Characteristics and classification of southern Appalachian spruce-fir forests

by

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Abstract

Southern Appalachian spruce-fir forests are relatively uncommon communities that occur at high elevations in the mountains of North Carolina, Virginia, Tennessee, and West Virginia. These forests are relicts of the Pleistocene left over from a period of glaciation during which spruce-fir forests were distributed contiguously throughout the Appalachians. Previous examinations of the southern Appalachian ecotones containing spruce and fir have indicated the importance of elevation as a driver of species composition. Dominant tree species exhibit a gradient from northern hardwoods to red spruce (*Picea rubens*) to Fraser fir (*Abies fraseri*) as elevation increases. These communities have been sampled by the Carolina Vegetation Survey (CVS), a large-scale research program aimed at inventory and monitoring of the natural vegetation of the Carolinas. I obtained spruce-fir forest data from the CVS database and used agglomerative hierarchical clustering methods to group plots based on species cover class values, as defined by CVS protocol. I examined community composition and environmental characteristics of these clusters and used them to identify distinct plant community types. I made reference to previous descriptions by the U.S. National Vegetation Classification and the North Carolina Natural Heritage Community Classification during the classification process. This was done with the goal of evaluating and improving upon these previous spruce-fir community type classifications. Given that future changes in climate are anticipated to affect the distribution of spruce-fir forests, further knowledge of their dynamics and distribution is needed to inform conservation planning.

Introduction

Southern Appalachian spruce-fir forests are relatively uncommon communities that occur at high elevations in the mountains of North Carolina, Virginia, Tennessee, and West Virginia. They are characterized by a dominance of one or both of red spruce (*Picea rubra*)[1] and Fraser fir (*Abies fraseri*) (Pyle and Schafale 1988; White and Cogbill 1992). The composition and distribution of southern Appalachian spruce-fir forest vegetation is distinct from that of northern Appalachian spruce-fir forests in which the dominant fir species is *Abies balsamea* (Hayes et al. 2007). Similarity of vegetation between northern and southern Appalachian spruce-fir forests remains fairly high, floristic similarity between the two regions being approximately 57% (White and Miller 1988; Hayes at al. 2007).

The disjunction in the distribution of Appalachian spruce-fir forests can be attributed to a lack of adequate elevation between northern and southern occurrences (Hayes et al. 2007). Elevation has been identified as a determinant of species composition in these forests. *Abies fraseri* tends to dominate at high elevations (above 1800 m), with *Picea rubens* co-dominating and then dominating at intermediate elevations (1400 to 1900 m), and with deciduous forests characterizing lower elevations (below 1300 m) (Busing et al. 1993). Previous examinations of the southern Appalachian spruce and fir ecotone have revealed past variation in its distribution with elevation, with apparent high points being reached during thermal maximums (Whittaker 1956; Delcourt and Delcourt 1984; Hayes et al. 2007). High-elevation spruce-fir forests of the southern Appalachians are relicts of the Pleistocene left over from a period of glaciation during which spruce-fir forests were distributed contiguously throughout the Appalachians (Cogbill and White 1991; Moore 2013). Today's warmer climate is not as conducive to a contiguous spruce-fir distribution. However, the conditions in high-elevation areas of the southern Appalachians allow for the persistence of spruce-fir in that region, despite its lower latitude.

The composition and dynamics of spruce-fir forests of the present are influenced by a history of logging and additional sources of disturbance. The recent distribution of spruce-fir forests in the region was reduced by extensive logging and by associated slash fires in the 1910s. Many areas that burned after logging have not returned to spruce-fir dominance in the 100+ years since (Hayes et al. 2007). The balsam woolly adelgid (*Adelges piceae* Ratz.), has caused a high degree of mortality in populations of *Abies fraseri* since the middle 1970s and has, thereby, affected high-elevation fir communities. Widespread fir mortality has greatly impacted ecosystem dynamics and community composition in the southern Appalachians (Witter and Ragenovich 1986; Nicholas et al. 1992; Busing et al. 1993; Busing et al. 1998). Spruce is reported to be declining owing to several other factors, including atmospheric deposition and air pollution (Moore 2013). Future changes in climate are expected to further alter the distribution of spruce-fir forests, which are considered to constitute one of the most threatened ecosystems in the southeastern U.S. (White and Miller 1988; Noss et al. 1995; Hayes et al. 2007).

Gradients in vegetation, such as the elevational gradient mentioned above, as well as the role of stochasticity in distribution patterns of such insular communities, contribute to the

[1] Botanical nomenclature follows Weakley 2015.

uniquely challenging nature of vegetation classification (Gleason 1926; Gleason 1939; Peet and Roberts 2013). However, the creation and maintenance of standardized descriptions of vegetation is imperative, given the increasing pressures of habitat loss, climate change, pollution, and exotic invasions on ecosystem processes (Overpeck et al. 1991; Vitousek et al. 1997; Wicove et al. 1998; Jennings et al. 2009). The U.S. National Vegetation Classification (hereafter referred to as the NVC) was first formally released in 1997 and implemented the general structure of the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Faber-Langendoen et al. 2016). In 2008, revisions were made to the NVC Standard, which is the set of guidelines for the creation and revision of the Classification, which is the hierarchy of vegetation. The Standard was revised in 2008 in order to allow for a more dynamic process of classification through which new data can be incorporated as information is gained (FGDC 2008). Features of the current system include the requirements that types include the known range of variation, that types not overlap one another, and that types be based on publically available data when possible (Jennings et al. 2009; Peet and Roberts 2013). The NVC Classification consists of eight levels, the upper three of which are based on physiognomic and ecological factors. The intermediate three levels are based on biogeographic factors, and lowest two levels are based on floristics (FDGC 2008). The NVC units relevant to this project are Group (an intermediate level), and Alliance and Association (the lowest levels).

Data acquisition and preparation, both primary components of vegetation classification, necessitate the procurement of vegetation plot data and its consolidation into a standardized dataset (Peet and Roberts 2013). Data used in this project were acquired by the Carolina Vegetation Survey (CVS), a research program that seeks to characterize natural vegetation through inventory and monitoring. The goals of the program are to characterize the vegetation of the Carolinas and adjacent areas to gain a more thorough understanding of variation of vegetation and to provide information relevant to conservation and management efforts (Peet et al. 1998, 2012, 2017).

This project seeks to contribute information to the body of knowledge concerning southern Appalachian spruce-fir forests. In accordance with the process of dynamic vegetation classification, the objective is to provide quantitatively derived characterizations of vegetation types that build upon the existing hierarchy. Prior to analysis and examination of communities, I hypothesized that alterations to the existing classification would primarily include the addition of detail to descriptions. This examination represented a relatively fine-scale evaluation of communities, which allowed them to be examined at scales as small as individual plots. Thus, I predicted that I would encounter floristic detail not discernable in examinations at broader scales. Additionally, I hypothesized that elevation and latitude would dictate community occurrences, based on prior examinations of environmental gradients in southern Appalachian spruce-fir forest communities (Busing et al. 1993).

Methods

Data and homogenization

Plot data were obtained from the Carolina Vegetation Survey (CVS) database (Peet et al. 1998, 2012). Specific data utilized include species presence, cover class values, environmental factors, and general plot information. In an attempt to limit the scope of this study to spruce-fir forest ecosystems, I searched the CVS database for plots with at least one stem of *P. rubra* and/or *A. fraseri* greater than or equal to five cm DBH (diameter at breast height). Dominance of one or both of these species is characteristic of spruce-fir forests. Plot selection was constrained further by deleting those plots in which cover of neither *P. rubra* nor *A. fraseri* received a value of 5% or greater (Table 1). In order to minimize the effects of spatial separation between occurrences of spruce-fir forests, I limited plot selection to those from western North Carolina, eastern Tennessee, and southwestern Virginia.

Carolina Vegetation Survey Cover Classes			
1	Trace (<0.1%)	6	10-25%
2	0-1%	7	25-50%
3	1-2%	8	50-75%
4	2-5%	9	75-95%
5	5-10%	10	95-100%

Table 1. CVS cover class values (Lee et al. 2008)

The final dataset included plots from or immediately adjacent to Cherokee National Forest, Nantahala National Forest, Pisgah National Forest, Great Smoky Mountains National Park, Mount Mitchell State Park, Long Hope Valley, Mount Rogers, and Joyce Kilmer-Slickrock Wilderness Area. Joyce Kilmer-Slickrock is thought to be beyond the native range of spruce-fir. Only one plot in the dataset is from that location, and plot notes include the assertion that the community was likely planted there. This plot is included within the lower elevation variant group of the Red Spruce-Fraser Fir Forest (Herb Type) (CEGL007131) and its location is discussed further in the subsequent description.

To allow for consistent analysis and comparison of communities, a system of standardization for taxonomy within the list of species was implemented (Appendix F). An attempt was made to homogenize observations to species level, which involved deleting certain genus-level observations in order to preserve finer-resolution taxa. When an observation was identified to variety, it was merged with species-level observations in order to maintain consistency of resolution. I eliminated occurrences of non-vascular plant species from the dataset owing to inconsistent observation of these taxa, as well as occurrences for which cover values were not included in the CVS database (presumably because they were not recorded during sampling).

Environmental parameters (Appendices A, B, and C) were obtained from the CVS database and were collected following CVS protocol (Peet et al. 1998). According to this protocol, slope, aspect, elevation, latitude, and longitude were recorded. Four 10 cm surface soil samples and one 50 cm sub-surface soil sample were taken from each plot and used to determine texture and nutrient content. Laboratory analyses were conducted to determine percentage organic matter, *p*H, texture (percentage clay, silt, and sand), bulk density, total cation exchange capacity, cation content (Ca, Mg, K, and Na), percentage base saturation, and Mg content.

Values from the four surface samples were averaged for each plot. In this dataset, plot size ranges from 100 m^2 to 1000 m^2.

Analyses

During analysis, I largely followed the protocols used by the CVS as described in Peet et al. (2017). In order to create plot groupings based on similarities in community composition, I used the multivariate analysis program PC-Ord (Version 6) to calculate a Sørenson dissimilarity matrix from the cover class values of the homogenized species dataset (McCune and Mefford 2011). From this matrix, I used agglomerative hierarchical clustering with flexible beta linkage ($\beta = -.25$) to group plots and to create a dendrogram of these groupings (Appendix E). Initial examination of group numbers was based off of the number of communities previously assigned within the CVS database. Since these 104 plots had originally been assigned to a total of 20 unique NVC Associations, I examined clusters ranging from 10 to 35 groups. I evaluated previous community classifications of plots by examining the results of the cluster analysis in addition to individual plot data. I used the CVS Viewer Tool (Peet et al. 2017) to create constancy tables and species matrices for clusters, which were used in this evaluation. Additionally, I referenced and incorporated previous community descriptions, particularly those of the NVC (2016) and the North Carolina Natural Heritage Community Classification (Fourth Approximation).

After preliminary groups were recognized, individual plots were examined for fit to clusters and fit to currently recognized communities. In some cases, plots were moved to groups outside their clusters based on compositional fit to those groups. This was done to minimize tension between the composition of recognized associations and those of previously existing NVC associations and Fourth Approximation communities. Thus, some associations (or communities) I recognized were composed of multiple clusters that were not necessarily adjacent in the dendrogram (Appendix E). Labels used in descriptions and appendices are based on groups to which these plots were ultimately assigned.

Upon farther examination of certain clusters or plots, it was determined that they did not fall within the scope of communities I wanted to examine, and so were removed. These included: Beech Gaps, Alder Balds, Rich Cove Forests, Red Oak Forests, Swamp Forests, and some Northern Hardwood Forests. Although several spruce-hardwood transitional communities are described in this examination, I removed groups that were more characteristic of northern hardwood forests than they were of spruce-fir forests or spruce-hardwood transitional forests. Types identified in the dataset that were excluded from description as out-of-scope were:

Rhododendron (maximum, catawbiense) – Ilex collina – Salix sericea / Eriophorum virginicum Seepage Shrubland (CEGL003913)
Fagus grandifolia / Carex pensylvanica – Ageratina altissima var. roanensis Forest (CEGL006130)
Picea rubens – (Tsuga canadensis) / Rhododendron maximum Swamp Forest (CEGL006277)
Quercus rubra / Carex pensylvanica – Ageratina altissima var. roanensis Forest (CEGL007298)

Quercus rubra / (Kalmia latifolia, Rhododendron catawbiense, Rhododendron maximum) / Galax urceolata Forest (CEGL007299)
Liriodendron tulipifera – Betula lenta – Tsuga canadensis / Rhododendron maximum Forest (CEGL007543)

Following the removal of these types, another iteration of clustering was conducted. Groups were evaluated once again and final constancy tables were created describing the floristic composition of each.

Constancy tables within this document include a column comprised of species and one or more columns that represent clusters within a group. The species list contains species found to be prevalent (or most constant, where the number of prevalents is the average number of species in 100 m^2) for at least one of the clusters in question. Additionally, the table contains the number of plots in each cluster and the average species richness per plot. Average plot species richness is based on species that were not deleted during homogenization and does not account for differences in plot size. Homoteneity, or the mean constancy of prevalent species expressed as a fraction, is also included. Within each cluster column are listed constancy and average cover. Constancy is the proportion (expressed as a percentage) of samples in a group in which a species occurs, while average cover is the mean percent cover calculated from midpoint values of cover class ranges. In descriptions of communities, I include characteristic vascular species. These are generally listed by growth form and then by prevalence (with both constancy and average cover considered).

To examine the influence of environmental factors on community composition, I used PC-Ord to ordinate plots based on species cover class values. Non-metric multidimensional scaling (NMS) methods were used and I mapped the following environmental variables onto the ordinations: elevation, slope, aspect, latitude, longitude, soil pH, exchange capacity, and incident solar radiation. Plots for which these parameters were blank in the CVS database (presumably due to not being recorded during sampling) were not included in ordinations. An ordination consisting of only groups that were included in community descriptions was created in addition to one consisting of the original spruce-fir dataset. Using PC-Ord, I created graph of plots (labeled with their associated clusters) with elevation and latitude as axes (Figure 3).

Results

Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group (G632)

Within the NVC the Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group (G632) describes high-elevation southern Appalachian forests dominated by *Picea rubens* and/or *Abies fraseri*. Currently, there are two NVC alliances within G632. The first, the Southern Appalachian Spruce-Fir Forest Alliance (A0136), contains four distinct community associations. Within this alliance, I identified eleven floristically distinct groups. Within the second alliance, the Central Appalachian Red Spruce Forest Alliance (A0138), there are seven community associations identified by the NVC. Only four of these were geographically and ecologically relevant to this examination. I identified eight distinct groups within this alliance.

Initial divisions were based upon species composition, but elevation, location, and conditions were taken into account during the subsequent classification process. I consulted both NVC and Fourth Approximation descriptions of existing community types in evaluation of groups. Nine of the groups I identified mapped closely onto existing NVC community descriptions, although some necessitated alterations to their descriptions. Eight represented phases of the existing community types. Two new community types are described.

The frequent dominance of *Picea rubens* and occasional dominance of *Abies fraseri* that the NVC describes as characteristic of Group 632 are consistent with this dataset, which is to be expected since this was included in plot search criteria. Soil *p*H of this group is described by the NVC as generally acidic. This is also consistent with the average soil *p*H values calculated for both alliances in this dataset, which were near or below 4 (Appendix A). Examples of this group are described to occur at elevations above 1370 m (4500 feet), although occurrences are thought to be limited at this lower range. Average elevations for both associations within this dataset were well above 1370 m, although three plots used in descriptions here fell below that lower range. All three of these were classified as Red Spruce Forest (Protected Slope Type) (CEGL006152).

The NVC includes *Betula alleghaniensis* and *Tsuga canadensis* as moderately diagnostic of this group. This seems to be true of *B. alleghaniensis* within this dataset (Table 2). However, *T. canadensis* does not seem to be prevalent in the Southern Appalachian Spruce-Fir Forest Alliance (A0136) and I propose the removal of it from consideration as a diagnostic species of the group as a whole. I propose the replacement of *T. canadensis* with *Sorbus americana* as a moderately diagnostic tree species for this group. The NVC includes *Acer spicatum, Rhododendron catawbiense, Rhododendron maximum, Vaccinium erythrocarpum*, and *Viburnum lantanoides* as shrubs characteristic of this group. I propose the addition of *Rubus canadensis.* Herbs included as characteristic by the NVC description are *Clintonia borealis, Dryopteris campyloptera, Mitchella repens, Oxalis montana*, and *Trillium undulatum.* I propose the removal of *Trillium undulatum* and the addition of *Athyrium asplenioides* and *Oclemena acuminata* as characteristic herbs based on prevalence or lack thereof in this dataset (Table 2).

This group is described by the NVC as occurring in West Virginia, Virginia, western North Carolina, and eastern Tennessee. This dataset captures occurrences of Group G632 in western North Carolina, eastern Tennessee, and southwestern-most Virginia.

Table 2. Constancy table of Southern Appalachian Spruce-Fir Forest Alliance (A0136) and Central Appalachian Red Spruce Forest Alliance (A0138)

Group Code	**A0136**		**A0138**	
Group Plot Count	37		38	
Group Avg Plot Spp Richness	22		33	
Group homoteneity	54%		54%	
taxon name	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri	**78%**	7	**55%**	5
Acer pensylvanicum	**24%**	3	**74%**	5
Acer rubrum	**11%**	4	**50%**	5
Acer saccharum	**3%**	2	**37%**	4
Acer spicatum	**43%**	5	**61%**	5
Aesculus flava	**5%**	2	**39%**	4
Ageratina altissima	**35%**	3	**55%**	4
Amelanchier [arborea + laevis]	**35%**	3	**50%**	4

Arisaema triphyllum s.1	**22%**	2	**68%**	2
Athyrium asplenioides	**57%**	5	**50%**	4
Betula alleghaniensis	**70%**	6	**92%**	7
Carex brunnescens	**30%**	5	**8%**	2
Carex intumescens	**43%**	5	**16%**	5
Carex pensylvanica	**27%**	4	**50%**	6
Clintonia borealis	**30%**	5	**34%**	5
Dennstaedtia punctilobula	**43%**	5	**32%**	5
Dryopteris campyloptera	**76%**	5	**45%**	4
Dryopteris intermedia	**22%**	4	**55%**	5
Fagus grandifolia	**27%**	5	**55%**	6
Huperzia lucidula	**19%**	4	**53%**	5
Ilex montana	**14%**	3	**55%**	4
Maianthemum canadense	**24%**	3	**53%**	4
Oclemena acuminata	**76%**	4	**84%**	4
Oxalis montana	**70%**	6	**50%**	6
Picea rubens	**95%**	7	**100%**	7
Polypodium appalachianum	**24%**	2	**45%**	5
Prunus serotina	**19%**	4	**37%**	4
Quercus rubra	**5%**	4	**39%**	6
Rhododendron catawbiense	**43%**	6	**29%**	5
Rhododendron maximum	**16%**	5	**45%**	7
Rubus canadensis	**62%**	3	**55%**	4
Solidago glomerata	**30%**	4	**8%**	2
Sorbus americana	**92%**	4	**63%**	4
Tsuga canadensis	**11%**	5	**63%**	6
Vaccinium erythrocarpum	**70%**	4	**34%**	5
Viburnum lantanoides	**32%**	3	**50%**	5

Southern Appalachian Spruce-Fir Forest Alliance (A0136)

This alliance is characterized by the NVC as having a canopy dominance of *Abies fraseri* and/or *Picea rubens*. This was consistent with the results as shown in the constancy table, although I found *P. rubens* to be the more dominant of the two. This is to be expected, given the extensive mortality of *A. fraseri* due to the balsam wooly adelgid. Also described is the potential codominance of *Betula alleghaniensis* and other northern hardwood species, which seemed the case in these results in regards to *B. alleghaniensis* and *Sorbus americana* (Table 2). I found the range of elevation of plots within this alliance to be approximately 1542 to 2003 m (5059-6572 feet), which is within the elevational range of 1350-2300 m (4400-6600 feet) described by the NVC. This alliance is described to occur in eastern Tennessee, western North Carolina, and southwestern Virginia, all within the geographic scope of this dataset. However, disjunct northern occurrences are found in West Virginia, outside the range of *Abies fraseri* and other southern Appalachian endemic species. This examination does not capture those geographic outliers.

