensylvanica (14%), Prunus serotina (15.1%), Celastrus orbiculatus (16%), are the leading dominants. Toxicodendron radicans (12.6%), Parthenocissus quinquefolia (8.4%) and Lonicera japonica (8%) are also common within this community.

6. Parthenocissus quinquefola-Myrica pensylvanica cluster (31 sites)

   This represents the Myrica shrubland community. Parthenocissus quinquefola (21.4%) vines has the highest cover in this cluster. Toxicodendron radicans (10.6%) is also a frequent vine species. The leading woody species in here are Myrica pensylvanica (19.7%), Prunus serotina (11.3) and Rosa multiflora (9.5%).

## 5. Geodesic Distance Clustering

Figure 9 gives the dendrogram for the Geodesic distance matrix. At the between-cluster sum of squares level 7.41 four cluster groups could be identified in that dendrogram. As in previous classifications, these cluster groups can be denominated as, a) Phragmites group, b) Andropogon group, c) Phragmites-Rubus-Rhus group, and d) Myrica-Prunus group.

a) Phragmites australis group (23 sites)

This group is same as in Chord distance classification (Table 12). Two clusters can be recognized at the level 1.4.

1. Phragmites australis cluster (12 sites)

   This is same as in Chord distance classification.

2. Phragmites australis-Parthenocissus quinquefolia cluster (21 sites)

   This is same as in Chord distance classification.

b) Andropogon scoparius-Ammophila breviligulata group (20 sites)

As in previous classification the following two clusters can be identified at 1.4 level.

1. Andropogon scoparius cluster (10 sites)

   This is same as in the previous classifications.

2. Andropogon scoparius-Ammophila breviligulata cluster (10 sites)

   This is the same as in previous classifications.

c) Phragmites-Rubus-Rhus group

As in previous classifications, the sites in this cluster group are mostly Phragmites stands with shrub or vine species (Table 15). Six clusters could be recognized at the between-cluster sum of squares level 1.4.

1. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster (28 sites)

   This cluster includes sites that are dominated by Rubus allegheniensis (23.3%), Rhus copallina(13.3%) and Solidago rugosa (10.5%). The other common species are Phragmites australis (9.6%), Toxicodendron radicans (6.7%), Parthenocissus quinquefolia (6.1%) and Myrica pensylvanica (5.7%).

2. Baccharis halimifolia-Phragmites australis cluster (9 sites)

   This is same as in the Chord distance clustering.

3. Rubus allegheniensis-Betula populifolia cluster (9 sites)

   This cluster includes a group of communities dominated by Betula populifolia (11.6%), Rubus allegheniensis (11.8), Onoclea sensibilis (8.8%), Epilobium coloratum(7.9%), Solidago rugosa (7.7%), Celastrus orbiculatus (7.5%), Artemisia vulgaris (9.9%) and Parthenocissus quinquefolia (5.2%).

4. Rhus copallina-Celastrus orbiculatus-Myrica pensylvanica cluster (18 sites)

   This is same as in Chord distance classification.

5. Phragmites australis-Rhus copallina cluster (12 sites)

   This is same as in Chord distance classification.

6. Phragmites australis-Celastrus orbiculatus cluster (26 sites)

   Phragmites stands overgrown with Celastrus vines are included in this cluster. Phragmites australis (27.9%) and Celastrus orbiculatus (27.9%) are co-dominants. Rubus allegheniensis(6.8%), and Ampelopsis brevipedunculata (5.3%) are the other species that have over 5% cover within this cluster.

d) Myrica-Prunus group

Woodlands and Myrica shrublands are included in this cluster group (Table 16). At the between-cluster sum of squares level 1.4, the following six clusters can be recognized within this cluster group cluster group.

1. Ailanthus altissima-Morus alba cluster (7 sites)

   This is same as in Chord distance classification.

2. Prunus serotina cluster (4 sites)

   This is same as in Chord distance clustering.

3. Celastrus orbiculatus-Prunus serotina cluster (9 sites)

   This is same as in Chord distance clustering.

4. Populus tremuloides cluster (11 sites)

   This is same as in Chord distance clustering.

5. Celastrus orbiculatus-Prunus serotina-Myrica pensylvanica cluster(32 sites)

   This is same as in Chord distance clustering.

6. Parthenocissus quinquefola-Myrica pensylvanica cluster (31 sites)

   This is same as in Chord distance clustering.

The clusters identified in the 5 methods are listed in Table 17.

**3. A. b. Clustering using Complete Linkage**

The major cluster groups obtained from the Euclidean Distance clustering were used in the Complete Linkage clustering. (Phragmites group was not used because it consisted only of Phragmites). Clustering was done using: 1) Euclidean Distance, 2) Bray-Curtis Dissimilarity, 3) Chord Distance, 4) Geodesic Distance and 5) Similarity Ratio. Dendrograms obtained from Euclidean Distance and Bray-Curtis Dissimilarity clustering were different from the dendrograms of other three methods (Figure 10). Dendrograms obtained from Chord Distance, Geodesic Distance and Similarity Ratio were similar (Figure 11).

**1. Euclidean Distance Clustering.**

a) Phragmites-Rhus-Rubus group (121 sites)

Figure 12 presents the dendrogram obtained for Euclidean Distance and Complete Linkage Clustering done on the Phragmites-Rhus-Rubus group. The following 6 clusters could be recognized at the distance level 85 (Table 18) .

1. Phragmites australis -Parthenocissus quinquefolia cluster

   This includes Phragmites stands mixed with species such as Parthenocissus quinquefolia (8.8%), Rubus allegheniensis (7.7%), Phytolacca americana (4.3%), and Polygonum scandens (2%). Phragmites australis constitutes 65.8% of the total cover in these sites.

2. Rhus copallina-Myrica pensylvanica cluster

   In this cluster, Rhus copallina (20.2%) and Myrica pensylvanica (18.9%) are the dominant species. In addition to Celastrus orbiculatus (6.8%), Phragmites australis (5.9%), Rubus allegheniensis (5.8%) and Solidago rugosa (5.6%), grassland species such as Corenephorus canescens (3.4%), Andropogon scoparius (2.7%) are also present in the sites included in here. As mentioned earlier, this cluster represents the ecotone between the Myrica shrubland and the grassland.

3. Phragmites australis-Celastrus orbiculatus cluster

   Dominant species in this cluster are, Phragmites australis (32.5%) and Celastrus orbiculatus (18.7%). Rhus copallina (10.1%) is the only other important species in here. This cluster represents Phragmites stands invaded by Celastrus.

4. Phragmites australis-Parthenocissus quinquefolia-Baccharis halimifolia cluster

   Maritime communities of Phragmites with Baccharis halimifolia are included in this cluster. Phragmites (24.6%) has the highest cover followed by Parthenocissus quinquefolia (18.4%) and Baccharis halimifolia (11.7%). Toxicdendron radicans (7.8%) is also a common species in these sites.

5. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster

   Sites included in this cluster are dominated by Rubus allegheniensis (24.8%), Rhus copallina (9.8%) and Solidago rugosa (9.6%). The other common species in these sites include, Phragmites australis (8.9%), Toxicodendron radicans (6.1%) and Parthenocissus quinquefolia (5.4%).

6. Celastrus orbiculatus-Rubus allegheniensis cluster

   This cluster is dominated by Celastrus orbiculatus (57.7%), and Rubus allegheniensis (11.1%). Ampelopsis brevipedunculata (7.2%), and Rhus copallina (6.7%) are among the other species that have higher cover value.

b) Prunus-Myrica group

The following seven clusters can be recognized at 85 level in this group (Figure 13 and Table 19 ).

1. Prunus serotina cluster

   This cluster includes the woodland stands dominated by Prunus serotina (74%). The other tree species recorded from these sites are, Morus alba (7.3%), Celtis occidentalis (6.3%) and Ailanthus altissima (3.2%),

2. Prunus serotina-Celastrus orbiculatus-Myrica pensylvanica cluster

   Myrica shrublands with Prunus saplings are represented in this cluster. Celastrus orbiculatus (18.9%) is an invasive vine has the second highest cover value, Prunus serotina (19.7%), is having the highest cover due to its canopy. Myrica pensylvanica (10.3%), Parthenocissus quinquefolia (8.6%) and Toxicodendron radicans (8.5%) very common in these sites.

3. Myrica pensylvanica-Parthenocissus quinquefolia cluster

   This cluster represents the Myrica shrublands. Myrica pensylvanica (26.7%), Parthenocissus quinquefolia (22.6%), Toxicodendron radicans (14.8%), and Rosa multiflora (12.6%) are the most common species present in these sites.

4. Populus tremuloides-Sambucus canadensis cluster

   This is as same as in minimum variance clustering.

5. Ailanthus altissima-Morus alba cluster

   This is same as in minimum variance clustering.

6. Artemisia vulgaris-Solidago rugosa cluster

   This small cluster represents the roadside communities dominated by Artemisia (43%), Solidago rugosa (22.3%), Celastrus orbiculatus (18.1), and Bromus tectorum (12.2%).

7. Betula populifolia cluster

   Betula woodlands in the Floyd Bennett Field are included in this cluster. Myrica pensylvanica (5.4%) is also present at the peripheral areas of this community.

**2. Bray-Curtis Dissimilarity Clustering.**

a) Phragmites-Rhus-Rubus group (121 sites)

Figure 14 presents the dendrogram obtained for Bray-Curtis Dissimilarity and Complete Linkage Clustering done on the Phragmites-Rhus-Rubus group. At the dissimilarity level .. this dendrogram branches into 3 main groups (Table 20). These groups can be recognized as a) Phragmites-Celastrus group, b) Rhus-Phragmites-Rubus group, and c) Rubus-Phragmites group. At 0.85 the following six clusters can be identified (Table 21).

1. Phragmites australis -Parthenocissus quinquefolia cluster

   This includes Phragmites stands with herbaceous and shrubby species such as Parthenocissus quinquefolia (15.4%) and Rubus allegheniensis (3.8%). Phragmites australis constitutes 61.7% of the total cover in these sites.

2. Celastrus orbiculatus-Phragmites australis cluster

   Dominant species in this cluster are, Phragmites australis (29.9%) and Celastrus orbiculatus (24.3%). This cluster represents Phragmites stands invaded by Celastrus.

3. Rhus copallina-Phragmites australis cluster

   In this cluster, Rhus copallina (25.6%), Phragmites australis (18.5%) and Celastrus orbiculatus (16.3%) are the dominant species. The lesser dominant species include Myrica pensylvaniva (8.1%), Parthenocissus quinquefolia (5.3%), and Festuca rubra (5.3%).

4. Rhus copallina-Rubus allegheniensis- Solidago rugosa cluster

   Sites included in this cluster are dominated by Rhus copallina (15.8%), Rubus allegheniensis (14.8%), and Solidago rugosa (10.6%). The other common species in these sites include, Myrica pensylvanica (10%), Phragmites australis (7.8%), Parthenocissus quinquefolia (5.9%) and Toxicodendron radicans (5.7%).

5. Rubus allegheniensis-Phragmites australis cluster

   This includes sites dominated by Rubus allegheniensis (30.9%) and Phragmites australis (17.1%). Onoclea sensibilis (7.9%), Epilobium coloratum (7.8%), and Solanum dulcamara (7.9%) are the other important species in this cluster.

6. Baccharis halimifolia- Phragmites australis cluster

   Maritime communities of Phragmites with Baccharis halimifolia are included in this cluster. Baccharis (20.2%) has the highest cover followed by Phragmites australis (17.1%), Toxicdendron radicans (12.8%), Parthenocissus quinquefolia (8.9%) and Rubus allegheniensis (8.9%).

b) Prunus-Myrica group

The following seven clusters can be recognized at 0.90 dissimilarity level in this group (Figure 15 and Table 22).

1. Prunus serotina cluster

   This is same as in Euclidean Distance clustering.

2. Myrica pensylvanica-Prunus serotina cluster

   Myrica shrublands with Prunus saplings are represented in this cluster. Celastrus orbiculatus (10.4%) is an invasive vine in these sites. Myrica pensylvanica (19.7%), is having the highest cover followed by Prunus serotina(16.2%), Parthenocissus quinquefolia (13.3%) and Toxicodendron radicans (11.5%).

3. Celastrus orbiculatus-Prunus serotina cluster

   Prunus woodlands overgrown by Celastrus orbiculatus are included in this cluster. Celastrus (29.8%) and Prunus (20.9%) are the dominant species here.

4. Populus tremuloides-Sambucus canadensis cluster

   This is same as in previous clustering procedure.

5. Ailanthus altissima-Morus alba cluster

   This is same as in previous clustering procedure.

6. Myrica pensylvanica-Betula populifolia cluster

   This cluster includes Betula woodlands and Myrica pensylvanica (21.3%) shrubs.

7. Artemisia-Solidago-Celastrus cluster

   This is same as in Euclidean Distance clustering.

**3. Chord Distance Clustering.**

a) Phragmites-Rhus-Rubus group (121 sites)

Figure 16 presents the dendrogram obtained for Chord Distance and Complete Linkage Clustering done on the Phragmites-Rhus-Rubus group. At the distance level 1.3 the following six clusters can be identified (Table 23).

1. Phragmites australis -Parthenocissus quinquefolia cluster

   This includes Phragmites stands with herbaceous and shrubby species such as Parthenocissus quinquefolia (14.1%), Baccharis halimifolia (6.15%). Phragmites australis constitutes 51.3% of the total cover in these sites.

2. Phragmites australis-Celastrus orbiculatus cluster

   Dominant species in this cluster are, Phragmites australis (32.1%) and Celastrus orbiculatus (20.6%). This cluster represents Phragmites stands invaded by Celastrus.

3. Rhus copallina-Phragmites australis cluster

   In this cluster, Rhus copallina (25.4%), Phragmites australis (13.4%) and Myrica pensylvanica (13.1%) are the dominant species. This represents the ecotone between the grassland and Myrica shrubland.

4. Rubus allegheniensis-Rhus copallina-Solidago rugosa cluster

   Sites included in this cluster are dominated by Rubus allegheniensis (24.9%), Rhus copallina (11%),and Solidago rugosa (10.7%). The other common species in these sites include: Phragmites australis (9.9%), Parthenocissus quinquefolia (6%) and Toxicodendron radicans (6.9%).

5. Celastrus australis-Rhus copallina Myrica pensylvanica cluster

   This includes sites dominated by Celastrus orbiculatus (20.4%), Rhus copallina (20.1%) and Myrica pensylvanica (15.3%).

6. Onoclea sensibilis-Rubus allegheniensis-Epilobium coloratum cluster

   Mixed shrub communities dominated by Onoclea sensibilis (25.9%), Rubus allegheniensis (24.5%) and Epilobium coloratum (23.7%) are represented in this cluster. These sites are present in moist areas adjoining Phragmites stands.

b) Prunus-Myrica group

The following six clusters can be recognized at 1.4 dissimilarity level in this group (Figure 17 and Table 24 ).

1. Prunus serotina cluster

This is same as in previous clustering procedures.

2. Prunus serotina-Celastrus orbiculatus cluster

Myrica shrublands with Prunus saplings are represented in this cluster. Celastrus orbiculatus (19%) is an invasive vine has the second highest cover value, Prunus serotina (20%), is having the highest cover due to its canopy. Myrica pensylvanica (10.9%), Toxicodendron radicans (9.4%) and Parthenocissus quinquefolia (8.7%) are very common in these sites

3. Myrica pensylvanica- Parthenocissus quinquefolia cluster

Myrica shrublands are represented in this cluster. Myrica pensylvanica (21.4%), is having the highest cover followed by Parthenocissus quinquefolia (19.4%) and Toxicodendron radicans (9.5%).

4. Populus tremuloides-Sambucus canadensis cluster

This is same as in previous clustering procedure.

5. Ailanthus altissima-Morus alba cluster

   This is same as in previous clustering procedure

6. Artemisia vulgaris-Solidago rugosa cluster

   This same as in Euclidean Distance clustering.

**4. Geodesic Distance Clustering.**

a) Phragmites-Rhus-Rubus group (121 sites)

   The cluster groups and clusters obtained for Geodesic Distance are similar to those of Chord Distance Clustering (Figure 18 and Table 23).

b) Prunus-Myrica group

   Same as in Chord Distance Clustering (Figure 19 and Table 24).

**5. Similarity Ratio Clustering.**

a) Phragmites-Rhus-Rubus group (121 sites)

   The cluster groups and clusters obtained for Geodesic distance are similar to those of Chord Distance Clustering (Figure 20 and Table 23).

b) Prunus-Myrica group

   Same as in Chord Distance Clustering (Figure 21 and Table 24).

The clusters recognized by all five methods are listed in Table 25.

## 3. B. Ordination

### 3. B. a. Principal Component Analysis

Figure 22 is the ordination diagram obtained from the Principal Component Analysis of the 249 sites studied. It shows the first two principal components. Table 26 shows that the variation explained by first and second axes is 23% and 11% respectively. Figure 23 is a 3-dimensional ordination diagram drawn using the first three axes. The four main groups of sites recognized by the Euclidean Distance and minimum variance clustering (Table 2) are superimposed on both ordination diagrams. The grassland sites stand out clearly as a separate group. Phragmites sites also form a single group while the shrub and woodland sites show a certain amount of overlapping. This is clearly seen when the different sites in each group are connected to the centroid of the group (Figure 24).

#### a) PCA of Rubus-Rhus-Phragmites group

Figure 25 is the ordination diagram drawn only for the shrubland group. The clusters recognized by complete linkage clustering are superimposed. Here again the sites are connected to the centroid so that members of each cluster can be identified. Principal Component Axis 1 appears to indicate the moisture gradient. Cluster 1, dominated by Phragmites with a few individual of Parthenocissus stands out in one end of this axis while at the other end are the shrubby sites such as Rhus-Myrica cluster and Rubus-Rhus Solidago cluster. Axis 2 seems to be indicative of the sites that are invaded by exotic vines rather than by Parthenocissus, and may indicate a disturbance regime. The total variation explained by the first two Prncipal Components is about 37%.

**b) PCA of woodland group**

A two dimensional ordination (Axis 1 and 2) diagram for the woodland group is given in Figure 26. Figure 27 is the three dimensional diagram constructed using the first three principal components. Here again the cluster structure obtained from the Complete Linkage and Euclidean Distance is superimposed. As in the previous diagram the sites identified with each cluster are connected to the centroid of each cluster. Except for a few stands in the Prunus/Myrica/Celastrus cluster (cluster 2) which overlap the Myrica-Parthenocissus cluster (cluster 3) and Prunus cluster (cluster 1), all others seem to separate clearly (Figure 26 ). Figure 26 shows that Populus site (cluster 4) and Myrica sites (cluster 2,3) are placed at two extremes along the first axis. Prunus/Myrica/Celastrus cluster overlaps with Prunus cluster and Myrica-Parthenocissus cluster due to the presence of Myrica pensylvanica in all three clusters. Betula cluster

(cluster 7) is placed near Prunus/Myrica/Celastrus cluster for the same reason. Axis 1 appears to indicate the soil texture. Populus sites are associated with harder, less sandy soil while Myrica sites are extremely sandy. Ailanthus (cluster 5) and Artemisia sites (cluster 6) are found in between. Presence of Prunus may be indicated by Axis 2. Axis 3 appears to separate sites based on the presence of undergrowth.

### c) PCA of dry grassland group

The grassland sites show two different clusters in the ordination diagram (Figure 28). Here the Andropogon cluster appears to be more homogeneous than the Andropogon-Ammophila-Panicum cluster, which shows a very distinct outlier. The outlier site has a very high cover of Corynephorus canescens. The variation explained by the first two axes is about 55%. Axis 1 may indicate the presence of organic matter. Sites included in Andropogon cluster are extremely sandy whereas the sites in the Andropogon-Ammophila-Panicum cluster appear to have a slightly higher organic matter (Table 27).

## 3. B. b.. Correspondence Analysis

Figure 29 gives the ordination diagram obtained from correspondence analysis for all the sites. Except for the two grassland clusters, all clusters tend to form an aggregate around the origin of the axes. As seen in PCA, Andropogon Cluster appears to be more homogeneous than Andropogon-Ammophila-Panicum Cluster. Affinities of the latter to species such as Hudsonia tomentosa, Panicum virgatum, Lechea maritima, Eragrostis curvula can also be seen.

**a) Correspondence Analysis of Rubus-Rhus-Phragmites group**

Since it was not possible to resolve the Rubus-Rhus-Phragmites group in the above analysis, I isolated the sites belonging to Rubus-Rhus-Phragmites group from the combined data set and conducted a separate correspondence analysis. Figure 30 shows the ordination diagram for that analysis. It appears that there is heavy crowding in that analysis too. All clusters tend to aggregate at the origin. Only three sites, belonging to Rubus-Rhus-Solidago cluster group, dissociate from the center. These three sites are characterized by the presence of Onoclea sensibilis and Epilobium coloratum. Axis 1 appears to indicate a moisture gradient.

**b) Correspondence Analysis of woodland group**

Figure 31 is the ordination diagram for the correspondence analysis done on the woodland sites. Unlike in the Rubus-Rhus-Phragmites group there is a certain degree of separation here. Betula sub-cluster, Ailanthus-Morus sub-cluster, Populus-

Sambucus sub-cluster and Prunus sub-cluster are recognizable while the other sub-clusters are aggregated together around the origin of the axes. Axis 1 appears to indicate presence of Ailanthus, whereas Axis 2 seems to be indicative of the presence of Salix.

**c) Correspondence Analysis of dry grassland group**

Ordination diagram for the correspondence analysis done on the dry grassland group is in Figure 32. Andropogon cluster seems to represent sites with Linaria vulgaris, Euthamia graminifolia, Rhus copallina, Parthenocissus quinquefolia; while Hudsonia tomentosa, Panicum lanuginosum, Lechea maritima, Conyza canadensis, Panicum virgatum, Heterotheca subaxiallaris, Asclepias syriaca, and Eragrostis curvula are the important species in the other cluster. In Figure 32, the axis 1 appears to indicate a successional trend (grassland to shrubland). Axis 2 may indicate disturbance.

### 3. B. c. Detrended Correspondence Analysis (DCA)

Figure 33 gives the ordination diagram for all the sites obtained by DCA. Although there is a certain degree of overlapping, it is better than the outcome of CA. This is clear in Figure 34 where only the cluster centroids are shown. The scale contraction and arch-effect is removed. Clusters belonging to dry grassland group, woodland group, Phragmites group and Rhus-Rubus-Phragmites group are all separated in an orderly fashion. Here the first DCA axis seems to represent the moisture gradient, as the drier sites (grassland group) and moist sites (Phragmites, Populus) are placed at the two extremes. It is interesting to note that Rhus-Myrica cluster, which represents the sites located at the border between the dry grassland and shrubland, is placed in between the two, the dry grassland clusters and the shrub clusters. Axis 2 appears to be related to a successional sequence, as the two extremes are represented by woody and grassland sites with shrub sites in the middle. The two wet grassland clusters (Phragmites, cluster 16 and Phragmites-Parthenocissus, cluster 8) are closely placed at one extreme while Myrica-Parthenocissus cluster (3) is placed at the center of the diagram. All clusters above (north of) it are mostly Phragmites while those below (south of it) are woodier.

### 3. B.d. Principal Coordinate Analysis (PCO)

Figure 35 presents the PCO ordination diagram plotted using Bray-Curtis Dissimilarity. Here also the four main cluster groups are indicated. The dry grassland sites, and the Phragmites group separate out very clearly from the rest of the sites. This is even clearer in the 3-dimensional diagram plotted with the first 3 PCO axes (Figure 36). In Figure 37 the sites are connected to the centroid of each cluster. In

Figure 38 the same diagram is shown only with cluster centroids. The wet grassland (Phragmites) clusters, dry grassland (Andropogon) clusters, Myrica shrublands and woodland clusters are separated in different groups. When PCO was done using Chord Distance matrix, the pattern was very similar except that Prunus cluster is shifted towards the left (Figure 39). The same trend can be seen in PCO ordinations done using Euclidean distance (Figure 40), Geodesic distance (Figure 41) and Similarity ratio matrices (Figure 42). Figure 41 clearly shows the successional gradient of clusters along the PCO axis 1 where the Phragmites sites and Prunus/Myrica sites are placed at the two extremes.

**3. B.e. Nonmetric Multidimensionl Scaling (NMDS)**

NMDS ordination diagram in Figure 43 shows the distribution of four different cluster groups (Table 2). As in the previous ordinations the grassland-woodland gradient can be seen along the first dimension. The sites are distributed in a triangular fashion. The same diagram with the 16 clusters superimposed is in Figure 44. Prunus cluster, dry grassland clusters and wet grassland (Phragmites) clusters are placed at the ends of the triangular swarm of sites. This is clearer when only the centroids are shown (Figure 45).

## 3. C. Correlation of species distributions with Environmental Variables

In the present study soil samples collected from representative sites were analyzed for various chemical properties with a view to finding possible soil-related plant distribution patterns. Table 27 lists these properties for each of the 16 clusters recognized in Euclidean Distance and Complete Linkage clustering.

### 3. C. a. Canonical Correspondence Analysis (CCA)

Figure 47 represents the ordination diagram plotted using scores for the sites that are linear combinations of environmental variables. For clarity, only the cluster centroids are shown in the diagram. Of the five environmental variables used in this analysis (concentrations of Al, Mn, Fe, Zn and Cu ) only Al was directing towards the right side of the diagram. The clusters that positively correlate with Al are the dry grassland clusters, Betula cluster and Rhus-Myrica cluster. All these clusters represent very sandy sites. The clusters on the right side, which are associated with the other micro-nutrients are the Phragmites, shrub and woody clusters. Phragmites clusters seem to be associated with high Fe levels. Fe appears to be the most important variable in this group.

Figure 48 is the CCA ordination with moisture content and organic matter as environmental variables. Both these variables seem to be equally important and follow more or less same pattern. Populus cluster, Ailanthus cluster, Phragmites cluster, Phragmites-Parthenocissus-cluster and Rhus-Celastrus cluster appear to represent sites with high moisture and organic matter. One would expect Phragmites sites also to have the highest moisture content. This is not so because the substratum of those sites is mostly sand. Although these sites are moist, the water holding capacity is very low probably due to the high proportion of sand and low organic matter content. Because all soil samples were air-dried before analysis it was unlikely that the samples collected from Phragmites sites retained much moisture.

Figure 49 represents the CCA ordination diagram plotted with macro-nutrients N, P and K. Here again the dry grassland clusters, Betula cluster and Rhus-Myrica cluster are in one side which corresponds to lower levels of N, P, and K. Myrica-Parthenocissus cluster and Ailanthus cluster also appear to have lower N, P, and K levels. Populus cluster (Cl. 4) seems to be associated with the highest NPK levels whereas the Prunus (Cl. 1) and Ailanthus (Cl. 5) clusters occupy a somewhat intermediate position. Phragmites (Cl. 16) cluster seems to have moderate N, P and K levels. In the ordination diagram shown in Figure 50, organic matter content (OMAT), moisture level (M), total nitrogen (ToN), and pH are represented. Populus cluster has the highest organic matter content, moisture and total nitrogen level. Ailanthus-Morus cluster also appears to be at the higher end. Myrica-Parthenocissus cluster and Phragmites clusters show a similar, intermediate organic matter content. All Prunus clusters, Ailanthus cluster, Rhus-Celastrus-Phragmites cluster, Baccharis-Phragmites cluster, and Populus cluster appear to be associated with low pH levels. Dry grassland sites, Rhus-Myrica cluster, Betula cluster, Rhus-Rubus-Solidago cluster, Rubus-Celastrus cluster and Artemisia-Solidago cluster are in placed on the left side of the diagram indicating their affinity to high pH levels.

Figure 51 indicates that Populus cluster and Ailanthus cluster are associated with high levels of Ca and Mg. Sites belonging to these clusters, specially the Populus cluster, are present in areas where the substratum includes construction debris including concrete and cement. Phragmites clusters, Rubus-Celastrus cluster and Artemisia-Solidago cluster are appear to exist in areas with intermediate levels of Ca and Mg. Dry grassland clusters, Betula cluster and the clusters of Rhus-Rubus-Phragmites group appear to be in low Ca and Mg soils.

# Chapter 4. DISCUSSION

Present vegetation in the North Forty area of Floyd Bennett Field is by no means uniform. Different vegetation types ranging from open, dry grasslands to dense, close woodlands can be found, depending on the location. There are numerous, distinct communities within those vegetation types.

One of the main objectives of this study is to identify and classify those plant communities present in the North Forty area of Floyd Bennett Field.

## 4. A. Plant Communities in North Forty area of Floyd Bennett Field

According to Whittaker (1962) the process of classification begins with the observation of landscape followed by a subjective recognition of different community types based on over-all character, or pattern, or gestalt of stands. I recognize the following communities as a result of this study (1995-97).

### 4. A. a. Prunus serotina Community

Mature Wild black cherry woodlands are represented by this community (Figure 52). Except in the peripheral areas, there is no shrub layer. The canopy tree layer is about 10-12 m tall with a ground herb layer of less than 1 m. Prunus serotina is the dominant tree species. The other species of trees observed within this community are: Morus alba, Celtis occidentalis, Rhus copallina (small tree), Ailanthus altissima, Populus tremuloides, and Betula populifolia.

Several shrub species are present at the periphery of this community. They include Elaeagnus umbellata, Elaeagnus commutata, Myrica pensylvanica, Pyrus sp., Rhus glabra and Rhus typhina.

Herbaceous plants in the ground layer include Eupatorium rugosum. Allium vineale, and Phytolacca americana. In some sites the ground is covered by vines such as Parthenocissus quinquefolia and Celastrus orbiculatus.

Almost all the trees in this community are festooned with Celastrus orbiculatus. Parthenocissus quinquefolia is also a common climber present but not to the same degree.

**4. A. b. Populus tremuloides-Sambucus canadensis Community**

This is a woodland community composed of Trembling aspen trees (Figure 53). Unlike in other woodland communities observed in North Forty this community has three distinct strata, namely a tree stratum (10-12 m), a shrub layer (1-2 m) and a ground herb layer (less than 1 m). The canopy layer consists almost entirely of Populus tremuloides. Occasionally, Salix matsudana, Salix fragilis, Acer rubrum, Salix babylonica, and Betula populifolia are also found in the canopy. Prunus serotina and Morus alba are found at the peripheral areas of this community.

The shrub layer (1-2 m) is formed mainly of Sambucus canadensis. The other woody shrubs in the undergrowth include Rosa multiflora, Salix discolor and Rubus pensilvanicus. Myrica pensylvanica is restricted to the periphery of this community.

The herb layer is very sparse in the interior of these woodlands. Phytolacca americana and Solidago juncea are among common herbs. Solidago rugosa is very frequent in the peripheral areas. Celastrus orbiculatus and Solanum dulcamara are the vines present in this community. The underlying substratum of this site appears to be domestic waste and construction debris. It is very shallow and hard.

In the fall of 1995 many larger trees in this woodland fell due to a storm. It was possible to see that the root system of the fallen trees were shallow. Pieces of bricks, glass, concrete and other rubble were among the roots of those trees.

### 4. A. c. Ailanthus altissima - Morus alba community

This is a woodland community with clumps of trees (Figure 54). As in the Prunus serotina community there are only two strata. The upper tree layer (10-12 m) is formed mostly of Ailanthus altissima. Morus alba is another tree commonly found in the canopy. Prunus serotina is found at the periphery of this community. Shrubs such as Baccharis halimifolia, Rhus copallina and Rhus glabra are also found at the border of this community. Vines in this community include Celastrus orbiculatus .

During summer of 1996, I noticed that some mature trees of Ailanthus were dying. This started with browning of leaves followed by defoliation. Although the number of trees affected by this has not been high at present, it could affect the community if this trend continued.

Substratum of this community is variable. In some areas it is sandy whereas in other places it is hard with construction debris. A common characteristic of these sites may well be the amount of macropore air space in the soil.

### 4. A. d. Betula populifolia community

Betula populifolia community is a woodland community (Figure 55) with only Betula populifolia in the canopy layer (10 m). There is a very sparse shrub layer (2 m) with mostly Myrica pensylvanica.

Herbs in this community include, Solidago rugosa, Linaria vulgaris, Solidago juncea, Saponaria officinalis, Eupatorum rugosum,

Betula populifolia community is found adjoining the Andropogon scoparius (Schizachyrium scoparium) community. Substratum of this community is sandy.

**4. A. e. Myrica pensylvanica -Prunus serotina community**

Unlike in the other shrub communities this community has an upper, discontinuous sapling stratum as well as a dense shrub layer and a ground herb layer (Figure 56).

The shrub layer (2-3 m) is dominated by Myrica pensylvanica. The other shrubs in this stratum include Rosa multiflora, Rhus copallina, Rubus pensilvanicus, Rubus allegheniensis, Rhus typhina, Viburnum dentatum, Elaeagnus commutata, Sambucus canadensis, Baccharis halimifolia, Aronia arbutifolia, Elaeagnus umbellata, Rhus glabra, Pyrus sieboldii, and Salix discolor

Vines in this community are, Celastrus orbiculatus, Parthenocissus quinquefolia, Solanum dulcamara, Toxicodendron radicans, and Lonicera japonica, The upper sapling layer (3-4 m) is formed mainly by saplings of Prunus serotina. The other saplings observed in this community are: Morus alba, Populus tremuloides, Betula populifolia, Acer rubrum. Juniperus virginiana, Elaeagnus angustifolius, and Ailanthus altissima.

Common herbaceous plants in this community are: Solidago rugosa, Solidago juncea, Saponaria officinalis, Eupatorum rugosum, Achilea miliformis, Asclepias syriaca, Equisetum arvensis,, Linaria vulgaris, Phytolacca americana, Solidago canadensis, and Thelypteris simulata. Substratum of this community is sandy with very little litter.

**4. A. f. Myrica pensylvanica-Parthenocissus quinquefolia community**

This community consists of a dense shrub layer about 2 m tall and a ground herb layer. Myrica pensylvanica is the dominant species in the shrub layer. The other common species present in the shrub layer include, Rosa multiflora, Elaeagnus commutata, Viburnum dentatum, Sambucus canadensis, Rubus allegheniensis, Rubus laciniatus, Rubus pensilvanicus, Rhamnus frangula, and Pyrus sieboldii. The shrubs are very closely placed so that it is not possible to walk through this community without clearing a path (Figure 57). Passage through the community is even more difficult due to the presence of such thorny shrubs as Rosa multiflora and Rubus spp .

There are several climbers that occupy both vertical and horizontal spaces available within the community. The most frequent species of vine in this community is Parthenocissus quinquefolia. Lonicera japonica, Toxicodendron radicans, Solanum dulcamara, and Celastrus orbiculatus are the other vines.

Herbaceous plants such as Solidago rugosa, Apocynum cannabinum, Phytolacca americana and Saponaria officinalis, are also found in open areas.

Scattered tree saplings are not uncommon. Most of these are saplings of Prunus serotina. The others include saplings of Populus deltoides, Populus tremuloides, and Morus alba.

Substratum of this community is almost totally sandy. There is very little litter or sub soil (about 1-2 inches thick). Celastrus orbiculatus (Oriental bittersweet), and Lonicera japonica (Japanese honeysuckle) are two exotic invasive plants present in these communities.

**4. A. g. Rhus copallina-Myrica pensylvanica community**

Rhus copallina-Myrica pensylvanica community is usually found between dry grassland and Myrica shrubland (Figure 58). This can be considered as an ecotone between the grassland and shrubland. As in the Myrica pensylvanica-Parthenocissus quinquefolia community, there are two strata in this community. The first layer, about 2m in height, consists mainly of shrubby species dominated by Myrica pensylvanica and Rhus copallina. The other shrub species include, Rubus allegheniensis, Baccharis halimifolia, Rosa multiflora, Solidago canadensis, Rubus laciniatus, Pyrus sieboldii, Viburnum dentatum, Rhus glabra, Sambucus canadensis, Elaeagnus commutata, Pyrus sp 2, and Rubus flagellaris. Saplings of Prunus serotina, Ailanthus altissima, and Betula populifolia are also found occasionally.

This community also has several species of vines. They include, Celastrus orbiculatus, Solanum dulcamara, Polygonum scandens, Lonicera japonica, Parthenocissus quinquefolia, and Toxicodendron radicans.

The second layer consists of herbaceous species less than 1 m in height. Diversity of herbs in this community is higher than that in the Myrica pensylvanica-Parthenocissus quinquefolia community. Some of the common species in the herb layer are: Solidago rugosa, Solidago juncea, Saponaria officinalis, Achillea millifolium, Anaphalis margaritacea, Oenothera biennis, Euthamia tenuifolia, Eupatorum rugosum, Linaria vulgaris, Lechea maritima, Eupatorium hyssopifolium, Eupatorium leucolepis, Circium arvensis.

Almost all the dominant grasses of the dry grassland communities are present within this community. They include, Andropogon scoparius (Schizachyrium scoparium), Ammophila breviligulata, Bromus tectorum, Corynephorus canescens, Festuca rubra, and Panicum virgatum. The substratum of this community is also very sandy with very little litter.

**4. A. h. Andropogon scoparius community**

A dry grassland community dominated by Andropogon scoparius is found in several areas of Floyd Bennett Field. The tussocks of Andropogon are very closely placed, with few open spaces (Figure 59). The other grasses that are occasionally found within this community are, Corynephorus canescens and Ammophila breviligulata.

Herbs such as Linaria vulgaris, Euthamia graminifolia, Eupatorium hyssopifolium, Lespedeza capitata, Gnaphalium obtusifolium, Conyza canadensis are commonly found in open spaces. Parthenocissus quinquefolia was the only vine found within this community. This community is being colonized by groups of shrubs. The shrub groups are formed mostly by bushes of Myrica pensylvanica and Rhus copallina.

I have observed small saplings of Prunus serotina also in some areas of this community. The substratum of this grassland is extremely sandy with no litter.

**4. A. i. Andropogon scoparius- Ammophila breviligulata -Panicum virgatum community**

Andropogon-Ammophila-Panicum community is the other dry grassland community found in the North Forty area. It is different from Andropogon community in having a wider diversity of grasses and herbs (Figure 60). Common grasses in this community are: Andropogon scoparius, Ammophila breviligulata, Panicum virgatum, Corynephorus canescens, Eragrostis curvula, Agropyron repens, and Panicum lanuginosum.

Herbs such as Lechea maritima, Hudsonia tomentosa, and Heterotheca subaxillaris, that are usually found in coastal sand dunes, are also found within this community.

Other herbs common to this community are: Conyza canadensis, Chrysopsis falcata, Lepidium virginicum, Eupatorium hyssopifolium, Asclepias syriaca, Euthamia graminifolia, Euthamia tenuifolia, Gnaphalium obtusifolium and Parthenocissus quinquefolia .

As in the Andropgon community, there are groups of invading shrubs. These shrubs are mainly Myrica pensylvanica, Rhus copallina and Rubus allegheniensis. The soil of this grassland is also extremely sandy with no litter.

**4. A. j. Rhus copallina - Rubus allegheniensis- Solidago rugosa community**

This is a community characterized by Rhus copallina, Rubus alleghaniensis, Solidago rugosa and Phragmites australis (Figure 61). There were remains of burnt stumps in these sites indicating previous fires. It is possible that this represent a shrub community modified by fire. Rubus allegheniensis, Rhus copallina, Baccharis halimifolia, Rhus glabra, Rhus typhina, Sambucus canadensis, Viburnum dentatum, Myrica pensylvanica, Pyrus sieboldii, Salix discolor and Rubus laciniatus are some of the common shrubs found in this community. The tall shrub layer is about 2-3 m tall with a shrub layer of about 1m.

Vines observed within this community include, Toxicodendron radicans, Parthenocissus quinquefolia, Solanum dulcamara, Celastrus orbiculatus, Polygonum scandens, Ampelopsis brevipedunculata and Lonicera japonica.

The diversity of herbaceous plants in this community is higher due to the openness of the shrub layer. Solidago rugosa is the most dominant and frequent herb. Some of these herbs include: Onoclea sensibilis, Solidago rugosa, Phragmites australis, Epilobium colaratum, Apocynum cannabinum, Solidago canadensis, Spirea tomentosa, Cyperus bipartitus, Euthamia tenuifolia, Osmunda regalis, Thelypteris simulata, Ambrosia artimisiifolia, Juncus canadensis, Oenothera biennis, Osmunda cinnamomea, Panicum lanuginosum, Thelypteris palustris, Linaria vulgaris, Polygonum hydropiperoides, and Scirpus cyperinus.

Saplings of Prunus serotina and Ailanthus altissima are also found within the shrub layer. In wetter areas saplings of Salix nigra, Acer rubrum, and Betula populifolia are found. Substrate of this community is also very sandy.

A sub-community of Onoclea sensibilis, Epilobium coloratum, and Rubus allegheniensis is found in wet areas within the Rhus-Rubus-Solidago community. There is only one layer (about 1 m tall) which consists mainly of Onoclea sensibilis, Epilobium coloratum, Rubus allegheniensis, and Polygonum hydropiperoides.

**4. A. k. Celastrus orbiculatus - Rubus allegheniensis community**

This is a shrubland community dominated by Rubus allegheniensis. Most of the shrubs in this community are overgrown by Celastrus orbiculatus. The shrub layer is about 2 m tall with a ground herb layer less than 1 m. In some sites saplings of Ailanthus altissima were also found in the shrub layer (Figure 62).

Rhus copallina, Rubus laciniatus and Sambucus canadensis are some other shrub species found in the shrub layer in addition to Rubus allegheniensis.

Several other vines such as Ampelopsis brevipedunculata, Parthenocissus quinquefolia and Solanum dulcamara are also found within this community.

In some areas Phragmites australis was also found. Oxalis corniculata, Rumex crispus, Barbarea vulgaris, and Solidago canadensis are some of the herbaceous species commonly found in this community.

**4. A. l. Celastrus orbiculatus - Phragmites australis community**

This community is found in between the Phragmites community and Myrica shrublands. Phragmites is the dominant species (Figure 63). In many of these communities Celastrus orbiculatus is found growing abundantly on Phragmites. Other vines such as Toxicodendron radicans, Parthenocissus quinquefolia, Ampelopsis brevipedunculata, and Solanum dulcamara are also common in this community.

Several species of shrubs are also occupying this community. These shrubs include, Rhus copallina, Rubus allegheniensis, Myrica pensylvanica, Rubus pensilvanicus, Rosa multiflora, Sambucus canadensis, and Viburnum dentatum.

Herbaceous plants such as Phytolacca americana, Festuca rubra, Solidago rugosa, Artemisia vulgaris, Linaria vulgaris, Fragaria pensylvanica, Verbena hastata, Lactuca canadensis, Solidago canadensis, Oenothera biennis, Solidago juncea, and Verbascum blattaria, are also observed in this community.

Saplings of some trees species were also present in this community. They are, Morus alba, Prunus serotina, Populus tremuloides, Populus deltoides, Salix nigra, Salix alba, Salix caprea, and Ailanthus altissima.

The substrate of this community is sandy with a thin litter layer.

**4. A. m. Baccharis halimifolia - Phragmites australis community**

Baccharis -Phragmites community is found near the shoreline. It is basically a Phragmites community mixed with shrubs dominated by

Baccharis halimifolia (Figure 64). The shrub layer is about 2 m tall. The other shrubs in this layer include: Rubus allegheniensis, Myrica pensylvanica, Rosa multiflora, Rhus copallina, Rhus glabra, Elaeagnus commutata, Viburnum dentatum, Salix discolor, Sambucus canadensis, and Rubus laciniatus.

Parthenocissus quinquefolia and Toxicodendron radicans are very frequent vines in this community. There are also other vines such as Celastrus orbiculatus, Lonicera japonica, Solanum dulcamara, and Polygonum scandens.

The ground herb layer (less than 1m) includes species such as, Asclepias syriaca, Circium arvensis, Eupatorium leucolepis, Euthamia tenuifolia, Artemisia vulgaris, Juncus gerardii, Linaria vulgaris, Osmunda regalis, Panicum virgatum, Phytolacca americana, Setaria glauca, and Solidago rugosa.

Saplings of Populus tremuloides, Prunus serotina, Salix nigra, Elaeagnus angustifolius, ilanthus altissima, and Salix babylonica are also observed within this community. The substrate of this community is sandy with very little litter.

**4. A. n. Phragmites australis - Parthenocissus quinquefolia community**

Some areas in the Phragmites australis community are invaded by various herbs, vines and shrubs. When walking through such areas, which look like a monoculture of Phragmites, one finds patches devoid of Phragmites (approximate diameter 2-3 m). Many of these patches are occupied by Phytolacca americana (Figure 65). The other herbaceous plants observed include: Apocynum cannabinum, Solidago rugosa, Cirsium arvense, Oenothera biennis, Asclepias syriaca, Saponaria officinalis, Linaria vulgaris, Epilobium colaratum, Verbena hastata, Artemisia vulgaris, Festuca rubra and Onoclea sensibilis.

In some of these openings shrubby plants such as Rubus allegheniensis, Sambucus canadensis. Baccharis halimifolia and, rarely, Rhus copallina are also found, in addition to herbaceous plants.

Parthenocissus quinquefolia is the most frequent vine found in this type of community. Other species of vines such as Polygonum scandens, Lonicera japonica, Celastrus orbiculatus, Solanum dulcamara, Toxicodendron radicans and Ampelopsis brevipedunculata are also not uncommon.

The substrate of this community is sandy and moist.

### 4. A. o. Phragmites australis community

This is the most common community within the North Forty area of Floyd Bennett Field. It consists of a uniform monoculture of

Phragmites (Figure 66). These dense stands of Phragmites are found mostly in moist areas.

Substratum in these areas is sandy. Depressions are soggy. This is especially so after rain. It could be due to either a hard pan underneath or a shallow water table.

**4. A. p. Artemisia vulgaris-Solidago rugosa community**

This is a herbaceous community found at the edges of woodlands, shrublands, and roadsides (Figure 67). Artemisia vulgaris is the most abundant plant species found in this community. Other herbs include, Solidago rugosa, Bromus tectorum, Asclepias syriaca, Saponaria officinalis, Hypericum perforatum, and Eupatorium hyssopifolium. In some areas vines such as Celastrus orbiculatus are also found within this community. The substratum of this community is dry and variable.

**4. B. Classification of vegetation in North Forty area of Floyd Bennett Field**

Classification methods are agglomerative or divisive (Williams and Dale, 1965; Kershaw, 1973). Agglomerative methods initially consider each unit as being a separate group and proceed by repeatedly combining the two closest groups until a single group is formed. Divisive methods start with all the units as one group and proceed by repeatedly dividing groups into two until all the units are separate. Due to the difficulties in computation of divisive methods, agglomerative methods became popular (Digby and Kempton, 1988).

Divisive methods can be monothetic or polythetic depending on the number of species used as division parameters. Since each division depends on the presence or absence of a single species, classifications obtained by monothetic methods are not considered very robust (Digby and Kempton, 1988).

One of the serious flaws of divisive methods is that an inappropriate division made at an early stage can lead to erroneous results (Willams and Dale, 1965; Sneath and Sokal, 1973). Of the divisive polythetic methods (Noy-Meir, 1973a; Hill et al, 1975) , Two-Way Indicator Species Analysis (TWINSPAN), of Hill (1979) is the most popular among phytosociologists (Gauch, 1980; Mucina and Van der Maarel, 1989). However, TWINSPAN is reported to dichotomize at times at an inappropriate point on the axis (Belbin and McDonald, 1993).

TWINSPAN is also affected by a predominant primary gradient within the data (Van Groenewoud, 1992; Belbin and McDonald, 1993).

In classifying communities in the North Forty, two agglomerative clustering algorithms were used; they were Minimum Variance clustering (Ward, 1963, Milligan, 1985) and Complete Linkage clustering (Pielou, 1984).

### 4. B. a Classifications using Minimum Variance Clustering

All data used in this study were angular-transformed (Sokal and Rohlf, 1995) percentage data. Although not widely used (Van der Maarel,1979), angular transformation was also used in several ecological studies (Bannister,1966; Smart et al, 1976). Data were not standardized as in phytosociology non-standardization seems effective (Ter Braak, 1985; Noy-Meir, 1973b, Noy-Meir et al, 1975). Kovar and Leps (1986) point out that standardization of data used in minimum variance clustering is extremely undesirable because importance of species with low frequencies is highly exaggerated.

All classifications based on minimum variance recognized four groups of clusters. Although the fine structure of each dendrogram was different these four higher groups were found in all of them. These groups are identified as, a) wet grassland (Phragmites) group, b) shrub group, c) woodlands and woodland associate group and d) dry grassland (Andropogon) group.

Classifications using Euclidean distance matrix identified the monocultures of Phragmites as a separate group whereas in the other classifications (Bray-Curtis dissimilarity, Chord distance, Geodesic distance, and Similarity ratio), the Phragmites group included Phragmites stands with Parthenocissus quinquefolia and few other species. Monocultures of Phragmites deserve to be in a separate group, since there is still another group with Phragmites mixed with other species. Euclidean distance is better than other methods in recognizing the monoculture as a separate group at a higher level.

Most of the clusters recognized by these classifications are similar. However, there are some clusters that may not represent real communities. For example, there are two Phragmites clusters in the Euclidean distance clustering. One of these is the monoculture and the other is in the Phragmites-shrub group. The Phragmites cluster in the shrub group should be combined with the adjoining cluster (Phragmites-Parthenocissus) as they both represent Phragmites sites with some Parthenocissus. Bray-Curtis dissimilarity recognizes a Phragmites-Myrica-Parthenocissus cluster within the woodlands and woodland associate group. That cluster does not represent any community observed in the field. The other "pseudo clusters" recognized by various clustering techniques include, Rubus-Betula cluster in geodesic distance clustering, Morus-Celastrus-Betula in Similarity Ratio clustering, and Celastrus-Myrica-Toxicodendron cluster in Chord and Geodesic distance clustering procedures. This shows the discrepancies and irregularities in the fine structure of dendrograms based on different distance matrices.

Minimum variance clustering may well join clusters with a small number of observations and be strongly biased towards producing clusters of even size (Milligan, 1980). This can be a problem at the lower levels of the dendrogram. But in the present study the branching at higher levels does not seem to be affected. The four groups recognized by the dendrogram that was constructed using Euclidean distance were selected because they appear to agree with the actual vegetation types that were observed within the study area. Recognition of Phragmites monocultures as a separate group was the main reason why the dendrogram produced by Euclidean distance clustering was selected. Classification using Complete Linkage clustering was used to explore the fine structure of the other three groups.

### 4. B. b. Classifications using Complete Linkage Clustering

Complete Linkage clustering (CLC) is useful when a relatively intense grouping strategy is needed (Lance and Williams, 1967). This is because CLC forms clear groups at higher levels of the dendrogram. CLC was successfully applied in community classification by many workers (Peinado et al, 1995; Mucina, 1989; Pysek and Srutek, 1989; Escudero and Pajaron, 1994; Nimis, 1989).

Classifications based on Chord distance, Geodesic distance and Similarity ratio recognized the same communities, while those based on Euclidean distance and Bray-Curtis dissimilarity were different from each other as well as from the other three. This may be because Chord distance, Similarity ratio and Geodesic distance measures compare species abundances relative to the abundance sum of squares for the sampling units. Therefore, two sites with approximately the same species abundances will be close in distance using Chord distance, Similarity ratio and Geodesic distance (Ludwig and Reynolds, 1988).

Although many of the communities are common to all five types of classifications, Chord, Geodesic and Similarity ratio clustering do not include some of the more noticeable and major communities. Their most notable example is the failure to include Betula woodland community as a separate cluster. However, these three clustering algorithms do recognize Onoclea-Rubus-Epilobium community on a par with the other communities. Euclidean distance and Bray-Curtis dissimilarity clustering seem to include this community within the Rhus-Rubus-Solidago cluster. Bray-Curtis dissimilarity clustering also has major, similar shortcomings. It does not recognize the Rhus-Myrica community and Myrica-Parthenocissus-Toxicodendron community.

One of the serious shortcomings of Bray-Curtis dissimilarity (Bray and Curtis, 1957) is extreme sensitivity to large outlying values in the data set (Digby and Kempton, 1987). On account of that, and on account of its not being a metric measure, Digby and Kempton (1987) do not recommend the use of Bray-Curtis dissimilarity in general ecology. They opt for Euclidean distance. However, Beals (1984) maintains that Bray-Curtis dissimilarity performs satisfactorily over a diverse set of ecological data sets.

Failure of Bray-Curtis dissimilarity in the present study can be attributed to the presence of very high cover values of dominant species. This is inevitable due to the presence of extensive stands of Phragmites, Populus, Prunus, Celastrus, Myrica, Rubus etc. in many different areas of North Forty.

Ludwig and Reynolds (1988) found that Bray-Curtis dissimilarity produces similar results as Chord distance and Geodesic distance. They also noted that results obtained from Bray-Curtis dissimilarity are very different from those of Euclidean distance.

Clusters recognized using Euclidean distance are meaningful because they could be identified as distinct communities in the field. The only apparent drawback of that clustering method is the non-recognition of

Onoclea-Rubus-Epilobium community as a major community. That community is recognized at a lower level of the dendrogram. This is not a serious problem as the Onoclea-Rubus-Epilobium community appears to be an edaphic variant of the Rhus-Rubus-Solidago community. Therefore, it may be appropriate to treat the Onoclea community as a sub-community of the Rhus-Rubus-Solidago community.

In summary, after comparing the two clustering methods I found that complete linkage gives results which correspond most closely with the situation observed in the field. This is also supported by observations by Pysek and Srutek, (1989) and Mucina, (1989).

**4. C. Ordination of vegetation in North Forty area of Floyd Bennett Field**

Ordination is used for arranging vegetation samples in relation to a multidimensional "species space". It could help elucidate the relationships and possible trends within the data. This is aided by a reduction of dimensions. According to Gauch et al (1981) there are two roles of the dimension reduction: 1) data reduction to proportions manageable for the study of plant communities and for communication of results and
2) hypothesis-generation for environmental interpretation of the composition of plant communities.

Relationships with environmental variables are investigated using indirect and direct ordination techniques (Gauch, 1982). The indirect and direct ordination techniques used in the present study are discussed in the following sections.

### 4. C. a. Principal Component Analysis

Since the introduction by Goodall (1954), Principal Component Analysis (PCA) has been perhaps the most widely used indirect ordination technique in ecology (Ludwig and Reynolds, 1988). This is mainly due to it's mathematical elegance and availability in popular computer packages. In the present study PCA was done with angular-transformed (Sokal and Rohlf, 1995) percentage-data using SAS (SAS, 1989).

In the present study PCA was applied to a covariance matrix, i.e., scores are expressed as deviations from the mean of the variable (species). This centering by species is widely used in ecological ordinations (Orloci, 1966; Yarranton, 1967). Feoli (1977) showed that when the aim is an ordination of plant communities, centered PCA is more appropriate than non-centered PCA. Centering leads to a more efficient concentration of information about between-site differences on the first few axes of the ordination (Noy-Meir, 1973b). This is very useful for graphic display and interpretation.

PCA is sensitive to outliers (James and McCulloch, 1990). In the present study the unusual, triangular shape of the scatter diagram is due to the total dominance of Phragmites australis, Andropogon scoparius, and Celastrus orbiculatus in some sites. Extreme cover values of these three species ensure that those sites will be placed as far as possible from each other, making the scatter of points look like a triangle. Although this makes the diagram look unusual, it meaningfully depicts the position of different communities in relation to each other.

When the four cluster groups identified by Euclidean Distance and Complete Linkage were labeled, their respective positions on the ordination diagram became conspicuous. Members of each cluster group were connected to the center of the group (centroid) by a line so that the size, spread and position of each group was apparent in the diagram. Phragmites group and dry grassland group separated very clearly from the woodland group and the shrub group (Figure 15). There were slight overlappings of shrub groups and woodland groups in the two- dimensional ordination diagram. Those overlappings are largely due to the presence of Myrica pensylvanica in sites belonging to both groups.

PCA ordination diagram of woodland sites showed some overlapping due to the presence of Myrica pensylvanica (Figure 17). Myrica-Prunus community overlaps with the Prunus community, the Myrica-Prunus community and the Betula community. Similarly, in the ordination diagram of the shrub group, communities overlap due to the ubiquitous presence of Phragmites australis (Figure 16). Significance of these overlappings will be discussed later in this chapter.

One of the limitations of PCA is that it only considers linear data (James and McCulloch, 1990). However, species responses to environmental gradients are reported to follow Gaussian (normal) response curves (Gauch and Whittaker, 1972). These curves may even be positively skewed, rather than bell-shaped or of another complex shape (Austin, 1980, 1987). The responses of major species tend to follow a uniform distribution along the environmental gradient while the responses of minor species seem to be randomly distributed (Austin, 1987).

### 4.C. b. Correspondence Analysis (CA)

CA enables one to see both sites and species on the same ordination diagram. Except for the two grassland clusters, all clusters tend to form an aggregate around the origin of the axes of the CA ordination diagram (Figure 20). Even when woodland group and shrub group were analyzed separately the resolution was very poor (Figure 21, 22). Only a few clusters separated from the aggregated mass of clusters at the origin. The two dry grassland clusters, Betula cluster, Populus cluster, Ailanthus cluster, and Prunus cluster were the only clusters that separated from the center. Those clusters that aggregated together represented shrubby communities within the area. This is due to the presence of Myrica pensylvanica and Phragmites australis in them. However, the three sites that represented Onoclea sub-community were clearly separated from the other sites (Figure 21).

CA is very susceptible to species-poor sites that contain rare species (Ter Braak, 1987). Those aberrant sites are placed at extreme ends of first ordination axes relegating the major vegetation trends in the data to later axes (Gauch, 1982). This may explain the separation of sites that contain Onoclea (a rare species) from the rest in this study.

James and McCulloch (1990) state that Correspondence Analysis is not the best method of ordination if the percentages or frequencies are used. They attribute this to the fact that CA uses chi-square which assumes that the data are counts rather than proportions or percentages.

Abundance measures used in the present study are percentage cover values. This may be another reason for poor performance of CA in the analysis. CA does not seem to be effective in resolving the shrub communities. Principal Component Analysis was better than CA in that respect. CA recognized the woodland communities, dry-grassland communities, and Onoclea sub-community. All other shrub communities were combined into one composite community. Whereas PCA recognized all the communities even though there were some overlappings.

### 4.C. c Detrended Correspondence Analysis (DCA)

Gauch et al (1981) report that better results than correspondence analysis can be obtained by DCA. It is also a useful ordination method for non-linear data (Pielou, 1984). DCA is devised to overcome the arch-effect and scale contraction effect of Correspondence Analysis (Hill, 1980). DCA ordination diagram for the present study did remove the aggregation of clusters at the center, but still the resolution was poor (Figure 24). It was advantageous to use only the cluster centroids (center of the cluster) to depict the position of each cluster in the ordination diagram. This helped to see the relative position of each cluster without much clutter since there was a high degree of overlapping. Using the distribution of cluster centroids within the DCA ordination diagram (Figure 25) it was possible to detect several trends. The inferred trends are:

a) (Dry grassland)⇨(Rhus-Myrica)-⇨(Myrica-Parthenocissus)⇨(Prunus-Myrica)⇨(Prunus)

b) (Wet grassland [Phragmites]) ⇨(Phragmites-Celastrus/Baccharis - Phragmites)⇨(Rubus-Celastrus)⇨(Myrica-Parthenocissus)⇨(Prunus-Myrica)⇨(Prunus)

c) (Ailanthus-Morus)⇨(Prunus)

d) (Betula)⇨(Prunus)

Rhus-Rubus-Solidago cluster, which shows signs of past fire, is placed in between the wet grassland sites and Phragmites-Celastrus/Baccharis Phragmites-Rubus-Celastrus sites.

Although DCA is a technique designed to remove arch effect (Chang and Gauch, 1986; Charles, 1985), Kenkel and Orloci (1986) claim that DCA sometimes fails and even introduces further distortion. Wartenberg et al (1987) suggest that detrending does not contribute to the analysis and the arch is not an anomaly but an important property of data. Allen (1987) indicated that DCA may cause some gradients to disappear and some to appear. He suggests that ordination curvature is a tool for investigating different biological and ecological principles.

### 4.C. d Multidimensional Scaling (MDS)

Individual species-abundance patterns over environmental gradients are sometimes nonlinear, e.g., bell-shaped (Gauch and Whittaker, 1972), or skewed (Austin, 1980, 1987). These nonlinear abundances can cause distribution of sites in "species space" to be "arched" (or even spiraled). Nonmetric multidimensional scaling is a useful ordination technique, particularly when there is a non-linearity in the data (Ludwig and Reynolds, 1988).

One of the drawbacks of MDS is that the interpretations must be subjective and qualitative (James and McCulloch, 1990). This is because the axes are not functions of original variables but distances. However, the results obtained from MDS are often similar to that of PCA. Both metric and nonmetric multidimensional scaling ordinations were done in this study. Principal coordinate analysis is the metric multidimensional scaling used.

### 4.C. e Principal Coordinate Analysis (PCO)

Results of Principal Coordinate Analysis are similar to that of PCA if the Euclidean distance is used as the distance (Pielou, 1984). Although PCO is more faithful to metric data (Marcus, 1990) even Bray-Curtis dissimilarity did produce, more or less, the same scatter diagram as those diagrams produced using metric data matrices. Euclidean distance, Bray-Curtis dissimilarity, Similarity ratio, Chord distance and Geodesic distance matrices produce more or less similar ordination diagrams. This suggests that there is some structure in the data.

In all ordination diagrams there was a similar pattern (Figures 29-33). It was possible to recognize the four major cluster groups. Within each group the communities were placed according to their within and between group affinities. For instance, in the shrub group the communities were arranged in four sub-groups from left to right along the Principal Coordinate Axis 1 (in Figures 29-33).

These groups are:

a) Phragmites-Parthenocissus community (cluster 8).

b) Celastrus-Phragmites community and Baccharis-Phragmites community (Clusters 10 and 11)

c) Rhus-Myrica community, Rubus-Celastrus community, and Rhus-Rubus-Solidago community (Clusters 9,13 and 12)

d) Myrica-Prunus community and Myrica-Parthenocissus community (Clusters 2 and 3).

It is interesting to note that these sub-groups (a to d) fit nicely into a successional sequence from Phragmites dominated community to a Myrica community with Prunus seedlings.

Woodland group also separates into two sub-groups depending on the dominance of Prunus serotina.

a) Prunus community (Cluster 1)

b) Populus community, Ailanthus community, Betula community and Artemisia community (Clusters 4,5,7 and 6).

Artemisia community, which usually occurs at roadsides and borders of woodlands, clusters with the woodland group although it is not a woodland community. This may due to the presence of Celastrus orbiculatus and absence of Phragmites, Myrica, or Andropogon in those sites.

## 4.C. f. Nonmetric Multidimensional Scaling (NMDS)

NMDS is a useful ordination method for reducing the dimensions without *a priori* transformations (Fasham, 1977). It often produces results similar to Principal Component Analysis (Oksanen, 1983; Wartenberg et al, 1987; James and McCulloch, 1990). In NMDS only the rank order of inter-site distance is used instead of actual distance (Berenson et al, 1983). This is done in order to estimate nonlinear, monotonic relationships (James and McCulloch, 1990). In computing NMDS, Alternating Least Squares Scaling Algorithm (ALSCAL) was used (Tukane, et al, 1977).

NMDS ordination of present data also showed the distribution of four main cluster groups within the ordination diagram (Figure 35). However, Artemisia community separated from the main woodland group unlike in Principal Coordinate Analysis (Figure 36). Also, the position of individual communities within the ordination diagram helped to formulate several possible successional trends that may be found within the study area. These trends, as indicated in Figure 46, are:

a) (Dry grassland)⇨(Rhus-Myrica)-⇨(Myrica-Parthenocissus)⇨(Prunus-Myrica)⇨(Prunus)
b) (Dry grassland)⇨(Ailanthus-Morus) ⇨(Prunus)
c) (Dry grassland)⇨(Betula) ⇨(Punus)
d) (Wet grassland [Phragmites]) ⇨(Phragmites-Celastrus/Baccharis Phragmites)⇨(Rubus-Celastrus)⇨(Myrica-Parhenocissus) ⇨ (Prunus-Myrica)⇨(Prunus)
e) (Populus) ⇨(Prunus)

**4.C. g. Canonical Correspondence Analysis (CCA)**

Canonical Correspondence Analysis is the most robust and advanced technique of direct gradient analysis in use at present (Palmer, 1993). Although CCA is a recently introduced ordination technique, (Ter Braak, 1986), it rapidly came into widespread use. Birks et al (1994) lists 379 references on CCA and related techniques that were published from 1986 to 1993, covering over 25 different disciplines.