Two southern Appalachian Fraser Fir Forest associations are described by the NVC as within this alliance: the Fraser Fir Forest Deciduous Shrub Type (CEGL006049) and the Fraser Fir Forest Evergreen Shrub Type (CEGL006308). The Fourth Approximation refers to these as the Fraser Fir Forest (Herb Subtype) and the Fraser Fir Forest (Rhododendron Subtype), respectively. In agreement with Schafale, I propose the change of the name of CEGL006049 from the Deciduous Shrub Type to the Herb Type. Four distinct Fraser Fir Forest community clusters were identified, all of which were similar enough to existing community associations to be described as such. Within the Herb Type (CEGL006049), I identified three distinct clusters. One of these represents a classic version of the community and the other two represent a variant group that I describe as a phase within the community. The variant phase may represent a cooler,

moister example of the community. It was found to have a lower elevation and greater amount of soil organic matter than the classic phase (Appendix B).

The southern Appalachian Red Spruce-Fraser Fir Forest communities within this alliance as described by the NVC and are: the Evergreen Shrub Type (CEGL007130) and the Deciduous Shrub Type (CEGL007131). These are referred to by Schafale as the Rhododendron Subtype and the Herb Subtype, respectively. In agreement with Schafale, I propose the change of the name of CEGL007131 from the Deciduous Shrub Type to the Herb Type. Within the parameters of these existing types, I identified seven floristically distinct groups, which I describe as phases of either the Evergreen Shrub Type or the Herb Type. The Herb Type, having more representative clusters and plots than the Evergreen Shrub Type in general, has a wider geographic distribution that includes western North Carolina, eastern Tennessee, and southwestern Virginia. Occurrences of the Evergreen Shrub Type in this dataset are limited to western North Carolina near Shining Rock.

Within the Red Spruce-Fraser Forest (Evergreen Shrub Type) (CEGL007130) association I identified two floristically distinct groups. One of these I consider to be the classic form of the community as previously described in the NVC and one I consider to be a phase that is a more herbaceous variant of the community, and which may be slightly transitional to the Herb Type. The variant phase is primarily distinguished by a higher species diversity, higher *Abies fraseri* cover, and greater coverage of deciduous species.

Five distinct plot groups were identified as the Red Spruce-Fraser Fir Forest (Herb Type) (CEGL007131). Two of these represent what I consider to be a classic form of the community and the other three represent variants within this relatively broadly defined group. These variant phases include a lower elevation group, a more herbaceous group, and a group that may be transitional to the Evergreen Shrub Type. Crandall (1958) also noted more variation within herbaceous-deciduous shrub spruce-fir forests, which both Schafale (2012) and the NVC chose not to recognize because it was considered too finely divided.

Fraser Fir Forest (Herb Type)
CEGL006049: *Abies fraseri / Oxalis montana - Athyrium asplenioides - Dryopteris campyloptera / Hylocomium splendens* Forest Association

Concept. This community is characterized by present or recent past dominance of *Abies fraseri*, which has cover values of greater than 50% in examples of this type. In addition to the *A. fraseri* dominated canopy are characteristic evergreen heaths, deciduous shrubs, and herbs. I have proposed the alteration of the name of CEGL006049 from the Deciduous Shrub Type to the Herb Type, as it is referred to in the Fourth Approximation. This change was made to reflect the abundance of herbs relative to deciduous shrubs found in this group.

I identified three distinct clusters that fit the concept of this community. One was relatively classic, having the highest coverage of characteristic deciduous herbs and shrubs. This cluster also had the greatest number of plots of the three, with six plots as opposed to the other three- and one-plot clusters. The two other clusters (6049A and 6049X) seemed to represent a

cooler, moister, more nutrient-rich phase. The variant phase clusters are distinguished by lower elevation, greater soil organic matter, and a slightly steeper slope gradient (Appendix B). However, I propose that these clusters are all compositionally similar enough to be classified as the Fraser Fir Forest (Herb Type).

Vegetation. *Viburnum lantanoides* was previously included as a characteristic species of this community, but I found it to be a very minor component of plots attributable to this group and only present in one of the three clusters (Table 3). Additionally, I have included *Athyrium asplenioides* as a characteristic species due to its relative abundance within this group. One of the variant clusters (6049A) seemed to be more ericaceous, having an abundance of *Rhododendron catawbiense.* It is possible that this cluster could represent an early phase of transition to the Evergreen Shrub Type (CEGL006308). One of the variant clusters (6049X) had a relatively low species richness, but was only comprised of one plot. It has been included in this group based on the presence of most species characteristic of this type.

Other differences between the three clusters were relatively minor: higher coverage of *Picea rubens* and *Vaccinium erythrocarpon* in the two variant phase clusters and higher coverage of *Oclemena acuminata, Oxalis montana,* and *Athyrium asplenioides* in the classic cluster (Table 3). Characteristic vascular species include *Abies fraseri, Oxalis montana, Athyrium asplenioides, Oclemena acuminata, Sorbus americana, Rubus canadensis, Carex intumescens, Dryopteris campyloptera, Chelone lyonii, Cinna latifolia* and *Picea rubens.*

Environmental Setting. This community occurs on relatively steep slopes above 1830 m (6000 feet) elevation. It is typically found on mesic, north-facing slopes. The group of six plots identified as the classic variation of this community type had an average elevation of approximately 1920 m (6300 feet). The variant clusters had average elevations of approximately 1858 m (6096 feet) and 1738 m (5702 feet). These relatively low elevations likely contribute to the compositional differences in the variant phases. These phases also seem to sort by geographic location, with the classic near Mount Mitchell and Mount Hardy in western North Carolina and the variant phases near Roan Mountain farther to the west in North Carolina (along the Tennessee border) and near Mount Rogers in southwestern Virginia.

Table 3. Constancy table of Fraser Fir Forest (Herb Type) (CEGL006049) clusters

Group Code	**6049-classic**		**6049A-variant**		**6049X-variant**	
Group Plot Count	6		3		1	
Group Avg Plot Spp Richness	23		26		10	
Group homoteneity	71%		76%		100%	
taxon name	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri	**100%**	8	**100%**	8	**100%**	9
Acer pensylvanicum			**33%**	2		
Acer spicatum	**33%**	2	**67%**	1		
Ageratina altissima	**50%**	2				
Athyrium asplenioides	**100%**	6	**67%**	2		
Avenella flexuosa	**33%**	3	**33%**	2		
Betula alleghaniensis	**17%**	5	**100%**	2		
Carex allegheniensis	**33%**	5	**33%**	2		
Carex appalachica			**33%**	2	**100%**	2
Carex brunnescens	**67%**	6	**67%**	4	**100%**	2
Carex flexuosa			**67%**	3		
Carex intumescens	**83%**	6	**100%**	3		
Castanea dentata	**67%**	7				
Chelone lyonii	**83%**	4	**33%**	1		

Cinna latifolia	**83%**	4				
Clintonia borealis	**50%**	2	**67%**	2		
Danthonia compressa			**67%**	2		
Dennstaedtia punctilobula	**17%**	6	**33%**	2		
Dryopteris campyloptera	**83%**	2	**100%**	2	**100%**	8
Fallopia cilinodis	**50%**	2				
Houstonia serpyllifolia	**50%**	1	**33%**	2		
Hydatica petiolaris	**50%**	1	**100%**	2		
Oclemena acuminata	**100%**	5	**100%**	2	**100%**	2
Oxalis montana	**100%**	7	**67%**	2	**100%**	6
Picea rubens	**83%**	4	**100%**	6	**100%**	5
Polypodium appalachianum			**67%**	1		
Prunus pensylvanica	**50%**	2	**33%**	2		
Rhododendron catawbiense	**17%**	1	**100%**	3		
Rubus allegheniensis			**33%**	4		
Rubus canadensis	**100%**	2	**67%**	4	**100%**	2
Rubus idaeus	**50%**	2				
Sambucus racemosa			**67%**	2		
Solidago glomerata	**67%**	3	**33%**	2		
Sorbus americana	**100%**	4	**100%**	4	**100%**	5
Vaccinium corymbosum	**33%**	4				
Vaccinium erythrocarpum	**33%**	3	**100%**	2	**100%**	2
Viola [blanda + incognita]			**100%**	2		

Fraser Fir Forest (Evergreen Shrub Type)
CEGL006308: *Abies fraseri / (Rhododendron catawbiense, Rhododendron carolinianum)* Forest Association

Concept. This community's canopy is dominated by *Abies fraseri*, but it has been described as differing from the Fraser Fir Forest (Herb Type) (CEGL006049) in its dominance of evergreen shrub species such as *Rhododendron catawbiense, R. carolinianum,* and *R. maximum*. I found that the plots from this group contained only *R. catawbiense* and *R. pilosum* (Table 4), but this may be due to the limited representation of this community type in the dataset. The group used to describe this relatively rare type only contains two plots, so this description must be considered a narrow subset, potentially limited by geographic and stochastic differences. The Fourth Approximation indicates that this community is rare and exists in small patches within a matrix of the Herb Type (CEGL006049). The low plot representation of the Evergreen Shrub Type and its geographic overlap with the Herb Type are consistent with this characterization. For the most part, my description of this type resembles those of the NVC and Fourth Approximation. However, it remains relatively sparsely described. Although I may have only captured a narrow subset of it, and therefore cannot describe it with high confidence, this community may be inherently rare and thus difficult to describe in general.

Vegetation. In addition to *Abies fraseri*, past descriptions of the type report an abundance of *Picea rubens, Sorbus americana,* and *Betula alleghaniensis,* and report that *Prunus pensylvanica* may occur non-dominantly in the canopy or subcanopy. Within this dataset, *P. pensylvanica* was not found to be present, but this may be due to low plot representation (Table 4). Characteristic vascular species include *Abies fraseri, Rhododendron catawbiense, Vaccinium erythrocarpum, Picea rubens, Sorbus americana, Oxalis montana, Oclemena acuminata, Dryopteris campyloptera, Rubus canadensis, Rhododendron pilosum* and *Betula alleghaniensis.*

Environmental Setting. These communities are generally associated with highly exposed topography, particularly sharp, south-facing ridge tops. It is possible that this community's

affinity for sharp, exposed areas is the reason for its relative rarity, as this topography is not common in the southern Appalachians. The NVC describes this type to be above 1830 m (6000 feet), but I found the average elevation of plots in this group to be 1770 m (5800 feet) (Appendix B). The elevational range of both the Herb Type (CEGL006049) and the Evergreen Shrub Type (CEGL006308) seem to be wider than the NVC indicates. Plot locations of the Evergreen Shrub Type include both Grandfather Mountain and Roan Mountain.

Table 4. Constancy table of Fraser Fir Forest (Evergreen Shrub Type) (CEGL006308) cluster

Group Code	**6308**	
Group Plot Count	2	
Group Avg Plot Spp Richness	18	
Group homoteneity	78%	
taxon name	**const.**	avg. cover
Abies fraseri	**100%**	8
Aronia melanocarpa	**50%**	2
Betula alleghaniensis	**50%**	4
Clintonia borealis	**50%**	3
Dryopteris campyloptera	**100%**	2
Dryopteris intermedia	**50%**	6
Kalmia buxifolia	**50%**	3
Oclemena acuminata	**100%**	2
Oxalis montana	**100%**	2
Picea rubens	**100%**	4
Polypodium appalachianum	**50%**	2
Rhododendron catawbiense	**100%**	7
Rhododendron pilosum	**50%**	6
Rubus canadensis	**100%**	2
Sorbus americana	**100%**	4
Vaccinium corymbosum	**50%**	6
Vaccinium erythrocarpum	**100%**	5
Viburnum lantanoides	**50%**	2

Red Spruce - Fraser Fir Forest (Evergreen Shrub Type)
CEGL007130: *Picea rubens – (Abies fraseri) / (Rhododendron catawbiense, Rhododendron maximum)* Forest Association

Concept. This high-elevation forest community is found on steep, exposed slopes dominated by *Picea rubens* and possessing a shrub stratum dominated by evergreen species. This community is defined relatively broadly in both the NVC and Fourth Approximation descriptions. One of the floristically distinct groups fit well under the previous description of the Evergreen Shrub Type (CEGL007130) but had clear geographic and compositional differences. I propose the recognition of two phases within this community type: one classic and one a more herbaceous variant that may be transitional to the Herb Type (CEGL007131).

The Fourth Approximation describes this as a relatively rare type, but I did not find that to be the case in this dataset as compared to other described types. The classic phase was more abundant in this dataset and had a lower species diversity than the variant phase (Table 5). However, both phases included substantial coverage of the species characteristic of the Red Spruce – Fraser Fir Forest (Evergreen Shrub Type).

Based on species composition, this type could be considered a lower-elevation version of the Fraser Fir Forest (Evergreen Shrub Type) (CEGL006308), with distinguishing characteristics

being a dominance of *Picea rubens* rather than *Abies fraseri* and the potential presence of *Rhododendron maximum* in addition to *R. catawbiense*, rather than *R. carolinianum* (Table 5). The average elevations of these two types are fairly similar in this dataset, with that of the Fraser Fir Forest (Evergreen Shrub Type) (CEGL006308) being only slightly higher than the Red Spruce - Fraser Fir Forest (Evergreen Shrub Type) (CEGL007130). However, the scope of this dataset has likely not captured the range of elevational variation of these types.

Vegetation. Dominance of *Picea rubens* is evident in both phases. In the variant phase, *Abies fraseri* is codominant along with *Betula alleghaniensis*, both of which are minor species in the classic phase. *A. fraseri* is far more abundant in the variant phase than in the classic, which may be due to its slightly higher elevation. Additionally, the variant phase has more *Oclemena acuminata, Oxalis montana,* and *Sorbus americana* than the variant. The primary *Rhododendron* species in both phases is *Rhododendron catawbiense*, which is far more abundant in the classic phase (Table 5). The variant phase contains a small amount of *R. maximum* in addition to *R. catawbiense*. Vascular species characteristic of the classic phase include *Picea rubens, Rhododendron catawbiense, Vaccinium stamineum, Vaccinium erythrocarpum, Pieris floribunda Aronia melanocarpa,* and *Sorbus americana.* Vascular species that distinguish the variant phase include: *Abies fraseri, Betula alleghaniensis, Oxalis montana, Dryopteris campyloptera, Prunus pensylvanica, Rubus canadensis, Oclemena acuminata,* and *Athyrium asplenioides.*

Environmental Setting. The two phases were at about the same elevation, with the classic ranging from approximately 1700 to 1810 m (5577-5938 feet) and the variant ranging approximately 1750 to 1820 m (5741-5971 feet). Both fall within the elevational range of 1550 to 1830 m (5100-6000 feet) described by the NVC. The average slope gradient of the classic phase was greater than that of the variant, which may contribute to its greater coverage of *Rhododendron catawbiense*. Examples of this type were found in several locations in Pisgah National Forest, near Deer Mountain, Earlham Meadows, Devil's Courthouse, and Shining Rock. The group considered to be the classic phase is described from plots exclusively located near Shining Rock.

Table 5. Constancy table of Red Spruce - Fraser Fir Forest (Evergreen Shrub Type) (CEGL007130) clusters

Group Code	**7130-classic**		**7130A-variant**	
Group Plot Count	5		3	
Group Avg Plot Spp Richness	12		23	
Group homoteneity	60%		81%	
taxon name	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri	**20%**	1	**100%**	6
Acer spicatum			**67%**	7
Amelanchier [arborea + laevis]	**60%**	2		
Aronia melanocarpa	**60%**	4		
Athyrium asplenioides			**100%**	4
Betula alleghaniensis	**40%**	5	**100%**	6
Carex brunnescens	**40%**	1		
Carex intumescens			**67%**	2
Castanea dentata			**67%**	1
Clintonia borealis			**67%**	7
Dennstaedtia punctilobula	**20%**	2	**67%**	4
Dryopteris campyloptera			**100%**	5
Eurybia divaricata			**67%**	4
Monotropa uniflora	**20%**	1	**67%**	1
Oclemena acuminata	**20%**	2	**100%**	4
Oxalis montana			**100%**	6
Picea rubens	**100%**	7	**100%**	7

Pieris floribunda	**60%**	6	**33%**	2
Prunus pensylvanica			**100%**	5
Rhododendron catawbiense	**100%**	7	**67%**	6
Ribes rotundifolium			**67%**	2
Rubus canadensis			**100%**	4
Rubus idaeus			**67%**	1
Sambucus racemosa			**67%**	2
Sorbus americana	**60%**	3	**100%**	6
Tsuga canadensis	**20%**	6		
Vaccinium erythrocarpum	**60%**	2	**67%**	2
Vaccinium pallidum	**40%**	2		
Vaccinium stamineum	**80%**	6		
Viburnum lantanoides			**67%**	4

Red Spruce - Fraser Fir Forest (Herb Type)
CEGL007131: *Picea rubens – (Abies fraseri) / Oxalis montana - Dryopteris campyloptera / Hylocomium splendens* Forest Association

Concept. I found the Red Spruce - Fraser Fir Forest (Herb Type) to be the most frequently occurring and broadly defined community type of those treated in this examination. It is characterized by a canopy dominated by *Picea rubens* and an abundance of deciduous herbs and shrubs. *Abies fraseri* may or may not be present in the canopy. Additionally, it may be found occurring as standing dead stems or as patches of seedlings within canopy gaps. The NVC refers to CEGL007131 as the Deciduous Shrub Type, but I propose a change of name to the Herb Type in agreement with the Fourth Approximation. Although this type has greater coverage of deciduous shrubs as compared to the Evergreen Shrub Type, the species found to be diagnostic are primarily herbs.

I identified five floristically distinct clusters that fit the characteristics of the Herb Type, although three of these represent variant phases that do not differ enough to be considered distinct. One of the distinct clusters differed primarily in its lack of *Abies fraseri,* so I have included this with the cluster representing the classic phase. In addition to what I consider to be the classic phase of the Herb Type, I identified a lower elevation variant, a more herbaceous variant, and a possible Evergreen Shrub Type (CEGL007130) transitional variant. According to the Fourth Approximation, this community is distinguished from the Red Spruce-Northern Hardwood Forest (Herb Type) (CEGL006256) by having a *Betula alleghaniensis* coverage of less than 33 percent. This is the case in these clusters, but I did find *B. alleghaniensis* to be a consistently abundant species.