In plotting the CCA ordination diagram linear combinations of site scores are used, as suggested by Palmer (1993). Hill (1991) reported that if a large number of explanatory variables are used, then the restriction becomes unimportant, and the canonical variates shall be linear combinations of the explanatory variables. The method then reduces to ordinary correspondence analysis. In this study, separate ordinations were done using: a) micro-nutrients, b) macro-nutrients, c) organic matter and moisture level, d) total nitrogen, pH, organic matter and moisture and, e) Ca and Mg.

Organic matter content, moisture level, and micro- and macro nutrient levels in dry grassland sites were the lowest (Figures 38-42). Of the two dry grassland sites Andropogon-Ammophila-Panicum site appears to be slightly more nutrient rich than the Andropogon scoparius site. Phragmites communities also showed poor micro-nutrient levels. It appears that dry areas of nutrient-poor, alkaline, sandy sites are occupied by Andropogon communities while the wet, sandy sites with moderate nutrient levels are favored by Phragmites community. Aluminum content is also higher in those sites (Figure 38). Phragmites communities seem to tolerate higher Iron levels.

The Phragmites sites, although usually found in moist or soggy sites, do not have as much moisture content as in the Populus community (Figure 39). This is because the underlying soil in Phragmites areas is mostly sandy. Air-drying may have removed most of the moisture in samples taken from those areas. The soggy and wet condition of the

Phragmites sites may be related to a high groundwater table or the presence of a hard pan to create a perched water table.

Phragmites-Parthenocissus community is drier than the Phragmites community. I interpret this as evidence that Parthenocissus invades the Phragmites monocultures when they become drier. The Celastrus-Phragmites community is higher in organic matter than the Phragmites community and Phragmites-Parthenocissus community. Decay of Celastrus orbiculatus vines may cause the relatively great amount of dead matter in these communities. Vines such as Celastrus are known to contribute to the mortality of their host plants (Lutz, 1943; Friedland and Smith, 1982; McNab and Meeker, 1987).

CCA ordination diagram with organic matter content and moisture level indicates that these variables are highly correlated. This is not surprising as the water holding capacity in soil increases with increasing organic matter content. Both these variables are correlated with the first axis (Figure 39). Populus community is placed at one extreme of this axis while dry grassland sites are at the other end.

Wilson and Kleb (1996) reported that soil under Populus tremuloides has more water and available N than that under adjacent prairie at the northern edge of the Great Plains. Present study also shows that macro-nutrient content, moisture level and organic matter are highest in Populus tremuloides community. This could be largely due to the origin of substratum of this community. In this case the substratum is formed by domestic waste and construction debris. Micro-nutrient content in the Populus community is not high. However, this community seems to have a high aluminum content as in dry grassland sites. The high in calcium content in this community may be due to the presence of construction debris. Magnesium content is also high in this community (Figure 42). Perala (1990) reports that the good P. tremuloides soils are usually well drained, loamy, and high in organic matter, calcium, magnesium, potassium and nitrogen.

Communities belonging to the shrub group occupy sites with moderate organic matter and macro-nutrient contents. I believe that these communities represent later stages of succession from dry or wet grassland sites. Continued presence of broad-leaved, herbaceous and shrubby species that produce readily decomposable biomass may have increased fertility in those communities. Several studies done on succession in Alaskan floodplains also show that the nutrient contents increase with time in primary succession (Walker et al, 1986; Berendse, 1994; Chapin et al, 1994).

Rhus-Myrica community and Betula community has similar soil properties to dry grasslands. These two communities are sandy and dry. This suggests that the substratum of dry grassland community could sustain Rhus-Myrica community or a Betula community. Betula community seems to have a high Al content. Betula species are known to have a high tolerance of Al (McCormick and Steiner, 1978).

Ailanthus community shows a higher organic matter content than the shrub communities (Figure 39). It also has a higher micro-nutrient content. It is similar to Populus community in having high calcium, and magnesium contents, but the organic matter content and moisture level are lower. Nitrogen, phosphorus and potassium levels in this community are low (Figure 40). Miller (1990) reports that Ailanthus is better adapted to acid soil and capable of growing on spoils with low to moderate phosphorus. The soil in this community also contains construction debris and domestic waste. However, it appears that in these sites there is more construction debris than domestic waste.

Prunus serotina community has moderate amounts of nutrients, moisture and organic matter. Relative position of different communities in the CCA ordination suggests that Prunus community is related to the Myrica shrubland communities. However, the Populus community, dry grassland communities, Ailanthus community, Betula community, and wet grassland communities do not seem to be closely related. Soils important to Prunus serotina are reported to be acidic, and relatively infertile, while very dry and very wet soils are not favored (Marquis, 1990).

Although there were 249 sites in the data set, only the soil samples collected from most representative sites from each community were analyzed. This may have caused the influence of environmental variables to appear somewhat less important (shorter arrows) in the ordination diagram.

The differences in disturbance regime and physico-chemical properties in different sites in the North Forty may reflect the soil origin. In grassland and shrubland sites, the substratum is mostly dredge fill. In many woodland sites it is either transported soil, domestic waste and/or construction debris.

**4. d. Successional trends**

There appears to be two main trends of succession observed within the North Forty area of Floyd Bennett Field. One appears to originate in the dry grassland and the other in the Phragmites stands. I have assumed that the different communities recognized within the study area may represent various "stages" of these successions. The origin of Populus tremuloides woodland may be outside these two trends. The following sections describe succession in different vegetation types found within North Forty area of FBF.

**4. d. a. Sucession in dry grassland.**

Dry grassland communities in FBF are formed by Andropogon scoparius, a perennial grass in open woods, pinelands and dry clearings. It is a native tussock grass widely distributed in United States (Fernald, 1950). This grass forms two different grassland associations in sandy coastal areas on Long Island (Conard, 1935). Of these, Andropogonetum scoparii association (Blizzard,1931) has fewer species and represent a seral stage of revegetation of abandoned agricultural land, whereas the Andropogonetum hempsteadi association is a species-rich, old, stabie natural community (Conard, 1935). A. hempsteadi once covered Hempstead Plains from Plainview on the east to Floral Park on the west, and from Hempstead on the south to Jericho Pike north of Hicksville (Conard, 1935). This association, in its original form, has been all but extirpated (Stalter, 1981).

Andropogon has an extensive root system that may reach 2-5 ft. in sand, growing into a tangled and interwoven mass of fibrous roots. It is able to bind the sand and hold it against the wind and forms a resistant and tough turf (Blizzard, 1931). Andropogon thrives on a dry

and predominantly sandy substrate, such as sandy dredge fill. It usually grows with lichens (Cladonia rangiferina) and mosses (Polytrichum piliferum), which aid formation of soil (Blizzard, 1931). In more open areas such as roadsides, grasses mostly found on or near beaches
(e.g., Ammophila breviligulata, Panicum virgatum), and some exotic grasses (e.g., Corynephorus canescens, Eragrostis curvula), are also found in the Andropogon stands.

**4. d. a. 1. Colonization of dry grassland by shrubs.**

Blizzard (1931) studied the grasslands of Andropogon scoparius on Long Island in the Hempstead Plains, Montauk, Shinnecock Hills and West Hill (High Hill). According to him Andropogon community (Andropogonetum scoparii association) existed on High Hill for about 150 years or more. Blizzard's (1931) model of succession in the Andropogon scoparius community consists of several phases. In the first phase, Myrica pensylvanica invades the grassland and transforms the ecological structure of the grassland association to that of a woody shrub association. Then in the next phase Myrica and other shrubs establish in the grassland, causing Andropogon to be shaded out.

Subsequently, in the Prunus phase, seedlings of Prunus serotina and P. pensylvanica appear in the center of clumps of Myrica. Prunus changes the physiognomy of vegetation. Secondary invaders such as Rubus spp. Smilax rotundifolia, Parthenocissus quinquifolia, Vitis labrusca and Toxicodendron radicans enter next. Increased shade by Prunus and climbers kills Myrica.

In Floyd Bennett Field the Andropogon scoparius community is also being invaded by Myrica pensylvanica (Rogers et al, 1984). Almost all dry grasslands in FBF are invaded by patches of those shrubs. It appears that the area covered by Andropogon community is decreasing rapidly.

Collins and Quinn (1982) report that Andropgon scoparius communities in the New Jersey Piedmont are invaded and displaced by Myrica pensylvanica. They attribute that to a complex interaction of shading, and allelochemical and competitive effects of Myrica. They hypothesize that soil enrichment beneath Myrica, partially due to the shrub's ability to fix nitrogen, may facilitate establishment of later successional species which may then also contribute to Andropogon displacement through competitive of allelopathic effects.

Studies of shrub thickets on Hog Island off the Atlantic coast of Virginia also reveal that Myrica seedlings will grow into thickets by vegetative reproduction, after initial colonization through bird dispersal (Young et al, 1995). The success of colonization is also attributed to allelopathic suppression of existing grasses. Allelopathic suppression of prairie grass species by Rhus copallina is reported in north-central Oklahoma by Petranka and McPherson (1979). They found that leachates of leaf litter, rhizomes, flowers and fruits of R. copallina significantly inhibit the growth of several prairie species including Andropogon scoparius and Panicum virgatum. R. copallina is another species that seems to invade the Andropogon community in Floyd Bennett Field. It is a co-dominant in the Rhus-Myrica community found adjoining the Andropogon community.

Myrica contributes to substrate stability and enriches the soil with nitrogen via symbiotic fixation with the actinomycete, Frankia (Morris et al, 1974; Schwintzer, 1983; Vitousek and Walker, 1989 ). Due to nitrogen enhancement of the soil and subsequent vegetative reproduction, Myrica can rapidly colonize grassland communities (Young et al, 1995).

In a study of old field succession on a fallow, Long Island farmland, Lanyon (1981) reported that 12 years after cultivation Myrica accounted for 53% of the relative density. Rogers et al (1984), having studied the growth of Myrica pensylvanica in Floyd Bennett Field, estimated that it would replace all grasslands in 35 years or less if left undisturbed. The present study also suggests that the grasslands are being invaded by Myrica pensylvanica and Rhus copallina. Results of our study show that the Rhus-Myrica community, adjoining the Andropogon community, has similar soil chemical characteristics. It may well be the next stage of succession.

**4. d. a. 2. Succession in Rhus-Myrica community.**

Establishment of tall shrubs in the grassland provides attractive perches that serve as recruitment foci for bird-dispersed seeds (McDonnell, 1986). Rhus and Myrica shrubs in the Andropogon community may attract birds and thereby cause more propagules to enter into the vicinity. McDonnell's (1986) studies at William L. Hutcheson Memorial Forest in New Jersey Piedmont show that most common seeds dispersed by birds are Toxicodendron 31.2%, Rosa multiflora (16.4%), and Phytolacca americana (16%). Bridges (1976b) states that about 35 different bird species use Parthenocissus quinquefolia as food.

Food is not the only reason why Myrica pensylvanica attracts birds. According to Lanyon (1981), Red-winged black bird (Agelaius phoeniceus), Indigo Bunting (Passerina cyanea) and Field Sparrow (Spizella pusilla) nest in Myrica. Common Yellowthroat (Geothlypis trichas) uses Myrica for song perches and for cover during their approach to and departure from nests (Lanyon, 1981). Presence of Myrica seems to attract birds and possibly enhances the arrival of bird-dispersed seeds into the community.

Increase of plant species diversity by bird dispersed seeds and the enrichment of the substrate by bird droppings may transform the Rhus-Myrica community gradually into a Myrica-Parthenocissus community. Floristic composition of the FBF Myrica-Parthenocissus community shows that the dominant species in this community are all bird-dispersed e.g., Myrica pensylvanica (26.7%), Parthenocissus quinquefolia (22.6%), Toxicodendron radicans (14.8%), and Rosa multiflora (12.6%).

Rosa multiflora is the shrub next in dominanance in Myrica-Parthenocissus community. It is also useful as food and cover for wildlife. About 38 species of birds including grouse (Bonasa umbellus), pheasants (Phasianus colchicus), and turkeys (Meleagris gallopavo), are known to use R. multiflora for food.

Animals such as chipmunks (Tamius striatus), deer (Odocoileus virginicus), opossums (Didelphis virginiana), coyotes (Canis latrans), bear (Ursus americanus), beavers (Castor canadensis), rabbits (e.g., Sylvilagus floridanus), snowshoe hare (Lepus americanus), skunks (Mephitis mephitis), voles (e.g., Microtus spp.) are also known to use R. multiflora as food (Jackson, 1987).

R. multiflora an exotic shrub which was imported into the United States from Japan and Korea before 1868 (Rehder, 1940). It was cultivated by horticulturists in New York during the period from 1875 through the turn of the century and later it was used as a utilitarian plant for hedgerows, windbreaks and snowbreaks (Jackson, 1987). In fact, the New York State Nursery made it available to the public in the 1950's for wildlife habitat improvement (for fencerows) and distributed over one million plants (Jackson, 1987). Due to its invasive habit, R. multiflora is now considered as a threat to the indigenous plant communities (Decker and Enck, 1987). However, it is a shade intolerant plant that seems to do poorly in woodland habitats. Robertson et al (1994) found that mature forests supported fewest and least dense colonies of R. multiflora .

Parthenocissus quinquefolia grows on both Myrica and Rosa shrubs and has a very high cover value (22.6%). Almost all Myrica plants in this community appear to serve as a host for this vine.

Bridges (1976b) assessed the ecological impact of Parthenocissus quinquefolia on other plant species in the West Pond Area of Jamaica Bay Wildlife Refuge. He listed Myrica, Elaeagnus, Rosa and Prunus among the plants most extensively affected by Parthenocissus. Bridges (1976b) did not find any evidence to indicate that Parthenocissus was directly and significantly harmful to the plants on which it was growing. There was no indication of leaf loss, leaf or stem lesions, discoloration, stunted growth, girdling, choking, death, dieback, or any other detectable abnormal condition that could be directly attributed to the presence of Parthenocissus. Bridges (1976b) concluded that Parthenocissus is a useful plant in the Jamaica Bay Wildlife Refuge because it serves as,
a) food source for more than 39 species of wildlife, b) cover for many
small birds and mammals, c) erosion control, and d) an important nectar source for honeybees and other flower-pollinating insects.

Another vine that is spreading rapidly within the shrub communities in FBF is Lonicera japonica. Dillenburg et al (1993) compare the effects of Parthenocissus quinquefolia and Lonicera japonica on availability of light, water, and nitrogen to Liquidambar styraciflua and find that Lonicera japonica is more aggressive than Parthenocissus quinquefolia. Lonicera exhibits shoot growth even in winter months and has an early burst of growth in spring, whereas Parthenocissus is deciduous. It sheds leaves mostly in October and has a shorter growing season. Moreover, Parthenocissus is susceptible to leaf damage by powdery mildew and leaf grazing by Japanese beetle (Papillia japonica) (Dillenburg et al, 1993).

Lonicera japonica was introduced from Asia in 1806 as an ornamental plant and now it is naturalized throughout much of the eastern United States (Jackson, 1987). It is used as food for cottontail rabbits, deer, northern bobwhite, ruffed grouse and wild turkeys and cover for cotton- tail rabbits, quail, songbirds, and wild turkeys (Jackson, 1987). However, because of its invasive behavior, Lonicera japonica is considered as a harmful species in New York State (Decker and Enck, 1987). Colonization dynamics of Lonicera japonica, show that mature forests (mixed oak associations) supported fewest and least dense colonies because of shading and limited colonization sites (Robertson et al, 1994).

### 4. d. a. 3. Succession in Myrica shrublands.

Continued presence of nitrogen-fixing Myrica and other shrubs increase the soil fertility (Morris et al, 1974; Schwintzer, 1983; Vitousek and Walker, 1989). Bard (1952) found that organic matter, moisture-holding capacity, and nitrate levels increase with succession. These conditions may be favorable to the growth of Prunus serotina which requires moderate nutrient levels for optimum growth (Marquis,1990). Even within the Myrica-Parthenocissus community Prunus seedlings are not uncommon. The Myrica-Parthenocissus community may gradually turn into a Myrica-Prunus community.

When Prunus seedlings grow into trees, Myrica will not be able to survive due to increased shade caused by canopy closure (Blizzard, 1931). Myrica-Prunus community may eventually turn into a Prunus woodland community.

Prunus serotina, the largest of native cherries, is found throughout the eastern United States (Marquis, 1990). It develops well on all soils except for the very wettest and very driest (Hough, 1965). The best soils for P.serotina are acidic, relatively infertile, and have high, coarse fragment content throughout their profile. It is a fast growing tree with an average annual diameter growth of 0.65 cm (0.25 in) between ages 10 and 40 years, 0.5 cm (0.20 in) between ages 40 and 70 years, and 0.4 cm (0.15 in) between ages 70 and 100 years (Marquis, 1990). The root system of P.serotina is shallow and even in well-drained soils most roots are restricted to the upper 60 cm of soil or less, with occasional sinker roots extending down to 90 to 120 cm (Marquis, 1990).

P.serotina is a common pioneer tree in coastal areas and also a component of many deciduous forest formations on Long Island (Conard, 1935). According to Blizzard (1931) the final stage in the succession initiated by Myrica in Andropogon grassland is mixed oak climax forest. However, in the Floyd Bennett Field the establishment of an oak woodland seems rather unrealistic at least in the near future. The shallow soil levels and the higher water table may not be favorable for the growth of these climax species which usually have a very deep root system even if a seed source were near (Greller, pers. comm).
Fruits of P.serotina are a valuable source of food for a variety of birds, squirrel, deer, turkey, mice and moles.

Woodland formations are also known to originate within the grassland without an intermediate shrub community. Some tree species (e.g., Juniperus, Robinia, Quercus) invade the grassland directly without any intermediate stages (Blizzard, 1931; Bard, 1952). It is possible that Betula populifolia may also be able to establish itself in the Andropogon community of Floyd Bennett Field. I have observed saplings of Betula within Andropogon communities. Soil chemical properties of the present Betula stands do not differ much from Andropogon stands.

**4. d. a. 4. A possible origin of Betula community.**

In Floyd Bennett Field, the Betula populifolia woodland is found adjoining the Andropogon community. It is possible that some Betula may invade the Andropogon communities as some wind-dispersed Betula seeds are blown into the grassland. Substrate of the Betula community is very dry and only slightly richer in nutrients than the dry grassland communities. Betula populifolia is a shade-intolerant tree and in the natural succession Betula species are reported to last only one generation and then are replaced by other species (Safford et al, 1990). It is possible that this community may become a Prunus serotina community

Figure 68 presents a successional model predicted for the dry grassland community assuming that there will be no disturbances.

**4. d. b. Sucession in Phragmites stands.**

Phragmites australis is found almost everywhere except in Antarctica and may have the widest distribution of any flowering plant (Tucker 1990). It is common in and near freshwater, brackish and alkaline wetlands, in the temperate parts of the world. In the United States Phragmites typically grows in marshes, swamps, fens, and prairie potholes and generally occupies the marsh-upland interface where it may form continuous belts (Roman et al, 1984).

Since it has invaded and formed extensive stands in some North American wetlands only recently there has been some debate as to whether Phragmites australis is indigenous to North America or not. The earliest collection of P.australis from Long Island was by William H. Leggett in 1864 (Lamont, 1997). Conard (1935) recognized Phragmitetum communis association as a distinct community in Long Island. There is plausible evidence that Phragmites was in the United States long before European contact. Niering and Warren (1977) found residues of Phragmites in cores of 3000-year-old peat from tidal marshes in Connecticut. However, the rapid spread of Phragmites at present is attributed to the introduction of a more aggressive biotype from Europe or elsewhere earlier in this century (Tucker, 1997).

Phragmites stands provide food and cover for wildlife (Tanacredi, 1983; Kiviat, 1987). Yet, it is an aggressive invader of wetland habitats replacing the native flora and fauna. Hence, Phragmites australis is considered as an exotic, invasive plant with detrimental impacts on wildlife habitats (Decker and Enck, 1987).

Monotypic stands of Phragmites are usually found in moist and soggy areas in Floyd Bennett Field. According to Lent and Litwin (1989), 20.8% (118.93 ha) of FBF is covered by Phragmites australis. Succession in these areas seems to be initiated by drying of the substrate. In areas where the substrate is drier, Parthenocissus quinquefolia and several other vines are found growing on Phragmites. This Phragmites-Parthenocissus community may be the next stage in the succession in Phragmites stands. In some sites in this community there are drier patches where the substrate is more or less bare. This could probably be due to the drying up of the substrate as a result of evapotranspiration by Phragmites (Kiviat, 1987). Some of these patches are occupied by species such as Phytolacca americana and Rubus allegheniensis. This is unusual because bird-dispersed seeds are less likely to arise in open areas (Gill and Marks, 1991). Perhaps other animals such as muskrats that live in Phragmites stands (Kiviat, 1987) are involved in the dispersal of these seeds.

## 4. d. b. 1. Colonization of Phragmites stands by woody plants.

The Phragmites-Parthenocissus community, which has dry, open areas, is vulnerable to colonization by invading shrubs and vines. A Baccharis-Phragmites community is located near the shore. Baccharis halimifolia is a shrub usually found in coastal marsh areas (Collins and Anderson, 1994); it has wind-dispersed seeds. Establishment of wind-borne seeds of Baccharis in open spaces in a Phragmites-Parthenocissus community may turn it into a Baccharis-Phragmites community.

Celastrus-Phragmites community, found next to the Myrica shrublands, may also be a former Phragmites-Parthenocissus community. Celastrus seeds are eaten by birds (McNab and Meeker, 1987). It is possible that birds, associated with the adjoining Myrica-Parthenocissus community, are responsible for the dispersion of Celastrus seeds into Phragmites-Parthenocissus community.

Celastrus orbiculatus is native to Japan, China and Korea (McNab and Meeker, 1987). It was introduced into the United States as an ornamental around 1860 (Patterson, 1975). Now, because of its copious seed production, shade-tolerant growth habits, and lack of natural enemies, it is quickly becoming naturalized in many areas of the northeast and south (McNab and Meeker, 1987). Some birds utilize C. scandens fruits for winter forage (Pitts, 1979). This probably applies to C. orbiculatus as well. C. orbiculatus is difficult to control by manual uprooting because any root fragment left after pulling can produce another plant (Dreyer, 1984). Robertson et al, (1994) found that mature forests supported fewest and least dense colonies. He believed limited colonization sites to be the reason that Celastrus and other invasive vines occurred more in mixed mesophytic forest than in mixed oak.

Celastrus-Rubus community may be an outcome of continued invasions of the Phragmites-Parthenocissus community by Celastrus and Rubus.

Baccharis-Phragmites community, Celastrus-Phragmites community and Celastrus-Rubus community are all drier and richer in nutrients than the Phragmites community (Table 27; Figures 29-33). These communities are frequented by birds because of their food and other resources. The composition of species within these communities will change with the addition of more plants dispersed by birds. It is possible that some of these communities may eventually turn into a Myrica-Parthenocissus community.

### 4. d. b. 2. Impact of fire on modified Phragmites stands.

Rhus-Rubus-Solidago community may appear after fire in Phragmites-shrub communities. Sign of past fire (e.g. partly burnt stumps, charcoal) can be seen in this community. Marks (1979) reports that R. typhina seed germination is stimulated by fire. This study confirms that finding as the Rhus-Rubus-Solidago community has the highest cover of R. typhina within the area sampled in FBF. Abundance of Solidago rugosa indicates the openness and recent disturbances of these sites.

Solidago is a useful plant for wildlife in the area. Several species of birds such as Red-winged black bird (Agelaius phoeniceus), Song Sparrow (Melospiza melodia), Field Sparrow (Spizella pusilla), Indigo Bunting (Passerina cyanea), and Common Yellowthroat (Geothlypis trichas) are reported to use Solidago for nest support (Lanyon, 1981). This community may gradually convert to a Myrica-Parthenocissus community. It would be interesting to study the changes in wildlife diversity in this community with time.

### 4. d. b. 3. Ailanthus woodlands in modified Phragmites stands.

Saplings of Ailanthus altissima were found in all the Phragmites sites mentioned above. A. altissima is native to China and was first introduced into Philadelphia from England in 1784 (Miller, 1990). It was widely planted in cities during the 1800's and now it is naturalized across the United States (Miller, 1990). Ailanthus can tolerate a wide range of soil textures, stoniness, and pH. Owing to its ability to withstand harsh conditions it was even tested for strip mine reclamation (Miller, 1990). It is drought hardy, flooding intolerant and reported to be better adapted to acidic spoil than to calcareous spoil. Although it produces wind-dispersed seeds, regeneration of natural stands is sparse and irregular except by sprouting because of its shade intolerance (Miller, 1990). Ailanthus is considered as a pioneer species in succession with known allelopathic effects (Heisey, 1990,1996). It is possible that some of the modified Phragmites communities may turn into Ailanthus woodland.

Figure 69 presents an original succesional model predicted for the wet grassland community of FBF. The model assumes that there will be no disturbances.

**4. D. c. Succession in woodland communities.**

Bard (1952) noted that as succession progresses the number of annuals and non-indigenous species decrease and the number of species disseminated epizoically (on animals) and endozoically (inside animals) increase. Lanyon (1981) found a rapid increase in species diversity of birds with the increase in age of fields. He reported that a more mature oak forest in the same region (60 years old) had a greater (bird) species diversity than that of any earlier stage of old field succession. It is possible that Ailanthus community may transform into a Prunus serotina community with time.

Populus tremuloides community of FBF is found in areas where the substrate is made of domestic waste and construction debris. It is unlikely that this community originated from a dry grassland or a Phragmites community. Populus tremuloides is probably the geographically most widely distributed tree species in North America. It is a long-lived, out-crossing tree with wind-dispersed pollen and seed and possesses a high level of genetic diversity (Jelinski and Cheliak, 1992). P. tremuloides grows on a great variety of soils ranging from shallow rocky soils and loamy sands to heavy clays. In New England it is one of several species that appear immediately after landslides. Growth on sandy soils is often poor because of low moisture and nutrient levels. It is regarded as a soil improver after forest fires, particularly with regards to its role in redistributing nitrogen to the surface layers by deposition of leaf layer (Stoeckeler, 1961). Populus tremuloides groves in the parkland region of the Canadian prairies are reported to provide microclimatic refuges for many wildlife species (Archibold et al, 1996). The root system of young (age 1-14) P. tremuloides is very shallow, often not exceeding 35 cm in depth below root crown, while the lateral roots often stay within 2-4 cm of the surface. (Marks, 1975). These data suggest that rooting habits of this fast growing, successional species is geared toward temporary occupying a site. Energy is preferentially invested in aboveground structure and roots are concentrated in the uppermost humus rich horizon of soil, offering poor long- term physical support (Marks, 1975). Maximum age of P.tremuloides is about 70-100 years. Success of Populus in many different soils may be attributed to its ability to form ecto-mycorrhizal associations (Vozzo, 1974). P. tremuloides is reported to grow vigorously even on coal mining wastes in Pennsylvania (Schramm,1966).

## 4.E. Conclusions

Vegetation in North Forty area of FBF is not uniform. The major vegetation types are: Phragmites stands, dry grasslands, shrub thickets, and woodlands. Phragmites stands and shrub thickets cover most of the area. Line interception method is useful in sampling a large area of Phragmites stands and shrub thickets in a relatively short time. The sampling unit size (15 m) proved to be adequate in recognizing the different communities in seemingly uniform areas. All data used in the study were percentage cover. Angular transformation facilitated the use of percentage data in classification and ordination, without distortions.

In spite of the small size of study area, the influence of dominance species and the occurrence of overlapping species, certain of the agglomerative classifications and ordination methods used in this study yielded meaningful clusters corresponding to recognizable plant communities in the field. However, not all methods yielded the accurate representation of the plant communities present within the study area.

Minimum Variance clustering helped to recognize the broader vegetational groups such as Phragmites stands and shrublands. But it did not provide realistic clusters at finer levels. Clusters recognized in Complete Linkage Clustering represented realistic species groupings that were close to the observations made in the field. Of the five different distance measures used (Bray-Curtis, Chord, Euclidean, Geodesic, Similarity Ratio), Euclidean distance was found to be most useful.

Of the indirect ordination methods used, multidimensional scaling techniques were most suitable. Both metric- (Principal Coordinate Analysis) and nonmetric multidimensional scaling provided interpretable ordinations with a better resolution than Correspondence Analysis. Correspondence Analysis (CA), which operate directly on the species data, failed to provide the resolution needed to interpret the structure in the data gathered in this study. Detrended correspondence analysis (DCA) removed the aggregation of clusters at the origin observed in the CA ordination diagram. However, DCA provided poor resolution and introduced a slight distortion.

This shows that the use of appropriate methods is vital in phytosociology. Methods that produce good results in one set of field conditions may not work in a different situation. In this study it was possible to compare the communities recognized by different methods with the actual field situation. If the analysis is limited by the use of "standard" computer software or algorithms, it may not be possible to depict the real situation in the field. In some programs such as TWINSPAN (Hill, 1979) clustering is based only on Correspondence Analysis (CA) or Detrended Correspondence Analysis (DCA). TWINSPAN does not allow one to use any other method (Duprêne and Legendre, 1997). In situations where CA and DCA are not appropriate, TWINSPAN will not provide accurate results.

In the graphical representations of ordinations, the clusters were shown by connecting each point of a cluster to the centroid of the cluster by a line (instead of encircling the points in each cluster). This was helpful because it facilitates: a) the detection of outliers with their affinity to other clusters, b) comparison of the heterogeneity or evenness of different clusters, and c) if there is a high degree of overlap, the cluster centroid can be used instead of using all the members of cluster. The use of cluster centroids in this study was helpful because, a) there were many data points, b) overlappings would have masked the trends, c) graphs were clearer and, d) interpretation was made easier.

As hypothesized, the structure, composition, and physiognomy of vegetation types found in different areas of FBF are correlated with the soil on which they are growing. Canonical Correspondence Analysis (CCA) provided a useful, direct ordination with soil chemical data. CCA showed that Populus and Ailanthus woodlands are found in the sites with highest organic matter content, Nitrogen, Phosphorus, Potassium, Calcium and Magnesium levels. Field observations reveal that Ailanthus and Populus communities are both located in areas filled with domestic waste and construction debris. Ailanthus sites appear to have less domestic waste and more construction debris than Populus sites.

Of the dredge fill sites, the nutrient-poor, dry areas with higher Aluminum content, high pH, and very low organic matter contents are occupied by Andropogon grasslands. Betula stands and Rhus-Myrica community occupy almost similar sites with slightly high moisture and nutrient levels. Soggy, moist areas of the dredge fill, probably with a higher water table underneath, are occupied by monotypic stands of Phragmites australis. These sites have moderate nutrient levels, low pH and higher Iron contents.

Shrub thickets and Prunus woodlands have moderate nutrient and organic matter contents. Moisture contents in these stands are intermediate to Phragmites sites and Andropogon sites.

There are 16 major communities within the North Forty area of FBF (Table 29). They represent various stages of succession either from dry grassland or from Phragmites stands to woodlands. Succession in dry grassland sites is initiated by colonization of these sites by Myrica pensylvanica and Rhus copallina. In Phragmites stands, Parthenocissus quinquefolia, Phytolacca americana, Celastrus orbiculatus, and Rubus spp. are the next species in succession following Phragmites, the pioneer.

Most of the plant species recorded within FBF are weedy, alien plants, with wide ranges of tolerance. Of these Celastrus orbiculatus, Lonicera japonica and Rosa multiflora are three invasive exotic plants in almost all the communities except dry grassland. Celastrus orbiculatus seems to damage the woodland species such as Prunus serotina by overgrowing them. Lonicera and Rosa seem to be less detrimental to the communities at present.

It is evident that there is a difference in rate of succession due to differences in substrate. Succession in sterile, dry sandy dredge fill is slower, while areas filled with domestic waste and construction debris it is much faster.

# Chapter 5. RECOMMENDATIONS

In discussing management policies for Gateway National Recreation Area, of which Floyd Bennett Field (FBF) is a unit, Tanacredi (1983) remarked "..coupling Gateway's management flexibility with evolutionary processes can only be accomplished by bringing home to visitors the inter-relatedness of all natural events. .... achieved by bridging the gap between scientific research in parks and traditional interpretive skills. I believe North Forty area of FBF is a unique place to do scientific research, which enhances its value as a urban national recreation area.

Ecologically, North Forty is unique in several different ways. First, it is a man-made upland created by filling a salt marsh with dredge fill. Second, it is an abandoned (non-managed) land located within the limits of one of the most populated cities in the world. It is different from other abandoned, barren or fallow areas on Long Island in never having been an agricultural area. Much of its substrate is almost sterile, sandy dredge fill. It is isolated, yet easily accessible; protected, because it is administered by National Park Service; and, being a former air field, its history is well documented.

One scientific use of North Forty would be to establish a permanent study site within it to investigate the dynamics of vegetation and animal populations in an urban setting. Within this site surveying, inventorying, and monitoring of the flora and fauna could be done regularly. Soil fertility, litter decomposition and soil microflora are other subjects of potential interest. This site can also serve as a valuable outdoor facility for teaching terrestrial ecology. Students can be taught how succession occurs with actual examples. This may be done as a collaborative, long term research project between a local university and the National Park Service.

Improving the amenity value is another important aspect that deserves attention. Improvement can begin with the tarring of internal roads (paths). Tarring will make the management easy. Public vehicles must not be allowed on these paths and more barriers should be posted at entry points. Tarring will also keep the dog-ticks (Dermacentor variabilis) away from the paths. Dog ticks are found on grassy paths more than in the vegetation. Tick infestations are particularly severe during early spring.

Nature trails could be created through selected habitat types such as, a) Populus woodland, b) Prunus woodland, c) Myrica thicket, d) Ailanthus-Morus woodland. These will help to show the variety of community types present within the area and facilitate monitoring of floristic changes. Trails may also be constructed to bunkers and other remnants of World War II, to show the historic significance of the site. All walks through nature trails should be guided by Park Service personnel. Drinking water fountains, benches and Interpretive signs can be placed along the walks.

Planting native or exotic trees in North Forty area may disturb the natural succession. In most of these areas planting native upland trees with deep tap roots may not be effective as they can be expected to die back once the root system comes in contact with the water table.

Removal of Celastrus orbiculatus vines in woodland sites may be necessary to enhance the growth of trees. Proliferation of this vine appears to be detrimental to the establishment of young saplings and also to mature trees. The role of this species and Lonicera japonica in the shrubland succession needs to be investigated.

Table 1. Phytosociological data for the entire area (249 sampling units) studied in Floyd Bennett Field. F=Frequency, R.F.=Relative Frequency, R.C.=Relative cover, IVI=Importance Value Index.

| SPECIES | | F | R.F. | R.C. | IVI | %IVI |
|---|---|---|---|---|---|---|
| 1 | *Phragmites australis* | 170 | 8.6 | 18.8 | 27.4 | 13.7 |
| 2 | *Celastrus orbiculatus* | 119 | 6.0 | 9.0 | 15.1 | 7.5 |
| 3 | *Parthenocissus quinquefolia* | 158 | 8.0 | 6.9 | 14.9 | 7.5 |
| 4 | *Prunus serotina* | 104 | 5.3 | 7.6 | 12.9 | 6.4 |
| 5 | *Myrica pensylvanica* | 116 | 5.9 | 6.7 | 12.6 | 6.3 |
| 6 | *Rubus allegheniensis* | 112 | 5.7 | 5.8 | 11.5 | 5.7 |
| 7 | *Rhus copallina* | 91 | 4.6 | 4.8 | 9.4 | 4.7 |
| 8 | *Toxicodendron radicans* | 79 | 4.0 | 4.3 | 8.3 | 4.1 |
| 9 | *Solidago rugosa* | 90 | 4.6 | 3.0 | 7.5 | 3.8 |
| 10 | *Andropogon scoparius* | 28 | 1.4 | 3.9 | 5.3 | 2.6 |
| 11 | *Rosa multiflora* | 57 | 2.9 | 2.0 | 4.8 | 2.4 |
| 12 | *Lonicera japonica* | 52 | 2.6 | 1.8 | 4.4 | 2.2 |
| 13 | *Sambucus canadensis* | 50 | 2.5 | 1.3 | 3.8 | 1.9 |
| 14 | *Baccharis halimifolia* | 36 | 1.8 | 1.7 | 3.5 | 1.8 |
| 15 | *Populus tremuloides* | 21 | 1.1 | 2.6 | 3.6 | 1.8 |
| 16 | *Solanum dulcamara* | 56 | 2.8 | 0.8 | 3.6 | 1.8 |
| 17 | *Rubus pensilvanicus* | 38 | 1.9 | 1.2 | 3.2 | 1.6 |
| 18 | *Ailanthus altissima* | 23 | 1.2 | 1.6 | 2.8 | 1.4 |
| 19 | *Morus alba* | 29 | 1.5 | 1.3 | 2.8 | 1.4 |
| 20 | *Phytolacca americana* | 31 | 1.6 | 1.0 | 2.6 | 1.3 |
| 21 | *Corynephorus canadensis* | 21 | 1.1 | 1.2 | 2.3 | 1.1 |
| 22 | *Ammophila breviligulata* | 17 | 0.9 | 1.2 | 2.0 | 1.0 |
| 23 | *Artemisia vulgaris* | 23 | 1.2 | 0.7 | 1.9 | 1.0 |
| 24 | *Solidago juncea* | 28 | 1.4 | 0.3 | 1.7 | 0.9 |
| 25 | *Viburnum dentatum* | 19 | 1.0 | 0.5 | 1.4 | 0.7 |
| 26 | *Ampelopsis brevipedunculata* | 13 | 0.7 | 0.6 | 1.3 | 0.6 |
| 27 | *Betula populifolia* | 11 | 0.6 | 0.6 | 1.1 | 0.6 |
| 28 | *Euthamia tenuifolia* | 16 | 0.8 | 0.3 | 1.1 | 0.6 |
| 29 | *Panicum virgatum* | 11 | 0.6 | 0.6 | 1.2 | 0.6 |
| 30 | *Polygonum scandens* | 19 | 1.0 | 0.3 | 1.3 | 0.6 |
| 31 | *Apocynum cannabinum* | 13 | 0.7 | 0.3 | 0.9 | 0.5 |
| 32 | *Euthamia graminifolia* | 12 | 0.6 | 0.4 | 1.0 | 0.5 |
| 33 | *Festuca rubra* | 9 | 0.5 | 0.4 | 0.9 | 0.5 |
| 34 | *Linaria vulgaris* | 15 | 0.8 | 0.3 | 1.1 | 0.5 |
| 35 | *Rubus laciniatus* | 16 | 0.8 | 0.2 | 1.0 | 0.5 |
| 36 | *Elaeagnus commutata* | 11 | 0.6 | 0.3 | 0.8 | 0.4 |

Table 1. Contd.

| | SPECIES | F | R.F. | R.C. | IVI | %IVI |
|---|---|---|---|---|---|---|
| 37 | *Eupatorium hyssopifolium* | 14 | 0.7 | 0.2 | 0.9 | 0.4 |
| 38 | *Oenothera biennis* | 13 | 0.7 | 0.1 | 0.7 | 0.4 |
| 39 | *Onoclea sensibilis* | 8 | 0.4 | 0.4 | 0.8 | 0.4 |
| 40 | *Rhus glabra* | 10 | 0.5 | 0.3 | 0.8 | 0.4 |
| 41 | *Rhus typhina* | 8 | 0.4 | 0.4 | 0.8 | 0.4 |
| 42 | *Saponaria officinalis* | 11 | 0.6 | 0.2 | 0.7 | 0.4 |
| 43 | *Asclepias syriaca* | 10 | 0.5 | 0.1 | 0.6 | 0.3 |
| 44 | *Epilobium coloratum* | 4 | 0.2 | 0.3 | 0.5 | 0.3 |
| 45 | *Eupatorium rugosum* | 10 | 0.5 | 0.1 | 0.6 | 0.3 |
| 46 | *Lechea maritima* | 5 | 0.3 | 0.3 | 0.5 | 0.3 |
| 47 | *Solidago canadensis* | 6 | 0.3 | 0.2 | 0.5 | 0.3 |
| 48 | *Eragrostis curvula* | 3 | 0.2 | 0.2 | 0.4 | 0.2 |
| 49 | *Bromus tectorum* | 4 | 0.2 | 0.2 | 0.4 | 0.2 |
| 50 | *Cirsium arvense* | 5 | 0.3 | 0.1 | 0.4 | 0.2 |
| 51 | *Conyza canadensis* | 4 | 0.2 | 0.1 | 0.3 | 0.2 |
| 52 | *Eupatorium leucolepis* | 7 | 0.4 | 0.0 | 0.4 | 0.2 |
| 53 | *Pyrus sieboldii* | 8 | 0.4 | 0.1 | 0.5 | 0.2 |
| 54 | *Populus deltoides* | 4 | 0.2 | 0.2 | 0.4 | 0.2 |
| 55 | *Salix discolor* | 5 | 0.3 | 0.2 | 0.4 | 0.2 |
| 56 | *Salix nigra* | 5 | 0.3 | 0.2 | 0.4 | 0.2 |
| 57 | *Spirea tomentosa* | 6 | 0.3 | 0.1 | 0.4 | 0.2 |
| 58 | *Acer rubrum* | 4 | 0.2 | 0.1 | 0.3 | 0.1 |
| 59 | *Achillea millefolium* | 3 | 0.2 | 0.0 | 0.2 | 0.1 |
| 60 | *Agropyron repens* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 61 | *Aster pilosus* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 62 | *Celtis occidentalis* | 2 | 0.1 | 0.1 | 0.2 | 0.1 |
| 63 | *Chrysopsis falcata* | 3 | 0.2 | 0.1 | 0.2 | 0.1 |
| 64 | *Cyperus bipartitus* | 3 | 0.2 | 0.1 | 0.2 | 0.1 |
| 65 | *Elaeagnus angustifolia* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 66 | *Elaeagnus umbellata* | 2 | 0.1 | 0.0 | 0.2 | 0.1 |
| 67 | *Eupatorium maculatum* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 68 | *Fragaria virginiana* | 2 | 0.1 | 0.1 | 0.2 | 0.1 |
| 69 | *Gleditsia triacanthos* | 2 | 0.1 | 0.1 | 0.2 | 0.1 |
| 70 | *Gnaphalium obtusifolium* | 4 | 0.2 | 0.0 | 0.2 | 0.1 |
| 71 | *Heterotheca subaxillaris* | 3 | 0.2 | 0.1 | 0.3 | 0.1 |
| 72 | *Hudsonia tomentosa* | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 73 | *Hypericum perforatum* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 74 | *Juniperus virginiana* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |

Table 1. Contd.

| | SPECIES | F | R.F. | R.C. | IVI | %IVI |
|---|---|---|---|---|---|---|
| 75 | *Lepidium virginicum* | 3 | 0.2 | 0.1 | 0.2 | 0.1 |
| 76 | *Pyrus* sp 2 | 4 | 0.2 | 0.0 | 0.2 | 0.1 |
| 77 | *Osmunda regalis* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 78 | *Oxalis corniculata* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 79 | *Panicum lanuginosum* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 80 | Poaceae sp1 | 1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 81 | Poaceae sp2 | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 82 | *Rhamnus frangula* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 83 | *Salix babylonica* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 84 | *Salix caprea* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 85 | *Salix* sp | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 86 | *Thelypteris simulata* | 2 | 0.1 | 0.1 | 0.2 | 0.1 |
| 87 | Unidentified sp3 | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 88 | *Verbascum thapsus* | 2 | 0.1 | 0.0 | 0.1 | 0.1 |
| 89 | *Verbena hastata* | 4 | 0.2 | 0.1 | 0.3 | 0.1 |
| 90 | *Allium vineale* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 91 | *Ambrosia artemisiifolia* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 92 | *Anaphalis margaritacea* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 93 | *Aronia arbutifolia* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 94 | *Barbarea vulgaris* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 95 | *Chenopodium album* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 96 | *Dianthus armeria* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 97 | *Equisetum arvensis* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 98 | *Galium aparine* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 99 | *Hibiscus palustris* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 100 | *Ilex opaca* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 101 | *Juncus canadensis* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 102 | *Juncus gerardii* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 103 | *Lactuca canadensis* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 104 | *Lathyrus latifolius* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 105 | *Lespedeza capitata* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 106 | *Pyrus baccata* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 107 | *Pyrus* sp.1 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 108 | *Osmunda cinnamomea .* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 109 | *Pastinaca sativa* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 110 | *Polygonum hydropiperoides* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 111 | *Prunus alleghenensis* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 112 | *Quercus rubra* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |

Table 1. Contd.

| | SPECIES | F | R.F. | R.C. | IVI | %IVI |
|---|---|---|---|---|---|---|
| 113 | *Rosa virginiana* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 114 | *Rubus flagellaris* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 115 | *Rumex crispus* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 116 | *Salix alba* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 117 | *Salix fragilis* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 118 | *Salix matsudana* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 119 | *Scirpus cyperinus* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 120 | *Setaria glauca* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 121 | *Thelypteris palustris* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 122 | Unidentified sp.1 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 123 | Unidentified sp.2 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 124 | Unidentified sp.4 | 1 | 0.1 | 0.0 | 0.1 | 0.0 |
| 125 | *Verbascum blattaria* | 1 | 0.1 | 0.0 | 0.1 | 0.0 |

Table 2. The percentage cover values of the species included in the four major cluster groups recognized using Euclidean Distance and Minimum Variance. The values in bold face are the higher cover values within each cluster group.

| | SPECIES | *Phragmites* Group (11 sites) | Dry Grassland (*Andropogon*) Group (20 sites) | *Rhus-Rubus-Phragmites* Group (121 sites) | Woodland and Woodland Associates Group (97 sites) |
|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | 0.06 | 0.11 |
| 2 | *Achilea millefolium* | . | . | 0.01 | 0.07 |
| 3 | *Agropyron repens* | . | 0.42 | 0.001 | . |
| 4 | *Eragrostis curvula* | . | 2.52 | . | . |
| 5 | *Ailanthus altissima* | . | . | 1.01 | 2.93 |
| 6 | *Allium vineale* | . | . | . | 0.01 |
| 7 | *Ambrosia artemisiifolia* | . | . | 0.04 | . |
| 8 | *Ammophila breviligulata* | . | **14.5** | 0.03 | . |
| 9 | *Ampelopsis brevipedunculata* | . | . | 1.22 | . |
| 10 | *Anaphalis margaritacea* | . | . | 0.02 | . |
| 11 | *Andropogon scoparius* | . | **44.9** | 0.47 | 0.06 |
| 12 | *Apocynum cannabinum* | . | . | 0.54 | 0.02 |
| 13 | *Aronia arbutifolia* | . | . | . | 0.03 |
| 14 | *Artemisia vulgaris* | . | . | 0.26 | 1.60 |
| 15 | *Asclepias syriaca* | . | 0.49 | 0.09 | 0.08 |
| 16 | *Aster pilosus* | . | . | 0.01 | 0.01 |
| 17 | *Baccharis halimifolia* | . | . | 3.20 | 0.36 |
| 18 | *Barbarea vulgaris* | . | . | 0.01 | . |
| 19 | *Betula populifolia* | . | . | 0.19 | 1.23 |
| 20 | *Bromus tectorum* | . | . | 0.20 | 0.25 |
| 21 | *Celastrus orbiculatus* | . | . | 8.04 | **13.2** |
| 22 | *Celtis occidentalis* | . | . | . | 0.33 |
| 23 | *Chenopodium album* | . | . | 0.01 | . |
| 24 | *Chrysopsis falcata* | . | 1.14 | . | . |
| 25 | *Cirsium arvense* | . | . | 0.30 | . |
| 26 | *Conyza canadensis* | . | 1.63 | . | . |
| 27 | *Corynephorus canescens* | . | **11.0** | 0.59 | 0.12 |
| 28 | *Cyperus bipartitus* | . | . | 0.13 | . |
| 29 | *Dianthus armeria* | . | . | 0.00 | . |
| 30 | *Elaeagnus angustifolia* | . | . | 0.01 | 0.05 |
| 31 | *Elaeagnus commutata* | . | . | 0.15 | 0.48 |
| 32 | *Elaeagnus umbellata* | . | . | . | 0.13 |
| 33 | *Epilobium coloratum* | . | . | 0.65 | . |
| 34 | *Equisetum arvensis* | . | . | . | 0.08 |
| 35 | *Eupatorium hyssopifolium* | . | 1.22 | 0.15 | 0.01 |
| 36 | *Eupatorium leucolepis* | . | . | 0.09 | . |
| 37 | *Eupatorium maculatum* | . | . | 0.01 | . |
| 38 | *Eupatorum rugosum* | . | . | 0.05 | 0.24 |
| 39 | *Euthamia graminifolia* | . | 4.98 | 0.01 | . |
| 40 | *Euthamia tenuifolia* | . | 0.11 | 0.57 | 0.01 |

Table 2. Contd.

| SPECIES | | *Phragmites* Group (11 sites) | Dry Grassland (*Andropogon*) Group (20 sites) | *Rhus-Rubus-Phragmites* Group (121 sites) | Woodland and Woodland Associates Group (97 sites) |
|---|---|---|---|---|---|
| 41 | *Festuca rubra* | . | . | 0.92 | . |
| 42 | *Fragaria virginiana* | . | . | 0.13 | . |
| 43 | *Galium aparine* | . | . | 0.01 | . |
| 44 | *Gleditsia triacanthos* | . | . | 0.18 | . |
| 45 | *Gnaphalium obtusifolium* | . | 0.53 | . | . |
| 46 | *Heterotheca subaxillaris* | . | 1.64 | . | . |
| 47 | *Hibiscus palustris* | . | . | 0.01 | . |
| 48 | *Hudsonia tomentosa* | . | 0.66 | . | . |
| 49 | *Hypericum perforatum* | . | . | 0.001 | 0.02 |
| 50 | *Ilex opaca* | . | . | . | 0.01 |
| 51 | *Juncus canadensis* | . | . | 0.04 | . |
| 52 | *Juncus gerardii* | . | . | 0.01 | . |
| 53 | *Juniperus virginiana* | . | . | . | 0.09 |
| 54 | *Lactuca canadensis* | . | . | 0.03 | . |
| 55 | *Lathyrus latifolius* | . | . | . | 0.01 |
| 56 | *Lechea maritima* | . | 3.47 | 0.01 | . |
| 57 | *Lepidium virginicum* | . | 0.78 | . | . |
| 58 | *Lespedeza capitata* | . | 0.51 | . | . |
| 59 | *Linaria vulgaris* | . | 0.12 | 0.55 | 0.06 |
| 60 | *Lonicera japonica* | . | . | 0.86 | 3.42 |
| 61 | *Morus alba* | . | . | 0.65 | 2.52 |
| 62 | *Myrica pensylvanica* | . | 0.06 | 5.73 | **10.0** |
| 63 | *Oenothera biennis* | . | . | 0.17 | . |
| 64 | *Onoclea sensibilis* | . | . | 0.79 | 0.01 |
| 65 | *Osmunda cinnamomea* | . | . | 0.05 | . |
| 66 | *Osmunda regalis* | . | . | 0.08 | . |
| 67 | *Oxalis corniculata* | . | . | 0.01 | . |
| 68 | *Panicum lanuginosum* | . | 0.13 | 0.03 | . |
| 69 | *Panicum virgatum* | . | 7.45 | 0.09 | . |
| 70 | *Parthenocissus quinquefolia* | . | 0.43 | 7.58 | 8.28 |
| 71 | *Pastinaca sativa* | . | . | . | 0.09 |
| 72 | *Phragmites australis* | **100** | . | **27.7** | 2.35 |
| 73 | *Phytolacca americana* | . | . | 1.93 | 0.11 |
| 74 | Poaceae sp1 | . | . | 0.11 | . |
| 75 | Poaceae sp2 | . | . | . | 0.05 |
| 76 | *Polygonum hydropiperoides* | . | . | 0.02 | . |
| 77 | *Polygonum scandens* | . | . | 0.63 | 0.03 |
| 78 | *Populus deltoides* | . | . | 0.19 | 0.23 |
| 79 | *Populus tremuloides* | . | . | 0.60 | 5.82 |
| 80 | *Prunus allegheniensis* | . | . | 0.01 | . |
| 81 | *Prunus serotina* | . | 0.07 | 1.43 | 17.7 |
| 82 | *Pyrus baccata* | . | . | 0.00 | . |
| 83 | *Pyrus sieboldii* | . | . | 0.11 | 0.09 |

Table 2. Contd.

| SPECIES | | *Phragmites* Group (11 sites) | Dry Grassland (*Andropogon*) Group (20 sites) | *Rhus-Rubus-Phragmites* Group (121 sites) | Woodland and Woodland Associates Group (97 sites) |
|---|---|---|---|---|---|
| 84 | *Pyrus* sp 1 | . | . | . | 0.001 |
| 85 | *Pyrus* sp 2 | . | . | 0.03 | 0.02 |
| 86 | *Quercus rubra* | . | . | . | 0.01 |
| 87 | *Rhamnus frangula* | . | . | . | 0.08 |
| 88 | *Rhus copallina* | . | 0.48 | **8.34** | 1.92 |
| 89 | *Rhus glabra* | . | . | 0.42 | 0.25 |
| 90 | *Rhus typhina* | . | . | 0.35 | 0.58 |
| 91 | *Rosa multiflora* | . | . | 0.89 | 3.90 |
| 92 | *Rosa virginiana* | . | . | . | 0.04 |
| 93 | *Rubus allegheniensis* | . | 0.76 | **9.54** | 2.87 |
| 94 | *Rubus flagellaris* | . | . | 0.01 | . |
| 95 | *Rubus laciniatus* | . | . | 0.31 | 0.02 |
| 96 | *Rubus pensilvanicus* | . | . | 0.21 | 2.91 |
| 97 | *Rumex crispus* | . | . | 0.01 | . |
| 98 | *Salix alba* | . | . | 0.04 | . |
| 99 | *Salix babylonica* | . | . | 0.06 | 0.04 |
| 100 | *Salix caprea* | . | . | 0.06 | . |
| 101 | *Salix discolor* | . | . | 0.28 | 0.07 |
| 102 | *Salix fragilis* | . | . | . | 0.02 |
| 103 | *Salix matsudana* | . | . | . | 0.01 |
| 104 | *Salix nigra* | . | . | 0.33 | 0.001 |
| 105 | *Salix* sp | . | . | . | 0.01 |
| 106 | *Sambucus canadensis* | . | . | 0.74 | 2.38 |
| 107 | *Saponaria officinalis* | . | . | 0.09 | 0.38 |
| 108 | *Scirpus cyperinus* | . | . | 0.01 | . |
| 109 | *Setaria glauca* | . | . | 0.02 | . |
| 110 | *Solanum dulcamara* | . | . | 1.41 | 0.31 |
| 111 | *Solidago canadensis* | . | . | 0.39 | 0.06 |
| 112 | *Solidago juncea* | . | . | 0.15 | 0.60 |
| 113 | *Solidago rugosa* | . | . | 3.66 | 3.09 |
| 114 | *Spirea tomentosa* | . | . | 0.18 | . |
| 115 | *Thelypteris simulata* | . | . | 0.09 | 0.05 |
| 116 | *Thelypteris palustris* | . | . | 0.04 | . |
| 117 | *Toxicodendron radicans* | . | . | 3.01 | 7.27 |
| 118 | Unidentified sp1 | . | . | . | 0.05 |
| 119 | Unidentified sp2 | . | . | . | 0.01 |
| 120 | Unidentified sp3 | . | . | . | 0.04 |
| 121 | Unidentified sp4 | . | . | . | 0.01 |
| 122 | *Verbascum blattaria* | . | . | 0.01 | . |
| 123 | *Verbascum thapsus* | . | . | 0.001 | 0.001 |
| 124 | *Verbena hastata* | . | . | 0.17 | . |
| 125 | *Viburnum dentatum* | . | . | 0.45 | 0.69 |

Table 3. The percentage cover values of the species included in the Phragmites Cluster Group and Rubus -Rhus- Phragmites Cluster Group using Euclidean Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | | *Phragmites* Group | *Rubus -Rhus- Phragmites* Group | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SPECIES | *Phragmites* Cluster | *Baccharis-Phragmites* Cluster | *Rhus-Rubus-Solidago* Cluster | *Rhus-Myrica* Cluster | *Phragmites-Rubus* Cluster | *Celastrus-Phragmites* Cluster | *Phragmites-* Cluster | *Phragmites-Parthenocissus* Cluster |
| 1 | *Acer rubrum* | . | 0.4 | 0.1 | . | . | . | . | . |
| 2 | *Achillea millefolium* | . | . | . | 0.1 | . | 0.02 | . | . |
| 3 | *Agropyron repens* | . | . | . | . | . | 0.01 | . | . |
| 4 | *Ailanthus altissima* | . | 0.9 | 0.7 | 2.0 | . | 1.6 | 0.2 | 1.5 |
| 5 | *Ambrosia artemisiifolia* | . | . | 0.2 | . | . | . | . | . |
| 6 | *Ammophila breviligulata* | . | . | . | 0.3 | . | . | . | . |
| 7 | *Ampelopsis brevipedunculata* | . | . | . | . | 6.1 | 1.3 | . | . |
| 8 | *Anaphalis margaritacea* | . | . | . | 0.2 | . | . | . | . |
| 9 | *Andropogon scoparius* | . | . | . | 4.7 | . | . | . | . |
| 10 | *Apocynum cannabinum* | . | . | 2.1 | . | . | . | 0.9 | . |
| 11 | *Artemesia vulgaris* | . | . | 0.02 | . | 0.3 | 0.8 | 0.05 | . |
| 12 | *Asclepias syriaca* | . | . | . | 0.03 | . | 0.1 | 0.6 | . |
| 13 | *Aster pilosus* | . | . | . | 0.1 | . | . | . | . |
| 14 | *Baccharis halimifolia* | . | **27.7** | 4.7 | 0.9 | . | 0.2 | 0.3 | . |
| 15 | *Barbarea vulgaris* | . | . | . | . | . | 0.02 | . | . |
| 16 | *Betula populifolia* | . | 1.4 | 0.4 | . | . | . | . | . |
| 17 | *Bromus tectorum* | . | . | . | 2.0 | . | . | . | . |
| 18 | *Celastrus orbiculatus* | . | 4.8 | 0.9 | 8.6 | 3.8 | **23.1** | 1.0 | 0.4 |

Table 3. Contd.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 19 | *Chenopodium album* | . | . | . | . | . | 0.02 | . | . |
| 20 | *Cirsium arvense* | . | . | 0.2 | . | 0.6 | 0.7 | . | . |
| 21 | *Corynephorus canescens* | . | . | . | 5.9 | . | . | . | . |
| 22 | *Cyperus bipartitus* | . | 0.1 | 0.6 | . | . | . | . | . |
| 23 | *Dianthus armeria* | . | . | . | 0.01 | . | . | . | . |
| 24 | *Elaeagnus angustifolia* | . | . | . | . | . | 0.04 | . | . |
| 25 | *Elaeagnus commutata* | . | 1.2 | . | 0.2 | . | 0.2 | . | . |
| 26 | *Epilobium colaratum* | . | . | . | . | 4.3 | . | . | . |
| 27 | *Eupatorium hyssopifolium* | . | 0.1 | 0.04 | 1.4 | . | . | . | . |
| 28 | *Eupatorium leucolepis* | . | . | 0.2 | 0.4 | . | . | . | 0.1 |
| 29 | *Eupatorium maculatum* | . | . | 0.03 | . | . | . | . | . |
| 30 | *Eupatorum rugosum* | . | . | 0.1 | 0.2 | . | 0.1 | . | . |
| 31 | *Euthamia graminifolia* | . | . | 0.02 | . | . | 0.01 | . | . |
| 32 | *Euthamia tenuifolia* | . | 0.3 | 0.8 | 3.9 | . | . | . | . |
| 33 | *Festuca rubra* | . | . | . | . | . | 3.0 | 1.4 | . |
| 34 | *Fragaria virginiana* | . | . | . | . | . | 0.5 | . | . |
| 35 | *Galium aparine* | . | . | 0.04 | . | . | . | . | . |
| 36 | *Gleditsia triacanthos* | . | . | . | . | . | 0.1 | 1.4 | . |
| 37 | *Hibiscus palustris* | . | . | 0.04 | . | . | . | . | . |
| 38 | *Hypericum perforatum* | . | 0.03 | . | . | . | . | . | . |
| 39 | *Juncus canadensis* | . | . | 0.2 | . | . | . | . | . |
| 40 | *Juncus gerardii* | . | 0.2 | . | . | . | . | . | . |
| 41 | *Lactuca canadensis* | . | . | . | . | . | 0.1 | . | . |
| 42 | *Lechea maritima* | . | . | . | 0.1 | . | . | . | . |
| 43 | *Linaria vulgaris* | . | 0.3 | 0.3 | 0.9 | . | 0.9 | 1.3 | . |
| 44 | *Lonicera japonica* | . | 1.9 | 3.0 | 0.6 | . | 0.01 | 0.3 | . |
| 45 | *Morus alba* | . | . | 0.02 | . | 1.1 | 1.9 | . | . |
| 46 | *Myrica pensylvanica* | . | 2.0 | 6.4 | **23.5** | . | 3.9 | . | 8.6 |
| 47 | *Oenothera biennis* | . | 0.05 | 0.1 | 0.1 | 0.4 | 0.1 | 0.6 | . |

Table 3. Contd.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 48 | *Onoclea sensibilis* | . | . | 0.7 | . | 4.4 | . | . | . |
| 49 | *Osmunda cinnamomea* | . | . | 0.3 | . | . | . | . | . |
| 50 | *Osmunda regalis* | . | 0.2 | 0.3 | . | . | . | . | . |
| 51 | *Oxalis corniculata* | . | . | . | . | . | 0.1 | . | . |
| 52 | *Panicum lanuginosum* | . | . | 0.2 | . | . | . | . | . |
| 53 | *Panicum virgatum* | . | 0.2 | 0.03 | 0.8 | . | . | . | . |
| 54 | *Parthenocissus quinquefolia* | . | 6.6 | 6.3 | 1.0 | 1.5 | 6.7 | 4.1 | **30.8** |
| 55 | *Phragmites australis* | **100** | **15.8** | 9.4 | 3.3 | **30.1** | **27.1** | **77.1** | **42.1** |
| 56 | *Phytolacca americana* | . | . | . | 0.04 | 6.0 | 2.1 | 4.1 | 0.5 |
| 57 | *Poaceae sp.1* | . | . | 0.5 | . | . | . | . | . |
| 58 | *Polygonum hydropiperoides* | . | . | . | . | 0.2 | . | . | . |
| 59 | *Polygonum scandens* | . | 0.1 | 0.6 | 0.3 | 0.1 | 0.1 | 3.9 | . |
| 60 | *Populus deltoides* | . | . | . | . | . | 0.8 | . | . |
| 61 | *Populus tremuloides* | . | 5.1 | . | . | . | 0.8 | . | 0.2 |
| 62 | *Prunus allegheniensis* | . | . | . | . | . | 0.04 | . | . |
| 63 | *Prunus serotina* | . | 0.03 | 1.0 | 2.9 | . | 2.5 | . | 2.7 |
| 64 | *Pyrus baccata* | . | . | . | . | . | . | . | 0.03 |
| 65 | *Pyrus sieboldii* | . | . | 0.5 | . | . | . | . | 0.04 |
| 66 | *Pyrus sp. 2* | . | . | 0.1 | . | . | . | . | . |
| 67 | *Rhus copallina* | . | 2.8 | **13.3** | **24.5** | 2.5 | 9.6 | 1.1 | . |
| 68 | *Rhus glabra* | . | 2.4 | 0.9 | . | . | 0.2 | . | . |
| 69 | *Rhus typhina* | . | 3.0 | 0.6 | . | . | . | . | . |
| 70 | *Rosa multiflora* | . | 0.1 | 0.3 | 0.5 | 0.1 | 1.3 | . | 3.9 |
| 71 | *Rubus allegheniensis* | . | 8.2 | **19.5** | 2.3 | **25.0** | 3.5 | 0.2 | 0.4 |
| 72 | *Rubus flagellaris* | . | . | . | . | . | 0.04 | . | . |
| 73 | *Rubus laciniatus* | . | 0.5 | 0.5 | 0.5 | . | 0.5 | . | . |
| 74 | *Rubus pensilvanicus* | . | . | . | . | . | 0.8 | . | 0.03 |
| 75 | *Rumex crispus* | . | . | . | . | . | 0.03 | . | . |
| 76 | *Salix alba* | . | . | . | . | . | 0.2 | . | . |