Vegetation. *Picea rubens* coverage is consistently high in these clusters, with the exception of one plot in the lower elevation variant. *Abies fraseri* is clearly codominant within all but one of the clusters examined here, which is otherwise compositionally representative of this type. Although the NVC includes *Vaccinium erythrocarpum* as a nominal species, I found its coverage to be inconsistent within clusters and thus have not included it as such. I have replaced it with *Oxalis montana*, which was more consistently abundant, particularly in the cluster I consider to be the classic phase. *Dryopteris campyloptera* was abundant in all clusters except for the lower elevation variant (Table 6).

Vascular species characteristic of the classic phase include *Picea rubens, Abies fraseri* (in one of the two clusters), *Betula alleghaniensis, Dryopteris campyloptera, Oxalis montana,*

Sorbus americana, Vaccinium erythrocarpum, Acer spicatum, Ageratina altissima, Athyrium asplenioides, Dennstaedtia punctilobula, Huperzia lucidula, Fagus grandifolia, Oclemena acuminata, and *Maianthemum canadense.* Vascular species that distinguish the lower elevation phase include *Prunus serotina, Carex pennsylvanica, Epifagus virginiana,* and *Vaccinium corymbosum.* Vascular species that distinguish the more herbaceous phase include *Solidago glomerata, Eurybia chlorolepis,* and *Sambucus racemosa.* Vascular species characteristic of the Evergreen Shrub Type transitional phase include *Pieris floribunda, Amelanchier* sp., *Carex flexuosa,* and *Rhododendron catawbiense.*

Environmental Setting. The elevation of clusters in this group ranged from approximately 1540 to 1756 m (5052-5761 feet), the lower end of which falls outside the elevational range of 1680 to 1990 m (5500-6200 feet) described by the NVC at which the community is thought to be best developed. The Evergreen Shrub transitional variant was highest in average elevation, while the lower-elevation variant was, as expected, lowest (Appendix B).

The NVC describes the existence of northern disjunct occurrences of this community in West Virginia's Allegheny Mountains. These fall outside the geographic scope of this examination, and thus this description may only apply to a subset of the type. Plot locations of the classic phase include Roan Mountain, Tamasee Bald in Nantahala National Forest, Mount Hardy in Pisgah National Forest, Unaka Mountain near the North Carolina-Tennessee border, and the Mount Rogers area. The lower elevation phase is described from plots near Bald Knob in Pisgah National Forest and Joyce Kilmer-Slickrock Wilderness Area. The latter is thought to be outside the range of spruce-fir forest in the southern Appalachians. The one plot located in Joyce Kilmer-Slickrock Wilderness is thought to be planted and thus should not be considered an example of a natural occurrence of this community type. The more herbaceous phase was limited to plots near Richland Balsam in Pisgah National Forest. Plot locations of the Evergreen Shrub Type transitional phase include Shining Rock and Mount Hardy in Pisgah National Forest. Clusters within this type appear to sort by elevation rather than geographic location.

Table 6. Constancy table of Red Spruce - Fraser Fir Forest (Herb Type) (CEGL007131) clusters

Group Code	**7131-classic**		**7131A-classic (no Abies)**		**7131B-variant (low elev)**		**7131X-variant (herbaceous)**		**7131/7130-variant (7130 trans)**	
Group Plot Count	4		4		3		3		3	
Group Avg Plot Spp Richness	35		20		21		20		34	
Group homoteneity	74%		71%		70%		75%		71%	
taxon name	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri	**100%**	7			**100%**	8	**100%**	7	**100%**	6
Acer pensylvanicum	**50%**	2	**50%**	4	**67%**	1			**67%**	2
Acer rubrum					33%	2	**33%**	4	**33%**	2
Acer spicatum	**100%**	5	**75%**	4			**67%**	2	**33%**	2
Ageratina altissima	**100%**	4			33%	1	33%	1	**100%**	2
Amelanchier [arborea + laevis]	**50%**	2	25%	3	**33%**	4	**67%**	4	**100%**	2
Angelica triquinata	**50%**	2			33%	2	33%	2	**33%**	2
Arisaema triphyllum s.1	**75%**	2					33%	2	**33%**	2
Athyrium asplenioides	**75%**	3	**75%**	5	33%	1	33%	2	**67%**	2
Betula alleghaniensis	**100%**	6	**100%**	6	**100%**	5	**100%**	6	**67%**	1
Betula lenta							**33%**	7		
Cardamine [clematitis + flagellifera]	**75%**	2								
Carex appalachica			25%	2					**33%**	2

Carex debilis			**50%**	4						
Carex flexuosa	**25%**	2	**50%**	2	**33%**	2			**100%**	2
Carex gynandra					**67%**	1				
Carex intumescens	**75%**	2	**25%**	2					**67%**	2
Carex pensylvanica	**25%**	2	**50%**	6	**100%**	2			**100%**	3
Chelone glabra	**75%**	2								
Chelone lyonii							**33%**	3		
Circaea alpina	**75%**	2							**33%**	2
Clintonia borealis	**50%**	2					**33%**	2		
Crataegus macrosperma					**33%**	3				
Danthonia compressa									**67%**	2
Danthonia spicata									**33%**	2
Dennstaedtia punctilobula	**75%**	2	**75%**	4			**67%**	5	**100%**	6
Diervilla sessilifolia									**33%**	2
Dryopteris campyloptera	**100%**	2	**100%**	6	**33%**	1	**67%**	3	**100%**	2
Dryopteris intermedia	**50%**	2	**50%**	2	**67%**	1	**33%**	2		
Epifagus virginiana					**100%**	1				
Eurybia chlorolepis	**75%**	2					**67%**	4	**33%**	1
Fagus grandifolia	**50%**	6	**50%**	4	**100%**	5			**100%**	2
Fallopia cilinodis									**33%**	2
Galium triflorum	**50%**	2								
Glyceria melicaria	**75%**	4					**33%**	2		
Glyceria nubigena									**33%**	2
Houstonia caerulea									**33%**	2
Huperzia lucidula	**75%**	4	**75%**	5						
Hypericum graveolens									**33%**	2
Ilex montana			**50%**	2	**33%**	1				
Impatiens [capensis + pallida]	**50%**	2					**33%**	2	**33%**	1
Luzula acuminata					**67%**	2			**33%**	1
Maianthemum canadense	**50%**	2	**75%**	4	**67%**	1				
Medeola virginiana					**67%**	1	**33%**	2		
Nabalus	**50%**	1			**33%**	1			**67%**	1
Oclemena acuminata	**100%**	5	**50%**	2			**100%**	2	**100%**	4
Osmundastrum cinnamomeum									**33%**	2
Oxalis montana	**100%**	4	**100%**	5			**100%**	2	**33%**	1
Parathelypteris noveboracensis									**33%**	2
Picea rubens	**100%**	7	**100%**	8	**67%**	9	**100%**	8	**100%**	7
Pieris floribunda									**100%**	5
Polypodium appalachianum	**25%**	1	**75%**	2						
Prunus pensylvanica			**25%**	2					**33%**	4
Prunus serotina	**25%**	2	**50%**	2	**100%**	5				
Quercus rubra					**67%**	4				
Rhododendron calendulaceum					**33%**	3				
Rhododendron catawbiense									**100%**	2
Rhododendron maximum	**100%**	4	**25%**	3						
Rhododendron pilosum									**33%**	2
Rubus canadensis	**50%**	2	**50%**	5	**67%**	2	**33%**	4	**67%**	2
Sambucus racemosa	**50%**	2					**67%**	2		
Solidago glomerata	**25%**	4					**100%**	3	**33%**	1
Sorbus americana	**100%**	2	**100%**	4	**67%**	1	**100%**	4	**100%**	2
Tiarella cordifolia	**75%**	2								
Tsuga canadensis					**33%**	5			**67%**	4
Vaccinium corymbosum			**50%**	4	**67%**	4			**33%**	4
Vaccinium erythrocarpum	**75%**	2	**75%**	2	**33%**	1	**100%**	6	**100%**	2
Vaccinium simulatum	**50%**	2							**67%**	4
Viburnum cassinoides							**33%**	2	**33%**	2
Viburnum lantanoides	**75%**	2	**50%**	2	**33%**	1	**67%**	2		
Viola [blanda + incognita]	**50%**	2			**33%**	1			**67%**	1
Viola pallens	**25%**	5			**33%**	1			**33%**	2

Central Appalachian Red Spruce Forest Alliance (A0138)

This alliance is described in the NVC as containing *Picea rubens* dominated forests with or without a combination of *Aesculus flava, Betula alleghaniensis*, and *Tsuga canadensis*. In examples of this alliance in the dataset, I did not find *A. flava* to be abundant. However, there was an abundance of *Acer pensylvanicum, Acer spicatum, Amelanchier* sp., and *Sorbus americana,* all of which are described by the NVC as being potential canopy or subcanopy species. Also described as such are *Halesia tetraptera var. monticola* and *Prunus pensylvanica*, neither of which is abundant in this dataset (Table 2). The NVC describes *Abies fraseri* as being "sparse to absent" within this alliance. This was not the case within this dataset, although *A. fraseri* coverage was certainly lower in this alliance than it is in the Southern Appalachian Spruce-Fir Forest Alliance (A0136). This may be due to the more northern distribution of the Central Appalachian Red Spruce Forest Alliance, which extends past the range of *A. fraseri.*

Because data from central Appalachian spruce-fir forests is not included, examination of these is beyond the scope of this study. However, I recommend further investigation of this alliance in the future. Although its common name indicates otherwise, the Central Appalachian Red Spruce Forest Alliance (A0138) includes more southern Appalachian associations than central Appalachian associations. Perhaps these associations are being grouped due to their lack of *Abies fraseri* as compared to the Southern Appalachian Spruce-Fir Forest Alliance (A0136). This lack of fir in low elevation, northern hardwood transitional communities may differ from a lack of fir in central Appalachian communities, which fall outside the range of *A. fraseri.* I recommend future consideration of a split in this alliance.

The NVC includes seven community associations within this alliance. Three are not described in this treatment, as they have a northern distribution, principally West Virginia, which is outside the range of the data I examined. These communities are: the High Allegheny Red Spruce Woodland (CEGL006254), the Red Spruce Forest (Central Appalachian Upland Type) (CEGL008501), and the *Picea rubens – Tsuga canadensis – Fagus grandifolia / Dryopteris intermedia* Forest (CEGL006029). The Red Spruce Forest (Central Appalachian Upland Type) does occur in Virginia and has been suggested to possibly occur in Tennessee, so it could be expected in North Carolina. However, I did not identify examples of this type in the dataset and suggest that the potential for its distribution in Tennessee be removed from the description.

Two Red Spruce – Northern Hardwood Forest subtypes are described by the NVC: the Shrub Type (CEGL004983) and the Herb Type (CEGL006256). The Fourth Approximation refers to these as the Birch Transition Shrub Subtype and the Birch Transition Herb Subtype, respectively. I identified six floristically distinct clusters with affinities with the Red Spruce – Northern Hardwood Forest types. Four of these align with existing community types, with two being variants within the Herb Type. These are split based on apparent differences in soil fertility. Two of the Red Spruce – Northern Hardwood Forest type aligned clusters represent potential new community types. One of these describes potentially rare communities found in the Black Mountains of North Carolina, and is proposed tentatively due to this relative rarity. The other proposed new type seems to be a rich-soil variation of the Herb Type (CEGL006256) that is floristically distinct enough to merit recognition as a separate community.

The other two community associations within this alliance are the Red Spruce Forest (Protected Slope Type) (CEGL006152) and the Appalachian Red Spruce Boulderfield Forest (CEGL007128). Within the Red Spruce Forest (Protected Slope Type) (CEGL006152), I identified one floristically distinct group. This mapped fairly well onto the existing CEGL006152 group, but should be considered only a subset of this community, given the geographic limitation of this examination. Within the Appalachian Red Spruce Boulderfield Forest (CEGL007128), I identified only one floristically distinct group. The concept of this group resembles that of CEGL007128, but I propose changes to characteristic species.

Red Spruce - Northern Hardwood Forest (Shrub Type)
CEGL004983: *Picea rubens – Betula alleghaniensis / Rhododendron (maximum, catawbiense)* Forest Association

Concept. The Red Spruce - Northern Hardwood Forest (Shrub Type) (CEGL004983) is described by the NVC as being dominated by *Picea rubens* with the potential presence of codominant canopy species such as *Betula alleghaniensis, Fagus grandifolia,* and *Tsuga canadensis*. Also characteristic of the Shrub Type is a well-developed evergreen shrub layer dominated by *Rhododendron maximum* and/or *R. catawbiense.* This type is generally located on steep slopes within a zone of transition between spruce-fir and northern hardwood forests.

The Fourth Approximation refers to this community as the Birch Transition Shrub Subtype of Red Spruce - Fraser Fir Forest. I have decided to retain the NVC description's name (Shrub Type), because the name "Red Spruce-Northern Hardwood Forest" implies what is conveyed by calling it a "Birch Transition" and provides further differentiation from similar, birch co-dominated types. The Fourth Approximation describes this type as being created specifically for plant communities in the Great Smoky Mountains and as having only questionable distinction from the Red Spruce Forest (Protected Slope Type) (CEGL006152). This examination of the Shrub Type found it to be both distinct from the Protected Slope Type and outside this proposed narrow range.

Vegetation. This association has relatively low diversity plus an abundance of evergreen shrubs, particularly *Rhododendron maximum*. The NVC description of the Shrub Type includes *Aesculus flava* and *Rhododendron catawbiense* as characteristic species. I did not find an abundance of *A. flava* in the dataset and have removed it from consideration as a nominal species for this community (Table 7). Although *R. catawbiense* was not particularly abundant in this dataset, there is likely variation in the abundance of *Rhododendron* spp. within this type. Characteristic vascular species include *Rhododendron maximum, Betula alleghaniensis, Picea rubens, Tsuga canadensis, Acer pensylvanicum, Ilex montana, Polypodium appalachianum, Quercus rubra, Fagus grandifolia,* and *Rhododendron catawbiense.*

Environmental Setting. Approximate average elevation of this group is 1410 m (4625 feet), which falls within the lower end of the elevational range of 1400-1550 m (4600-5100 feet) described by the NVC for this type. Average slope aspect was found to be north-facing and soil organic matter was found to be relatively high (Appendix C). Average slope gradient was steep

(as compared with other groups), which is consistent with the NVC description of this type. Although Schafale described this type as being possibly limited to the Great Smoky Mountains, I found it to extend farther east into Pisgah National Forest. One plot of this type was located near Mount Rogers in southwestern Virginia. Occurrences of this community within Pisgah were identified near Grandfather Mountain, Cherry Log Ridge, Shining Rock, and East Fork.

Table 7. Constancy table of Red Spruce - Northern Hardwood Forest (Shrub Type) (CEGL004983) cluster

Group Code	**4983**	
Group Plot Count	7	
Group Avg Plot Spp Richness	20	
Group homoteneity	61%	
taxon name	**const.**	avg. cover
Abies fraseri	**43%**	2
Acer pensylvanicum	**86%**	2
Acer rubrum	**43%**	4
Acer spicatum	**43%**	5
Amelanchier [arborea + laevis]	**43%**	4
Arisaema triphyllum s.1	**43%**	2
Betula alleghaniensis	**100%**	8
Dryopteris campyloptera	**57%**	2
Dryopteris intermedia	**57%**	2
Fagus grandifolia	**43%**	4
Ilex montana	**71%**	2
Oclemena acuminata	**57%**	2
Picea rubens	**100%**	7
Polypodium appalachianum	**57%**	6
Quercus rubra	**57%**	4
Rhododendron catawbiense	**43%**	2
Rhododendron maximum	**100%**	8
Tsuga canadensis	**86%**	7
Viburnum lantanoides	**43%**	2

Red Spruce Forest (Protected Slope Type)
CEGL006152: *Picea rubens - Betula alleghaniensis - (Tsuga canadensis) / Rhododendron maximum* Forest Association

Concept. The Red Spruce Forest (Protected Slope Type) (CEGL006152) is described by the NVC as a closed-canopy forest characterized by dominance of *Picea rubens,* with *Tsuga canadensis* and hardwoods co-dominating, and a well-developed "ericad desert" shrub layer of *Rhododendron maximum*. The Fourth Approximation refers to this community as the Low Rhododendron Subtype and describes it as a narrow subset occurring at lower elevations on sheltered sites, particularly at Alarka Laurel and Long Hope Valley. I maintain the NVC description name (Protected Slope Type) and present this as a narrowly defined subset. The NVC description is based on examples from North Carolina, Tennessee, West Virginia, and possibly Virginia, while the group described here is based on plots located exclusively in North Carolina.

Vegetation. I found the Protected Slope Type to have an even lower species diversity than the Shrub Type (CEGL004983), with an average plot species richness of only 17 (Table 8). The NVC previously identified a *Picea rubens – Tsuga canadensis / Rhododendron maximum* Forest type (CEGL006272), which has since been lumped with the Protected Slope Type (CEGL006152). It appears that the primary distinguishing characteristic between these two is the degree of *T. canadensis* coverage, and I have maintained the merging of CEGL006272 with

CEGL006152. I found the characteristics of the NVC description of the Protected Slope Type to match fairly well with those of this cluster, with the exception of an abundance of *Betula alleghaniensis* (Table 8). I have included *B. alleghaniensis* as a nominal species in this description. Characteristic vascular species include *Betula alleghaniensis, Rhododendron maximum, Picea rubens, Tsuga canadensis, Polypodium appalachianum, Acer pensylvanicum, Acer rubrum,* and *Ilex montana.*

Environmental Setting. The average elevation of this group was found to be approximately 1335 m (4380 feet), which is within the 945 to 1524 m (3100-5000 feet) elevational range described by the NVC for this type. The NVC describes this community as typically occurring on flat slopes and consisting of soils with high levels of organic matter, both of which were consistent with this cluster (Appendix C). Plot locations include Alarka Laurel, Long Hope Valley, and Rich Mountain in Nantahala National Forest.

Table 8. Constancy table of Red Spruce Forest (Protected Slope Type) (CEGL006152) cluster

Group Code	**6152**	
Group Plot Count	4	
Group Avg Plot Spp Richness	17	
Group homoteneity	71%	
taxon name	**const.**	avg. cover
Acer rubrum	**100%**	1
Amelanchier [arborea + laevis]	**75%**	4
Arisaema triphyllum s.1	**50%**	1
Aronia melanocarpa	**50%**	3
Ilex montana	**75%**	2
Ilex verticillata	**50%**	5
Kalmia latifolia	**100%**	7
Listera smallii	**50%**	2
Oclemena acuminata	**50%**	1
Picea rubens	**100%**	8
Rhododendron maximum	**100%**	9
Sorbus americana	**50%**	2
Trillium undulatum	**75%**	1
Tsuga canadensis	**50%**	2
Vaccinium simulatum	**50%**	4
Viburnum cassinoides	**75%**	5

Red Spruce - Northern Hardwood Forest (Herb Type)
CEGL006256: *Picea rubens - Betula alleghaniensis – (Acer pensylvanicum) / Viburnum lantanoides / Oxalis montana* Forest Association

Concept. The NVC characterizes this community as being co-dominated by *Picea rubens* and deciduous species, with the potential for *Abies fraseri* at higher elevations. *A. fraseri* was found to be present in several examples of this type within the dataset, which is likely due to their relatively high elevations. An abundance of herbs, and generally high species diversity, is also characteristic of the Herb Type, which is consistent with the high average plot species richness and abundance of herbs that I found to be characteristic of this group (Table 9).