Table 3. Contd.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 77 | *Salix babylonica* | . | . | . | . | . | . | . | 0.6 |
| 78 | *Salix caprea* | . | . | . | . | . | 0.2 | . | . |
| 79 | *Salix discolor* | . | 1.0 | . | . | 1.4 | . | . | . |
| 80 | *Salix nigra* | . | . | . | . | 1.0 | 0.2 | . | 1.1 |
| 81 | *Sambucus canadensis* | . | 2.6 | 0.3 | 0.1 | 2.3 | 0.5 | . | 0.1 |
| 82 | *Saponaria officinalis* | . | . | . | 0.2 | . | . | 0.6 | 0.0 |
| 83 | *Scirpus cyperinus* | . | . | 0.1 | . | . | . | . | . |
| 84 | *Setaria glauca* | . | . | . | . | . | 0.1 | . | . |
| 85 | *Solanum dulcamara* | . | 0.6 | 0.2 | 0.2 | 5.5 | 1.7 | 0.6 | . |
| 86 | *Solidago canadensis* | . | . | 0.9 | 1.5 | . | 0.2 | . | . |
| 87 | *Solidago juncea* | . | . | 0.0 | 1.1 | . | 0.1 | . | . |
| 88 | *Solidago rugosa* | . | 0.2 | **11.7** | 4.6 | 1.5 | 2.0 | 0.3 | . |
| 89 | *Spirea tomentosa* | . | 0.1 | 0.8 | . | . | . | . | . |
| 90 | *Thelypteris palustris* | . | . | 0.2 | . | . | . | . | . |
| 91 | *Thelypteris simulata* | . | . | 0.4 | . | . | . | . | . |
| 92 | *Toxicodendron radicans* | . | 9.5 | 7.5 | 0.1 | 0.4 | 0.2 | . | 5.8 |
| 93 | *Verbascum blattaria* | . | . | . | . | 0.1 | . | . | . |
| 94 | *Verbascum thapsus* | . | . | . | 0.04 | . | . | . | . |
| 95 | *Verbena hastata* | . | . | . | . | 1.2 | . | . | . |
| 96 | *Viburnum dentatum* | . | . | 1.5 | . | 0.2 | . | 0.03 | 1.0 |

Table 4. The percentage cover values of the species included in the Andropogon Cluster Group using Euclidean Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Andropogon* Cluster | *Andropogon-Ammophila* Cluster |
|---|---|---|---|
| 1 | *Agropyron repens* | . | 0.8 |
| 3 | *Ammophila breviligulata* | 8.7 | **20.3** |
| 4 | *Andropogon scoparius* | **67.5** | **22.2** |
| 5 | *Asclepias syriaca* | . | 1.0 |
| 6 | *Chrysopsis falcata* | . | 2.3 |
| 7 | *Conyza canadensis* | 0.5 | 2.8 |
| 8 | *Corynephorus canescens* | 9.4 | **12.7** |
| 2 | *Eragrostis curvula* | . | 5.0 |
| 9 | *Eupatorium hyssopifolium* | 1.1 | 1.3 |
| 10 | *Euthamia graminifolia* | 9.3 | 0.6 |
| 11 | *Euthamia tenuifolia* | . | 0.2 |
| 12 | *Gnaphalium obtusifolium* | 0.6 | 0.4 |
| 13 | *Heterotheca subaxillaris* | . | 3.3 |
| 14 | *Hudsonia tomentosa* | . | 1.3 |
| 15 | *Lechea maritima* | . | 6.9 |
| 16 | *Lepidium virginicum* | . | 1.6 |
| 17 | *Lespedeza capitata* | 1.0 | . |
| 18 | *Linaria vulgaris* | 0.2 | . |
| 19 | *Myrica pensylvanica* | . | 0.1 |
| 20 | *Panicum lanuginosum* | . | 0.3 |
| 21 | *Panicum virgatum* | . | **14.9** |
| 22 | *Parthenocissus quinquefolia* | 0.5 | 0.4 |
| 23 | *Prunus serotina* | 0.1 | . |
| 24 | *Rhus copallina* | 1.0 | . |
| 25 | *Rubus allegheniensis* | . | 1.5 |

Table 5. The percentage cover values of the species included in the Prunus-Myrica Cluster Group using Euclidean Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Prunus-* Cluster | *Ailanthus-Morus-Prunus* Cluster | *Celastrus-Prunus* Cluster | *Myrica-Betula* Cluster | *Populus-Sambucus* Cluster | *Prunus-Myrica-Celastrus* Cluster | *Myrica-Parthenocissus-Toxicodendron* Cluster |
|---|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | . | 0.1 | 0.2 | . |
| 2 | *Achillea millefolium* | . | . | . | 0.8 | . | . | . |
| 3 | *Ailanthus altissima* | 4.0 | **62.6** | 0.5 | 1.2 | 0.01 | . | . |
| 4 | *Allium vineale* | . | . | . | . | . | 0.01 | . |
| 5 | *Andropogon scoparius* | . | . | . | 0.3 | . | 0.1 | . |
| 6 | *Apocynum cannabinum* | . | . | . | 0.2 | . | . | 0.01 |
| 7 | *Aronia arbutifolia* | . | . | . | . | . | . | 0.2 |
| 8 | *Artemisia vulgaris* | . | . | 1.0 | 11.0 | . | 1.0 | . |
| 9 | *Asclepias syriaca* | . | . | 0.1 | 0.6 | . | 0.04 | . |
| 10 | *Aster pilosus* | . | . | 0.1 | . | . | . | . |
| 11 | *Baccharis halimifolia* | . | 2.0 | . | 0.1 | . | 0.6 | . |
| 12 | *Betula populifolia* | 0.1 | . | . | **11.6** | 0.2 | 0.1 | 0.5 |
| 13 | *Bromus tectorum* | . | . | . | 2.7 | . | . | . |
| 14 | *Celastrus orbiculatus* | 0.2 | 0.2 | **35.4** | **14.7** | 5.1 | **14.8** | 0.2 |
| 15 | *Celtis occidentalis* | . | . | 0.01 | 3.5 | . | . | . |
| 16 | *Corynephorus canescens* | . | . | 0.2 | 0.8 | . | 0.03 | . |
| 17 | *Elaeagnus angustifolia* | . | . | . | 0.5 | . | . | . |
| 18 | *Elaeagnus commutata* | 0.1 | . | . | 0.1 | . | 1.1 | . |
| 19 | *Elaeagnus umbellata* | . | . | . | 1.0 | . | 0.1 | . |
| 20 | *Equisetum arvensis* | . | . | . | 0.9 | . | . | . |
| 21 | *Eupatorium hyssopifolium* | . | . | . | 0.1 | . | . | . |
| 22 | *Eupatorum rugosum* | . | . | 1.0 | 1.0 | . | . | . |
| 23 | *Euthamia tenuifolia* | . | . | . | . | . | 0.03 | . |
| 24 | *Hypericum perforatum* | . | . | . | 0.2 | . | . | . |
| 25 | *Ilex opaca* | . | . | . | . | . | 0.02 | . |
| 26 | *Juniperus virginiana* | . | . | 0.6 | . | . | . | . |

Table 5. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 27 | *Lathyrus latifolius* | . | . | . | . | . | 0.02 | . |
| 28 | *Linaria vulgaris* | . | . | . | 0.6 | . | 0.01 | . |
| 29 | *Lonicera japonica* | . | . | 1.9 | 0.9 | . | 6.6 | 2.2 |
| 30 | *Morus alba* | 1.7 | **23.1** | 2.0 | **10.2** | 1.8 | 0.1 | . |
| 31 | *Myrica pensylvanica* | 0.4 | . | 0.2 | 1.9 | 0.2 | **14.3** | **25.0** |
| 32 | *Onoclea sensibilis* | . | . | . | 0.1 | . | . | . |
| 33 | *Parthenocissus quinquefolia* | 0.02 | . | 3.5 | 7.3 | . | 9.4 | **20.9** |
| 34 | *Pastinaca sativa* | . | . | . | 1.0 | . | . | . |
| 35 | *Phragmites australis* | . | . | 1.8 | 0.1 | 0.2 | 4.3 | 1.8 |
| 36 | *Phytolacca americana* | . | . | 0.1 | . | 0.1 | 0.1 | 0.3 |
| 37 | *Poaceae sp.2* | . | . | . | . | . | 0.1 | . |
| 38 | *Polygonum scandens* | . | . | . | . | . | 0.1 | . |
| 39 | *Populus deltoides* | . | . | . | . | 0.01 | . | 1.5 |
| 40 | *Populus tremuloides* | 2.4 | . | 0.7 | 2.3 | **45.7** | 0.04 | 1.4 |
| 41 | *Prunus serotina* | **86.7** | **10.3** | **32.4** | 5.3 | 2.8 | **15.2** | **12.6** |
| 42 | *Pyrus sieboldii* | . | . | . | . | . | 0.1 | 0.3 |
| 43 | *Pyrus sp.1* | 0.1 | . | . | . | . | . | . |
| 44 | *Pyrus sp.2* | . | . | . | . | 0.1 | 0.02 | . |
| 45 | *Quercus rubra* | . | . | . | 0.1 | . | . | . |
| 46 | *Rhamnus frangula* | . | . | . | . | . | . | 0.5 |
| 47 | *Rhus copallina* | 4.3 | 1.7 | 6.6 | 0.1 | . | 1.4 | 0.8 |
| 48 | *Rhus glabra* | 0.1 | 0.04 | 0.4 | . | . | 0.4 | . |
| 49 | *Rhus typhina* | . | . | . | 0.6 | . | 1.0 | 0.7 |
| 50 | *Rosa multiflora* | . | . | 2.1 | 0.3 | 0.1 | 5.1 | 9.5 |
| 51 | *Rosa virgata* | . | . | . | . | . | 0.1 | . |
| 52 | *Rubus allegheniensis* | . | . | 1.1 | 3.6 | . | 5.3 | 1.2 |
| 53 | *Rubus laciniatus* | . | . | . | . | . | 0.03 | 0.1 |
| 54 | *Rubus pensylvanica* | . | . | . | . | **11.6** | 2.7 | 3.0 |
| 55 | *Salix babylonica* | . | . | . | . | 0.3 | . | . |
| 56 | *Salix discolor* | . | . | . | . | 0.1 | 0.1 | . |
| 57 | *Salix fragilis* | . | . | . | . | 0.2 | . | . |

Table 5. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 58 | *Salix matsudana.* | . | . | . | . | 0.1 | . | . |
| 59 | *Salix nigra* | . | . | . | . | 0.04 | . | . |
| 60 | *Salix sp.* | . | . | . | . | 0.1 | . | . |
| 61 | *Sambucus canadensis* | . | . | 0.2 | 0.2 | **16.3** | 0.8 | 1.1 |
| 62 | *Saponaria officinalis* | . | . | 0.9 | 0.8 | . | 0.3 | 0.4 |
| 63 | *Solanum dulcamara* | . | . | 1.0 | 0.1 | 0.8 | . | 0.4 |
| 64 | *Solidago canadensis* | . | . | . | . | . | 0.1 | . |
| 65 | *Solidago juncea* | . | . | 2.3 | 1.0 | 0.4 | 0.3 | . |
| 66 | *Solidago rugosa* | . | . | 1.7 | 7.7 | **13.0** | 1.5 | 0.2 |
| 67 | *Thelypteris simulata* | . | . | . | . | . | 0.1 | . |
| 68 | *Toxicodendron radicans* | . | . | 2.1 | . | . | **11.7** | **13.8** |
| 69 | *Unidentified sp.1* | . | . | . | . | 0.5 | . | . |
| 70 | *Unidentified sp.2* | . | . | . | . | . | . | 0.1 |
| 71 | *Unidentified sp.3* | . | . | . | . | . | 0.1 | . |
| 72 | *Unidentified sp.4* | . | . | . | . | . | 0.02 | . |
| 73 | *Verbascum thapsus* | . | . | . | . | . | 0.01 | . |
| 74 | *Viburnum dentatum* | . | . | . | 4.5 | . | 0.2 | 1.3 |

Table 6. The percentage cover values of the species included in the Phragmites Cluster Grroup and Rhus-Rubus-Phragmites Cluster Group using Similarity Ratio and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | | *Phragmites* Group | *Rhus -Rubus- Phragmites* Group | | | | |
|---|---|---|---|---|---|---|---|
| | SPECIES | *Phragmites* Cluster | *Baccharis-Phragmites* Cluster | *Rubus-Rhus-Solidago* Cluster | *Phragmites-Rubus* Cluster | *Celastrus-Phragmites* Cluster | *Phragmites-Rhus-Celastrus* Cluster |
| 1 | *Acer rubrum* | . | 0.4 | 0.1 | . | . | . |
| 2 | *Achillea millefolium* | . | . | . | . | . | 0.02 |
| 3 | *Agropyron repens* | . | . | . | . | . | 0.01 |
| 4 | *Ailanthus altissima* | 0.8 | 0.9 | 0.6 | . | . | 2.1 |
| 5 | *Ambrosia artemisiifolia* | . | . | 0.2 | . | . | . |
| 6 | *Ampelopsis brevipedunculata* | . | . | 0.1 | 9.3 | 2.9 | 0.6 |
| 7 | *Apocynum cannabinum* | 0.4 | . | 1.7 | . | . | . |
| 8 | *Artemisia vulgaris* | 0.02 | . | 0.02 | 0.5 | 0.8 | 0.8 |
| 9 | *Asclepias syriaca* | 0.3 | . | . | . | . | 0.1 |
| 10 | *Baccharis halimifolia* | 0.1 | **27.7** | 3.8 | . | . | 0.2 |
| 11 | *Barbarea vulgaris* | . | . | . | . | 0.1 | . |
| 12 | *Betula populifolia* | . | 1.4 | 0.3 | . | . | . |
| 13 | *Celastrus orbiculatus* | 0.5 | 4.8 | 0.7 | 4.5 | **38.2** | **11.9** |
| 14 | *Chenopodium album* | . | . | . | . | . | 0.03 |
| 15 | *Cirsium arvense* | . | . | 0.1 | 0.9 | . | 1.0 |
| 16 | *Cyperus bipartitus* | . | 0.1 | 0.5 | . | . | . |
| 17 | *Elaeagnus angustifolia* | . | . | . | . | . | 0.1 |
| 18 | *Elaeagnus commutata* | . | 1.2 | . | . | . | 0.2 |
| 19 | *Epilobium colaratum* | . | . | 2.3 | 0.6 | . | . |
| 20 | *Eupatorium hyssopifolium* | . | 0.1 | 0.03 | . | . | . |
| 21 | *Eupatorium leucolepis* | . | . | 0.2 | . | . | . |

Table 6. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 22 | *Eupatorium maculatum* | . | . | 0.02 | . | . | . |
| 23 | *Eupatorum rugosum* | . | . | 0.04 | . | . | 0.1 |
| 24 | *Euthamia graminifolia* | . | . | 0.02 | . | . | 0.01 |
| 25 | *Euthamia tenuifolia* | . | 0.3 | 0.6 | . | . | . |
| 26 | *Festuca rubra* | 0.1 | . | . | . | . | 4.9 |
| 27 | *Fragaria virginiana* | . | . | . | . | . | 0.7 |
| 28 | *Galium aparine* | . | . | 0.04 | . | . | . |
| 29 | *Gleditsia triacanthos* | 0.7 | . | . | . | 0.3 | . |
| 30 | *Hibiscus palustris* | . | . | 0.03 | . | . | . |
| 31 | *Hypericum perforatum* | . | 0.03 | . | . | . | . |
| 32 | *Juncus canadensis* | . | . | 0.1 | . | . | . |
| 33 | *Juncus gerardii* | . | 0.2 | . | . | . | . |
| 34 | *Lactuca canadensis* | . | . | . | . | . | 0.2 |
| 35 | *Linaria vulgaris* | 0.1 | 0.3 | 0.2 | . | . | 1.9 |
| 36 | *Lonicera japonica* | 0.1 | 1.9 | 2.4 | . | . | 0.6 |
| 37 | *Pyrus sieboldii* | . | . | 0.4 | . | . | . |
| 38 | *Pyrus sp. 2* | . | . | 0.1 | . | . | . |
| 39 | *Morus alba* | . | . | 0.01 | 1.8 | 5.6 | 0.4 |
| 40 | *Myrica pensylvanica* | . | 2.0 | 5.1 | . | . | 5.5 |
| 41 | *Oenothera biennis* | 0.3 | 0.05 | 0.2 | 0.2 | . | 0.1 |
| 42 | *Onoclea sensibilis.* | . | . | 3.0 | 0.1 | . | . |
| 43 | *Osmunda cinnamomea* | . | . | 0.2 | . | . | . |
| 44 | *Osmunda regalis* | . | 0.2 | 0.2 | . | . | . |
| 45 | *Oxalis corniculata* | . | . | . | . | 0.1 | 0.03 |
| 46 | *Panicum lanuginosum* | . | . | 0.1 | . | . | . |
| 47 | *Panicum virgatum* | . | 0.2 | 0.02 | . | . | . |
| 48 | *Parthenocissus quinquefolia* | 7.5 | 6.6 | 5.6 | 1.2 | 2.2 | 9.0 |
| 49 | *Phragmites australis* | **83.6** | **15.8** | 8.8 | **43.1** | **33.8** | **25.8** |
| 50 | *Phytolacca americana* | 2.1 | . | 0.03 | 9.7 | . | 3.0 |
| 51 | *Poaceae sp.1* | . | . | 0.4 | . | . | . |
| 52 | *Polygonum hydropiperoides* | . | . | 0.1 | . | . | . |
| 53 | *Polygonum scandens* | 1.8 | 0.1 | 0.6 | . | . | 0.1 |

Table 6. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 54 | *Populus deltoides* | . | . | . | . | . | 1.1 |
| 55 | *Populus tremuloides* | . | 5.1 | . | . | 1.0 | 0.6 |
| 56 | *Prunus allegheniensis* | . | . | . | . | . | 0.1 |
| 57 | *Prunus serotina* | . | 0.03 | 0.8 | . | . | 4.2 |
| 58 | *Rhus copallina* | . | 2.8 | **12.0** | 0.2 | . | **12.6** |
| 59 | *Rhus glabra* | . | 2.4 | 0.8 | . | . | 0.3 |
| 60 | *Rhus typhina* | . | 3.0 | 0.5 | . | . | . |
| 61 | *Rosa multiflora* | . | 0.1 | 0.3 | 0.2 | . | 1.9 |
| 62 | *Rubus allegheniensis* | 0.2 | 8.2 | **23.4** | **16.1** | 7.1 | 3.4 |
| 63 | *Rubus flagellaria* | . | . | . | . | . | 0.1 |
| 64 | *Rubus laciniatus* | . | 0.5 | 0.4 | . | 1.6 | . |
| 65 | *Rubus pensilvanicus* | . | . | . | . | 2.3 | 0.1 |
| 66 | *Rumex crispus* | . | . | . | . | 0.1 | . |
| 67 | *Salix alba* | . | . | . | . | . | 0.2 |
| 68 | *Salix caprea* | . | . | . | . | . | 0.3 |
| 69 | *Salix discolor* | . | 1.0 | 0.8 | . | . | . |
| 70 | *Salix nigra* | . | . | 0.6 | . | . | 0.3 |
| 71 | *Sambucus canadensis* | 0.02 | 2.6 | 0.6 | 1.6 | 2.5 | 0.1 |
| 72 | *Saponaria officinalis* | 0.3 | . | . | . | . | . |
| 73 | *Scirpus cyperinus* | . | . | 0.1 | . | . | . |
| 74 | *Setaria glauca* | . | . | . | . | . | 0.1 |
| 75 | *Solanum dulcamara* | 0.3 | 0.6 | 1.7 | 4.6 | 0.6 | 2.1 |
| 76 | *Solidago canadensis* | . | . | 0.7 | . | 0.03 | 0.3 |
| 77 | *Solidago juncea* | . | . | 0.03 | . | . | 0.1 |
| 78 | *Solidago rugosa* | 0.1 | 0.2 | 9.5 | 2.3 | 0.6 | 2.5 |
| 79 | *Spirea tomentosa* | . | 0.1 | 0.7 | . | . | . |
| 80 | *Thelypteris palustris* | . | . | 0.2 | . | . | . |
| 81 | *Thelypteris simulata* | . | . | 0.3 | . | . | . |
| 82 | *Toxicodendron radicans* | 0.7 | 9.5 | 6.1 | 0.7 | . | 0.3 |
| 83 | *Verbascum blattaria* | . | . | . | 0.2 | . | . |
| 84 | *Verbena hastata* | . | . | . | 1.9 | . | . |
| 85 | *Viburnum dentatum* | . | . | 1.2 | 0.3 | . | 0.02 |

Table 7. The percentage cover values of the species included in the Prunus-Myrica Cluster Group using Similarity Ratio and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster

| | SPECIES | *Populus-Sambucus* Cluster | *Prunus*-Cluster | *Celastrus-Prunus* Cluster | *Ailanthus-Morus-Prunus* Cluster | *Morus-Celastrus-Betula* Cluster | *Rhus-Celastrus-Myrica* Cluster | *Celastrus-Prunus-Myrica* Cluster | *Parthenocissus-Myrica-Prunus* Cluster |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.1 | . | . | . | . | . | 0.3 | . |
| 2 | *Achilea millefolium* | . | . | . | . | 0.8 | 0.05 | . | . |
| 3 | *Ailanthus altissima* | 0.01 | 4.0 | 0.2 | **62.6** | 1.2 | 1.9 | . | . |
| 4 | *Allium vineale* | . | . | . | . | . | . | 0.02 | . |
| 5 | *Ammophila breviligulata* | . | . | . | . | . | 0.2 | . | . |
| 6 | *Anaphalis margaritacea* | . | . | . | . | . | 0.1 | . | . |
| 7 | *Andropogon scoparius* | . | . | . | . | 0.3 | 3.1 | 0.1 | . |
| 8 | *Apocynum cannabinum* | . | . | . | . | 0.2 | . | . | 0.01 |
| 9 | *Aronia arbutifolia* | . | . | . | . | . | . | . | 0.1 |
| 10 | *Artemisia vulgaris* | . | . | 0.6 | . | **11.0** | 0.5 | 0.3 | 1.0 |
| 11 | *Asclepias syriaca* | . | . | . | . | 0.6 | 0.1 | 0.1 | . |
| 12 | *Aster pilosus* | . | . | . | . | . | 0.1 | . | . |
| 13 | *Baccharis halimifolia* | . | . | . | 2.0 | 0.1 | 0.6 | 0.8 | . |
| 14 | *Betula populifolia* | 0.2 | 0.1 | . | . | **11.6** | . | 0.1 | 0.3 |
| 15 | *Bromus tectorum* | . | . | . | . | 2.7 | 1.3 | . | . |
| 16 | *Celastrus orbiculatus* | 5.1 | 0.2 | **41.8** | 0.2 | **14.7** | **17.4** | **16.0** | 2.8 |
| 17 | *Celtis occidentalis* | . | . | 0.02 | . | 3.5 | . | . | . |
| 18 | *Corynephorus canescens* | . | . | . | . | 0.8 | 4.1 | 0.03 | . |
| 19 | *Dianthus armeria* | . | . | . | . | . | 0.01 | . | . |
| 20 | *Elaeagnus angustifolia* | . | . | . | . | 0.5 | . | . | . |
| 21 | *Elaeagnus commutata* | . | 0.1 | . | . | 0.1 | 0.1 | 0.4 | 1.1 |
| 22 | *Elaeagnus umbellata* | . | . | . | . | 1.0 | . | 0.1 | . |
| 23 | *Equisetum arvensis* | . | . | . | . | 0.9 | . | . | . |
| 24 | *Eupatorium hyssopifolium* | . | . | . | . | 0.1 | 0.9 | . | . |
| 25 | *Eupatorium leucolepis* | . | . | . | . | . | 0.3 | . | 0.04 |
| 26 | *Eupatorum rugosum* | . | . | 1.6 | . | 1.0 | 0.1 | . | . |

Table 7. Contd.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 27 | *Euthamia tenuifolia* | . | . | . | . | . | 2.6 | 0.04 | . |
| 28 | *Hypericum perforatum* | . | . | . | . | 0.2 | . | . | . |
| 29 | *Ilex opaca* | . | . | . | . | . | . | 0.03 | . |
| 30 | *Juniperus virginiana* | . | . | . | . | . | 0.5 | . | . |
| 31 | *Lathyrus latifolius* | . | . | . | . | . | . | 0.03 | . |
| 32 | *Lechea maritima* | . | . | . | . | . | 0.1 | . | . |
| 33 | *Linaria vulgaris* | . | . | . | . | 0.6 | 0.6 | 0.01 | . |
| 34 | *Lonicera japonica* | . | . | 1.6 | . | 0.9 | 0.4 | 8.0 | 1.4 |
| 35 | *Pyrus baccata* | . | . | . | . | . | . | . | 0.0 |
| 36 | *Pyrus sieboldii* | . | . | . | . | . | . | 0.1 | 0.2 |
| 37 | *Pyrus sp. 1* | . | 0.1 | . | . | . | . | . | . |
| 38 | *Pyrus sp. 2* | 0.1 | . | . | . | . | . | . | 0.01 |
| 39 | *Morus alba* | 1.8 | 1.7 | 2.4 | **23.1** | **10.2** | 0.02 | . | 0.2 |
| 40 | *Myrica pensylvanica* | 0.2 | 0.4 | . | . | 1.9 | **15.8** | **14.0** | **19.7** |
| 41 | *Oenothera biennis* | . | . | . | . | . | 0.1 | . | . |
| 42 | *Onoclea sensibilis* | . | . | . | . | 0.1 | . | . | . |
| 43 | *Panicum virgatum* | . | . | . | . | . | 0.5 | . | . |
| 44 | *Parthenocissus quinquefolia* | . | 0.02 | 1.9 | . | 7.3 | 1.9 | 8.4 | **21.4** |
| 45 | *Pastinaca sativa* | . | . | . | . | 1.0 | . | . | . |
| 46 | *Phragmites australis* | 0.2 | . | 0.8 | . | 0.1 | 4.2 | 2.7 | **11.8** |
| 47 | *Phytolacca americana* | 0.1 | . | . | . | . | 0.1 | 0.1 | 0.2 |
| 48 | *Poaceae sp. 2* | . | . | . | . | . | . | 0.1 | . |
| 49 | *Polygonum scandens* | . | . | . | . | . | 0.2 | 0.1 | 0.01 |
| 50 | *Populus deltoides* | 0.01 | . | . | . | . | . | . | 0.7 |
| 51 | *Populus tremuloides* | **45.7** | 2.4 | 1.1 | . | 2.3 | . | 0.05 | 0.8 |
| 52 | *Prunus serotina* | 2.8 | **86.7** | **38.1** | **10.3** | 5.3 | 7.3 | **15.1** | **11.3** |
| 53 | *Quercus rubra* | . | . | . | . | 0.1 | . | . | . |
| 54 | *Rhamnus frangula* | . | . | . | . | . | . | . | 0.3 |
| 55 | *Rhus copallina* | . | 4.3 | . | 1.7 | 0.1 | 23.5 | 1.6 | 0.5 |
| 56 | *Rhus glabra* | . | 0.1 | 0.7 | 0.04 | . | . | 0.5 | . |
| 57 | *Rhus typhina* | . | . | . | . | 0.6 | . | 1.3 | 0.3 |

Table 7. Contd.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 58 | *Rosa multiflora* | 0.1 | . | 3.0 | . | 0.3 | 0.3 | 3.1 | 9.5 |
| 59 | *Rosa virginiana* | . | . | . | . | . | . | 0.1 | . |
| 60 | *Rubus allegheniensis* | . | . | 0.6 | . | 3.6 | 2.0 | 6.5 | 0.8 |
| 61 | *Rubus laciniatus* | . | . | . | . | . | 0.3 | 0.0 | 0.03 |
| 62 | *Rubus pensilvanicus* | **11.6** | . | . | . | . | . | 3.2 | 1.7 |
| 63 | *Salix babylonica* | 0.3 | . | . | . | . | . | . | 0.3 |
| 64 | *Salix discolor* | 0.1 | . | . | . | . | . | 0.2 | . |
| 65 | *Salix fragilis* | 0.2 | . | . | . | . | . | . | . |
| 66 | *Salix matsudana.* | 0.1 | . | . | . | . | . | . | . |
| 67 | *Salix nigra* | 0.04 | . | . | . | . | . | . | 0.5 |
| 68 | *Salix sp.* | 0.1 | . | . | . | . | . | . | . |
| 69 | *Sambucus canadensis* | **16.3** | . | 0.2 | . | 0.2 | 0.05 | 0.8 | 0.7 |
| 70 | *Saponaria officinalis* | . | . | . | . | 0.8 | 0.8 | 0.3 | 0.2 |
| 71 | *Solanum dulcamara* | 0.8 | . | 0.6 | . | 0.1 | 0.6 | . | 0.2 |
| 72 | *Solidago canadensis* | . | . | . | . | . | 1.0 | 0.2 | . |
| 73 | *Solidago juncea* | 0.4 | . | 3.2 | . | 1.0 | 1.0 | 0.3 | 0.1 |
| 74 | *Solidago rugosa* | **13.0** | . | 1.0 | . | 7.7 | 3.9 | 1.9 | 0.1 |
| 75 | *Thelypteris simulata* | . | . | . | . | . | . | 0.2 | . |
| 76 | *Toxicodendron radicans* | . | . | 0.6 | . | . | 1.4 | **12.6** | **10.6** |
| 77 | *Unidentified sp.1* | 0.5 | . | . | . | . | . | . | . |
| 78 | *Unidentified sp.2* | . | . | . | . | . | . | . | 0.04 |
| 79 | *Unidentified sp.3* | . | . | . | . | . | . | 0.1 | 0.1 |
| 80 | *Unidentified sp.4* | . | . | . | . | . | . | 0.02 | . |
| 81 | *Verbascum thapsus* | . | . | . | . | . | 0.03 | 0.01 | . |
| 82 | *Viburnum dentatum* | . | . | . | . | 4.5 | . | 0.2 | 1.0 |

Table 8. The percentage cover values of the species included in the four major cluster groups recognized using Similarity Ratio and Minimum Variance. The values in bold face are the higher cover values (≥ 10.0%) within each cluster

| SPECIES | | *Phragmites* *Cluster* | Woodland and Woodland Associates Cluster | Dry Grassland (*Andropogon*) Cluster | *Rhus-* *Rubus-* *Phragmites* Cluster |
|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | 0.09 | . | 0.09 |
| 2 | *Achillea millefolium* | . | 0.06 | . | 0.01 |
| 3 | *Agropyron repens* | . | . | 0.42 | 0.001 |
| 4 | *Eragrostis curvula* | . | . | 2.52 | . |
| 5 | *Ailanthus altissima* | 0.77 | 2.65 | . | 0.87 |
| 6 | *Allium vineale* | . | 0.001 | . | . |
| 7 | *Ambrosia artimiisifolia* | . | . | . | 0.06 |
| 8 | *Ammophila breviligulata* | . | 0.03 | **14.5** | . |
| 9 | *Ampelopsis brevipedunculata* | . | . | . | 1.78 |
| 10 | *Anaphalis margaritacea* | . | 0.02 | . | . |
| 11 | *Andropogon scoparius* | . | 0.53 | **44.9** | . |
| 12 | *Apocynum cannabinum* | 0.41 | 0.01 | . | 0.64 |
| 13 | *Aronia arbutifolia* | . | 0.03 | . | . |
| 14 | *Artemisia vulgaris* | 0.02 | 1.31 | . | 0.37 |
| 15 | *Asclepias syriaca* | 0.26 | 0.07 | 0.49 | 0.04 |
| 16 | *Aster pilosus* | . | 0.01 | . | . |
| 17 | *Baccharis halimifolia* | 0.14 | 0.39 | . | 4.49 |
| 18 | *Barbarea vulgaris* | . | . | . | 0.01 |
| 19 | *Betula populifolia* | . | 1.01 | . | 0.28 |
| 20 | *Bromus tectorum* | . | 0.41 | . | . |
| 21 | *Celastrus orbiculatus* | 0.52 | **12.5** | . | 8.16 |
| 22 | *Celtis occidentalis* | . | 0.27 | . | . |
| 23 | *Chenopodium album* | . | . | . | 0.01 |
| 24 | *Chrysopsis falcata* | . | . | 1.14 | . |
| 25 | *Cirsium arvense* | . | . | . | 0.43 |
| 26 | *Conyza canadensis* | . | . | 1.63 | . |
| 27 | *Corynephorus canescens* | . | 0.70 | **11.0** | . |
| 28 | *Cyperus bipartitus* | . | . | . | 0.18 |
| 29 | *Dianthus armeria* | . | 0.001 | . | . |
| 30 | *Elaeagnus angustifolia* | . | 0.04 | . | 0.02 |
| 31 | *Elaeagnus commutata* | . | 0.41 | . | 0.19 |
| 32 | *Elaeagnus umbellata* | . | 0.10 | . | . |
| 33 | *Epilobium coloratum* | . | . | . | 0.94 |
| 34 | *Equisetum arvensis* | . | 0.07 | . | . |
| 35 | *Eupatorium hyssopifolium* | . | 0.15 | 1.22 | 0.02 |
| 36 | *Eupatorium leucolepis* | . | 0.05 | . | 0.06 |
| 37 | *Eupatorium maculatum* | . | . | . | 0.01 |
| 38 | *Eupatorum rugosum* | . | 0.21 | . | 0.04 |
| 39 | *Euthamia graminifolia* | . | . | 4.98 | 0.01 |
| 40 | *Euthamia tenuifolia* | . | 0.41 | 0.11 | 0.27 |
| 41 | *Festuca rubra* | 0.14 | . | . | 1.29 |

Table 8. Contd.

| SPECIES | | *Phragmites Cluster* | Woodland and Woodland Associates Cluster | Dry Grassland (*Andropogon*) Cluster | *Rhus-Rubus-Phragmites* Cluster |
|---|---|---|---|---|---|
| 42 | *Fragaria virginiana* | . | . | . | 0.19 |
| 43 | *Galium aparine* | . | . | . | 0.01 |
| 44 | *Gleditsia triacanthos* | 0.67 | . | . | 0.04 |
| 45 | *Gnaphalium obtusifolium* | . | . | 0.53 | . |
| 46 | *Heterotheca subaxillaris* | . | . | 1.64 | . |
| 47 | *Hibiscus palustris* | . | . | . | 0.01 |
| 48 | *Hudsonia tomentosa* | . | . | 0.66 | . |
| 49 | *Hypericum perforatum* | . | 0.01 | . | 0.001 |
| 50 | *Ilex opaca* | . | 0.01 | . | . |
| 51 | *Juncus canadensis* | . | . | . | 0.05 |
| 52 | *Juncus gerardii* | . | . | . | 0.02 |
| 53 | *Juniperus virginiana* | . | 0.07 | . | . |
| 54 | *Lactuca canadensis* | . | . | . | 0.05 |
| 55 | *Lathyrus latifolius* | . | 0.01 | . | . |
| 56 | *Lechea maritima* | . | 0.01 | 3.47 | . |
| 57 | *Lepidium virginicum* | . | . | 0.78 | . |
| 58 | *Lespedeza capitata* | . | . | 0.51 | . |
| 59 | *Linaria vulgaris* | 0.10 | 0.14 | 0.12 | 0.63 |
| 60 | *Lonicera japonica* | 0.14 | 2.77 | . | 1.27 |
| 61 | *Morus alba* | . | 2.02 | . | 1.02 |
| 62 | *Myrica pensylvanica* | . | **11.6** | 0.06 | 3.59 |
| 63 | *Oenothera biennis* | 0.26 | 0.01 | . | 0.14 |
| 64 | *Onoclea sensibilis* | . | 0.01 | . | 1.15 |
| 65 | *Osmunda cinnamomea* | . | . | . | 0.08 |
| 66 | *Osmunda regalis* | . | . | . | 0.11 |
| 67 | *Oxalis corniculata* | . | . | . | 0.02 |
| 68 | *Panicum lanuginosum* | . | . | 0.13 | 0.05 |
| 69 | *Panicum virgatum* | . | 0.08 | 7.45 | 0.03 |
| 70 | *Parthenocissus quinquefolia* | 7.49 | 8.88 | 0.43 | 5.59 |
| 71 | *Pastinaca sativa* | . | 0.08 | . | . |
| 72 | *Phragmites australis* | **83.6** | 4.57 | . | **21.6** |
| 73 | *Phytolacca americana* | 2.11 | 0.10 | . | 2.09 |
| 74 | *Poaceae sp.1* | . | . | . | 0.16 |
| 75 | *Poaceae sp.2* | . | 0.04 | . | . |
| 76 | *Polygonum hydropiperoides* | . | . | . | 0.03 |
| 77 | *Polygonum scandens* | 1.79 | 0.05 | . | 0.27 |
| 78 | *Populus deltoides* | . | 0.19 | . | 0.28 |
| 79 | *Populus tremuloides* | . | 4.81 | . | 0.84 |
| 80 | *Prunus allegheniensis* | . | . | . | 0.01 |
| 81 | *Prunus serotina* | . | **15.0** | 0.07 | 1.43 |
| 82 | *Pyrus baccata* | . | 0.001 | . | . |
| 83 | *Pyrus sieboldii* | . | 0.08 | . | 0.15 |
| 84 | *Pyrus sp. 1* | . | 0.001 | . | . |
| 85 | *Pyrus sp. 2* | . | 0.02 | . | 0.04 |
| 86 | *Quercus rubra* | . | 0.01 | . | . |

Table 8. Contd.

| SPECIES | | *Phragmites* *Cluster* | Woodland and Woodland Associates Cluster | Dry Grassland (*Andropogon*) Cluster | *Rhus-Rubus-Phragmites* Cluster |
|---|---|---|---|---|---|
| 87 | *Rhamnus frangula* | . | 0.07 | . | . |
| 88 | *Rhus copallina* | . | 4.37 | 0.48 | **10.0** |
| 89 | *Rhus glabra* | . | 0.20 | . | 0.61 |
| 90 | *Rhus typhina* | . | 0.48 | . | 0.50 |
| 91 | *Rosa multiflora* | . | 3.66 | . | 0.65 |
| 92 | *Rosa virginiana* | . | 0.03 | . | . |
| 93 | *Rubus allegheniensis* | 0.18 | 2.60 | 0.76 | **13.5** |
| 94 | *Rubus flagellaris* | . | . | . | 0.01 |
| 95 | *Rubus laciniatus* | . | 0.06 | . | 0.39 |
| 96 | *Rubus pensilvanicus* | . | 2.39 | . | 0.29 |
| 97 | *Rumex crispus* | . | . | . | 0.01 |
| 98 | *Salix alba* | . | . | . | 0.06 |
| 99 | *Salix babylonica* | . | 0.10 | . | . |
| 100 | *Salix caprea* | . | . | . | 0.08 |
| 101 | *Salix discolor* | . | 0.05 | . | 0.41 |
| 102 | *Salix fragilis* | . | 0.02 | . | . |
| 103 | *Salix matsudana* | . | 0.01 | . | . |
| 104 | *Salix nigra* | . | 0.13 | . | 0.31 |
| 105 | *Salix sp.* | . | 0.01 | . | . |
| 106 | *Sambucus canadensis* | 0.02 | 1.97 | . | 1.05 |
| 107 | *Saponaria officinalis* | 0.27 | 0.34 | . | . |
| 108 | *Scirpus cyperinus* | . | . | . | 0.02 |
| 109 | *Setaria glauca* | . | . | . | 0.03 |
| 110 | *Solanum dulcamara* | 0.25 | 0.27 | . | 1.95 |
| 111 | *Solidago canadensis* | . | 0.20 | . | 0.35 |
| 112 | *Solidago juncea* | . | 0.62 | . | 0.03 |
| 113 | *Solidago rugosa* | 0.13 | 3.01 | . | 4.62 |
| 114 | *Spirea tomentosa* | . | . | . | 0.26 |
| 115 | *Thelypteris palustris* | . | . | . | 0.06 |
| 116 | *Thelypteris simulata* | . | 0.04 | . | 0.13 |
| 117 | *Toxicodendron radicans* | 0.70 | 6.46 | . | 3.47 |
| 118 | *Unidentified sp.1* | . | 0.04 | . | . |
| 119 | *Unidentified sp.2* | . | 0.01 | . | . |
| 120 | *Unidentified sp.3* | . | 0.03 | . | . |
| 121 | *Unidentified sp.4* | . | 0.01 | . | . |
| 122 | *Verbascum blattaria* | . | . | . | 0.02 |
| 123 | *Verbascum thapsus* | . | 0.01 | . | . |
| 124 | *Verbena hastata* | . | . | . | 0.25 |
| 125 | *Viburnum dentatum* | . | 0.67 | . | 0.50 |

Table 9. The percentage cover values of the species included in the Phragmites Cluster Group using Bray Curtis Dissimilarity and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| SPECIES | | *Phragmites* Cluster | *Phragmites-Parthenocissus* Cluster |
|---|---|---|---|
| 1 | *Ailanthus altissima* | . | 1.4 |
| 2 | *Artemisia vulgaris* | 0.1 | . |
| 3 | *Asclepias syriaca* | . | 0.4 |
| 4 | *Celastrus orbiculatus* | . | 0.9 |
| 5 | *Festuca rubra* | . | 1.1 |
| 6 | *Gleditsia triacanthos* | . | 1.2 |
| 7 | *Linaria vulgaris* | . | 1.1 |
| 8 | *Lonicera japonica* | 0.3 | . |
| 9 | *Parthenocissus quinquefolia* | . | **13.1** |
| 10 | *Phragmites australis* | **99.6** | **72.2** |
| 11 | *Phytolacca americana* | . | 3.7 |
| 12 | *Polygonum scandens* | . | 1.5 |
| 13 | *Rhus copallina* | . | 0.9 |
| 14 | *Rubus allegheniensis* | . | 0.2 |
| 15 | *Sambucus canadensis* | . | 0.03 |
| 16 | *Saponaria officinalis* | . | 0.5 |
| 17 | *Solanum dulcamara* | . | 0.3 |
| 18 | *Solidago rugosa* | . | 0.3 |
| 19 | *Toxicodendron radicans* | . | 1.2 |
| 20 | *Viburnum dentatum* | . | 0.02 |

Table 10. The percentage cover values of the species included in the Rhus-Rubus-Phragmites Cluster Group using Bray Curtis Dissimilarity and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Baccharis-Phragmites* Cluster | *Rubus-Rhus-Solidago* Cluster | *Rhus-Myrica-Celastrus* Cluster | *Phragmites-Rubus* Cluster | *Celastrus-Phragmites* Cluster |
|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.4 | 0.2 | . | . | . |
| 2 | *Achillea millefolium* | . | . | 0.5 | . | . |
| 3 | *Ailanthus altissima* | . | . | 5.5 | . | . |
| 4 | *Ambrosia artemisiifolia* | . | 0.2 | . | . | . |
| 5 | *Ammophila breviligulata* | . | . | 0.2 | . | . |
| 6 | *Ampelopsis brevipedunculata* | . | . | . | 4.8 | 3.2 |
| 7 | *Anaphalis margaritacea* | . | . | 0.1 | . | . |
| 8 | *Andropogon scoparius* | . | . | 3.2 | . | . |
| 9 | *Apocynum cannabinum* | 4.1 | 1.0 | 0.1 | . | . |
| 10 | *Artemisia vulgaris* | 0.05 | . | 0.2 | 0.1 | 0.9 |
| 11 | *Asclepias syriaca* | . | . | 0.2 | . | . |
| 12 | *Aster pilosus* | . | . | 0.04 | . | . |
| 13 | *Baccharis halimifolia* | **20.5** | 3.8 | 0.04 | . | . |
| 14 | *Barbarea vulgaris* | . | . | . | . | 0.03 |
| 15 | *Betula populifolia* | 1.2 | 0.5 | . | . | . |
| 16 | *Bromus tectorum* | . | . | 1.5 | . | . |
| 17 | *Celastrus orbiculatus* | 3.3 | 0.3 | **11.6** | 2.5 | **23.8** |
| 18 | *Chenopodium album* | . | . | 0.0 | . | . |
| 19 | *Cirsium arvense* | . | 0.2 | . | 0.6 | . |

Table 10. Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| 20 | *Corynephorus canescens* | . | . | 4.9 | . | . |
| 21 | *Cyperus bipartitus* | 0.1 | 0.6 | . | . | . |
| 22 | *Dianthus armeria* | . | . | 0.01 | . | . |
| 23 | *Elaeagnus angustifolia* | . | . | 0.3 | . | . |
| 24 | *Elaeagnus commutata* | 1.1 | . | 0.2 | . | . |
| 25 | *Epilobium coloratum* | . | . | . | 4.9 | . |
| 26 | *Equisetum arvensis* | . | . | 0.5 | . | . |
| 27 | *Eupatorium hyssopifolium* | 0.1 | 0.04 | 0.8 | . | . |
| 28 | *Eupatorium leucolepis* | . | 0.2 | 0.3 | . | . |
| 29 | *Eupatorium maculatum* | . | 0.03 | . | . | . |
| 30 | *Eupatorum rugosum* | . | 0.1 | 0.3 | . | . |
| 31 | *Euthamia graminifolia* | . | . | 0.04 | . | . |
| 32 | *Euthamia tenuifolia* | 0.2 | 0.9 | 2.3 | . | . |
| 33 | *Festuca rubra* | . | . | 0.8 | . | 3.2 |
| 34 | *Fragaria virginiana* | . | . | . | . | 0.7 |
| 35 | *Galium aparine* | . | 0.05 | . | . | . |
| 36 | *Gleditsia triacanthos* | . | . | . | . | 0.1 |
| 37 | *Hibiscus palustris* | . | 0.05 | . | . | . |
| 38 | *Hypericum perforatum* | 0.03 | . | . | . | . |
| 39 | *Juncus canadensis* | . | 0.2 | . | . | . |
| 40 | *Juncus gerardii* | 0.2 | . | . | . | . |
| 41 | *Lactuca canadensis* | . | . | . | . | 0.2 |
| 42 | *Linaria vulgaris* | 0.2 | 0.3 | 2.2 | . | 0.3 |
| 43 | *Lonicera japonica* | 1.7 | 3.8 | 0.1 | . | . |
| 44 | *Morus alba* | . | 0.0 | . | . | 3.6 |
| 45 | *Myrica pensylvanica* | 1.1 | 7.3 | **15.5** | . | . |

Table 10. Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| 46 | *Oenothera biennis* | 0.8 | 0.1 | 0.1 | 0.5 | 0.1 |
| 47 | *Onoclea sensibilis.* | 0.8 | 0.3 | . | 4.9 | . |
| 48 | *Osmunda cinnamomea* | . | 0.3 | . | . | . |
| 49 | *Osmunda regalis* | 0.2 | 0.3 | . | . | . |
| 50 | *Oxalis corniculata* | . | . | . | . | 0.04 |
| 51 | *Panicum lanuginosum* | . | 0.2 | . | . | . |
| 52 | *Panicum virgatum* | 0.2 | 0.03 | 0.3 | . | . |
| 53 | *Parthenocissus quinquefolia* | 6.6 | 6.5 | 3.4 | 1.7 | 5.7 |
| 54 | *Pastinaca sativa* | . | . | 0.6 | . | . |
| 55 | *Phragmites australis* | **17.2** | 8.7 | 5.1 | **30.7** | **31.3** |
| 56 | *Phytolacca americana* | . | . | 0.03 | 6.4 | 3.1 |
| 57 | *Poaceae* sp.1 | . | 0.6 | . | . | . |
| 58 | *Polygonum hydropiperoides* | . | . | . | 0.2 | . |
| 59 | *Polygonum scandens* | 3.2 | 0.5 | 0.2 | 0.1 | 0.03 |
| 60 | *Populus tremuloides* | 4.6 | . | . | . | . |
| 61 | *Prunus serotina* | . | 2.3 | 1.3 | . | 1.8 |
| 62 | *Pyrus sieboldii* | . | 0.5 | . | . | . |
| 63 | *Pyrus* sp. 2 | . | 0.1 | . | . | . |
| 64 | *Rhus copallina* | 2.9 | **13.7** | **19.8** | 2.8 | **11.7** |
| 65 | *Rhus glabra* | 2.5 | 1.6 | 0.4 | . | . |
| 66 | *Rhus typhina* | 2.7 | 1.1 | . | . | . |
| 67 | *Rosa multiflora* | 0.1 | 0.4 | 0.7 | . | 0.6 |
| 68 | *Rosa virginiana* | . | 0.1 | . | . | . |
| 69 | *Rubus allegheniensis* | **12.2** | **18.2** | 4.7 | **26.0** | 5.2 |
| 70 | *Rubus flagellaris* | . | . | 0.1 | . | . |
| 71 | *Rubus laciniatus* | 0.4 | 0.6 | 0.3 | . | 0.7 |

Table 10. Contd.

| | | | | | | |
|---|---|---|---|---|---|---|
| 72 | *Rubus pensilvanicus* | . | . | . | . | 0.2 |
| 73 | *Rumex crispus* | . | . | . | . | 0.04 |
| 74 | *Salix discolor* | 0.9 | . | . | 1.6 | . |
| 75 | *Salix nigra* | . | . | . | 1.2 | . |
| 76 | *Sambucus canadensis* | 2.9 | 0.1 | 0.1 | 1.5 | 1.0 |
| 77 | *Saponaria officinalis* | . | . | 0.5 | . | . |
| 78 | *Scirpus cyperinus* | . | 0.1 | . | . | . |
| 79 | *Solanum dulcamara* | 1.0 | 0.1 | 0.3 | 6.2 | 1.2 |
| 80 | *Solidago canadensis* | . | 1.0 | 1.1 | . | 0.3 |
| 81 | *Solidago juncea* | . | 0.04 | 0.8 | . | 0.1 |
| 82 | *Solidago rugosa* | 0.6 | 11.1 | 8.3 | 1.4 | 0.4 |
| 83 | *Spirea tomentosa* | . | 0.9 | 0.04 | . | . |
| 84 | *Thelypteris palustris* | . | 0.2 | . | . | . |
| 85 | *Thelypteris simulata* | 1.1 | . | . | . | . |
| 86 | *Toxicodendron radicans* | 5.1 | 9.2 | 0.1 | 0.5 | 0.3 |
| 87 | *Verbascum blattaria* | . | . | . | 0.1 | . |
| 88 | *Verbascum thapsus* | . | . | 0.03 | . | . |
| 89 | *Verbena hastata* | . | . | . | 1.3 | . |
| 90 | *Viburnum dentatum* | . | 1.5 | 0.4 | . | 0.2 |

Table 11. The percentage cover values of the species included in the Prunus -Myrica Cluster Group using Bray Curtis Dissimilarity and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Populus-Sambucus* Cluster | *Ailanthus-Morus-Prunus* Cluster | *Celastrus-Prunus* Cluster | *Phragmites-Myrica-Parthenocissus* Cluster | *Myrica-Parthenocissus-Toxicodendron* Cluster | *Prunus-Myrica-Celastrus* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.1 | . | . | . | 0.3 | . |
| 2 | *Agropyron repens* | . | . | . | 0.01 | . | . |
| 3 | *Ailanthus altissima* | 0.01 | **29.6** | 0.9 | 0.9 | . | . |
| 4 | *Allium vineale* | . | . | . | . | . | 0.0 |
| 5 | *Andropogon scoparius* | . | . | . | . | 0.1 | 0.4 |
| 6 | *Apocynum cannabinum* | . | . | . | 0.01 | . | . |
| 7 | *Aronia arbutifolia* | . | . | . | . | 0.1 | . |
| 8 | *Artemisia vulgaris* | . | . | 5.3 | 0.5 | . | 1.8 |
| 9 | *Asclepias syriaca* | . | . | 0.3 | 0.2 | . | . |
| 10 | *Aster pilosus* | . | . | 0.1 | . | . | . |
| 11 | *Baccharis halimifolia* | . | 0.9 | 0.2 | 3.0 | 1.1 | 1.5 |
| 12 | *Betula populifolia* | 0.2 | 0.04 | . | . | 0.2 | 4.9 |
| 13 | *Bromus tectorum* | . | . | 1.2 | . | . | . |
| 14 | *Celastrus orbiculatus* | 7.0 | 0.2 | **33.3** | 8.0 | 8.5 | **11.2** |
| 15 | *Celtis occidentalis* | . | 3.5 | 0.01 | . | . | . |
| 16 | *Cirsium arvense* | . | . | . | 1.5 | . | . |
| 17 | *Corynephorus canescens* | . | . | 0.2 | . | 0.03 | . |
| 18 | *Elaeagnus angustifolia* | . | . | . | 0.1 | . | . |
| 19 | *Elaeagnus commutata* | . | 0.02 | 0.3 | 0.3 | 0.1 | 1.6 |
| 20 | *Elaeagnus umbellata* | . | 1.0 | . | . | . | 0.1 |
| 21 | *Eupatorium hyssopifolium* | . | . | 0.1 | . | . | 0.2 |
| 22 | *Eupatorium leucolepis* | . | . | . | 0.1 | . | . |
| 23 | *Eupatorum rugosum* | . | . | 1.1 | . | . | . |
| 24 | *Euthamia graminifolia* | . | . | . | 0.01 | . | . |

Table 11. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Euthamia tenuifolia* | . | . | . | . | 0.02 | 0.5 |
| 26 | *Festuca rubra* | . | . | . | 0.6 | . | . |
| 27 | *Hypericum perforatum* | . | . | 0.1 | . | . | . |
| 28 | *Ilex opaca* | . | . | . | . | . | 0.04 |
| 29 | *Juniperus virginiana* | . | . | 0.4 | . | . | . |
| 30 | *Lathyrus latifolius* | . | . | . | . | . | 0.04 |
| 31 | *Lechea maritima* | . | . | . | . | . | 0.1 |
| 32 | *Linaria vulgaris* | . | . | 0.02 | 0.2 | . | . |
| 33 | *Lonicera japonica* | . | . | 1.5 | 0.02 | 3.5 | 7.8 |
| 34 | *Morus alba* | 1.7 | **14.3** | 4.3 | . | 0.2 | . |
| 35 | *Myrica pensylvanica* | 0.2 | 0.2 | 0.9 | **15.0** | **17.5** | **16.9** |
| 36 | *Oenothera biennis* | . | . | . | . | . | 0.03 |
| 37 | *Onoclea sensibilis* | . | . | . | . | . | 0.1 |
| 38 | *Oxalis corniculata* | . | . | . | 0.04 | . | . |
| 39 | *Panicum virgatum* | . | . | . | . | . | 0.2 |
| 40 | *Parthenocissus quinquefolia* | . | 0.01 | 3.6 | **19.0** | **16.0** | 7.7 |
| 41 | *Phragmites australis* | 2.6 | . | 2.4 | **25.7** | 6.1 | 0.5 |
| 42 | *Phytolacca americana* | 0.1 | . | 0.1 | 0.2 | 0.1 | 0.2 |
| 43 | *Poaceae* sp.2 | . | . | . | . | 0.1 | . |
| 44 | *Polygonum scandens* | . | . | . | 0.2 | 0.1 | 0.02 |
| 45 | *Populus deltoides* | 0.01 | . | . | 1.6 | 0.6 | . |
| 46 | *Populus tremuloides* | **42.7** | 1.1 | 0.5 | 2.5 | . | 1.0 |
| 47 | *Prunus allegheniensis* | . | . | . | 0.1 | . | . |
| 48 | *Prunus serotina* | 2.6 | **45.7** | **23.6** | 4.7 | **11.7** | **16.5** |
| 49 | *Pyrus baccata* | . | . | . | 0.02 | . | . |
| 50 | *Pyrus sieboldii* | . | . | . | 0.3 | 0.1 | . |
| 51 | *Pyrus* sp. 1 | . | 0.03 | . | . | . | . |
| 52 | *Pyrus* sp. 2 | 0.1 | . | . | . | 0.02 | . |
| 53 | *Quercus rubra* | . | . | . | . | . | 0.04 |
| 54 | *Rhamnus frangula* | . | . | . | . | 0.2 | . |
| 55 | *Rhus copallina* | . | 2.8 | 4.5 | 0.1 | 0.4 | 3.8 |

Table 11. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Rhus glabra* | . | 0.1 | 0.3 | . | . | . |
| 57 | *Rhus typhina* | . | 0.6 | . | . | . | 1.9 |
| 58 | *Rosa multiflora* | 0.1 | . | 1.5 | 6.4 | 4.6 | 7.5 |
| 59 | *Rubus allegheniensis* | . | . | 0.7 | 2.0 | 4.1 | 4.4 |
| 60 | *Rubus laciniatus* | . | . | . | . | 0.02 | . |
| 61 | *Rubus pensilvanicus* | **12.3** | . | . | 0.02 | 4.0 | 0.7 |
| 62 | *Salix alba* | . | . | . | 0.3 | . | . |
| 63 | *Salix babilonica* | 0.3 | . | . | . | 0.2 | . |
| 64 | *Salix caprea* | . | . | . | 0.4 | . | . |
| 65 | *Salix discolor* | 0.07 | . | . | . | . | 0.3 |
| 66 | *Salix fragilis* | 0.2 | . | . | . | . | . |
| 67 | *Salix matsudana* | 0.1 | . | . | . | . | . |
| 68 | *Salix nigra* | 0.04 | . | . | 0.5 | 0.4 | . |
| 69 | *Salix* sp. | 0.1 | . | . | . | . | . |
| 70 | *Sambucus canadensis* | **15.6** | . | 0.1 | 0.5 | 1.1 | 0.4 |
| 71 | *Saponaria officinalis* | . | . | 0.7 | 0.04 | 0.4 | 0.04 |
| 72 | *Setaria glauca* | . | . | . | 0.1 | . | . |
| 73 | *Solanum dulcamara* | 0.7 | . | 0.7 | 1.6 | 0.2 | . |
| 74 | *Solidago canadensis* | . | . | 0.1 | . | . | 0.2 |
| 75 | *Solidago juncea* | 0.4 | . | 2.0 | . | 0.04 | 0.6 |
| 76 | *Solidago rugosa* | **12.4** | . | 3.3 | 1.7 | 0.4 | 2.5 |
| 77 | *Spirea tomentosa* | . | . | . | . | 0.02 | . |
| 78 | *Thelypteris simulata* | . | . | . | . | . | 0.2 |
| 79 | *Toxicodendron radicans* | . | . | 6.0 | 0.5 | **16.7** | 2.4 |
| 80 | Unidentified sp.1 | 0.4 | . | . | . | . | . |
| 81 | Unidentified sp.2 | . | . | . | 0.1 | . | . |
| 82 | Unidentified sp.3 | . | . | . | . | 0.1 | . |
| 83 | Unidentified sp.4 | . | . | . | . | 0.02 | . |
| 84 | *Verbascum thapsus* | . | . | . | . | 0.01 | . |
| 85 | *Viburnum dentatum* | . | . | . | 0.8 | 0.7 | 1.8 |

Table 12. The percentage cover values of the species included in the Phragmites Cluster Group using Chord Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster

| SPECIES | | *Phragmites* Cluster | *Phragmites-Parthenocissus* Cluster |
|---|---|---|---|
| 1 | *Ailanthus altissima* | . | 1.0 |
| 2 | *Ampelopsis brevipedunculata* | . | 0.3 |
| 3 | *Apocynum cannabinum* | . | 0.6 |
| 4 | *Artemisia vulgaris* | 0.1 | . |
| 5 | *Asclepias syriaca* | . | 0.3 |
| 6 | *Baccharis halimifolia* | . | 0.2 |
| 7 | *Celastrus orbiculatus* | . | 1.4 |
| 8 | *Cirsium arvense* | . | 0.5 |
| 9 | *Epilobium coloratum* | . | 0.04 |
| 10 | *Festuca rubra* | . | 0.2 |
| 11 | *Gleditsia triacanthos* | . | 0.9 |
| 12 | *Linaria vulgaris* | . | 0.1 |
| 13 | *Lonicera japonica* | 0.3 | . |
| 14 | *Oenothera biennis* | . | 0.3 |
| 15 | *Onoclea sensibilis* | . | 0.1 |
| 16 | *Parthenocissus quinquefolia* | . | **10.1** |
| 17 | *Phragmites australis* | **99.6** | **69.2** |
| 18 | *Phytolacca americana* | . | 3.6 |
| 19 | *Polygonum scandens* | . | 2.4 |
| 20 | *Rhus copallina* | . | 0.1 |
| 21 | *Rubus allegheniensis* | . | 5.6 |
| 22 | *Sambucus canadensis* | . | 0.02 |
| 23 | *Saponaria officinalis* | . | 0.4 |
| 24 | *Solanum dulcamara* | . | 1.3 |
| 25 | *Solidago rugosa* | . | 0.2 |
| 26 | *Toxicodendron radicans* | . | 1.1 |

Table 13. The percentage cover values of the species included in the Rhus-Rubus-Phragmites Cluster Group using Chord Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Rhus-Rubus-Solidago* Cluster | *Rhus-Celastrus-Myrica* Cluster | *Baccharis-Phragmites* Cluster | *Rubus-Phragmites* Cluster | *Phragmites-Rubus* Cluster | *Celastrus-Phragmites* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.1 | . | 0.4 | . | . | . |
| 2 | *Achillea millefolium* | . | 0.3 | . | . | 0.04 | . |
| 3 | *Agropyron repens* | . | . | . | . | . | 0.01 |
| 4 | *Ailanthus altissima* | 0.7 | 1.4 | 0.9 | . | 3.0 | 0.5 |
| 5 | *Ambrosia artemisiifolia* | 0.2 | . | . | . | . | . |
| 6 | *Ammophila breviligulata* | . | 0.1 | . | . | . | . |
| 7 | *Ampelopsis brevipedunculata* | . | . | . | 8.2 | 0.1 | 2.1 |
| 8 | *Anaphalis margaritacea* | . | 0.1 | . | . | . | . |
| 9 | *Andropogon scoparius* | . | 2.5 | . | . | . | . |
| 10 | *Apocynum cannabinum* | 2.1 | 0.1 | . | . | . | . |
| 11 | *Artemisia vulgaris* | 0.02 | 4.1 | . | 0.4 | 0.7 | 0.8 |
| 12 | *Asclepias syriaca* | . | 0.3 | . | . | . | 0.2 |
| 13 | *Aster pilosus* | . | 0.1 | . | . | . | . |
| 14 | *Baccharis halimifolia* | 4.7 | 0.5 | **27.7** | . | . | 0.3 |
| 15 | *Barbarea vulgaris* | . | . | . | . | . | 0.03 |
| 16 | *Betula populifolia* | 0.4 | 4.3 | 1.4 | . | . | . |
| 17 | *Bromus tectorum* | . | 2.0 | . | . | . | . |
| 18 | *Celastrus orbiculatus* | 0.9 | **15.8** | 4.8 | 2.9 | 8.3 | **27.2** |
| 19 | *Chenopodium album* | . | . | . | . | 0.1 | . |
| 20 | *Cirsium arvense* | 0.2 | . | . | . | . | 1.1 |
| 21 | *Corynephorus canescens* | . | 3.4 | . | . | . | . |
| 22 | *Cyperus bipartitus* | 0.6 | . | 0.1 | . | . | . |
| 23 | *Dianthus armeria* | . | 0.01 | . | . | . | . |
| 24 | *Elaeagnus angustifolia* | . | 0.2 | . | . | . | 0.1 |

Table 13. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Elaeagnus commutata* | . | 0.1 | 1.2 | . | . | 0.3 |
| 26 | *Epilobium coloratum* | . | . | . | 6.5 | . | . |
| 27 | *Equisetum arvensis* | . | 0.3 | . | . | . | . |
| 28 | *Eupatorium hyssopifolium* | 0.04 | 0.7 | 0.1 | . | . | . |
| 29 | *Eupatorium leucolepis* | 0.2 | 0.2 | . | . | . | . |
| 30 | *Eupatorium maculatum* | 0.03 | . | . | . | . | . |
| 31 | *Eupatorum rugosum* | 0.1 | 0.1 | . | . | 0.2 | . |
| 32 | *Euthamia graminifolia* | 0.02 | . | . | . | . | 0.01 |
| 33 | *Euthamia tenuifolia* | 0.8 | 1.9 | 0.3 | . | . | . |
| 34 | *Festuca rubra* | . | . | . | . | 8.2 | 0.5 |
| 35 | *Fragaria virginiana* | . | . | . | . | 0.5 | 0.5 |
| 36 | *Galium aparine* | 0.04 | . | . | . | . | . |
| 37 | *Gleditsia triacanthos* | . | . | . | . | . | 0.2 |
| 38 | *Hibiscus palustris* | 0.04 | . | . | . | . | . |
| 39 | *Hypericum perforatum* | . | 0.1 | 0.03 | . | . | . |
| 40 | *Juncus canadensis* | 0.2 | . | . | . | . | . |
| 41 | *Juncus gerardii* | . | . | 0.2 | . | . | . |
| 42 | *Juniperus virginiana* | . | 0.4 | . | . | . | . |
| 43 | *Lactuca canadensis* | . | . | . | . | 0.3 | . |
| 44 | *Lechea maritima* | . | 0.05 | . | . | . | . |
| 45 | *Linaria vulgaris* | 0.3 | 0.7 | 0.3 | . | 3.3 | 0.1 |
| 46 | *Lonicera japonica* | 3.0 | 0.4 | 1.9 | . | . | 0.6 |
| 47 | *Morus alba* | 0.02 | 0.01 | . | 1.7 | 0.2 | 3.1 |
| 48 | *Myrica pensylvanica* | 6.4 | **12.6** | 2.0 | . | 0.7 | 5.6 |
| 49 | *Oenothera biennis* | 0.1 | 0.1 | 0.05 | 0.6 | 0.1 | . |
| 50 | *Onoclea sensibilis* | 0.7 | 0.1 | . | 6.5 | . | . |
| 51 | *Osmunda cinnamomea* | 0.3 | . | . | . | . | . |
| 52 | *Osmunda regalis* | 0.3 | . | 0.2 | . | . | . |
| 53 | *Oxalis corniculata* | . | . | . | . | . | 0.1 |
| 54 | *Panicum lanuginosum* | 0.2 | . | . | . | . | . |
| 55 | *Panicum virgatum* | 0.03 | 0.4 | 0.2 | . | . | . |

Table 13. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Parthenocissus quinquefolia* | 6.3 | 3.3 | 6.6 | 2.1 | 10.0 | 5.0 |
| 57 | *Pastinaca sativa* | . | 0.4 | . | . | . | . |
| 58 | *Phragmites australis* | 9.4 | 3.2 | **15.8** | **17.0** | **29.0** | **27.9** |
| 59 | *Phytolacca americana* | . | 0.1 | . | 7.5 | 4.7 | 0.5 |
| 60 | *Poaceae sp.1* | 0.5 | . | . | . | . | . |
| 61 | *Polygonum hydropiperoides* | . | . | . | 0.2 | . | . |
| 62 | *Polygonum scandens* | 0.6 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 |
| 63 | *Populus deltoides* | . | . | . | . | . | 1.2 |
| 64 | *Populus tremuloides* | . | 0.9 | 5.1 | . | . | 1.2 |
| 65 | *Prunus allegheniensis* | . | . | . | . | . | 0.1 |
| 66 | *Prunus serotina* | 1.0 | 6.2 | 0.03 | . | 0.1 | 4.5 |
| 67 | *Pyrus sieboldii* | 0.5 | . | . | . | . | . |
| 68 | *Pyrus sp. 2* | 0.1 | . | . | . | . | . |
| 69 | *Quercus rubra* | . | 0.04 | . | . | . | . |
| 70 | *Rhus copallina* | **13.3** | **17.6** | 2.8 | 3.5 | **21.9** | 0.8 |
| 71 | *Rhus glabra* | 0.9 | . | 2.4 | . | 0.5 | . |
| 72 | *Rhus typhina* | 0.6 | . | 3.0 | . | . | . |
| 73 | *Rosa multiflora* | 0.3 | 0.2 | 0.1 | 0.2 | 0.4 | 1.8 |
| 74 | *Rubus allegheniensis* | **19.5** | 2.8 | 8.2 | **25.2** | 2.7 | 5.6 |
| 75 | *Rubus flagellaris* | . | . | . | . | 0.1 | . |
| 76 | *Rubus laciniatus* | 0.5 | 0.2 | 0.5 | . | . | 0.8 |
| 77 | *Rubus pensilvanicus* | . | . | . | . | 0.1 | 1.2 |
| 78 | *Rumex crispus* | . | . | . | . | . | 0.05 |
| 79 | *Salix alba* | . | . | . | . | . | 0.2 |
| 80 | *Salix caprea* | . | . | . | . | . | 0.3 |
| 81 | *Salix discolor* | . | . | 1.0 | 2.1 | . | . |
| 82 | *Salix nigra* | . | . | . | 1.6 | . | 0.4 |
| 83 | *Sambucus canadensis* | 0.3 | 0.1 | 2.6 | 2.4 | . | 1.4 |
| 84 | *Saponaria officinalis* | . | 0.9 | . | . | . | . |
| 85 | *Scirpus cyperinus* | 0.1 | . | . | . | . | . |
| 86 | *Setaria glauca* | . | . | . | . | . | 0.1 |

Table 13. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 87 | *Solanum dulcamara* | 0.2 | 0.5 | 0.6 | 6.6 | 1.8 | 1.6 |
| 88 | *Solidago canadensis* | 0.9 | 0.8 | . | . | 0.5 | 0.02 |
| 89 | *Solidago juncea* | 0.0 | 0.8 | . | . | 0.2 | . |
| 90 | *Solidago rugosa* | **11.7** | 5.8 | 0.2 | 2.3 | 2.3 | 1.7 |
| 91 | *Spirea tomentosa* | 0.8 | . | 0.1 | . | . | . |
| 92 | *Thelypteris palustris* | 0.2 | . | . | . | . | . |
| 93 | *Thelypteris simulata* | 0.4 | . | . | . | . | . |
| 94 | *Toxicodendron radicans* | 7.5 | 1.1 | 9.5 | 0.3 | . | 0.3 |
| 95 | *Verbascum blattaria* | . | . | . | 0.1 | . | . |
| 96 | *Verbascum thapsus* | . | 0.02 | . | . | . | . |
| 97 | *Verbena hastata* | . | . | . | 1.7 | . | . |
| 98 | *Viburnum dentatum* | 1.5 | 1.7 | . | 0.3 | 0.03 | . |

Table 14. The percentage cover values of the species included in the Prunus -Myrica Cluster Group using Chord Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Ailanthus-Morus-Prunus* Cluster | *Prunus* Cluster | *Celastrus-Prunus* Cluster | *Populus-Sambucus* Cluster | *Celastrus-Myrica-Parthenocissus* Cluster | *Parthenocissus-Myrica-Prunus* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | 0.1 | 0.3 | . |
| 2 | *Ailanthus altissima* | **37.3** | 4.0 | 0.2 | 0.01 | . | . |
| 3 | *Allium vineale* | . | . | . | . | 0.02 | . |
| 4 | *Andropogon scoparius* | . | . | . | . | 0.1 | . |
| 5 | *Apocynum cannabinum* | . | . | . | . | . | 0.01 |
| 6 | *Aronia arbutifolia* | . | . | . | . | . | 0.1 |
| 7 | *Artemisia vulgaris* | 1.4 | . | 0.6 | . | 0.3 | 1.0 |
| 8 | *Asclepias syriaca* | . | . | . | . | 0.1 | . |
| 9 | *Baccharis halimifolia* | 1.1 | . | . | . | 0.8 | . |
| 10 | *Betula populifolia* | . | 0.1 | . | 0.2 | 0.1 | 0.3 |
| 11 | *Celastrus orbiculatus* | 9.3 | 0.2 | **41.8** | 5.1 | **16.0** | 2.8 |
| 12 | *Celtis occidentalis* | 4.5 | . | 0.0 | . | . | . |
| 13 | *Corynephorus canescens* | . | . | . | . | 0.03 | . |
| 14 | *Elaeagnus commutata* | . | 0.1 | . | . | 0.4 | 1.1 |
| 15 | *Elaeagnus umbellata* | 1.3 | . | . | . | 0.1 | . |
| 16 | *Eupatorium leucolepis* | . | . | . | . | . | 0.04 |
| 17 | *Eupatorum rugosum* | 1.2 | . | 1.6 | . | . | . |
| 18 | *Euthamia tenuifolia* | . | . | . | . | 0.04 | . |
| 19 | *Ilex opaca* | . | . | . | . | 0.03 | . |
| 20 | *Lathyrus latifolius* | . | . | . | . | 0.03 | . |
| 21 | *Linaria vulgaris* | . | . | . | . | 0.01 | . |
| 22 | *Lonicera japonica* | 0.6 | . | 1.6 | . | 8.0 | 1.4 |
| 23 | *Morus alba* | **26.4** | 1.7 | 2.4 | 1.8 | . | 0.2 |
| 24 | *Myrica pensylvanica* | . | 0.4 | . | 0.2 | **14.0** | **19.7** |

Table 14. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Parthenocissus quinquefolia* | 2.9 | 0.02 | 1.9 | . | 8.4 | **21.4** |
| 26 | *Phragmites australis* | 0.05 | . | 0.8 | 0.2 | 2.7 | **11.8** |
| 27 | *Phytolacca americana* | . | . | . | 0.1 | 0.1 | 0.2 |
| 28 | *Poaceae* sp. 2 | . | . | . | . | 0.1 | . |
| 29 | *Polygonum scandens* | . | . | . | . | 0.1 | 0.01 |
| 30 | *Populus deltoides* | . | . | . | 0.01 | . | 0.7 |
| 31 | *Populus tremuloides* | . | 2.4 | 1.1 | **45.7** | 0.05 | 0.8 |
| 32 | *Prunus serotina* | **10.3** | **86.7** | **38.1** | 2.8 | **15.1** | **11.3** |
| 33 | *Pyrus baccata* | . | . | . | . | . | 0.01 |
| 34 | *Pyrus sieboldii* | . | . | . | . | 0.1 | 0.2 |
| 35 | *Pyrus* sp. 1 | . | 0.1 | . | . | . | . |
| 36 | *Pyrus* sp. 2 | . | . | . | 0.1 | . | 0.02 |
| 37 | *Rhamnus frangula* | . | . | . | . | . | 0.3 |
| 38 | *Rhus copallina* | 1.1 | 4.3 | . | . | 1.6 | 0.5 |
| 39 | *Rhus glabra* | 0.02 | 0.1 | 0.7 | . | 0.5 | . |
| 40 | *Rhus typhina* | 0.7 | . | . | . | 1.3 | 0.3 |
| 41 | *Rosa multiflora* | 0.3 | . | 3.0 | 0.1 | 3.1 | 9.5 |
| 42 | *Rosa virginiana* | . | . | . | . | 0.1 | . |
| 43 | *Rubus allegheniensis* | . | . | 0.6 | . | 6.5 | 0.8 |
| 44 | *Rubus laciniatus* | . | . | . | . | 0.03 | 0.03 |
| 45 | *Rubus pensilvanicus* | . | . | . | **11.6** | 3.2 | 1.7 |
| 46 | *Salix babilonica* | . | . | . | 0.3 | . | 0.3 |
| 47 | *Salix discolor* | . | . | . | 0.1 | 0.2 | . |
| 48 | *Salix fragilis* | . | . | . | 0.2 | . | . |
| 49 | *Salix matsudana* | . | . | . | 0.1 | . | . |
| 50 | *Salix nigra* | . | . | . | 0.04 | . | 0.5 |
| 51 | *Salix sp.* | . | . | . | 0.1 | . | . |
| 52 | *Sambucus canadensis* | . | . | 0.2 | **16.3** | 0.8 | 0.7 |
| 53 | *Saponaria officinalis* | . | . | . | . | 0.3 | 0.2 |
| 54 | *Solanum dulcamara* | 0.1 | . | 0.6 | 0.8 | . | 0.2 |
| 55 | *Solidago canadensis* | . | . | . | . | 0.2 | . |

Table 14. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Solidago juncea* | 1.1 | . | 3.2 | 0.4 | 0.3 | 0.1 |
| 57 | *Solidago rugosa* | . | . | 1.0 | **13.0** | 1.9 | 0.1 |
| 58 | *Thelypteris simulata* | . | . | . | . | 0.2 | . |
| 59 | *Toxicodendron radicans* | . | . | 0.6 | . | **12.6** | **10.6** |
| 60 | *Unidentified sp.1* | . | . | . | 0.5 | . | . |
| 61 | *Unidentified sp.2* | . | . | . | . | . | 0.04 |
| 62 | *Unidentified sp.3* | . | . | . | . | 0.1 | 0.1 |
| 63 | *Unidentified sp.4* | . | . | . | . | 0.02 | . |
| 64 | *Verbascum thapsus* | . | . | . | . | 0.01 | . |
| 65 | *Viburnum dentatum* | . | . | . | . | 0.2 | 1.0 |

Table 15. The percentage cover values of the species included in the Rhus-Rubus-Phragmites Cluster Group using Geodesic Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Rubus-Rhus-Solidago Cluster* | *Baccharis-Phragmites Cluster* | *Rubus-Betula Cluster* | *Rhus-Celastrus-Myrica Cluster* | *Phragmites-Rhus Cluster* | *Celastrus-Phragmites Cluster* |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.1 | 0.4 | . | . | . | . |
| 2 | *Achillea millefolium* | . | . | 0.8 | 0.05 | 0.04 | . |
| 3 | *Agropyron repens* | . | . | . | . | . | 0.01 |
| 4 | *Ailanthus altissima* | 0.7 | 0.9 | . | 1.9 | 3.0 | 0.4 |
| 5 | *Ambrosia artemisiifolia* | 0.2 | . | . | . | . | . |
| 6 | *Ammophila breviligulata* | . | . | . | 0.2 | . | . |
| 7 | *Ampelopsis brevipedunculata* | . | . | 0.4 | . | 0.1 | 5.3 |
| 8 | *Anaphalis margaritacea* | . | . | . | 0.1 | . | . |
| 9 | *Andropogon scoparius* | . | . | 0.3 | 3.1 | . | . |
| 10 | *Apocynum cannabinum* | 1.9 | . | 0.2 | . | . | . |
| 11 | *Artemisia vulgaris* | 0.02 | . | 9.9 | 0.5 | 0.7 | 0.8 |
| 12 | *Asclepias syriaca* | . | . | 0.6 | 0.1 | . | 0.1 |
| 13 | *Aster pilosus* | . | . | . | 0.1 | . | . |
| 14 | *Baccharis halimifolia* | 4.2 | 27.7 | 0.1 | 0.6 | . | 0.2 |
| 15 | *Barberea vulgaris* | . | . | . | . | . | 0.02 |
| 16 | *Betula populifolia* | 0.4 | 1.4 | **11.6** | . | . | . |
| 17 | *Bromus tectorum* | . | . | 2.7 | 1.3 | . | . |
| 18 | *Celastrus orbiculatus* | 0.8 | 4.8 | 7.5 | **17.4** | 8.3 | **22.3** |
| 19 | *Chenopodium album* | . | . | . | . | 0.1 | . |
| 20 | *Cirsium arvense* | 0.1 | . | . | . | . | 0.8 |
| 21 | *Corynephorus canescens* | . | . | 0.8 | 4.1 | . | . |
| 22 | *Cyperus bipartitus* | 0.5 | 0.1 | . | . | . | . |
| 23 | *Dianthus armeria* | . | . | . | 0.01 | . | . |
| 24 | *Elaeagnus angustifolia* | . | . | 0.5 | . | . | 0.05 |

Table 15. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Elaeagnus commutata* | . | 1.2 | 0.1 | 0.1 | . | 0.2 |
| 26 | *Epilobium coloratum* | . | . | 7.9 | . | . | 0.2 |
| 27 | *Equisetum arvensis* | . | . | 0.9 | . | . | . |
| 28 | *Eupatorium hyssopifolium* | 0.03 | 0.1 | 0.1 | 0.9 | . | . |
| 29 | *Eupatorium leucolepis* | 0.2 | . | . | 0.3 | . | . |
| 30 | *Eupatorium maculatum* | 0.03 | . | . | . | . | . |
| 31 | *Eupatorum rugosum* | 0.05 | . | . | 0.1 | 0.2 | . |
| 32 | *Euthamia graminifolia* | 0.02 | . | . | . | . | 0.01 |
| 33 | *Euthamia tenuifolia* | 0.7 | 0.3 | . | 2.6 | . | . |
| 34 | *Festuca rubra* | . | . | . | . | 8.2 | 0.4 |
| 35 | *Fragaria virginiana* | . | . | . | . | 0.5 | 0.4 |
| 36 | *Galium aparine* | 0.04 | . | . | . | . | . |
| 37 | *Gleditsia triacanthos* | . | . | . | . | . | 0.1 |
| 38 | *Hibiscus palustris* | 0.04 | . | . | . | . | . |
| 39 | *Hypericum perforatum* | . | 0.03 | 0.2 | . | . | . |
| 40 | *Juncus canadensis* | 0.2 | . | . | . | . | . |
| 41 | *Juncus gerardii* | . | 0.2 | . | . | . | . |
| 42 | *Juniperus virginiana* | . | . | . | 0.5 | . | . |
| 43 | *Lactuca canadensis* | . | . | . | . | 0.3 | . |
| 44 | *Lechea maritima* | . | . | . | 0.1 | . | . |
| 45 | *Linaria vulgaris* | 0.3 | 0.3 | 0.6 | 0.6 | 3.3 | 0.1 |
| 46 | *Lonicera japonica* | 2.7 | 1.9 | 0.4 | 0.4 | . | 0.5 |
| 47 | *Morus alba* | 0.01 | . | . | 0.02 | 0.2 | 3.2 |
| 48 | *Myrica pensylvanica* | 5.7 | 2.0 | 1.9 | **15.8** | 0.7 | 4.3 |
| 49 | *Oenothera biennis* | 0.1 | 0.05 | 0.6 | 0.1 | 0.1 | 0.1 |
| 50 | *Onoclea sensibilis* | 0.6 | . | 8.8 | . | . | . |
| 51 | *Osmunda cinnamomea* | 0.2 | . | . | . | . | . |
| 52 | *Osmunda regalis* | 0.3 | 0.2 | . | . | . | . |
| 53 | *Oxalis corniculata* | . | . | . | . | . | 0.1 |
| 54 | *Panicum lanuginosum* | 0.1 | . | . | . | . | . |
| 55 | *Panicum virgatum* | 0.0 | 0.2 | . | 0.5 | . | . |

Table 15. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Parthenocissus quinquefolia* | 6.1 | 6.6 | 5.2 | 1.9 | **10.0** | 4.3 |
| 57 | *Pastinaca sativa* | . | . | 1.0 | . | . | . |
| 58 | *Phragmites australis* | 9.6 | **15.8** | 0.5 | 4.2 | **29.0** | **27.9** |
| 59 | *Phytolacca americana* | . | . | 0.1 | 0.1 | 4.7 | 3.8 |
| 60 | *Poaceae sp.1* | 0.5 | . | . | . | . | . |
| 61 | *Polygonum hydropiperoides* | . | . | 0.3 | . | . | . |
| 62 | *Polygonum scandens* | 0.6 | 0.1 | . | 0.2 | 0.1 | 0.1 |
| 63 | *Populus deltoides* | . | . | . | . | . | 0.9 |
| 64 | *Populus tremuloides* | . | 5.1 | 2.3 | . | . | 0.9 |
| 65 | *Prunus allegheniensis* | . | . | . | . | . | 0.04 |
| 66 | *Prunus serotina* | 0.9 | 0.03 | 1.9 | 7.3 | 0.1 | 3.5 |
| 67 | *Pyrus sieboldii* | 0.4 | . | . | . | . | . |
| 68 | *Pyrus* sp. 2 | 0.1 | . | . | . | . | . |
| 69 | *Quercus rubra* | . | . | 0.1 | . | . | . |
| 70 | *Rhus copallina* | **13.3** | 2.8 | . | **23.5** | **21.9** | 0.6 |
| 71 | *Rhus glabra* | 0.8 | 2.4 | . | . | 0.5 | . |
| 72 | *Rhus typhina* | 0.5 | 3.0 | . | . | . | . |
| 73 | *Rosa multiflora* | 0.3 | 0.1 | . | 0.3 | 0.4 | 1.5 |
| 74 | *Rubus allegheniensis* | **23.3** | 8.2 | **11.8** | 2.0 | 2.7 | 6.8 |
| 75 | *Rubus flagellaris* | . | . | . | . | 0.1 | . |
| 76 | *Rubus laciniatus* | 0.4 | 0.5 | . | 0.3 | . | 0.6 |
| 77 | *Rubus pensilvanicus* | . | . | . | . | 0.1 | 0.9 |
| 78 | *Rumex crispus* | . | . | . | . | . | 0.04 |
| 79 | *Salix alba* | . | . | . | . | . | 0.2 |
| 80 | *Salix caprea* | . | . | . | . | . | 0.3 |
| 81 | *Salix discolor* | . | 1.0 | 2.8 | . | . | . |
| 82 | *Salix nigra* | . | . | 2.1 | . | . | 0.3 |
| 83 | *Sambucus canadensis* | 0.7 | 2.6 | 0.2 | 0.05 | . | 1.7 |
| 84 | *Saponaria officinalis* | . | . | 0.8 | 0.8 | . | . |
| 85 | *Scirpus cyperinus* | 0.1 | . | . | . | . | . |
| 86 | *Setaria glauca* | . | . | . | . | . | 0.1 |

Table 15. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 87 | *Solanum dulcamara* | 1.3 | 0.6 | 1.8 | 0.6 | 1.8 | 2.4 |
| 88 | *Solidago canadensis* | 0.8 | . | . | 1.0 | 0.5 | 0.01 |
| 89 | *Solidago juncea* | 0.03 | . | 0.1 | 1.0 | 0.2 | . |
| 90 | *Solidago rugosa* | **10.5** | 0.2 | 7.7 | 3.9 | 2.3 | 2.3 |
| 91 | *Spirea tomentosa* | 0.8 | 0.1 | . | . | . | . |
| 92 | *Thelypteris palustris* | 0.2 | . | . | . | . | . |
| 93 | *Thelypteris simulata* | 0.4 | . | . | . | . | . |
| 94 | *Toxicodendron radicans* | 6.7 | 9.5 | 0.1 | 1.4 | . | 0.3 |
| 95 | *Verbascum blattaria* | . | . | . | . | . | 0.1 |
| 96 | *Verbascum thapsus* | . | . | . | 0.03 | . | . |
| 97 | *Verbena hastata* | . | . | . | . | . | 0.8 |
| 98 | *Viburnum dentatum* | 1.4 | . | 4.5 | . | 0.03 | 0.1 |

Table 16. The percentage cover values of the species included in the <u>Myrica</u> -<u>Prunus</u> Cluster Group using Geodesic Distance and Minimum Variance as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Ailanthus Morus Prunus* Cluster | *Prunus* Cluster | *Celastrus Prunus* Cluster | *Populus Sambucus* Cluster | *Celastrus Myrica Toxicodendron* Cluster | *Myrica Parthenocissus Prunus* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | 0.1 | 0.3 | . |
| 2 | *Ailanthus altissima* | **37.3** | 4.0 | 0.2 | 0.0 | . | . |
| 3 | *Allium vineale* | . | . | . | . | 0.0 | . |
| 4 | *Andropogon scoparius* | . | . | . | . | 0.1 | . |
| 5 | *Apocynum cannabinum* | . | . | . | . | . | 0.0 |
| 6 | *Aronia arbutifolia* | . | . | . | . | . | 0.1 |
| 7 | *Artemisia vulgaris* | 1.4 | . | 0.6 | . | 0.3 | 1.0 |
| 8 | *Asclepias syriaca* | . | . | . | . | 0.1 | . |
| 9 | *Baccharis halimifolia* | 1.1 | . | . | . | 0.8 | . |
| 10 | *Betula populifolia* | . | 0.1 | . | 0.2 | 0.1 | 0.3 |
| 11 | *Celastrus orbiculatus* | 9.3 | 0.2 | **41.8** | 5.1 | **16.0** | 2.8 |
| 12 | *Celtis occidentalis* | 4.5 | . | 0.0 | . | . | . |
| 13 | *Corynephorus canescens* | . | . | . | . | 0.0 | . |
| 14 | *Elaeagnus commutata* | . | 0.1 | . | . | 0.4 | 1.1 |
| 15 | *Elaeagnus umbellata* | 1.3 | . | . | . | 0.1 | . |
| 16 | *Eupatorium leucolepis* | . | . | . | . | . | 0.0 |
| 17 | *Eupatorum rugosum* | 1.2 | . | 1.6 | . | . | . |
| 18 | *Euthamia tenuifolia* | . | . | . | . | 0.0 | . |
| 19 | *Ilex opaca* | . | . | . | . | 0.0 | . |
| 20 | *Lathyrus latifolius* | . | . | . | . | 0.0 | . |
| 21 | *Linaria vulgaris* | . | . | . | . | 0.0 | . |
| 22 | *Lonicera japonica* | 0.6 | . | 1.6 | . | 8.0 | 1.4 |
| 23 | *Morus alba* | **26.4** | 1.7 | 2.4 | 1.8 | . | 0.2 |
| 24 | *Myrica pensylvanica* | . | 0.4 | . | 0.2 | **14.0** | **19.7** |
| 25 | *Parthenocissus quinquefolia* | 2.9 | 0.0 | 1.9 | . | 8.4 | **21.4** |
| 26 | *Phragmites australis* | 0.0 | . | 0.8 | 0.2 | 2.7 | **11.8** |

Table 16. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | *Phytolacca americana* | . | . | . | 0.1 | 0.1 | 0.2 |
| 28 | *Poaceae sp2* | . | . | . | . | 0.1 | . |
| 29 | *Polygonum scandens* | . | . | . | . | 0.1 | 0.0 |
| 30 | *Populus deltoides* | . | . | . | 0.0 | . | 0.7 |
| 31 | *Populus tremuloides* | . | 2.4 | 1.1 | **45.7** | 0.0 | 0.8 |
| 32 | *Prunus serotina* | **10.3** | **86.7** | **38.1** | 2.8 | **15.1** | **11.3** |
| 33 | *Pyrus baccata* | . | . | . | . | . | 0.0 |
| 34 | *Pyrus sieboldii* | . | . | . | . | 0.1 | 0.2 |
| 35 | *Pyrus* sp. 1 | . | 0.1 | . | . | . | . |
| 36 | *Pyrus* sp. 2 | . | . | . | 0.1 | . | 0.0 |
| 37 | *Rhamnus frangula* | . | . | . | . | . | 0.3 |
| 38 | *Rhus copallina* | 1.1 | 4.3 | . | . | 1.6 | 0.5 |
| 39 | *Rhus glabra* | 0.0 | 0.1 | 0.7 | . | 0.5 | . |
| 40 | *Rhus typhina* | 0.7 | . | . | . | 1.3 | 0.3 |
| 41 | *Rosa multiflora* | 0.3 | . | 3.0 | 0.1 | 3.1 | 9.5 |
| 42 | *Rosa virginiana* | . | . | . | . | 0.1 | . |
| 43 | *Rubus allegheniensis* | . | . | 0.6 | . | 6.5 | 0.8 |
| 44 | *Rubus laciniatus* | . | . | . | . | 0.0 | 0.0 |
| 45 | *Rubus pensilvanicus* | . | . | . | 11.6 | 3.2 | 1.7 |
| 46 | *Salix babilonica* | . | . | . | 0.3 | . | 0.3 |
| 47 | *Salix discolor* | . | . | . | 0.1 | 0.2 | . |
| 48 | *Salix fragilis* | . | . | . | 0.2 | . | . |
| 49 | *Salix matsudana* | . | . | . | 0.1 | . | . |
| 50 | *Salix nigra* | . | . | . | 0.0 | . | 0.5 |
| 51 | *Salix sp.* | . | . | . | 0.1 | . | . |
| 52 | *Sambucus canadensis* | . | . | 0.2 | **16.3** | 0.8 | 0.7 |
| 53 | *Saponaria officinalis* | . | . | . | . | 0.3 | 0.2 |
| 54 | *Solanum dulcamara* | 0.1 | . | 0.6 | 0.8 | . | 0.2 |
| 55 | *Solidago canadensis* | . | . | . | . | 0.2 | . |
| 56 | *Solidago juncea* | 1.1 | . | 3.2 | 0.4 | 0.3 | 0.1 |
| 57 | *Solidago rugosa* | . | . | 1.0 | **13.0** | 1.9 | 0.1 |

Table 16. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 58 | *Thelypteris simulata* | . | . | . | . | 0.2 | . |
| 59 | *Toxicodendron radicans* | . | . | 0.6 | . | **12.6** | **10.6** |
| 60 | *Unidentified sp.1* | . | . | . | 0.5 | . | . |
| 61 | *Unidentified sp.2* | . | . | . | . | . | 0.0 |
| 62 | *Unidentified sp.3* | . | . | . | . | 0.1 | 0.1 |
| 63 | *Unidentified sp.4* | . | . | . | . | 0.0 | . |
| 64 | *Verbascum thapsus* | . | . | . | . | 0.0 | . |
| 65 | *Viburnum dentatum* | . | . | . | . | 0.2 | 1.0 |

Table 17. Comparison of clusters recognized by the different clustering algorithms using Minimum Variance. The + sign indicates the presence and - indicates the absence of a particular cluster in the dendrogram produced by each method. The clusters with numbers in bold face are recognized by at least 4 methods.

| CLUSTER | | Bray Curtis | Chord | Euclidean | Geodesic | Similarity Ratio |
|---|---|---|---|---|---|---|
| **1** | *Phragmites* cluster | + | + | + | + | + |
| **2** | *Phragmites -Parthenocissus* cluster | + | + | + | + | - |
| **3** | *Phragmites -Celastrus* cluster | + | + | + | + | + |
| **4** | *Baccharis Phragmites* cluster | + | + | + | + | + |
| **5** | *Rubus -Rhus -Solidago* cluster | + | + | + | + | + |
| **6** | *Andropogon* cluster | + | + | + | + | + |
| **7** | *Andropogon -Ammophila -Panicum* cluster | + | + | + | + | + |
| **8** | *Rhus -Myrica* cluster | + | + | + | + | + |
| **9** | *Celastrus -Prunus* cluster | + | + | + | + | + |
| **10** | *Prunus* cluster | - | + | + | + | + |
| **11** | *Populus -Sambucus -Solidago* cluster | + | + | + | + | + |
| **12** | *Ailanthus -Morus* cluster | + | + | + | + | + |
| 13 | *Prunus-Myrica-Celastrus* cluster | + | - | + | - | + |
| 14 | *Myrica -Betula* cluster | - | - | + | - | - |
| 15 | *Morus-Celastrus-Betula* cluster | - | - | - | - | + |
| 16 | *Rubus-Betula* cluster | - | - | - | + | - |
| 17 | *Rhus-Rubus* cluster | - | + | + | - | - |
| 18 | *Phragmites -Rubus* cluster | + | - | - | - | + |
| 19 | *Phragmites-Myrica-Parthenocissus* cluster | + | - | - | - | - |
| 20 | *Phragmites -Rhus* cluster | - | + | - | + | + |
| 21 | *Myrica -Parthenocissus -Toxicodendron* cluster | + | - | + | - | - |
| 22 | *Celastrus- Myrica-Toxicodendron* cluster | - | + | - | + | - |
| 23 | *Myrica -Parthenocissus-Prunus* cluster | - | + | - | + | + |

Table 18. The percentage cover values of the species included in the Phragmites -Rhus-Rubus Cluster Group using Euclidean Distance and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Phragmites-Parthenocissus* Cluster | *Rhus-Myrica* Cluster | *Phragmites-Celastrus-Rhus* Cluster | *Phragmites-Parthenocissus-Baccharis* Cluster | *Rubus-Rhus-Solidago* Cluster | *Celastrus-Rubus* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | . | 0.3 | . |
| 2 | *Achillea millefolium* | . | 0.1 | . | . | . | . |
| 3 | *Agropyron repens* | . | . | 0.0 | . | . | . |
| 4 | *Ailanthus altissima* | 0.9 | 2.9 | 0.2 | 0.4 | 0.7 | 3.1 |
| 5 | *Ambrosia artemisiifolia* | . | . | . | . | 0.2 | . |
| 6 | *Amophila breviligulata* | . | 0.2 | . | . | . | . |
| 7 | *Ampelopsis brevipedunculata* | 0.9 | . | 3.8 | . | 0.1 | 7.2 |
| 8 | *Anaphalis margaritacea* | . | 0.1 | . | . | . | . |
| 9 | *Andropogon scoparius* | . | 2.7 | . | . | . | . |
| 10 | *Apocynum cannabinum* | 0.5 | . | . | . | 2.0 | . |
| 11 | *Artemisia vulgaris* | 0.1 | . | 0.8 | 0.4 | 0.0 | . |
| 12 | *Asclepias syriaca* | 0.3 | 0.0 | . | 0.2 | . | . |
| 13 | *Aster pilosus* | . | 0.0 | . | . | . | . |
| 14 | *Baccharis halimifolia* | 0.2 | 2.4 | . | **11.7** | 4.5 | . |
| 15 | *Barbarea vulgaris* | . | . | . | . | . | 0.2 |
| 16 | *Betula populifolia* | . | 0.2 | . | . | 0.7 | . |
| 17 | *Bromus tectorum* | . | 1.1 | . | . | . | . |
| 18 | *Celastrus orbiculatus* | 1.9 | 6.8 | **18.7** | 4.6 | 0.9 | **57.7** |
| 19 | *Chenopodium album* | . | 0.0 | . | . | . | . |
| 20 | *Cirsium arvense* | 0.4 | 0.2 | . | 1.2 | 0.0 | . |
| 21 | *Corynephorus canescens* | . | 3.4 | . | . | . | . |
| 22 | *Cyperus bipartitus* | . | . | . | 0.0 | 0.5 | . |
| 23 | *Dianthus armeria* | . | 0.0 | . | . | . | . |
| 24 | *Elaeagnus angustifolia* | . | . | . | 0.1 | . | . |
| 25 | *Elaeagnus commutata* | . | 0.1 | . | 0.9 | . | . |

Table 18. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 26 | *Epilobium colaratum* | 0.3 | . | . | . | 2.6 | . |
| 27 | *Eupatorium hyssopifolium* | . | 0.8 | . | 0.0 | 0.0 | . |
| 28 | *Eupatorium leucolepis* | . | 0.4 | . | 0.1 | 0.0 | . |
| 29 | *Eupatorium maculatum* | . | 0.0 | . | . | 0.0 | . |
| 30 | *Eupatorum rugosum* | . | 0.2 | . | . | 0.0 | . |
| 31 | *Euthamia graminifolia* | . | . | . | 0.0 | 0.0 | . |
| 32 | *Euthamia tenuifolia* | . | 2.6 | . | 0.1 | 0.4 | . |
| 33 | *Festuca rubra* | 0.2 | 0.7 | 3.4 | . | . | . |
| 34 | *Fragaria virginiana* | . | . | 0.6 | . | . | . |
| 35 | *Galium aparine* | . | . | . | . | 0.0 | . |
| 36 | *Gleditsia triacanthos* | 0.7 | . | . | . | . | 1.0 |
| 37 | *Hibiscus palustris* | . | . | . | . | 0.0 | . |
| 38 | *Hypericum perforatum* | . | . | . | 0.0 | . | . |
| 39 | *Juncus canadensis* | . | . | . | . | 0.2 | . |
| 40 | *Juncus gerardii* | . | . | . | 0.1 | . | . |
| 41 | *Lactuca canadensis* | . | . | 0.2 | . | . | . |
| 42 | *Lechea maritima* | . | 0.1 | . | . | . | . |
| 43 | *Linaria vulgaris* | 0.1 | 1.8 | 0.8 | 0.1 | 0.1 | . |
| 44 | *Lonicera japonica* | 0.2 | 2.9 | 0.0 | 0.9 | 0.8 | . |
| 45 | *Morus alba* | . | 0.0 | 2.9 | . | . | . |
| 46 | *Myrica pensylvanica* | . | **18.9** | 2.0 | 9.2 | 2.9 | . |
| 47 | *Oenothera biennis* | 0.4 | 0.1 | 0.1 | 0.0 | 0.2 | . |
| 48 | *Onoclea sensibilis* | 0.1 | . | . | . | 3.5 | . |
| 49 | *Osmunda cinnamomea* | . | . | . | . | 0.2 | . |
| 50 | *Osmunda regalis* | . | . | . | 0.1 | 0.3 | . |
| 51 | *Oxalis corniculata* | . | . | . | 0.0 | . | 0.3 |
| 52 | *Panicum lanuginosum* | . | . | . | . | 0.2 | . |
| 53 | *Panicum virgatum* | . | 0.4 | . | 0.1 | 0.0 | . |
| 54 | *Parthenocissus quinquefolia* | 8.8 | 4.4 | 4.6 | **18.4** | 5.4 | 1.1 |
| 55 | *Phragmites australis* | **65.8** | 5.9 | **32.5** | **24.6** | 8.9 | 5.0 |
| 56 | *Phytolacca americana* | 4.3 | 0.0 | 4.6 | 0.1 | 0.0 | . |

Table 18. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 57 | *Poaceae sp.1* | . | . | . | . | 0.5 | . |
| 58 | *Polygonum hydropiperoides* | . | . | . | . | 0.1 | . |
| 59 | *Polygonum scandens* | 2.0 | 0.2 | 0.0 | 0.2 | 0.7 | . |
| 60 | *Populus deltoides* | . | . | 0.9 | . | . | . |
| 61 | *Populus tremuloides* | . | . | 0.4 | 3.5 | . | . |
| 62 | *Prunus allegheniensis* | . | 0.1 | . | . | . | . |
| 63 | *Prunus serotina* | . | 1.9 | 2.8 | 2.0 | 0.8 | . |
| 64 | *Pyrus baccata* | . | . | . | 0.0 | . | . |
| 65 | *Pyrus sieboldii* | . | 0.4 | . | 0.0 | 0.2 | . |
| 66 | *Pyrus sp. 2* | . | 0.1 | . | . | 0.1 | . |
| 67 | *Rhus copallina* | 0.1 | **20.2** | **10.1** | 1.4 | 9.8 | 6.7 |
| 68 | *Rhus glabra* | . | 0.3 | . | 0.1 | 1.6 | . |
| 69 | *Rhus typhina* | . | . | . | 0.0 | 1.5 | . |
| 70 | *Rosa multiflora* | . | 1.9 | 0.5 | 3.0 | 0.0 | . |
| 71 | *Rubus allegheniensis* | 7.7 | 5.8 | 2.6 | 3.7 | **24.8** | **11.1** |
| 72 | *Rubus flagellaris* | . | 0.1 | . | . | . | . |
| 73 | *Rubus laciniatus* | . | 0.5 | . | 0.2 | 0.3 | 5.5 |
| 74 | *Rubus pensilvanicus* | . | . | 0.9 | 0.0 | . | . |
| 75 | *Rumex crispus* | . | . | . | . | . | 0.3 |
| 76 | *Salix alba* | . | . | 0.2 | . | . | . |
| 77 | *Salix babylonica* | . | . | . | 0.4 | . | . |
| 78 | *Salix caprea* | . | . | 0.2 | . | . | . |
| 79 | *Salix discolor* | . | . | . | 0.5 | 0.9 | . |
| 80 | *Salix nigra* | . | . | 0.3 | 0.8 | 0.7 | . |
| 81 | *Sambucus canadensis* | 0.7 | 0.2 | 0.9 | 0.5 | 1.2 | 0.5 |
| 82 | *Saponaria officinalis* | 0.3 | 0.1 | . | 0.0 | . | . |
| 83 | *Scirpus cyperinus* | . | . | . | . | 0.1 | . |
| 84 | *Setaria glauca* | . | . | . | 0.1 | . | . |
| 85 | *Solanum dulcamara* | 1.6 | 0.2 | 1.9 | 1.2 | 2.0 | 0.1 |
| 86 | *Solidago canadensis* | . | 0.9 | 0.2 | . | 0.8 | 0.1 |
| 87 | *Solidago juncea* | . | 0.7 | 0.1 | . | . | . |

Table 18. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 88 | *Solidago rugosa* | 0.5 | 5.6 | 2.0 | 0.1 | 9.6 | . |
| 89 | *Spirea tomentosa* | . | . | . | 0.0 | 0.8 | . |
| 90 | *Thelypteris palustris* | . | . | . | . | 0.2 | . |
| 91 | *Thelypteris simulata* | . | . | . | . | 0.4 | . |
| 92 | *Toxicodendron radicans* | 1.1 | 1.2 | 0.2 | 7.8 | 6.1 | . |
| 93 | *Verbascum blattaria* | . | . | 0.1 | . | . | . |
| 94 | *Verbascum thapsus* | . | 0.0 | . | . | . | . |
| 95 | *Verbena hastata* | 0.2 | . | 0.6 | . | . | . |
| 96 | *Viburnum dentatum* | . | 0.4 | 0.1 | 0.7 | 1.1 | . |

Table 19. The percentage cover values of the species included in the Prunus -Myrica Cluster Group using Euclidean Distance and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Prunus* Cluster | *Prunus-Celastrus-Myrica* Cluster | *Myrica-Parthenocissus* Cluster | *Populus-Sambucus* Cluster | *Ailanthus-Morus* Cluster | *Artemisia-Solidago* Cluster | *Betula* Cluster |
|---|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | 0.2 | . | 0.1 | . | . | . |
| 2 | *Achillea millefolium* | . | 0.1 | . | . | . | . | . |
| 3 | *Ailanthus altissima* | 3.2 | 0.3 | . | 0.0 | **62.6** | . | . |
| 4 | *Allium vineale* | . | 0.0 | . | . | . | . | . |
| 5 | *Andropogon scoparius* | . | 0.1 | . | . | . | . | . |
| 6 | *Apocynum cannabinum* | . | 0.0 | 0.0 | . | . | . | . |
| 7 | *Aronia arbutifolia* | . | 0.1 | . | . | . | . | . |
| 8 | *Artemisia vulgaris* | . | 1.1 | . | . | . | **43.0** | . |
| 9 | *Asclepias syriaca* | . | 0.1 | . | . | . | 1.8 | . |
| 10 | *Aster pilosus* | . | 0.0 | . | . | . | . | . |
| 11 | *Baccharis halimifolia* | . | 0.4 | . | . | 2.0 | . | . |
| 12 | *Betula populifolia* | 0.1 | 0.4 | . | 0.2 | . | . | **94.6** |
| 13 | *Bromus tectorum* | . | . | . | . | . | **12.2** | . |
| 14 | *Celastrus orbiculatus* | 0.1 | **18.9** | 1.2 | 5.1 | 0.2 | **18.1** | . |
| 15 | *Celtis occidentalis* | 6.3 | 0.0 | . | . | . | . | . |
| 16 | *Corynephorus canescens* | . | 0.2 | . | . | . | . | . |
| 17 | *Elaeagnus angustifolia* | . | 0.1 | . | . | . | . | . |
| 18 | *Elaeagnus commutata* | 0.0 | 0.7 | 0.1 | . | . | . | . |
| 19 | *Elaeagnus umbellata* | 1.8 | 0.1 | . | . | . | . | . |
| 20 | *Equisetum arvensis* | . | 0.1 | . | . | . | . | . |
| 21 | *Eupatorium hyssopifolium* | . | . | . | . | . | 0.6 | . |
| 22 | *Eupatorum rugosum* | . | 0.4 | . | . | . | . | . |
| 23 | *Euthamia tenuifolia* | . | 0.0 | . | . | . | . | . |
| 24 | *Hypericum perforatum* | . | . | . | . | . | 0.8 | . |
| 25 | *Ilex opaca* | . | 0.0 | . | . | . | . | . |

Table 19. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 26 | *Juniperus virginiana* | . | 0.1 | . | . | . | . | . |
| 27 | *Lathyrus latifolius* | . | 0.0 | . | . | . | . | . |
| 28 | *Linaria vulgaris* | . | 0.1 | . | . | . | . | . |
| 29 | *Lonicera japonica* | . | 4.9 | 2.4 | . | . | . | . |
| 30 | *Morus alba* | 7.3 | 1.5 | 0.5 | 1.8 | **23.1** | . | . |
| 31 | *Myrica pensylvanica* | 0.3 | **10.3** | **26.7** | 0.2 | . | . | 5.4 |
| 32 | *Onoclea sensibilis* | . | 0.0 | . | . | . | . | . |
| 33 | *Parthenocissus quinquefolia* | 0.0 | 8.6 | **22.6** | . | . | . | . |
| 34 | *Pastinaca sativa* | . | 0.1 | . | . | . | . | . |
| 35 | *Phragmites australis* | . | 2.9 | 3.7 | 0.2 | . | . | . |
| 36 | *Phytolacca americana* | . | 0.1 | 0.3 | 0.1 | . | . | . |
| 37 | *Poaceae sp. 2* | . | 0.1 | . | . | . | . | . |
| 38 | *Polygonum scandens* | . | 0.0 | . | . | . | . | . |
| 39 | *Populus deltoides* | . | . | 1.8 | 0.0 | . | . | . |
| 40 | *Populus tremuloides* | 1.9 | 0.5 | 1.7 | **45.7** | . | . | . |
| 41 | *Prunus serotina* | **74.0** | **19.7** | 4.9 | 2.8 | **10.3** | . | . |
| 42 | *Pyrus sieboldii* | . | 0.1 | 0.4 | . | . | . | . |
| 43 | *Pyrus* sp. 1 | 0.1 | . | . | . | . | . | . |
| 44 | *Pyrus* sp. 2 | . | 0.0 | . | 0.1 | . | . | . |
| 45 | *Quercus rubra* | . | 0.0 | . | . | . | . | . |
| 46 | *Rhamnus frangula* | . | 0.0 | 0.6 | . | . | . | . |
| 47 | *Rhus copallina* | 3.6 | 2.6 | . | . | 1.7 | . | . |
| 48 | *Rhus glabra* | 0.1 | 0.4 | . | . | 0.0 | . | . |
| 49 | *Rhus typhina* | 1.0 | 0.8 | . | . | . | . | . |
| 50 | *Rosa multiflora* | . | 3.6 | **12.6** | 0.1 | . | . | . |
| 51 | *Rosa virginiana* | . | 0.1 | . | . | . | . | . |
| 52 | *Rubus allegheniensis* | . | 4.4 | 0.5 | . | . | . | . |
| 53 | *Rubus laciniatus* | . | 0.0 | 0.1 | . | . | . | . |
| 54 | *Rubus pensilvanicus* | . | 2.2 | 1.3 | **11.6** | . | . | . |
| 55 | *Salix babylonica* | | | | 0.3 | | | |
| 56 | *Salix discolor* | . | 0.1 | . | 0.1 | . | . | . |

Table 19. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 57 | *Salix fragilis* | | | | 0.2 | | | |
| 58 | *Salix matsudana* | . | . | . | 0.1 | . | . | . |
| 59 | *Sanix nigra* | | | | 0.0 | | | |
| 60 | *Salix* sp. 1 | | | | 0.1 | | | |
| 61 | *Sambucus canadensis* | . | 0.6 | 1.4 | **16.3** | . | . | . |
| 62 | *Saponaria officinalis* | . | 0.5 | . | . | . | 1.2 | . |
| 63 | *Solanum dulcamara* | . | 0.3 | 0.5 | 0.8 | . | . | . |
| 64 | *Solidago canadensis* | . | 0.1 | . | . | . | . | . |
| 65 | *Solidago juncea* | . | 0.9 | . | 0.4 | . | . | . |
| 66 | *Solidago rugosa* | . | 1.8 | 0.2 | **13.0** | . | **22.3** | . |
| 67 | *Thelypteris simulata* | . | 0.1 | . | . | . | . | . |
| 68 | *Toxicodendron radicans* | . | 8.5 | **14.8** | . | . | . | . |
| 69 | Unidentified sp.1 | . | . | . | 0.5 | . | . | . |
| 70 | Unidentified sp.2 | . | . | 0.1 | . | . | . | . |
| 71 | Unidentified sp.3 | . | 0.1 | . | . | . | . | . |
| 72 | Unidentified sp.4 | . | 0.0 | . | . | . | . | . |
| 73 | *Verbascum thapsus* | . | 0.0 | . | . | . | . | . |
| 74 | *Viburnum dentatum* | . | 0.8 | 1.6 | . | . | . | . |

Table 20. The percentage cover values of the species included in the Phragmites-Rhus-Rubus Group using Bray-Curtis Dissimilarity and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Phragmites-Celastrus* Cluster Group | *Rhus-Phragmites-Rubus* Cluster Group | *Rubus-Phragmites* Cluster Group |
|---|---|---|---|---|
| 1 | *Acer rubrum* | 0.1 | 0.1 | |
| 2 | *Achillea millefolium* | . | 0.03 | . |
| 3 | *Agropyron repens* | 0.01 | . | . |
| 4 | *Ailanthus altissima* | 0.6 | 1.8 | . |
| 5 | *Ambrosia artemisiifolia* | . | 0.1 | . |
| 6 | *Ammophila breviligulata* | . | 0.1 | . |
| 7 | *Ampelopsis brevipedunculata* | 1.7 | 0.03 | 4.0 |
| 8 | *Anaphalis margaritacea* | . | 0.04 | . |
| 9 | *Andropogon scoparius* | . | 1.2 | . |
| 10 | *Apocynum cannabinum* | 0.4 | 0.8 | . |
| 11 | *Artimesia vulgaris* | 0.3 | 0.2 | 0.2 |
| 12 | *Asclepias syriaca* | 0.2 | 0.01 | . |
| 13 | *Aster pilosus* | . | 0.01 | . |
| 14 | *Baccharis halimifolia* | 4.3 | 2.4 | . |
| 15 | *Barberea vulgaris* | 0.01 | . | . |
| 16 | *Betula populifolia* | 0.2 | 0.2 | . |
| 17 | *Bromus tectorum* | . | 0.5 | . |
| 18 | *Celastrus orbiculatus* | **10.6** | 6.3 | 0.3 |
| 19 | *Chenopodium album* | . | 0.01 | . |
| 20 | *Cirsium arvense* | 0.3 | 0.1 | 1.0 |
| 21 | *Corynephorus canescens* | . | 1.5 | . |
| 22 | *Cyperus bipartitus* | 0.01 | 0.3 | . |
| 23 | *Dianthus armeria* | . | 0.01 | . |
| 24 | *Elaeagnus angustifolia* | 0.02 | . | . |
| 25 | *Elaeagnus commutata* | 0.2 | 0.04 | . |
| 26 | *Epilobium coloratum* | . | . | 7.8 |
| 27 | *Eupatorium hyssopifolium* | 0.01 | 0.4 | . |
| 28 | *Eupatorium leucolepis* | 0.02 | 0.2 | . |
| 29 | *Eupatorium maculatum* | . | 0.02 | . |
| 30 | *Eupatorum rugosum* | . | 0.1 | . |
| 31 | *Euthamia graminifolia* | 0.01 | 0.01 | . |
| 32 | *Euthamia tenuifolia* | 0.04 | 1.4 | . |
| 33 | *Festuca rubra* | 0.2 | 2.0 | . |
| 34 | *Fragaria virginiana* | 0.2 | 0.1 | . |
| 35 | *Galium aparine* | . | 0.02 | . |
| 36 | *Gleditsia triacanthos* | 0.3 | . | . |
| 37 | *Hibiscus palustris* | . | 0.02 | . |
| 38 | *Hypericum perforatum* | 0.01 | . | . |
| 39 | *Juncus canadensis* | . | 0.1 | . |
| 40 | *Juncus gerardii* | 0.03 | . | . |
| 41 | *Lactuca canadensis* | . | 0.1 | . |

Table 20. Contd.

| | SPECIES | *Phragmites-Celastrus* Cluster Group | *Rhus-Phragmites-Rubus* Cluster Group | *Rubus-Phragmites* Cluster Group |
|---|---|---|---|---|
| 42 | *Lechea maritima* | . | 0.02 | . |
| 43 | *Linaria vulgaris* | 0.1 | 1.2 | . |
| 44 | *Lonicera japonica* | 0.3 | 1.7 | . |
| 45 | *Morus alba* | 1.2 | 0.1 | . |
| 46 | *Myrica pensylvanica* | 3.9 | 9.3 | . |
| 47 | *Oenothera biennis* | 0.1 | 0.1 | 0.8 |
| 48 | *Onoclea sensibilis* | . | 0.3 | 7.9 |
| 49 | *Osmunda cinnamomea* | . | 0.1 | . |
| 50 | *Osmunda regalis* | 0.03 | 0.1 | . |
| 51 | *Oxalis corniculata* | 0.02 | . | . |
| 52 | *Panicum lanuginosum* | . | 0.1 | . |
| 53 | *Panicum virgatum* | 0.03 | 0.2 | . |
| 54 | *Parthenocissus quinquefolia* | 9.8 | 5.7 | 2.7 |
| 55 | *Phragmites australis* | **41.8** | **11.4** | **17.1** |
| 56 | *Phytolacca americana* | 2.8 | 0.3 | 4.1 |
| 57 | *Poaceae sp. 1* | . | 0.3 | . |
| 58 | *Polygonum hydropiperoides* | . | . | 0.3 |
| 59 | *Polygonum scandens* | 0.9 | 0.3 | 0.2 |
| 60 | *Populus deltoides* | 0.4 | . | . |
| 61 | *Populus tremuloides* | 1.1 | . | . |
| 62 | *Prunus allegheniensis* | 0.02 | . | . |
| 63 | *Prunus serotina* | 1.7 | 1.3 | . |
| 64 | *Pyrus baccata* | 0.01 | . | . |
| 65 | *Pyrus sieboldii* | 0.01 | 0.3 | . |
| 66 | *Pyrus sp. 2* | . | 0.1 | . |
| 67 | *Rhus copallina* | 0.8 | **19.1** | 4.2 |
| 68 | *Rhus glabra* | 0.3 | 0.6 | . |
| 69 | *Rhus typhina* | 0.4 | 0.3 | . |
| 70 | *Rosa multiflora* | 1.4 | 0.4 | . |
| 71 | *Rubus allegheniensis* | 5.1 | **10.9** | **30.9** |
| 72 | *Rubus flagellaris* | . | 0.02 | . |
| 73 | *Rubus laciniatus* | 0.3 | 0.4 | . |
| 74 | *Rubus pensilvanicus* | 0.4 | 0.03 | . |
| 75 | *Rumex crispus* | 0.01 | . | . |
| 76 | *Salix alba* | 0.1 | . | . |
| 77 | *Salix babilonica* | 0.1 | . | . |
| 78 | *Salix caprea* | 0.1 | . | . |
| 79 | *Salix discolor* | 0.1 | . | 2.5 |
| 80 | *Salix nigra* | 0.3 | . | 1.9 |
| 81 | *Sambucus canadensis* | 1.0 | 0.04 | 2.4 |
| 82 | *Saponaria officinalis* | 0.1 | 0.1 | . |
| 83 | *Scirpus cyperinus* | . | 0.03 | . |
| 84 | *Setaria glauca* | 0.03 | . | . |

Table 20. Contd.

| SPECIES | | *Phragmites-Celastrus* Cluster Group | *Rhus-Phragmites-Rubus* Cluster Group | *Rubus-Phragmites* Cluster Group |
|---|---|---|---|---|
| 85 | *Solanum dulcamara* | 1.1 | 0.5 | 7.9 |
| 86 | *Solidago canadensis* | 0.01 | 1.0 | . |
| 87 | *Solidago juncea* | . | 0.4 | . |
| 88 | *Solidago rugosa* | 0.7 | 7.8 | 2.3 |
| 89 | *Spirea tomentosa* | 0.01 | 0.4 | . |
| 90 | *Thelypteris simulata* | . | 0.2 | . |
| 91 | *Thelypteris palustris* | . | 0.1 | . |
| 92 | *Toxicodendron radicans* | 2.8 | 3.8 | 0.8 |
| 93 | *Verbascum blattaria* | . | . | 0.2 |
| 94 | *Verbascum thapsus* | . | 0.01 | . |
| 95 | *Verbena hastata* | 0.2 | . | 0.6 |
| 96 | *Viburnum dentatum* | 0.3 | 0.8 | . |

Table 21. The percentage cover values of the species included in the Phragmites -Rhus-Rubus Cluster Group using Bray-Curtis Dissimilarity and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Phragmites-Parthenocissus* Cluster | *Celastrus-Phragmites* Cluster | *Rhus-Phragmites-Celastrus* Cluster | *Rhus-Rubus-Solidago* Cluster | *Rubus-Phragmites* Cluster | *Baccharis-Phragmites* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | 0.1 | . | 0.3 |
| 2 | *Achillea millefolium* | . | . | 0.1 | 0.0 | . | . |
| 3 | *Agropyron repens* | . | 0.0 | . | . | . | . |
| 4 | *Ailanthus altissima* | 0.8 | 0.6 | 2.1 | 1.7 | . | . |
| 5 | *Ambrosia artemisiifolia* | . | . | . | 0.2 | . | . |
| 6 | *Ammophila breviligulata* | . | . | . | 0.1 | . | . |
| 7 | *Ampelopsis brevipedunculata* | . | 4.4 | 0.1 | . | 4.0 | . |
| 8 | *Anaphalis margaritacea* | . | . | 0.1 | . | . | . |
| 9 | *Andropogon scoparius* | . | . | . | 1.8 | . | . |
| 10 | *Apocynum cannabinum* | 0.4 | . | . | 1.2 | . | 1.4 |
| 11 | *Artemisia vulgaris* | 0.0 | 0.8 | 0.5 | . | 0.2 | 0.0 |
| 12 | *Asclepias syriaca* | 0.4 | . | 0.0 | . | . | . |
| 13 | *Aster pilosus* | . | . | 0.0 | . | . | . |
| 14 | *Baccharis halimifolia* | 0.1 | 1.9 | 0.7 | 3.3 | . | **20.2** |
| 15 | *Barbarea vulgaris* | . | 0.0 | . | . | . | . |
| 16 | *Betula populifolia* | . | . | . | 0.3 | . | 1.1 |
| 17 | *Bromus tectorum* | . | . | 1.5 | . | . | . |
| 18 | *Celastrus orbiculatus* | 1.8 | **24.3** | **16.3** | 1.3 | 0.3 | 3.0 |
| 19 | *Chenopodium album* | . | . | . | 0.0 | . | . |
| 20 | *Cirsium arvense* | . | 0.9 | . | 0.1 | 1.0 | . |
| 21 | *Corynephorus canescens* | . | . | 2.1 | 1.2 | . | . |
| 22 | *Cyperus bipartitus* | . | . | . | 0.4 | . | 0.1 |
| 23 | *Dianthus armeria* | . | . | 0.0 | . | . | . |
| 24 | *Elaeagnus angustifolia* | . | 0.1 | . | . | . | . |

Table 21. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Elaeagnus commutata* | . | 0.2 | 0.1 | . | . | 1.0 |
| 26 | *Epilobium colaratum* | . | . | . | . | 7.8 | . |
| 27 | *Eupatorium hyssopifolium* | . | . | 0.3 | 0.4 | . | 0.1 |
| 28 | *Eupatorium leucolepis* | 0.0 | . | 0.3 | 0.2 | . | . |
| 29 | *Eupatorium maculatum* | . | . | . | 0.0 | . | . |
| 30 | *Eupatorum rugosum* | . | . | 0.1 | 0.1 | . | . |
| 31 | *Euthamia graminifolia* | 0.0 | . | . | 0.0 | . | . |
| 32 | *Euthamia tenuifolia* | . | . | 0.0 | 2.0 | . | 0.2 |
| 33 | *Festuca rubra* | 0.1 | 0.4 | 5.3 | 0.4 | . | . |
| 34 | *Fragaria virginiana* | . | 0.4 | 0.4 | . | . | . |
| 35 | *Galium aparine* | . | . | . | 0.0 | . | . |
| 36 | *Gleditsia triacanthos* | 0.7 | 0.1 | . | . | . | . |
| 37 | *Hibiscus palustris* | . | . | . | 0.0 | . | . |
| 38 | *Hypericum perforatum* | . | . | . | . | . | 0.0 |
| 39 | *Juncus canadensis* | . | . | . | 0.1 | . | . |
| 40 | *Juncus gerardii* | . | . | . | . | . | 0.2 |
| 41 | *I.actuca canadensis* | . | . | 0.3 | . | . | . |
| 42 | *Lechea maritima* | . | . | . | 0.0 | . | . |
| 43 | *Linaria vulgaris* | 0.1 | 0.1 | 1.4 | 1.1 | . | 0.2 |
| 44 | *Lonicera japonica* | 0.1 | 0.0 | 0.1 | 2.5 | . | 1.5 |
| 45 | *Morus alba* | . | 3.2 | 0.1 | 0.0 | . | . |
| 46 | *Myrica pensylvanica* | 3.2 | 4.6 | 8.1 | **10.0** | . | 4.1 |
| 47 | *Oenothera biennis* | 0.3 | . | 0.2 | 0.1 | 0.8 | 0.0 |
| 48 | *Onoclea sensibilis* | . | . | . | 0.5 | 7.9 | . |
| 49 | *Osmunda cinnamomea* | . | . | . | 0.2 | . | . |
| 50 | *Osmunda regalis* | . | . | . | 0.2 | . | 0.2 |
| 51 | *Oxalis corniculata* | 0.0 | 0.0 | . | . | . | . |
| 52 | *Panicum lanuginosum* | . | . | . | 0.1 | . | . |
| 53 | *Panicum virgatum* | . | . | 0.2 | 0.2 | . | 0.1 |
| 54 | *Parthenocissus quinquefolia* | **15.4** | 3.6 | 5.3 | 5.9 | 2.7 | 8.9 |
| 55 | *Phragmites australis* | **61.7** | **29.9** | **18.5** | 7.8 | **17.1** | **17.0** |