I identified three floristically distinct clusters within the Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256), one of which represents a classic form of the community and two of which represent a transitional variant phase. This phase seems to be a

lower elevation, hardwood transitional version of the Herb Type that I propose as a variant. I propose alteration to the nominal species to include *Acer pensylvanicum* rather than *Aesculus flava.* These alterations are based on the cluster considered to be classic.

Vegetation. Previous descriptions of this type include as characteristic species *Aesculus flava*, which had low coverage in this group, and *Solidago glomerata*, which was absent. *Solidago curtisii* was present in two of the clusters, although not abundant. As compared to the NVC's description of this community, the transitional phase has less *Oxalis montana*, but more *Quercus rubra, Acer rubrum,* and *Ilex montana*. These differences in species composition seem to indicate that it is a hardwood transitional phase that maintains dominant coverage of *Picea rubens*. Although *Tsuga canadensis* and *Rhododendron maximum*, both characteristic of the Protected Slope Type (CEGL006152), were present in this group, the abundance of hardwood species did not seem to fit the description of that community. Vascular species characteristic of the classic phase include *Picea rubens, Betula alleghaniensis, Acer pensylvanicum, Acer spicatum, Fagus grandifolia, Maianthemum canadense, Oclemena acuminata, Viburnum lantanoides, Oxalis montana, Huperzia lucidula,* and *Dryopteris intermedia.* Vascular species that distinguish the transitional phase include *Quercus rubra, Carex pensylvanica, Acer rubrum, Acer saccharum, Tsuga canadensis, Rhododendron maximum, Ilex montana,* and *Solidago curtisii.*

Environmental Setting. The NVC describes the elevational range of the Herb Type as being 1400 to 1555 m (4600-5100 feet), but I propose extending this range, given that the elevational range of plots in the classic phase was 1372 to 1727 m (4501-5666 feet). It is possible that I have captured the uncharacteristically high end of this community's elevational gradient, and thus this description may have limited application to lower-elevation Herb Type communities. The average elevation of the transitional phase was approximately 1400 m (4595 feet), which coincides with the minimum elevation in this community's elevational range as described by the NVC. This likely explains the group's hardwood transitional characteristics.

Plot locations of the classic phase include various locations in Pisgah National Forest, particularly Brush Fence Ridge, Point Misery, Grandfather Mountain, Bald Knob, and Pinnacle Springs. The classic cluster also includes several plots near Mount Rogers. Plot locations of the transitional phase include Grandfather Mountain, Shining Rock, Pinnacle Springs, Bald Knob, and Long Hope Valley. There is geographic overlap between the classic and variant clusters, and it appears that they are sorting by elevation.

Table 9. Constancy table of Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256) clusters

Group Code	**6256-classic**		**6256A-variant**		**6256C-variant**	
Group Plot Count	9		6		2	
Group Avg Plot Spp Richness	33		42		27	
Group homoteneity	70%		68%		78%	
taxon name	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri	**44%**	6	**67%**	3		
Acer pensylvanicum	**100%**	6	**100%**	5	**100%**	2
Acer rubrum	**22%**	3	**100%**	6	**100%**	5
Acer saccharum	**44%**	2	**67%**	5	**100%**	4
Acer spicatum	**100%**	5	**33%**	2		
Aesculus flava	**44%**	2	**67%**	2	**100%**	2
Ageratina altissima	**56%**	2	**50%**	2	**100%**	4
Amelanchier [arborea + laevis]	**33%**	3	**100%**	4	**50%**	2

Amianthium muscitoxicum			**50%**	2		
Angelica triquinata	**44%**	2				
Arisaema triphyllum s.1	**67%**	2	**67%**	2	**50%**	2
Athyrium asplenioides	**56%**	5	**50%**	2	**50%**	1
Betula alleghaniensis	**100%**	7	**100%**	7	**100%**	6
Betula lenta			**50%**	4	**100%**	7
Carex aestivalis			**17%**	1	**50%**	2
Carex pensylvanica	**67%**	6	**67%**	7	**100%**	7
Clintonia borealis	**56%**	6	**67%**	6		
Collinsonia canadensis						
Conopholis americana					**50%**	1
Cornus alternifolia	**33%**	2	**50%**	2		
Dennstaedtia punctilobula	**11%**	4	**83%**	5	**50%**	5
Dioscorea villosa			**33%**	2	**50%**	1
Dryopteris campyloptera	**89%**	4	**33%**	5		
Dryopteris intermedia	**89%**	6	**50%**	3	**50%**	1
Epifagus virginiana	**22%**	1	**17%**	1	**50%**	2
Eurybia chlorolepis			**33%**	2	**50%**	1
Eurybia divaricata	**56%**	4	**33%**	2		
Fagus grandifolia	**100%**	5	**50%**	7	**100%**	6
Goodyera pubescens					**50%**	1
Hamamelis virginiana			**83%**	3		
Huperzia lucidula	**89%**	6	**67%**	5		
Ilex montana	**56%**	4	**83%**	6	**50%**	1
Isotrema macrophyllum					**50%**	1
Luzula acuminata	**22%**	1	**17%**	1	**50%**	1
Maianthemum canadense	**100%**	4	**100%**	4		
Maianthemum racemosum	**22%**	1	**50%**	2		
Medeola virginiana	**56%**	2	**33%**	2		
Monotropa uniflora					**100%**	2
Nabalus	**33%**	2	**67%**	2		
Oclemena acuminata	**100%**	4	**100%**	3	**100%**	2
Osmundastrum cinnamomeum	**11%**	2	**50%**	2		
Oxalis montana	**89%**	7				
Parathelypteris noveboracensis	**56%**	2	**50%**	2	**50%**	1
Picea rubens	**100%**	8	**100%**	7	**100%**	8
Polypodium appalachianum	**78%**	3	**33%**	3		
Prunus pensylvanica	**11%**	2	**33%**	5	**50%**	2
Prunus serotina	**33%**	5	**83%**	4	**50%**	1
Quercus rubra			**100%**	6	**100%**	6
Rhododendron catawbiense	**22%**	4	**33%**	6		
Rhododendron maximum	**11%**	2	**33%**	5	**50%**	2
Robinia pseudoacacia					**50%**	3
Rubus allegheniensis	**11%**	1			**50%**	2
Rubus canadensis	**67%**	5	**67%**	3		
Smilax [herbacea + pulverulenta]	**33%**	1	**50%**	2		
Smilax rotundifolia			**17%**	2	**50%**	1
Solidago curtisii			**50%**	2	**100%**	2
Sorbus americana	**78%**	3	**83%**	2		
Streptopus lanceolatus	**44%**	2	**33%**	2		
Trillium erectum	**33%**	1	**50%**	2		
Tsuga canadensis	**56%**	3	**83%**	3	**100%**	7
Vaccinium erythrocarpum	**56%**	6	**33%**	2		
Veratrum parviflorum	**22%**	1	**83%**	2		
Viburnum lantanoides	**89%**	6	**67%**	3		
Viola [blanda + incognita]			**33%**	2	**50%**	2
Viola pallens	**44%**	3	**17%**	1		
Viola rotundifolia	**22%**	1	**17%**	1	**50%**	2

Red Spruce - Mountain Paper Birch Forest
CEGL006256B: *Picea rubens - Betula alleghaniensis – Betula cordifolia / Oclemena acuminata* Forest Association

Concept. This group was rare within the dataset, consisting of only two plots, and therefore this description has low confidence regarding the community as whole. However, the group is

floristically distinct from the others described here. Although aligned with the Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL06256), it is perhaps a rare phase worthy of distinction. I tentatively propose this type, although further data will be required to increase confidence. However, this may not be available if it truly is a rare community. Characteristic of this group are a high average elevation and a unique set of species that indicate its distinction from existing communities. The two plots reported here are found only near Mount Mitchell.

Vegetation. Relative to the Red Spruce - Northern Hardwood Forest (Herb Type) group, this group had a lower average plot species richness. Unique to this group was a codominance of *Betula cordifolia* and *B. alleghaniensis* (Table 10). *B. cordifolia* is a rare, disjunct species with a range extending into New England and possibly Canada. Relictual subpopulations are found near the Black Mountain range and Mount Mitchell (Shaw et al. 2014). Since *B. cordifolia* is considered a diagnostic species in this description and is limited in range in this region, it is likely that this type is limited to the Black Mountain range. The group described here captures these southern Appalachian relicts. Additionally, this group is unique in its coverage of *Castanea dentata*. Abundance of *Prunus pensylvanica* may indicate that this is an area of primary succession, perhaps post landslide or other disturbance. Characteristic vascular species include *Picea rubens, Betula alleghaniensis, Oclemena acuminata, Castanea dentata, Betula cordifolia, Carex intumescens, Dennstaedtia punctilobula, Prunus pensylvanica,* and *Sorbus americana.*

Environmental Setting. Characteristic of this group is a relatively high average elevation, 1775 m (5820 feet), which falls well outside the 1400 to 1555 m (4600-5100 feet) elevational range of the NVC's description of the Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256), with which it has affinities. Average slope aspect is north-facing and average slope gradient is relatively low (Appendix C). Plot locations are limited to Commissary Ridge, immediately east of Mount Mitchell along the massif. This area experienced extensive disturbance due to logging in the 1910s, and also is near plantings of various native and non-native tree species in an attempt to reforest the area after slash fires. Further investigation is needed to determine if the vegetation is natural or results solely from these disturbances.

Table 10. Constancy table of Red Spruce – Mountain Paper Birch Forest (CEGL006256B) cluster

Group Code	**6256B**	
Group Plot Count	2	
Group Avg Plot Spp Richness	26	
Group homoteneity	94%	
taxon name	**const.**	avg. cover
Abies fraseri	**100%**	3
Acer spicatum	**100%**	3
Ageratina altissima	**100%**	1
Angelica triquinata	**50%**	4
Arisaema triphyllum s.1	**100%**	1
Betula alleghaniensis	**100%**	8
Betula cordifolia	**100%**	6
Carex gynandra	**100%**	1
Carex intumescens	**100%**	6
Carex pensylvanica	**50%**	6
Castanea dentata	**100%**	7
Cinna latifolia	**100%**	1
Dennstaedtia punctilobula	**100%**	6
Houstonia serpyllifolia	**100%**	1
Hydatica petiolaris	**100%**	1
Hypericum graveolens	**50%**	4
Oclemena acuminata	**100%**	7

Oxalis montana	**100%**	2
Picea rubens	**100%**	8
Prunus pensylvanica	**100%**	6
Rhododendron catawbiense	**100%**	2
Rubus canadensis	**100%**	1
Solidago glomerata	**100%**	2
Sorbus americana	**100%**	6
Viola pallens	**100%**	3

Red Spruce - Northern Hardwood Forest (Rich Soil Transitional Type)
CEGLXXX1: *Picea rubens - Betula alleghaniensis – (Quercus rubra) - Aesculus flava / Ageratina altissima* Forest Association

Concept. Although this group has affinities with the Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256), it is floristically distinct. It seems to resemble a more transitional hardwood phase of CEGL006256, but is distinguished by a greater abundance of herbs, indicating high fertility and rich soil. I propose the recognition of this group as a distinct association that resembles the Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256) but is distinct.

Vegetation. This group is characterized by an abundance of herbs, particularly *Ageratina altissima* and *Eurybia chlorolepis*. *Betula allegheniensis, Picea rubens* and *Aesculus flava* are dominant in the canopy, with *Acer pensylvanicum* and *Abies fraseri* also present (Table 11). Characteristic species include *Betula alleghaniensis, Picea rubens, Aesculus flava, Ageratina altissima, Eurybia chlorolepis, Acer pensylvanicum, Abies fraseri, Quercus rubra, Arisaema triphyllum, Athyrium asplenioides, Carex pensylvanica, Carex aestivalis, Carex flexuosa, Houstonia serpyllifolia, Tiarella cordifolia,* and *Viola* sp. Species suggestive of richer soils include *Laportea canadensis*, *Actaea racemosa*, *Rudbeckia laciniata, Brachyelytrum erectum*, and *Thalictrum clavatum*.

Environmental Setting. The elevational range of this group is 1370 to 16420 m (4495-5387 feet), which is outside the 1400 to 1555 m (4600-5100 feet) range of the NVC description of Red Spruce - Northern Hardwood Forest (Herb Type) (CEGL006256), with which this group has affinities. Relative to other groups the soil calcium and manganese levels appear to be high, as well as average base saturation (Appendix C). This group is described from plots near Shining Rock in Pisgah National Forest, and seems to cluster based on geographic location.

Table 11. Constancy table of Red Spruce - Northern Hardwood Forest (Rich Soil Transitional Type) (CEGL00XXX1) clusters

Group Code	**XXX1**	
Group Plot Count	4	
Group Avg Plot Spp Richness	56	
Group homoteneity	69%	
taxon name	**const.**	avg. cover
Abies fraseri	**100%**	3
Acer pensylvanicum	**100%**	4
Acer rubrum	**25%**	7
Acer saccharum	**75%**	5
Acer spicatum	**50%**	4
Actaea pachypoda	**50%**	2
Aesculus flava	**100%**	6
Ageratina altissima	**100%**	6
Agrostis perennans	**75%**	2

Angelica triquinata	**75%**	2
Arisaema triphyllum s.1	**100%**	2
Athyrium asplenioides	**100%**	2
Avenella flexuosa	**50%**	2
Betula alleghaniensis	**100%**	8
Brachyelytrum [aristosum + erectum]	**50%**	2
Carex aestivalis	**100%**	2
Carex flexuosa	**100%**	2
Carex pensylvanica	**75%**	6
Carex ruthii	**50%**	4
Chelone glabra	**50%**	2
Circaea alpina	**75%**	2
Cuscuta	**50%**	1
Danthonia compressa	**50%**	2
Dennstaedtia punctilobula	**75%**	2
Eurybia chlorolepis	**100%**	5
Eutrochium purpureum	**75%**	2
Fagus grandifolia	**50%**	6
Galium triflorum	**75%**	2
Halesia tetraptera	**25%**	4
Houstonia serpyllifolia	**100%**	2
Impatiens [capensis + pallida]	**50%**	2
Laportea canadensis	**75%**	6
Luzula acuminata	**50%**	2
Maianthemum racemosum	**50%**	1
Medeola virginiana	**50%**	2
Nabalus	**75%**	2
Oclemena acuminata	**75%**	4
Oxalis montana	**50%**	2
Parathelypteris noveboracensis	**25%**	5
Picea rubens	**100%**	6
Pieris floribunda	**50%**	1
Polystichum acrostichoides	**75%**	2
Quercus rubra	**75%**	6
Rhododendron catawbiense	**25%**	6
Rhododendron maximum	**50%**	4
Rubus canadensis	**50%**	2
Rudbeckia laciniata	**25%**	4
Smilax [herbacea + pulverulenta]	**50%**	1
Solidago curtisii	**50%**	2
Stachys latidens	**50%**	2
Thalictrum clavatum	**75%**	2
Tiarella cordifolia	**75%**	5
Trillium erectum	**75%**	2
Tsuga canadensis	**75%**	3
Viola [blanda + incognita]	**100%**	2
Viola rotundifolia	**75%**	2

Appalachian Red Spruce Boulderfield Forest
CEGL007128: *Picea rubens – Betula alleghaniensis - (Abies fraseri) / (Ribes rotundifolium) – Polypodium appalachianum* Forest Association

Concept. This community type is characteristic of southern Appalachian boulderfields, largely formed by freeze-thaw cycles during periods of glaciation further north. Although this group resembles the NVC description of an Appalachian Red Spruce Boulderfield Forest (CEGL007128), I propose alteration in the characteristic species. The NVC describes this type as being transitional to the Southern Appalachian Boulderfield Forest (Currant and Rockcap Fern Type) (CEGL006124), which is characterized by a dominance of *Betula alleganhiensis.* I do not consider this group to be a transitional phase due to prevalence of *Picea rubens* (Table 12). The Fourth Approximation describes this to be the rarest of the spruce-fir forest types, found only in a well-developed form on Grandfather Mountain. The alterations to nominal species proposed

here may reflect the fact that past descriptions of this community have been based on data from a more narrow geographic range.

Vegetation. Although the NVC's previous description of the Appalachian Red Spruce Boulderfield Forest does not include *Abies fraseri, Betula alleghaniensis*, or *Polypodium appalachianum* as nominals, I found these species to be characteristic of this group (Table 12). The NVC does include *Betula alleghaniensis* and *Polypodium appalachianum* as characteristic of the *Betula alleghaniensis / Ribes glandulosum / Polypodium appalachinum* Forest (CEGL006124), a lower elevation boulderfield type. However, this group is present at a relatively high elevation and does not likely represent a transition between the two. Additionally, the abundance of *Picea rubens* distinguishes this group from the lower elevation boulderfield type.

Although listed by the NVC and Schafale as a nominal species, *Ribes glandulosum* was not present in this group. Because *Ribes* is a genus often characteristic of boulderfields in the southern Appalachians, I have replaced it with *Ribes rotundifolium,* which was found to be present but not abundant in this group. However, absence of *R. glandulosum* may be due to geographic factors. Average plot species richness was relatively low for this group (Table 12). Characteristic vascular species include *Betula alleghaniensis, Picea rubens, Polypodium appalachianum, Abies fraseri, Acer spicatum, Eurybia chlorolepis, Viburnum lantanoides, Vaccinium erythrocarpum, Oxalis montana, Dryopteris intermedia,* and *Ribes rotundifolium.*

Environmental Setting. Average elevation of this group was approximately 1632 m (5354 feet), so it likely represents a high-elevation boulderfield community. In contrast to the Fourth Approximation description, I found what is considered in this examination to be a well-developed example of this type outside the Grandfather Mountain area. This group contains plots located in near Grandfather Mountain and Roan Mountain in Pisgah National Forest, as well as near Mount Collins in Great Smoky Mountains National Park.

Table 12. Constancy table of Appalachian Red Spruce Boulderfield Forest (CEGL007128) cluster

Group Name	**7128**	
Group Plot Count	4	
Group Avg Plot Spp Richness	45	
Group homoteneity	74%	
taxon name	**const.**	avg. cover
Abies fraseri	**100%**	6
Acer spicatum	**100%**	6
Ageratina altissima	**75%**	3
Amelanchier [arborea + laevis]	**50%**	4
Arisaema triphyllum s.1	**100%**	2
Athyrium asplenioides	**100%**	3
Betula alleghaniensis	**100%**	8
Brachyelytrum [aristosum + erectum]	**50%**	1
Cardamine [clematitis + flagellifera]	**75%**	2
Carex aestivalis	**50%**	1
Carex appalachica	**75%**	2
Carex intumescens	**50%**	2
Carex leptonervia	**50%**	2
Carex pensylvanica	**50%**	4
Chelone lyonii	**50%**	2
Cinna latifolia	**100%**	2
Circaea alpina	**50%**	2
Clintonia borealis	**75%**	4
Cornus alternifolia	**50%**	3

Dryopteris campyloptera	**50%**	4
Dryopteris intermedia	**100%**	4
Eurybia chlorolepis	**100%**	5
Eutrochium purpureum	**50%**	3
Fagus grandifolia	**50%**	5
Galium triflorum	**50%**	1
Houstonia serpyllifolia	**50%**	2
Huperzia lucidula	**100%**	3
Hydrangea arborescens	**50%**	3
Luzula echinata	**75%**	2
Micranthes micranthidifolia	**50%**	2
Oclemena acuminata	**100%**	2
Oxalis montana	**100%**	4
Picea rubens	**100%**	7
Polygonatum pubescens	**50%**	1
Polypodium appalachianum	**100%**	6
Polystichum acrostichoides	**50%**	2
Prunus pensylvanica	**50%**	3
Prunus serotina	**50%**	3
Ribes rotundifolium	**50%**	2
Rubus canadensis	**75%**	4
Sambucus racemosa	**100%**	2
Smilax [herbacea + pulverulenta]	**75%**	2
Sorbus americana	**100%**	2
Streptopus lanceolatus	**100%**	2
Tiarella cordifolia	**50%**	2
Vaccinium erythrocarpum	**100%**	4
Viburnum lantanoides	**100%**	5
Viola cucullata	**50%**	1

Undescribed Types

There were several clusters within the original dataset that were not included in the above descriptions, either because they were outliers or because they represented types that I did not intend to evaluate in this examination of communities. The three broad characterizations of the communities I chose to remove are shrublands, swamp forests, and hardwood forests. Many of these groups included *Picea rubens* as a moderately abundant species, and one of them included *Abies fraseri.* However, they possess characteristic features that set them apart from the Central & Southern Appalachian Red Spruce - Fir - Hardwood Forest Group (G632). In the case of shrublands, dominance of *Rhododendron maximum* or *R. catawbiense* is a distinguishing feature. Hardwood forests that are not transitional to spruce are distinguished by a dominance of deciduous species such as *Fagus grandifolia, Quercus rubra,* or *Liriodendron tulipifera* as opposed to *Picea rubens* or *Abies fraseri* (Appendices D and E). While swamp forests may be characterized by dominance of *P. rubens*, the unique environmental conditions of these communities set them apart from other spruce forests in terms of species composition, and as a consequence they were placed in different Groups in the NVC.

Ordinations

Based on an NMS ordination of species cover class values and environmental variables for each plot, the variables elevation, latitude, and longitude are drivers of species composition in this dataset. Elevation, the strongest of these drivers, is positioned along axis 1, while latitude and longitude are positioned along axis 3. Groups delineated by color represent clusters created during agglomerative hierarchical clustering analyses, and appear to be sorting in space in accordance with these axes (Fig. 1).

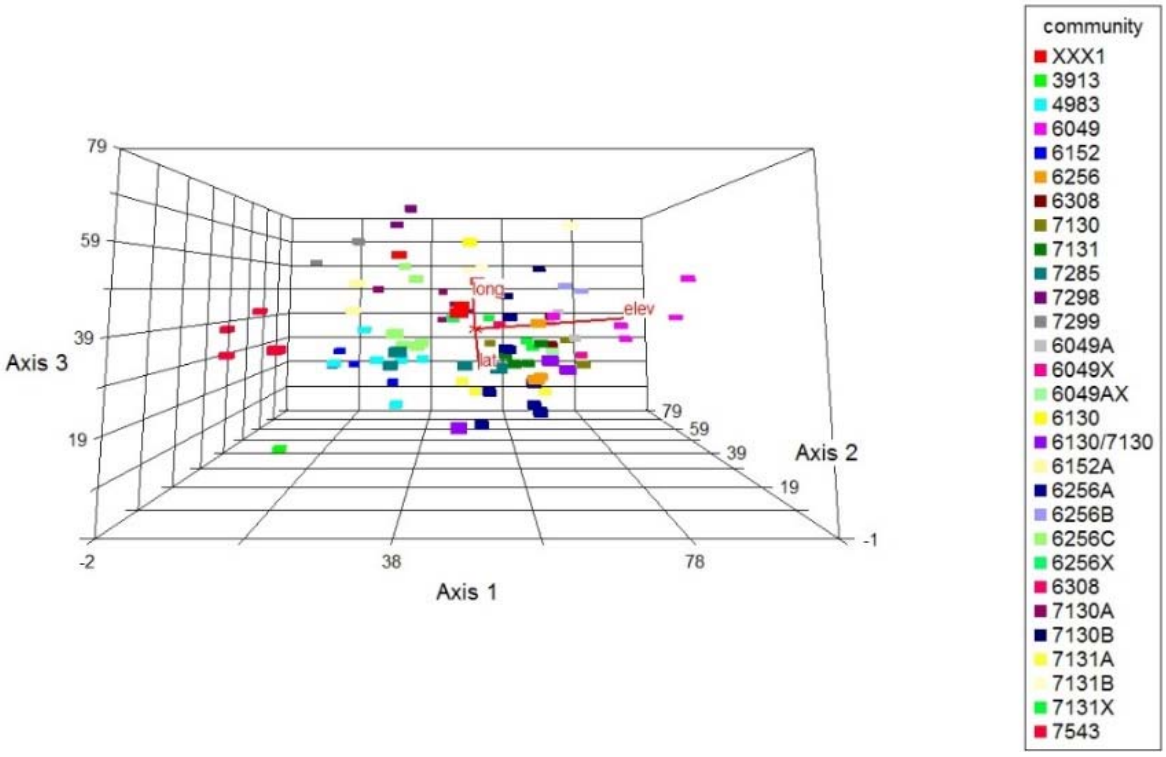

Fig. 1 NMS ordination of cover class and environment for full dataset

An NMS ordination of only plots within community groups that I chose to describe is shown below. Elevation, latitude, and longitude are no longer apparent drivers of species composition. Based on these analyses, the other environmental parameters analyzed in this ordination, which include slope, aspect, soil *p*H, exchange capacity, and incident solar radiation, are not determinants of species cover class in this dataset. However, community groups appear to be sorting in space, particularly along axis 3 (Fig. 2).

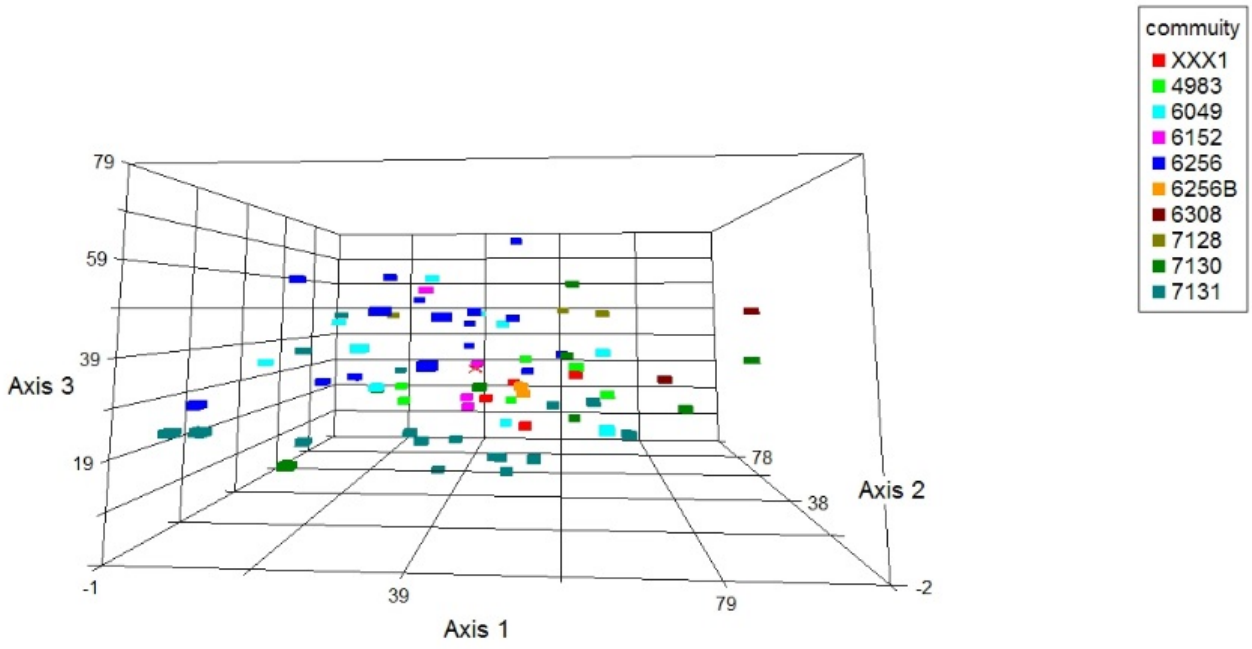

Fig. 2 NMS ordination of cover class and environment for described types

Based on these analyses, elevation and geographic position are drivers of species composition at larger scales, but become less influential at a more narrow scope of examination. Included below is a scatterplot showing plots (only those from types described in this examination) along axes of elevation and latitude (Fig. 3).

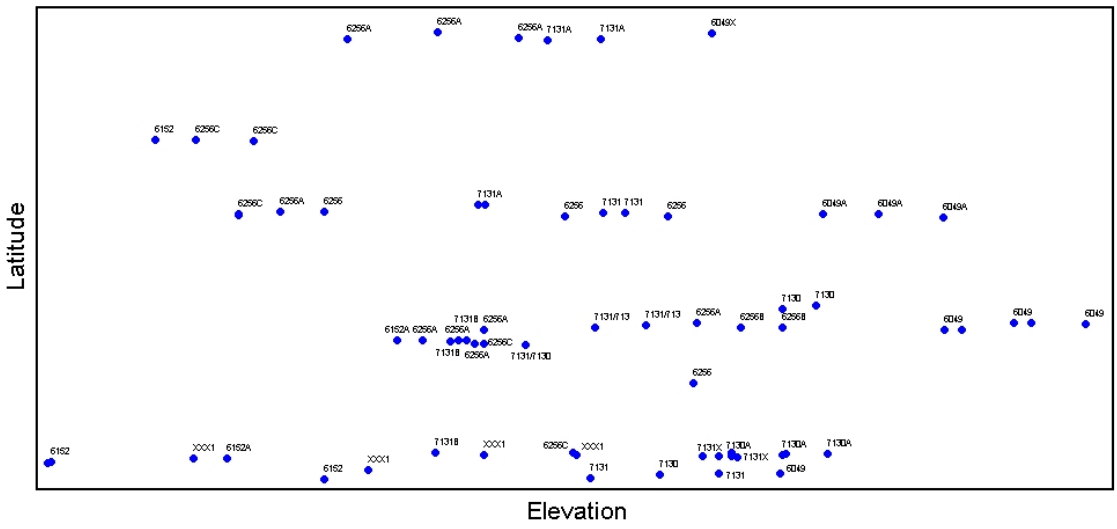

Fig. 3 Scatterplot of plots included in described types along axes of elevation (m) and latitude (degrees). Plots are labeled by dendrogram cluster (Appendix E)

Discussion

There are several trends apparent in proposed alterations to the NVC and Fourth Approximation. Of the proposed community name changes, all involve changing a type referred to as a "Deciduous Shrub Type" to an "Herb Type", often in agreement with the Fourth Approximation. Although examples of these typically include an abundance of deciduous shrubs relative to evergreen shrubs, I found herb coverage to be a more diagnostic characteristic. While referring to deciduous shrub coverage is useful in differentiating a type from a similar but more evergreen type, the name of a community should provide a description of the type itself rather than a comparison with another type.

Trends in proposals for nominal species alterations include the removal of *Vaccinium erythrocarpum* and *Viburnum lantanoides.* This likely contributed to the name changes discussed above, as these are both deciduous shrub species. In examples of proposed removal of these, I replaced them with species that were found to be characteristically abundant in this dataset, often the herb species *Athyrium asplenioides* or *Oxalis montana.* In several of the communities described in this examination, I proposed the inclusion of *Betula alleghaniensis* as a nominal species due to its abundant coverage. A trend within this dataset seemed to be a higher coverage of *B. alleghaniensis* than included in previous descriptions. It is possible that qualitative descriptions of a community fail to capture the prevalence of a species such as *B. alleghaniensis* to the same degree that quantitative analyses do.

Many of the community descriptions presented here were limited by group size. Geographically constraining the dataset in order to avoid compositional differences based on geographic separation further limited the dataset. This represents a fundamental trade-off in community classification between examination at a fine scope and failure to capture the extent of a community. Descriptions of groups that are only narrow subsets of larger types have low confidence due to the potential influence of site-specific factors or chance on species composition. These descriptions are useful in their contribution to the body of knowledge regarding a type, but must interpreted in the context of their limitations. The issue of limited plot representation was also pertinent in proposals of new, potentially rare types, particularly the Red Spruce – Mountain Paper Birch Forest (CEGL006256B). The question of how to treat these potentially rare types leads to a dilemma that is central to community classification itself. A type cannot be described with high confidence and detail if there are very few occurrences of it. However, this could prevent rare communities from being described, which may have repercussions in the conservation and management of these areas.

Within many of the types I have described, I include phases that indicate the potential range of variation within that type. Although these variant phases were distinct enough to sort out from the classic phase during cluster analyses, I do not consider them to be distinct enough to be split at the association level. Plant communities generally exist as gradients rather than clearly defined units. Dividing a gradient into units is inherently difficult, which can produce subjective decisions in the classification process.

Despite the potential for subjectivity in community classification, there are two potential methods of minimizing this: quantitative examination and iterative classification. The first of

these involves the use of quantitative methods of analysis as corroboration of qualitative descriptions. This examination of communities seeks to utilize this method by combining quantitative analyses with qualitative description. The second of these methods is exemplified by the process of dynamic classification. Although I have proposed alterations, the existing classification system has proved to be a useful framework for examining communities. Both the NVC and the Fourth Approximation provided a context under which this dataset could be interpreted and the classification system built upon. Synthesis of existing concepts with additional data and analyses is at the core of the NVC's dynamic standard of classification. As more information is gained, our understanding of how communities relate to one another may change, along with the communities themselves. Classification must be able to accurately represent this. An understanding of current distributions and characteristics is necessary in order to document potential changes in these.

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Appendices

Appendix A: Environmental parameters of the Southern Appalachian Spruce-Fir Forest Alliance (A0136) and the Central Appalachian Red Spruce Forest Alliance (A0138)

field	soil horizon	A0136	A0138
elevation		1754.838	1502.526
slopeAspect_avg		94.77916	94.39394
slopeGradient_avg		14.18268	15.31579
baseSaturation_avg	A	22.15267	23.74242
baseSaturation_avg	B	30.45333	39.68
Ca_ppm_avg	A	250.3965	306.7745
Ca_ppm_avg	B	140.2667	215.1
Density_avg	A	0.740167	0.658977
Density_avg	B	0.953333	0.8
K_ppm_avg	A	85.73657	86.13292
K_ppm_avg	B	30.93333	38.6
Mg_ppm_avg	A	57.97828	68.92938
Mg_ppm_avg	B	30.66667	46.3
Mn_ppm_avg	A	14.21687	25.51177
Mn_ppm_avg	B	5.066667	24.44444
Na_ppm_avg	A	19.38667	17.51894
Na_ppm_avg	B	18.33333	16.9
exchangeCapacity_avg	A	10.5046	11.32065
exchangeCapacity_avg	B	3.892667	4.216
soilClay_avg	A	5.584167	9.065
soilClay_avg	B	6.158462	11.41625
soilOrganic_avg	A	41.8706	37.82595
soilOrganic_avg	B	10.914	16.17
soilPH_avg	A	3.662879	3.759375
soilSand_avg	A	50.59292	64.90682
soilSand_avg	B	65.50385	59.1175
soilSilt_avg	A	43.82292	26.02909
soilSilt_avg	B	28.33769	29.46625

Appendix B: Environmental parameters of Southern Appalachian Spruce-Fir Forest Alliance (A0136) as compared by cluster

field	soil horizon	6049-classic	6049A-variant	6049X-variant	6308	7130-classic	7130A-variant	7131-classic	7131A-classic (no Abies)	7131B-variant (low elev)	7131X-variant (herb)	7131-variant (7130 trans)
elevation (m)		1920.5	1858.3	1738	1769.5	1780.4	1767	1683	1607.3	1552.7	1743.3	1767.3
slopeAspect_avg		125.8	30.667	60	137.5	125.6	72.667	152.25	67.5	80.333	47.333	72.333
slopeGradient_avg		7.2098	16.167	10	16.5	22.4	13	10.5	13.5	6.3333	23	18.333
baseSaturation_avg	A	23.2	20.3		21.55	19.42	15.9	35.2	20.95	15.867	17.467	20.883
baseSaturation_avg	B	30	27.267		25.6		24.4	37.333	31.1		28.8	34.4
Ca_ppm_avg	A	122.18	275.25		303.88	326.25	206.63	313	117.13	299.34	353.5	174.25
Ca_ppm_avg	B	93	162.33		116		137	133.33	115.5		116.67	290
Density_avg	A	0.54	1.01		0.95	0.504	0.42	0.81	0.7638	2.1367	0.3333	0.73
Density_avg	B	0.96	0.96		1.12		0.6	1.1333	1.11		0.72	0.96
K_ppm_avg	A	82.434	89.5		90.25	94.85	113.67	73.188	59.75	77.872	101.33	67.667
K_ppm_avg	B	16	42.333		30		30	24	37		32	19
Mg_ppm_avg	A	35.754	59.5		67.125	74	50.383	63.938	27.5	59.121	78.667	58.833
Mg_ppm_avg	B	24	36		26		30	30.667	17		37.667	33
Mn_ppm_avg	A	5.07	4		3.625	5.1	5.4733	70.813	2.375	13.462	9.3333	8.75
Mn_ppm_avg	B	1	3.6667		1		2	5	4.5		11	4
Na_ppm_avg	A	19.75	18.333		11	15.7	20.25	19.563	45	15.667	18.833	16.25
Na_ppm_avg	B	18	11.667		10		24	13.667	44.5		13	19
exchangeCapacity avg	A	8.4155	10.968		10.949	13.611	11.119	7.4381	5.6288	12.642	15.375	7.7675
exchangeCapacity avg	B	2.61	5.2267		3.58		4.57	2.7933	3.48		3.7367	5.4
soilClay_avg	A	0	7.1867		7.78	4.496	5.56	3.14	7.79	18.2	3.7	5.04
soilClay_avg	B	0	9.14		6.28		1.56	4.64	14.53		5.2	0
soilOrganic_avg	A	25.5	38.375		37.013	69.33	46.55	28.194	12.308	12.3	63.267	33.142
soilOrganic_avg	B	5	15.7		9.6		16.2	9.7333	2.955		15.1	5.4
soilPH_avg	A	3.84	3.5583		3.6625	3.485	3.5333	4.3313	3.6125	3.4333	3.3333	3.6
soilSand_avg	A	90.8	52.467		31.25	7.52	76	74.175	68.215	24	75.6	60.533
soilSand_avg	B	90.6	38.9		65.8		74.3	71.5	68.625		59.133	85.4
soilSilt_avg	A	9.2	40.347		60.97	87.984	18.44	22.685	23.995	57.8	20.7	34.427
soilSilt_avg	B	9.4	51.96		27.92		24.14	23.86	16.845		35.667	14.6