Table 21. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Phytolacca americana* | 2.7 | 4.3 | 0.8 | . | 4.1 | 0.1 |
| 57 | *Poaceae sp. 1* | . | . | . | 0.4 | . | . |
| 58 | *Polygonum hydropiperoides* | . | . | . | . | 0.3 | . |
| 59 | *Polygonum scandens* | 1.8 | 0.1 | 0.3 | 0.4 | 0.2 | 0.5 |
| 60 | *Populus deltoides* | . | 1.0 | . | . | . | . |
| 61 | *Populus tremuloides* | 0.6 | 0.4 | . | . | . | 4.1 |
| 62 | *Prunus allegheniensis* | . | 0.0 | . | . | . | . |
| 63 | *Prunus serotina* | 1.1 | 3.1 | 0.7 | 1.6 | . | 0.3 |
| 64 | *Pyrus baccata* | 0.0 | . | . | . | . | . |
| 65 | *Pyrus sieboldii* | 0.0 | . | . | 0.4 | . | . |
| 66 | *Pyrus sp. 2* | . | . | . | 0.1 | . | . |
| 67 | *Rhus copallina* | 0.1 | 1.0 | **25.6** | **15.8** | 4.2 | 2.3 |
| 68 | *Rhus glabra* | . | . | . | 0.9 | . | 1.9 |
| 69 | *Rhus typhina* | . | . | . | 0.5 | . | 2.4 |
| 70 | *Rosa multiflora* | 1.9 | 1.4 | . | 0.6 | . | 0.1 |
| 71 | *Rubus allegheniensis* | 3.8 | 4.9 | 3.0 | **14.8** | **30.9** | 8.9 |
| 72 | *Rubus flagellaris* | . | . | . | 0.0 | . | . |
| 73 | *Rubus laciniatus* | . | 0.7 | 0.3 | 0.4 | . | 0.4 |
| 74 | *Rubus pensilvanicus* | 0.0 | 1.0 | 0.1 | . | . | . |
| 75 | *Rumex crispus* | . | 0.0 | . | . | . | . |
| 76 | *Salix alba* | . | 0.2 | . | . | . | . |
| 77 | *Salix babylonica* | . | . | . | . | . | 0.7 |
| 78 | *Salix caprea* | . | 0.3 | . | . | . | . |
| 79 | *Salix discolor* | . | . | . | . | 2.5 | 0.8 |
| 80 | *Salix nigra* | . | 0.3 | . | . | 1.9 | 1.3 |
| 81 | *Sambucus canadensis* | 0.0 | 1.3 | . | 0.1 | 2.4 | 2.8 |
| 82 | *Saponaria officinalis* | 0.3 | . | 0.2 | . | . | . |
| 83 | *Scirpus cyperinus* | . | . | . | 0.1 | . | . |
| 84 | *Setaria glauca* | 0.1 | . | . | . | . | . |
| 85 | *Solanum dulcamara* | 0.7 | 1.7 | 1.1 | 0.2 | 7.9 | 0.5 |
| 86 | *Solidago canadensis* | . | 0.0 | 0.4 | 1.3 | . | . |

Table 21. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 87 | *Solidago juncea* | . | . | 1.0 | 0.1 | . | . |
| 88 | *Solidago rugosa* | 0.1 | 1.6 | 2.3 | **10.6** | 2.3 | 0.2 |
| 89 | *Spirea tomentosa* | . | . | . | 0.7 | . | 0.1 |
| 90 | *Thelypteris simulata* | . | . | . | 0.3 | . | . |
| 91 | *Thelypteris palustris* | . | . | . | 0.2 | . | . |
| 92 | *Toxicodendron radicans* | 1.0 | 0.2 | . | 5.7 | 0.8 | **12.8** |
| 93 | *Verbascum blattaria* | . | . | . | . | 0.2 | . |
| 94 | *Verbascum thapsus* | . | . | 0.0 | . | . | . |
| 95 | *Verbena hastata* | . | 0.6 | . | . | 0.6 | . |
| 96 | *Viburnum dentatum* | 0.4 | 0.1 | 0.0 | 1.2 | . | . |

Table 22. The percentage cover values of the species included in the Prunus -Myrica Cluster Group using Bray-Curtis Dissimilarity and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Prunus*-Cluster | *Myrica-Prunus* Cluster | *Celastrus-Prunus* Cluster | *Populus-Sambucus* Cluster | *Ailanthus-Morus* Cluster | *Myrica-Rosa-Betula* Cluster | *Artemisia-Solidago-Celastrus* Cluster |
|---|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | 0.2 | . | 0.1 | . | . | . |
| 2 | *Achillea millefolium* | . | . | . | . | . | . | 2.3 |
| 3 | *Ailanthus altissima* | 3.2 | . | 0.8 | 0.0 | **62.6** | . | . |
| 4 | *Allium vineale* | . | 0.0 | . | . | . | . | . |
| 5 | *Andropogon scoparius* | . | 0.1 | . | . | . | . | 0.9 |
| 6 | *Apocynum cannabinum* | . | . | . | . | . | 0.0 | 0.5 |
| 7 | *Aronia arbutifolia* | . | 0.1 | . | . | . | . | . |
| 8 | *Artemisia vulgaris* | . | 0.9 | 1.2 | . | . | . | **29.8** |
| 9 | *Asclepias syriaca* | . | . | 0.1 | . | . | . | 1.9 |
| 10 | *Aster pilosus* | . | . | 0.0 | . | . | . | . |
| 11 | *Baccharis halimifolia* | . | 0.2 | 0.8 | . | 2.0 | . | 0.2 |
| 12 | *Betula populifolia* | 0.1 | 0.5 | . | 0.2 | . | **15.8** | . |
| 13 | *Bromus tectorum* | . | . | . | . | . | . | 8.2 |
| 14 | *Celastrus orbiculatus* | 0.1 | **10.4** | **31.8** | 5.1 | 0.2 | . | **14.7** |
| 15 | *Celtis occidentalis* | 6.3 | . | 0.0 | . | . | . | . |
| 16 | *Corynephorus canescens* | . | 0.0 | 0.2 | . | . | . | 2.3 |
| 17 | *Elaeagnus angustifolia* | . | . | . | . | . | . | 1.5 |
| 18 | *Elaeagnus commutata* | 0.0 | 0.8 | 0.3 | . | . | . | 0.4 |
| 19 | *Elaeagnus umbellata* | 1.8 | 0.1 | . | . | . | . | . |
| 20 | *Equisetum arvensis* | . | . | . | . | . | . | 2.7 |
| 21 | *Eupatorium hyssopifolium* | . | . | . | . | . | . | 0.4 |
| 22 | *Eupatorum rugosum* | . | . | 1.0 | . | . | . | . |
| 23 | *Euthamia tenuifolia* | . | . | 0.1 | . | . | . | . |
| 24 | *Hypericum perforatum* | . | . | . | . | . | . | 0.5 |
| 25 | *Ilex opaca* | . | 0.0 | . | . | . | . | . |
| 26 | *Juniperus virginiana* | . | . | 0.4 | . | . | . | . |

Table 22. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 27 | *Lathyrus latifolius* | . | 0.0 | . | . | . | . | . |
| 28 | *Linaria vulgaris* | . | . | 0.0 | . | . | . | 1.7 |
| 29 | *Lonicera japonica* | . | 5.1 | 3.2 | . | . | 4.4 | . |
| 30 | *Morus alba* | 7.3 | 0.1 | 4.1 | 1.8 | **23.1** | . | . |
| 31 | *Myrica pensylvanica* | 0.3 | **17.4** | 1.7 | 0.2 | . | **21.3** | . |
| 32 | *Onoclea sensibilis* | . | 0.0 | . | . | . | . | . |
| 33 | *Parthenocissus quinquefolia* | 0.0 | **13.3** | 4.0 | . | . | **15.1** | 5.1 |
| 34 | *Pastinaca sativa* | . | . | . | . | . | . | 3.0 |
| 35 | *Phragmites australis* | . | 3.1 | 3.0 | 0.2 | . | 2.6 | 0.2 |
| 36 | *Phytolacca americana* | . | 0.2 | 0.1 | 0.1 | . | . | . |
| 37 | *Poaceae sp. 2* | . | 0.1 | . | . | . | . | . |
| 38 | *Polygonum scandens* | . | 0.1 | . | . | . | . | . |
| 39 | *Populus deltoides* | . | . | . | 0.0 | . | 3.7 | . |
| 40 | *Populus tremuloides* | 1.9 | 0.5 | 0.5 | **45.7** | . | 3.5 | . |
| 41 | *Prunus serotina* | **74.0** | **16.2** | **23.8** | 2.8 | **10.3** | 1.5 | . |
| 42 | *Pyrus sieboldii* | . | 0.1 | . | . | . | 0.7 | . |
| 43 | *Pyrus sp. 1* | 0.1 | . | . | . | . | . | . |
| 44 | *Pyrus sp. 2* | . | 0.0 | . | 0.1 | . | . | . |
| 45 | *Quercus rubra* | . | 0.0 | . | . | . | . | . |
| 46 | *Rhamnus frangula* | . | 0.2 | . | . | . | . | . |
| 47 | *Rhus copallina* | 3.6 | 1.1 | 5.1 | . | 1.7 | . | . |
| 48 | *Rhus glabra* | 0.1 | . | 1.1 | . | 0.0 | . | . |
| 49 | *Rhus typhina* | 1.0 | 1.1 | . | . | . | . | . |
| 50 | *Rosa multiflora* | . | 4.7 | 1.6 | 0.1 | . | **20.7** | . |
| 51 | *Rosa virginiana* | . | . | 0.2 | . | . | . | . |
| 52 | *Rubus allegheniensis* | . | 5.0 | 2.1 | . | . | . | 0.8 |
| 53 | *Rubus laciniatus* | . | 0.0 | 0.0 | . | . | . | . |
| 54 | *Rubus pensilvanicus* | . | 3.1 | . | **11.6** | . | 1.5 | . |
| 55 | *Salix babylonica* | | | . | 0.3 | | . | . |
| 56 | *Salix discolor* | . | . | 0.3 | 0.1 | . | . | . |
| 57 | *Salix fragilis* | | | . | 0.2 | | . | . |

Table 22. Contd.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 58 | *Salix matsudana* | . | . | . | 0.1 | . | . | . |
| 59 | *Salix nigra* | | | . | 0.0 | | . | . |
| 60 | *Salix sp. 1* | | | . | 0.1 | | . | . |
| 61 | *Sambucus canadensis* | . | 0.8 | 0.1 | **16.3** | . | 1.9 | . |
| 62 | *Saponaria officinalis* | . | 0.4 | 0.6 | . | . | . | 2.4 |
| 63 | *Solanum dulcamara* | . | 0.0 | 0.7 | 0.8 | . | 0.9 | 0.2 |
| 64 | *Solidago canadensis* | . | 0.1 | 0.1 | . | . | . | . |
| 65 | *Solidago juncea* | . | 0.2 | 1.9 | 0.4 | . | . | 0.4 |
| 66 | *Solidago rugosa* | . | 1.2 | 2.0 | **13.0** | . | . | **19.3** |
| 67 | *Thelypteris simulata* | . | . | 0.2 | . | . | . | . |
| 68 | *Toxicodendron radicans* | . | **11.5** | 7.1 | . | . | 3.2 | . |
| 69 | *Unidentified sp. 1* | . | . | . | 0.5 | . | . | . |
| 70 | *Unidentified sp. 2* | . | . | . | . | . | 0.2 | . |
| 71 | *Unidentified sp. 3* | . | 0.1 | . | . | . | . | . |
| 72 | *Unidentified sp. 4* | . | 0.0 | . | . | . | . | . |
| 73 | *Verbascum thapsus* | . | 0.0 | . | . | . | . | . |
| 74 | *Viburnum dentatum* | . | 1.0 | . | . | . | 3.2 | 0.8 |

Table 23. The percentage cover values of the species included in the Phragmites -Rhus-Rubus Cluster Group using Chord Distance and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Phragmites-Parthenocissus* Cluster | *Phragmites-Celastrus* Cluster | *Rhus-Phragmites-Myrica* Cluster | *Rubus-Rhus-Solidago* Cluster | *Celastrus-Rhus-Myrica* Cluster | *Onoclea - Rubus-Epilobium* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | . | . | 0.3 | . | . |
| 2 | *Achillea millefolium* | . | . | . | . | 0.1 | . |
| 3 | *Agropyron repens* | . | 0.0 | . | . | . | . |
| 4 | *Ailanthus altissima* | 0.8 | 0.2 | . | 0.8 | 7.7 | . |
| 5 | *Ambrosia artemisiifolia* | . | . | . | 0.2 | . | . |
| 6 | *Ammophila breviligulata* | . | . | 0.2 | . | . | . |
| 7 | *Ampelopsis brevipedunculata* | 0.2 | 4.3 | 0.1 | . | . | 1.1 |
| 8 | *Anaphalis margaritacea* | . | . | . | . | 0.2 | . |
| 9 | *Andropogon scoparius* | . | . | 3.1 | . | . | . |
| 10 | *Apocynum cannabinum* | 0.3 | . | . | 2.2 | . | . |
| 11 | *Artemisia vulgaris* | 0.0 | 0.7 | 0.4 | 0.0 | . | . |
| 12 | *Asclepias syriaca* | 0.2 | 0.1 | . | . | 0.0 | . |
| 13 | *Aster pilosus* | . | . | . | . | 0.1 | . |
| 14 | *Baccharis halimifolia* | 6.1 | 0.2 | 2.0 | 5.1 | 1.2 | . |
| 15 | *Barbarea vulgaris* | . | 0.0 | . | . | . | . |
| 16 | *Betula populifolia* | . | . | 0.3 | 0.7 | . | . |
| 17 | *Bromus tectorum* | . | . | . | . | 2.6 | . |
| 18 | *Celastrus orbiculatus* | 2.2 | **20.6** | 1.7 | 1.0 | **20.4** | . |
| 19 | *Chenopodium album* | . | . | . | . | 0.1 | . |
| 20 | *Cirsium arvense* | 0.3 | 0.7 | 0.2 | 0.0 | . | . |
| 21 | *Corynephorus canescens* | . | . | 2.1 | . | 3.7 | . |
| 22 | *Cyperus bipartitus* | 0.0 | . | . | 0.6 | . | . |
| 23 | *Dianthus armeria* | . | . | . | . | 0.0 | . |
| 24 | *Elaeagnus angustifolia* | . | 0.0 | . | . | . | . |

Table 23. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 25 | *Elaeagnus commutata* | 0.3 | 0.2 | . | . | 0.2 | . |
| 26 | *Epilobium coloratum* | 0.0 | 0.2 | . | . | . | **23.7** |
| 27 | *Eupatorium hyssopifolium* | 0.0 | . | 0.6 | 0.0 | 0.6 | . |
| 28 | *Eupatorium leucolepis* | 0.0 | . | 0.3 | 0.0 | 0.5 | . |
| 29 | *Eupatorium maculatum* | . | . | 0.0 | 0.0 | . | . |
| 30 | *Eupatorum rugosum* | . | . | 0.0 | 0.0 | 0.5 | . |
| 31 | *Euthamia graminifolia* | . | 0.0 | . | 0.0 | . | . |
| 32 | *Euthamia tenuifolia* | 0.1 | . | 3.0 | 0.5 | 0.1 | . |
| 33 | *Festuca rubra* | 0.1 | 0.3 | 4.7 | . | 1.4 | . |
| 34 | *Fragaria virginiana* | . | 0.3 | 0.3 | . | . | . |
| 35 | *Galium aparine* | . | . | . | 0.0 | . | . |
| 36 | *Gleditsia triacanthos* | 0.5 | 0.1 | . | . | . | . |
| 37 | *Hibiscus palustris* | . | . | . | 0.0 | . | . |
| 38 | *Hypericum perforatum* | 0.0 | . | . | . | . | . |
| 39 | *Juncus canadensis* | . | . | . | 0.2 | . | . |
| 40 | *Juncus gerardii* | 0.1 | . | . | . | . | . |
| 41 | *Lactuca canadensis* | . | . | 0.2 | . | . | . |
| 42 | *Lechea maritima* | . | . | 0.1 | . | . | . |
| 43 | *Linaria vulgaris* | 0.1 | 0.1 | 2.2 | 0.1 | 2.1 | . |
| 44 | *Lonicera japonica* | 0.6 | 0.0 | 3.3 | 0.9 | 0.2 | . |
| 45 | *Morus alba* | . | 2.4 | 0.1 | . | . | . |
| 46 | *Myrica pensylvanica* | 3.6 | 3.5 | **13.1** | 3.3 | **15.3** | . |
| 47 | *Oenothera biennis* | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 1.7 |
| 48 | *Onoclea sensibilis* | 0.0 | . | . | 0.7 | . | **25.9** |
| 49 | *Osmunda cinnamomea* | . | . | . | 0.3 | . | . |
| 50 | *Osmunda regalis* | 0.1 | . | . | 0.3 | . | . |
| 51 | *Oxalis corniculata* | . | 0.0 | . | . | . | . |
| 52 | *Panicum lanuginosum* | . | . | . | 0.2 | . | . |
| 53 | *Panicum virgatum* | 0.0 | . | 0.3 | 0.0 | 0.4 | . |
| 54 | *Parthenocissus quinquefolia* | **14.1** | 4.6 | 5.4 | 6.0 | 3.6 | 0.5 |
| 55 | *Phragmites australis* | **51.3** | **32.1** | **13.4** | 9.9 | 4.7 | 1.4 |

Table 23. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 56 | *Phytolacca americana* | 1.7 | 5.2 | 0.4 | . | 0.1 | 0.3 |
| 57 | *Poaceae sp. 1* | . | . | . | 0.5 | . | . |
| 58 | *Polygonum hydropiperoides* | . | . | . | . | . | 0.9 |
| 59 | *Polygonum scandens* | 1.5 | 0.1 | 0.0 | 0.7 | 0.4 | . |
| 60 | *Populus deltoides* | . | 0.7 | . | . | . | . |
| 61 | *Populus tremuloides* | 1.4 | 0.8 | . | . | . | . |
| 62 | *Prunus allegheniensis* | . | 0.0 | . | . | . | . |
| 63 | *Prunus serotina* | 1.0 | 2.4 | 1.8 | 0.9 | 0.9 | . |
| 64 | *Pyrus baccata* | 0.0 | . | . | . | . | . |
| 65 | *Pyrus sieboldii* | 0.0 | . | 0.4 | 0.2 | . | . |
| 66 | *Pyrus sp. 2* | . | . | 0.1 | 0.1 | . | . |
| 67 | *Rhus copallina* | 0.8 | 2.5 | **25.4** | **11.0** | **20.1** | . |
| 68 | *Rhus glabra* | 0.0 | . | . | 1.8 | 0.6 | . |
| 69 | *Rhus typhina* | 0.0 | . | . | 1.7 | . | . |
| 70 | *Rosa multiflora* | 1.5 | 1.1 | 0.7 | 0.0 | 0.6 | . |
| 71 | *Rubus allegheniensis* | 3.3 | 7.5 | 6.1 | **24.9** | 2.2 | **24.5** |
| 72 | *Rubus flagellaris* | . | . | . | . | 0.1 | . |
| 73 | *Rubus laciniatus* | 0.1 | 0.5 | 0.2 | 0.3 | 0.6 | . |
| 74 | *Rubus pensilvanicus* | 0.0 | 0.7 | 0.1 | . | . | . |
| 75 | *Rumex crispus* | . | 0.0 | . | . | . | . |
| 76 | *Salix alba* | . | 0.1 | . | . | . | . |
| 77 | *Salix babylonica* | 0.2 | . | . | . | . | . |
| 78 | *Salix caprea* | . | 0.2 | . | . | . | . |
| 79 | *Salix discolor* | 0.3 | . | . | . | . | 8.3 |
| 80 | *Salix nigra* | 0.4 | 0.2 | . | . | . | 6.2 |
| 81 | *Sambucus canadensis* | 0.3 | 1.4 | 0.1 | 1.4 | . | . |
| 82 | *Saponaria officinalis* | 0.2 | . | . | . | 0.3 | . |
| 83 | *Scirpus cyperinus* | . | . | . | 0.1 | . | . |
| 84 | *Setaria glauca* | . | 0.1 | . | . | . | . |
| 85 | *Solanum dulcamara* | 0.5 | 2.7 | 0.4 | 1.6 | 0.3 | 5.2 |
| 86 | *Solidago canadensis* | . | 0.0 | 1.3 | 1.0 | . | . |

Table 23. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 87 | *Solidago juncea* | . | 0.0 | 0.2 | . | 1.4 | . |
| 88 | *Solidago rugosa* | 0.1 | 1.8 | 3.5 | **10.7** | 6.4 | . |
| 89 | *Spirea tomentosa* | 0.0 | . | . | 0.9 | . | . |
| 90 | *Thelypteris simulata* | . | . | . | 0.4 | . | . |
| 91 | *Thelypteris palustris* | . | . | . | 0.2 | . | . |
| 92 | *Toxicodendron radicans* | 4.7 | 0.3 | 1.4 | 6.9 | . | 0.2 |
| 93 | *Verbascum blattaria* | . | 0.1 | . | . | . | . |
| 94 | *Verbascum thapsus* | . | . | . | . | 0.1 | . |
| 95 | *Verbena hastata* | . | 0.7 | . | . | . | . |
| 96 | *Viburnum dentatum* | 0.4 | 0.1 | 0.5 | 1.2 | . | . |

Table 24. The percentage cover values of the species included in the Prunus -Myrica Cluster Group obtained using Chord Distance and Complete Linkage as the clustering procedure. The values in bold face are the higher cover values (≥ 10.0%) within each cluster.

| | SPECIES | *Prunus* Cluster | *Prunus-Celastrus* Cluster | *Myrica-Parthenocissus* Cluster | *Populus-Sambucus* Cluster | *Artemisia-Solidago* Cluster | *Ailanthus-Morus* Cluster |
|---|---|---|---|---|---|---|---|
| 1 | *Acer rubrum* | . | 0.2 | . | 0.1 | . | . |
| 2 | *Achillea millefolium* | . | 0.1 | . | . | . | . |
| 3 | *Ailanthus altissima* | 3.2 | 0.3 | . | 0.0 | . | **62.6** |
| 4 | *Allium vineale* | . | 0.0 | . | . | . | . |
| 5 | *Andropogon scoparius* | . | 0.1 | . | . | . | . |
| 6 | *Apocynum cannabinum* | . | 0.0 | 0.0 | . | . | . |
| 7 | *Aronia arbutifolia* | . | 0.1 | . | . | . | . |
| 8 | *Artemisia vulgaris* | . | 0.7 | 1.9 | . | **43.0** | . |
| 9 | *Asclepias syriaca* | . | 0.1 | . | . | 1.8 | . |
| 10 | *Aster pilosus* | . | 0.0 | . | . | . | . |
| 11 | *Baccharis halimifolia* | . | 0.4 | . | . | . | 2.0 |
| 12 | *Betula populifolia* | 0.1 | 0.4 | 6.8 | 0.2 | . | . |
| 13 | *Bromus tectorum* | . | . | . | . | **12.2** | . |
| 14 | *Celastrus orbiculatus* | 0.1 | **19.0** | 2.1 | 5.1 | **18.1** | 0.2 |
| 15 | *Celtis occidentalis* | 6.3 | 0.0 | . | . | . | . |
| 16 | *Corynephorus canescens* | . | 0.2 | . | . | . | . |
| 17 | *Elaeagnus angustifolia* | . | 0.1 | . | . | . | . |
| 18 | *Elaeagnus commutata* | 0.0 | 0.2 | 2.4 | . | . | . |
| 19 | *Elaeagnus umbellata* | 1.8 | 0.1 | . | . | . | . |
| 20 | *Equisetum arvensis* | . | 0.1 | . | . | . | . |
| 21 | *Eupatorium hyssopifolium* | . | . | . | . | 0.6 | . |
| 22 | *Eupatorum rugosum* | . | 0.4 | . | . | . | . |
| 23 | *Euthamia tenuifolia* | . | 0.0 | . | . | . | . |
| 24 | *Hypericum perforatum* | . | . | . | . | 0.8 | . |
| 25 | *Ilex opaca* | . | 0.0 | . | . | . | . |
| 26 | *Juniperus virginiana* | . | 0.1 | . | . | . | . |

Table 24. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 27 | *Lathyrus latifolius* | . | 0.0 | . | . | . | . |
| 28 | *Linaria vulgaris* | . | 0.1 | . | . | . | . |
| 29 | *Lonicera japonica* | . | 4.0 | 6.2 | . | . | . |
| 30 | *Morus alba* | 7.3 | 1.6 | . | 1.8 | . | **23.1** |
| 31 | *Myrica pensylvanica* | 0.3 | **10.9** | **21.4** | 0.2 | . | . |
| 32 | *Onoclea sensibilis* | . | 0.0 | . | . | . | . |
| 33 | *Parthenocissus quinquefolia* | 0.0 | 8.7 | **19.4** | . | . | . |
| 34 | *Pastinaca sativa* | . | 0.1 | . | . | . | . |
| 35 | *Phragmites australis* | . | 3.3 | 1.9 | 0.2 | . | . |
| 36 | *Phytolacca americana* | . | 0.1 | 0.3 | 0.1 | . | . |
| 37 | *Poaceae sp. 2* | . | 0.1 | . | . | . | . |
| 38 | *Polygonum scandens* | . | 0.0 | 0.0 | . | . | . |
| 39 | *Populus deltoides* | . | . | 1.6 | 0.0 | . | . |
| 40 | *Populus tremuloides* | 1.9 | 0.5 | 1.5 | **45.7** | . | . |
| 41 | *Prunus serotina* | **74.0** | **20.0** | 4.3 | 2.8 | . | **10.3** |
| 42 | *Pyrus sieboldii* | . | 0.1 | 0.3 | . | . | . |
| 43 | *Pyrus sp. 1* | 0.1 | . | . | . | . | . |
| 44 | *Pyrus sp. 2* | . | 0.0 | . | 0.1 | . | . |
| 45 | *Quercus rubra* | . | 0.0 | . | . | . | . |
| 46 | *Rhamnus frangula* | . | 0.1 | . | . | . | . |
| 47 | *Rhus copallina* | 3.6 | 2.5 | 0.5 | . | . | 1.7 |
| 48 | *Rhus glabra* | 0.1 | 0.4 | . | . | . | 0.0 |
| 49 | *Rhus typhina* | 1.0 | 0.8 | . | . | . | . |
| 50 | *Rosa multiflora* | . | 3.2 | **12.8** | 0.1 | . | . |
| 51 | *Rosa virginiana* | . | 0.1 | . | . | . | . |
| 52 | *Rubus allegheniensis* | . | 4.2 | 1.5 | . | . | . |
| 53 | *Rubus laciniatus* | . | 0.0 | 0.1 | . | . | . |
| 54 | *Rubus pensilvanicus* | . | 2.0 | 2.4 | **11.6** | . | . |
| 55 | *Salix babylonica* | | | | 0.3 | | |
| 56 | *Salix discolor* | . | 0.1 | . | 0.1 | . | . |
| 57 | *Salix fragilis* | | | | 0.2 | | |

Table 24. Contd.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 58 | *Salix matsudana* | . | . | . | 0.1 | . | . |
| 59 | *Salix nigra* | | | | 0.0 | | |
| 60 | *Sallix sp. 1* | | | | 0.1 | | |
| 61 | *Sambucus canadensis* | . | 0.6 | 1.2 | **16.3** | . | . |
| 62 | *Saponaria officinalis* | . | 0.5 | 0.1 | . | 1.2 | . |
| 63 | *Solanum dulcamara* | . | 0.3 | 0.4 | 0.8 | . | . |
| 64 | *Solidago canadensis* | . | 0.1 | . | . | . | . |
| 65 | *Solidago juncea* | . | 0.9 | 0.1 | 0.4 | . | . |
| 66 | *Solidago rugosa* | . | 1.8 | 0.0 | **13.0** | **22.3** | . |
| 67 | *Thelypteris simulata* | . | 0.1 | . | . | . | . |
| 68 | *Toxicodendron radicans* | . | 9.4 | 9.5 | . | . | . |
| 69 | *Unidentified sp. 1* | . | . | . | 0.5 | . | . |
| 70 | *Unidentified sp. 2* | . | . | 0.1 | . | . | . |
| 71 | *Unidentified sp. 3* | . | 0.1 | . | . | . | . |
| 72 | *Unidentified sp. 4* | . | 0.0 | . | . | . | . |
| 73 | *Verbascum thapsus* | . | 0.0 | . | . | . | . |
| 74 | *Viburnum dentatum* | . | 0.8 | 1.4 | . | . | . |

Table 25. Comparison of clusters recognized by the different clustering algorithms using Complete Linkage. The + sign indicates the presence and - indicates the absence of a particular cluster in the dendrogram produced by each method. The clusters with numbers in bold face are recognized by at least 4 methods.

| CLUSTER | | Bray-Curtis | Chord | Euclidean | Geodesic | Similarity Ratio |
|---|---|---|---|---|---|---|
| **1** | *Phragmites* cluster | + | + | + | + | + |
| **2** | *Phragmites -Parthenocissus* cluster | + | + | + | + | + |
| **3** | *Phragmites -Celastrus* cluster | + | + | + | + | + |
| **4** | *Phragmites-Rhus* cluster | + | + | - | + | + |
| **5** | *Baccharis Phragmites* cluster | + | + | + | + | + |
| **6** | *Rubus -Rhus -Solidago* cluster | + | + | + | + | + |
| **7** | *Andropogon* cluster | + | + | + | + | + |
| **8** | *Andropogon -Ammophila -Panicum* cluster | + | + | + | + | + |
| **9** | *Rhus -Myrica* cluster | - | + | + | + | + |
| **10** | *Myrica -Parthenocissus -Toxicodendron* cluster | - | + | + | + | + |
| **11** | *Celastrus -Prunus* cluster | + | + | - | + | + |
| **12** | *Prunus* cluster | + | + | + | + | + |
| **13** | *Populus -Sambucus -Solidago* cluster | + | + | + | + | + |
| **14** | *Ailanthus -Morus* cluster | + | + | + | + | + |
| **15** | *Artemisia-Solidago* cluster | + | + | + | + | + |
| 16 | *Myrica -Betula* cluster | + | - | + | - | - |
| 17 | *Prunus-Myrica-Celastrus* cluster | - | - | + | - | - |
| 18 | *Myrica -Parthenocissus-Prunus* cluster | + | - | - | - | - |
| 19 | *Phragmites -Rubus* cluster | + | - | - | - | - |
| 20 | *Celastrus-Rubus* cluster | - | - | + | - | - |
| 21 | *Onoclea-Rubus-Epilobium* cluster | - | + | - | + | + |

Table 26. Principal Component Analysis of all the sites sampled. Eigenvalues of the first 15 principal components are given.

| Principal Component | Eigenvalue | Difference | Proportion | Cumulative |
|---|---|---|---|---|
| PRIN1 | 664.658 | 343.139 | 0.231734 | 0.23173 |
| PRIN2 | 321.519 | 57.120 | 0.112098 | 0.34383 |
| PRIN3 | 264.399 | 59.207 | 0.092183 | 0.43601 |
| PRIN4 | 205.192 | 50.924 | 0.071540 | 0.50755 |
| PRIN5 | 154.267 | 18.165 | 0.053785 | 0.56134 |
| PRIN6 | 136.102 | 20.180 | 0.047452 | 0.60879 |
| PRIN7 | 115.922 | 21.943 | 0.040416 | 0.64921 |
| PRIN8 | 93.979 | 9.711 | 0.032766 | 0.68197 |
| PRIN9 | 84.267 | 13.542 | 0.029380 | 0.71135 |
| PRIN10 | 70.725 | 11.798 | 0.024658 | 0.73601 |
| PRIN11 | 58.927 | 6.677 | 0.020545 | 0.75656 |
| PRIN12 | 52.250 | 8.070 | 0.018217 | 0.77477 |
| PRIN13 | 44.179 | 0.277 | 0.015403 | 0.79018 |
| PRIN14 | 43.902 | 4.479 | 0.015307 | 0.80548 |
| PRIN15 | 39.423 | 1.323 | 0.013745 | 0.81923 |

Table 27 Soil chemical data for the 16 clusters recognized within the study area.

| Cluster | Moisture content % | P mg/kg | K mg/kg | Mg mg/kg | Ca mg/kg | Fe mg/kg | Al mg/kg | Mn mg/kg | Zn mg/kg | Cu mg/kg | pH | Exchange Acidity cmol/kg | Organic Matter % | No3 mg/kg | Total N mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phragmites* | 0.640 | 8.7 | 39 | 29.4 | 305 | 40.1 | 37.30 | 3.7 | 3.16 | 0.5 | 5.02 | 6.89 | 3.20 | 4.40 | 675.68 |
| *Phragmites-Parthenocissus* | 0.280 | 1.7 | 26 | 31.2 | 140 | 25.5 | 21.00 | 1.2 | 1.61 | 0.5 | 4.58 | 3.88 | 1.68 | 0.00 | 229.06 |
| *Celastrus-Phragmites* | 0.315 | 4.9 | 35 | 28.3 | 305 | 7.9 | 15.60 | 3.2 | 7.87 | 0.6 | 5.32 | 2.82 | 1.93 | 3.81 | 459.92 |
| *Baccharis-Phragmites* | 0.377 | 1.7 | 41 | 113.5 | 244 | 13.2 | 11.30 | 2.4 | 5.96 | 0.4 | 6.21 | 1.65 | 1.84 | 0.00 | 273.97 |
| *Rubus-Celastrus* | 0.377 | 1.7 | 41 | 23.5 | 244 | 13.2 | 11.30 | 2.4 | 5.96 | 0.4 | 6.21 | 1.65 | 1.84 | 0.00 | 273.97 |
| *Rubus-Rhus* | 0.268 | 1.5 | 28 | 28.8 | 167 | 16.6 | 19.01 | 2.0 | 1.66 | 0.4 | 5.02 | 2.83 | 1.38 | 0.00 | 352.94 |
| *Rhus-Myrica* | 0.180 | 1.2 | 20 | 23.4 | 263 | 8.2 | 23.40 | 1.2 | 1.19 | 0.4 | 5.54 | 2.13 | 1.17 | 0.00 | 288.36 |
| *Andropogon* | 0.135 | 0.7 | 10 | 5.6 | 21 | 6.4 | 40.30 | 0.2 | 0.31 | 0.5 | 5.02 | 1.65 | 0.45 | 0.00 | 236.73 |
| *Andropogon-Ammophila-Panicum* | 0.210 | 0.9 | 14 | 30.3 | 106 | 2.2 | 11.90 | 0.8 | 1.22 | 0.4 | 5.64 | 1.43 | 0.71 | 0.00 | 235.14 |
| *Ailanthus-Morus* | 0.485 | 4.3 | 33 | 57.9 | 536 | 1.9 | 14.40 | 4.3 | 2.72 | 0.7 | 6.06 | 3.77 | 2.64 | 0.00 | 402.43 |
| *Populus-Sambucus* | 1.268 | 6.4 | 72 | 63.2 | 579 | 15.4 | 76.70 | 3.3 | 34.75 | 1.6 | 5.26 | 11.58 | 8.24 | 12.70 | 1133.05 |
| *Prunus* | 0.305 | 2.9 | 39 | 40.2 | 203 | 13.6 | 33.80 | 2.2 | 6.60 | 0.4 | 5.18 | 4.60 | 2.24 | 3.88 | 240.72 |
| *Prunus-Celastrus* | 0.400 | 2.7 | 44 | 59.4 | 366 | 4.7 | 12.30 | 2.0 | 21.61 | 5.4 | 5.78 | 2.79 | 2.10 | 0.00 | 226.32 |
| *Betula* | 0.134 | 2.3 | 15 | 20.9 | 96 | 18.7 | 38.30 | 0.8 | 1.49 | 0.2 | 4.83 | 2.92 | 1.25 | 0.00 | 288.36 |
| *Myrica-Parthenocissus* | 0.319 | 1.7 | 26 | 36.0 | 164 | 22.2 | 27.20 | 1.6 | 2.28 | 0.5 | 4.63 | 4.58 | 1.91 | 0.00 | 320.37 |
| *Artemisia-Solidago* | 0.098 | 3.5 | 9 | 41.6 | 170 | 0.5 | 2.80 | 0.5 | 1.22 | 0.2 | 6.47 | 2.07 | 0.68 | 0.00 | 287.38 |

Table. 28. List of Plant communities observed in Floyd Bennett Field.

| | Community | Number of sites |
|---|---|---|
| 1 | *Prunus serotina* Community | 5 |
| 2 | *Populus tremuloides/Sambucus canadensis* community | 11 |
| 3 | Ailanthus altissima - Morus alba community | 4 |
| 4 | Betula populifolia community | 1 |
| 5 | *Myrica pensylvanica -Prunus serotina* community | 62 |
| 6 | *Myrica pensylvanica-Parthenocissus quinquefolia* community | 12 |
| 7 | *Rhus copallina-Myrica pensylvanica* community | 21 |
| 8 | *Andropogon scoparius* community | 10 |
| 9 | *Andropogon scoparius- Ammophila breviligulata -Panicum virgatum* community | 10 |
| 10 | *Rhus copallina - Rubus alleghaniensis- Solidago rugosa* community | 27 |
| 11 | *Celastrus orbiculatus - Rubus allegheniensis* community | 3 |
| 12 | *Celastrus orbiculatus - Phragmites australis* community | 27 |
| 13 | *Baccharis halimifolia - Phragmites australis* community | 18 |
| 14 | *Phragmites australis - Parthenocissus quinquefolia* community | 25 |
| 15 | *Phragmites australis* community | 11 |
| 16 | *Artemisia vulgaris-Solidago rugosa* community | 2 |

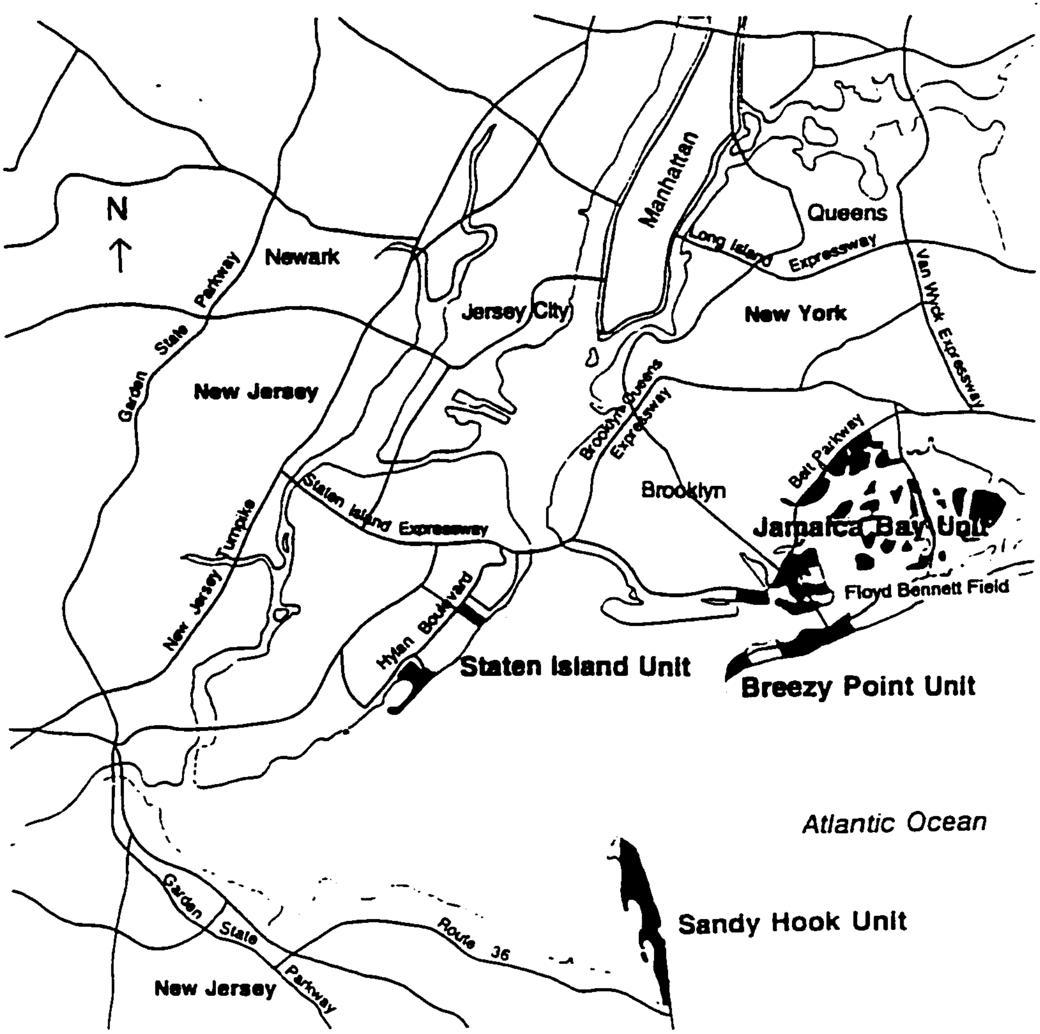



Figure 1. A map showing the location of Floyd Bennett Field. Different units of Gateway National Recreation Area are also shown. General areas used by the National Park service are indicated in black.

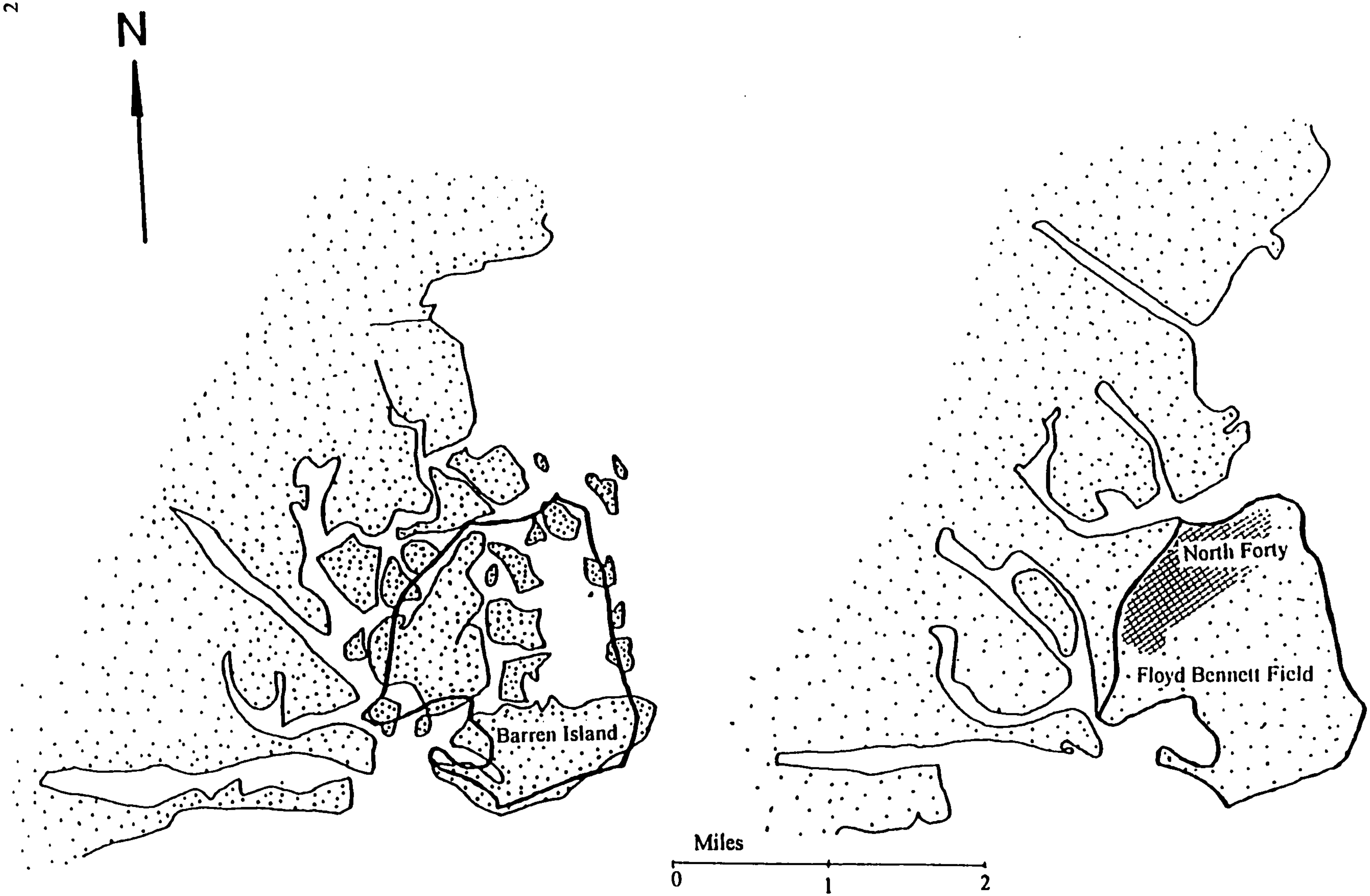



Figure 2. A map showing pre-settlement (left) and present-day (right) configuration of marsh islands in the vicinity of Floyd Bennett Field (FBF). Heavy dark line indicates the present boundary of FBF (Lent and Litwin, 1989a).

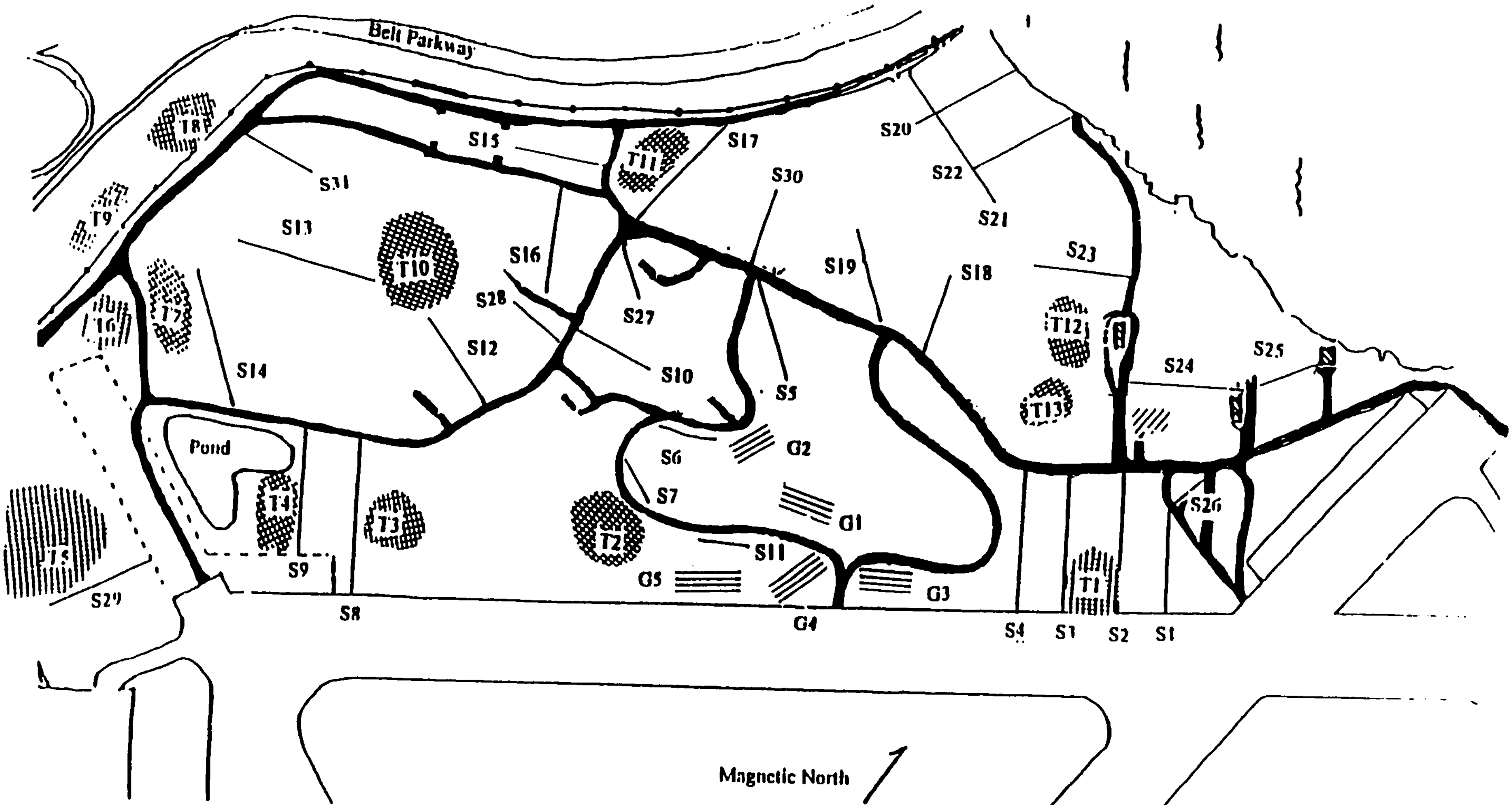



Figure 3. A map of North Forty area of Floyd Bennett Field showing the layout of sampling sites (G1-G5=dry grassland sites, S1-S31=line transects, and T1-T13=woodland sites). Scale 1:8,000.

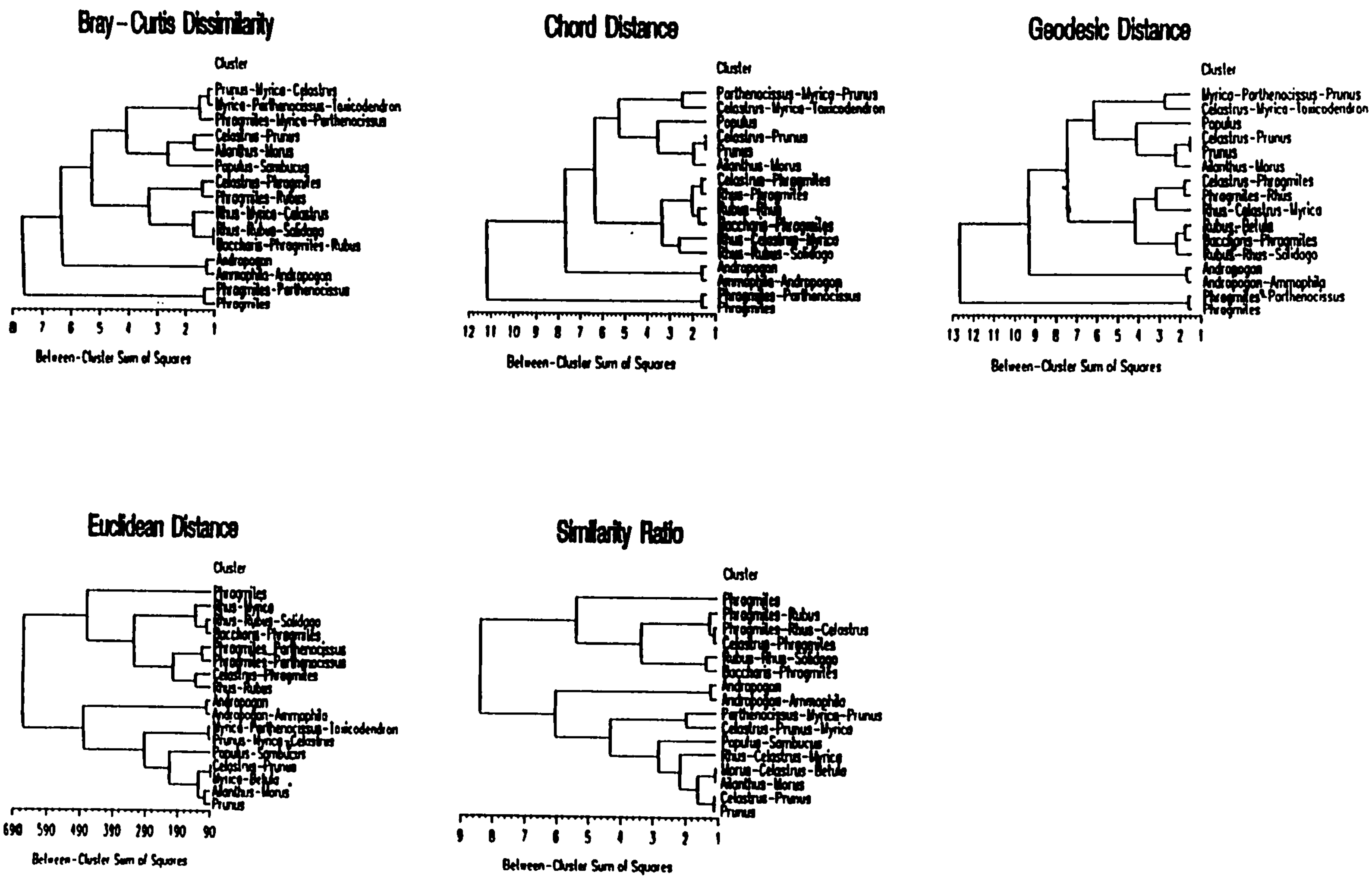



Figure 4. Dendrograms obtained from the five distance matrices used with minimum variance clustering depicting the different clusters recognized in each dendrogram.

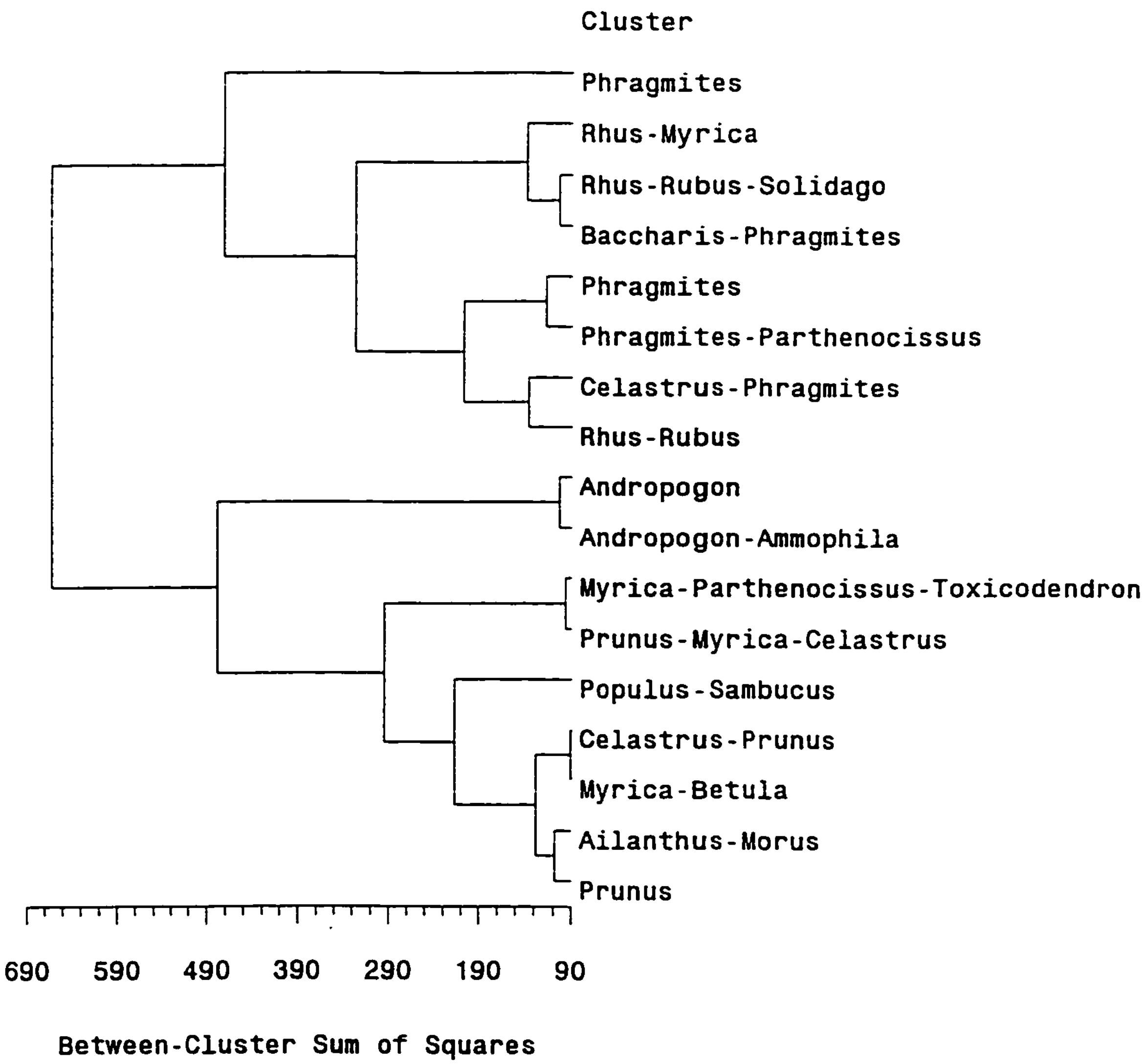



Figure 5. Dendrogram obtained for Euclidean Distance and Minimum Variance clustering for the 249 sampling units studied at Floyd Bennett Field. Only the clusters recognized at between-cluster sum of squares level 90 are shown. Clusters are named using dominant species present.

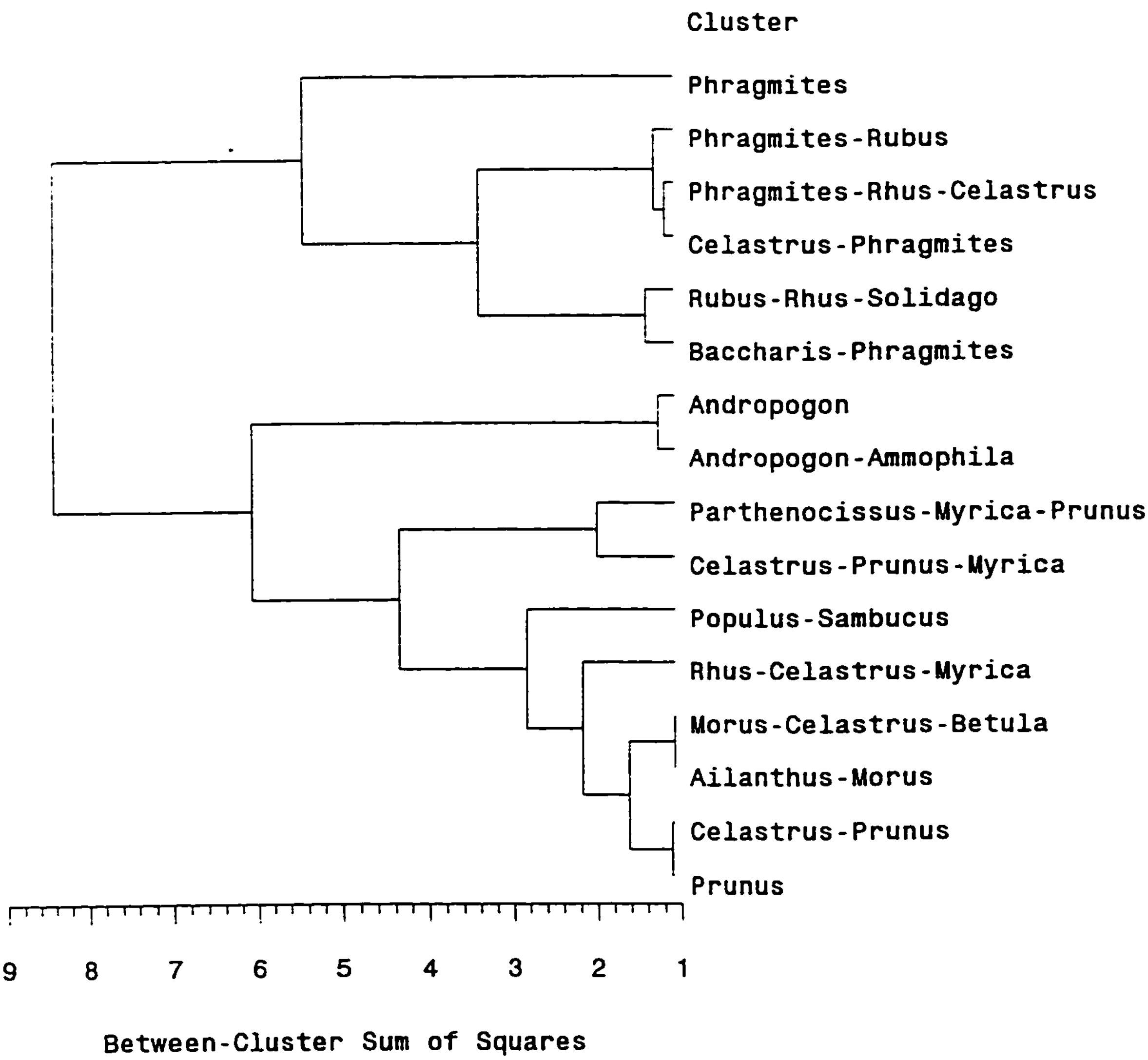



Figure 6. Dendrogram obtained for Similarity Ratio and Minimum Variance clustering for the 249 sampling units studied at Floyd Bennett Field. Only the clusters recognized at between-cluster sum of squares level 1 are shown. Clusters are named using dominant species present.

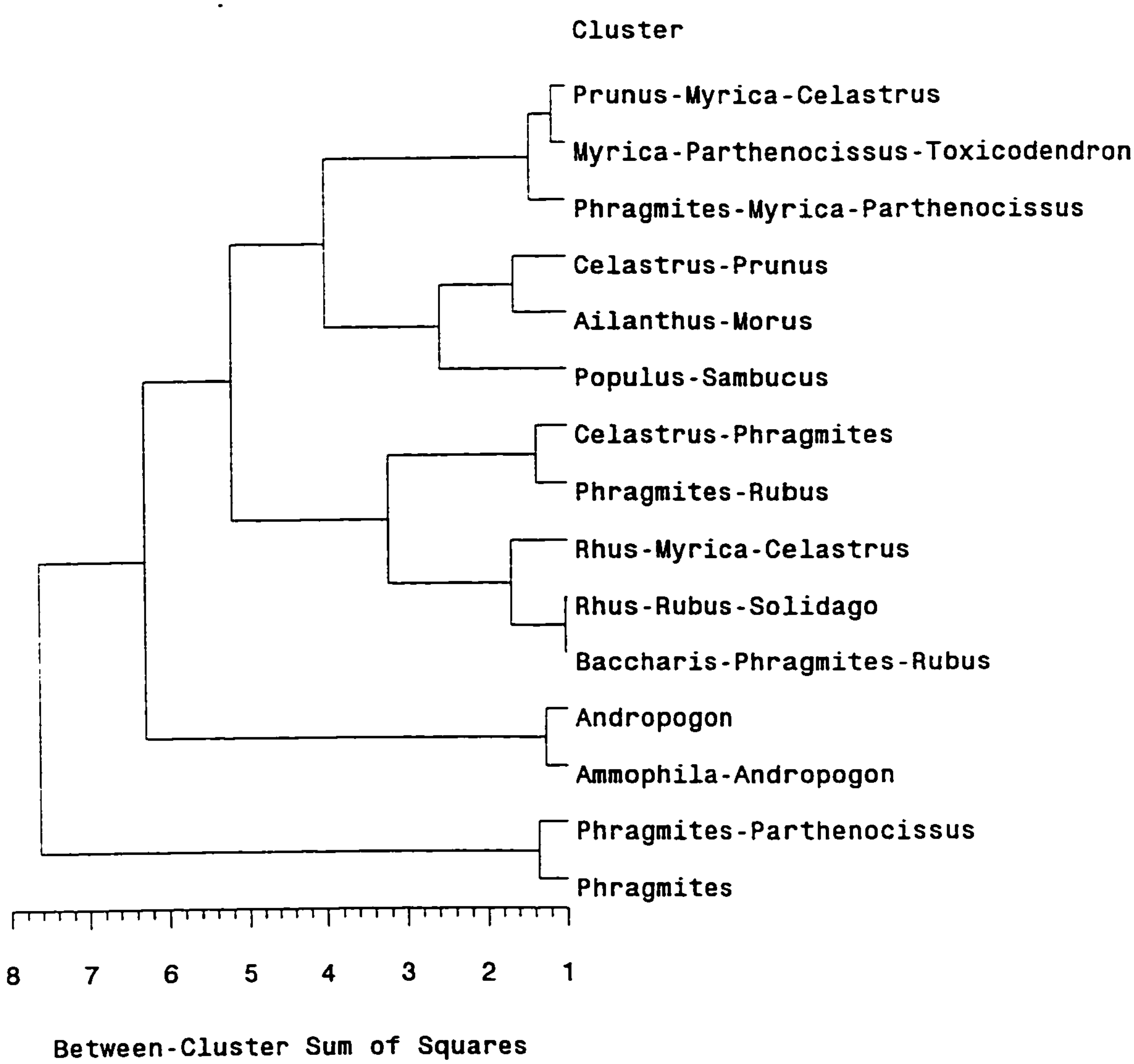



Figure 7. Dendrogram obtained for Bray-Curtis Dissimilarity and Minimum Variance clustering for the 249 sampling units studied at Floyd Bennett Field. Only the clusters recognized at between-cluster sum of squares level 1 are shown. Clusters are named using dominant species present.

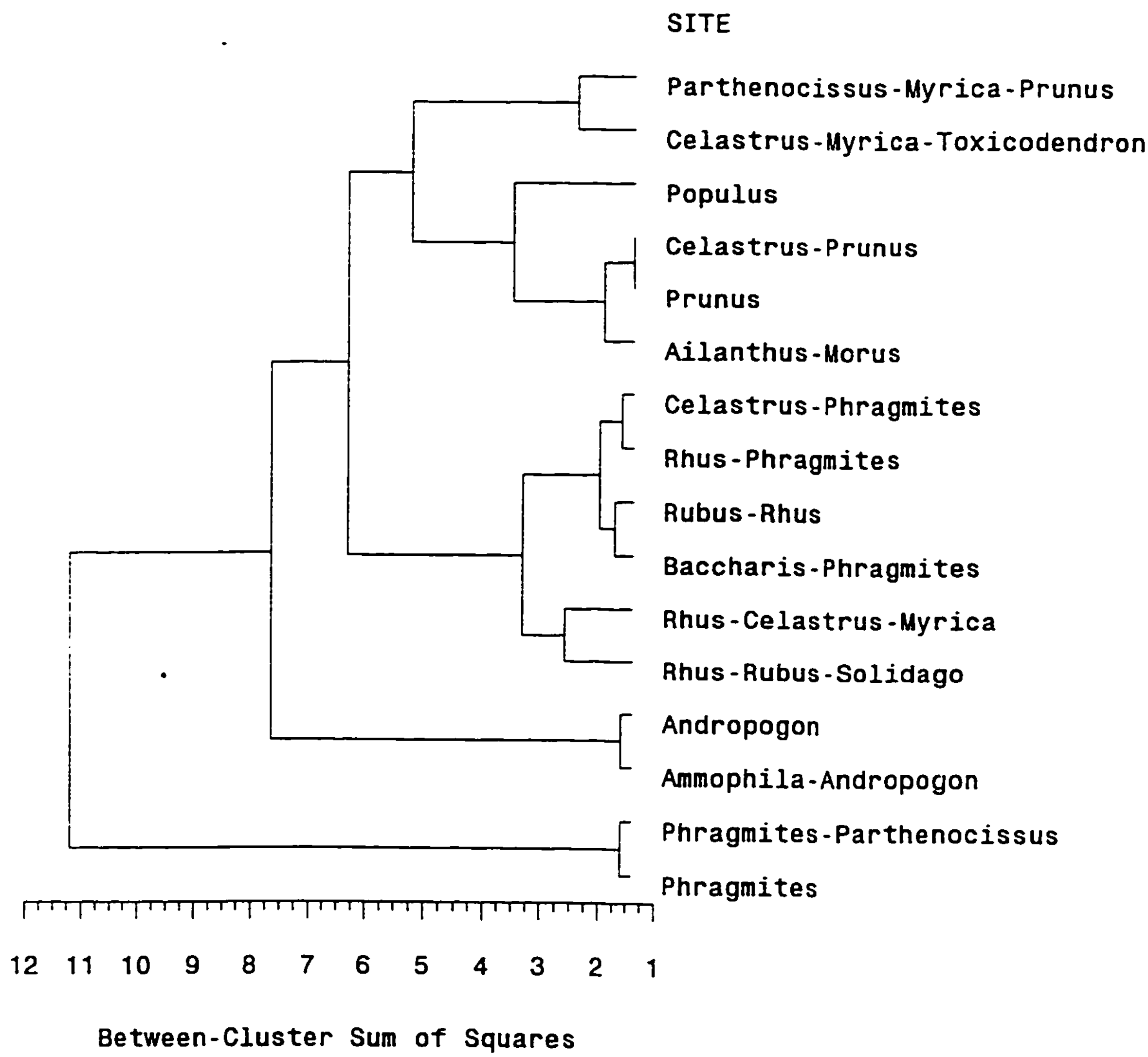



Figure 8. Dendrogram obtained for Chord Distance and Minimum Variance clustering for the 249 sampling units studied at Floyd Bennett Field. Only the clusters recognized at between-cluster sum of squares level 1 are shown. Clusters are named using dominant species present.

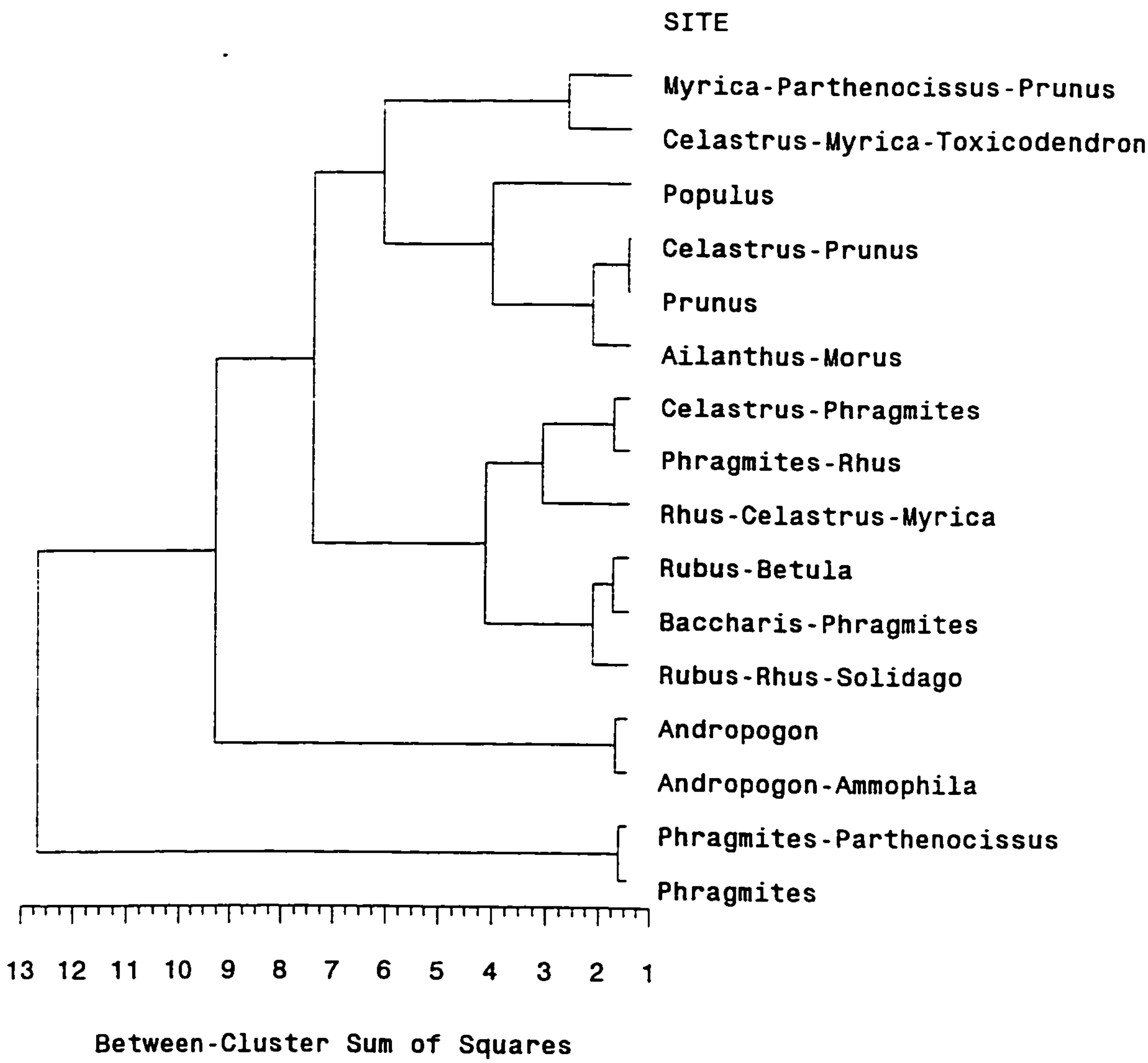



Figure 9. Dendrogram obtained for Geodesic Distance and Minimum Variance clustering for the 249 sampling units studied at Floyd Bennett Field. Only the clusters recognized at between-cluster sum of squares level 1 are shown. Clusters are named using dominant species present.

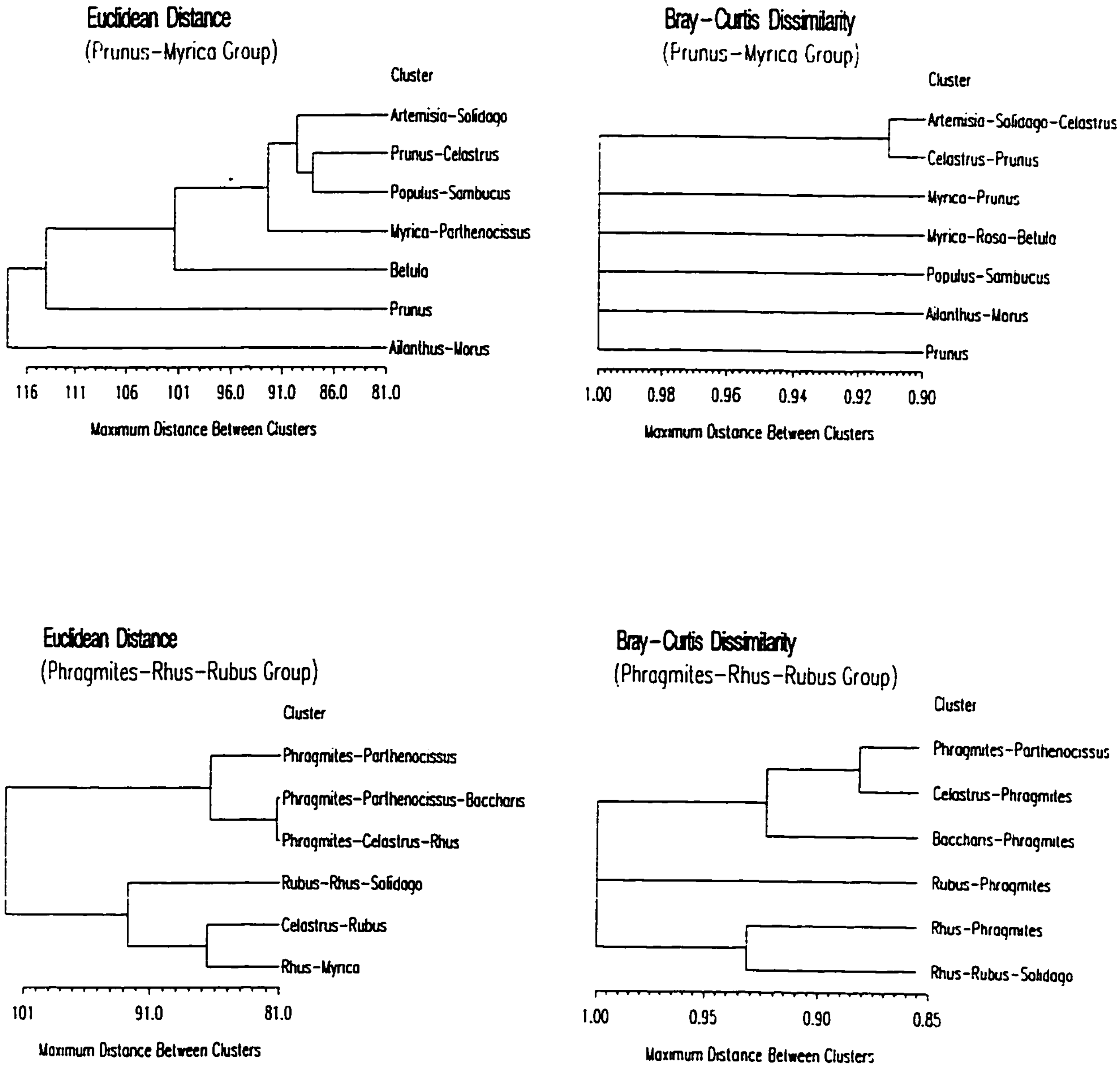



Figure 10. Dendrograms obtained from the Bray-Curtis Dissimilarity and Euclidean Distance matrices used with Complete Linkage clustering depicting the different clusters recognized in each dendrogram.

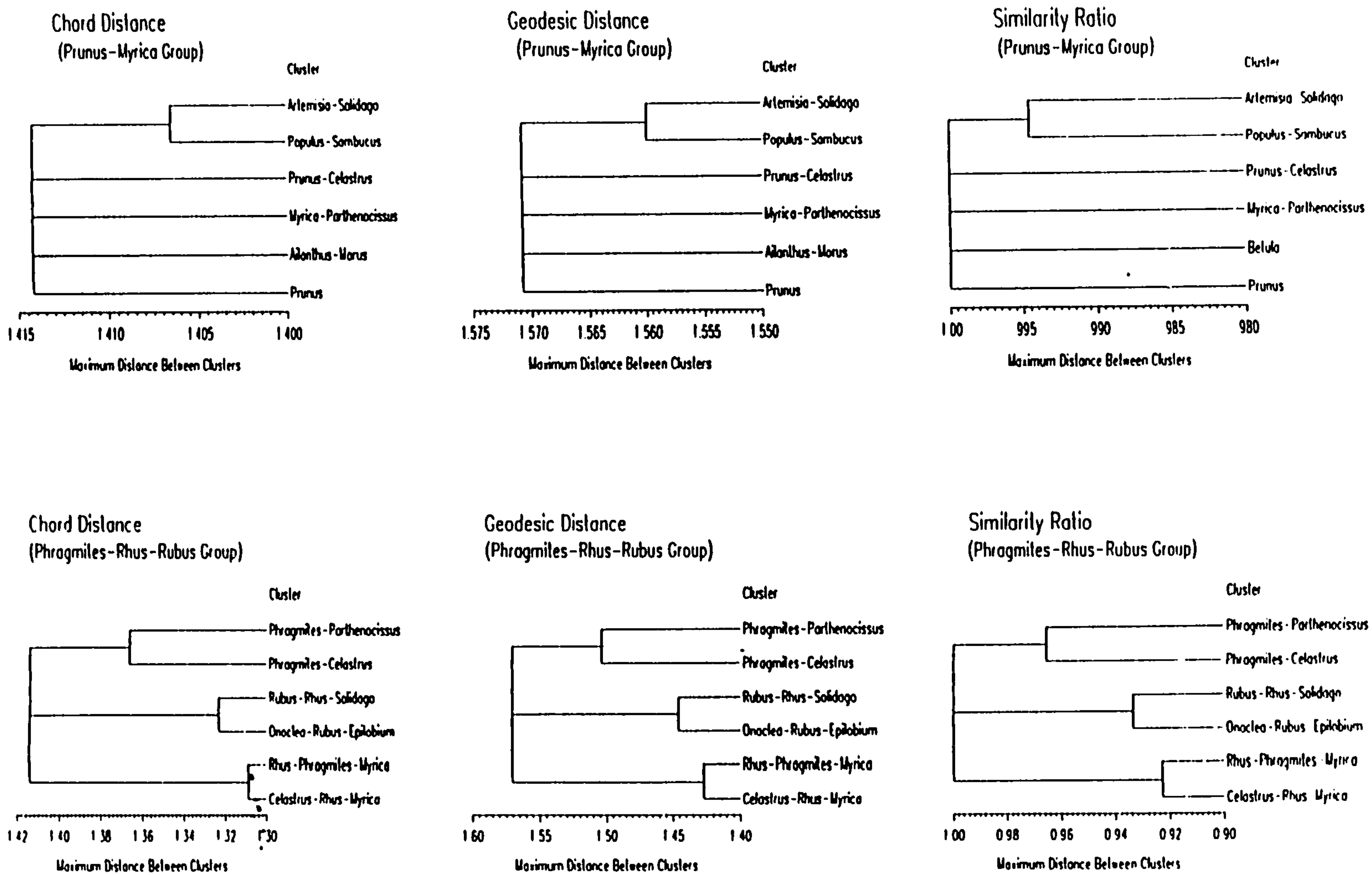



Figure 11. Dendrograms obtained from the Chord distance, Geodesic distance and Similarity ratio distance matrices used with Complete Linkage clustering depicting the different clusters recognized in each dendrogram.

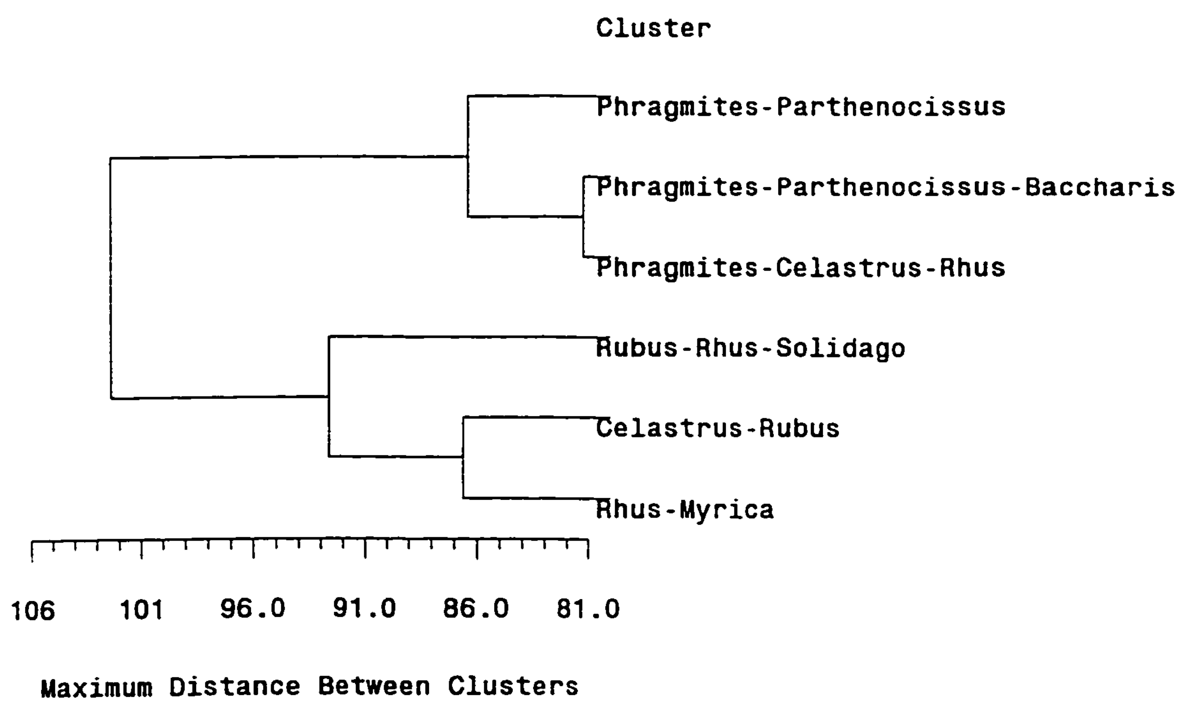



Figure 12. Dendrogram obtained for Euclidean Distance and Complete Linkage clustering for the Phragmites-Rhus-Rubus Group. Only the clusters recognized at distance level 80 are shown. Clusters are named using dominant species present.

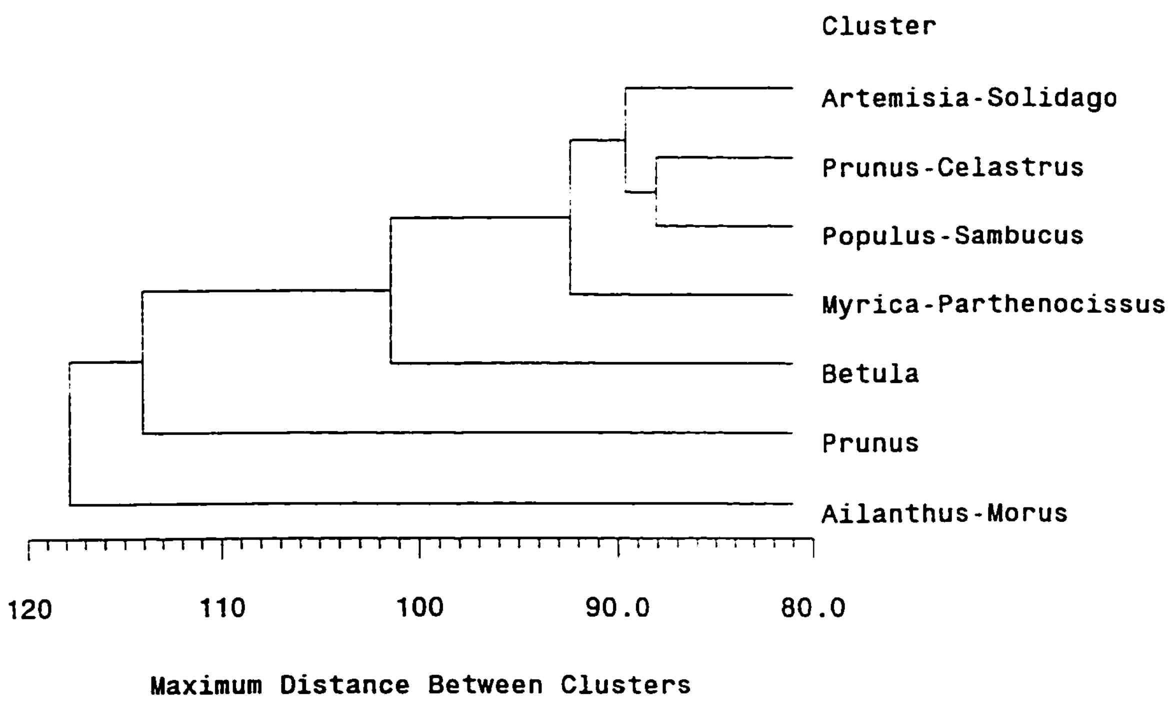



Figure 13. Dendrogram obtained for Euclidean Distance and Complete Linkage clustering for the Prunus-Myrica Group. Only the clusters recognized at distance level 85 are shown. Clusters are named using dominant species present.

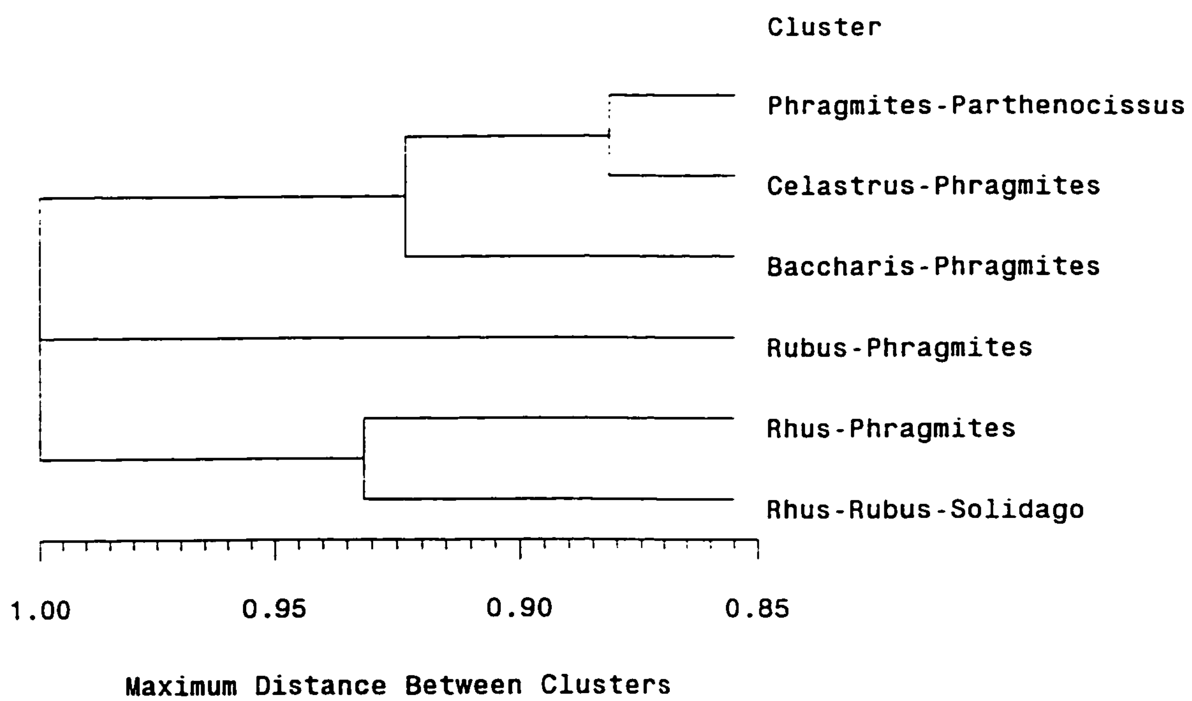



Figure 14. Dendrogram obtained for Bray-Curtis Dissimilarity and Complete Linkage clustering for the Phragmites-Rhus-Rubus Group. Only the clusters recognized at distance level 0.85 are shown. Clusters are named using dominant species present.

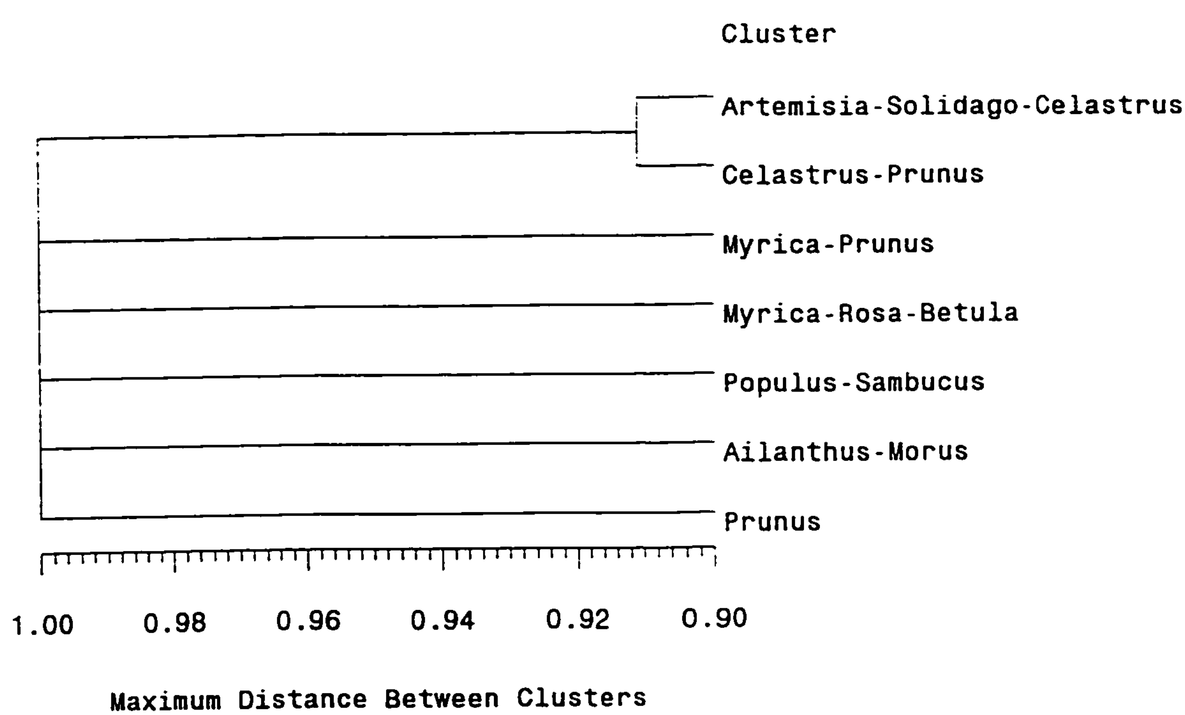



Figure 15. Dendrogram obtained for Bray-Curtis Dissimilarity and Complete Linkage clustering for the Prunus-Myrica Group. Only the clusters recognized at distance level 0.90 are shown. Clusters are named using dominant species present.

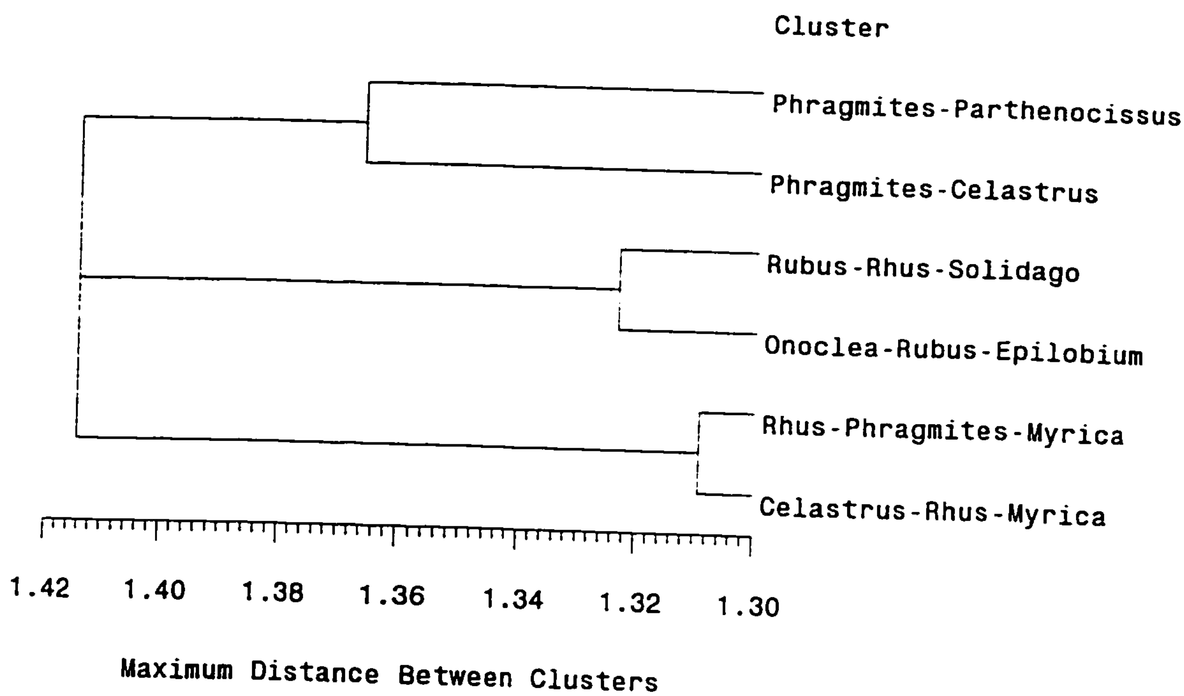



Figure 16. Dendrogram obtained for Chord Distance and Complete Linkage clustering for the Phragmites-Rhus-Rubus Group. Only the clusters recognized at distance level 1.3 are shown. Clusters are named using dominant species present.

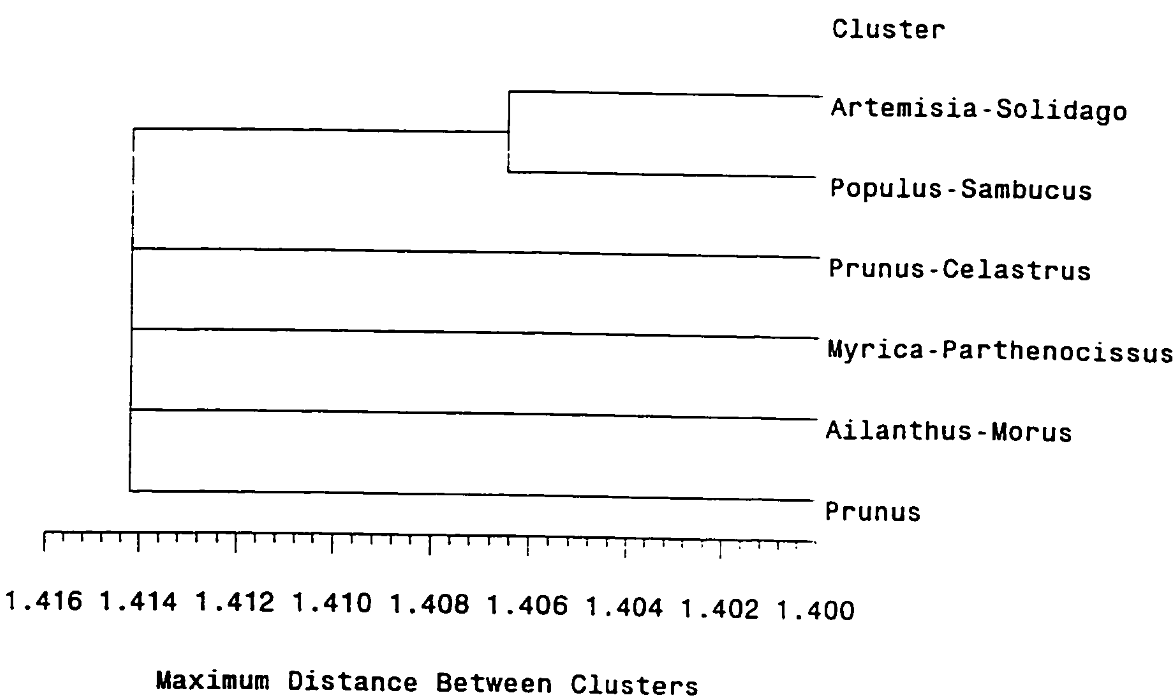



Figure 17. Dendrogram obtained for Chord Distance and Complete Linkage clustering for the Prunus-Myrica Group. Only the clusters recognized at distance level 1.4 are shown. Clusters are named using dominant species present.

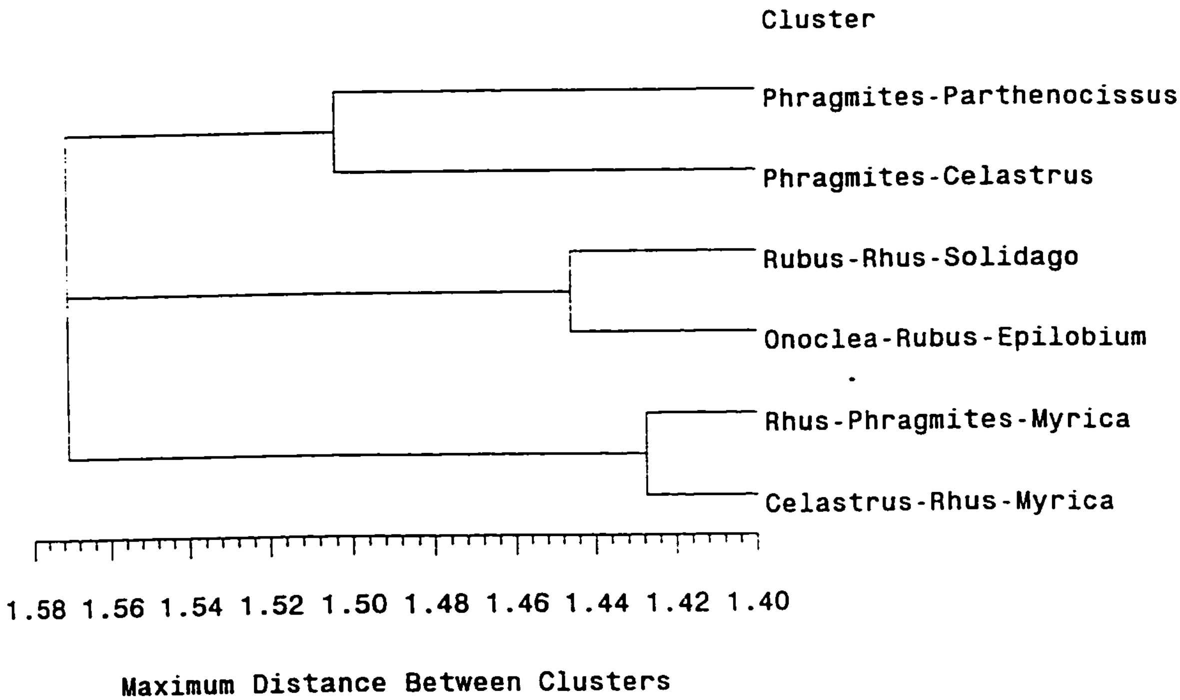



Figure 18. Dendrogram obtained for Geodesic Distance and Complete Linkage clustering for the Phragmites-Rhus-Rubus Group. Only the clusters recognized at distance level 1.4 are shown. Clusters are named using dominant species present.

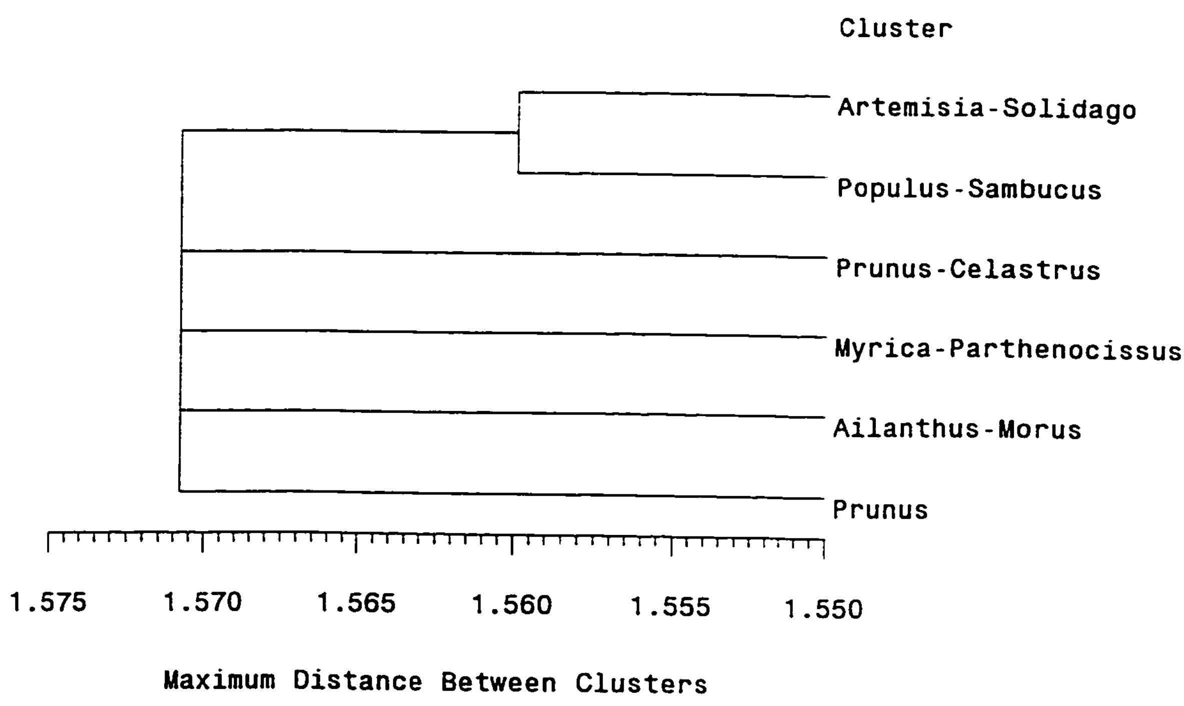



Figure 19. Dendrogram obtained for Geodesic Distance and Complete Linkage clustering for the Prunus-Myrica Group. Only the clusters recognized at distance level 1.55 are shown. Clusters are named using dominant species present.

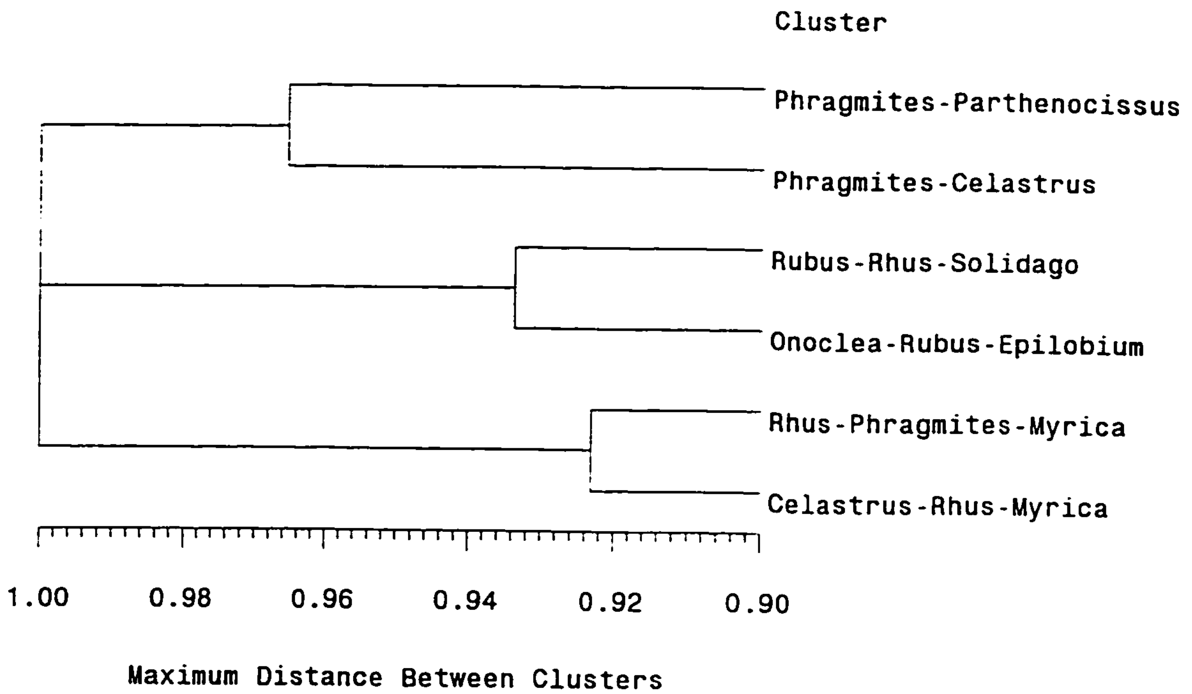



Figure 20. Dendrogram obtained for Similarity Ratio and Complete Linkage clustering for the Phragmites-Rhus-Rubus Group. Only the clusters recognized at distance level 0.9 are shown. Clusters are named using dominant species present.

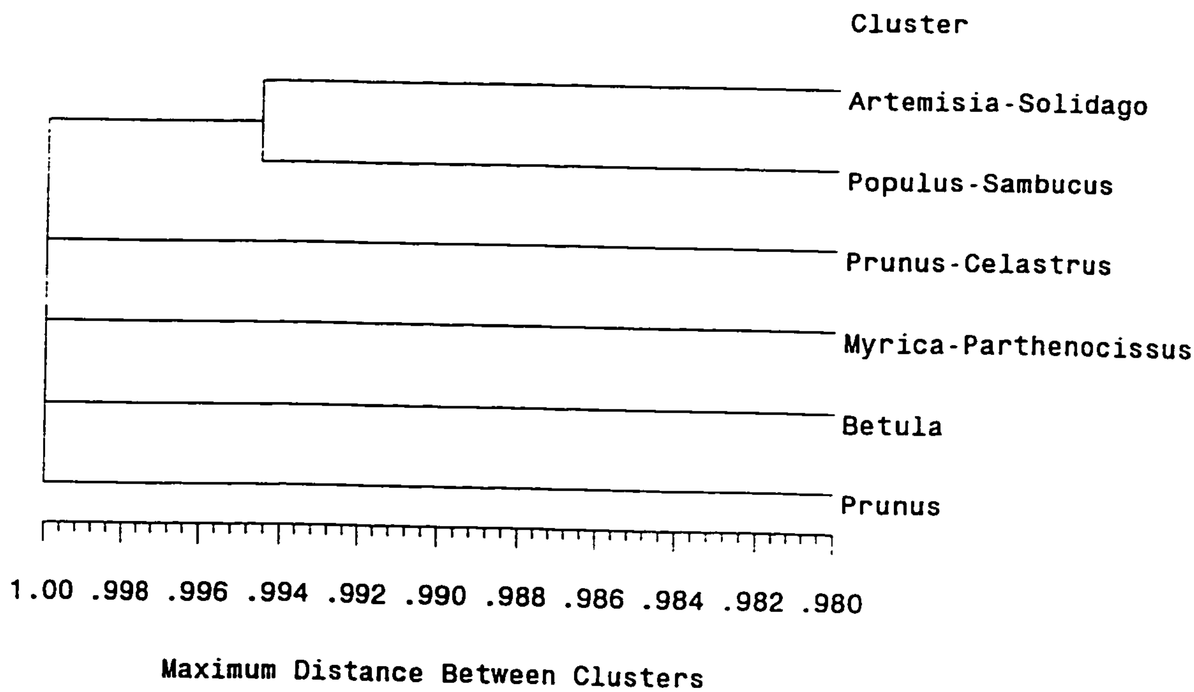



Figure 21. Dendrogram obtained for Similarity Ratio and Complete Linkage clustering for the Prunus-Myrica Group. Only the clusters recognized at distance level 0.98 are shown. Clusters are named using dominant species present.

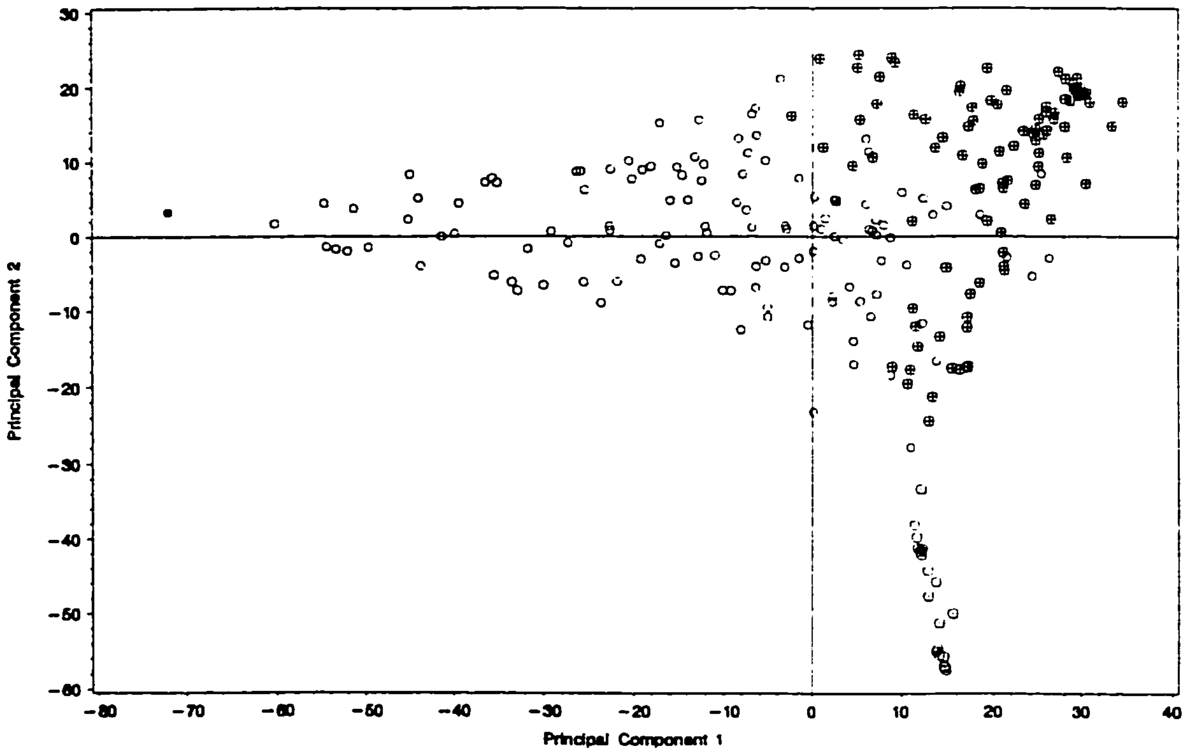



Figure 22. Principal Component Analysis Ordination diagram depicting the four major cluster groups recognized in Euclidean Distance and Minimum Variance Clustering. (Filled circle=Phragmites group, open circle=Rhus-Rubus-Phragmites group, crossed circle=woodland group, dotted circle=dry grassland group).

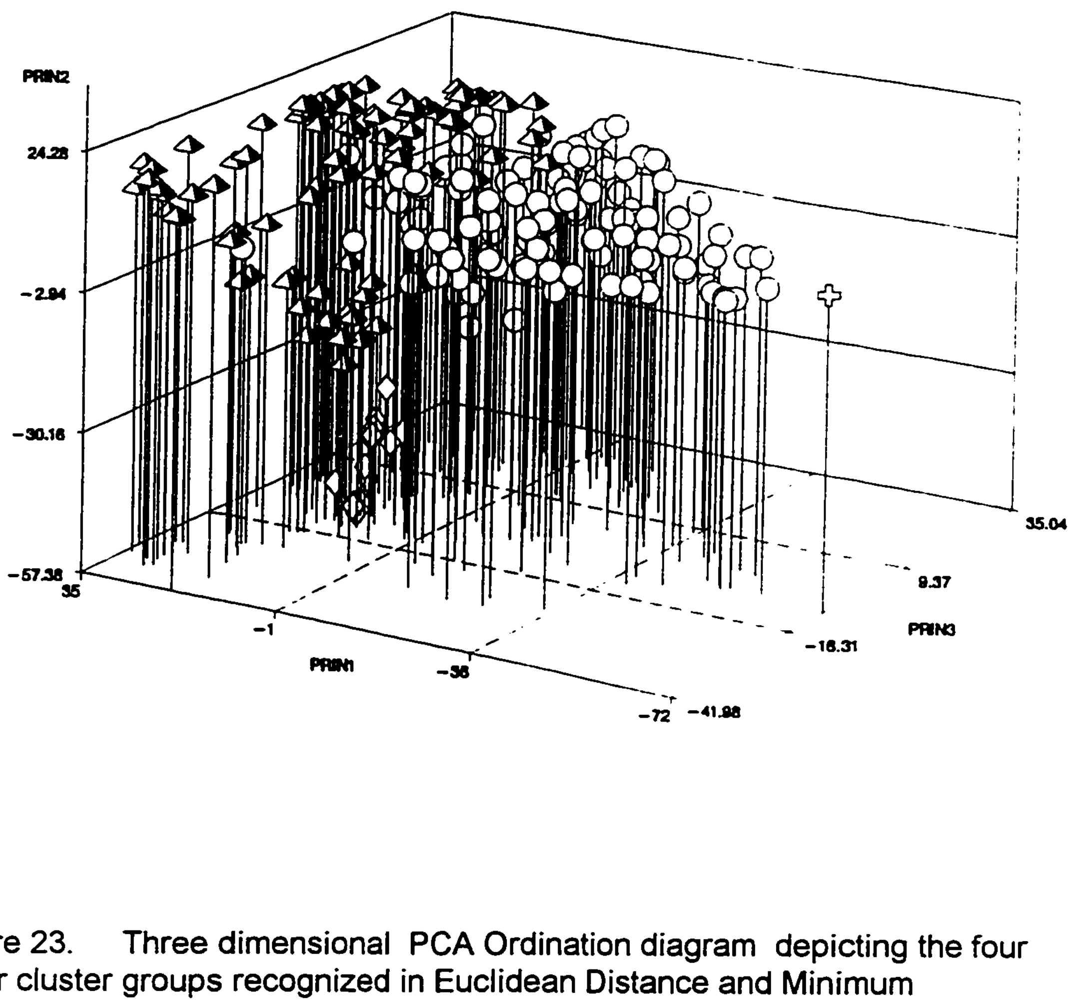



Figure 23. Three dimensional PCA Ordination diagram depicting the four major cluster groups recognized in Euclidean Distance and Minimum Variance Clustering (Pyramid=woodland group, diamond=dry grassland group, circle=Rhus-Rubus-Phragmites group, cross=Phragmites group).

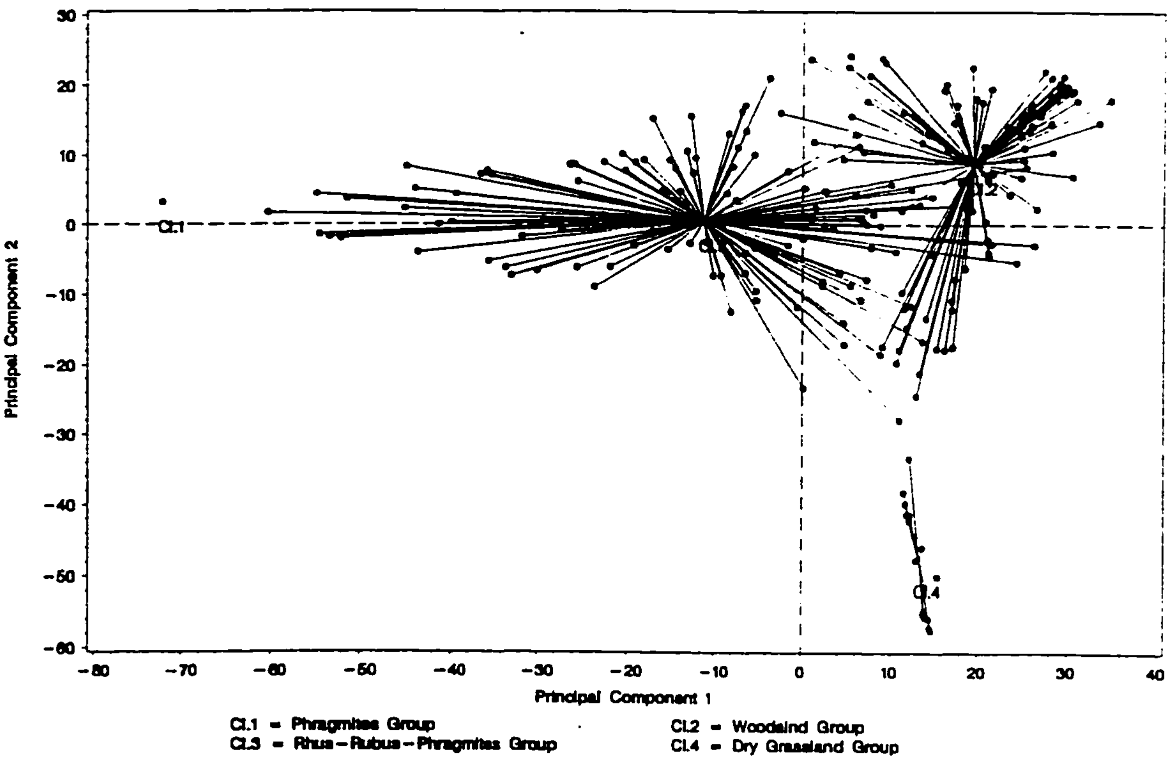



Figure 24. PCA Ordination diagram depicting the four cluster groups with sites connected to cluster centroids (as recognized in Euclidean Distance and Complete Linkage Clustering).

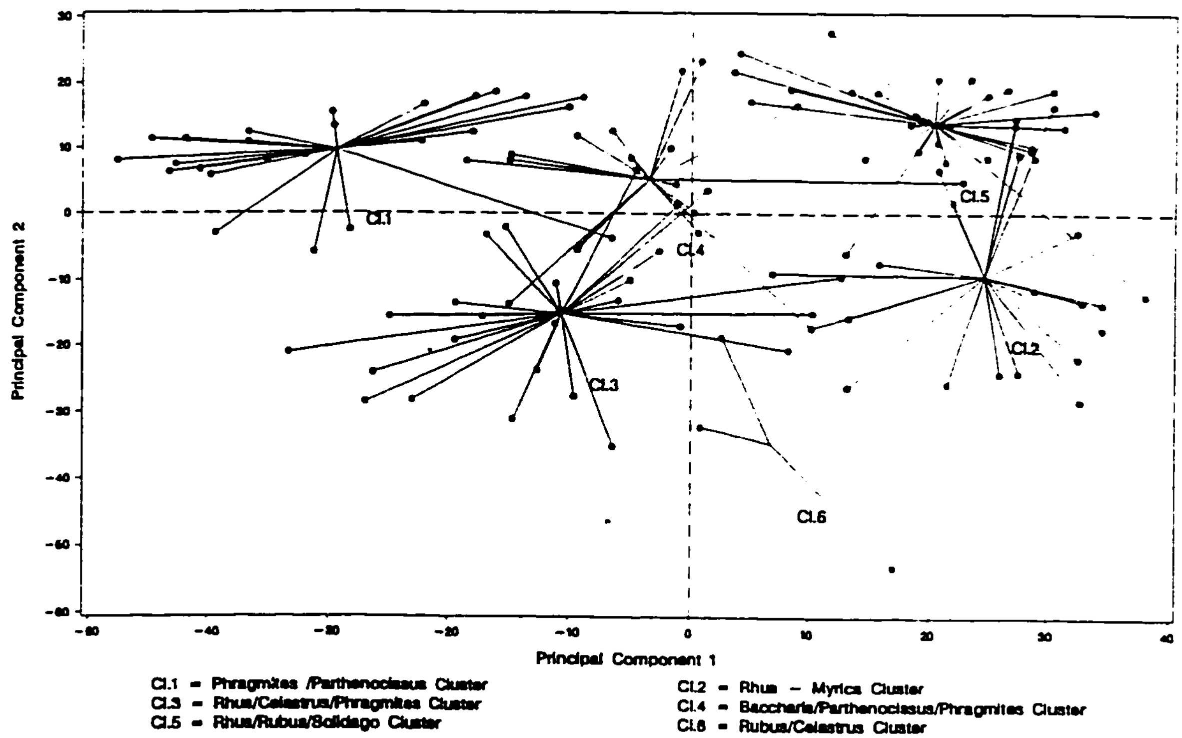



Figure 25. PCA Ordination diagram of <u>Rhus</u>-<u>Rubus</u>-<u>Phragmites</u> Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

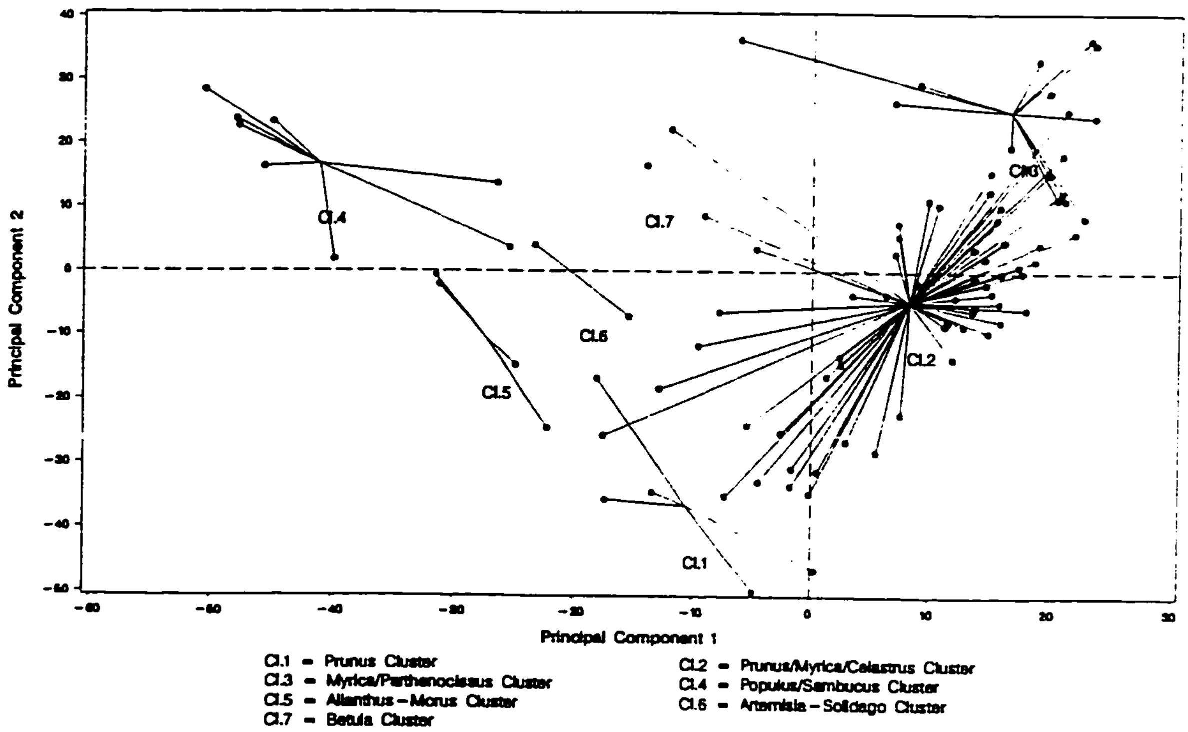



Figure 26. PCA Ordination diagram of Woodland Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

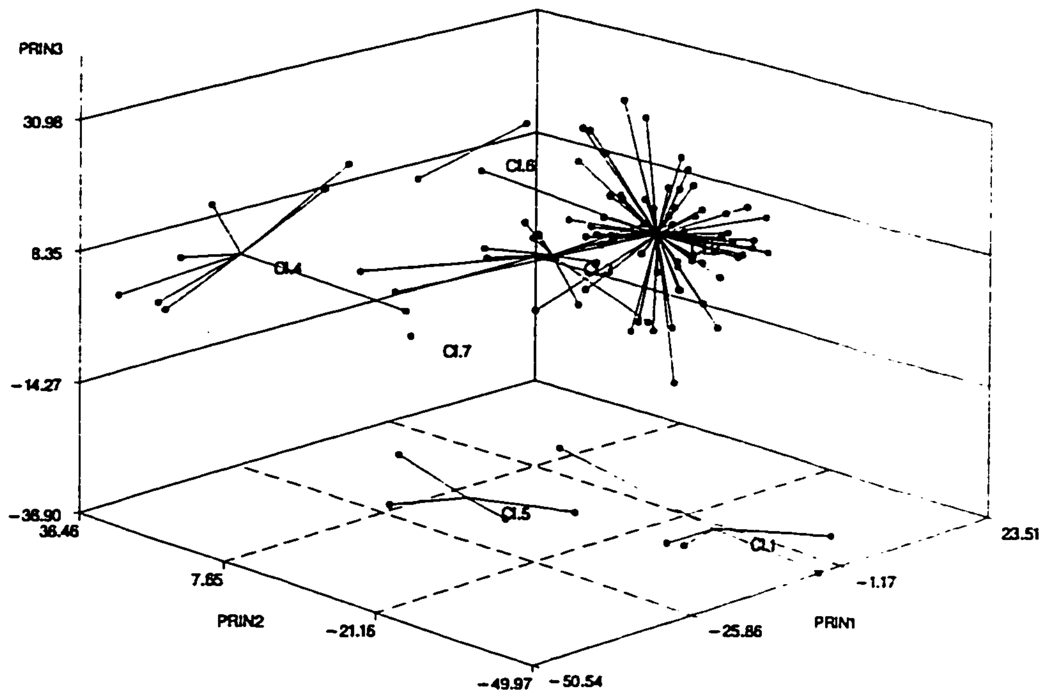



Figure 27. Three dimensional PCA Ordination diagram of Woodland Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

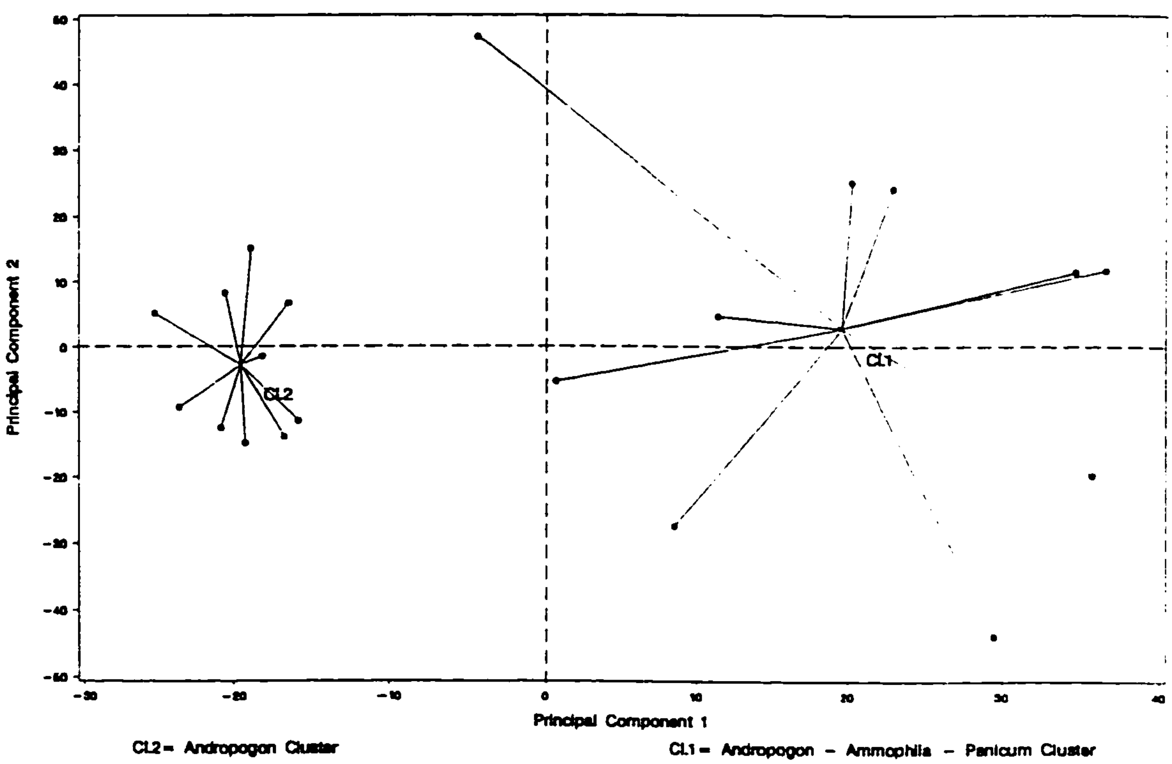



Figure 28. PCA Ordination diagram of dry grassland Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

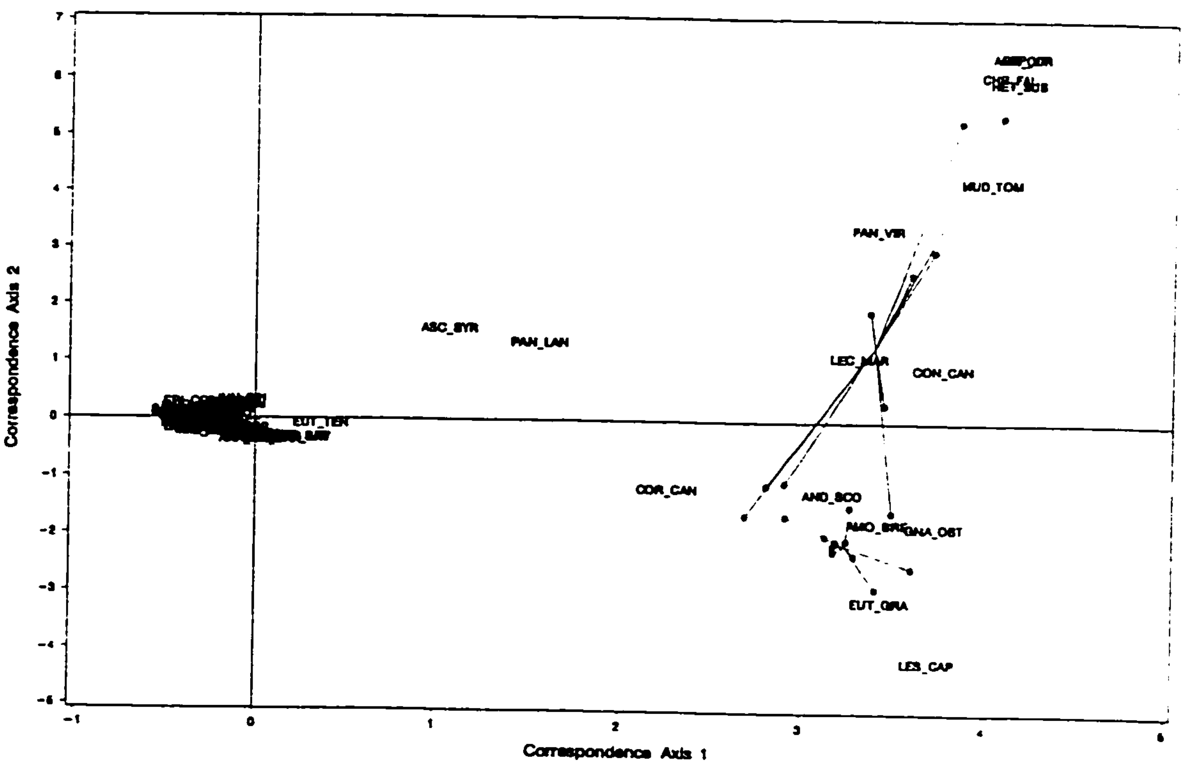



Figure 29. Correspondence Analysis Ordination diagram of all the samples depicting the species and (clusters of) sites (List of abbreviated species is in Appendix 1).