Appendix C: Environmental parameters of Central Appalachian Red Spruce Forest Alliance (A0138) as compared by cluster

field	soil horizon	4983	6152	6256-classic	6256-variant	6256-variant	6256B	XXX1	7128
elevation (m)		1409.3	1335.5	1557.7	1467.3	1454.5	1773	1520.5	1632.3
slopeAspect_avg		89.857	60	120.75	121	38	40	106	51.333
slopeGradient_avg		23.143	1.75	9.4444	14.667	17.5	4	19	30.25
baseSaturation_avg	A	19.95	23.358		19.57	21.4		32.163	25.3
baseSaturation_avg	B		49.05		31.733			34.4	35.5
Ca_ppm_avg	A	365.71	302.02	240.26	280.58	356.68	90.4	238.5	511.81
Ca_ppm_avg	B		236.25		210.67			138	218
Density_avg	A	0.6042	0.424		0.605	0.68		0.7775	0.8925
Density_avg	B		0.7125		0.7967			0.72	1.02
K_ppm_avg	A	98.953	75.375	97.75	82.948	72.225	68.425	74.75	98.313
K_ppm_avg	B		34		36.667			40	50
Mg_ppm_avg	A	81.215	105.46	49.756	56.655	43.92	30.89	65.563	94.313
Mg_ppm_avg	B		54		35			40	51
Mn_ppm_avg	A	15.579	5.75	10.368	38.917	37.225	8.72	46.313	38.25
Mn_ppm_avg	B		31		20.333			25	20.5
Na_ppm_avg	A	19.563	33.667		11.3	11.25		12.313	13.875
Na_ppm_avg	B		23.75		11			16	12.5
exchangeCapacity_avg	A	14.84	11.76	10.9	11.523	11.32	7.7	6.4494	13.386
exchangeCapacity_avg	B		3.52		5.02			3.5	4.76
soilClay_avg	A	4.14	11.848		6.32	10.92		5.855	17.385
soilClay_avg	B		6.4567		16.8				10.78
soilOrganic_avg	A	43.875	63.317		32.327	33.225		18.188	33.949
soilOrganic_avg	B		22.635		9.62			9.9	16.2
soilPH_avg	A	3.5033	3.7021	3.72	3.5125	3.775	4.05	4.2813	3.8813
soilSand_avg	A	77.65	71.73		62.28	79.6		68.95	40.908
soilSand_avg	B		68.247		56.7				49.05
soilSilt_avg	A	18.21	16.423		31.4	9.48		25.2	41.708
soilSilt_avg	B		25.297		26.5				40.17

Appendix D1: Constancy table of undescribed types (part 1)

Group Code	**3913**		**6130**		**6277**		**7285**	
Group Plot Count	4		1		5		4	
Group Avg Plot Spp Richness	42		38		37		34	
Group homoteneity	72%		100%		72%		71%	
taxon name	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover
Abies fraseri			**100%**	4			**25%**	2
Acer rubrum	**100%**	4			**100%**	7	**75%**	4
Acer saccharum							**100%**	6
Acer spicatum			**100%**	1			**50%**	4
Ageratina altissima			**100%**	4			**100%**	3
Agrostis perennans							**50%**	2
Alnus serrulata					**80%**	6		
Amelanchier [arborea + laevis]	**25%**	2	**100%**	1	**80%**	3		
Anemone quinquefolia			**100%**	2	**20%**	1		
Arisaema triphyllum s.1			**100%**	2	**80%**	2	**50%**	2
Aronia melanocarpa	**25%**	2			**80%**	4		
Aronia prunifolia	**50%**	2			**20%**	2		
Athyrium asplenioides			**100%**	2	**20%**	2	**25%**	2
Avenella flexuosa			**100%**	2				
Betula alleghaniensis	**50%**	5	**100%**	1			**100%**	7
Betula lenta	**25%**	5			**60%**	6		
Brachyelytrum [aristosum + erectum]			**100%**	2				
Carex aestivalis							**75%**	2
Carex appalachica			**100%**	1				
Carex austrolucorum							**100%**	4
Carex digitalis							**50%**	2
Carex echinata	**100%**	6						
Carex flexuosa			**100%**	1			**100%**	2
Carex gynandra	**25%**	5						
Carex leptalea	**100%**	4			**60%**	5		
Carex pensylvanica			**100%**	8				
Carex trisperma	**50%**	2			**40%**	2		
Chelone lyonii	**25%**	2			**40%**	2		
Clethra acuminata					**40%**	5		
Crataegus macrosperma			**100%**	3				
Dennstaedtia punctilobula							**75%**	3
Dioscorea villosa			**100%**	1				
Drosera rotundifolia	**75%**	2						
Dryopteris campyloptera			**100%**	1			**25%**	3
Dryopteris intermedia					**20%**	2	**75%**	5
Dulichium arundinaceum					**40%**	2		
Epifagus virginiana			**100%**	1			**50%**	2
Epilobium leptophyllum	**50%**	2						
Eurybia chlorolepis			**100%**	1			**100%**	4
Eutrochium purpureum							**50%**	2
Fagus grandifolia			**100%**	9			**100%**	7
Fraxinus [americana + biltmoreana + smallii]							**75%**	5
Gentiana decora			**100%**	1				
Gillenia trifoliata			**100%**	1				
Glyceria melicaria					**20%**	6		
Glyceria striata					**60%**	2		
Hamamelis virginiana							**50%**	3
Houstonia serpyllifolia	**100%**	2					**25%**	2
Hydrangea arborescens							**50%**	2
Ilex collina	**100%**	6						
Ilex montana			**100%**	4	**20%**	3	**50%**	1
Ilex verticillata	**75%**	6			**80%**	5		
Impatiens [capensis + pallida]					**80%**	4		
Kalmia carolina					**40%**	3		
Kalmia latifolia	**100%**	4			**100%**	4		
Lilium grayi	**50%**	2						
Lonicera dioica	**75%**	2						
Luzula multiflora			**100%**	2				
Lyonia ligustrina	**100%**	5			**60%**	4		
Lysimachia quadrifolia			**100%**	1				

Maianthemum canadense	**50%**	2	**100%**	2	**100%**	6	**25%**	3
Mitchella repens	**50%**	1			**100%**	2	**25%**	2
Nabalus			**100%**	2				
Oclemena acuminata			**100%**	4			**75%**	4
Osmundastrum cinnamomeum	**100%**	5			**100%**	5		
Oxalis montana	**25%**	2					**50%**	3
Oxypolis rigidior	**75%**	2			**40%**	2		
Packera aurea	**75%**	2			**40%**	3		
Parathelypteris noveboracensis			**100%**	2			**25%**	2
Parnassia asarifolia	**75%**	3						
Picea rubens	**100%**	6	**100%**	5	**100%**	5	**100%**	6
Pinus rigida					**80%**	6		
Platanthera clavellata	**25%**	2			**40%**	2		
Polygonatum biflorum			**100%**	2				
Polypodium appalachianum							**75%**	2
Prunus serotina					**20%**	2	**50%**	4
Quercus rubra			**100%**	6	**40%**	4	**50%**	1
Rhododendron catawbiense					**100%**	5		
Rhododendron maximum	**100%**	6			**100%**	6	**25%**	8
Rhododendron pilosum	**50%**	4						
Ribes cynosbati							**50%**	2
Rosa multiflora					**60%**	2		
Rosa palustris	**75%**	4						
Rubus [hispidus + trivialis]	**50%**	2			**100%**	2		
Rubus canadensis	**25%**	2			**20%**	2	**75%**	2
Salix sericea	**100%**	5						
Sambucus canadensis	**25%**	2			**60%**	3		
Scirpus expansus	**75%**	7						
Smilax [herbacea + pulverulenta]			**100%**	2	**20%**	2		
Smilax glauca			**100%**	1				
Solidago curtisii							**75%**	4
Solidago patula	**100%**	5			**60%**	4		
Solidago speciosa					**60%**	2		
Sorbus americana	**25%**	1	**100%**	1	**20%**	5	**50%**	4
Symphyotrichum puniceum	**25%**	2			**60%**	2		
Taxus canadensis	**50%**	4						
Thelypteris palustris	**50%**	2			**40%**	3		
Toxicodendron vernix					**40%**	2		
Trillium undulatum	**25%**	2	**100%**	1	**40%**	2		
Tsuga canadensis	**50%**	4			**80%**	6		
Vaccinium corymbosum	**50%**	2			**60%**	4		
Vaccinium erythrocarpum							**50%**	4
Vaccinium macrocarpon	**50%**	2						
Vaccinium simulatum	**50%**	3			**20%**	2		
Veratrum parviflorum			**100%**	1				
Vernonia noveboracensis	**50%**	2						
Viburnum cassinoides	**100%**	5			**100%**	5		
Viburnum lantanoides							**50%**	4
Viola [blanda + incognita]					**40%**	3	**100%**	3
Viola cucullata	**75%**	2						
Viola hastata			**100%**	1			**25%**	2
Viola pallens	**75%**	2			**60%**	3		
Viola rotundifolia							**50%**	4

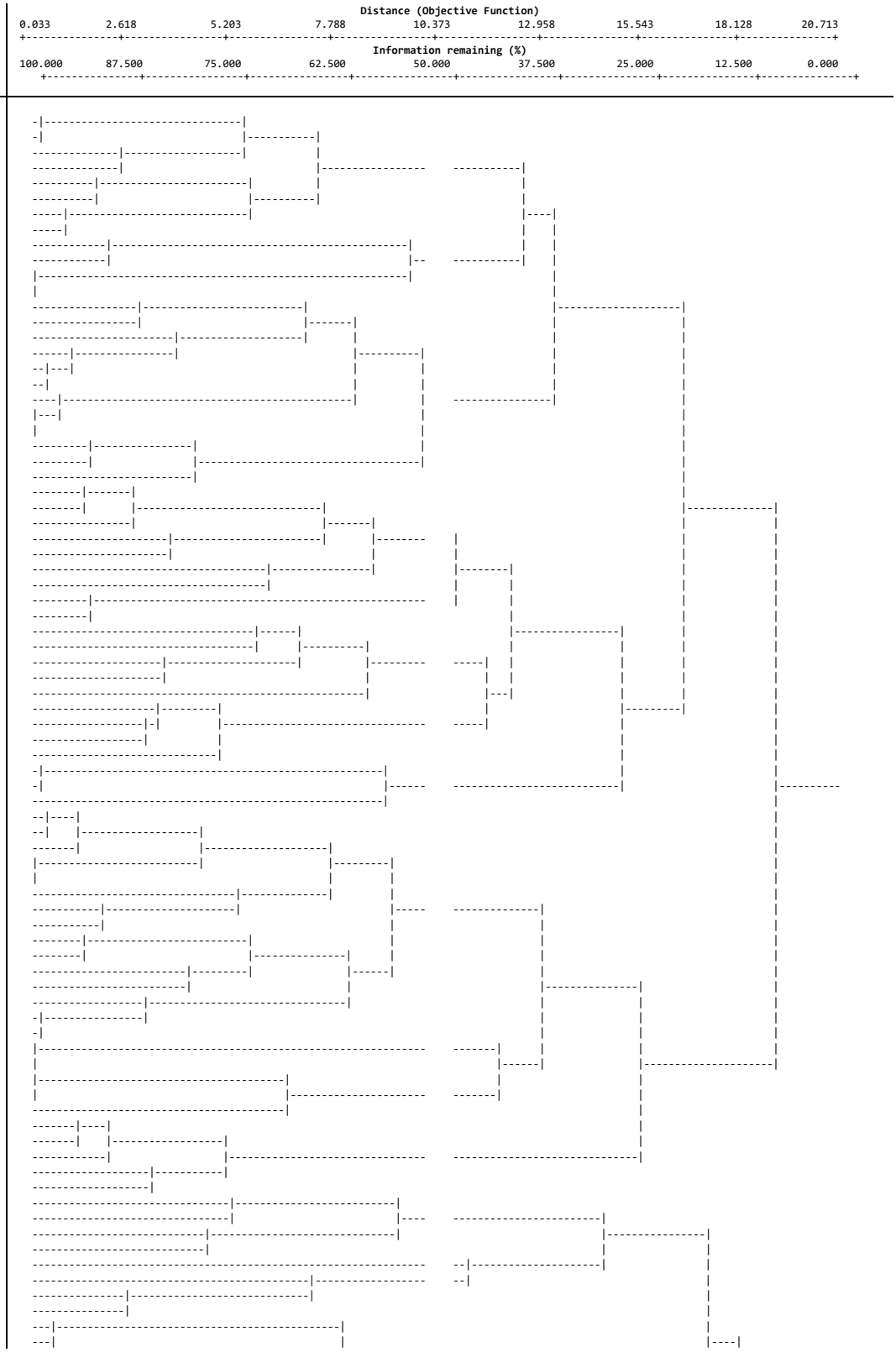
Appendix D2: Constancy table of undescribed types (part 2)

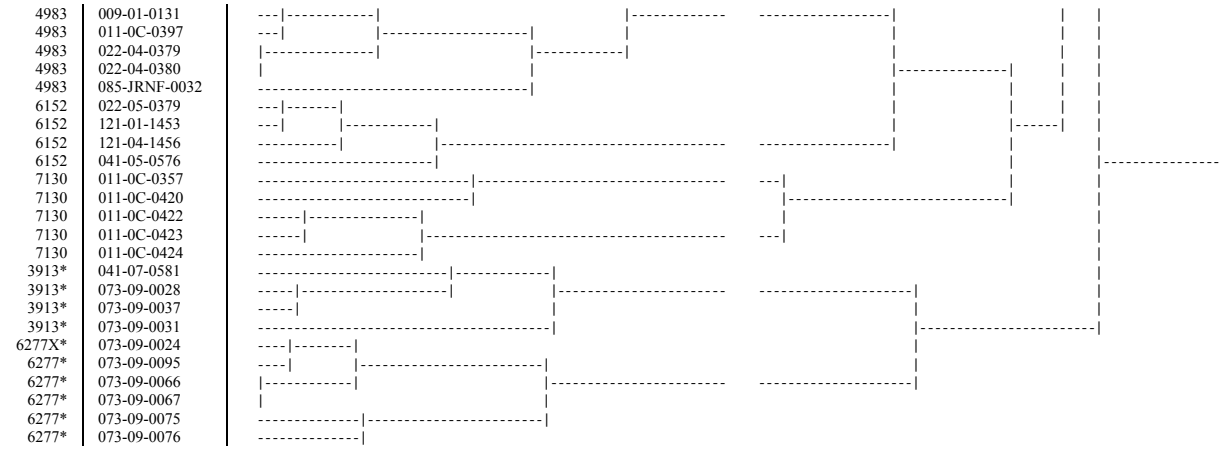
Group Code	**7299**		**7534**		**7543**	
Group Plot Count	2		1		3	
Group Avg Plot Spp Richness	32		51		42	
Group homoteneity	67%		100%		61%	
taxon name	**const.**	avg. cover	**const.**	avg. cover	**const.**	avg. cover
Acer rubrum	**100%**	6	**100%**	5	**100%**	5
Acer saccharum					**33%**	6
Ageratina altissima	**50%**	1			33%	2
Alnus serrulata			**100%**	2	**33%**	3
Amelanchier [arborea + laevis]	**100%**	2	**100%**	2	33%	1
Amianthium muscitoxicum	**50%**	1				
Arisaema triphyllum s.1					**67%**	2
Aristida			**100%**	1		
Aronia melanocarpa					**33%**	5
Avenella flexuosa	**50%**	2				
Betula lenta	**50%**	6			**67%**	6
Carex aestivalis	**50%**	2				
Carex flexuosa	**50%**	1			33%	2
Carex pensylvanica	**50%**	4				
Carex stipata			**100%**	1		
Castanea dentata	**100%**	2				
Chamaelirium luteum	**50%**	1				
Chimaphila maculata	**50%**	1	**100%**	2		
Clematis virginiana			**100%**	1		
Clethra acuminata			**100%**	2	**33%**	4
Clintonia umbellulata	**50%**	1			33%	1
Conopholis americana	**100%**	1				
Cuscuta	**50%**	1				
Danthonia compressa	**50%**	1				
Dendrolycopodium obscurum			**100%**	2		
Dennstaedtia punctilobula	**50%**	4			33%	2
Dioscorea villosa	**50%**	2				
Dryopteris intermedia			**100%**	1	**33%**	3
Eubotrys recurvus	**50%**	2				
Eurybia chlorolepis	**50%**	2			33%	2
Eurybia macrophylla	**50%**	2				
Eutrochium purpureum	**50%**	1				
Fraxinus [americana + biltmoreana + smallii]					**67%**	4
Fraxinus pennsylvanica			**100%**	2	**33%**	3
Galax urceolata	**50%**	2	**100%**	2	**100%**	3
Gentiana decora	**50%**	1				
Glyceria melicaria			**100%**	1	**33%**	5
Goodyera pubescens			**100%**	2	33%	2
Halesia tetraptera	**50%**	1				
Hamamelis virginiana			**100%**	5	**100%**	4
Hieracium paniculatum	**50%**	1				
Houstonia serpyllifolia	**50%**	1			**33%**	3
Huperzia lucidula			**100%**	1	33%	1
Ilex montana	**100%**	4	**100%**	4	**67%**	1
Ilex verticillata					**33%**	5
Impatiens [capensis + pallida]					**67%**	2
Isotrema macrophyllum					**33%**	4
Kalmia latifolia	**100%**	8	**100%**	7	**100%**	5
Lindera benzoin			**100%**	1	**33%**	3
Liriodendron tulipifera			**100%**	5	**100%**	2
Listera smallii			**100%**	1		
Lycopus virginicus			**100%**	1	33%	2
Lysimachia quadrifolia	**100%**	2				
Magnolia fraseri			**100%**	6	**100%**	6
Maianthemum canadense			**100%**	1	**67%**	2
Medeola virginiana	**50%**	2	**100%**	2	33%	1
Melampyrum lineare	**50%**	1				
Mitchella repens			**100%**	2		
Monotropsis odorata			**100%**	1		
Nabalus	**50%**	2			33%	1

Nyssa sylvatica			**100%**	5	**33%**	6
Oclemena acuminata	**50%**	2	**100%**	2	**67%**	2
Osmunda spectabilis			**100%**	1	**33%**	2
Osmundastrum cinnamomeum			**100%**	1	**33%**	5
Ostrya virginiana					**33%**	3
Oxydendrum arboreum			**100%**	5		
Oxypolis rigidior			**100%**	1	**33%**	2
Parathelypteris noveboracensis			**100%**	2	**33%**	2
Picea rubens	**100%**	5	**100%**	6	**100%**	6
Pinus strobus			**100%**	2		
Polypodium appalachianum	**50%**	1			**33%**	2
Polystichum acrostichoides					**67%**	2
Quercus alba			**100%**	6		
Quercus montana	**50%**	6			**33%**	7
Quercus rubra	**100%**	8	**100%**	1	**100%**	5
Quercus velutina	**50%**	1				
Rhododendron [carolinianum + minus]	**50%**	5				
Rhododendron calendulaceum	**50%**	1				
Rhododendron catawbiense	**100%**	7				
Rhododendron maximum			**100%**	4	**100%**	7
Robinia pseudoacacia			**100%**	3		
Rubus canadensis					**67%**	2
Sambucus canadensis			**100%**	1		
Sassafras albidum			**100%**	5		
Scirpus expansus						
Silene stellata			**100%**	2		
Smilax rotundifolia			**100%**	2	**67%**	4
Solidago erecta	**50%**	1	**100%**	1		
Thalictrum clavatum					**67%**	2
Tilia americana					**33%**	6
Trillium grandiflorum			**100%**	2		
Trillium undulatum	**50%**	1				
Tsuga canadensis	**50%**	4	**100%**	6	**100%**	7
Vaccinium corymbosum	**50%**	2	**100%**	1		
Vaccinium erythrocarpum	**50%**	2				
Vaccinium pallidum	**50%**	2				
Vaccinium simulatum	**50%**	4				
Viburnum cassinoides	**50%**	1	**100%**	2	**67%**	4
Viburnum lantanoides					**33%**	3
Viola [blanda + incognita]			**100%**	2	**67%**	3
Viola rotundifolia					**67%**	1

Appendix E: Dendrogram of clusters and assigned communities (* indicates plots that were not included in descriptions)

Cluster community	CVS plot code
7131	005-01-0300
7131	005-01-0301
7131	022-05-0378
7131	022-06-0377
7128	005-01-0307
7128	142-08-1640
7128	005-03-0308
7128	005-03-0309
7131A	121-01-1452
7131A	121-07-1451
7131A	085-JRNF-0016
7131A	085-JRNF-0031
6256	009-01-0067
6256	081-04-0015
6256	009-01-0130
6256	085-JRNF-0014
6256	085-JRNF-0021
6256	085-JRNF-0085
6256	009-01-0072
6256	009-01-0073
6256	009-01-0074
7130/7131*	009-01-0068
7130/7131*	009-01-0069
7130/7131*	009-01-0099
6256A	005-02-0307
6256A	041-09-0576
6256A	041-09-0577
6256A	005-03-0307
6256A	011-0C-0415
6256A	009-01-0075
6130*	022-05-0377
6256C	009-01-0142
6256C	011-0C-0398
XXX1	011-0C-0396
6256X*	011-0C-0412
XXX1	011-0C-0409
XXX1	011-0C-0457
XXX1	022-03-0386
7285*	085-GHSP-0007
7285*	085-GHSP-0008
7285*	085-GHSP-0011
7285*	085-GHSP-0010
7131B	009-01-0070
7131B	009-01-0071
7131B	012-0C-0650
6049A	005-01-0302
6049A	005-02-0300
6049A	005-05-0314
6049X	085-JRNF-0025
6049AX*	085-JRNF-0026
6308	005-02-0301
6308X*	005-03-0317
6308	005-03-0318
7130A	009-01-0106
7130A	009-01-0109
7130A	022-08-0381
6049	022-09-0381
7131X	022-01-0380
7131X	022-01-0381
7131X	022-01-0382
6256B	009-01-0084
6256B	009-01-0085
7131/7130	011-0C-0355
7131/7130	011-0C-0408
7131/7130	022-06-0378
6049	009-01-0086
6049	009-01-0087
6049	009-01-0089
6049	009-01-0088
6049	009-01-0101
7543	005-03-0303
7543	005-03-0304
7543	046-01-0668
7543	046-01-0669
7299*	011-0C-0341
7298*	011-0C-0416
7298*	011-0C-0421
7299*	011-0C-0456
4983	005-04-0313
4983	005-06-0301




4983 009-01-0131
4983 011-0C-0397
4983 022-04-0379
4983 022-04-0380
4983 085-JRNF-0032
6152 022-05-0379
6152 121-01-1453
6152 121-04-1456
6152 041-05-0576
7130 011-0C-0357
7130 011-0C-0420
7130 011-0C-0422
7130 011-0C-0423
7130 011-0C-0424
3913* 041-07-0581
3913* 073-09-0028
3913* 073-09-0037
3913* 073-09-0031
6277X* 073-09-0024
6277* 073-09-0095
6277* 073-09-0066
6277* 073-09-0067
6277* 073-09-0075
6277* 073-09-0076

Appendix F: Homogenized species names

CVS dataset occurrences	Homogenized species name
Abies balsamea	*Abies balsamea*
Abies fraseri	*Abies fraseri*
Acer nigrum	*Acer nigrum*
Acer pensylvanicum	*Acer pensylvanicum*
Acer rubrum	*Acer rubrum*
Acer saccharum	*Acer saccharum*
Acer spicatum	*Acer spicatum*
Achillea borealis	*Achillea borealis*
Aconitum reclinatum	*Aconitum reclinatum*
Actaea pachypoda	*Actaea pachypoda*
Actaea podocarpa	*Actaea podocarpa*
Actaea racemosa	*Actaea racemosa*
Aesculus flava	*Aesculus flava*
Ageratina altissima	*Ageratina altissima*
Agrostis [gigantea + stolonifera]	*Agrostis [gigantea + stolonifera]*
Agrostis gigantea	*Agrostis [gigantea + stolonifera]*
Agrostis stolonifera	*Agrostis [gigantea + stolonifera]*
Agrostis [hyemalis + scabra]	*Agrostis [hyemalis + scabra]*
Agrostis hyemalis	*Agrostis [hyemalis + scabra]*
Agrostis scabra	*Agrostis [hyemalis + scabra]*
Agrostis canina	*Agrostis canina*
Agrostis capillaris	*Agrostis capillaris*
Agrostis perennans	*Agrostis perennans*
Allium tricoccum	*Allium tricoccum*
Alnus incana	*Alnus incana*
Alnus serrulata	*Alnus serrulata*
Alnus viridis	*Alnus viridis*
Amelanchier [arborea + laevis]	*Amelanchier [arborea + laevis]*
Amelanchier arborea	*Amelanchier [arborea + laevis]*
Amelanchier laevis	*Amelanchier [arborea + laevis]*
Amelanchier bartramiana	*Amelanchier bartramiana*
Amelanchier sanguinea	*Amelanchier sanguinea*
Amianthium muscitoxicum	*Amianthium muscitoxicum*
Andreaea rupestris	*Andreaea rupestris*
Andropogon gerardi	*Andropogon gerardi*
Andropogon tracyi	*Andropogon tracyi*
Anemone lancifolia	*Anemone lancifolia*
Anemone [minima + quinquefolia]	*Anemone quinquefolia*
Anemone quinquefolia	*Anemone quinquefolia*
Angelica triquinata	*Angelica triquinata*
Anthoxanthum odoratum	*Anthoxanthum odoratum*
Apocynum androsaemifolium	*Apocynum androsaemifolium*
Aralia nudicaulis	*Aralia nudicaulis*
Arisaema dracontium	*Arisaema dracontium*
Arisaema [pusillum + quinatum + stewardsonii + triphyllum]	*Arisaema triphyllum* s.1
Arisaema quinatum	*Arisaema triphyllum* s.2
Arisaema stewardsonii	*Arisaema triphyllum* s.3
Arisaema triphyllum	*Arisaema triphyllum* s.4
Aristida	*Aristida*
Arnoglossum reniforme	*Arnoglossum reniforme*
Aronia arbutifolia	*Aronia arbutifolia*
Aronia melanocarpa	*Aronia melanocarpa*
Aronia prunifolia	*Aronia prunifolia*
Asclepias incarnata	*Asclepias incarnata*
Asclepias syriaca	*Asclepias syriaca*
Asplenium montanum	*Asplenium montanum*
Athyrium angustum	*Athyrium angustum*
Athyrium asplenioides	*Athyrium asplenioides*
Aureolaria levigata	*Aureolaria levigata*
Avenella flexuosa	*Avenella flexuosa*
Bartonia virginica	*Bartonia virginica*
Betula alleghaniensis	*Betula alleghaniensis*
Betula cordifolia	*Betula cordifolia*
Betula lenta	*Betula lenta*
Bidens	*Bidens*
Bidens connata	*Bidens*
Boechera canadensis	*Boechera canadensis*
Boechera laevigata	*Boechera laevigata*
Botrypus virginianus	*Botrypus virginianus*
Brachyelytrum [aristosum + erectum]	*Brachyelytrum [aristosum + erectum]*
Brachyelytrum aristosum	*Brachyelytrum [aristosum + erectum]*
Brachyelytrum erectum	*Brachyelytrum [aristosum + erectum]*
Brachythecium rivulare	*Brachythecium rivulare*
Bromus ciliatus	*Bromus ciliatus*
Bromus pubescens	*Bromus pubescens*
Calamagrostis canadensis	*Calamagrostis canadensis*
Callitriche palustris	*Callitriche palustris*
Calopogon tuberosus	*Calopogon tuberosus*
Caltha palustris	*Caltha palustris*
Campanula divaricata	*Campanula divaricata*
Cardamine [clematitis + flagellifera]	*Cardamine [clematitis + flagellifera]*
Cardamine diphylla	*Cardamine diphylla*
Cardamine hirsuta	*Cardamine hirsuta*
Cardamine parviflora	*Cardamine parviflora*
Cardamine pensylvanica	*Cardamine pensylvanica*
Carex [amplisquama + communis]	*Carex [amplisquama + communis]*
Ipomoea	*Ipomoea*
Ipomoea pandurata	*Ipomoea*
Iris cristata	*Iris cristata*
Iris verna	*Iris verna*
Isotrema macrophyllum	*Isotrema macrophyllum*
Isotria verticillata	*Isotria verticillata*
Juncus [anthelatus + tenuis]	*Juncus [anthelatus + tenuis]*
Juncus brevicaudatus	*Juncus brevicaudatus*
Juncus effusus	*Juncus effusus*
Juncus subcaudatus	*Juncus subcaudatus*
Kalmia buxifolia	*Kalmia buxifolia*
Kalmia carolina	*Kalmia carolina*
Kalmia latifolia	*Kalmia latifolia*
Krigia montana	*Krigia montana*
Lactuca	*Lactuca*
Laportea canadensis	*Laportea canadensis*
Larix laricina	*Larix laricina*
Lecidea auriculata	*Lecidea auriculata*
Leersia oryzoides	*Leersia oryzoides*
Leersia virginica	*Leersia virginica*
Liatris helleri	*Liatris helleri*
Ligusticum canadense	*Ligusticum canadense*
Ligustrum sinense	*Ligustrum sinense*
Lilium grayi	*Lilium grayi*
Lilium michauxii	*Lilium michauxii*
Lilium superbum	*Lilium superbum*
Lindera benzoin	*Lindera benzoin*
Linum striatum	*Linum striatum*
Liriodendron tulipifera	*Liriodendron tulipifera*
Listera cordata	*Listera cordata*
Listera smallii	*Listera smallii*
Lolium pratense	*Lolium pratense*
Lonicera canadensis	*Lonicera canadensis*
Lonicera dioica	*Lonicera dioica*
Lonicera japonica	*Lonicera japonica*
Ludwigia alternifolia	*Ludwigia alternifolia*
Luzula acuminata	*Luzula acuminata*
Luzula bulbosa	*Luzula bulbosa*
Luzula echinata	*Luzula echinata*
Luzula multiflora	*Luzula multiflora*
Lycopodiella inundata	*Lycopodiella inundata*
Lycopodium clavatum	*Lycopodium clavatum*
Lycopus americanus	*Lycopus americanus*
Lycopus uniflorus	*Lycopus uniflorus*
Lycopus virginicus	*Lycopus virginicus*
Lyonia ligustrina	*Lyonia ligustrina*
Lysimachia borealis	*Lysimachia borealis*
Lysimachia ciliata	*Lysimachia ciliata*
Lysimachia quadrifolia	*Lysimachia quadrifolia*
Lysimachia terrestris	*Lysimachia terrestris*
Magnolia acuminata	*Magnolia acuminata*
Magnolia fraseri	*Magnolia fraseri*
Maianthemum canadense	*Maianthemum canadense*
Maianthemum racemosum	*Maianthemum racemosum*
Malus pumila	*Malus pumila*
Medeola virginiana	*Medeola virginiana*
Melampyrum lineare	*Melampyrum lineare*
Mentha [arvensis ssp. *arvensis + canadensis]*	*Mentha arvensis*
Menyanthes trifoliata	*Menyanthes trifoliata*
Micranthes micranthidifolia	*Micranthes micranthidifolia*
Mimulus ringens	*Mimulus ringens*
Mitchella repens	*Mitchella repens*
Mitella diphylla	*Mitella diphylla*
Monarda clinopodia	*Monarda clinopodia*
Monarda didyma	*Monarda didyma*
Monotropa uniflora	*Monotropa uniflora*
Monotropsis odorata	*Monotropsis odorata*
Muhlenbergia tenuiflora	*Muhlenbergia tenuiflora*
Myosotis scorpioides	*Myosotis scorpioides*
Nabalus	*Nabalus*
Nabalus [cylindricus + roanensis]	*Nabalus*
Nabalus altissimus	*Nabalus*
Nabalus serpentarius	*Nabalus*
Nabalus trifoliolatus	*Nabalus*
Nemopanthus mucronatus	*Nemopanthus mucronatus*
Nyssa sylvatica	*Nyssa sylvatica*
Oclemena acuminata	*Oclemena acuminata*
Onoclea sensibilis	*Onoclea sensibilis*
Orontium aquaticum	*Orontium aquaticum*
Osmorhiza claytonii	*Osmorhiza claytonii*
Osmunda claytoniana	*Osmunda claytoniana*
Osmunda spectabilis	*Osmunda spectabilis*
Osmundastrum cinnamomeum	*Osmundastrum cinnamomeum*
Ostrya virginiana	*Ostrya virginiana*
Oxalis montana	*Oxalis montana*
Oxalis stricta	*Oxalis stricta*

Carex [austrolucorum + lucorum]	*Carex [austrolucorum + lucorum]*
Carex aestivalis	*Carex aestivalis*
Carex [allegheniensis + debilis + flexuosa]	*Carex allegheniensis*
Carex amphibola	*Carex amphibola*
Carex appalachica	*Carex appalachica*
Carex argyrantha	*Carex argyrantha*
Carex atlantica	*Carex atlantica*
Carex austrolucorum	*Carex austrolucorum*
Carex baileyi	*Carex baileyi*
Carex blanda	*Carex blanda*
Carex bromoides	*Carex bromoides*
Carex brunnescens	*Carex brunnescens*
Carex bullata	*Carex bullata*
Carex canescens	*Carex canescens*
Carex crinita	*Carex crinita*
Carex debilis	*Carex debilis*
Carex digitalis	*Carex digitalis*
Carex echinata	*Carex echinata*
Carex flexuosa	*Carex flexuosa*
Carex folliculata	*Carex folliculata*
Carex fraseriana	*Carex fraseriana*
Carex gracillima	*Carex gracillima*
Carex gynandra	*Carex gynandra*
Carex interior	*Carex interior*
Carex intumescens	*Carex intumescens*
Carex laxiculmis	*Carex laxiculmis*
Carex laxiflora	*Carex laxiflora*
Carex leptalea	*Carex leptalea*
Carex leptonervia	*Carex leptonervia*
Carex lupulina	*Carex lupulina*
Carex lurida	*Carex lurida*
Carex misera	*Carex misera*
Carex pensylvanica	*Carex pensylvanica*
Carex plantaginea	*Carex plantaginea*
Carex polymorpha	*Carex polymorpha*
Carex prasina	*Carex prasina*
Carex projecta	*Carex projecta*
Carex ruthii	*Carex ruthii*
Carex scabrata	*Carex scabrata*
Carex scoparia	*Carex scoparia*
Carex stipata	*Carex stipata*
Carex stricta	*Carex stricta*
Carex swanii	*Carex swanii*
Carex tonsa	*Carex tonsa*
Carex torta	*Carex torta*
Carex tribuloides	*Carex tribuloides*
Carex trisperma	*Carex trisperma*
Carex umbellata	*Carex umbellata*
Carex virescens	*Carex virescens*
Carex vulpinoidea	*Carex vulpinoidea*
Carpinus caroliniana	*Carpinus caroliniana*
Carya ovata	*Carya ovata*
Carya tomentosa	*Carya tomentosa*
Castanea dentata	*Castanea dentata*
Caulophyllum thalictroides	*Caulophyllum thalictroides*
Chamaelirium luteum	*Chamaelirium luteum*
Chamerion platyphyllum	*Chamerion platyphyllum*
Chelone glabra	*Chelone glabra*
Chelone lyonii	*Chelone lyonii*
Chelone obliqua	*Chelone obliqua*
Chimaphila maculata	*Chimaphila maculata*
Chrysosplenium americanum	*Chrysosplenium americanum*
Cicuta maculata	*Cicuta maculata*
Cinna arundinacea	*Cinna arundinacea*
Cinna latifolia	*Cinna latifolia*
Circaea ×sterilis	*Circaea ×sterilis*
Circaea alpina	*Circaea alpina*
Claytonia caroliniana	*Claytonia caroliniana*
Claytonia virginica	*Claytonia virginica*
Clematis virginiana	*Clematis virginiana*
Clethra acuminata	*Clethra acuminata*
Clinopodium vulgare	*Clinopodium vulgare*
Clintonia borealis	*Clintonia borealis*
Clintonia umbellulata	*Clintonia umbellulata*
Collinsonia canadensis	*Collinsonia canadensis*
Comptonia peregrina	*Comptonia peregrina*
Conioselinum chinense	*Conioselinum chinense*
Conopholis americana	*Conopholis americana*
Convallaria pseudomajalis	*Convallaria pseudomajalis*
Coptis trifolia	*Coptis trifolia*
Corallorhiza maculata	*Corallorhiza maculata*
Coreopsis major	*Coreopsis major*
Cornus alternifolia	*Cornus alternifolia*
Cornus canadensis	*Cornus canadensis*
Coryphopteris species 1	*Coryphopteris*
Crataegus [alleghaniensis + aprica + lancei + munda + senta]	*Crataegus [alleghaniensis + aprica + lancei + munda + senta]*
Crataegus [collina + punctata]	*Crataegus [collina + punctata]*
Crataegus macrosperma	*Crataegus macrosperma*
Crataegus punctata	*Crataegus punctata*
Crataegus viridis	*Crataegus viridis*