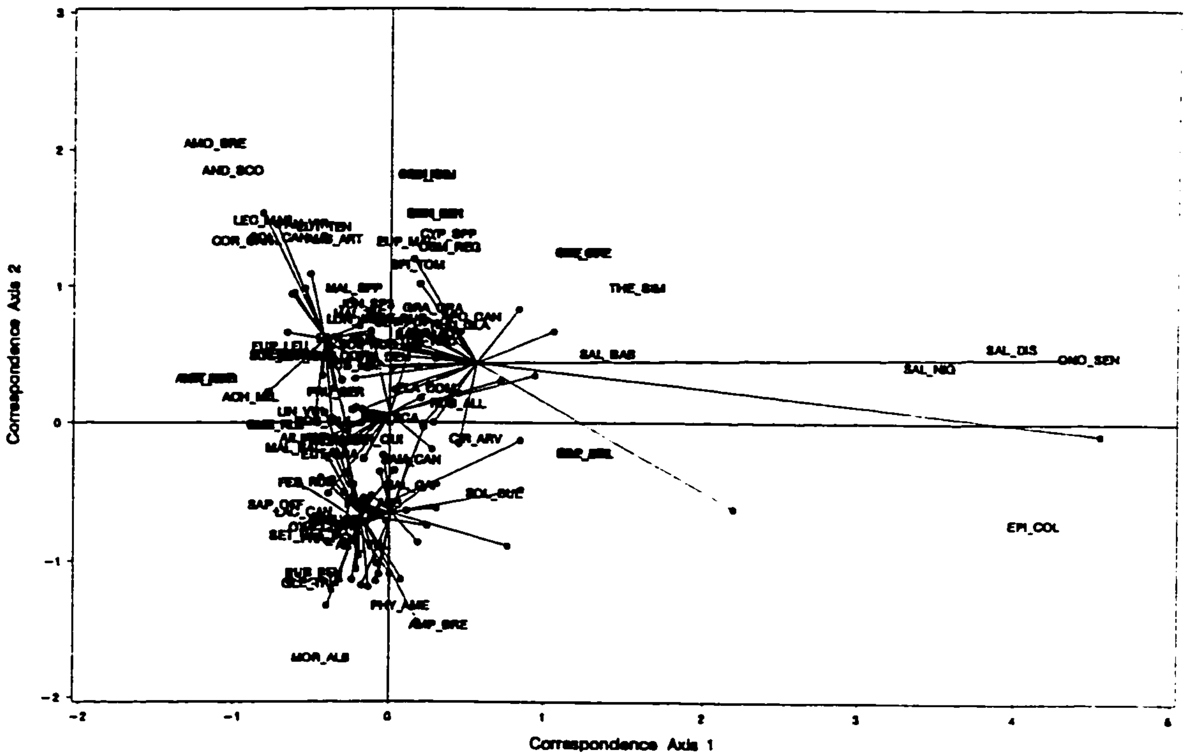



Figure 30. Correspondence Analysis Ordination diagram for Rhus-Rubus-Phragmites Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

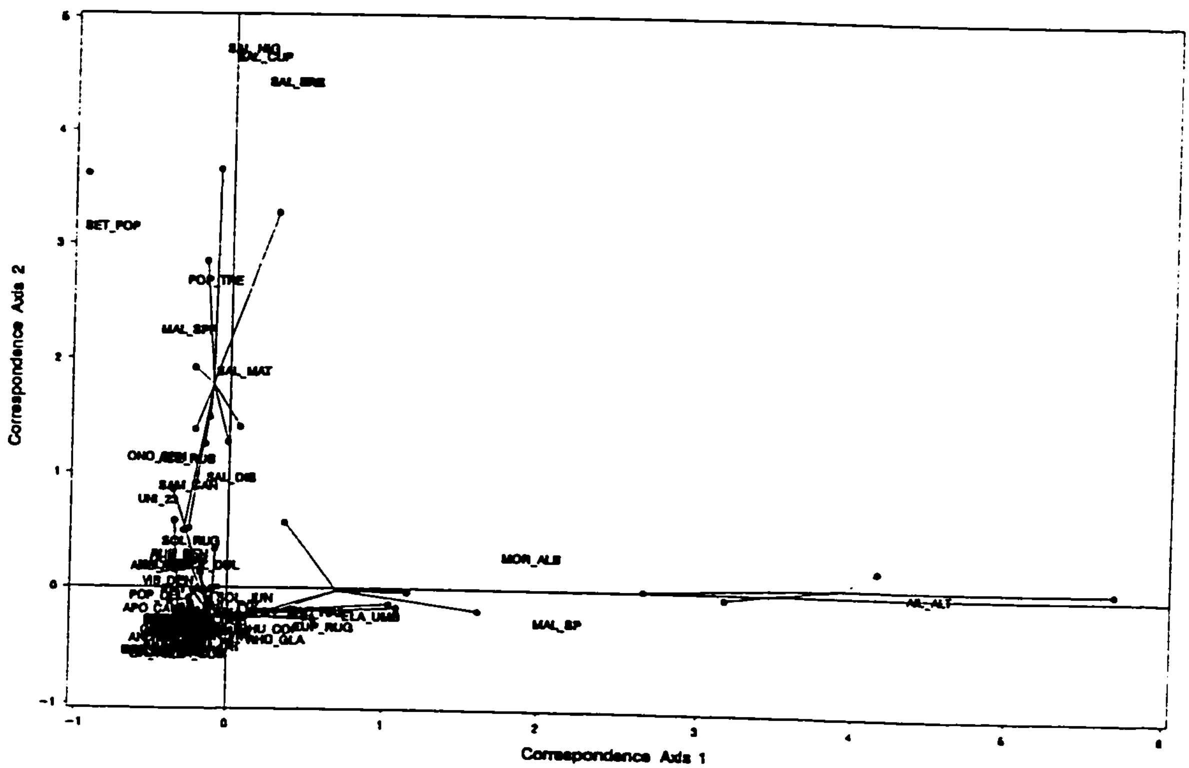



Figure 31. Correspondence Analysis Ordination diagram for the woodland Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

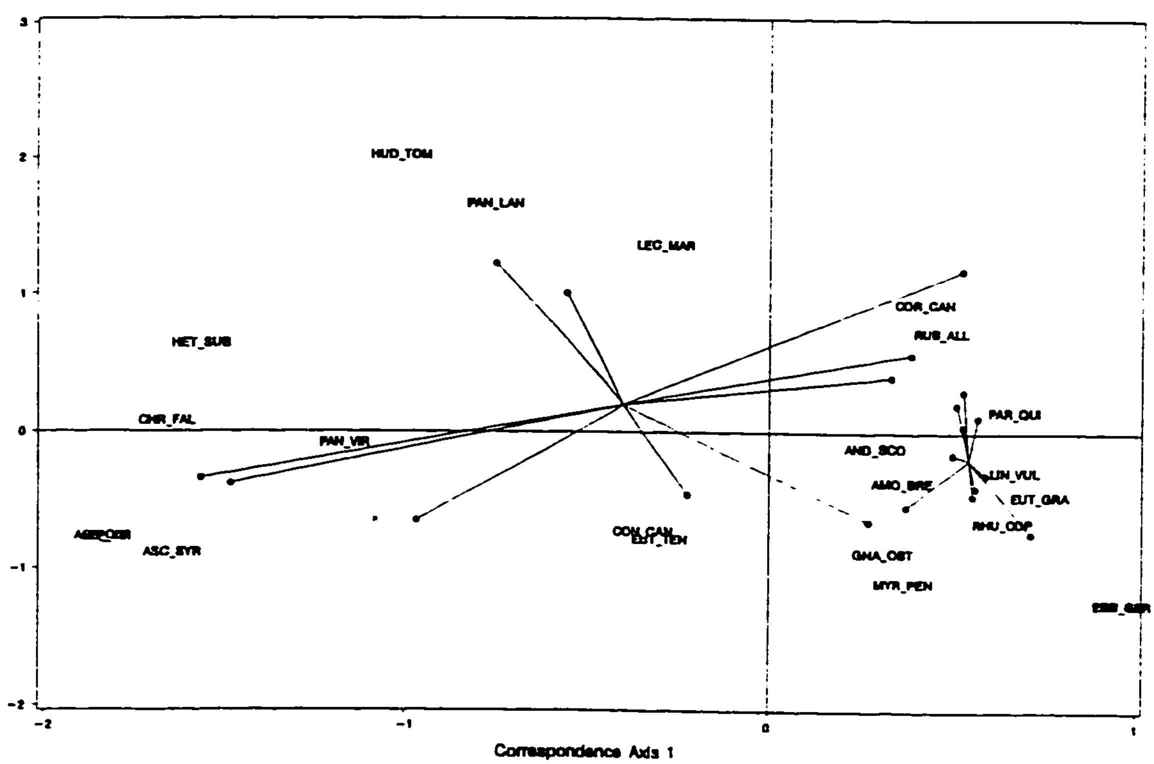



Figure 32. Correspondence Analysis Ordination diagram for the dry grassland Cluster group with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

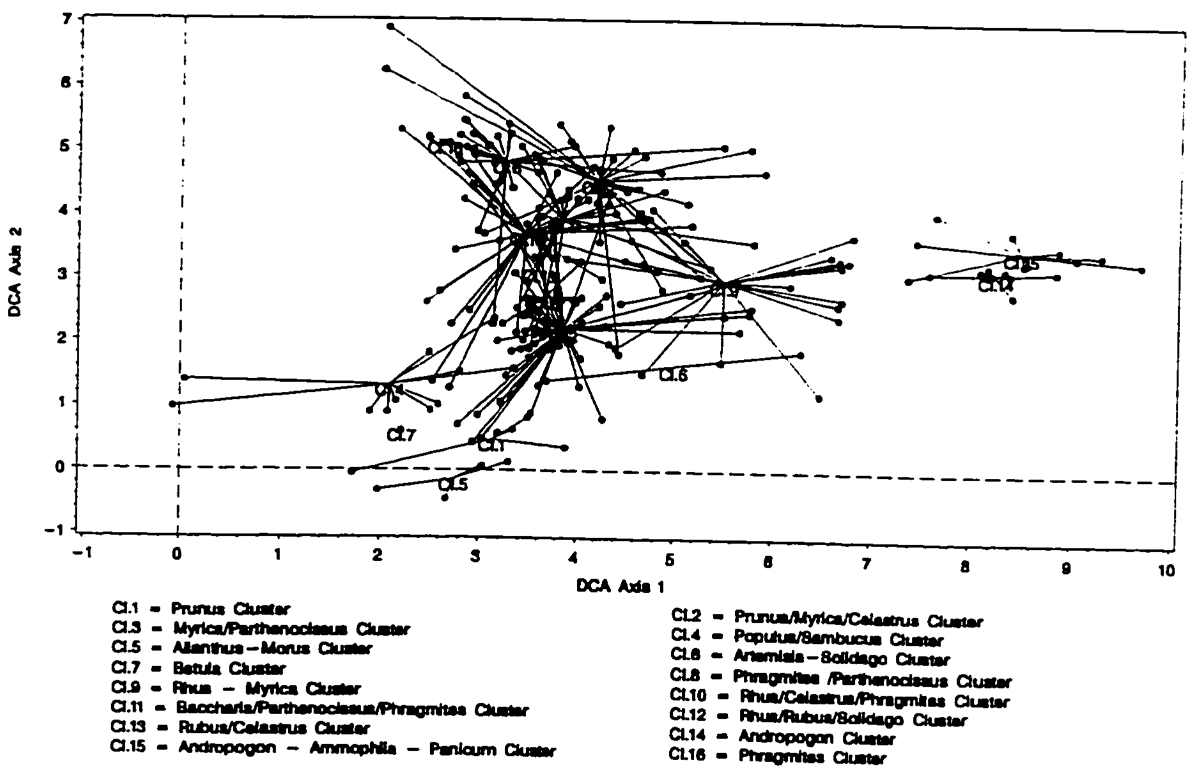



Figure 33. Detrended Correspondence Analysis Ordination diagram of all the samples with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

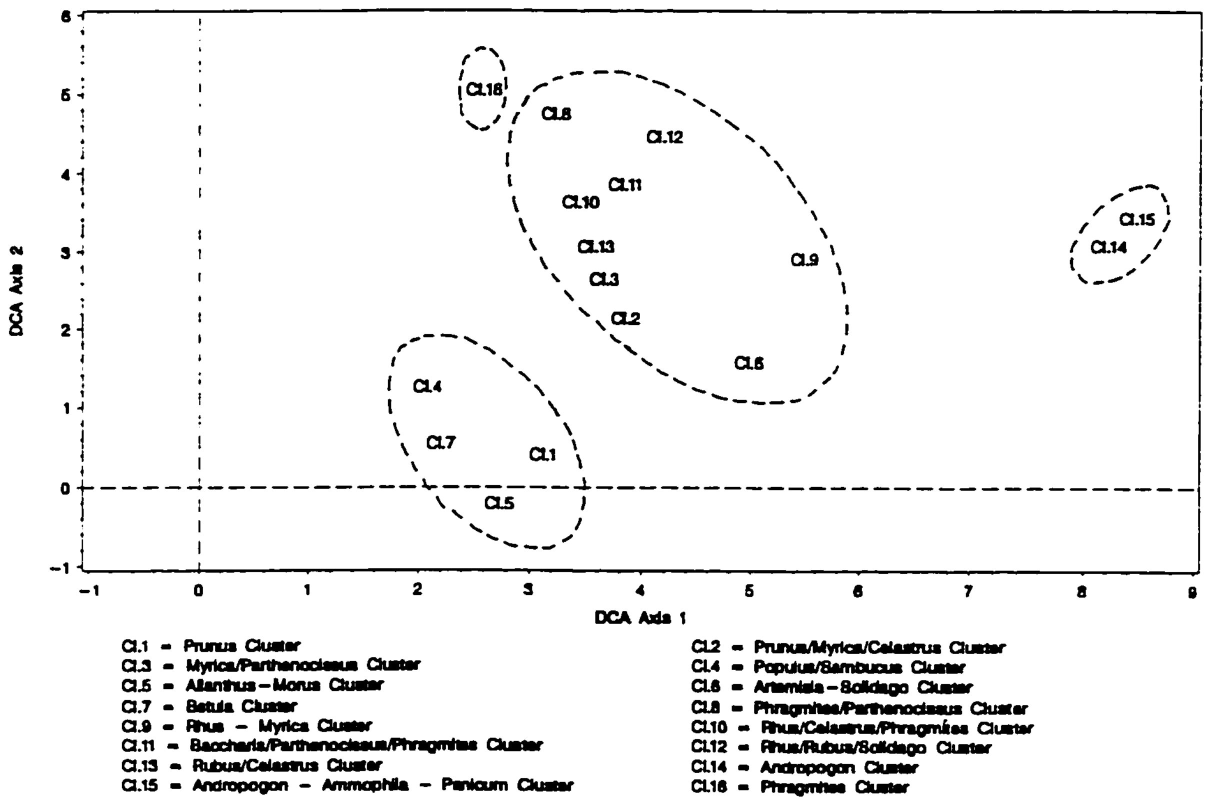



Figure 34. Detrended Correspondence Analysis Ordination diagram of all the samples depicting the cluster centroids (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

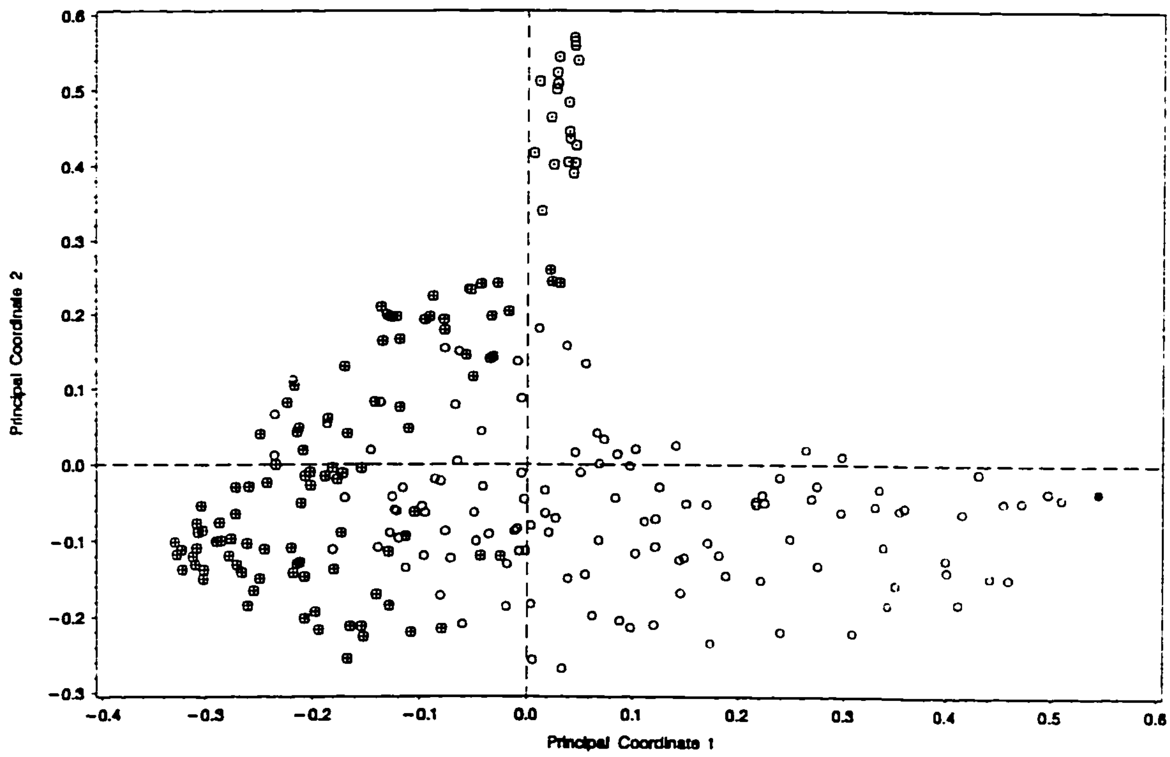



Figure 35 Principal Coordinate Analysis (PCO) Ordination diagram depicting the four major cluster groups recognized in Euclidean Distance and Minimum Variance Clustering (Filled circle=Phragmites group, open circle=Rhus-Rubus-Phragmites group, crossed circle=woodland group, dotted circle=dry grassland group).

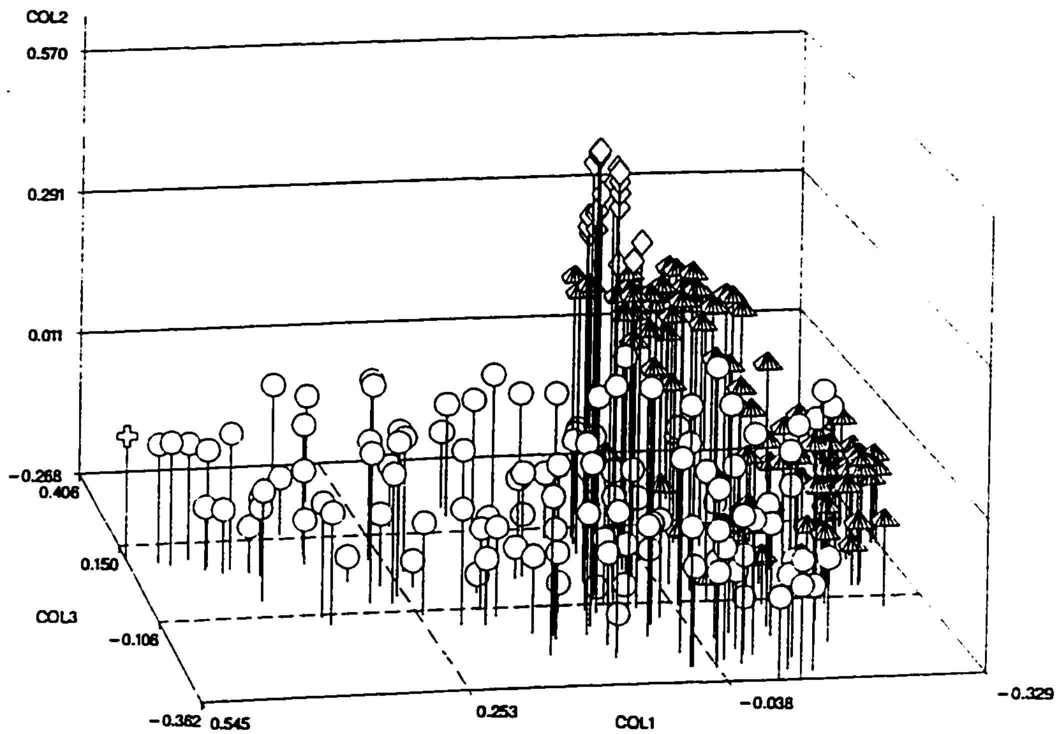



Figure 36. Three dimensional PCO Ordination diagram depicting the four major cluster groups recognized in Euclidean Distance and Minimum Variance Clustering (pyramid =woodland group, diamond=dry grassland group, circle=Rhus-Rubus-Phragmites group, cross=Phragmites group).

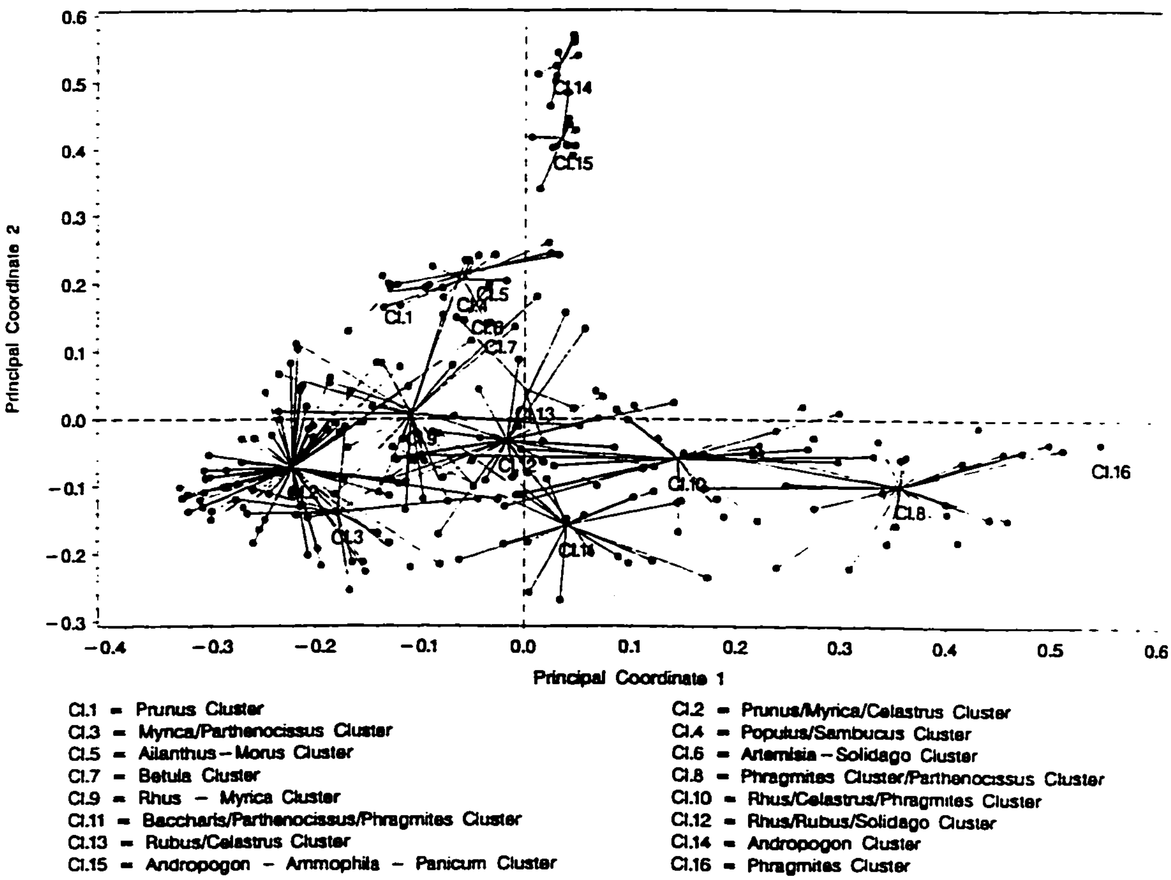



Figure 37. PCO Ordination diagram of all the with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).

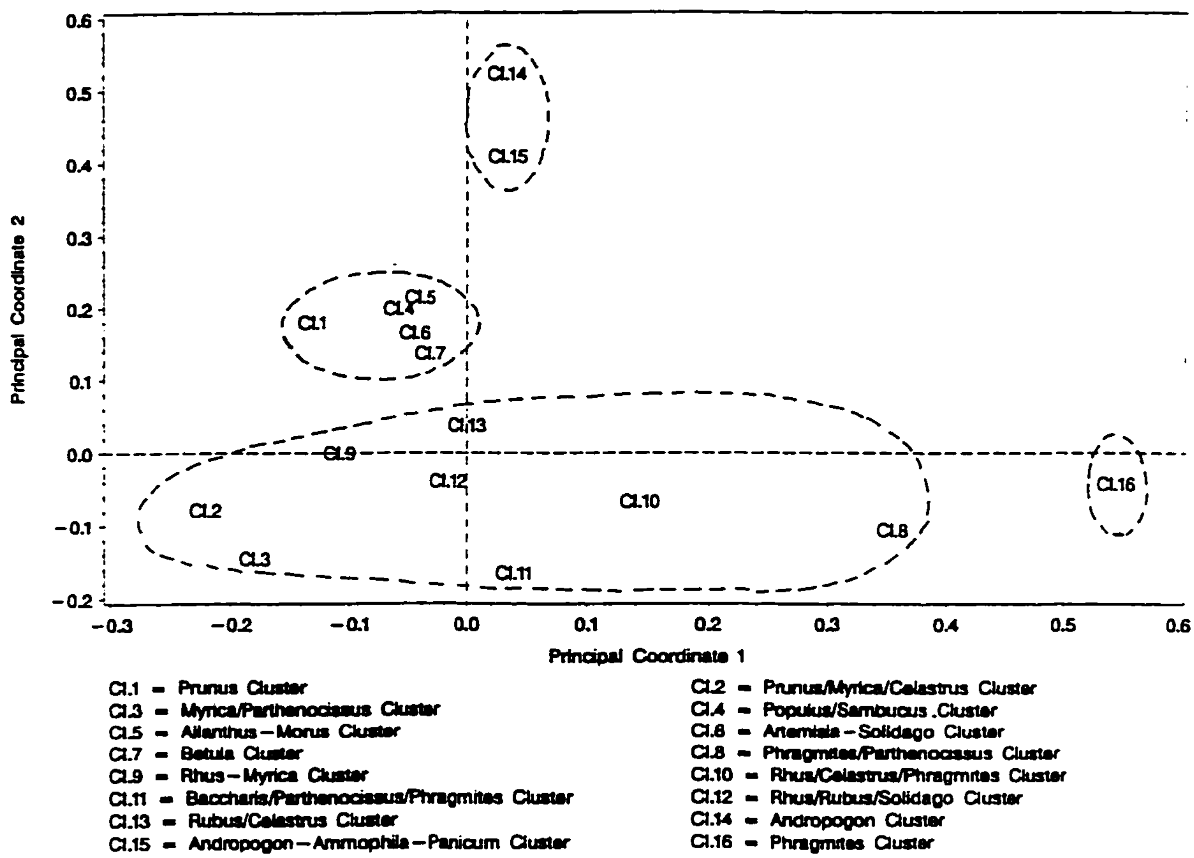



Figure 38. PCO Ordination diagram depicting the cluster centroids (distance=Bray-Curtis Dissimilarity).

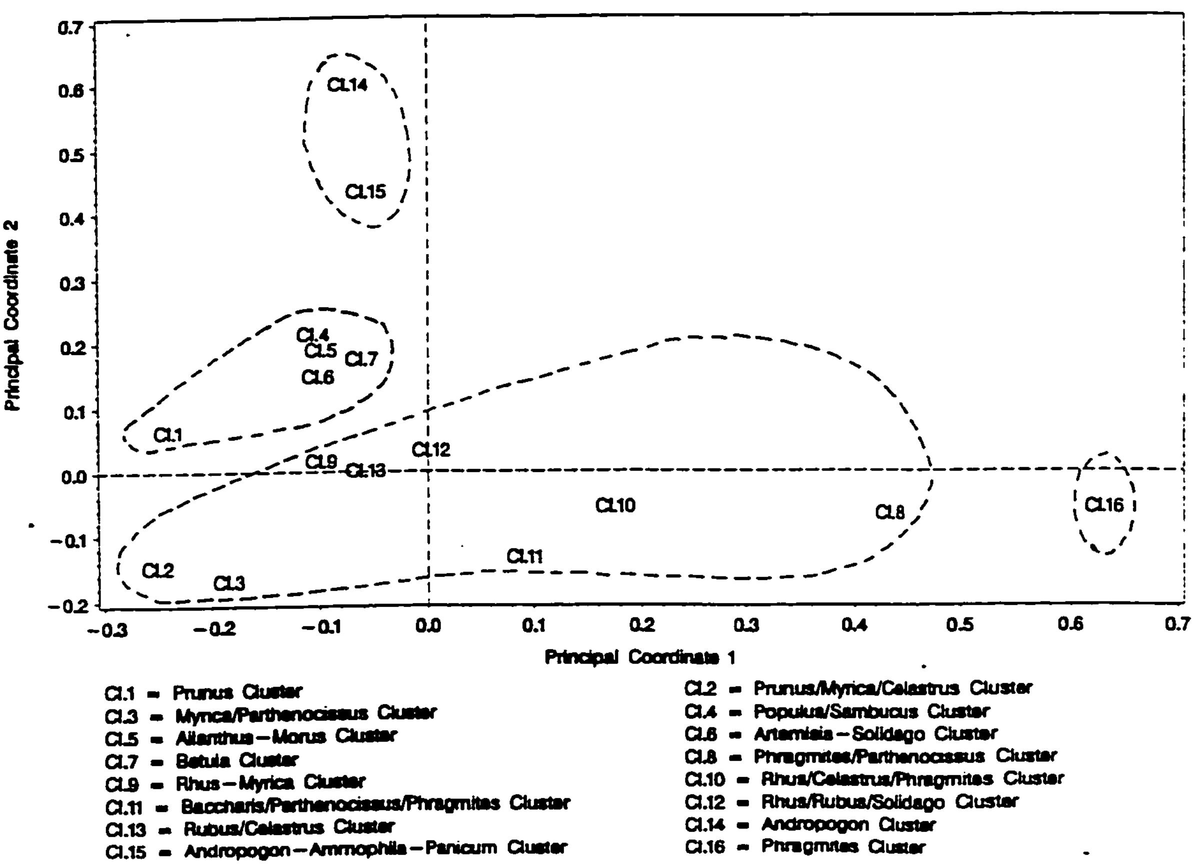
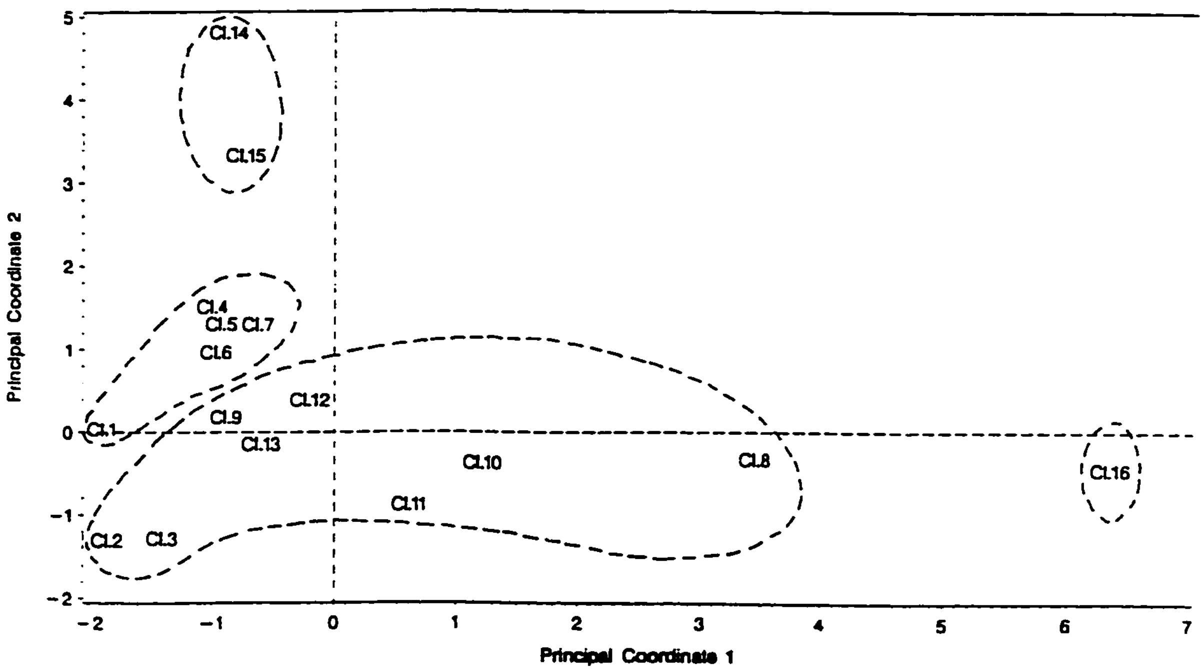



Figure 39. PCO Ordination diagram depicting the cluster centroids (distance=Chord Distance).




Cl.1 = Prunus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.5 = Ailanthus–Morus Cluster
Cl.7 = Betula Cluster
Cl.9 = Rhus–Myrica Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.15 = Andropogon–Ammophila–Panicum Cluster

Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.6 = Artemisia–Solidago Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.14 = Andropogon Cluster
Cl.16 = Phragmites Cluster

Figure 40. PCO Ordination diagram depicting the cluster centroids (distance=Euclidean Distance).

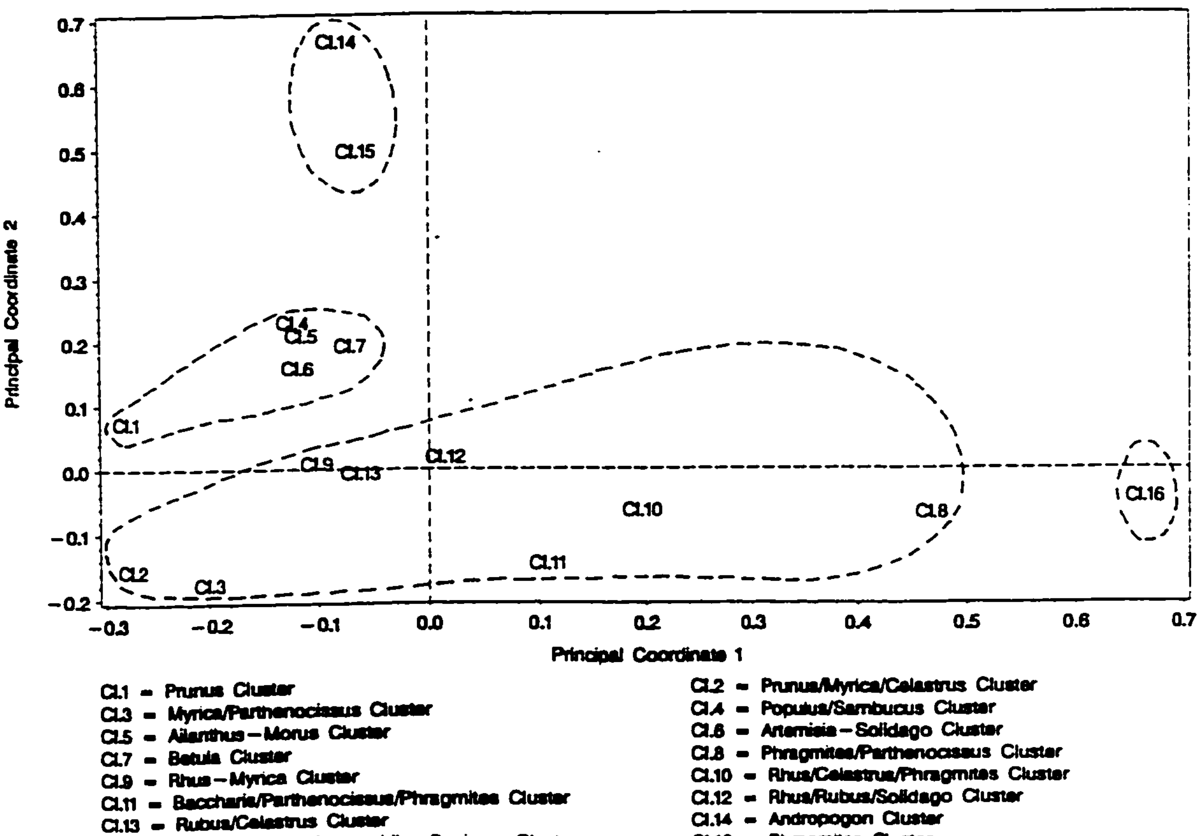



Figure 41. PCO Ordination diagram depicting the cluster centroids (distance=Geodesic Distance).

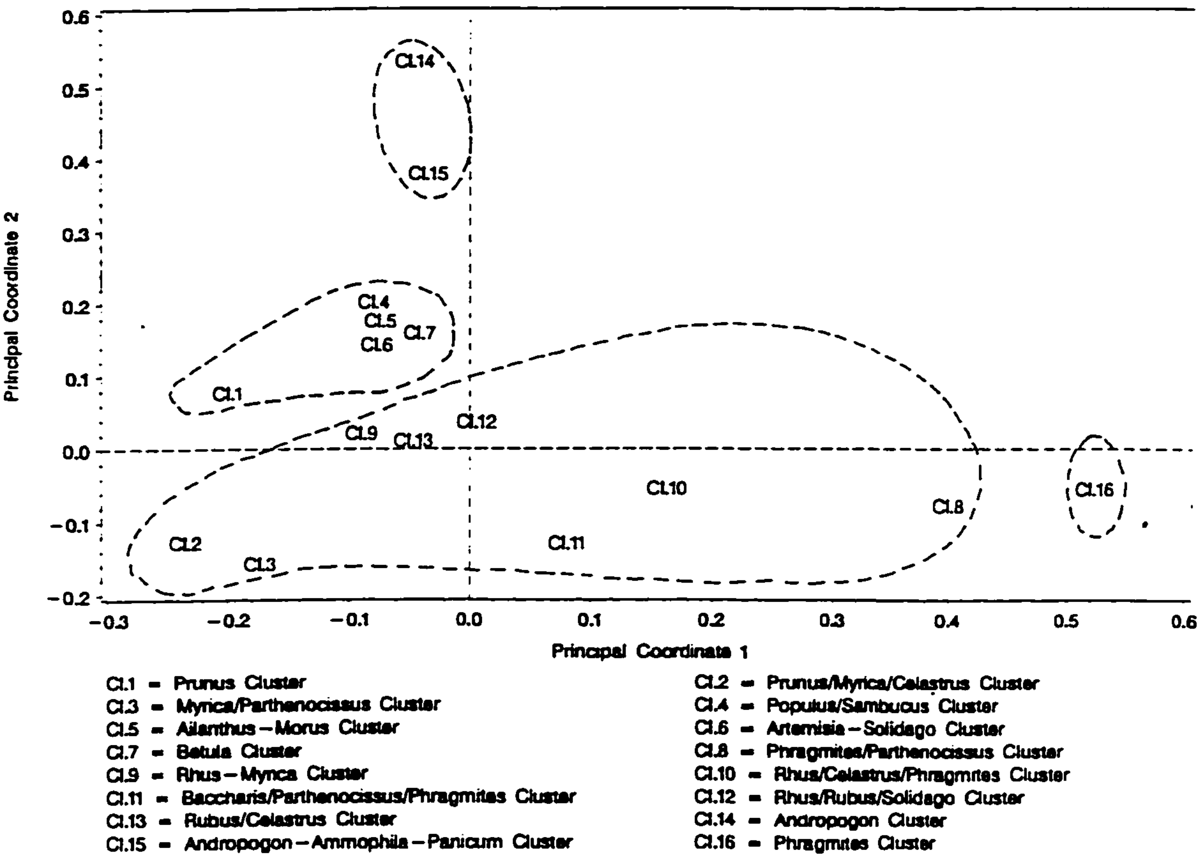



Figure 42. PCO Ordination diagram depicting the cluster centroids (distance=Similarity Ratio).

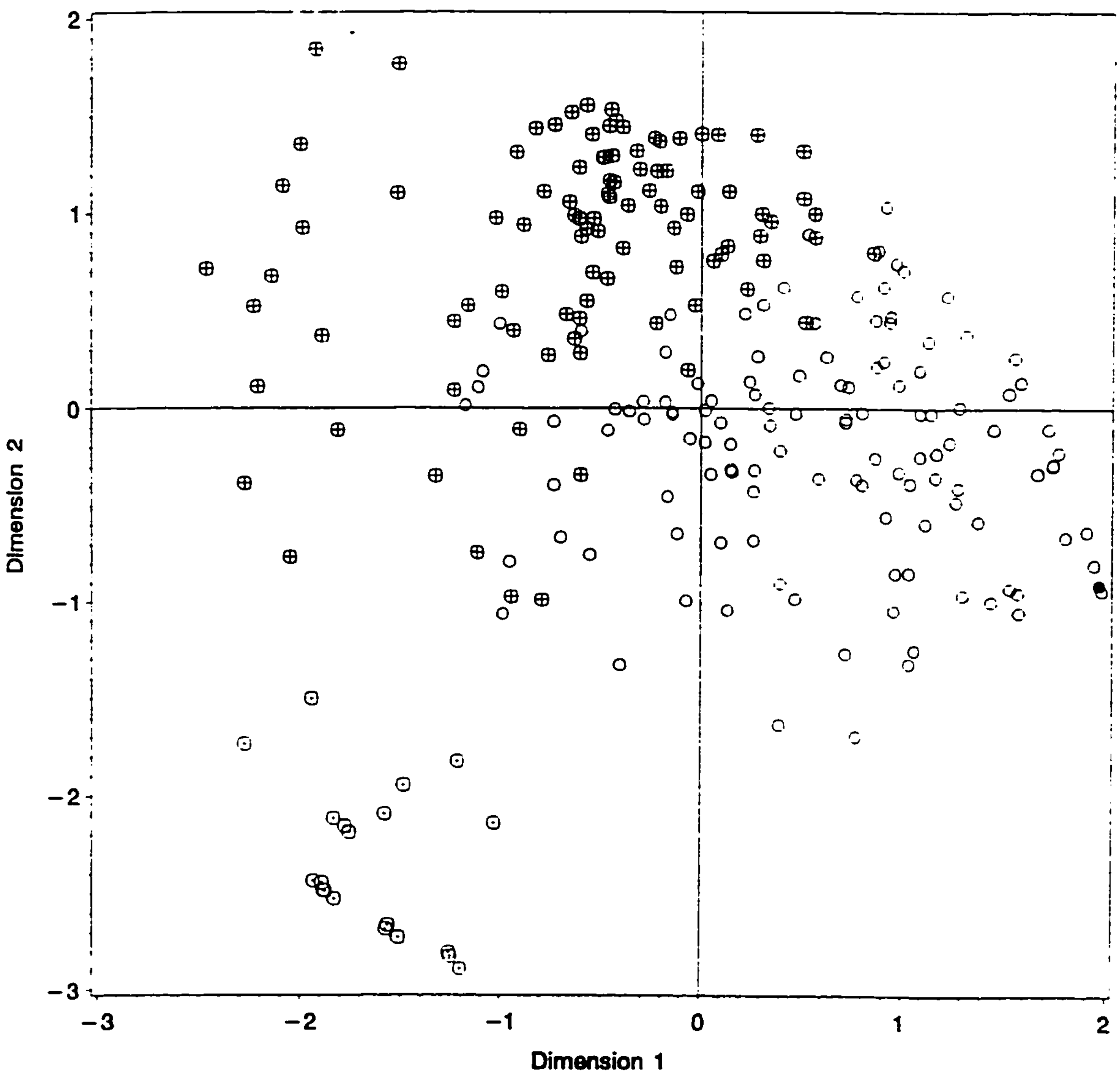
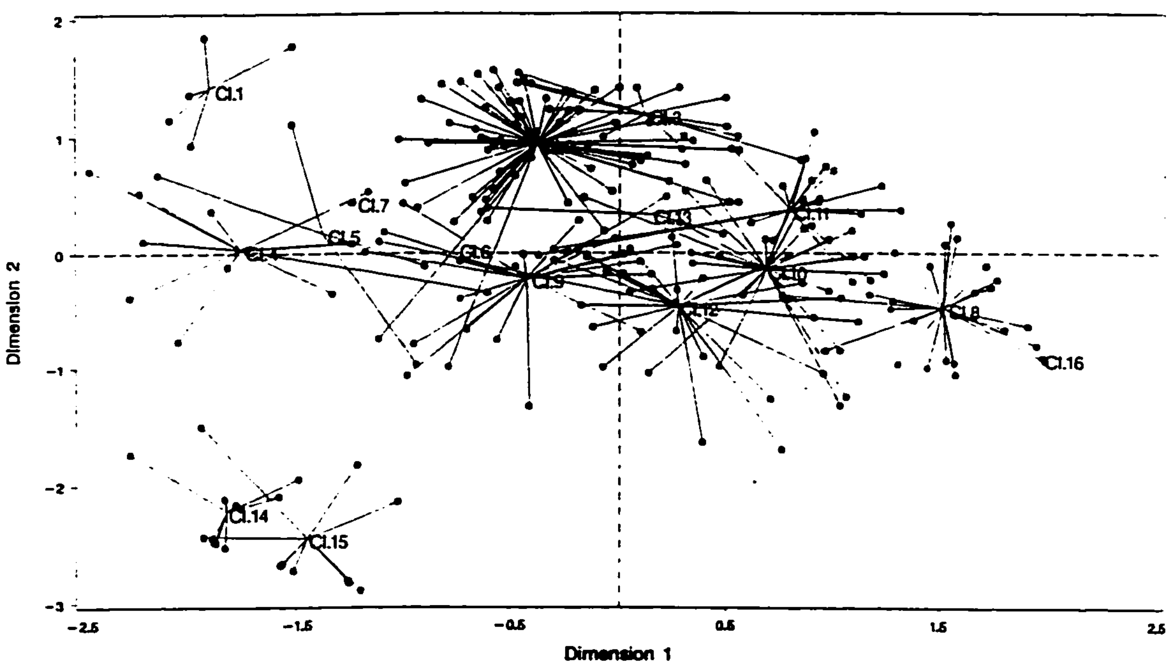
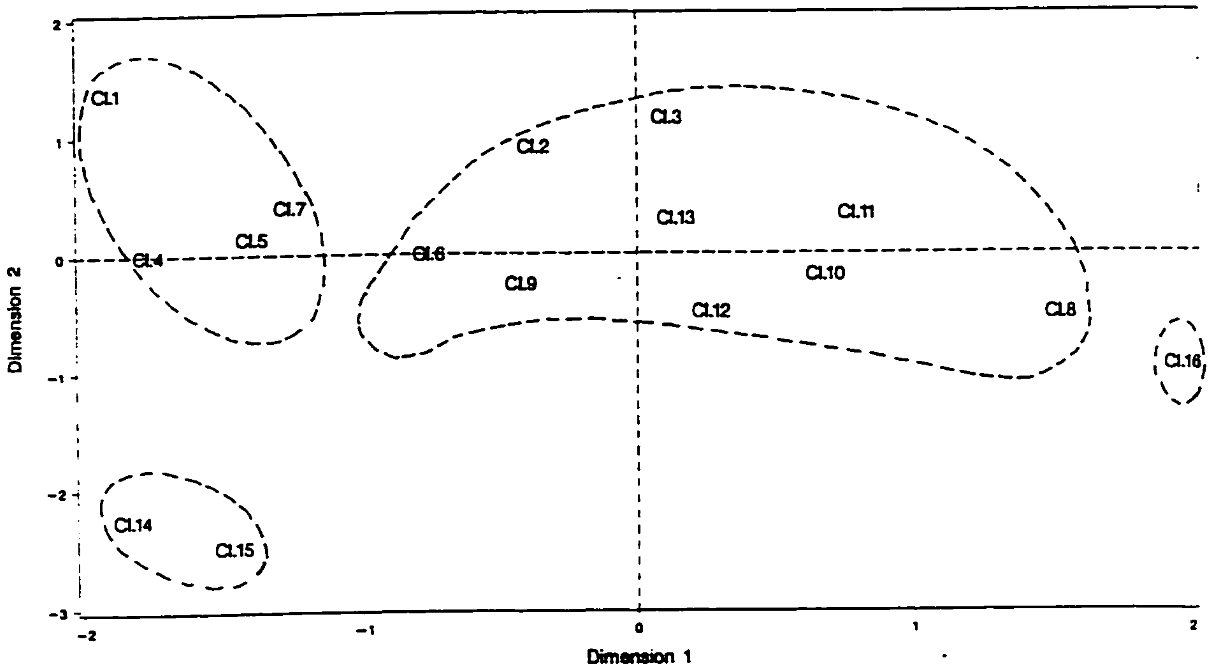



Figure 43. Ordination diagram obtained from Nonmetric Multidimensional Scaling, depicting the four major cluster groups recognized in Euclidean Distance and Minimum Variance Clustering (Filled circle=Phragmites group, open circle=Rhus-Rubus-Phragmites group, crossed circle=woodland group, dotted circle=dry grassland group).




Cl.1 = Prunus Cluster
Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.5 = Ailanthus – Morus Cluster
Cl.6 = Artemisia – Solidago Cluster
Cl.7 = Betula Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.9 = Rhus – Myrica Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.14 = Andropogon Cluster
Cl.15 = Andropogon – Ammophila – Panicum Cluster
Cl.16 = Phragmites Cluster

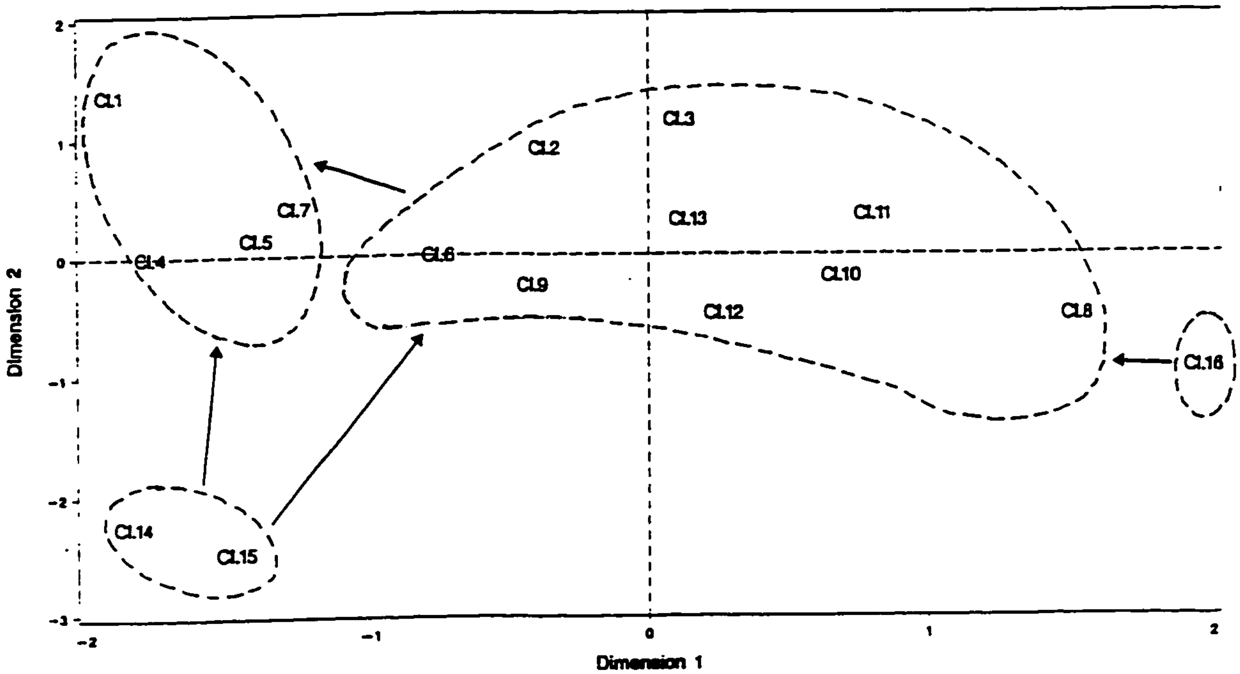
Figure 44. NMDS Ordination diagram with members of each cluster connected to the centroid (clusters as recognized in Euclidean Distance and Complete Linkage Clustering).




Cl.1 = Prunus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.5 = Ailanthus–Morus Cluster
Cl.7 = Betula Cluster
Cl.9 = Rhus–Myrica Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.15 = Andropogon–Ammophila–Panicum Cluster

Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.6 = Artemisia–Solidago Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.14 = Andropogon Cluster
Cl.16 = Phragmites Cluster

Figure 45. NMDS Ordination diagram depicting the cluster centroids (as recognized in Euclidean Distance and Complete Linkage Clustering).




Cl.1 = Prunus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.5 = Ailanthus – Morus Cluster
Cl.7 = Betula Cluster
Cl.9 = Rhus – Myrica Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.15 = Andropogon – Ammophila – Panicum Cluster

Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.6 = Artemisia – Solidago Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.14 = Andropogon Cluster
Cl.16 = Phragmites Cluster

Figure 46. NMDS Ordination diagram depicting the possible successional trends.

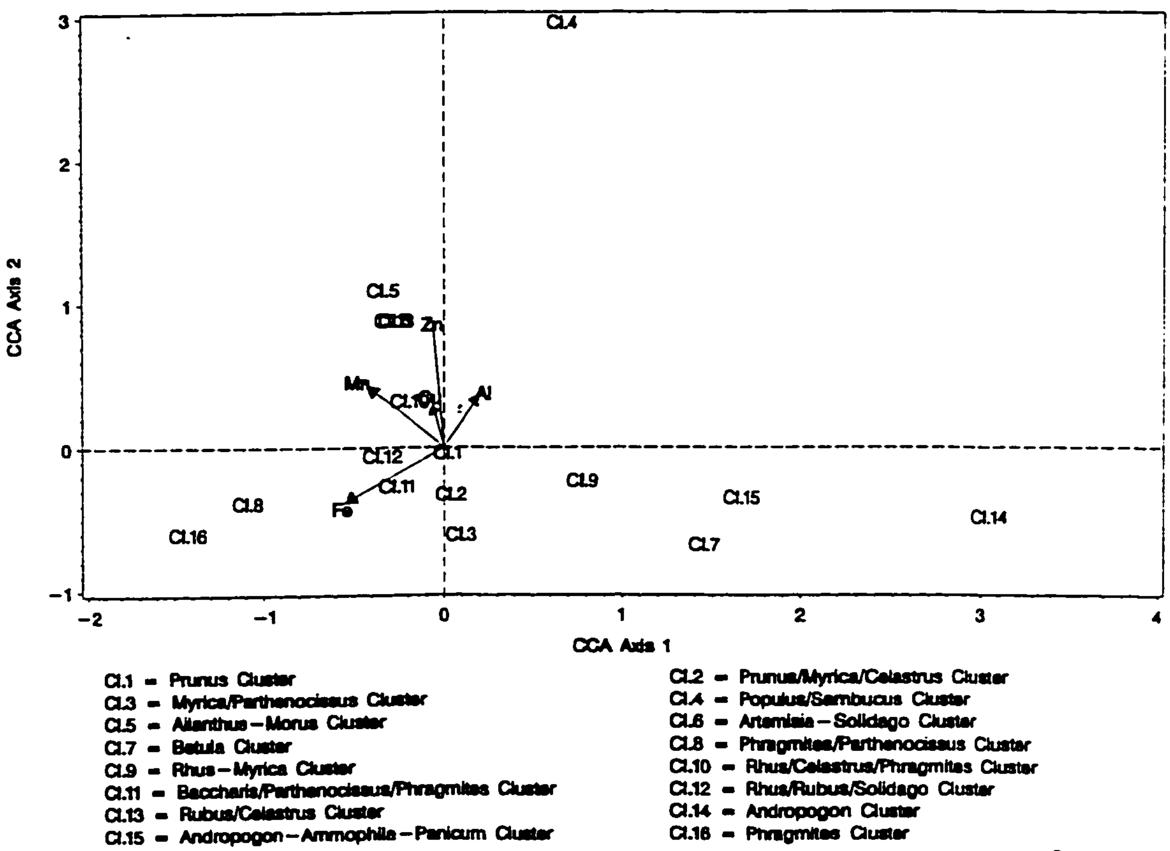
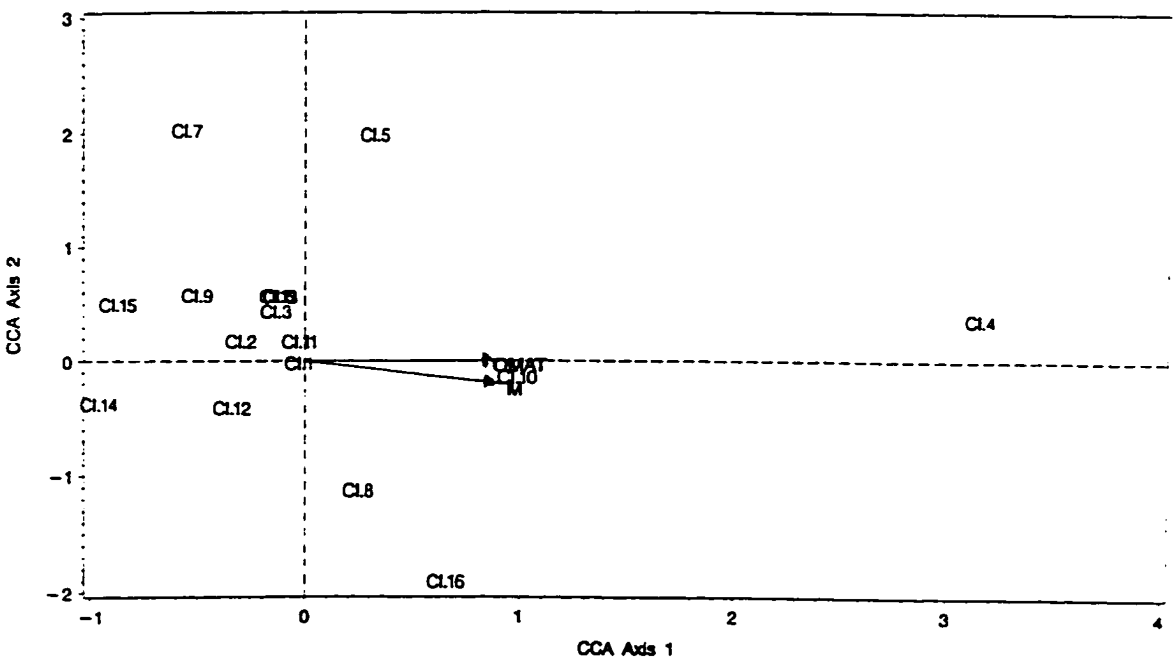



Figure 47. Canonical Correspondence Analysis Ordination diagram of all the sites sampled. Site scores are linear combinations of environmental variables. Environmental variables are: Al, Cu, Fe, Mn and Zn. Cluster 6 and cluster 13 overlap. Cluster 10 is at the end of the arrow indicating Cu.




Cl.1 = Prunus Cluster
Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.5 = Ailanthus−Morus Cluster
Cl.6 = Artemisia−Solidago Cluster
Cl.7 = Betula Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.9 = Rhus−Myrica Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.14 = Andropogon Cluster
Cl.15 = Andropogon−Ammophila−Panicum Cluster
Cl.16 = Phragmites Cluster

Figure 48. Canonical Correspondence Analysis Ordination diagram of all the sites sampled. Site scores are linear combinations of environmental variables. Environmental variables are: M=Moisture content, OMAT=Organic matter content. Cluster 6 and cluster 13 overlap.