Oxalis violacea	*Oxalis violacea*
Oxydendrum arboreum	*Oxydendrum arboreum*
Oxypolis rigidior	*Oxypolis rigidior*
Packera aurea	*Packera aurea*
Panax trifolius	*Panax trifolius*
Parathelypteris noveboracensis	*Parathelypteris noveboracensis*
Parnassia asarifolia	*Parnassia asarifolia*
Parnassia grandifolia	*Parnassia grandifolia*
Paronychia	*Paronychia argyrocoma*
Paronychia argyrocoma	*Paronychia argyrocoma*
Parthenocissus quinquefolia	*Parthenocissus quinquefolia*
Pedicularis canadensis	*Pedicularis canadensis*
Pellia epiphylla	*Pellia epiphylla*
Persicaria hydropiper	*Persicaria hydropiper*
Persicaria punctata	*Persicaria punctata*
Persicaria sagittata	*Persicaria sagittata*
Phalaris arundinacea	*Phalaris arundinacea*
Phegopteris connectilis	*Phegopteris connectilis*
Philonotis fontana	*Philonotis fontana*
Photinia pyrifolia	*Photinia pyrifolia*
Physocarpus opulifolius	*Physocarpus opulifolius*
Picea rubens	*Picea rubens*
Pieris floribunda	*Pieris floribunda*
Pilea pumila	*Pilea pumila*
Pilosella aurantiaca	*Pilosella aurantiaca*
Pilosella caespitosa	*Pilosella caespitosa*
Pinus pungens	*Pinus pungens*
Pinus rigida	*Pinus rigida*
Pinus strobus	*Pinus strobus*
Platanthera clavellata	*Platanthera clavellata*
Platanthera flava	*Platanthera flava*
Platanthera grandiflora	*Platanthera grandiflora*
Platanthera lacera	*Platanthera lacera*
Platanthera orbiculata	*Platanthera orbiculata*
Platanthera psycodes	*Platanthera psycodes*
Platismatia tuckermanii	*Platismatia tuckermanii*
Pleopeltis michauxiana	*Pleopeltis michauxiana*
Poa alsodes	*Poa alsodes*
Poa compressa	*Poa compressa*
Poa cuspidata	*Poa cuspidata*
Poa palustris	*Poa palustris*
Poa pratensis	*Poa pratensis*
Poa sylvestris	*Poa sylvestris*
Poa trivialis	*Poa trivialis*
Podophyllum peltatum	*Podophyllum peltatum*
Pohlia nutans	*Pohlia nutans*
Polemonium vanbruntiae	*Polemonium vanbruntiae*
Polygonatum biflorum	*Polygonatum biflorum*
Polygonatum pubescens	*Polygonatum pubescens*
Polygonum	*Polygonum*
Polygonum punctatum	*Polygonum*
Polypodium [appalachianum + virginianum]	*Polypodium appalachianum*
Polypodium appalachianum	*Polypodium appalachianum*
Polypodium virginianum	*Polypodium appalachianum*
Polystichum acrostichoides	*Polystichum acrostichoides*
Populus tremuloides	*Populus tremuloides*
Potentilla canadensis	*Potentilla canadensis*
Potentilla simplex	*Potentilla simplex*
Pourthiaea	*Pourthiaea*
Prosartes lanuginosa	*Prosartes lanuginosa*
Prunella vulgaris	*Prunella vulgaris*
Prunus avium	*Prunus avium*
Prunus pensylvanica	*Prunus pensylvanica*
Prunus serotina	*Prunus serotina*
Prunus virginiana	*Prunus virginiana*
Pteridium latiusculum	*Pteridium latiusculum*
Pycnanthemum montanum	*Pycnanthemum montanum*
Pyrola elliptica	*Pyrola elliptica*
Quercus alba	*Quercus alba*
Quercus ilicifolia	*Quercus ilicifolia*
Quercus montana	*Quercus montana*
Quercus rubra	*Quercus rubra*
Quercus velutina	*Quercus velutina*
Ranunculus abortivus	*Ranunculus abortivus*
Ranunculus acris	*Ranunculus acris*
Ranunculus carolinianus	*Ranunculus carolinianus*
Ranunculus hispidus	*Ranunculus hispidus*
Ranunculus recurvatus	*Ranunculus recurvatus*
Rhododendron [carolinianum + minus]	*Rhododendron [carolinianum + minus]*
Rhododendron calendulaceum	*Rhododendron calendulaceum*
Rhododendron catawbiense	*Rhododendron catawbiense*
Rhododendron maximum	*Rhododendron maximum*
Rhododendron periclymenoides	*Rhododendron periclymenoides*
Rhododendron pilosum	*Rhododendron pilosum*
Rhododendron prinophyllum	*Rhododendron prinophyllum*
Rhododendron vaseyi	*Rhododendron vaseyi*
Rhododendron viscosum	*Rhododendron viscosum*
Rhynchospora alba	*Rhynchospora alba*
Rhynchospora capitellata	*Rhynchospora capitellata*
Ribes cynosbati	*Ribes cynosbati*

Cuscuta	*Cuscuta*
Cuscuta rostrata	*Cuscuta*
Cypripedium acaule	*Cypripedium acaule*
Cystopteris bulbifera	*Cystopteris bulbifera*
Cystopteris fragilis	*Cystopteris fragilis*
Cystopteris protrusa	*Cystopteris protrusa*
Danthonia compressa	*Danthonia compressa*
Danthonia spicata	*Danthonia spicata*
Dendrolycopodium dendroideum	*Dendrolycopodium dendroideum*
Dendrolycopodium hickeyi	*Dendrolycopodium hickeyi*
Dendrolycopodium obscurum	*Dendrolycopodium obscurum*
Dennstaedtia punctilobula	*Dennstaedtia punctilobula*
Deparia acrostichoides	*Deparia acrostichoides*
Dicentra canadensis	*Dicentra canadensis*
Dicentra eximia	*Dicentra eximia*
Dichanthelium acuminatum	*Dichanthelium acuminatum*
Dichanthelium boscii	*Dichanthelium boscii*
Dichanthelium clandestinum	*Dichanthelium clandestinum*
Dichanthelium commutatum	*Dichanthelium commutatum*
Dichanthelium dichotomum	*Dichanthelium dichotomum*
Dichanthelium latifolium	*Dichanthelium latifolium*
Diervilla sessilifolia	*Diervilla sessilifolia*
Dioscorea quaternata	*Dioscorea quaternata*
Dioscorea villosa	*Dioscorea villosa*
Diphasiastrum digitatum	*Diphasiastrum digitatum*
Diphasiastrum tristachyum	*Diphasiastrum tristachyum*
Diphylleia cymosa	*Diphylleia cymosa*
Doellingeria umbellata	*Doellingeria umbellata*
Drosera rotundifolia	*Drosera rotundifolia*
Dryopteris campyloptera	*Dryopteris campyloptera*
Dryopteris carthusiana	*Dryopteris carthusiana*
Dryopteris cristata	*Dryopteris cristata*
Dryopteris intermedia	*Dryopteris intermedia*
Dryopteris marginalis	*Dryopteris marginalis*
Dulichium arundinaceum	*Dulichium arundinaceum*
Eleocharis tenuis	*Eleocharis tenuis*
Elymus hystrix	*Elymus hystrix*
Epifagus virginiana	*Epifagus virginiana*
Epigaea repens	*Epigaea repens*
Epilobium leptophyllum	*Epilobium leptophyllum*
Equisetum	*Equisetum*
Eriophorum virginicum	*Eriophorum virginicum*
Erythronium americanum	*Erythronium americanum*
Erythronium umbilicatum	*Erythronium umbilicatum*
Eubotrys recurvus	*Eubotrys recurvus*
Euonymus obovatus	*Euonymus obovatus*
Eupatorium perfoliatum	*Eupatorium perfoliatum*
Eupatorium pubescens	*Eupatorium pubescens*
Euphorbia [corollata + pubentissima]	*Euphorbia [corollata + pubentissima]*
Euphorbia purpurea	*Euphorbia purpurea*
Eurybia chlorolepis	*Eurybia chlorolepis*
Eurybia divaricata	*Eurybia divaricata*
Eurybia macrophylla	*Eurybia macrophylla*
Euthamia graminifolia	*Euthamia graminifolia*
Eutrochium fistulosum	*Eutrochium fistulosum*
Eutrochium maculatum	*Eutrochium maculatum*
Eutrochium purpureum	*Eutrochium purpureum*
Eutrochium steelei	*Eutrochium steelei*
Fagus grandifolia	*Fagus grandifolia*
Fallopia cilinodis	*Fallopia cilinodis*
Fallopia convolvulus	*Fallopia convolvulus*
Festuca rubra	*Festuca rubra*
Festuca subverticillata	*Festuca subverticillata*
Festuca trachyphylla	*Festuca trachyphylla*
Flavoparmelia caperata	*Flavoparmelia caperata*
Fragaria vesca	*Fragaria vesca*
Fragaria virginiana	*Fragaria virginiana*
Fraxinus [americana + biltmoreana + smallii]	*Fraxinus [americana + biltmoreana + smallii]*
Fraxinus [biltmoreana + smallii]	*Fraxinus [americana + biltmoreana + smallii]*
Fraxinus nigra	*Fraxinus nigra*
Fraxinus pennsylvanica	*Fraxinus pennsylvanica*
Galax urceolata	*Galax urceolata*
Galium aparine	*Galium aparine*
Galium asprellum	*Galium asprellum*
Galium circaezans	*Galium circaezans*
Galium lanceolatum	*Galium lanceolatum*
Galium tinctorium	*Galium tinctorium*
Galium triflorum	*Galium triflorum*
Gaultheria hispidula	*Gaultheria hispidula*
Gaultheria procumbens	*Gaultheria procumbens*
Gaylussacia baccata	*Gaylussacia baccata*
Gaylussacia ursina	*Gaylussacia ursina*
Gentiana [austromontana + clausa]	*Gentiana [austromontana + clausa]*
Gentiana decora	*Gentiana decora*
Gentiana linearis	*Gentiana linearis*
Geranium maculatum	*Geranium maculatum*
Geum geniculatum	*Geum geniculatum*
Geum rivale	*Geum rivale*
Gillenia trifoliata	*Gillenia trifoliata*
Glyceria canadensis	*Glyceria canadensis*
Glyceria grandis	*Glyceria grandis*
Ribes glandulosum	*Ribes glandulosum*
Ribes rotundifolium	*Ribes rotundifolium*
Robinia pseudoacacia	*Robinia pseudoacacia*
Rosa multiflora	*Rosa multiflora*
Rosa palustris	*Rosa palustris*
Rubus [hispidus + trivialis]	*Rubus [hispidus + trivialis]*
Rubus hispidus	*Rubus [hispidus + trivialis]*
Rubus allegheniensis	*Rubus allegheniensis*
Rubus canadensis	*Rubus canadensis*
Rubus flagellaris	*Rubus flagellaris*
Rubus idaeus	*Rubus idaeus*
Rubus pensilvanicus	*Rubus pensilvanicus*
Rubus pubescens	*Rubus pubescens*
Rubus repens	*Rubus repens*
Rudbeckia laciniata	*Rudbeckia laciniata*
Rugelia nudicaulis	*Rugelia nudicaulis*
Rumex acetosella	*Rumex acetosella*
Sagittaria latifolia	*Sagittaria latifolia*
Salix [humilis + occidentalis]	*Salix [humilis + occidentalis]*
Salix sericea	*Salix sericea*
Sambucus canadensis	*Sambucus canadensis*
Sambucus racemosa	*Sambucus racemosa*
Sanicula odorata	*Sanicula odorata*
Sassafras albidum	*Sassafras albidum*
Sceptridium dissectum	*Sceptridium dissectum*
Sceptridium oneidense	*Sceptridium oneidense*
Scirpus cyperinus	*Scirpus cyperinus*
Scirpus expansus	*Scirpus expansus*
Scutellaria lateriflora	*Scutellaria lateriflora*
Sedum ternatum	*Sedum ternatum*
Senecio suaveolens	*Senecio suaveolens*
Silene stellata	*Silene stellata*
Silene virginica	*Silene virginica*
Smilax [herbacea + pulverulenta]	*Smilax [herbacea + pulverulenta]*
Smilax herbacea	*Smilax [herbacea + pulverulenta]*
Smilax ecirrata	*Smilax ecirrata*
Smilax glauca	*Smilax glauca*
Smilax hispida	*Smilax hispida*
Smilax rotundifolia	*Smilax rotundifolia*
Solanum dulcamara	*Solanum dulcamara*
Solidago [puberula + pulverulenta]	*Solidago [puberula + pulverulenta]*
Solidago altissima	*Solidago altissima*
Solidago arguta	*Solidago arguta*
Solidago caesia	*Solidago caesia*
Solidago curtisii	*Solidago curtisii*
Solidago erecta	*Solidago erecta*
Solidago flaccidifolia	*Solidago flaccidifolia*
Solidago flexicaulis	*Solidago flexicaulis*
Solidago glomerata	*Solidago glomerata*
Solidago patula	*Solidago patula*
Solidago rugosa	*Solidago rugosa*
Solidago speciosa	*Solidago speciosa*
Solidago uliginosa	*Solidago uliginosa*
Sorbus americana	*Sorbus americana*
Sparganium	*Sparganium*
Sparganium emersum	*Sparganium*
Sphenopholis intermedia	*Sphenopholis intermedia*
Sphenopholis pensylvanica	*Sphenopholis pensylvanica*
Spinulum annotinum	*Spinulum annotinum*
Spiraea alba	*Spiraea alba*
Spiraea tomentosa	*Spiraea tomentosa*
Spiranthes cernua	*Spiranthes cernua*
Stachys latidens	*Stachys latidens*
Stellaria corei	*Stellaria corei*
Stellaria media	*Stellaria media*
Stellaria pubera	*Stellaria pubera*
Stenanthium gramineum	*Stenanthium gramineum*
Stenanthium leimanthoides	*Stenanthium leimanthoides*
Streptopus lanceolatus	*Streptopus lanceolatus*
Symphyotrichum cordifolium	*Symphyotrichum cordifolium*
Symphyotrichum lateriflorum	*Symphyotrichum lateriflorum*
Symphyotrichum prenanthoides	*Symphyotrichum prenanthoides*
Symphyotrichum puniceum	*Symphyotrichum puniceum*
Symphyotrichum undulatum	*Symphyotrichum undulatum*
Symplocarpus foetidus	*Symplocarpus foetidus*
Symplocos tinctoria	*Symplocos tinctoria*
Taraxacum officinale	*Taraxacum officinale*
Taxus canadensis	*Taxus canadensis*
Tetraphis pellucida	*Tetraphis pellucida*
Thalictrum [hepaticum + pubescens]	*Thalictrum [hepaticum + pubescens]*
Thalictrum clavatum	*Thalictrum clavatum*
Thalictrum thalictroides	*Thalictrum thalictroides*
Thaspium barbinode	*Thaspium barbinode*
Thelypteris palustris	*Thelypteris palustris*
Tiarella cordifolia	*Tiarella cordifolia*
Tilia americana	*Tilia americana*
Toxicodendron vernix	*Toxicodendron vernix*
Trautvetteria caroliniensis	*Trautvetteria caroliniensis*
Trichoglossum hirsutum	*Trichoglossum hirsutum*
Trillium cuneatum	*Trillium cuneatum*
Trillium [erectum + flexipes + simile]	*Trillium erectum*

Glyceria laxa	*Glyceria laxa*
Glyceria melicaria	*Glyceria melicaria*
Glyceria nubigena	*Glyceria nubigena*
Glyceria septentrionalis	*Glyceria septentrionalis*
Glyceria striata	*Glyceria striata*
Goodyera pubescens	*Goodyera pubescens*
Goodyera repens	*Goodyera repens*
Gratiola [graniticola + neglecta + quartermaniae]	*Gratiola [graniticola + neglecta + quartermaniae]*
Gratiola neglecta	*Gratiola [graniticola + neglecta + quartermaniae]*
Gymnocarpium dryopteris	*Gymnocarpium dryopteris*
Halesia tetraptera	*Halesia tetraptera*
Hamamelis virginiana	*Hamamelis virginiana*
Helenium autumnale	*Helenium autumnale*
Heterophyllium affine	*Heterophyllium affine*
Heuchera villosa	*Heuchera villosa*
Hexastylis heterophylla	*Hexastylis heterophylla*
Hexastylis shuttleworthii	*Hexastylis shuttleworthii*
Hieracium paniculatum	*Hieracium paniculatum*
Hieracium venosum	*Hieracium venosum*
Holcus lanatus	*Holcus lanatus*
Houstonia caerulea	*Houstonia caerulea*
Houstonia [lanceolata + purpurea]	*Houstonia purpurea*
Houstonia purpurea	*Houstonia purpurea*
Houstonia serpyllifolia	*Houstonia serpyllifolia*
Huperzia lucidula	*Huperzia lucidula*
Hydatica petiolaris	*Hydatica petiolaris*
Hydrangea [arborescens + cinerea + radiata]	*Hydrangea arborescens*
Hydrangea arborescens	*Hydrangea arborescens*
Hydrastis canadensis	*Hydrastis canadensis*
Hydrocotyle americana	*Hydrocotyle americana*
Hydrophyllum canadense	*Hydrophyllum canadense*
Hydrophyllum virginianum	*Hydrophyllum virginianum*
Hypericum canadense	*Hypericum canadense*
Hypericum densiflorum	*Hypericum densiflorum*
Hypericum ellipticum	*Hypericum ellipticum*
Hypericum fraseri	*Hypericum fraseri*
Hypericum graveolens	*Hypericum graveolens*
Hypericum mitchellianum	*Hypericum mitchellianum*
Hypericum mutilum	*Hypericum mutilum*
Hypericum prolificum	*Hypericum prolificum*
Hypericum punctatum	*Hypericum punctatum*
Ilex collina	*Ilex collina*
Ilex montana	*Ilex montana*
Ilex opaca	*Ilex opaca*
Ilex verticillata	*Ilex verticillata*
Impatiens	*Impatiens [capensis + pallida]*
Impatiens [capensis + pallida]	*Impatiens [capensis + pallida]*
Impatiens capensis	*Impatiens [capensis + pallida]*
Impatiens pallida	*Impatiens [capensis + pallida]*
Trillium erectum	*Trillium erectum*
Trillium grandiflorum	*Trillium grandiflorum*
Trillium undulatum	*Trillium undulatum*
Tsuga canadensis	*Tsuga canadensis*
Tsuga caroliniana	*Tsuga canadensis*
Tussilago farfara	*Tussilago farfara*
Tylopilus fellus	*Tylopilus fellus*
Typha latifolia	*Typha latifolia*
Ulota crispa	*Ulota crispa*
Uvularia grandiflora	*Uvularia grandiflora*
Uvularia perfoliata	*Uvularia perfoliata*
Uvularia puberula	*Uvularia puberula*
Uvularia sessilifolia	*Uvularia sessilifolia*
Vaccinium angustifolium	*Vaccinium angustifolium*
Vaccinium corymbosum	*Vaccinium corymbosum*
Vaccinium erythrocarpum	*Vaccinium erythrocarpum*
Vaccinium macrocarpon	*Vaccinium macrocarpon*
Vaccinium myrtilloides	*Vaccinium myrtilloides*
Vaccinium oxycoccos	*Vaccinium oxycoccos*
Vaccinium pallidum	*Vaccinium pallidum*
Vaccinium simulatum	*Vaccinium simulatum*
Vaccinium stamineum	*Vaccinium stamineum*
Veratrum hybridum	*Veratrum hybridum*
Veratrum parviflorum	*Veratrum parviflorum*
Veratrum virginicum	*Veratrum virginicum*
Veratrum viride	*Veratrum viride*
Vernonia noveboracensis	*Vernonia noveboracensis*
Veronica americana	*Veronica americana*
Viburnum acerifolium	*Viburnum acerifolium*
Viburnum cassinoides	*Viburnum cassinoides*
Viburnum lantanoides	*Viburnum lantanoides*
Viburnum nudum	*Viburnum nudum*
Viburnum recognitum	*Viburnum recognitum*
Viola [blanda + incognita]	*Viola [blanda + incognita]*
Viola blanda	*Viola [blanda + incognita]*
Viola [eriocarpa + pubescens]	*Viola [eriocarpa + pubescens]*
Viola affinis	*Viola affinis*
Viola canadensis	*Viola canadensis*
Viola cucullata	*Viola cucullata*
Viola hastata	*Viola hastata*
Viola hirsutula	*Viola hirsutula*
Viola pallens	*Viola pallens*
Viola rotundifolia	*Viola rotundifolia*
Viola sagittata	*Viola sagittata*
Viola sororia	*Viola sororia*
Vittaria appalachiana	*Vittaria appalachiana*
Xanthorhiza simplicissima	*Xanthorhiza simplicissima*
Xerophyllum asphodeloides	*Xerophyllum asphodeloides*
Zizia trifoliata	*Zizia trifoliata*