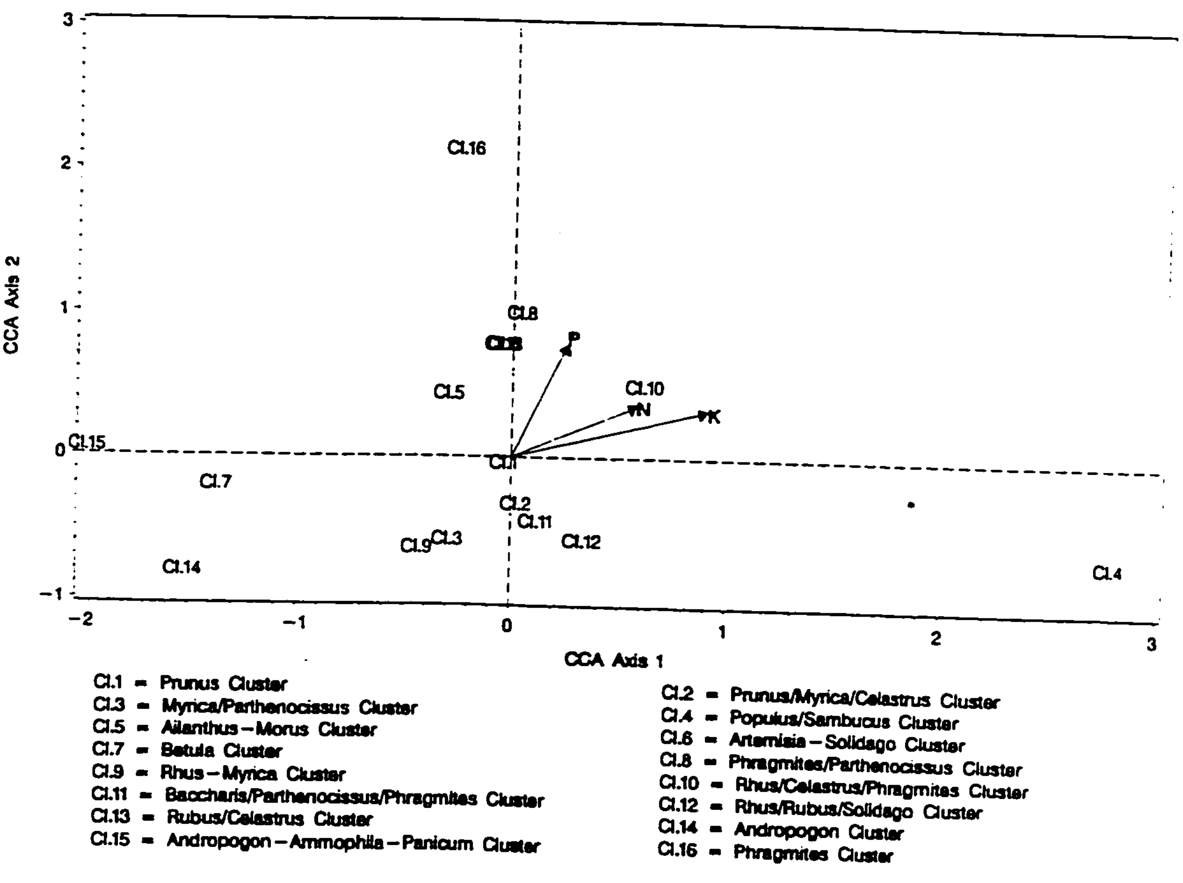



Figure 49 Canonical Correspondence Analysis Ordination diagram of all the sites sampled. Site scores are linear combinations of environmental variables. Environmental variables are: N=Total Nitrogen, P= Phosphorus , K= Potassium. Cluster 6 and cluster 13 overlap.

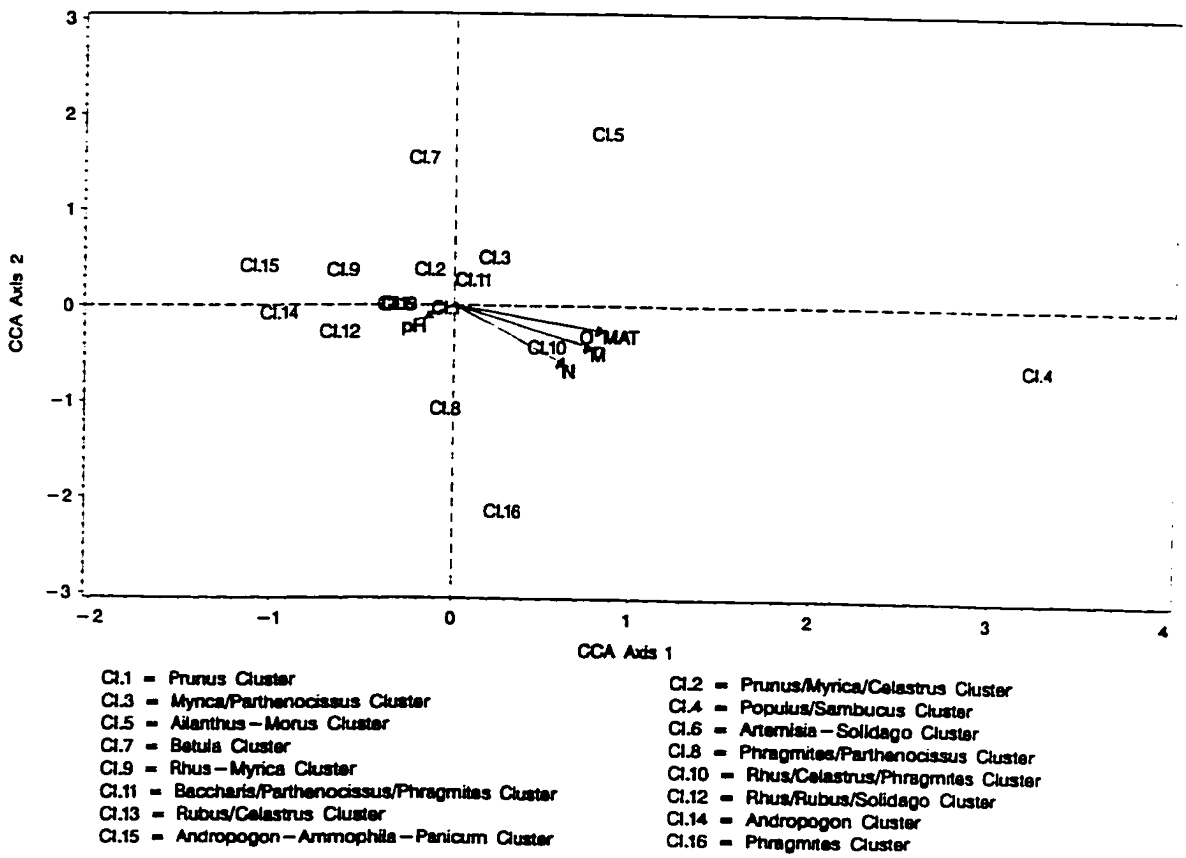
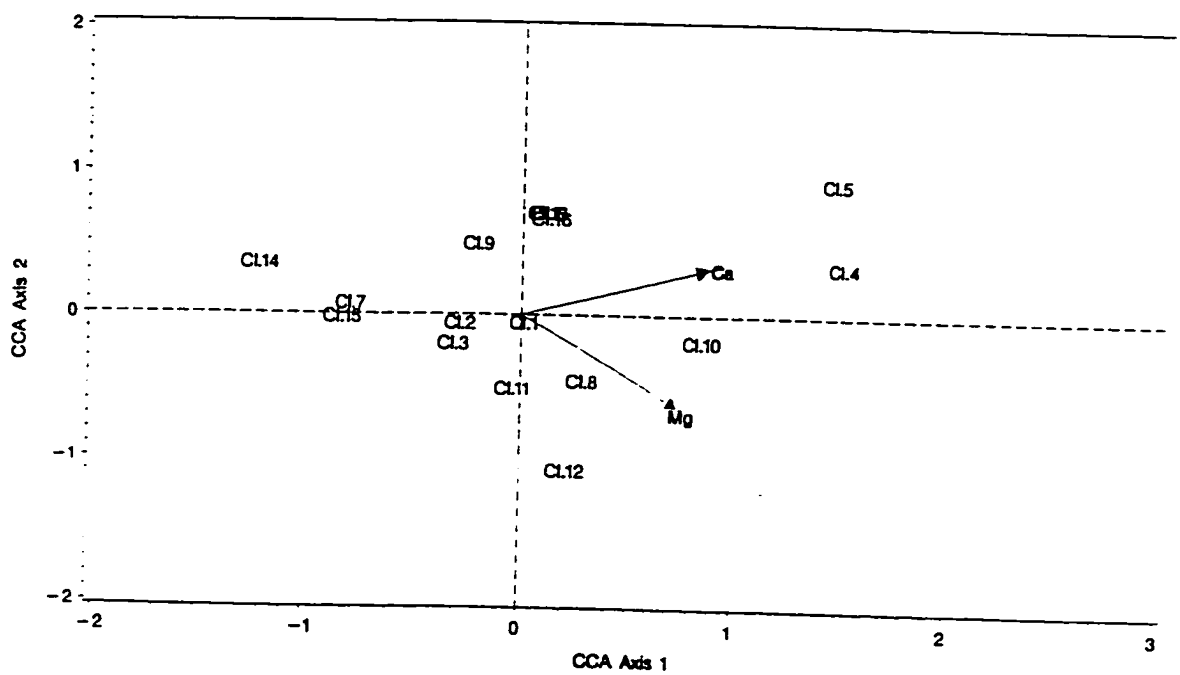



Figure 50. Canonical Correspondence Analysis Ordination diagram of all the sites sampled. Site scores are linear combinations of environmental variables. Environmental variables are: N=Total Nitrogen, M=Moisture content, O_MAT=Organic matter content, and pH=pH level. Clusters 6 and 13 overlap.




Cl.1 = Prunus Cluster
Cl.3 = Myrica/Parthenocissus Cluster
Cl.5 = Ailanthus–Morus Cluster
Cl.7 = Betula Cluster
Cl.9 = Rhus–Myrica Cluster
Cl.11 = Baccharis/Parthenocissus/Phragmites Cluster
Cl.13 = Rubus/Celastrus Cluster
Cl.15 = Andropogon–Ammophila–Panicum Cluster

Cl.2 = Prunus/Myrica/Celastrus Cluster
Cl.4 = Populus/Sambucus Cluster
Cl.6 = Artemisia–Solidago Cluster
Cl.8 = Phragmites/Parthenocissus Cluster
Cl.10 = Rhus/Celastrus/Phragmites Cluster
Cl.12 = Rhus/Rubus/Solidago Cluster
Cl.14 = Andropogon Cluster
Cl.16 = Phragmites Cluster

Figure 51. Canonical Correspondence Analysis Ordination diagram of all the sites sampled. Site scores are linear combinations of environmental variables. Environmental variables are: Mg and Ca. Clusters 6, 13 and 16 overlap.

Figure 52. A photograph of Prunus serotina community showing the mature trees of Prunus overgrown by Celastrus orbiculatus.

Figure 53. A photograph taken within the Populus tremuloides-Sambucus canadensis community. Note the thick undergrowth made of Sambucus canadensis.

Figure 54. A photograph taken within the Ailanthus altissima-Morus alba community. Plant growing in between the trees (Ailanthus) is Celastrus orbiculatus.

Figure 55. A photograph showing the Betula populifolia community. The shrubs in the background are Myrica pensylvanica.

Figure 56. A photograph showing the Myrica pensylvanica-Prunus serotina community. The tall arborescent shrubs on the right are Myrica pensylvanica. Plants on the left are mostly Prunus serotina.

Figure 57. A photograph showing the Myrica pensylvanica-Parthenocissus quinquefolia community. The shrub on the right is Rosa multiflora.

Figure 58. A photograph showing the Rhus copallina-Myrica pensylvanica community at the edge of Andropogon scoparius community (bottom right). Rhus copallina is in flower.

Figure 59. A photograph showing the Andropogon scoparius community. Myrica shrub thickets are in the background.

Figure 60. A photograph showing Andropogon scoparius-Ammophila breviligulata-Panicum virgatum community. The dark colored tussocks are Panicum virgatum. The flowers in the foreground are of Heterotheca subaxillaris.

Figure 61. A photograph showing the Rhus copallina-Rubus allegheniensis-Solidago rugosa community. Phragmites is flowering.

Figure 62. A photograph showing the Celastrus orbiculatus-Rubus allegheniensis community. Ailanthus-Morus woodland is in the background.

Figure 63. A photograph showing the Celastrus orbiculatus-Phragmites australis community.

Figure 64. A photograph showing the Baccharis halimifolia-Phragmites australis community.

Figure 65. A photograph showing the Phragmites australis-Parthenocissus quinquefolia community. The broad-leaved plant shown among Phragmites (at the center) is Phytolacca americana.

Figure 66. A photograph showing the Phragmites australis community.

Figure 67. A photograph showing a roadside community of Artemisia vulgaris-Solidago rugosa-Celastrus orbiculatus.

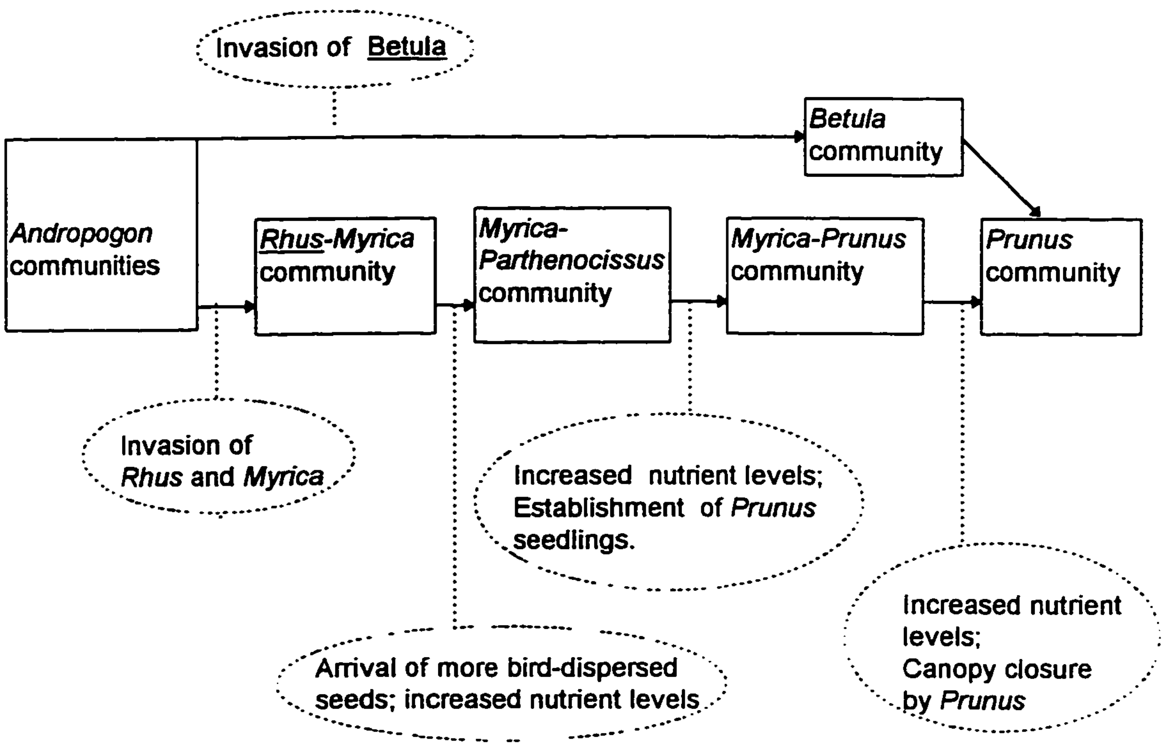



Figure 68. A successional model predicted for the dry grassland community assuming that there will be no disturbances.

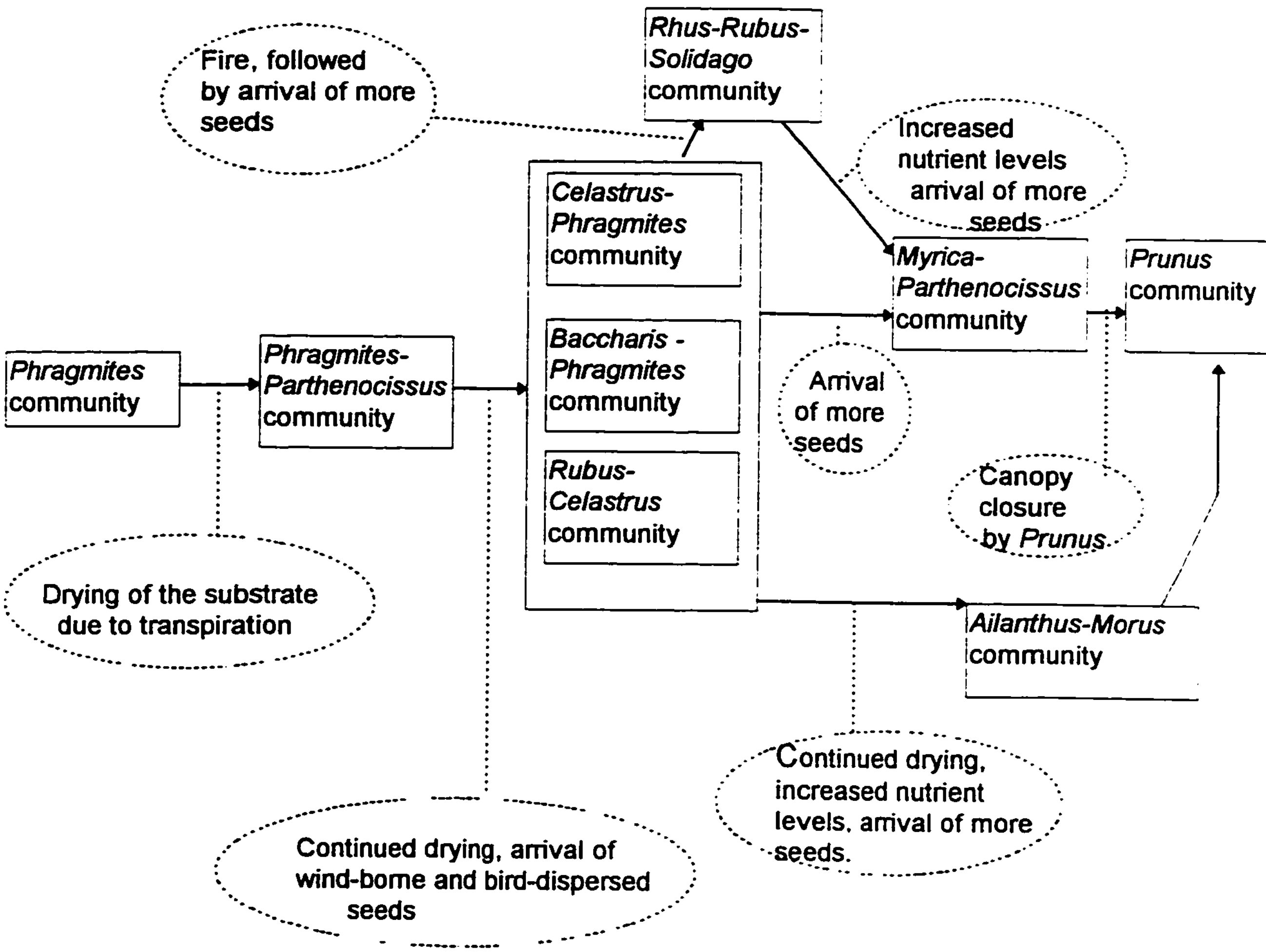



Figure 69. A successional model predicted for the wet grassland (Phragmites) community assuming that there will be no disturbances.

Appendix 1. List of species recorded within the area studied at Floyd Bennett Field (N=Native, E=Exotic)

| | Family | Species | Common Name | Origin |
|---|---|---|---|---|
| 1 | **Aceraceae** | *Acer rubrum* L. | Red maple | N |
| 2 | **Anacardiaceae** | *Rhus copallina* L. | Winged sumac | N |
| | | *R. glabra* L. | Smooth sumac | N |
| | | *R. typhina* L. | Staghorn sumac | N |
| | | *Toxicodendron radicans* (L.) Kuntze. | Poison ivy | N |
| 3 | **Apiaceae** | *Pastinaca sativa* L. | Wild parsnip | E |
| 4 | **Apocynaceae** | *Apocynum cannabinum* L. | Indian hemp | N |
| 5 | **Aquifoliaceae** | *Ilex opaca* Ait. | American holy | N |
| 6 | **Asclepiadaceae** | *Asclepias syriaca* L. | Milkweed | N |
| 7 | **Aspleniaceae** | *Onoclea sensibilis* L. | Sensitive fern | N |
| 8 | **Asteraceae** | *Achillea millefolium* L. | Yarrow | E |
| | | *Ambrosia artemisiifolia* L. | Ragweed | N |
| | | *Anaphalis margaritacea* (L.) Benth. & Hook. | Pearly everlasting | N |
| | | *Artemisia vulgaris* L. | Mugwort | E |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| **8** | **Asteraceae** | *Aster pilosus* Willd. | Awl aster | N |
| | | *Baccharis halimifolia* L. | Groundsel | N |
| | | *Chrysopsis falcata* (Pursh) Elliot | Falcate golden aster | N |
| | | *Cirsium arvense* (L.) Scop. | Canada thistle | E |
| | | *Conyza canadensis* (L.) Cronq. | Horseweed | N |
| | | *Eupatorium hyssopifolium* L. | Hyssop-leaved thoroughwort | N |
| | | *E. leucolepis* (DC.) T. & G. | White boneset | N |
| | | *E. maculatum* L. | Joe-pye-weed | N |
| | | *E. rugosum* Houttuyn | White snakeroot | N |
| | | *Euthamia graminifolia* (L.) Nutt. | Flat-topped golden rod | N |
| | | *E. tenuifolia* (Pursh.) Nutt. | Coastal plain Flat-topped golden rod | N |
| | | *Gnaphalium obtusifolium* L. | Fragrant cudweed | N |
| | | *Heterotheca subaxillaris* (Lam.) Britton & Rusby | Camphor weed | N |
| | | *Lactuca canadensis* L. | Tall lettuce | N |
| | | *Solidago canadensis* L. | Common goldenrod | N |
| | | *S. juncea* Aiton | Early goldenrod | N |
| | | *S. rugosa* Miller | Wrinkle-leaved goldenrod | N |
| **9** | **Betulaceae** | *Betula populifolia* Marshall | Gray birch | N |
| **10** | **Brassicaceae** | *Barbarea vulgaris* R. Br. | Yellow rocket | E |
| | | *Lepidium virginicum* L. | Poor man's pepper | N |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| **11** | **Caprifoliaceae** | *Lonicera japonica* Thunb. | Japanese honeysuckle | E |
| | | *Sambucus canadensis* L. | Common elder | N |
| | | *Viburnum dentatum* L. | Arrow-wood | N |
| **12** | **Caryophyllaceae** | *Dianthus armeria* L. | Deptford pink | E |
| | | *Saponaria officinalis* L. | Soapwort | E |
| **13** | **Celastraceae** | *Celastrus orbiculatus* L. | Oriental bittersweet | E |
| **14** | **Chenopodiaceae** | *Chenopodium album* L. | Lamb's quarters | E |
| **15** | **Cistaceae** | *Hudsonia tomentosa* Nutt. | False beach heather | N |
| | | *Lechea maritima* Leggett. | Pinweed | N |
| **16** | **Cupressaceae** | *Juniperus virginiana* L. | Eastern red cedar | N |
| **17** | **Cyperaceae** | *Cyperus bipartitus* Torr. | Sedge | N |
| | | *Scirpus cyperinus* (L.) Kunth. | Wool grass | N |
| **18** | **Elaeagnaceae** | *Elaeagnus angustifolia* L. | Russian olive | E |
| | | *E. commutata* Bernh. | Silver berry | N |
| | | *E. umbellata* Thunb. | Autumn olive | E |
| **19** | **Equisetaceae** | *Equisetum arvensis* L. | Field horsetail | N |
| **20** | **Fabaceae** | *Gleditsia triacanthos* L. | Honey locust | N |
| | | *Lathyrus latifolius* L. | Everlasting pea | E |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| 20 | **Fabaceae** | *Lespedeza capitata* Michx. | Bush clover | N |
| 21 | **Fagaceae** | *Quercus rubra* L. | Red oak | N |
| 22 | **Hypericaceae** | *Hypericum perforatum* L. | St. John's-wort | E |
| 23 | **Juncaceae** | *Juncus canadensis* J. Gay | Canadian rush | N |
| | | *Juncus gerardii* Loisel | Black grass | N |
| 24 | **Liliaceae** | *Allium vineale* L. | Field garlic | E |
| 25 | **Malvaceae** | *Hibiscus palustris* L. | Marsh mallow | N |
| 26 | **Moraceae** | *Morus alba* L. | White mulberry | E |
| 27 | **Myricaceae** | *Myrica pensylvanica* Mirbel. | Northern bayberry | N |
| 28 | **Onagraceae** | *Epilobium coloratum* Biehler | Eastern willow-herb | N |
| | | *Oenothera biennis* L. | Evening primrose | N |
| 29 | **Osmundaceae** | *Osmunda cinnamomea* L. | Cinnamon fern | N |
| | | *Osmunda regalis* L. | Royal fern | N |
| 30 | **Oxalidaceae** | *Oxalis corniculata* L. | Creeping wood sorrel | E |
| 31 | **Phytolaccaceae** | *Phytolačca americana* L. | Pokeweed | N |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| **32** | **Poaceae** | *Agropyron repens* L. | Quack grass | E |
| | | *Ammophila breviligulata* Fern. | Beach grass | N |
| | | *Schizachyrium scoparium* (Michx.) Nash. (*Andropogon scoparius* Michx.) | Little blue-stem | N |
| | | *Bromus tectorum* L. | Junegrass | E |
| | | *Corynephorus canadensis* (L.) P.Beauv. | Gray hairgrass | E |
| | | *Eragrostis curvula* (Schrader) Nees | Weeping Lovegrass | E |
| | | *Festuca rubra* L. | Red fescue | E |
| | | *Panicum lanuginosum* Elliott | Panic grass | N |
| | | *P. virgatum* L. | Switch grass | N |
| | | *Phragmites australis* (Cav.) Trin. | Reed | E |
| | | Poaceae sp1 | | |
| | | Poaceae sp2 | | |
| | | *Setaria glauca* (L.) P.Beauv | Yellow foxtail-grass | E |
| **33** | **Polygonaceae** | *Polygonum hydropiperoides* Michx. | False water-pepper | N |
| | | *P. scandens* L. | False buckwheat | N |
| | | *Rumex crispus* L. | Curly dock | E |
| **34** | **Rhamnaceae** | *Rhamnus frangula* L. | European alder-buckthorn | E |
| **35** | **Rosaceae** | Aronia arbutifolia (L.) Elliott | Red chokeberry | N |
| | | *Fragaria virginiana* Duchesne | Thick-leaved-wild strawberry | N |
| | | *Prunus allegheniensis* T.C. Porter | Allegheny-plum | N |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| **35** | **Rosaceae** | *P. serotina* Ehrh. | Wild black cherry | N |
| | | *Pyrus baccata* L. | Siberian crab | E |
| | | *Pyrus sieboldii* Regel | Toringo crab. | E |
| | | *Pyrus* sp. 1 | | - |
| | | *Pyrus* sp. 2 | | - |
| | | *Rosa multiflora* Thunb. | Multiflora rose | E |
| | | *R. virginiana* Miller | Virginia rose | N |
| | | *Rubus allegheniensis* T.C. Porter | Blackberry | N |
| | | *R. flagellaris* Willd. | Northern dewberry | N |
| | | *R. laciniatus* Wiild. | Evergreen blackberry | E |
| | | *R. pensilvanicus* Poiret. | High-bush blackberry | N |
| | | *Spirea tomentosa* L. | Steeple-rush | N |
| **36** | **Rubiaceae** | *Galium aparine* L. | Goose grass | N |
| **37** | **Salicaceae** | *Populus deltoides* Marshall | Cottonwood | N |
| | | *Populus tremuloides* Michx. | Quaking aspen | N |
| | | *Salix alba* L. | White willow | E |
| | | *Salix babylonica* L. | Weeping willow | E |
| | | *Salix caprea* L. | Goat willow | E |
| | | *Salix discolor* Muhl. | Pussy willow | N |
| | | *Salix fragilis* L. | Crack willow | E |
| | | *Salix matsudana* Koidz. | Pekin willow | E |
| | | *Salix nigra* Marshall | Black willow | N |
| | | *Salix* sp. | | - |

Appendix 1. Contd.

| | | | | |
|---|---|---|---|---|
| **38** | **Scrophulariaceae** | *Linaria vulgaris* Miller | Butter-and-eggs | E |
| | | *Verbascum blattaria* L. | Moth-mullein | E |
| | | *V. thapsus* L. | Common mullein | E |
| **39** | **Simaroubaceae** | *Ailanthus altissima* (Miller) Swingle | Tree of heaven | E |
| **40** | **Solanaceae** | *Solanum dulcamara* L. | Bittersweet nightshade | E |
| **41** | **Thelypteridaceae** | *Thelypteris simulata* (Davenp.) Nieuwl. | Massachusetts fern | N |
| | | *T. palustris* Schott | Marsh fern | N |
| **42** | **Ulmaceae** | *Celtis occidentalis* L. | Northern Hackberry | N |
| **43** | **Verbenaceae** | *Verbena hastata* L. | Common vervain | N |
| **44** | **Vitaceae** | *Ampelopsis brevipedunculata* (Maxim.)Trautv. | Porcelain-berry | E |
| | | *Parthenocissus quinquefolia* (L.) Planc. | Virginia-creeper | N |

## Appendix 2. SAS Programs used in the data analysis

### 1. Program used in Angular Transformation (Sokal & Rohlf, 1995) of percentage data

```
Libname fbf 'fbf';
data fbf.arc;
set combined; *combined is the data set that contained all
percentage data;
 array arc{*} _numeric_;
do i=1 to dim(arc);
      if arc{i} ne 0 then
      arc{i}=(180/(22/7))*(arsin(sqrt(arc{i}/100)));
end;
drop i;
proc print;
run;
```

### 2. Program used in calculating the distance matrices.

```
/* This macro produces the following different distance matrices.
            a) Bray-Curtis distance (Percentage Similarity)
                                    {BRAYCURTIS}
            b) Similarity ratio     {SIMILARITY}
            c) Chord distance       {CHORD}
            d) Geodesic distance    {GEODESIC}
            e) Euclidean distance   {EUCLIDEAN}
            f) City Block (Manhattan) {MANHATTAN}
            g) Ruzicka Index {RUZICKA}
            h) Morisita Index {MORISITA1}
            i) Morisita Index (Horn's 1966 modification) {MORISITA2}
and
            j) Canberra distance {CANBERRA}
To execute this program type the following
 %INCLUDE DISTANCE;
 %COMPUTE(DATA=dataset name,dis=distance,OUT=output dataset name);
Here the dataset name, distance, and output dataset name can be
altered by the user. Distance may be BRAYCURTIS, SIMILARITY, CHORD,
GEODESIC, EUCLIDEAN, MANHATTAN, RUZICKA, MORISITA1, MORISITA2 or
CANBERRA. The output dataset is a symmetrical distance matrix that
can be used in cluster analysis.
Please note that a comma should be placed after DATA and DIS. The
following is an example to show how Euclidean Distance Matrix is
computed (for three sites) using species abundance values.
```

```
data mydata;
input  species $  site1 site2 site3;*The species column is optional;
cards;
sp1  10    10    0
sp2  23    33    4
sp4  0     2     10
sp4  1     1     3
run;
%include distance;
%compute(data=mydata,dis=euclidean,out=eucdis);*This produces a new
dataset called eucdis which is a 3 X 3 Euclidean distance matrix;
*/

%macro compute(data=,dis=,out=);
%let dis = %UPCASE(&dis);
proc iml;
use &data;
read all into x[colname=site];
stasum=x[+,];
n=nrow(x);
m=ncol(x);
dismat=j(m,m,0);
col=j(n,2,0);
g=j(n,1,0);
w=j(n,1,0);
s=j(n,1,0);
do i=1 to m-1;
  do j=i+1 to m;
    col[,1]=x[,i];
    col[,2]=x[,j];
%if &dis=BRAYCURTIS %then %do;
 do k=1 to n;
    if col[k,1]>col[k,2] then col[k,1]=col[k,2];
 end;
    dismat[i,j]=1-(2*(col[+,1])/(stasum[1,i]+stasum[1,j])); *multifly
by 200 if percentages are used;
    dismat[j,i]=dismat[i,j];
%end;
%if &dis=CANBERRA %then %do;
 do k=1 to n;
      if col[k,1]>col[k,2] then col[k,1]=col[k,2];
      if col[k,1]>col[k,2] then col[k,2]=col[k,1];
      g[k,1]=(col[k,2]-col[k,1])/(col[k,2]+col[k,1]);
 end;
  dismat[i,j]=(g[+,1])/n;
```

```
  dismat[j,i]=dismat[i,j];
%end;
 do k=1 to n;
      g[k,1]=(col[k,1])*(col[k,2]);
      s[k,1]=(col[k,1])**2;
      w[k,1]=(col[k,2])**2;
 end;
%if &dis=SIMILARITY %then %do;
    dismat[i,j]=1-((g[+,1])/((w[+,1])+(s[+,1])-(g[+,1])));
    dismat[j,i]=dismat[i,j];
%end;
%if &dis=CHORD %then %do;
    dismat[i,j]=(2*(1-((g[+,1])/(((w[+,1])*(s[+,1]))**.5))))**.5;
    dismat[j,i]=dismat[i,j];
%end;
%if &dis=GEODESIC %then %do;
    dismat[i,j]=arcos((g[+,1])/(((w[+,1])*(s[+,1]))**.5));
    dismat[j,i]=dismat[i,j];
%end;
%if &dis=MORISITA2 %then %do;
     dismat[i,j]=2*(g[+,1])/((s[+,1]/(col[+,1]**2)
     +(w[+,1]/(col[+,2]**2)))*(col[+,1])*(col[+,2]));
     dismat[j,i]=dismat[i,j];
%end;
%if &dis=EUCLIDEAN %then %do;
do k=1 to n;
     s[k,1]=((col[k,1])-(col[k,2]))**2;
      end;
  dismat[i,j]=((s[+,1]))**.5;
  dismat[j,i]=dismat[i,j];
%end;
%if &dis=MANHATTAN %then %do;
do k=1 to n;
       if col[k,1]>col[k,2] then
       s[k,1]=((col[k,1])-(col[k,2]));
       else s[k,1]=((col[k,2])-(col[k,1]));
end;
dismat[i,j]=s[+,1]/n; * Sometimes it is divided by range;
dismat[j,i]=dismat[i,j];
%end;
%if &dis=RUZICKA %then %do;
do k=1 to n;
       if col[k,1]>col[k,2] then col[k,1]=col[k,2];
       if col[k,1]>col[k,2] then col[k,2]=col[k,1];
      end;
 dismat[i,j]=1-((col[+,1])/(col[+,2]));
```

```
 dismat[j,i]=dismat[i,j];
%end;
%if &dis=MORISITA1 %then %do;
    do k=1 to n;
          s[k,1]=col[k,1]*col[k,2];
          g[k,1]=(col[k,1]*((col[k,1])-1));
          w[k,1]=(col[k,2]*((col[k,2])-1));
       end;
     dismat[i,j]=2*(s[+,1])/(((g[+,1]
     /(col[+,1]*((col[+,1])-1)))+(w[+,1]
     /(col[+,2]*((col[+,2])-1))))*(col[+,1])*(col[+,2]));
     dismat[j,i]=dismat[i,j];
%end;
end;
end;
create &out from dismat [colname=site rowname=site];
append from dismat[colname=site rowname=site];
proc print data=&out;title &dis' DISTANCE MATRIX';
quit;
%put Written by Siril Wijesundara. January 1997.;
%mend;
```

### 3. Program to plot dendrograms using different distance matrices.

Data matrices used in this program are SAS library data sets (in /SAS/FBF/ sub directory). The files are, a) earc.sd2 (Euclidean distance matriix), b) carc.sd2 (Chord distance matrix), c) barc.sd2 (Bray Curtis dissimilarity matrix), d) garc.sd2 (Geodesic distance matrix) and e) sarc.sd2 (Similarity Ratio matrix).

```
/* Plotting all five dendrograms on on page*/

goptions htext=;
libname fbf 'fbf';
proc cluster method=wards outtree=tr3 noprint nonorm nosquare
data=fbf.earc(type=distance);
id site;
goptions device=;
data cc;
set tr3;
```

```
proc sort;by _height_;
proc tree horizontal hordisplay=right graphics level=90  vaxis=axis1
haxis=axis2 data=cc gout=cat;
axis1 value=(
 'Phragmites'
 'Rhus-Myrica'
 'Rhus-Rubus-Solidago'
 'Baccharis-Phragmites'
 'Phragmites_Parthenocissus'
 'Phragmites-Parthenocissus'
 'Celastrus-Phragmites'
 'Rhus-Rubus'
 'Andropogon'
 'Andropogon-Ammophila'
 'Myrica-Parthenocissus-Toxicodendron'
 'Prunus-Myrica-Celastrus'
 'Populus-Sambucus'
 'Celastrus-Prunus'
 'Myrica-Betula'
 'Ailanthus-Morus'
 'Prunus')
  label=('Cluster'); *These labels were determined after examining
                      the dendrogram;
axis2 order=(90 to 700 by 100);
id site;
TITLE ' ';
proc cluster method=wards outtree=tr3 noprint nonorm nosquare
data=fbf.sarc(type=distance);
id site;
data c; *this is to get a similar arrangement as in euclidean
distance;
set tr3;
proc sort;by _height_;
proc tree horizontal hordisplay=right graphics level=1.09 vaxis=axis1
data=c gout=cat;
axis1 value=(
 'Phragmites'
 'Phragmites-Rubus'
 'Phragmites-Rhus-Celastrus'
 'Celastrus-Phragmites'
 'Rubus-Rhus-Solidago'
 'Baccharis-Phragmites'
 'Andropogon'
 'Andropogon-Ammophila'
 'Parthenocissus-Myrica-Prunus'
 'Celastrus-Prunus-Myrica'
```

```
 'Populus-Sambucus'
 'Rhus-Celastrus-Myrica'
 'Morus-Celastrus-Betula'
 'Ailanthus-Morus'
 'Celastrus-Prunus'
 'Prunus'
   ) label=('Cluster');
id site;
TITLE ' ';
libname fbf 'fbf';
proc cluster method=wards outtree=tr3 noprint nonorm nosquare
data=fbf.barc(type=distance);
id site;
proc tree horizontal hordisplay=right graphics level=1.01
vaxis=axis1 gout=cat  data=tr3 ;
axis1 value=(
 'Prunus-Myrica-Celastrus'
 'Myrica-Parthenocissus-Toxicodendron'
 'Phragmites-Myrica-Parthenocissus'
 'Celastrus-Prunus'
 'Ailanthus-Morus'
 'Populus-Sambucus'
 'Celastrus-Phragmites'
 'Phragmites-Rubus'
 'Rhus-Myrica-Celastrus'
 'Rhus-Rubus-Solidago'
 'Baccharis-Phragmites-Rubus'
 'Andropogon'
 'Ammophila-Andropogon'
 'Phragmites-Parthenocissus'
 'Phragmites'   ) label=('Cluster');
id site;
TITLE '       ';
proc cluster method=wards outtree=tr3 noprint nonorm nosquare
data=fbf.carc(type=distance);
id site;
proc tree horizontal hordisplay=right graphics level=1.4  vaxis=axis1
gout=cat data=tr3;
axis1 value=(
 'Parthenocissus-Myrica-Prunus'
 'Celastrus-Myrica-Toxicodendron'
 'Populus'
 'Celastrus-Prunus'
 'Prunus'
 'Ailanthus-Morus'
 'Celastrus-Phragmites'
```

```
 'Rhus-Phragmites'
 'Rubus-Rhus'
 'Baccharis-Phragmites'
 'Rhus-Celastrus-Myrica'
 'Rhus-Rubus-Solidago'
 'Andropogon'
 'Ammophila-Andropogon'
 'Phragmites-Parthenocissus'
 'Phragmites'   ) label=('Cluster');
id site;
run;
proc cluster method=wards outtree=tr3 noprint nonorm nosquare
data=fbf.garc(type=distance);
id site;
proc tree horizontal hordisplay=right graphics level=1.45  gout=cat
data=tr3 vaxis=axis1;
axis1 value=(
 'Myrica-Parthenocissus-Prunus'
 'Celastrus-Myrica-Toxicodendron'
 'Populus'
 'Celastrus-Prunus'
 'Prunus'
 'Ailanthus-Morus'
 'Celastrus-Phragmites'
 'Phragmites-Rhus'
 'Rhus-Celastrus-Myrica'
 'Rubus-Betula'
 'Baccharis-Phragmites'
 'Rubus-Rhus-Solidago'
 'Andropogon'
 'Andropogon-Ammophila'
 'Phragmites-Parthenocissus'
 'Phragmites'  ) label=('Cluster');
id site;
TITLE '      ';

proc greplay igout=cat tc=tempcat nofs;* the trees are stored in the
graph catalogue called 'cat';
goptions cback=white  display ;
tdef newfive des='Plotting five trees on one page'

  1/llx=10 lly=55
    ulx=10 uly=95
    urx=42 ury=95
    lrx=42 lry=55
    color=white
```

```
  2/llx=45 lly=55
    ulx=45 uly=95
    urx=70 ury=95
    lrx=70 lry=55
    color=white

  3/llx=10 lly=10
    ulx=10 uly=45
    urx=35 ury=45
    lrx=35 lry=10
    color=white

  4/llx=40 lly=10
    ulx=40 uly=45
    urx=65 ury=45
    lrx=65 lry=10
    color=white

  5/llx=70 lly=10
    ulx=70 uly=45
    urx=95 ury=45
    lrx=95 lry=10
    color=white;

template newfive;

treplay 1:tree
        2:tree1
        3:tree2
        4:tree3
        5:tree4;

quit;
```

## 4. Principal Component Analysis

```
*This program is to do PCA (2D and 3D) using the angular-transformed
data. This shows the 4 major cluster groups (from Euclidean Distance
and Minimum Variance clustering). Data are stored in the data file
"arc.sd2" in the "fbf" sub-directory;

goptions device= hsize=6 vsize=6 ftext=swissl;
libname fbf 'fbf';
proc cluster method=wards outtree=cc noprint nonorm nosquare
data=fbf.earc(type=distance);
```

```
id site;
proc tree horizontal hordisplay=right graphics level=400  data=cc
out=eu noprint;
id site;
TITLE ' ';
run;

proc sort data=eu;by site;
proc sort data=fbf.arc;by site;
data c(keep=cluster site clus);
set eu;
if cluster=1 then clus='1';
if cluster=2 then clus='2';
if cluster=3 then clus='3';
if cluster=4 then clus='4';
data bb;
merge c fbf.arc;by site;
drop cluster;
proc princomp data=bb cov out=prin noprint;
data anno1; set prin;
set prin;
xsys='2';
ysys='2';
x=prin1;y=prin2;
when='a';
size=2;
function='symbol';
if clus='3' then  text='circle';
if clus='1' then  text='dot';
if clus='4' then  text='-' ;
if clus='2' then  text='+';
*To view the clusters in different colors;
/*if clus='3' then  color='BLUE    ';
 if clus='1' then  color='BLACK    ';
 if clus='4' then  color='ORANGE   ';
 if clus='2' then  color='GREEN    '; */
goptions device= hsize=9 vsize=6 vpos=100 hpos=100 ftext=swiss
htext=2 htitle=2 ftitle=swiss;
proc gplot data=prin;
plot prin2*prin1/anno=anno1 href=0 vref=0 vaxis=axis2 haxis=axis1
frame;
axis1  label=( 'Principal Component 1' f=swiss) value=(f=swiss);
axis2  label=(a=90 r=0  'Principal Component 2' f=swiss)
value=(f=swiss);
symbol1 i=none;
symbol2 i=none;
```

```
symbol3 i=none;
symbol4 i=none;
title 'Principal Component Analysis of all the sites sampled';
run;
*The following part plots the 3-D plot;
goptions device=;
data g;
set prin;
if clus='1' then shape='cross';
if clus='2' then shape='balloon';
if clus='3' then shape='pyramid';
if clus='4' then shape='diamond';
proc g3d data=g anno=anno1;
scatter prin1*prin3=prin2 /grid  rotate=60 shape=shape  grid;
run;

* The following part of the program produces the table containing
percentage cover of each species in the four cluster groups;
data etret(keep=site cluster);
set eu;
proc sort data=etret;by site;
proc sort data=fbf.combined;by site;
data euc ;
merge etret fbf.combined;by site;
proc sort data=euc;by cluster;
proc means mean data=euc noprint;
output out=mm;by cluster;
data avegs;
set mm;
drop _freq_ _type_;if _stat_='MEAN';
proc transpose out=avggs name=code;
id cluster;
proc sort;by code;
data last;
set avggs;
attrib _1-_4 format=4.1;
if code ne 'CLUSTER';
array dot{*} _numeric_;
do i=1 to dim(dot);
if dot{i}=0 then dot{i}=.;
end;
drop i;
proc print;
var code;
sum _1-_4;
RUN;
```

## 5. Principal Component Analysis of Woodland and Woodland Associate sites

```
*Principal Component Analysis of the Woodland sites (7 sites);

goptions htext=;
libname fbf 'fbf';
proc cluster method=complete outtree=tr noprint nonorm nosquare
data=fbf.euwood(type=distance);
id site;
proc tree level=85 out=h noprint data=tr;
id site;
proc sort; by site;
proc princomp data=fbf.earcl2 cov out=prin noprint;
proc sort data=prin;
by site;
data new(keep=prin1 prin2 prin3 cluster);;
merge h prin;by site;
if cluster ne .;
run;
proc sort;by cluster descending prin2;
run;
proc means data=new noprint;
by cluster;
var prin1 prin2 prin3;
output out=averages mean=xave yave zave
max=xmax ymax zmax min=xmin ymin zmin;
run;
data plotstar(drop=_type_ _freq_ xmax ymax zmax xmin ymin zmin XAVE
YAVE
zave  prin1 prin2 prin3 CLUSTER);
retain xave yave zave;
merge averages new;
by cluster;
length function color style $ 8 text $ 17;
retain text 'dot' xsys ysys zsys '2'
position '5' line 1 style ' ' color size x y z;
if prin2 < yave then do;
when='a';
function='symbol';
x=prin1;
y=prin2;
z=prin3;
size=1.5;
output;
```

```
when='b';
end;
else do;
when='b';
function='symbol';
x=prin1;
y=prin2;
z=prin3;
size=1.5;
output;
when='a';
end;
function='move';
x=xave;
y=yave;
z=zave;
output;
function='draw';
x=prin1;
y=prin2;
z=prin3;
size=0.1;
color='green';output;
run;
data setone;
set new(keep=cluster);
by cluster;
if first.cluster;
run;
data labels;
retain function 'label' xsys ysys zsys '2' hsys '3'
       position '5' when 'a' color 'black' line 1
       style 'swissl' size 2;
merge setone averages (where=(cluster ne .));
drop _type_ _freq_ xave yave zave xmax ymax zmax xmin ymin zmin
texttmp cluster;
length text $ 20;
texttmp=trim(left(put(cluster,2.)));
text=  'Cl.'||texttmp||' ';
x=xave+1;y=yave-8;z=zave;
run;

data annoall;
set plotstar labels;
run;
data plotdata (keep=prin1 prin2 prin3);
```

```
set averages;
prin1=xmax;
prin2=ymax;
prin3=zmax;
output;
prin1=xmin;
prin2=ymin;
prin3=zmin;
output;
run;
goptions device= hsize=9 vsize=6 vpos=100 hpos=100 ftext=swissl
htext=2 ;
proc gplot data=new annotate=plotstar ;
plot prin2*Prin1=cluster/haxis=axis1 vaxis=axis2 href=0 vref=0 frame
anno=labels legend=legend
                      lvref=2 lhref=2;
legend label=('Key to clusters') value=
(j=l 'Cl.1 = Prunus Cluster'
'Cl.2 = Prunus/Myrica/Celastrus Cluster'
'Cl.3 = Myrica/Parthenocissus Cluster'
'Cl.4 = Populus/Sambucus Cluster'
'Cl.5 = Ailanthus-Morus Cluster'
'Cl.6 = Artemisia-Solidago Cluster'
'Cl.7 = Betula Cluster');
symbol1 i=none;
symbol17 i=none;
axis1  minor=none  label=(f=swiss 'Principal Component 1')
value=(f=swiss h=1.5)  ;
axis2  minor=none  label=(a=90 r=0 f=swiss 'Principal Component 2')
value=(f=swiss h=1.5) ;
title1'Principal Component Analysis of the Woodland and Woodland
Associate sites';
title2 '(Clusters with each point connected to the centroid)';
PROC G3D DATA=PLOTDATA ;
SCATTER prin2*prin1=prin3/GRID ROTATE=50 NONEEDLE SHAPE='POINT'
ANNOTATE=ANNOALL ;
run;
```

## 6. Correspondence Analysis of Dry Grassland sites

```
goptions device=win  htext=;
libname fbf 'fbf';
proc corresp data=fbf.earcl4  out=coord noprint dimens=3;
var ALL_VIN ART_VUL CEL_ORB ELA_COM JUN_VIR LON_JAP MAL_SIE MOR_ALB
MYR_PEN PAR_QUI PHR_AUS PRU_SER RHA_FRA ROS_MUL RUB_PEN SAM_CAN
```

```
SET_GLA SOL_DUL SOL_RUG TOX_RAD APO_CAN ARO_ARB BET_POP EUP_LEU
MAL_BAC PHY_AME POP_DEL RHU_COP SAP_OFF VIB_DEN UNI_23 ASC_SYR
EUT_GRA OXA_COR POL_SCA POP_TRE RUB_ALL UNI_9 ACE_RUB AND_SCO BAC_HAL
COR_CAN GRA_SP ILE_AQU MAL_SPP RUB_LAC SOL_JUN UNI_7 VER_THA LIN_VUL
SOL_CAN AMO_BRE ACH_MIL AIL_ALT BAR_VUL CHE_ALB EUP_RUG FES_RUB
GLE_TRI PRU_ALL RHU_GLA RUB_FLA RUM_CRI AMP_BRE SAL_MAT EPI_COL
ONO_SEN SAL_DIS SAL_NIG CIR_ARV LAC_CAN FRA_PEN QUE_RUB AST_PIL
DIA_ARE ANA_MAG SPI_TOM GRA_GRA EUT_TEN CYP_SPP JUN_SP3 PAN_VIR
OSM_REG EUP_MAC HIB_PAL OSM_CIN RHU_TYP ROS_VIR THE_SIM LAT_LAT
ELA_UMB LEC_MAR EQU_ARV PAS_SAT SAL_CAP SAL_BAB SAL_ALB AMB_ART
JUN_SP1 PAN_LAN GAL_APE SCI_CYP THE_PAL MAL_SP SAL_CUP SAL_FRA
GNA_OBT LES_CAP CON_CAN CHR_FAL HUD_TOM LEP_VIR  HET_SUB AGR_CUR;
id site;
data cbb;
set coord;
If site='GL1' then clus='14' ;If site='GL9' then clus='15' ;
If site='GL2' then clus='14' ;If site='GL12' then clus='15' ;
If site='GL3' then clus='14' ;If site='GL13' then clus='15' ;
If site='GL4' then clus='14' ;If site='GL14' then clus='15' ;
If site='GL5' then clus='14' ;If site='GL15' then clus='15' ;
If site='GL6' then clus='14' ;If site='GL16' then clus='15' ;
If site='GL7' then clus='14' ;If site='GL17' then clus='15' ;
If site='GL10' then clus='14' ;If site='GL18' then clus='15' ;
If site='GL11' then clus='14' ;If site='GL19' then clus='15' ;
If site='GL8' then clus='14' ;If site='GL20' then clus='15' ;
data lab;
set coord;
if _type_='VAR';
xsys='2' ;ysys='2';
x=dim1;y=dim2;
text=site;
size=1.5;
function='label';
data new (keep=dim1 dim2  clus );
set cbb;
if clus ne '  ';
proc sort;by clus descending dim2;
run;
proc means data=new noprint;
by clus;
var dim1 dim2 ;
output out=averages mean=xave yave
max=xmax ymax  min=xmin ymin ;
run;
data plotstar(drop=_type_ _freq_ xmax ymax  xmin ymin  XAVE YAVE
  dim1 dim2  clus);
```

```
retain xave yave ;
merge averages new;
by clus;
length function color style $ 8 text $ 17;
retain text 'dot' xsys ysys zsys '2'
position '5' line 1 style ' ' color size x y ;
if dim2 < yave then do;
when='a';
function='symbol';
x=dim1;
y=dim2;
size=1.5;
output;
when='b';
end;
else do;
when='b';
function='symbol';
x=dim1;
y=dim2;
size=1.5;
output;
when='a';
end;
function='move';
x=xave;
y=yave;
output;
function='draw';
x=dim1;
y=dim2;
size=0.1;
color='green';output;
run;
data setone;
set new(keep=clus);
by clus;
if first.clus;
run;
data annoall;
set plotstar;
run;
data plotdata (keep=dim1 dim2 );
set averages;
dim1=xmax;
dim2=ymax;
```

```
output;
dim1=xmin;
dim2=ymin;
output;
run;
goptions device=win hsize=9 vsize=6 vpos=100 hpos=100 ftext=swiss
htext=2 htitle=2 ftitle=swiss ;
proc gplot data=cbb annotate=plotstar ;
plot dim2*dim1/ haxis=axis1 vaxis=axis2 anno=lab;
symbol i=none;
axis1  minor=none  label=(f=swiss 'Correspondence Axis 1')
value=(f=swiss h=1.5)  ;
axis2  minor=none  label=(a=90 r=0 f=swiss 'Correspondence Axis 2')
value=(f=swiss h=1.5) ;
title1 justify=c'Correspondence Analysis of all the sites sampled';
title2 justify=l'Clusters with each point connected to the centroid.
Species are indicated';
title3 justify=l 'by their name';
run;
```

## 7. Principal Coordinate Analysis

```
*This program is for Principal Coordinate Analysis. The data are in
the data set 'earc.sd2' in fbf sub-directory [A modified version of
Marcus (1991)] ;

goptions device=;
libname fbf 'fbf';
proc iml;
use fbf.earc;  *Euclidean Distance matrix;
read all into dist [colname=site];
n=nrow(dist);
rmean=dist[:,];
gmean=rmean[,:];
q=-.5*(dist-j(n,1,1)*rmean-rmean`*j(n,1,1)`+j(n,n,1)*gmean);
call eigen(d,u,q);
u=u[,1:3];
d=d[1:3,];
print d;
coord=u*diag(sqrt(d));
print coord[format=5.2];
create pcord from coord [rowname=site];
append from coord [rowname=site];
quit;
```

## 8. Nonmetric Multidimensional Scaling

```
*This program performs NMDS using Euclidean Distance (data matrix is
earc.sd2 in fbf sub-directory );

libname fbf 'fbf';
proc mds data=fbf.earc pfinal out=nmdsall dimension=3;
id site;
run;
```

# Appendix 3. SOIL ANALYSIS

The following methods were used in the soil chemical analysis (Page et al, 1982).

## 1. pH determination (glass electrode method)

**Reagents**

1. Distilled water
2. Buffer solutions: pH 4,7,9

**Procedure**

Weigh 10 g of air-dry soil in a 50 ml beaker and add 25 ml distilled water. Stir regularly for 25 minutes and keep for 5 minutes to settle.

Set the pH meter at pH 7 with standard buffer solution of pH 7 and set the manual temperature compensator at the temperature of the buffer. Check to see that the instrument reads very near pH 4 with standard pH 4 buffer. If necessary, adjust the reading to pH 4, using temperature compensator knob.

Repeat the above standardization procedure with both buffer pH's.

After calibration, insert the electrode into the container containing soil solution and read pH immediately.

**2. Exchangeable acidity,**

**Reagents**

1. Replacing solution, 1N KCl (74.6 g KCl/liter).

2. Aluminum complexing solution, 1N potassium fluoride (KF): Titrate 58.1 g of KF/liter to a phenolphthalein endpoint with NaOH.

3. HCl, approximately 0.1N, standardized.

4. NaOH, approximately 0.1N, standardized.

5. Phenolphthalein, 1 g of Phenolphthalein/100 ml of ethanol.

**Procedure**

To a 10-g sample of soil, add 25 ml of 1N KCl solution, mix and let stand for 30 minutes. Transfer to a Büchner funnel fitted with filter paper and mounted on a 250-ml vacuum flask, and follow with an additional volume of 125 ml of KCl in 25-ml increments to a total of 150 ml.

To obtain KCl acidity, add 4 or 5 drops of Phenolphthalein, and titrate with 0.1N NaOH to the first permanent pink endpoint. Correct for a blank of NaOH titer on 150 ml of KCl solution. Milliequivalents of KCl-extracted acidity are calculated as shown below.

To estimate amounts of $Al^{3+}$ and $H^+$, record the titer for NaOH, add 10 ml of 1N KF, and titrate with 0.1N HCl until pink color disappears. Wait for 30 minutes, and add additional HCl to a clear endpoint. Aluminum and hydrogen are calculated as shown below.

$$\text{meq KCl acidity} = \frac{(\text{ml NaOH sample} - \text{ml NaOH blank}) \times N \times 100}{\text{g sample}}$$

$$\text{meq KCl exch. Al} = \frac{\text{ml HCl} \times N \times 100}{\text{g sample}}$$

Meq H=KCl acidity - KCl exch. Al.

**3. Total Nitrogen (micro-Kjeldhal method)**

**Reagents**

1. $Na_2SO_4$
2. Selenium granules (boiling bits)
3. Conc. $H_2SO_4$
4. 50% NaOH
5. 0.05 N HCl
6. 1% $K_2S$

**Procedure**

Place a sample of soil containing 1 g. of soil in a micro-Kjeldhal digestion flask. Add 1.5 g of $Na_2SO_4$, 3 granules of Selenium and 5 ml of Conc. $H_2SO_4$. Heat the flask on the digestion stand until the mixture turns light brown. Cool in ice as a thin shell. Then slowly add 15 ml $H_2O$.

Add the sample into the rapid distillation chamber. Add 15.5 ml 50% NaOH and 1% $K_2S$. Distill into 100ml beaker filled with 50 ml HCl.

Titrate blank (50 ml 0.5 N HCl) + 4 drops of indicator and sample with 0.1 N NaOH.

**Calculations**

mg N=14*0.1*(titratration blank-titratration sample)

**4. Nitrate Nitrogen**

**Reagents**

1. KCl 1 N

2. Devarda alloy

3. $H_2SO_4$ 0.01 N

4. Indicator: 500 mg methylred and 750 mg bromocresolgreen in 250 ml ethanol.

5. Receiver solution: 2% boric acid: 100 g $H_3BO_3$ and 12.5 ml indicator diluted to 5l distilled water.

**Procedure**

Weigh exactly 50 g soil sample in a jar and add 100 ml KCL 1 N. Shake for 30 minutes. Let the mixture to settle for a few minutes and the supernatant is filtered using a Büchner funnel.

Take 100 ml of the clear filtrate into a conical flask and add 100 ml distilled water. Add one teaspoonful of Devarda alloy and connect the flask immediately to the distillation unit. Put 20 ml of receiver solution into 250 ml conical flask and place it under the condenser.

Distillation is stopped when about 70 ml is distilled. Titrate the distillate with $H_2SO_4$ .

**Calculations**

| | |
|---|---|
| 1 N $H_2SO_4$ 1 ml | = 14 Mg N |
| 0.01 N $H_2SO_4$ 1 ml | = 0.14 mg N |
| Dilution factor | =1/2 (100 g soil in 200 ml KCl) |

| | |
|---|---|
| 1 ml $H_2SO_4$ 0.01 N | =0.28 mg/100 g soil |
| | =2.8 ppm |
| ppm Nitrate Nitrogen | = (titration sample-titration blank) X 2.8 |

**5. Soil organic matter (by loss on ignition)**

**Apparatus**

1. Oven - capable of maintaining a temperature of 50°C.
2. Muffle furnace or oven - capable of maintaining a temperature of 500°C.
3. Crucibles, 10 ml, porcelain.
4. Balance - minimum capacity of 50±0.001 g.
5. Scoop - 1 ml capacity.

**Procedure**

If the sample was not dried within the last 24 hours, it should be re-dried in an oven set at 50oC for at least one hour. Place the crucible on the balance and record the weight. Remove the crucible from the balance.

Using the 1 ml scoop, place a sample of the soil into the crucible, and record the weight of the crucible and soil sample. Remove the crucible from the balance.

When all the crucibles containing a soil sample have been weighed place into a muffle furnace, which has equilibrated at $500^0$ C, for 2 hours.

Remove the crucibles and allow to cool for 1 hour.

Place the crucible and the ashed sample on the balance and record the weight. Remove the crucible from the balance.

Using the 1 ml scoop, place a sample of the soil into the crucible. Record the weight of the crucible and soil sample. Place the crucible containing sample into a muffle furnace, which has equilibrated to $500^0$ C, for two hours.

Remove the crucible containing sample, and allow to cool for hour.

Tare the balance. Record the combined weight of the crucible and ashed sample.

**Calculations**

1. Loss on ignition

$$\mathrm{LOI}(\%) = \frac{(\mathrm{Wcs} - \mathrm{Wc}) - (\mathrm{Wca} - \mathrm{Wc})}{\mathrm{Wcs} - \mathrm{Wc}} \times 100$$

where:

LOI = Percent weight loss on ignition.

Wc = Weight of crucible.

Wcs = Weight of crucible plus soil before ashing.

Wca = Weight of crucible plus ashed soil.

2. Organic matter

OM = (0.7 x LOI) - 0.23

where:

OM = Percent organic matter.

LOI = Percent weight loss on ignition.

**6. Moisture content**

**Apparatus**

1.Balance, minimum 100 g capacity, ±0.1 g.

2.Glass or Aluminum pan, 25 cm diameter.

3. Oven - capable of maintaining a temperature of 105 $^{0}$ C.

**Procedure**

Prepare the soil sample for weighing by removing any stones, twigs, plant matter, etc. Tare the balance, and weigh the glass or aluminum pan. Record the weight of the pan. Weigh 20 g of prepared sample into the pan, and record the weight. Remove from the balance, and allow to dry at 105 $^{0}$ C for forty-eight hours. Tare the balance, and record the weight of the pan and dried sample.

**Calculations**

Moisture (%) = {[(Wps - Wp) - (Wpd - Wp)]/(Wps - Wp)} x 100

where:

Wp = Weight of pan

Wps = Weight of pan plus undried sample

Wpd = Weight of pan plus dried sample

**7. Potassium, Magnesium, Calcium, Iron, Aluminum, Copper, Manganese and Zinc determination (by Atomic Absorption Spectrophotometry)**

**Reagents**

1. 1 M $NH_4OAc$ pH 7: dissolve 77.08 g $NH_4OAc$ in 700 ml de-ionized water, adjust the pH with $NH_4OH$ or $NH_4OAc$ and dilute to 1 L).

2. Standard solutions of K, Mg, Ca etc.

**Procedure**

Weigh 5g air-dried soil into and record the exact weight. Add 100 ml of extraction solution ($NH_4OAc$). Prepare a blank (100 ml extraction solution without soil). Shake for 2 hours and filter.

The filtrate is analyzed by Atomic Absorption Spectrophotometer (AAS).

**Calculations**

ppm K, Mg, Ca = ppm reading in AAS x filtrate dilution x extraction dilution x weight of soil in g

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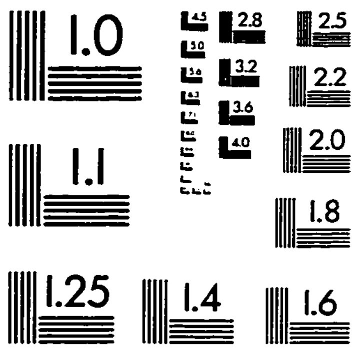
# IMAGE EVALUATION TEST TARGET (QA-3)

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